DOE/EIS-0391

Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington

Volume 1
Chapters 1–12

U.S. Department of Energy

October 2009

Cover Sheet

Responsible Agency: U.S. Department of Energy (DOE)

Cooperating Agency: Washington State Department of Ecology (Ecology)

Title: *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (*TC & WM EIS*) (DOE/EIS-0391)

Location: Benton County, Washington

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Abstract: The Hanford Site (Hanford), located in southeastern Washington State and situated along the Columbia River, is approximately 1,518 square kilometers (586 square miles) in size. Hanford's mission from the early 1940s to approximately 1989 included defense-related nuclear research, development, and weapons production activities. These activities created a wide variety of chemical and radioactive wastes. Hanford's mission now is focused on the cleanup of those wastes and ultimate closure of Hanford. To this end, several types of radioactive waste are being managed at Hanford: (1) high-level radioactive waste (HLW) as defined in DOE Manual 435.1-1; (2) transuranic (TRU) waste, which is waste containing alpha-particle-emitting radionuclides with atomic numbers greater than uranium (92) and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram of waste; (3) low-level radioactive waste (LLW), which is radioactive waste that is neither HLW nor TRU waste; and (4) mixed low-level radioactive waste (MLLW), which is LLW containing hazardous constituents as defined under the Resource Conservation and Recovery Act of 1976 (42 U.S.C 6901 et seq.). Thus, this *TC & WM EIS* analyzes the following three key areas:

1. **Retrieval, treatment, and disposal of waste from 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs) and closure of the SST system.** In this *TC & WM EIS*, DOE proposes to retrieve and treat waste from 177 underground tanks and ancillary equipment and dispose of this waste in compliance with applicable regulatory requirements. At present, DOE is constructing a Waste Treatment Plant (WTP) in the 200-East Area of Hanford. The WTP would separate waste stored in Hanford's underground tanks into HLW and low-activity waste (LAW) fractions. HLW would be treated in the WTP and stored at Hanford until disposition decisions are made and implemented. (The analyses in this EIS are not affected by recent DOE plans to study alternatives for the disposition of the Nation's spent nuclear fuel and HLW because the EIS analysis shows that vitrified HLW can be stored safely at Hanford for many years.) LAW would

be treated in the WTP and disposed of at Hanford as decided in DOE's Record of Decision (ROD) issued in 1997 (62 FR 8693), pursuant to the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (DOE/EIS-0189, August 1996). DOE proposes to provide additional treatment capacity for the tank LAW that can supplement the planned WTP capacity in fulfillment of DOE's obligations under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) as soon as possible. DOE would dispose of immobilized LAW and Hanford's (and other DOE sites') LLW and MLLW in lined trenches on site. These trenches would be closed in accordance with applicable regulatory requirements.

2. **Final decontamination and decommissioning of the Fast Flux Test Facility, a nuclear test reactor.** DOE proposes to determine the final end state for the aboveground, belowground, and ancillary support structures.

3. **Disposal of Hanford's waste and other DOE sites' LLW and MLLW.** DOE needs to decide where to locate onsite disposal facilities for Hanford's waste and other DOE sites' LLW and MLLW. DOE committed in the ROD (69 FR 39449) for the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (DOE/EIS-0286F, January 2004) that henceforth LLW would be disposed of in lined trenches. Specifically, DOE proposes to dispose of the waste in either the existing 200-East Area Integrated Disposal Facility (IDF) or the proposed 200-West Area IDF.

DOE has identified Preferred Alternatives for two of the three program areas and a range for the three key activities, as presented in this *TC & WM EIS*.

Public Comments: Comments on this draft EIS may be submitted during the 140-day comment period, which will begin when the U.S. Environmental Protection Agency publishes a Notice of Availability in the *Federal Register*. Public meetings on this EIS will be held during the comment period. The dates, times, and locations of these meetings will be published in a DOE *Federal Register* notice, and will also be announced by other means.

Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (Draft TC & WM EIS)

Washington State Department of Ecology (Ecology) Foreword

Note: Ecology, as a cooperating agency, reviewed, provided comments on, and participated in the comment resolution process for the "preliminary draft" of this *Draft TC & WM EIS*. However, this foreword should be considered draft and subject to revision until Ecology has reviewed this *Draft TC & WM EIS* and, if necessary, supporting information.

Summary

Ecology believes that the U.S. Department of Energy (DOE) and its contractors have prepared a *Draft TC & WM EIS* that presents many important issues for discussion. Ecology's involvement to date shows that this document has benefitted from quality reviews and quality assurance procedures. The information in this document will help shed light on many key decisions that remain to be made about the Hanford Site (Hanford) cleanup.

Ecology expects DOE to consider our input through this foreword, as well as through any further comments made during the public comment process. We expect DOE to provide written responses to the major issues and comments prior to completion of the *Final TC & WM EIS*. Ecology will continue to work with DOE with the intent of helping to produce a final environmental impact statement (EIS) that fully informs future decisionmaking.

I. Introduction

Ecology has been a cooperating agency with DOE in the production of this *Draft TC & WM EIS*. DOE prepared this EIS to meet the requirements of the National Environmental Policy Act. In addition, Ecology will review this EIS to determine if it can be adopted in whole or in part to satisfy the requirements of the State Environmental Policy Act (SEPA). The information in this EIS will help inform Ecology and others about critical future cleanup decisions impacting Hanford's closure.

Ecology provides the following comments regarding this *Draft TC & WM EIS* to document areas of agreement or concern with this EIS and to assist the public in their review. Public and regulator input on this *Draft TC & WM EIS* are critical for the completion of an acceptable *Final TC & WM EIS*. Ecology encourages tribal nations, stakeholder groups, and the public to participate in the public comment process for this draft document.

When the *Final TC & WM EIS* is issued, Ecology will include a revised foreword to comment on the EIS conclusions. The foreword will also include the disposition of the comments we provided during the *Draft TC & WM EIS* review process.

II. Ecology's Role as a Cooperating Agency

Ecology is a cooperating agency in the preparation of this EIS. A state agency may be a cooperating agency on a Federal EIS when the agency has jurisdiction by law over, or specialized expertise concerning, a major Federal action under evaluation in the EIS.

As a cooperating agency, Ecology does not coauthor or direct the production of this EIS. Ecology does have access to certain data and information as this document is being prepared by DOE and its contractors. Our roles and responsibilities in this process are defined in a Memorandum of Understanding (MOU) between Ecology and DOE.

DOE retains responsibility for making final decisions in the preparation of the *Final TC & WM EIS*, as well as for determining the preferred alternative(s) presented in the EIS. However, Ecology's participation as a cooperating agency enables us to help formulate the alternatives presented in this *TC & WM EIS*.

Ecology's involvement as a cooperating agency—and the current scope of the *Draft TC & WM EIS*—is grounded in a series of events.

In February 2002, DOE initiated the "Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington," known as the "Tank Closure EIS." On March 25, 2003, Ecology became a cooperating agency for the "Tank Closure EIS." DOE and Ecology developed an MOU outlining respective agency roles and responsibilities.

While the "Tank Closure EIS" was being developed, another DOE EIS, the *Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington (HSW EIS)*, was in the review stage. Among other matters, the HSW EIS examined the impacts of disposal at Hanford of certain volumes of radioactive waste and mixed radioactive and hazardous waste, including waste generated from beyond Hanford.

In March 2003, Ecology filed a lawsuit in the U.S. District Court seeking to prevent the importation and storage of certain offsite transuranic (TRU) and mixed TRU wastes that DOE had decided to send to Hanford prior to issuance of the *Final HSW EIS*. Ecology and intervening plaintiffs obtained a preliminary injunction against these shipments.

In January 2004, DOE issued the *Final HSW EIS*. Based on the *Final HSW EIS*, DOE amended a Record of Decision that directed offsite radioactive and hazardous wastes to Hanford (within certain volume limits) for disposal and/or storage. In response, Ecology amended its lawsuit to challenge the adequacy of the *HSW EIS* analysis.

In May 2005, the U.S. District Court expanded the existing preliminary injunction to enjoin a broader class of waste and to grant Ecology a discovery period to further explore issues with the *HSW EIS*.

In January 2006, DOE and Ecology signed a Settlement Agreement, ending litigation on the *HSW EIS* and addressing concerns found in the *HSW EIS* quality assurance review during the discovery period. The Settlement Agreement called for expanding the scope of the "Tank Closure EIS" to provide a single, integrated set of analyses of (1) tank closure impacts considered in the "Tank Closure EIS" and (2) the disposal of all waste types considered in the *Final HSW EIS*. The Settlement Agreement also called for an integrated cumulative impacts analysis.

Under the Settlement Agreement, the "Tank Closure EIS" was renamed the *TC & WM EIS*. Ecology's existing MOU with DOE was revised along with the Settlement Agreement so that Ecology remained a cooperating agency on the expanded *TC & WM EIS*.

The Settlement Agreement defined specific tasks to address concerns Ecology had with the *HSW EIS*. DOE has now revised information and implemented quality assurance measures used in this *TC & WM EIS* related to the solid waste portion of the analysis. Ecology has performed discrete quality

assurance reviews of that information to help confirm that the quality assurance processes of DOE's EIS contractor have been followed.

Based on Ecology's involvement to date, we believe that positive changes have been made to address data quality shortcomings in the *HSW EIS*. These specifically relate to the following:

- The data used in analyzing impacts on groundwater
- The integration of analyses of all waste types that DOE may dispose of at Hanford
- The adequacy of the cumulative impact analysis

Ecology will review this *Draft TC & WM EIS* to confirm that the terms of the Settlement Agreement have been addressed to our satisfaction.

III. Regulatory Relationships and SEPA

After this *TC & WM EIS* is finalized, Ecology will proceed with approving regulatory actions required to complete the Hanford cleanup. These include actions under the Hanford Federal Facility Agreement and Consent Order (HFFACO, or Tri-Party Agreement) and actions that require state permits or modifications to existing permits, such as the Hanford Sitewide Permit. This permit regulates hazardous waste treatment, storage, and disposal activity at Hanford, including actions such as tank closure and supplemental treatment for tank waste.

Ecology must comply with SEPA when undertaking permitting actions. It is Ecology's hope that the *Final TC & WM EIS* will be suitable for adoption in whole or in part to satisfy SEPA.

In addition, Ecology will have a substantial role in establishing standards and methods for the cleanup of contaminated soil and groundwater at Hanford. These include areas that are regulated under hazardous waste corrective action authority and/or under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) through a CERCLA Record of Decision. Information developed in this EIS will thus be useful in other applications for the cleanup of Hanford.

IV. Ecology Insights and Alternatives Considered

This *Draft TC & WM EIS* considers 17 alternatives. DOE has not identified a specific preferred alternative. However, for the many decisions that are addressed in this EIS, DOE has selected a set of preferred alternatives. Ecology understands that the selection of a smaller number of preferred alternatives, or of a specific preferred alternative from that set, will be considered by DOE throughout public review of the *Draft TC & WM EIS*. When the final EIS is prepared, a preferred alternative will be identified by DOE.

The alternatives and tank closure options considered in this draft EIS include the following key decision areas:

- Additional tank waste treatment options (in addition to the Hanford Waste Treatment Plant [WTP] as provided in the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement)*
- Tank farm closure options
- Waste management options for the Central Plateau (including disposal of offsite defense wastes)
- Fast Flux Test Facility (FFTF) decommissioning

Ecology will update this foreword in the *Final TC & WM EIS* and will express its agreement or disagreement with DOE's preferred alternative for specific decisions in the foreword. In the interim, Ecology's insights, technical perspectives, and legal and policy perspectives are provided below. Areas of agreement with DOE and points of concern are noted.

Single-Shell Tank Retrieval Options

Ecology believes that DOE has presented an appropriate range of alternatives for evaluating tank waste retrieval and tank closure impacts. However, based on the hazardous waste tank closure standards of the "Dangerous Waste Regulations" (WAC 173-303-610[2]) and the HFFACO requirements, Ecology supports only alternatives that involve the retrieval of 99 percent or more of the waste from each of the 149 single-shell tanks (SSTs).

High-Level Radioactive Waste Disposal

High-level radioactive waste (HLW) associated with the tank waste includes, but may not be limited to, immobilized high-level radioactive waste (IHLW) and HLW melters (both spent and failed). It has been DOE's longstanding plan to store these wastes at Hanford and then ship and dispose of them in a deep geologic repository. The idea was that the nature of the geology would isolate the waste and protect humans from exposure to these very long-lived, lethal radionuclides. The Nuclear Waste Policy Act indicates that these waste streams require permanent isolation. By contrast, the immobilized low-activity waste (ILAW) glass, and perhaps other waste streams, may not require deep geologic disposal due to the level of pretreatment resulting in radionuclide removal and the degree of immobilization provided for in the ILAW glass.

However, the final decision on HLW disposal has recently become an issue with significant uncertainty. The *Draft TC & WM EIS* contains the following statement:

> As indicated in the Administration's fiscal year 2010 budget request, the Administration intends to terminate the Yucca Mountain program while developing nuclear waste disposal alternatives. Notwithstanding the decision to terminate the Yucca Mountain program, DOE remains committed to meeting its obligations to manage and ultimately dispose of HLW and SNF. The Administration intends to convene a blue ribbon commission to evaluate alternative approaches for meeting these obligations. The commission will provide the opportunity for a meaningful dialogue on how best to address this challenging issue and will provide recommendations that will form the basis for working with Congress to revise the statutory framework for managing and disposing of HLW and SNF.

Ecology reminds the readers that the Nuclear Waste Policy Act requires permanent isolation of these most difficult waste streams. Leaving these wastes stored at Hanford indefinitely is not a legal option, nor an acceptable option to the State of Washington.

Ecology is concerned about the glass standards and canister requirements for the IHLW. These standards were developed based on what was acceptable to Yucca Mountain. Now that Yucca Mountain is no longer the assumed disposal location, Ecology is concerned about what standards for glass and canisters will be utilized by the WTP. Ecology insists that DOE implement the most conservative approach in these two areas to guarantee that the glass and canister configurations adopted at the WTP will be acceptable at the future deep geologic repository.

In addition, Ecology maintains that DOE should build and operate adequate interim storage capacity for the IHLW and the HLW melters in a manner that does not slow down the treatment of tank waste.

This *Draft TC & WM EIS* assumes that the used (both spent and failed) HLW melters are HLW and, therefore, should be disposed of in a deep geologic repository. This EIS also assumes that the used HLW melters will stay on site before shipment to such a repository. DOE has not requested, and Ecology has not accepted, long-term interim storage of failed or spent HLW melters at Hanford.

Ecology does not agree that the HLW melters will or should stay on site. We do agree with the final disposal in a deep geologic repository. The disposal pathway for both the failed and the spent melters will require further evaluation than is presented in this *Draft TC & WM EIS*. Ecology and DOE will need to reach a mutual understanding and agreement on the regulatory framework for disposal.

Pretreatment of Tank Waste

This *Draft TC & WM EIS* includes numerous alternatives that pretreat tank waste to separate the high-activity components and direct them to a HLW stream. The HLW stream will be vitrified, resulting in a glass waste product that will be sent to a deep geologic repository. However, this draft EIS has one alternative that provides no pretreatment for some portion of the waste in the 200-West Area.

As a legal and policy issue, Ecology does not agree with alternatives that do not require pretreatment of the tank waste. Such alternatives do not meet the intent of the Nuclear Waste Policy Act to remove as many of the fission products and radionuclides as possible to concentrate them in the HLW stream. For this reason, Ecology requests that DOE rule out any alternative that does not pretreat tank waste.

TRU Tank Waste

This *Draft TC & WM EIS* considers the option of treating and sending waste from specific tanks to the Waste Isolation Pilot Plant (WIPP) as mixed TRU waste. This draft EIS also considers WTP processing of the waste from these specific tanks.

Ecology has legal and technical concerns with any tank waste being classified as mixed TRU waste at this time. DOE must provide peer-reviewed data and a strong, defensible, technically and legally detailed justification for the designation of any tank waste as mixed TRU waste, rather than as HLW. DOE must also complete the WIPP certification process and assure Ecology that there is a viable disposal pathway (i.e., permit approval from the State of New Mexico) before Ecology will modify the Hanford Sitewide Permit to allow tank waste to be treated as mixed TRU waste.

Supplemental Treatment

In this *Draft TC & WM EIS*, DOE considers changes to the treatment processes that the WTP would use. Specifically, this draft EIS considers technologies to supplement the WTP's treatment of low-activity waste (LAW). The WTP as it is currently designed does not have the capacity to treat the entire volume of LAW in a reasonable timeframe.

Ecology agrees on the need to evaluate supplemental LAW treatment. An additional supplemental LAW treatment system is necessary to treat all the tank waste in a reasonable amount of time. Ecology fully supports the *Draft TC & WM EIS* alternative that assumes a second LAW Vitrification Facility would provide additional waste processing. Building a second LAW Vitrification Facility has consistently been Ecology's baseline approach. We would prefer a second LAW Vitrification Facility as the preferred alternative for the following reasons:

- LAW vitrification is a mature technology that is ready to be implemented with no further testing.
- LAW vitrification produces a well-understood waste form that is extremely protective of the environment (the bulk vitrification waste form is not as protective).

- Negative data from the last bulk vitrification experimental testing indicate waste form performance and technology implementation issues.
- There has been a lack of significant progress on advancing a bulk vitrification test facility for actual waste.
- The environmental results from the waste performance presented in this *Draft TC & WM EIS* indicate that LAW vitrification is superior to bulk vitrification.
- A recently published DOE report indicates that a second LAW Vitrification Facility would be preferable.

Consistent with the standard of HFFACO Milestone M-62-08, Ecology will analyze the information from the bulk vitrification alternative. From this analysis, Ecology will determine if the performance of the waste forms is comparable with WTP borosilicate glass. Ecology's measuring stick for a successful supplemental treatment technology has always been whether it is "as good as glass" (from the WTP).

As a technical issue, Ecology does not think that the waste treatment processes of steam reforming and cast stone would provide adequate primary waste forms for disposal of tank waste in onsite landfills. This has already been the subject of a previous DOE down-select process, in which Ecology and other participants rated these treatment technologies as low. This draft EIS shows that the waste form performance would be inadequate for both cast stone and steam reforming. These alternatives do not merit any further review.

Specifically related to the steam reforming alternative, Ecology has technical concerns about the *Draft TC & WM EIS's* assumptions for contaminant partitioning and its effects on waste form performance. It is inappropriate to assign the same assumptions to steam reforming as those used for bulk vitrification, given the different maturities of the two technologies.

Secondary Waste from Tank Waste Treatment

This *Draft TC & WM EIS* evaluates the impacts of disposing of secondary waste that results from tank waste treatment. Ecology agrees with DOE that secondary waste from the WTP and supplemental treatment operations would need additional mitigation before disposal. This assumption is not reflected in (and, in fact, is contradicted by) the current DOE baseline, which does not assume such additional mitigation. DOE has not determined what the secondary waste treatment would be, but DOE and its contractor are evaluating various treatment options.

Tank Waste Treatment Flowsheet

In preparing this *Draft TC & WM EIS*, some assumptions were made about highly technical issues such as the tank waste treatment flowsheet, which is a representation of how much of which constituent ends up in which waste form and in what amount.

Certain constituents such as technetium-99 and iodine-129 are significant risk drivers because they are mobile in the environment and have long half-lives. This draft EIS assumes that 20 percent of the iodine-129 from the tank waste would end up in vitrified glass and 80 percent in the grouted secondary waste. The same assumption is made for bulk vitrification and the WTP LAW Vitrification Facility.

Based on its review of the *Draft TC & WM EIS's* contaminant flowsheets for the WTP and bulk vitrification, Ecology has technical concerns with this approach. The design configuration for the WTP indicates that iodine-129 recycles past the melter multiple times, which leads to a higher retention in the glass and less in the secondary waste. Therefore, Ecology believes the retention rate of iodine-129 in the

ILAW glass may be higher than that in bulk vitrification glass. However, Ecology is aware that there is uncertainty in the actual glass retention results.

Through our cooperating agency interactions, DOE has agreed to run a sensitivity analysis to show the information under a different approach. The sensitivity analysis in this *Draft TC & WM EIS* shows that if recycling of iodine-129 is as effective as the WTP flowsheets indicate, then the WTP with a Bulk Vitrification Facility alternative would place 80 percent of iodine-129 in secondary waste (a less-robust waste form). This compares to an alternative that includes a second LAW Vitrification Facility in addition to the WTP, which would place 30 percent of the iodine-129 in secondary waste. This 50 percent difference in capture reinforces Ecology's opinion that choosing Tank Closure Alternative 2B, which would use the WTP and a second LAW Vitrification Facility, would be best from a tank waste treatment perspective.

Waste Release

This *Draft TC & WM EIS* models waste releases from several different types of final waste forms, including the following:

- ILAW glass
- Failed and spent LAW melters
- Waste in bulk vitrification boxes
- Steam reformed waste
- Grouted LAW from tank waste
- Grouted secondary waste
- Waste left in waste sites
- Grouted waste in the bottom of tanks
- Direct buried waste in landfills
- Waste that has been macroencapsulated

Ecology understands the methods and formulas used for the waste form release calculations (for all waste types). However, we will need to see the modeling results and complete our technical review before we can validate this portion of this EIS.

Offsite Waste

DOE is decades behind its legal schedule in retrieving tank waste from SSTs and years behind its legal schedule in completing construction of the WTP. DOE has not even begun treating Hanford's 200 million liters (53 million gallons) of tank waste.

At its current pace, DOE is in danger of falling years behind its legal schedule in processing contact-handled TRU waste for disposal at WIPP. DOE has not yet even completed planning for a facility to process remote-handled TRU waste for such disposal. Massive areas of Hanford's soil and groundwater are contaminated, and many of these areas will likely remain contaminated for generations to come, even after final cleanup remedies have been instituted.

The State of Washington is aware that under DOE's plans, more curies of radioactivity would leave Hanford (in the form of vitrified HLW and processed TRU waste) than would be added to Hanford through proposed offsite waste disposal. However, based on the current state of Hanford's cleanup and the analysis in this *Draft TC & WM EIS*, the State of Washington objects to the disposal at Hanford of additional wastes that have been generated from beyond Hanford.

As this *Draft TC & WM EIS* shows, disposal of the proposed offsite waste would significantly increase groundwater impacts to beyond acceptable levels. Such disposal would add to the risk term at Hanford today, at a time when progress on reducing the bulk of Hanford's existing risk term has yet to be realized. DOE should take a conservative approach to ensure that the impact of proposed offsite waste disposal,

when added to other existing Hanford risks, does not result in exceeding the "reasonable expectation" standard of DOE's own performance objectives (see DOE Manual 435.1-1, Section IV.P[1]) and of other environmental standards (e.g., drinking water standards).

The State of Washington supports a "no offsite waste disposal" alternative as its preferred alternative in the *Final TC & WM EIS*, to be adopted in a Record of Decision. DOE should forgo offsite waste disposal at Hanford (subject to the exceptions in the current *State of Washington v. Bodman* Settlement Agreement), at least until such time as it has made significant progress on SST waste retrieval and the tank waste treatment process. If DOE wishes to use Hanford as an offsite waste repository after that point, DOE should then re-evaluate the potential impacts of any proposed offsite waste disposal in light of the then-existing Hanford risk term.

Waste Disposal Location Alternatives

Ecology agrees with DOE that a preferred alternative locating the Integrated Disposal Facility in the 200-East Area appears better for long-term disposal of waste than in the 200-West Area because of the faster rate of groundwater flow in the 200-East Area.

Black Rock Reservoir

This *Draft TC & WM EIS* considers the groundwater impacts of locating Black Rock Reservoir upgradient of Hanford. This is noteworthy because leakage associated with the reservoir could have impacts on Hanford groundwater contamination. Ecology has reviewed the evaluation basis assumed in this draft EIS. On a technical basis, Ecology accepts that potential groundwater impacts of the proposed reservoir could (or likely would) adversely impact human health and the environment at Hanford.

Vadose Zone Modeling

This *Draft TC & WM EIS* uses the STOMP [Subsurface Transport Over Multiple Phases] modeling code for vadose zone modeling. Based on its current review, Ecology believes that the Hanford parameters used with this code are adequate for the purposes served by this EIS. Ecology notes that the *TC & WM EIS* STOMP modeling code parameters are based on a regional scale and may not be appropriate for site-specific closure decisions or other Hanford assessments. Use of STOMP in other assessments requires careful technical review and consideration of site-specific parameters. Further revisions of these STOMP parameters may be necessary.

Risk Assessment and Cumulative Impacts

This *Draft TC & WM EIS* evaluates risk under the alternatives and in the cumulative impact analyses. The risk assessment modeling presented in this draft EIS should not be interpreted as a Hanford sitewide comprehensive human health and ecological risk assessment, applied to the river corridor or other specific Hanford areas. Specific Hanford areas will require unique site parameters that are applicable to that area's specific use.

This *Draft TC & WM EIS* presents an evaluation of the cumulative environmental impacts of treatment and disposal of wastes at Hanford. The cumulative impact analyses allow DOE to consider the impacts of all cleanup actions it has taken or plans to take at Hanford.

V. Noteworthy Areas of Agreement

Ecology and DOE have discussed and reached agreement on the following significant issues and parameters for the purposes of this *Draft TC & WM EIS*:

- The manner in which DOE presents groundwater data and information (i.e. with pictures).

- The quality assurance requirements that DOE and Ecology identified in the *HSW EIS* (*State of Washington v. Bodman*) Settlement Agreement
- The Technical Guidance Document for *Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* Agreement, which focused on parameters shown to be important in groundwater analysis
- The location of calculation points for contaminant concentrations in groundwater
- The use of tank farm closure descriptions and alternative analysis
- The use of tank waste treatment descriptions and alternative analysis
- Inclusion of the US Ecology site and the cocooned reactors transported to the Central Plateau in the comprehensive cumulative impacts assessment
- Overall modeling approaches for vadose zone and groundwater
- The use of modeling assumptions for the double-shell tanks
- Alternative assumptions about how processes would treat existing wastes and generate other wastes during treatment processes, and how DOE would dispose of all of the wastes.
- The methods for evaluating and using waste inventory data
- Release mechanisms for contaminants from various waste forms
- An alternative in this *Draft TC & WM EIS* that evaluates impacts of treating and disposal of all tank waste and residue to meet the Resource Conservation and Recovery Act / Hazardous Waste Management Act HLW treatment standard of vitrification
- The inventory assumptions used for the pre-1970 burial grounds

Ecology's agreement on these issues and parameters is specifically for the purposes of this *Draft TC & WM EIS* and is based on Ecology's current knowledge and best professional judgment. Ecology's agreement should not be construed as applicable to any future documents, evaluations, or decisions at Hanford.

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List of Acronyms and Abbreviations

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
AADT	annual average daily traffic
AEA	Atomic Energy Act of 1954
AEGL	Acute Exposure Guideline Level
ALARA	as low as is reasonably achievable
AMWTP	Advanced Mixed Waste Treatment Project
ANL-W	Argonne National Laboratory-West
ATR	Advanced Test Reactor
BLM	U.S. Bureau of Land Management
BRMaP	*Hanford Site Biological Resources Management Plan*
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CH	contact-handled
CH-TRU	contact-handled transuranic
COPC	constituent of potential concern
CSB	Canister Storage Building
CTR	commute trip reduction
CWC	Central Waste Complex
CY	calendar year
D&D	decontamination and decommissioning
dBA	decibels A-weighted
DOE	U.S. Department of Energy
DOE-ID	DOE Idaho Operations Office
DOE-RL	DOE Richland Operations Office
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DST	double-shell tank
EA	environmental assessment
EBR-II	Experimental Breeder Reactor II
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ERPG	Emergency Response Planning Guideline
ETF	Effluent Treatment Facility
Fermi	Enrico Fermi Nuclear Generating Station

FFTF	Fast Flux Test Facility
"FFTF Decommissioning EIS"	"Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, Washington" (rescoped in 2006 to the *TC & WM EIS)*
FFTF Deactivation EA	*Environmental Assessment – Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington*
Final Comprehensive Conservation Plan and EIS	*Hanford Reach National Monument Final Comprehensive Conservation Plan and Environmental Impact Statement, Adams, Benton, Grant and Franklin Counties, Washington*
FMEF	Fuels and Materials Examination Facility
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
Gable Gap	Gable Mountain–Gable Butte Gap
GTCC	greater-than-Class C
GTCC EIS	*Environmental Impact Statement for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste*
Hanford	Hanford Site
Hanford Comprehensive Land-Use Plan EIS	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
Hanford Comprehensive Land-Use Plan EIS SA	*Final Supplement Analysis – Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
Hanford Defense Waste EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
Hanford NEPA Characterization Report	*Hanford Site National Environmental Policy Act (NEPA) Characterization Report*
Hanford Site Environmental Report	*Hanford Site Environmental Report for Calendar Year 2005 (Including Some Early 2006 Information)*
HCRMP	*Hanford Cultural Resources Management Plan*
HEDR	Hanford Environmental Dose Reconstruction
HEPA	high-efficiency particulate air
HIHTL	hose-in-hose transfer line
HLW	high-level radioactive waste
HSW EIS	*Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*
IDAPA	Idaho Administrative Procedures Act
IDEQ	State of Idaho Department of Environmental Quality

IDF	Integrated Disposal Facility
IDF-East	200-East Area Integrated Disposal Facility
IDF-West	200-West Area Integrated Disposal Facility
IHLW	immobilized high-level radioactive waste
ILAW	immobilized low-activity waste
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IPCC	Intergovernmental Panel on Climate Change
LAW	low-activity waste
LCF	latent cancer fatality
LERF	Liquid Effluent Retention Facility
LIGO	Laser Interferometer Gravitational-Wave Observatory
LLBG	low-level radioactive waste burial ground
LLW	low-level radioactive waste
LOS	level of service
LWPF	Liquid Waste Processing Facility
MCL	maximum contaminant level
MEI	maximally exposed individual
MFC	Materials and Fuels Complex
MLLW	mixed low-level radioactive waste
MMI	Modified Mercalli Intensity
MODFLOW	modular three-dimensional finite-difference groundwater flow model
MRS	mobile retrieval system
MTHM	metric ton(s) of heavy metal
MUST	miscellaneous underground storage tank
NAAQS	National Ambient Air Quality Standards
National Register	National Register of Historic Places
NDA	nondestructive assay
NDE	nondestructive examination
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NI PEIS	*Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility (Nuclear Infrastructure PEIS)*
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRDWL	Nonradioactive Dangerous Waste Landfill

NTS	Nevada Test Site
ORP	Office of River Protection
ORR	Oak Ridge Reservation
P.L.	Public Law
PCB	polychlorinated biphenyl
PM	particulate matter
PM_n	particulate matter with an aerodynamic diameter less than or equal to *n* micrometers
PNNL	Pacific Northwest National Laboratory
PPA	Property Protected Area
ppb	part(s) per billion
PPF	Preprocessing Facility
ppm	part(s) per million
PSD	Prevention of Significant Deterioration
PT	Pretreatment
PUREX	Plutonium-Uranium Extraction
Quality Review	*Report of the Review of the "Hanford Solid Waste Environmental Impact Statement (EIS)" Data Quality, Control and Management Issues*
R&D	research and development
RADTRAN 5	Radioactive Material Transportation risk assessment computer code
RCB	Reactor Containment Building
RCRA	Resource Conservation and Recovery Act
RCW	*Revised Code of Washington*
REDOX	Reduction-Oxidation
RH	remote-handled
RH-SC	remote-handled special component
RH-TRU	remote-handled transuranic
RISKIND	Risks and Consequences of Radiological Material Transport computer code
ROD	Record of Decision
ROI	region of influence
RPP	River Protection Project
RPPDF	River Protection Project Disposal Facility
RTC	Reactor Technology Complex
RTP	Remote Treatment Project
RWMC	Radioactive Waste Management Complex
SA	supplement analysis
SALDS	State-Approved Land Disposal Site
SC	special component
SEPA	State Environmental Policy Act
SNF	spent nuclear fuel

SNF PEIS	*Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*
SPF	Sodium Processing Facility
SRE	Sodium Reactor Experiment
SRF	Sodium Reaction Facility
SRS	Savannah River Site
SSF	Sodium Storage Facility
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases
STTS	Supplemental Treatment Technology Site
STTS-East	200-East Area Supplemental Treatment Technology Site
STTS-West	200-West Area Supplemental Treatment Technology Site
SWIFT	*Solid Waste Integrated Forecast Technical (SWIFT) Report*
SWITS	Solid Waste Information and Tracking System
SWOC	Solid Waste Operations Complex
T&ESMP-SS	*Threatened and Endangered Species Management Plan, Salmon and Steelhead*
"Tank Closure EIS"	"Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington" (rescoped in 2006 to the *TC & WM EIS*)
TC & WM EIS	*Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*
TCP	traditional cultural property
TEDF	Treated Effluent Disposal Facility
The Green Book	*Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*
TMC	theoretical maximum capacity
TPA	Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)
TRAGIS	Transportation Routing Analysis Geographic Information System
trenches	ditches
TRC	total recordable cases
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TWRS EIS	*Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement*
U.S.C.	*United States Code*
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VBR	vacuum-based retrieval
VRM	Visual Resource Management

WAC	*Washington Administrative Code*
WAG	Waste Area Group
Waste Management	*Final Waste management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*
WESF	Waste Encapsulation and Storage Facility
WIPP	Waste Isolation Pilot Plant
WIPP SEIS-II	*Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*
WLAP	Wastewater-Land Application Permit
WM PEIS	*Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*
WRAP	Waste Receiving and Processing Facility
WRF	waste receiver facility
WSDOT	Washington State Department of Transportation
WTP	Waste Treatment Plant

Measurement Units

The principal measurement units used in this *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (*TC & WM EIS*) are SI units (the abbreviation for the Système International d'Unites). The SI system is an expanded version of the metric system that was accepted in 1966 in Elsinore, Denmark, as the legal standard by the International Organization of Standardization. In this system, most units are made up of combinations of seven basic units, of which length in meters, mass in kilograms, and volume in liters are of most importance in this *TC & WM EIS*. Exceptions are radiological units that use the English system (e.g., rem, millirem).

SCIENTIFIC (EXPONENTIAL) NOTATION

Numbers that are very small or very large are often expressed in scientific, or exponential, notation as a matter of convenience. For example, the number 0.000034 may be expressed as 3.4×10^{-5} or 3.4E-05, and 65,000 may be expressed as 6.5×10^{4} or 6.5E+04. In this *TC & WM EIS*, numerical values that are less than 0.001 or greater than 9,999 are generally expressed in scientific notation, i.e., 1.0×10^{-3} and 9.9×10^{3}, respectively.

Multiples or submultiples of the basic units are also used. A partial list of prefixes that denote multiples and submultiples follows, with the equivalent multiplier values expressed in scientific notation.

Prefix	Symbol	Multiplier	
atto	a	0.000 000 000 000 000 001	1×10^{-18}
femto	f	0.000 000 000 000 001	1×10^{-15}
pico	p	0.000 000 000 001	1×10^{-12}
nano	n	0.000 000 001	1×10^{-9}
micro	μ	0.000 001	1×10^{-6}
milli	m	0.001	1×10^{-3}
centi	c	0.01	1×10^{-2}
deci	d	0.1	1×10^{-1}
deka	da	10	1×10^{1}
hecto	h	100	1×10^{2}
kilo	k	1,000	1×10^{3}
mega	M	1,000,000	1×10^{6}
giga	G	1,000,000,000	1×10^{9}
tera	T	1,000,000,000,000	1×10^{12}
peta	P	1,000,000,000,000,000	1×10^{15}
exa	E	1,000,000,000,000,000,000	1×10^{18}

The following symbols are occasionally used in conjunction with numerical expressions:

$<$ less than
$\leq$ less than or equal to
$>$ greater than
$\geq$ greater than or equal to

Conversions

English to Metric			Metric to English		
Multiply	**by**	**To get**	**Multiply**	**by**	**To get**
Area			**Area**		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092903	square meters	square meters	10.7639	square feet
square yards	0.8361	square meters	square meters	1.196	square yards
acres	0.40469	hectares	hectares	2.471	acres
square miles	2.58999	square kilometers	square kilometers	0.3861	square miles
Length			**Length**		
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Temperature			**Temperature**		
degrees Fahrenheit	Subtract 32, then multiply by 0.55556	degrees Celsius	degrees Celsius	Multiply by 1.8, then add 32	degrees Fahrenheit
Volume			**Volume**		
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.308	cubic yards
Weight			**Weight**		
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.45360	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons

DOE/EIS-0391

Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington

Reader's Guide

U.S. Department of Energy

October 2009

Cover Sheet

Responsible Agency: U.S. Department of Energy (DOE)

Cooperating Agency: Washington State Department of Ecology (Ecology)

Title: *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (*TC & WM EIS*) (DOE/EIS-0391)

Location: Benton County, Washington

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Abstract: The Hanford Site (Hanford), located in southeastern Washington State and situated along the Columbia River, is approximately 1,518 square kilometers (586 square miles) in size. Hanford's mission from the early 1940s to approximately 1989 included defense-related nuclear research, development, and weapons production activities. These activities created a wide variety of chemical and radioactive wastes. Hanford's mission now is focused on the cleanup of those wastes and ultimate closure of Hanford. To this end, several types of radioactive waste are being managed at Hanford: (1) high-level radioactive waste (HLW) as defined in DOE Manual 435.1-1; (2) transuranic (TRU) waste, which is waste containing alpha-particle-emitting radionuclides with atomic numbers greater than uranium (92) and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram of waste; (3) low-level radioactive waste (LLW), which is radioactive waste that is neither HLW nor TRU waste; and (4) mixed low-level radioactive waste (MLLW), which is LLW containing hazardous constituents as defined under the Resource Conservation and Recovery Act of 1976 (42 U.S.C 6901 et seq.). Thus, this *TC & WM EIS* analyzes the following three key areas:

1. **Retrieval, treatment, and disposal of waste from 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs) and closure of the SST system.** In this *TC & WM EIS*, DOE proposes to retrieve and treat waste from 177 underground tanks and ancillary equipment and dispose of this waste in compliance with applicable regulatory requirements. At present, DOE is constructing a Waste Treatment Plant (WTP) in the 200-East Area of Hanford. The WTP would separate waste stored in Hanford's underground tanks into HLW and low-activity waste (LAW) fractions. HLW would be treated in the WTP and stored at Hanford until disposition decisions are made and implemented. (The analyses in this EIS are not affected by recent DOE plans to study alternatives for the disposition of the Nation's spent nuclear fuel and HLW because the EIS analysis shows that vitrified HLW can be stored safely at Hanford for many years.) LAW would

be treated in the WTP and disposed of at Hanford as decided in DOE's Record of Decision (ROD) issued in 1997 (62 FR 8693), pursuant to the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (DOE/EIS-0189, August 1996). DOE proposes to provide additional treatment capacity for the tank LAW that can supplement the planned WTP capacity in fulfillment of DOE's obligations under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) as soon as possible. DOE would dispose of immobilized LAW and Hanford's (and other DOE sites') LLW and MLLW in lined trenches on site. These trenches would be closed in accordance with applicable regulatory requirements.

2. **Final decontamination and decommissioning of the Fast Flux Test Facility, a nuclear test reactor.** DOE proposes to determine the final end state for the aboveground, belowground, and ancillary support structures.

3. **Disposal of Hanford's waste and other DOE sites' LLW and MLLW.** DOE needs to decide where to locate onsite disposal facilities for Hanford's waste and other DOE sites' LLW and MLLW. DOE committed in the ROD (69 FR 39449) for the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (DOE/EIS-0286F, January 2004) that henceforth LLW would be disposed of in lined trenches. Specifically, DOE proposes to dispose of the waste in either the existing 200-East Area Integrated Disposal Facility (IDF) or the proposed 200-West Area IDF.

DOE has identified Preferred Alternatives for two of the three program areas and a range for the three key activities, as presented in this *TC & WM EIS*.

Public Comments: Comments on this draft EIS may be submitted during the 140-day comment period, which will begin when the U.S. Environmental Protection Agency publishes a Notice of Availability in the *Federal Register*. Public meetings on this EIS will be held during the comment period. The dates, times, and locations of these meetings will be published in a DOE *Federal Register* notice, and will also be announced by other means.

Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (Draft TC & WM EIS)

Washington State Department of Ecology (Ecology) Foreword

Note: Ecology, as a cooperating agency, reviewed, provided comments on, and participated in the comment resolution process for the "preliminary draft" of this *Draft TC & WM EIS*. However, this foreword should be considered draft and subject to revision until Ecology has reviewed this *Draft TC & WM EIS* and, if necessary, supporting information.

Summary

Ecology believes that the U.S. Department of Energy (DOE) and its contractors have prepared a *Draft TC & WM EIS* that presents many important issues for discussion. Ecology's involvement to date shows that this document has benefitted from quality reviews and quality assurance procedures. The information in this document will help shed light on many key decisions that remain to be made about the Hanford Site (Hanford) cleanup.

Ecology expects DOE to consider our input through this foreword, as well as through any further comments made during the public comment process. We expect DOE to provide written responses to the major issues and comments prior to completion of the *Final TC & WM EIS*. Ecology will continue to work with DOE with the intent of helping to produce a final environmental impact statement (EIS) that fully informs future decisionmaking.

I. Introduction

Ecology has been a cooperating agency with DOE in the production of this *Draft TC & WM EIS*. DOE prepared this EIS to meet the requirements of the National Environmental Policy Act. In addition, Ecology will review this EIS to determine if it can be adopted in whole or in part to satisfy the requirements of the State Environmental Policy Act (SEPA). The information in this EIS will help inform Ecology and others about critical future cleanup decisions impacting Hanford's closure.

Ecology provides the following comments regarding this *Draft TC & WM EIS* to document areas of agreement or concern with this EIS and to assist the public in their review. Public and regulator input on this *Draft TC & WM EIS* are critical for the completion of an acceptable *Final TC & WM EIS*. Ecology encourages tribal nations, stakeholder groups, and the public to participate in the public comment process for this draft document.

When the *Final TC & WM EIS* is issued, Ecology will include a revised foreword to comment on the EIS conclusions. The foreword will also include the disposition of the comments we provided during the *Draft TC & WM EIS* review process.

II. Ecology's Role as a Cooperating Agency

Ecology is a cooperating agency in the preparation of this EIS. A state agency may be a cooperating agency on a Federal EIS when the agency has jurisdiction by law over, or specialized expertise concerning, a major Federal action under evaluation in the EIS.

As a cooperating agency, Ecology does not coauthor or direct the production of this EIS. Ecology does have access to certain data and information as this document is being prepared by DOE and its contractors. Our roles and responsibilities in this process are defined in a Memorandum of Understanding (MOU) between Ecology and DOE.

DOE retains responsibility for making final decisions in the preparation of the *Final TC & WM EIS*, as well as for determining the preferred alternative(s) presented in the EIS. However, Ecology's participation as a cooperating agency enables us to help formulate the alternatives presented in this *TC & WM EIS*.

Ecology's involvement as a cooperating agency—and the current scope of the *Draft TC & WM EIS*—is grounded in a series of events.

In February 2002, DOE initiated the "Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington," known as the "Tank Closure EIS." On March 25, 2003, Ecology became a cooperating agency for the "Tank Closure EIS." DOE and Ecology developed an MOU outlining respective agency roles and responsibilities.

While the "Tank Closure EIS" was being developed, another DOE EIS, the *Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington (HSW EIS)*, was in the review stage. Among other matters, the HSW EIS examined the impacts of disposal at Hanford of certain volumes of radioactive waste and mixed radioactive and hazardous waste, including waste generated from beyond Hanford.

In March 2003, Ecology filed a lawsuit in the U.S. District Court seeking to prevent the importation and storage of certain offsite transuranic (TRU) and mixed TRU wastes that DOE had decided to send to Hanford prior to issuance of the *Final HSW EIS*. Ecology and intervening plaintiffs obtained a preliminary injunction against these shipments.

In January 2004, DOE issued the *Final HSW EIS*. Based on the *Final HSW EIS*, DOE amended a Record of Decision that directed offsite radioactive and hazardous wastes to Hanford (within certain volume limits) for disposal and/or storage. In response, Ecology amended its lawsuit to challenge the adequacy of the *HSW EIS* analysis.

In May 2005, the U.S. District Court expanded the existing preliminary injunction to enjoin a broader class of waste and to grant Ecology a discovery period to further explore issues with the *HSW EIS*.

In January 2006, DOE and Ecology signed a Settlement Agreement, ending litigation on the *HSW EIS* and addressing concerns found in the *HSW EIS* quality assurance review during the discovery period. The Settlement Agreement called for expanding the scope of the "Tank Closure EIS" to provide a single, integrated set of analyses of (1) tank closure impacts considered in the "Tank Closure EIS" and (2) the disposal of all waste types considered in the *Final HSW EIS*. The Settlement Agreement also called for an integrated cumulative impacts analysis.

Under the Settlement Agreement, the "Tank Closure EIS" was renamed the *TC & WM EIS*. Ecology's existing MOU with DOE was revised along with the Settlement Agreement so that Ecology remained a cooperating agency on the expanded *TC & WM EIS*.

The Settlement Agreement defined specific tasks to address concerns Ecology had with the *HSW EIS*. DOE has now revised information and implemented quality assurance measures used in this *TC & WM EIS* related to the solid waste portion of the analysis. Ecology has performed discrete quality

assurance reviews of that information to help confirm that the quality assurance processes of DOE's EIS contractor have been followed.

Based on Ecology's involvement to date, we believe that positive changes have been made to address data quality shortcomings in the *HSW EIS*. These specifically relate to the following:

- The data used in analyzing impacts on groundwater
- The integration of analyses of all waste types that DOE may dispose of at Hanford
- The adequacy of the cumulative impact analysis

Ecology will review this *Draft TC & WM EIS* to confirm that the terms of the Settlement Agreement have been addressed to our satisfaction.

III. Regulatory Relationships and SEPA

After this *TC & WM EIS* is finalized, Ecology will proceed with approving regulatory actions required to complete the Hanford cleanup. These include actions under the Hanford Federal Facility Agreement and Consent Order (HFFACO, or Tri-Party Agreement) and actions that require state permits or modifications to existing permits, such as the Hanford Sitewide Permit. This permit regulates hazardous waste treatment, storage, and disposal activity at Hanford, including actions such as tank closure and supplemental treatment for tank waste.

Ecology must comply with SEPA when undertaking permitting actions. It is Ecology's hope that the *Final TC & WM EIS* will be suitable for adoption in whole or in part to satisfy SEPA.

In addition, Ecology will have a substantial role in establishing standards and methods for the cleanup of contaminated soil and groundwater at Hanford. These include areas that are regulated under hazardous waste corrective action authority and/or under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) through a CERCLA Record of Decision. Information developed in this EIS will thus be useful in other applications for the cleanup of Hanford.

IV. Ecology Insights and Alternatives Considered

This *Draft TC & WM EIS* considers 17 alternatives. DOE has not identified a specific preferred alternative. However, for the many decisions that are addressed in this EIS, DOE has selected a set of preferred alternatives. Ecology understands that the selection of a smaller number of preferred alternatives, or of a specific preferred alternative from that set, will be considered by DOE throughout public review of the *Draft TC & WM EIS*. When the final EIS is prepared, a preferred alternative will be identified by DOE.

The alternatives and tank closure options considered in this draft EIS include the following key decision areas:

- Additional tank waste treatment options (in addition to the Hanford Waste Treatment Plant [WTP] as provided in the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement)*
- Tank farm closure options
- Waste management options for the Central Plateau (including disposal of offsite defense wastes)
- Fast Flux Test Facility (FFTF) decommissioning

Ecology will update this foreword in the *Final TC & WM EIS* and will express its agreement or disagreement with DOE's preferred alternative for specific decisions in the foreword. In the interim, Ecology's insights, technical perspectives, and legal and policy perspectives are provided below. Areas of agreement with DOE and points of concern are noted.

Single-Shell Tank Retrieval Options

Ecology believes that DOE has presented an appropriate range of alternatives for evaluating tank waste retrieval and tank closure impacts. However, based on the hazardous waste tank closure standards of the "Dangerous Waste Regulations" (WAC 173-303-610[2]) and the HFFACO requirements, Ecology supports only alternatives that involve the retrieval of 99 percent or more of the waste from each of the 149 single-shell tanks (SSTs).

High-Level Radioactive Waste Disposal

High-level radioactive waste (HLW) associated with the tank waste includes, but may not be limited to, immobilized high-level radioactive waste (IHLW) and HLW melters (both spent and failed). It has been DOE's longstanding plan to store these wastes at Hanford and then ship and dispose of them in a deep geologic repository. The idea was that the nature of the geology would isolate the waste and protect humans from exposure to these very long-lived, lethal radionuclides. The Nuclear Waste Policy Act indicates that these waste streams require permanent isolation. By contrast, the immobilized low-activity waste (ILAW) glass, and perhaps other waste streams, may not require deep geologic disposal due to the level of pretreatment resulting in radionuclide removal and the degree of immobilization provided for in the ILAW glass.

However, the final decision on HLW disposal has recently become an issue with significant uncertainty. The *Draft TC & WM EIS* contains the following statement:

> As indicated in the Administration's fiscal year 2010 budget request, the Administration intends to terminate the Yucca Mountain program while developing nuclear waste disposal alternatives. Notwithstanding the decision to terminate the Yucca Mountain program, DOE remains committed to meeting its obligations to manage and ultimately dispose of HLW and SNF. The Administration intends to convene a blue ribbon commission to evaluate alternative approaches for meeting these obligations. The commission will provide the opportunity for a meaningful dialogue on how best to address this challenging issue and will provide recommendations that will form the basis for working with Congress to revise the statutory framework for managing and disposing of HLW and SNF.

Ecology reminds the readers that the Nuclear Waste Policy Act requires permanent isolation of these most difficult waste streams. Leaving these wastes stored at Hanford indefinitely is not a legal option, nor an acceptable option to the State of Washington.

Ecology is concerned about the glass standards and canister requirements for the IHLW. These standards were developed based on what was acceptable to Yucca Mountain. Now that Yucca Mountain is no longer the assumed disposal location, Ecology is concerned about what standards for glass and canisters will be utilized by the WTP. Ecology insists that DOE implement the most conservative approach in these two areas to guarantee that the glass and canister configurations adopted at the WTP will be acceptable at the future deep geologic repository.

In addition, Ecology maintains that DOE should build and operate adequate interim storage capacity for the IHLW and the HLW melters in a manner that does not slow down the treatment of tank waste.

This *Draft TC & WM EIS* assumes that the used (both spent and failed) HLW melters are HLW and, therefore, should be disposed of in a deep geologic repository. This EIS also assumes that the used HLW melters will stay on site before shipment to such a repository. DOE has not requested, and Ecology has not accepted, long-term interim storage of failed or spent HLW melters at Hanford.

Ecology does not agree that the HLW melters will or should stay on site. We do agree with the final disposal in a deep geologic repository. The disposal pathway for both the failed and the spent melters will require further evaluation than is presented in this *Draft TC & WM EIS*. Ecology and DOE will need to reach a mutual understanding and agreement on the regulatory framework for disposal.

Pretreatment of Tank Waste

This *Draft TC & WM EIS* includes numerous alternatives that pretreat tank waste to separate the high-activity components and direct them to a HLW stream. The HLW stream will be vitrified, resulting in a glass waste product that will be sent to a deep geologic repository. However, this draft EIS has one alternative that provides no pretreatment for some portion of the waste in the 200-West Area.

As a legal and policy issue, Ecology does not agree with alternatives that do not require pretreatment of the tank waste. Such alternatives do not meet the intent of the Nuclear Waste Policy Act to remove as many of the fission products and radionuclides as possible to concentrate them in the HLW stream. For this reason, Ecology requests that DOE rule out any alternative that does not pretreat tank waste.

TRU Tank Waste

This *Draft TC & WM EIS* considers the option of treating and sending waste from specific tanks to the Waste Isolation Pilot Plant (WIPP) as mixed TRU waste. This draft EIS also considers WTP processing of the waste from these specific tanks.

Ecology has legal and technical concerns with any tank waste being classified as mixed TRU waste at this time. DOE must provide peer-reviewed data and a strong, defensible, technically and legally detailed justification for the designation of any tank waste as mixed TRU waste, rather than as HLW. DOE must also complete the WIPP certification process and assure Ecology that there is a viable disposal pathway (i.e., permit approval from the State of New Mexico) before Ecology will modify the Hanford Sitewide Permit to allow tank waste to be treated as mixed TRU waste.

Supplemental Treatment

In this *Draft TC & WM EIS*, DOE considers changes to the treatment processes that the WTP would use. Specifically, this draft EIS considers technologies to supplement the WTP's treatment of low-activity waste (LAW). The WTP as it is currently designed does not have the capacity to treat the entire volume of LAW in a reasonable timeframe.

Ecology agrees on the need to evaluate supplemental LAW treatment. An additional supplemental LAW treatment system is necessary to treat all the tank waste in a reasonable amount of time. Ecology fully supports the *Draft TC & WM EIS* alternative that assumes a second LAW Vitrification Facility would provide additional waste processing. Building a second LAW Vitrification Facility has consistently been Ecology's baseline approach. We would prefer a second LAW Vitrification Facility as the preferred alternative for the following reasons:

- LAW vitrification is a mature technology that is ready to be implemented with no further testing.
- LAW vitrification produces a well-understood waste form that is extremely protective of the environment (the bulk vitrification waste form is not as protective).

- Negative data from the last bulk vitrification experimental testing indicate waste form performance and technology implementation issues.
- There has been a lack of significant progress on advancing a bulk vitrification test facility for actual waste.
- The environmental results from the waste performance presented in this *Draft TC & WM EIS* indicate that LAW vitrification is superior to bulk vitrification.
- A recently published DOE report indicates that a second LAW Vitrification Facility would be preferable.

Consistent with the standard of HFFACO Milestone M-62-08, Ecology will analyze the information from the bulk vitrification alternative. From this analysis, Ecology will determine if the performance of the waste forms is comparable with WTP borosilicate glass. Ecology's measuring stick for a successful supplemental treatment technology has always been whether it is "as good as glass" (from the WTP).

As a technical issue, Ecology does not think that the waste treatment processes of steam reforming and cast stone would provide adequate primary waste forms for disposal of tank waste in onsite landfills. This has already been the subject of a previous DOE down-select process, in which Ecology and other participants rated these treatment technologies as low. This draft EIS shows that the waste form performance would be inadequate for both cast stone and steam reforming. These alternatives do not merit any further review.

Specifically related to the steam reforming alternative, Ecology has technical concerns about the *Draft TC & WM EIS's* assumptions for contaminant partitioning and its effects on waste form performance. It is inappropriate to assign the same assumptions to steam reforming as those used for bulk vitrification, given the different maturities of the two technologies.

Secondary Waste from Tank Waste Treatment

This *Draft TC & WM EIS* evaluates the impacts of disposing of secondary waste that results from tank waste treatment. Ecology agrees with DOE that secondary waste from the WTP and supplemental treatment operations would need additional mitigation before disposal. This assumption is not reflected in (and, in fact, is contradicted by) the current DOE baseline, which does not assume such additional mitigation. DOE has not determined what the secondary waste treatment would be, but DOE and its contractor are evaluating various treatment options.

Tank Waste Treatment Flowsheet

In preparing this *Draft TC & WM EIS*, some assumptions were made about highly technical issues such as the tank waste treatment flowsheet, which is a representation of how much of which constituent ends up in which waste form and in what amount.

Certain constituents such as technetium-99 and iodine-129 are significant risk drivers because they are mobile in the environment and have long half-lives. This draft EIS assumes that 20 percent of the iodine-129 from the tank waste would end up in vitrified glass and 80 percent in the grouted secondary waste. The same assumption is made for bulk vitrification and the WTP LAW Vitrification Facility.

Based on its review of the *Draft TC & WM EIS's* contaminant flowsheets for the WTP and bulk vitrification, Ecology has technical concerns with this approach. The design configuration for the WTP indicates that iodine-129 recycles past the melter multiple times, which leads to a higher retention in the glass and less in the secondary waste. Therefore, Ecology believes the retention rate of iodine-129 in the

ILAW glass may be higher than that in bulk vitrification glass. However, Ecology is aware that there is uncertainty in the actual glass retention results.

Through our cooperating agency interactions, DOE has agreed to run a sensitivity analysis to show the information under a different approach. The sensitivity analysis in this *Draft TC & WM EIS* shows that if recycling of iodine-129 is as effective as the WTP flowsheets indicate, then the WTP with a Bulk Vitrification Facility alternative would place 80 percent of iodine-129 in secondary waste (a less-robust waste form). This compares to an alternative that includes a second LAW Vitrification Facility in addition to the WTP, which would place 30 percent of the iodine-129 in secondary waste. This 50 percent difference in capture reinforces Ecology's opinion that choosing Tank Closure Alternative 2B, which would use the WTP and a second LAW Vitrification Facility, would be best from a tank waste treatment perspective.

Waste Release

This *Draft TC & WM EIS* models waste releases from several different types of final waste forms, including the following:

- ILAW glass
- Failed and spent LAW melters
- Waste in bulk vitrification boxes
- Steam reformed waste
- Grouted LAW from tank waste
- Grouted secondary waste
- Waste left in waste sites
- Grouted waste in the bottom of tanks
- Direct buried waste in landfills
- Waste that has been macroencapsulated

Ecology understands the methods and formulas used for the waste form release calculations (for all waste types). However, we will need to see the modeling results and complete our technical review before we can validate this portion of this EIS.

Offsite Waste

DOE is decades behind its legal schedule in retrieving tank waste from SSTs and years behind its legal schedule in completing construction of the WTP. DOE has not even begun treating Hanford's 200 million liters (53 million gallons) of tank waste.

At its current pace, DOE is in danger of falling years behind its legal schedule in processing contact-handled TRU waste for disposal at WIPP. DOE has not yet even completed planning for a facility to process remote-handled TRU waste for such disposal. Massive areas of Hanford's soil and groundwater are contaminated, and many of these areas will likely remain contaminated for generations to come, even after final cleanup remedies have been instituted.

The State of Washington is aware that under DOE's plans, more curies of radioactivity would leave Hanford (in the form of vitrified HLW and processed TRU waste) than would be added to Hanford through proposed offsite waste disposal. However, based on the current state of Hanford's cleanup and the analysis in this *Draft TC & WM EIS*, the State of Washington objects to the disposal at Hanford of additional wastes that have been generated from beyond Hanford.

As this *Draft TC & WM EIS* shows, disposal of the proposed offsite waste would significantly increase groundwater impacts to beyond acceptable levels. Such disposal would add to the risk term at Hanford today, at a time when progress on reducing the bulk of Hanford's existing risk term has yet to be realized. DOE should take a conservative approach to ensure that the impact of proposed offsite waste disposal,

when added to other existing Hanford risks, does not result in exceeding the "reasonable expectation" standard of DOE's own performance objectives (see DOE Manual 435.1-1, Section IV.P[1]) and of other environmental standards (e.g., drinking water standards).

The State of Washington supports a "no offsite waste disposal" alternative as its preferred alternative in the *Final TC & WM EIS*, to be adopted in a Record of Decision. DOE should forgo offsite waste disposal at Hanford (subject to the exceptions in the current *State of Washington v. Bodman* Settlement Agreement), at least until such time as it has made significant progress on SST waste retrieval and the tank waste treatment process. If DOE wishes to use Hanford as an offsite waste repository after that point, DOE should then re-evaluate the potential impacts of any proposed offsite waste disposal in light of the then-existing Hanford risk term.

Waste Disposal Location Alternatives

Ecology agrees with DOE that a preferred alternative locating the Integrated Disposal Facility in the 200-East Area appears better for long-term disposal of waste than in the 200-West Area because of the faster rate of groundwater flow in the 200-East Area.

Black Rock Reservoir

This *Draft TC & WM EIS* considers the groundwater impacts of locating Black Rock Reservoir upgradient of Hanford. This is noteworthy because leakage associated with the reservoir could have impacts on Hanford groundwater contamination. Ecology has reviewed the evaluation basis assumed in this draft EIS. On a technical basis, Ecology accepts that potential groundwater impacts of the proposed reservoir could (or likely would) adversely impact human health and the environment at Hanford.

Vadose Zone Modeling

This *Draft TC & WM EIS* uses the STOMP [Subsurface Transport Over Multiple Phases] modeling code for vadose zone modeling. Based on its current review, Ecology believes that the Hanford parameters used with this code are adequate for the purposes served by this EIS. Ecology notes that the *TC & WM EIS* STOMP modeling code parameters are based on a regional scale and may not be appropriate for site-specific closure decisions or other Hanford assessments. Use of STOMP in other assessments requires careful technical review and consideration of site-specific parameters. Further revisions of these STOMP parameters may be necessary.

Risk Assessment and Cumulative Impacts

This *Draft TC & WM EIS* evaluates risk under the alternatives and in the cumulative impact analyses. The risk assessment modeling presented in this draft EIS should not be interpreted as a Hanford sitewide comprehensive human health and ecological risk assessment, applied to the river corridor or other specific Hanford areas. Specific Hanford areas will require unique site parameters that are applicable to that area's specific use.

This *Draft TC & WM EIS* presents an evaluation of the cumulative environmental impacts of treatment and disposal of wastes at Hanford. The cumulative impact analyses allow DOE to consider the impacts of all cleanup actions it has taken or plans to take at Hanford.

V. Noteworthy Areas of Agreement

Ecology and DOE have discussed and reached agreement on the following significant issues and parameters for the purposes of this *Draft TC & WM EIS*:

- The manner in which DOE presents groundwater data and information (i.e. with pictures).

- The quality assurance requirements that DOE and Ecology identified in the *HSW EIS* (*State of Washington v. Bodman*) Settlement Agreement
- The Technical Guidance Document for *Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* Agreement, which focused on parameters shown to be important in groundwater analysis
- The location of calculation points for contaminant concentrations in groundwater
- The use of tank farm closure descriptions and alternative analysis
- The use of tank waste treatment descriptions and alternative analysis
- Inclusion of the US Ecology site and the cocooned reactors transported to the Central Plateau in the comprehensive cumulative impacts assessment
- Overall modeling approaches for vadose zone and groundwater
- The use of modeling assumptions for the double-shell tanks
- Alternative assumptions about how processes would treat existing wastes and generate other wastes during treatment processes, and how DOE would dispose of all of the wastes.
- The methods for evaluating and using waste inventory data
- Release mechanisms for contaminants from various waste forms
- An alternative in this *Draft TC & WM EIS* that evaluates impacts of treating and disposal of all tank waste and residue to meet the Resource Conservation and Recovery Act / Hazardous Waste Management Act HLW treatment standard of vitrification
- The inventory assumptions used for the pre-1970 burial grounds

Ecology's agreement on these issues and parameters is specifically for the purposes of this *Draft TC & WM EIS* and is based on Ecology's current knowledge and best professional judgment. Ecology's agreement should not be construed as applicable to any future documents, evaluations, or decisions at Hanford.

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List of Acronyms and Abbreviations

CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CWC	Central Waste Complex
DOE	U.S. Department of Energy
DST	double-shell tank
EIS	environmental impact statement
FFTF	Fast Flux Test Facility
FR	*Federal Register*
Hanford	Hanford Site
HLW	high-level radioactive waste
IDF	Integrated Disposal Facility
IDF-East	200-East Area Integrated Disposal Facility
IDF-West	200-West Area Integrated Disposal Facility
IHLW	immobilized high-level radioactive waste
ILAW	immobilized low-activity waste
INL	Idaho National Laboratory
LAW	low-activity waste
LLBG	low-level radioactive waste burial ground
LLW	low-level radioactive waste
MFC	Materials and Fuels Complex
MLLW	mixed low-level radioactive waste
NEPA	National Environmental Policy Act
PPA	Property Protected Area
PPF	Preprocessing Facility
RCB	Reactor Containment Building
RCRA	Resource Conservation and Recovery Act
RH-SC	remote-handled special component
RPPDF	River Protection Project Disposal Facility
RTP	Remote Treatment Project
SST	single-shell tank
TC & WM EIS	*Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*
TMC	theoretical maximum capacity
TPA	Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)
TRU	transuranic
TWRS EIS	*Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement*

List of Acronyms and Abbreviations *(continued)*

WAC	*Washington Administrative Code*
WESF	Waste Encapsulation and Storage Facility
WIPP	Waste Isolation Pilot Plant
WRAP	Waste Receiving and Processing Facility
WRF	waste receiver facility
WTP	Waste Treatment Plant

Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington

READER'S GUIDE

INTRODUCTION

This Reader's Guide serves as an introduction and guide to the contents of the U.S. Department of Energy's (DOE's) *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* to highlight the key features of the reasonable alternatives and to help readers review the technical analyses presented in this environmental impact statement (EIS). Included here are descriptions of the proposed actions; the scope of this EIS; the alternatives evaluated; and the organization of this EIS itself. Readers are encouraged to use this guide to assist them in navigating through the complex information presented in this *TC & WM EIS*.

PROPOSED ACTIONS

The Hanford Site (Hanford), located in southeastern Washington State, has a waste inventory of about 206 million liters (54.5 million gallons) of mixed radioactive and chemically hazardous waste resulting from defense production activities conducted during the Cold War years. This waste is stored in 177 large and 61 smaller underground storage tanks and is a major potential risk to public health and the environment. DOE proposes to reduce this risk by updating its waste storage methodology and retrieving, treating, and disposing of key elements of this waste inventory. This EIS addresses the potential environmental impacts for three sets of proposed actions at Hanford: tank closure, Fast Flux Test Facility (FFTF) decommissioning, and waste management.

Figure 1 is a simplified process flow diagram displaying the general flow of waste from the single-shell tanks (SSTs) and double-shell tanks (DSTs) through the proposed treatment, interim storage, and disposal options. For the reader's ease, the flow diagram does not reflect a single alternative or set of alternatives; instead, the diagram displays all the options that were analyzed under the 17 proposed alternatives (11 for tank closure, 3 for FFTF decommissioning, and 3 for waste management). A distinction between current and proposed facilities is also made in Figure 1 to assist the reader in understanding which capabilities currently exist and which proposed additional capabilities were analyzed.

SCOPE

The scope of this *TC & WM EIS* includes analyses of the potential environmental impacts and relative cost consequences of proposed actions and reasonable alternatives for accomplishing the proposed actions. These analyses focused on three key elements:

1. Revising and updating the analyses of the August 1996 *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (*TWRS EIS*), as well as subsequent supplement analyses, which addressed retrieval, treatment, and disposal of the tank waste, by also evaluating the impacts of different scenarios for final closure of Hanford's SST system.

2. Evaluating the potential environmental impacts of proposed activities to decommission FFTF, a nuclear test reactor, and associated auxiliary facilities at Hanford, including management of the waste generated by the decommissioning process (such as remote-handled special components [RH-SCs]) and disposition of Hanford's inventory of radioactively contaminated bulk sodium from FFTF and other onsite facilities.

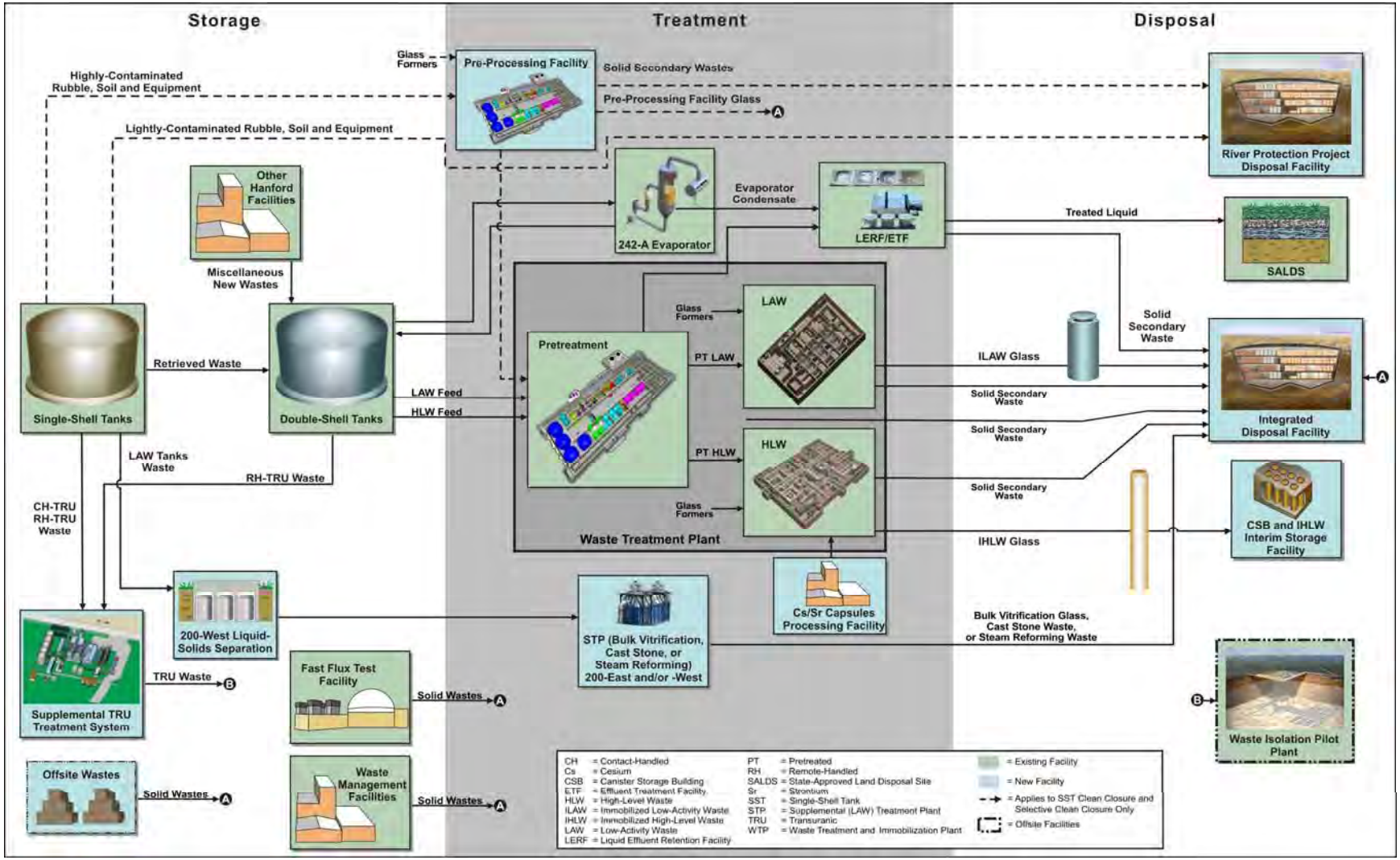


Figure 1. Simplified Process Flow Diagram

3. Evaluating the potential environmental impacts of ongoing solid waste management operations at Hanford, as well as the proposed disposal of Hanford low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) and a limited volume of LLW and MLLW from other DOE sites in an Integrated Disposal Facility (IDF) located at Hanford.

This *TC & WM EIS* was prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 *United States Code* 4321 et seq.); DOE implementing procedures for NEPA (*Code of Federal Regulations*, Title 10, Part 1021 [10 CFR 1021]); and Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500–1508). Further, this *TC & WM EIS* implements a Settlement Agreement signed on January 6, 2006, by DOE, the Washington State Department of Ecology, and the Washington State Attorney General's Office. The agreement settles NEPA claims made in the case *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM), which addressed the January 2004 *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*. The Washington State Department of Ecology is participating in this NEPA activity as a cooperating agency; as such, it is responsible for reviewing the content of this *TC & WM EIS* under the authority of Washington's State Environmental Policy Act to ensure it satisfies the State of Washington's requirements and supports its proposed action to issue permits under its hazardous waste program. The information provided in this *TC & WM EIS* will be considered, along with other pertinent information, in the decision process for DOE's proposed actions.

ALTERNATIVES

The following sections present the alternatives analyzed in this *TC & WM EIS*. More-detailed discussions of the alternatives are provided in Chapters 1 and 2 of this EIS.

TANK CLOSURE

DOE reviewed all comments generated during the scoping process for this EIS and determined that revision of the alternatives for tank closure proposed in the Notice of Intent was needed. Accordingly, DOE modified the alternatives as presented in the sections below. In creating and modifying the alternatives, emphasis was placed on including all reasonable component options to allow maximum flexibility in selecting the technologies, methods, time periods, and locations of the treatment and closure activities. The alternatives include combinations of the treatment and closure options under consideration.

Tank Closure Alternative 1: No Action

In the Council on Environmental Quality's "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations" (46 *Federal Register* [FR] 18026), two types of No Action Alternative are allowed. In one case, work is stopped and impacts are evaluated. In the second case, ongoing activities are evaluated as a "no change" and continuation of the present course of action.

In this EIS, DOE has chosen to show both types of no action. Under this alternative, the work would be stopped and impacts would be evaluated. Under Tank Closure Alternative 2A, DOE would evaluate retrieval from the tanks and treatment through the Waste Treatment Plant (WTP), in accordance with the *TWRS EIS* Record of Decision.

Storage: DOE would continue to store and monitor waste in the SSTs and DSTs for 100 years. Tanks showing signs of deterioration affecting their structural integrity would be filled with grout or gravel as a corrective action or emergency response. The cesium and strontium capsules would remain in storage in the Waste Encapsulation and Storage Facility (WESF).

Retrieval: Waste from the tanks would not be retrieved.

Treatment: No vitrification or treatment capacity would be built after 2008. Ongoing WTP construction would be terminated, and the WTP site would be isolated pending some future use, if any. No immobilized low-activity waste (ILAW) or immobilized high-level radioactive waste (IHLW) would be produced.

Disposal: The waste in the SST and DST systems would remain in the tank farms indefinitely.

Closure: Tank closure would not be addressed under this alternative. DOE would maintain security and management of the site for a 100-year administrative control period. During this period, DOE would continue to store and conduct routine monitoring of the waste in the SSTs, DSTs, and miscellaneous underground storage tanks.

Tank Closure Alternative 2: Implement the *Tank Waste Remediation System EIS* Record of Decision with Modifications

Tank Closure Alternative 2 would implement the decisions made in the Record of Decision for the *TWRS EIS* and considered in three supplement analyses completed through 2001. Under this alternative, all waste retrieved from the tanks would be vitrified, resulting in either an ILAW or IHLW glass product.

Tank Closure Alternative 2 consists of two subalternatives: (1) Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure and (2) Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure, as described below.

Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure

Storage: DOE would continue current waste management operations using existing tank storage facilities. Because all of the DSTs will exceed their 40-year design life during the approximate 80-year period of waste retrieval, they would be replaced in a phased manner through 2054.

Retrieval: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the minimum goal of the Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (TPA), i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for the 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval. This approach would be the same under Tank Closure Alternative 2B.

Treatment: The existing WTP configuration (two high-level radioactive waste [HLW] melters and two low-activity waste [LAW] melters) would operate at a theoretical maximum capacity (TMC) of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in 2093. All of the waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur. The WTP would need to be replaced after 60 years due to design-life constraints. No supplemental or transuranic (TRU) waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized via the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. This approach would be the same under Tank Closure Alternative 2B.

Closure: Tank closure would not be addressed under this alternative. For analysis purposes, administrative control of the tank farms would cease following a 100-year period ending in 2193.

Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new waste receiver facilities (WRFs), which are below-grade lag storage and minimal waste treatment facilities, would be constructed.

Retrieval: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for the 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval. This approach would be the same under Tank Closure Alternative 2A.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented with expanded LAW vitrification capacity (an addition of four LAW melters) to provide a vitrification TMC of 6 metric tons of glass IHLW per day and 90 metric tons of glass ILAW per day. Treatment would start in 2018 and end in approximately 2040 (for HLW) and 2043 (for LAW). All of the waste streams routed to the WTP would be pretreated, including technetium-99 removal from the LAW stream. No facilities would need to be replaced. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized via the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. This approach would be the same under Tank Closure Alternative 2A.

Closure: As operations are completed, the SST system at Hanford would be closed as a Resource Conservation and Recovery Act (RCRA) hazardous waste landfill unit under Section 173-303 of the *Washington Administrative Code* (WAC 173-303), "Dangerous Waste Regulations," and DOE Order 435.1, *Radioactive Waste Management*, as applicable, or it would be decommissioned under DOE Order 430.1B, *Real Property Asset Management*. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent future tank subsidence, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soil from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the River Protection Project Disposal Facility (RPPDF), a new facility similar to an IDF. The closed tank systems and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years.

Tank Closure Alternative 3: Existing WTP Vitrification with Supplemental Treatment Technology; Landfill Closure

This alternative consists of three subalternatives: (1) Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure, (2) Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure, and (3) Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure. These subalternatives would involve the use of either thermal or nonthermal treatment technologies to supplement the WTP treatment processes. TRU tank waste would be packaged and interim-stored pending shipment to the Waste Isolation Pilot Plant (WIPP) for disposal.

Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. This approach would be the same under Tank Closure Alternatives 3B and 3C.

Retrieval: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for the 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval. This approach would be the same under Tank Closure Alternatives 3B and 3C.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2040. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. WTP capacity would be supplemented with bulk vitrification treatment capacity to immobilize a portion of the LAW. Bulk vitrification supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas. In the 200-East Area, the waste feed would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and treated and packaged for disposal at WIPP.[1] The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized both via the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be stored on site in a new storage facility, pending disposal at WIPP. This approach would be the same under Tank Closure Alternatives 3B and 3C.

Closure: As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, *Radioactive Waste Management*, as applicable, or it would be decommissioned under DOE Order 430.1B, *Real Property Asset Management*. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent future tank subsidence, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soils from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the RPPDF. The closed tank systems and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years. This approach would be the same under Tank Closure Alternatives 3B and 3C.

[1] DOE believes there may be certain HLW storage tanks that it could demonstrate should be classified as TRU waste based on the origin of the waste. This *Draft TC & WM EIS* evaluates the environmental impacts of managing this waste as TRU waste because it assumes the historical processing data support this classification. For Alternatives 3 through 5, the EIS analyses evaluated treating the waste stream associated with the TRU waste portion as both TRU waste and HLW because this waste has not gone through the TRU waste confirmation and certification process.

Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. This approach would be the same under Tank Closure Alternatives 3A and 3C.

Retrieval: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for the 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval. This approach would be the same under Tank Closure Alternatives 3A and 3C.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2040. All waste streams routed to the WTP would be pretreated, including technetium-99 removal from the LAW stream. WTP capacity would be supplemented with cast stone treatment capacity to immobilize a portion of the LAW. Cast stone supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas. In the 200-East Area, the waste feed would be pretreated in the WTP, including technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized both via the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be stored on site in a new storage facility, pending disposal at WIPP. This approach would be the same under Tank Closure Alternatives 3A and 3C.

Closure: As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, *Radioactive Waste Management*, as applicable, or it would be decommissioned under DOE Order 430.1B, *Real Property Asset Management*. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent future tank subsidence, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soils from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the RPPDF. The closed tank systems and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years. This approach would be the same under Tank Closure Alternatives 3A and 3C.

Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. This approach would be the same under Tank Closure Alternatives 3A and 3B.

Retrieval: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for the 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series

tanks, corresponding to 99 percent retrieval. This approach would be the same under Tank Closure Alternatives 3A and 3B.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2040. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. WTP capacity would be supplemented with steam reforming treatment capacity to immobilize a portion of the LAW. The steam reforming supplemental treatment for the LAW would occur in both the 200-East and 200-West Areas. In the 200-East Area, the waste feed would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and treated and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized both via the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be stored on site in a new storage facility, pending disposal at WIPP. This approach would be the same under Tank Closure Alternatives 3A and 3B.

Closure: As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, *Radioactive Waste Management*, as applicable, or it would be decommissioned under DOE Order 430.1B, *Real Property Asset Management*. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent future tank subsidence, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soils from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the RPPDF. The closed tank systems and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years. This approach would be the same under Tank Closure Alternatives 3A and 3B.

Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

This alternative involves the use of both thermal and nonthermal treatment technologies (bulk vitrification and cast stone, respectively) to supplement WTP treatment. This alternative also evaluates treatment of 99.9 percent of the waste volume in the tank farms, clean closure of two representative (BX and SX) tank farms, and landfill closure of the remaining tank farms.

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed.

Retrieval: Using currently available liquid-based retrieval and leak detection systems and a final chemical wash step, waste would be retrieved to a volume corresponding to 99.9 percent retrieval, equal to residual tank waste of no more than 1 cubic meter (36 cubic feet) for the 100-series tanks or 0.08 cubic meters (3 cubic feet) for the smaller 200-series tanks.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2043, including

treatment of the highly contaminated waste stream resulting from clean closure of the BX and SX tank farms. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. WTP capacity would be supplemented with additional waste treatment capacity to immobilize a portion of the LAW. Supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas and consist of a combination of cast stone treatment in the 200-East Area and bulk vitrification treatment in the 200-West Area. The waste stream feed for the 200-East Area cast stone supplemental treatment facility would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized both via the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be packaged and stored on site in an existing or new storage facility, pending disposal at WIPP.

Closure: As operations are completed, the SST system at Hanford, except the BX and SX tank farms, would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, *Radioactive Waste Management*, as applicable, or it would be decommissioned under DOE Order 430.1B, *Real Property Asset Management*. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent long term degradation of the tanks, and discourage intruder access. The closed tank systems, except the BX and SX tank farms and six sets of adjacent cribs and trenches (ditches), would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years. The BX and SX tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. The removed tanks, ancillary equipment, and soils would be treated, as appropriate, in the Preprocessing Facility (PPF), resulting in MLLW and a highly contaminated liquid waste stream. The MLLW would be disposed of on site, and the highly contaminated liquid waste stream would be processed as HLW in the WTP, resulting in additional IHLW. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. Highly contaminated soils from deep soil excavation would be treated in the PPF. This process would generate a contaminated liquid waste stream that would be processed as LAW in the WTP, resulting in additional ILAW. The washed soils would be disposed of in the RPPDF. The BX and SX tank farms would be backfilled with clean soil.

Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

This alternative involves the use of both thermal and nonthermal treatment technologies (bulk vitrification and cast stone, respectively) to supplement the WTP treatment. This alternative also evaluates retrieval and treatment of 90 percent of the tank waste volume in the tank farms, but on an accelerated schedule, as well as landfill closure of the SST system.

Storage: DOE would continue current waste management operations using existing tank storage facilities. Four new DSTs and four WRFs would be constructed.

Retrieval: Using currently available liquid-based retrieval and leak detection systems, waste would be retrieved to a volume corresponding to 90 percent retrieval, less than the TPA Milestone M-45-00 minimum goal of 99 percent. Retrieval to 90 percent represents a programmatic risk analysis for the tank farms as defined by Appendix H of the TPA, "Single-Shell Tank Waste Retrieval Criteria Procedure."

The 90 percent retrieval level would be equal to residual tank waste of no more than 102 cubic meters (3,600 cubic feet) for the 100-series tanks or 8.5 cubic meters (300 cubic feet) for the smaller 200-series tanks.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented with expanded LAW vitrification capacity (an addition of one LAW melter) to provide a vitrification TMC of 6 metric tons of glass IHLW per day and 45 metric tons of glass ILAW per day. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. Treatment would start in 2018 and end in approximately 2034. This alternative considers implementation of a sulfate removal technology following WTP pretreatment that would potentially reduce the amount of glass produced in the WTP by increasing the waste loading in the ILAW glass. WTP capacity would be supplemented with additional waste treatment capacity to immobilize a portion of the LAW. Supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas and consist of a combination of cast stone treatment in the 200-East Area and bulk vitrification treatment in the 200-West Area. The waste stream feed for the 200-East Area Cast Stone Facility would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized both via the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be packaged and stored on site in a new storage facility, pending disposal at WIPP.

Closure: As operations are completed, the SST system would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, *Radioactive Waste Management*, or it would be decommissioned under DOE Order 430.1B, *Real Property Asset Management*. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. The tank systems (tanks, ancillary equipment, and soils) and the six sets of adjacent cribs and trenches (ditches) would be closed in place and covered with the Hanford barrier (a barrier with performance characteristics that exceed RCRA requirements for disposal of hazardous waste). To support this schedule, SST system ancillary equipment outside the boundaries of the surface barriers would not be removed or decontaminated. Postclosure care would continue for 100 years.

Tank Closure Alternative 6: All Waste as Vitrified HLW[2]

This alternative consists of three subalternatives: (1) Alternative 6A: All Vitrification/No Separations; Clean Closure (Base and Option Cases), (2) Alternative 6B: All Vitrification with Separations; Clean Closure (Base and Option Cases), and (3) Alternative 6C: All Vitrification with Separations; Landfill Closure. These alternatives evaluate an all-vitrification case wherein all vitrified waste would be managed as HLW.

[2] Alternatives 6A, 6B, and 6C of this EIS evaluate management of tank waste as HLW combined with different closure scenarios. The purpose of Alternative 6A is to evaluate the bounding case for no-separation scenarios. The DOE Manual 435.1-1, "*Radioactive Waste Management Manual,*" waste incidental to reprocessing evaluation determination process is not required for treatment of the waste under these alternatives.

Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure (Base and Option Cases)

Storage: DOE would continue current waste management operations using existing tank storage facilities that would be modified as needed to support SST waste retrieval and treatment. New DSTs would be required after the existing DSTs reach the end of their design life.

Retrieval: Using currently available liquid-based retrieval and leak detection systems and a final chemical wash step, waste would be retrieved to a volume corresponding to 99.9 percent retrieval, equal to residual tank waste of no more than 1 cubic meter (36 cubic feet) for the 100-series tanks or 0.08 cubic meters (3 cubic feet) for the smaller 200-series tanks. This approach would be the same under Tank Closure Alternative 6B.

Treatment: The existing WTP configuration would be modified to process all waste as HLW through expanded HLW vitrification capacity. This new WTP configuration (five HLW melters and no LAW melters) would provide a total vitrification TMC of 15 metric tons of glass IHLW per day. Treatment would start in 2018 and end in approximately 2163, requiring two WTP replacement facilities due to design-life constraints. There would be no pretreatment, LAW treatment, or technetium-99 removal. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: IHLW canisters would be stored on site until disposition decisions are made and implemented. Replacement of the canister storage facilities would be required after a 60-year design life. The HLW debris from clean closure would be managed as HLW and stored on site.

Closure: Clean closure of all twelve 200-East and 200-West Area SST farms following deactivation would involve removal of all tanks, associated ancillary equipment, and contaminated soil to a depth of 3 meters (10 feet) directly beneath the tank base. These materials would be packaged as HLW for onsite storage in shielded boxes. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The new PPF would process the highly contaminated deep soil to render it acceptable for onsite disposal. The liquid waste stream from the PPF soil washing would be thermally treated in the PPF and disposed of on site in an IDF. The washed soils would be disposed of in the RPPDF. Clean closure of the SST system would preclude the need for postclosure care. The six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier (Base Case). Optional clean closure of these cribs and trenches (ditches) would occur under the Option Case. This approach would be the same under Tank Closure Alternative 6B.

Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure (Base and Option Cases)

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. This approach would be the same under Tank Closure Alternative 6C.

Retrieval: Using currently available liquid-based retrieval and leak detection systems and a final chemical wash step, waste would be retrieved to a volume corresponding to 99.9 percent retrieval, equal to residual tank waste of no more than 1 cubic meter (36 cubic feet) for the 100-series tanks or 0.08 cubic meters (3 cubic feet) for the smaller 200-series tanks. This approach would be the same under Tank Closure Alternative 6A.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented with expanded LAW vitrification capacity (an addition of four LAW melters) to provide a

vitrification TMC of 6 metric tons of glass IHLW per day and 90 metric tons of glass ILAW per day. Treatment would start in 2018 and end in approximately 2040 (for HLW) and 2043 (for LAW). All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP. This approach would be the same under Tank Closure Alternative 6C.

Disposal: IHLW canisters would be stored on site until disposition decisions are made and implemented. ILAW glass canisters would be managed as HLW and stored on site. HLW debris from clean closure also would be managed as HLW and stored on site. This approach would be the same under Tank Closure Alternative 6C.

Closure: Clean closure of all twelve 200-East and 200-West Area SST farms following deactivation would involve removal of all tanks, associated ancillary equipment, and contaminated soil to a depth of 3 meters (10 feet) directly beneath the tank base. These materials would be packaged as HLW for onsite storage in shielded boxes. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The new PPF would process the highly contaminated deep soil to render it acceptable for onsite disposal. The liquid waste stream from the PPF soil washing would be thermally treated in the PPF and disposed of on site in an IDF. The washed soils would be disposed of in the RPPDF. Clean closure of the SST system would preclude the need for postclosure care. The six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier (Base Case). Optional clean closure of these cribs and trenches (ditches) would occur under the Option Case. This approach would be the same under Tank Closure Alternative 6A.

Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure (Base and Option Cases)

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. This approach would be the same under Tank Closure Alternative 6B.

Retrieval: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for the 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented with expanded LAW vitrification capacity (an addition of four LAW melters) to provide a vitrification TMC of 6 metric tons of glass IHLW per day and 90 metric tons of glass ILAW per day. Treatment would start in 2018 and end in approximately 2040 (for HLW) and 2043 (for LAW). All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP. This approach would be the same under Tank Closure Alternative 6B.

Disposal: IHLW canisters would be stored on site until disposition decisions are made and implemented. ILAW glass canisters would be managed as HLW and stored on site. This approach would be the same under Tank Closure Alternative 6B.

Closure: As operations are completed, the SST system would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and under DOE Order 435.1, *Radioactive Waste Management,* or it would be decommissioned under DOE Order 430.1B,

Real Property Asset Management. The tanks would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soils from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the RPPDF. The closed tank systems and the six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years.

Table 1 compares each of the tank closure alternatives by component.

FFTF DECOMMISSIONING

In 2004, DOE published in the *Federal Register* a "Notice of Intent for the Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, Washington" (69 FR 50176) that identified three alternatives for decommissioning FFTF and auxiliary facilities at Hanford. That EIS was not completed; however, the same alternatives—no action, entombment, and removal—were adopted for analysis in this *TC & WM EIS*.

FFTF Decommissioning Alternative 1: No Action

As previously stated, Council on Environmental Quality NEPA regulations (40 CFR 1500–1508) and DOE NEPA regulations (10 CFR 1021) require analysis of a "no action" alternative. The FFTF Decommissioning No Action Alternative includes completion of actions in accordance with previous DOE NEPA decisions. Final decommissioning of FFTF would not occur. Specifically, only deactivation activities for the FFTF complex and support buildings, as described in the 2006 *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE/EA-1547F), would be conducted. Deactivation activities would include removal and packaging of the four RH-SCs for storage in the 400 Area, as described in the Finding of No Significant Impact, dated March 31, 2006. The FFTF Reactor Containment Building (RCB) and the rest of the buildings within the 400 Area Property Protected Area (PPA) would be maintained through 2107 (for 100 years after the *TC & WM EIS* Record of Decision is published) under administrative controls such as site security and management. After 2107, administrative controls would cease and remaining waste is assumed to become available for release to the environment.

Table 1. Comparison of Tank Closure Alternatives

	Alternative 1: No Action	Alternative 2A: Existing WTP Vitrification; No Closure	Alternative 2B: Expanded WTP Vitrification; Landfill Closure	Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	Alternative 6A: All Vitrification/No Separations; Clean Closure	Alternative 6B: All Vitrification with Separations; Clean Closure	Alternative 6C: All Vitrification with Separations; Landfill Closure
Storage											
Existing	✓										
New WRFs			✓	✓	✓	✓	✓	✓		✓	✓
New DSTs		✓						✓	✓		
Retrieval											
90 percent								✓			
99 percent		✓	✓	✓	✓	✓					✓
99.9 percent							✓		✓	✓	
Treatment											
WTP											
Existing vitrification only		✓		✓	✓	✓	✓				
Expanded LAW vitrification			✓					✓		✓	✓
Expanded HLW vitrification									✓		
Replacement of WTP		✓							✓		
Technetium-99 removal			✓		✓						
Sulfate removal								✓			
Cesium and strontium capsules		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Non-WTP											
Tank mixed TRU waste supplemental treatment				✓	✓	✓	✓	✓			
Thermal supplemental treatment				✓		✓	✓	✓			
Nonthermal supplemental treatment					✓		✓	✓			
Disposal (including post-treatment storage)											
On Site											
ILAW		✓	✓	✓	✓	✓	✓	✓		a	a
IHLW[b]		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grouted sulfate								✓			
Contaminated soil			✓	✓	✓	✓	✓		✓	✓	✓
SSTs							c		d	d	
Off Site											
Tank mixed TRU waste to WIPP				✓	✓	✓	✓	✓			
Closure											
Clean closure									✓	✓	
Selective clean closure/landfill closure							✓				
Landfill closure			✓	✓	✓	✓		✓			✓
Modified RCRA Subtitle C barrier			✓	✓	✓	✓	✓		e	e	✓
Hanford barrier								✓			

a Under Alternatives 6B and 6C, ILAW glass would be interim-stored on site and managed as IHLW glass.

b Although disposition decisions have not been made and implemented, these alternatives do not assume the inventory in the IHLW canisters remains on site. However, the number of storage facilities needed to store all the IHLW is one more than the number of canister storage facilities analyzed under Tank Closure Alternative 2B.

c Under Alternative 4, SSTs at the BX and SX tank farms would be removed and treated in the Preprocessing Facility.

d Under Alternatives 6A and 6B, all SSTs would be removed and packaged in shielded boxes for onsite storage pending disposition.

e Base Case: Construct modified RCRA Subtitle C barrier over six sets of cribs and trenches (ditches) in the B and T Areas. Option Case: Remove six sets of cribs and trenches (ditches) in the B and T Areas and remediate their deep-soil plumes.

Key: DST=double-shell tank; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; RCRA=Resource Conservation and Recovery Act; SST=single-shell tank; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WRF=waste receiver facility; WTP=Waste Treatment Plant.

FFTF Decommissioning Alternative 2: Entombment

Facility Disposition: The Entombment Alternative consists of removing all aboveground structures within the 400 Area PPA and minimal removal of below-grade structures, equipment, and materials as required for compliance with regulatory standards. The RCB would be demolished and removed to grade, and the auxiliary facilities would be removed to 0.91 meters (3 feet) below grade. Equipment, piping, and components containing hazardous and radioactive materials would be removed from below-grade structures only as needed for treatment to meet regulatory requirements. Any other necessary treatment of equipment or components would occur in place (without removal from the facilities). After treatment, some of the components could be returned to below-grade spaces and grouted in place with the remaining structures and equipment to stabilize them and minimize void space. Most other equipment and materials removed from the facilities would be disposed of in the 200 Areas. An RCRA-compliant barrier would be constructed over the remains of the RCB and any other remaining below-grade structures (including the reactor vessel) that contain residual radioactive and treated hazardous materials. Equipment to be removed under this alternative would include the RH-SCs, which contain sufficient quantities of metallic sodium and radionuclides that they could not be treated and entombed in the RCB with the remaining materials.

Disposition of Remote-Handled Special Components: The RH-SCs consist of four large filter assemblies designed to remove radionuclides and other contaminants from the FFTF sodium coolant systems and the inert-cover gas systems. These components contain sufficient quantities of radionuclides to require remote handling and would require treatment to drain and stabilize residual metallic sodium prior to disposal. Removal and storage of the RH-SCs in the 400 Area are covered in a Finding of No Significant Impact dated March 31, 2006. It would be necessary to treat these components in a specialized facility that is equipped to handle hazardous reactive materials and components with high radiological dose rates. Such a facility does not currently exist within the DOE waste management complex; however, most other waste generated during facility decommissioning could be managed using existing or proposed capabilities. Therefore, DOE needs to decide on an approach for treating and disposing of the FFTF RH-SCs. The two options discussed below are being considered for managing these components.

- **Hanford Option.** The RH-SCs would be shipped to an onsite treatment facility. The capability to treat these components does not currently exist at Hanford, nor has such a capability been previously proposed, although construction of a facility to treat remote-handled and oversized MLLW or TRU waste was evaluated in a previous NEPA review. Following treatment, the components and residuals would be disposed of with other Hanford waste in the 200 Areas. DOE is considering this option for management of the FFTF RH-SCs in response to scoping comments that recommended minimizing offsite transportation of these components and treatment residuals.

- **Idaho Option.** The RH-SCs would be shipped to the proposed Remote Treatment Project (RTP) at Idaho National Laboratory's (INL's) Materials and Fuels Complex (MFC). The proposed RTP would treat remote-handled components containing comparable levels of radiological materials, as well as metallic sodium. An environmental assessment was prepared at INL to evaluate this proposed treatment and a Finding of No Significant Impact was issued on February 18, 2009. However, DOE will make a decision on the treatment of FFTF RH-SCs as part of the *TC & WM EIS* NEPA process. Following treatment at the RTP, the FFTF components and residuals would be disposed of with other INL waste at an offsite facility, or they could be returned to Hanford for disposal. DOE is considering this option for the FFTF RH-SCs to utilize the existing sodium management expertise at the MFC and to consolidate waste management activities within the DOE complex at existing or proposed facilities.

Disposition of Bulk Sodium: The Hanford radioactively contaminated bulk sodium inventory consists of approximately 1.1 million liters (300,000 gallons) of metallic sodium, including sodium from the Hallam Reactor and the Sodium Reactor Experiment, in addition to sodium drained from the FFTF cooling systems during deactivation. Hallam and Sodium Reactor Experiment sodium are currently stored in the Hanford 200-West Area Central Waste Complex (CWC). Sodium from FFTF is stored in the 400 Area within the RCB or adjacent storage facilities. The current DOE plan for this sodium is to convert it to a caustic for product reuse by the DOE Office of River Protection. The two options discussed below are being considered for managing the Hanford radioactively contaminated bulk sodium inventory.

- **Hanford Reuse Option.** The bulk sodium would be stored in its current locations until it is shipped to an onsite facility for processing into a caustic (sodium hydroxide). The capability to process the bulk sodium does not currently exist at Hanford. The treated caustic would be transferred to the 200-East Area for product reuse by the Office of River Protection for the WTP. DOE is considering this option for processing the Hanford bulk sodium inventory in response to scoping comments that recommended minimizing the need for offsite transportation of the bulk sodium and caustic.

- **Idaho Reuse Option.** The bulk sodium would be stored in its current locations until it is shipped to the MFC for processing. The capability to process bulk metallic sodium currently exists at the MFC Sodium Processing Facility, which was previously used to process metallic sodium from the Experimental Breeder Reactor II and other facilities. Following processing, the caustic would be returned to Hanford for use in the WTP. DOE is considering this option for processing the Hanford bulk sodium inventory to utilize existing sodium management expertise and facilities at the MFC.

FFTF Decommissioning Alternative 3: Removal

Facility Disposition: The Removal Alternative consists of removing all above-grade structures within the 400 Area PPA, as well as contaminated below-grade structures, equipment, and materials. The RCB would be demolished and removed to grade, and all auxiliary facilities would be removed to 0.91 meters (3 feet) below grade. Most equipment, piping, and components containing chemically hazardous and radioactive materials, including the reactor vessel, lead shielding, depleted uranium shielding, and asbestos, would be removed from below-grade structures. Most equipment and materials removed from the facilities would be disposed of in the 200 Areas. The remaining structures and equipment, consisting mainly of the external RCB structure and associated components, as well as uncontaminated below-grade portions of auxiliary facilities, would be backfilled or grouted to minimize void space. The PPA would be backfilled to grade, contoured, and revegetated as necessary to stabilize the ground surface or to prepare the site for future industrial use.

Disposition of Remote-Handled Special Components: The two options being considered under FFTF Decommissioning Alternative 2 are the same options being considered under FFTF Decommissioning Alternative 3 for disposition of the RH-SCs.

Disposition of Bulk Sodium: The two options being considered under FFTF Decommissioning Alternative 2 are the same options being considered under FFTF Decommissioning Alternative 3 for the disposition of the bulk sodium.

Table 2 outlines key activities under each of the three components (disposition of facilities, RH-SCs, and bulk sodium) and compares these parameters by alternative.

Table 2. Comparison of FFTF Decommissioning Alternatives

	Alternative 1: No Action	Alternative 2: Entombment	Alternative 3: Removal
Facility Disposition			
Facility equipment and components left in place under inert gas blanket	X		
Dismantlement of RCB and adjacent support buildings		X	X
Removal of reactor vessel (internal piping and equipment, attached depleted-uranium shield)			X
Onsite disposal of reactor vessel (internal piping and equipment, attached depleted-uranium shield)			X
Removal and onsite disposal of radioactive or chemical waste	X	X	X
Backfill and revegetation of ancillary facility areas		X	
Backfill and revegetation of Property Protected Area			X
Landfill barrier over RCB		X	
Administrative controls for 100 years	X		
Postclosure care and/or institutional controls for 100 years		X	X
Disposition of Remote-Handled Special Components			
Removal and storage on site per FONSI[a]	X	X	X
Treatment at the Hanford Site		X	X
Treatment at Idaho National Laboratory		X	X
Onsite disposal		X	X
Offsite disposal		X	X
Disposition of Bulk Sodium			
Onsite storage	X	X	X
Onsite conversion to caustic sodium hydroxide solution		X	X
Offsite conversion to caustic sodium hydroxide solution		X	X
Caustic sodium hydroxide solution shipped to the Waste Treatment Plant		X	X

[a] Per 2006 FONSI regarding *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006b:Appendix B).

Key: FFTF=Fast Flux Test Facility; FONSI=Finding of No Significant Impact; RCB=Reactor Containment Building.

WASTE MANAGEMENT

The Waste Management alternatives evaluated in this *TC & WM EIS* address the expansion of waste disposal capacity at Hanford to dispose of both on- and offsite waste, thus facilitating cleanup of Hanford and other DOE sites. The major mission components include onsite storage and disposal of Hanford-generated and other sites' LLW and MLLW; onsite storage of Hanford-generated TRU waste; and eventual closure of the waste facilities.

Waste Management Alternative 1: No Action

Storage: LLW, MLLW, and TRU waste would be stored at the CWC until it is processed for disposal in low-level radioactive waste burial ground (LLBG) 218-W-5, trenches 31 and 34. Processing of waste prior to disposal would continue at existing facilities at the CWC, Waste Receiving and Processing Facility (WRAP), and T Plant. No offsite LLW, MLLW, or TRU waste would be received.

Disposal: Waste would be disposed of in LLBG 218-W-5, trenches 31 and 34, through 2035. Further construction of the 200-East Area IDF (IDF-East) would be discontinued in 2008, and IDF-East would be deactivated.

Closure: Administrative control would be implemented for 100 years.

Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

Storage: LLW, MLLW, and TRU waste would be stored at the CWC until it is processed for disposal. Processing of waste prior to disposal would occur at existing and expanding facilities at the CWC, WRAP, and T Plant. No offsite TRU waste would be received. Offsite LLW and MLLW would be

received from other DOE sites. A total volume of 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW was assumed to be received.

Disposal: LLBG 218-W-5, trenches 31 and 34, would continue to operate through 2050. Construction, operations, deactivation, closure, and postclosure care would take place at IDF-East. Waste from tank treatment operations, onsite sources not regulated under the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA), FFTF decommissioning, waste management operations, and other DOE sites would be disposed of in IDF-East. Waste from tank farm cleanup operations would be disposed of in the RPPDF.

Closure: Disposal facilities would be covered with engineered modified RCRA Subtitle C barrier.

Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Storage: LLW, MLLW, and TRU waste would be stored at the CWC until it is processed for disposal. Processing of waste prior to disposal would occur at existing and expanding facilities at the CWC, WRAP, and T Plant. No offsite TRU waste would be received. Offsite LLW and MLLW would be received from other DOE sites. A total volume of 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW was assumed to be received.

Disposal: LLBG 218-W-5, trenches 31 and 34, would continue to operate through 2050. Construction, operations, deactivation, closure, and postclosure care would take place in IDF-East and an IDF to be constructed in the 200-West Area (IDF-West). Waste from onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-West. Waste from tank farm cleanup operations would be disposed of in the RPPDF.

Closure: Disposal facilities would be covered with engineered modified RCRA Subtitle C barrier.

Table 3 outlines key activities by alternative for waste storage, treatment, and disposal, as well as facility closure.

Table 3. Comparison of Waste Management Alternatives

	Alternative 1: No Action	Alternative 2: Disposal in IDF, 200-East Area Only	Alternative 3: Disposal in IDF, 200-East and 200-West Areas
Storage			
Existing storage of LLW, MLLW, and TRU waste at CWC	X		
Expanded storage of LLW, MLLW, and TRU waste at CWC		X	X
Existing storage of LLW, MLLW, and TRU waste at WRAP and T Plant	X		
Expanded storage of LLW, MLLW, and TRU waste at WRAP and T Plant		X	X
Treatment			
Existing treatment of LLW, MLLW, and TRU waste at CWC	X		
Expanded treatment of LLW, MLLW, and TRU waste at CWC		X	X
Existing treatment of LLW, MLLW, and TRU waste at WRAP and T Plant	X		
Expanded treatment of LLW, MLLW, and TRU waste at WRAP and T Plant		X	X

Table 3. Comparison of Waste Management Alternatives *(continued)*

	Alternative 1: No Action	Alternative 2: Disposal in IDF, 200-East Area Only	Alternative 3: Disposal in IDF, 200-East and 200-West Areas
Disposal			
Continued disposal of onsite-generated non-CERCLA, nontank LLW and MLLW in onsite lined trenches	X	X	X
Construction of IDF-East terminated and facility deactivated	X		
Disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW at IDF-East		X	
Disposal of tank waste only at IDF-East and onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW at IDF-West			X
Disposal of rubble, ancillary equipment, and soils (not highly contaminated) from closure activities at RPPDF		X	X
Closure			
None	X		
Landfill closure of IDF(s) and RPPDF		X	X
Administrative control for 100 years	X		
Postclosure care for 100 years		X	X

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; CWC=Central Waste Complex; FFTF=Fast Flux Test Facility; IDF=Integrated Disposal Facility; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WRAP=Waste Receiving and Processing Facility.

ROADMAPS TO THE ALTERNATIVES

Tables 4, 5, and 6 are roadmaps to the Tank Closure, FFTF Decommissioning, and Waste Management alternatives analyzed in this *TC & WM EIS*. Key features and potential issues regarding each alternative are identified, along with the sections of Chapters 2, 4, and 5 and Appendices D and E of this EIS where related discussions can be found. The potential issues listed in Tables 4, 5, and 6 are presented only to make readers of this *TC & WM EIS* aware of their existence. These issues are covered in greater detail in the chapters and appendices of this EIS. These tables are not meant to be all-inclusive, but are provided to help readers navigate through the document.

Table 4. Roadmap to the Tank Closure Alternatives

TANK CLOSURE ALTERNATIVE 1: No Action									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 100-year administrative control		*Key Features* • No retrieval		*Key Features* • No treatment • Waste Treatment Plant construction terminated		*Key Features* • No disposal		*Key Features* • No closure	
Potential Issues • Waste remains in single-shell tanks and double-shell tanks beyond their design lives		*Potential Issues* • No retrieval of tank waste		*Potential Issues* • Waste Treatment Plant construction ends before completion • No treatment		*Potential Issues* • No disposal		*Potential Issues* • No closure of RCRA units	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.1 • D.1 • E.1	*Impacts* • 4.1.4.1 AQ • 4.1.6.1 WR • 4.1.7.1 ER • 4.1.9.1 S • 4.1.10.1 NO • 4.1.11.1 FA • 4.1.15.1 IS • 5.1.1.1 GW • 5.1.2.1 HH • 5.1.3.1 LER	*Description* • 2.2.2.1 • 2.5.2.1	*Impacts* • None	*Description* • 2.2.2.2 • 2.5.2.1 • E.1	*Impacts* • 4.1.4.1 AQ • 4.1.7.1 ER • 4.1.9.1 S	*Description* • 2.2.2.3 • 2.5.2.1	*Impacts* • None	*Description* • 2.2.2.4 • 2.5.2.1	*Impacts* • None

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; IS=Industrial Safety; LER=Long-Term Ecological Risk; NO=Normal Operations; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; WR=Water Resources.

Table 4. Roadmap to the Tank Closure Alternatives (*continued*)

TANK CLOSURE ALTERNATIVE 2A: Existing WTP Vitrification; No Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 28 replacement double-shell tanks • No waste receiver facilities		*Key Features* • 99 percent tank waste retrieval • Liquid-based retrieval technologies • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2093 • 6 MTG/day (2 HLW melters) × 30 MTG/day (2 LAW melters) • No Tc-99 removal • No sulfate removal • No tank-derived TRU waste treatment		*Key Features* • ILAW disposal on site • IHLW storage includes CSB + 3 additional vaults		*Key Features* • No closure • 100-year administrative control	
Potential Issues • New double-shell tanks required		*Potential Issues* • Assumed retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Potential Issues* • Waste Treatment Plant replacement • Extended operating period		*Potential Issues* • ILAW disposal on site • Tc-99 in ILAW • No waste acceptance criteria for HLW melters (stored indefinitely)		*Potential Issues* • No closure, 100-year administrative control only	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.2.1 • D.1 • E.1	*Impacts* • 4.1.1.2 LR • 4.1.4.2 AQ • 4.1.7.2 ER • 4.1.9.2 S • 4.1.10.2 NO • 4.1.11.2 FA	*Description* • 2.2.2.1 • 2.5.2.2.1 • D.1 • E.1	*Impacts* • 4.1.4.2 AQ • 4.1.6.2 WR • 4.1.9.2 S • 4.1.10.2 NO • 4.1.11.2 FA • 5.1.1.2 GW • 5.1.2.2 HH • 5.1.3.2 LER	*Description* • 2.2.2.2 • 2.5.2.2.1 • D.1 • E.1	*Impacts* • 4.1.1.2 LR • 4.1.4.2 AQ • 4.1.6.2 WR • 4.1.7.2 ER • 4.1.9.2 S • 4.1.10.2 NO • 4.1.11.2 FA • 4.1.14.2 WM • 5.1.1.2 GW • 5.1.2.2 HH • 5.1.3.2 LER	*Description* • 2.2.2.3 • 2.5.2.2.1 • D.1 • E.1	*Impacts* • 4.1.1.2 LR • 4.1.4.2 AQ • 4.1.6.2 WR • 4.1.7.2 ER • 4.1.14.2 WM • 5.1.1.2 GW • 5.1.2.2 HH • 5.1.3.2 LER	*Description* • 2.2.2.4 • 2.5.2.2.1	*Impacts* • 4.1.4.2 AQ • 4.1.6.2 WR • 4.1.12.2 T • 5.1.1.2 GW • 5.1.2.2 HH • 5.1.3.2 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WM=Waste Management; WR=Water Resources; WTP=Waste Treatment Plant.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 2B: Expanded WTP Vitrification; Landfill Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • No new double-shell tanks		*Key Features* • 99 percent tank waste retrieval • Liquid-based retrieval technologies • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2043 • 6 MTG/day (2 HLW melters) × 90 MTG/day (6 LAW melters) • Tc-99 removal • No sulfate removal • No tank-derived TRU waste treatment		*Key Features* • ILAW disposal on site • IHLW storage includes CSB + 4 additional vaults		*Key Features* • Landfill closure (modified RCRA Subtitle C barrier) • Upper 4.6 meters (15 feet) of soil in BX and SX tank farms and ancillary equipment removed • 100-year postclosure care	
Potential Issues • Construction of 4 waste receiver facilities		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Potential Issues* • Construction of expanded WTP		*Potential Issues* • ILAW disposal on site • No waste acceptance criteria for HLW melters (stored indefinitely)		*Potential Issues* • Landfill closure of all single-shell tank farms with 1 percent residual waste and adjacent cribs and trenches (ditches) • Benefit of removing upper 4.6 meters (15 feet) of soil in BX and SX tank farms	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.2.2 • D.1 • E.1	*Impacts* • 4.1.1.3 LR • 4.1.4.3 AQ • 4.1.10.3 NO • 4.1.11.3 FA	*Description* • 2.2.2.1 • 2.5.2.2.2 • D.1 • E.1	*Impacts* • 4.1.4.3 AQ • 4.1.6.3 WR • 4.1.9.3 S • 4.1.10.3 NO • 4.1.11.3 FA • 5.1.1.3 GW • 5.1.2.3 HH • 5.1.3.3 LER	*Description* • 2.2.2.2 • 2.5.2.2.2 • D.1 • E.1	*Impacts* • 4.1.1.3 LR • 4.1.4.3 AQ • 4.1.6.3 WR • 4.1.7.3 ER • 4.1.9.3 S • 4.1.10.3 NO • 4.1.11.3 FA • 4.1.14 .3 WM • 5.1.1.3 GW • 5.1.2.3 HH • 5.1.3.3 LER	*Description* • 2.2.2.3 • 2.5.2.2.2 • D.1 • E.1	*Impacts* • 4.1.1.3 LR • 4.1.4.3 AQ • 4.1.6.3 WR • 4.1.7.3 ER • 4.1.11.3 FA • 4.1.12.3 T • 4.1.14.3 WM • 5.1.1.3 GW • 5.1.2.3 HH • 5.1.3.3 LER	*Description* • 2.2.2.4 • 2.5.2.2.2 • E.1	*Impacts* • 4.1.4.3 AQ • 4.1.6.3 WR • 4.1.10.3 NO • 4.1.14 .3 WM • 5.1.1.3 GW • 5.1.2.3 HH • 5.1.3.3 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WM=Waste Management; WR=Water Resources; WTP=Waste Treatment Plant.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • No new double-shell tanks		*Key Features* • 99 percent tank waste retrieval • Liquid-based retrieval technologies • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2040 • 6 MTG/day (2 HLW melters) × 30 MTG/day (2 LAW melters) • Supplemental treatment (bulk vitrification) • No Tc-99 removal • No sulfate removal • Tank-derived TRU waste treatment		*Key Features* • ILAW disposal on site • IHLW storage includes CSB + 4 additional vaults		*Key Features* • Landfill closure (modified RCRA Subtitle C barrier) • Upper 4.6 meters (15 feet) of soil in BX and SX tank farms and ancillary equipment removed • 100-year postclosure care	
Potential Issues • Construction of 4 waste receiver facilities		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Potential Issues* • Construction in 200-East and 200-West Areas • Addition of bulk vitrification supplemental treatment capacity		*Potential Issues* • ILAW disposal on site • Tc-99 in ILAW and bulk vitrification • No waste acceptance criteria for HLW melters (stored indefinitely) • Tank-derived TRU waste disposal at WIPP		*Potential Issues* • Landfill closure of all single-shell tank farms with 1 percent residual waste and adjacent cribs and trenches (ditches) • Benefit of removing upper 4.6 meters (15 feet) of soil in BX and SX tank farms	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.3.1 • D.1 • E.1	*Impacts* • 4.1.1.4 LR • 4.1.4.4 AQ • 4.1.10.4 NO • 4.1.11.4 FA	*Description* • 2.2.2.1 • 2.5.2.3.1 • D.1 • E.1	*Impacts* • 4.1.4.4 AQ • 4.1.6.4 WR • 4.1.9.4 S • 4.1.10.4 NO • 4.1.11.4 FA • 5.1.1.4 GW • 5.1.2.4 HH • 5.1.3.4 LER	*Description* • 2.2.2.2 • 2.5.2.3.1 • D.1 • E.1	*Impacts* • 4.1.1.4 LR • 4.1.4.4 AQ • 4.1.6.4 WR • 4.1.7.4 ER • 4.1.9.4 S • 4.1.10.4 NO • 4.1.11.4 FA • 4.11.14.4 WM • 5.1.1.4 GW • 5.1.2.4 HH • 5.1.3.4 LER	*Description* • 2.2.2.3 • 2.5.2.3.1 • D.1 • E.1	*Impacts* • 4.1.1.4 LR • 4.1.4.4 AQ • 4.1.6.4 WR • 4.1.7.4 ER • 4.1.11.4 FA • 4.1.12.4 T • 4.1.14.4 WM • 5.1.1.4 GW • 5.1.2.4 HH • 5.1.3.4 LER	*Description* • 2.2.2.4 • 2.5.2.3.1 • E.1	*Impacts* • 4.1.4.4 AQ • 4.1.6.4 WR • 4.1.10.4 NO • 4.1.14.4 WM • 5.1.1.4 GW • 5.1.2.4 HH • 5.1.3.4 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WM=Waste Management; WR=Water Resources; WTP=Waste Treatment Plant.

Table 4. Roadmap to the Tank Closure Alternatives (*continued*)

TANK CLOSURE ALTERNATIVE 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • No new double-shell tanks		*Key Features* • 99 percent tank waste retrieval • Liquid-based retrieval technologies • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2040 • 6 MTG/day (2 HLW melters) × 30 MTG/day (2 LAW melters) • Supplemental treatment (cast stone) • Tc-99 removal • No sulfate removal • Tank-derived TRU waste treatment		*Key Features* • ILAW disposal on site • IHLW storage includes CSB + 4 additional vaults		*Key Features* • Landfill closure (modified RCRA Subtitle C barrier) • Upper 4.6 meters (15 feet) of soil in BX and SX tank farms and ancillary equipment removed • 100-year postclosure care	
Potential Issues • Construction of 4 waste receiver facilities		*Potential Issues* • 120 liters (4,000 gallons) per single-shell tank		*Potential Issues* • Construction in 200-East and 200-West Areas • Addition of cast stone supplemental treatment capacity		*Potential Issues* • ILAW disposal on site • No waste acceptance criteria for HLW melters (stored indefinitely) • Tank-derived TRU waste disposal at WIPP		*Potential Issues* • Landfill closure of all single-shell tank farms with 1 percent residual waste and adjacent cribs and trenches (ditches) • Benefit of removing upper 4.6 meters (15 feet) of soil in BX and SX tank farms	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.3.2 • D.1 • E.1	*Impacts* • 4.1.1.5 LR • 4.1.4.5 AQ • 4.1.10.5 NO • 4.1.11.5 FA	*Description* • 2.2.2.1 • 2.5.2.3.2 • D.1 • E.1	*Impacts* • 4.1.4.5 AQ • 4.1.6.5 WR • 4.1.9.5 S • 4.1.10.5 NO • 4.1.11.5 FA • 5.1.1.5 GW • 5.1.2.5 HH • 5.1.3.5 LER	*Description* • 2.2.2.2 • 2.5.2.3.2 • D.1 • E.1	*Impacts* • 4.1.1.5 LR • 4.1.4.5 AQ • 4.1.6.5 WR • 4.1.7.5 ER • 4.1.9.5 S • 4.1.10.5 NO • 4.1.11.5 FA • 4.1.14.5 WM • 5.1.1.5 GW • 5.1.2.5 HH • 5.1.3.5 LER	*Description* • 2.2.2.3 • 2.5.2.3.2 • D.1 • E.1	*Impacts* • 4.1.1.5 LR • 4.1.4.5 AQ • 4.1.6.5 WR • 4.1.7.5 ER • 4.1.11.5 FA • 4.1.12.5 T • 4.1.14 .5 WM • 5.1.1.5 GW • 5.1.2.5 HH • 5.1.3.5 LER	*Description* • 2.2.2.4 • 2.5.2.3.2 • E.1	*Impacts* • 4.1.4.5 AQ • 4.1.6.5 WR • 4.1.10.5 NO • 4.1.14.5 WM • 5.1.1.5 GW • 5.1.2.5 HH • 5.1.3.5 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WM=Waste Management; WR=Water Resources; WTP=Waste Treatment Plant.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • No new double-shell tanks		*Key Features* • 99 percent tank waste retrieval • Liquid-based retrieval technologies • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2040 • 6 MTG/day (2 HLW melters) × 30 MTG/day (2 LAW melters) • Supplemental treatment (steam reforming) • No Tc-99 removal • No sulfate removal • Tank-derived TRU waste treatment		*Key Features* • ILAW disposal on site • IHLW storage includes CSB + 4 additional vaults		*Key Features* • Landfill closure (modified RCRA Subtitle C barrier) • Upper 4.6 meters (15 feet) of soil in BX and SX tank farms and ancillary equipment removed • 100-year postclosure care	
Potential Issues • Construction of 4 waste receiver facilities		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Potential Issues* • Construction in 200-East and 200-West Areas • Addition of steam reforming supplemental treatment capacity		*Potential Issues* • ILAW disposal on site • Tc-99 in ILAW and steam reforming • No waste acceptance criteria for HLW melters (stored indefinitely) • Tank-derived TRU waste disposal at WIPP		*Potential Issues* • Landfill closure of all single-shell tank farms with 1 percent residual waste and adjacent cribs and trenches (ditches) • Benefit of removing upper 4.6 meters (15 feet) of soil in BX and SX tank farms	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.3.3 • D.1 • E.1	*Impacts* • 4.1.1.6 LR • 4.1.4.6 AQ • 4.1.10.6 NO • 4.1.11.6 FA	*Description* • 2.2.2.1 • 2.5.2.3.3 • D.1 • E.1	*Impacts* • 4.1.4.6 AQ • 4.1.6.6 WR • 4.1.9.6 S • 4.1.10.6 NO • 4.1.11.6 FA • 5.1.1.6 GW • 5.1.2.6 HH • 5.1.3.6 LER	*Description* • 2.2.2.2 • 2.5.2.3.3 • D.1 • E.1	*Impacts* • 4.1.1.6 LR • 4.1.4.6 AQ • 4.1.6.6 WR • 4.1.7.6 ER • 4.1.9.6 S • 4.1.10.6 NO • 4.1.11.6 FA • 4.1.14.6 WM • 5.1.1.6 GW • 5.1.2.6 HH • 5.1.3.6 LER	*Description* • 2.2.2.3 • 2.5.2.3.3 • D.1 • E.1	*Impacts* • 4.1.1.6 LR • 4.1.4.6 AQ • 4.1.6.6 WR • 4.1.7.6 ER • 4.1.11.6 FA • 4.1.12.6 T • 4.1.14 .6 WM • 5.1.1.6 GW • 5.1.2.6 HH • 5.1.3.6 LER	*Description* • 2.2.2.4 • 2.5.2.3.3 • E.1	*Impacts* • 4.1.4.6 AQ • 4.1.6.6 WR • 4.1.10.6 NO • 4.1.14.6 WM • 5.1.1.6 GW • 5.1.2.6 HH • 5.1.3.6 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; PPF=Preprocessing Facility; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WM=Waste Management; WR=Water Resources; WTP=Waste Treatment Plant.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • No new double-shell tanks		*Key Features* • 99.9 percent tank waste retrieval • Liquid-based retrieval technologies and new retrieval technology • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2043 • 6 MTG/day (2 HLW melters) × 30 MTG/day (2 LAW melters) • Supplemental treatment (bulk vitrification and cast stone) • No Tc-99 removal • No sulfate removal • Tank-derived TRU waste treatment		*Key Features* • ILAW disposal on site • IHLW storage includes CSB + 5 additional vaults		*Key Features* • Landfill closure (modified RCRA Subtitle C barrier) • Clean closure of representative (BX and SX) tank farms • 100-year postclosure care of 10 single-shell tank farms	
Potential Issues • Construction of 4 waste receiver facilities		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank • Additional tank-cleaning process (chemical wash)		*Potential Issues* • Construction in 200-East and 200-West Areas • Addition of bulk vitrification and cast stone supplemental treatment capacity		*Potential Issues* • ILAW disposal on site • Tc-99 in ILAW, bulk vitrification, and cast stone • No waste acceptance criteria for HLW melters (stored indefinitely) • Onsite disposal of waste from clean closure of BX and SX tank farms • Tank-derived TRU waste disposal at WIPP		*Potential Issues* • Landfill closure of 10 single-shell tank farms with 0.1 percent residual waste and adjacent cribs and trenches (ditches)	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.4 • D.1 • E.1	*Impacts* • 4.1.1.7 LR • 4.1.4.7 AQ • 4.1.10.7 NO • 4.1.11.7 FA	*Description* • 2.2.2.1 • 2.5.2.4 • D.1 • E.1	*Impacts* • 4.1.4.7 AQ • 4.1.6.7 WR • 4.1.9.7 S • 4.1.10.7 NO • 4.1.11.7 FA • 5.1.1.7 GW • 5.1.2.7 HH • 5.1.3.7 LER	*Description* • 2.2.2.2 • 2.5.2.4 • D.1 • E.1	*Impacts* • 4.1.1.7 LR • 4.1.4.7 AQ • 4.1.6.7 WR • 4.1.7.7 ER • 4.1.9.7 S • 4.1.10.7 NO • 4.1.11.7 FA • 4.1.14.7 WM • 5.1.1.7 GW • 5.1.2.7 HH • 5.1.3.7 LER	*Description* • 2.2.2.3 • 2.5.2.4 • D.1 • E.1	*Impacts* • 4.1.1.7 LR • 4.1.4.7 AQ • 4.1.6.7 WR • 4.1.7.7 ER • 4.1.11.7 FA • 4.1.12.7 T • 4.1.14 .7 WM • 5.1.1.7 GW • 5.1.2.7 HH • 5.1.3.7 LER	*Description* • 2.2.2.4 • 2.5.2.4 • E.1	*Impacts* • 4.1.4.7 AQ • 4.1.6.7 WR • 4.1.10.7 NO • 4.1.14.7 WM • 5.1.1.7 GW • 5.1.2.7 HH • 5.1.3.7 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WM=Waste Management; WR=Water Resources; WTP=Waste Treatment Plant.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • 4 new double-shell tanks		*Key Features* • 90 percent tank waste retrieval • Liquid-based retrieval technologies • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2009–2024 • 6 MTG/day (2 HLW melters) × 45 MTG/day (3 LAW melters) • Supplemental treatment (bulk vitrification and cast stone) • No Tc-99 removal • Sulfate removal • Tank-derived TRU waste treatment		*Key Features* • ILAW disposal on site • IHLW storage includes CSB + 5 additional vaults		*Key Features* • Landfill closure (Hanford barrier) • 100-year postclosure care	
Potential Issues • Construction of 4 waste receiver facilities • Construction of 4 new double-shell tanks		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank • Reduced tank retrieval volume		*Potential Issues* • Construction of expanded Waste Treatment Plant • Construction in 200-East and 200-West Areas • Addition of bulk vitrification and cast stone supplemental treatment capacity		*Potential Issues* • ILAW disposal on site • Tc-99 in ILAW, bulk vitrification, and cast stone • No waste acceptance criteria for HLW melters (stored indefinitely) • Disposal of sulfate grout waste form on site • Tank-derived TRU waste disposal at WIPP		*Potential Issues* • Landfill closure of all single-shell tank farms and adjacent cribs and trenches (ditches) using improved barrier • Increased waste residues remaining in closed tanks (10 percent)	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.5 • D.1 • E.1	*Impacts* • 4.1.1.8 LR • 4.1.4.8 AQ • 4.1.10.8 NO • 4.1.11.8 FA	*Description* • 2.2.2.1 • 2.5.2.5 • D.1 • E.1	*Impacts* • 4.1.4.8 AQ • 4.1.6.8 WR • 4.1.9.8 S • 4.1.10.8 NO • 4.1.11.8 FA • 5.1.1.8 GW • 5.1.2.8 HH • 5.1.3.8 LER	*Description* • 2.2.2.2 • 2.5.2.5 • D.1 • E.1	*Impacts* • 4.1.1.8 LR • 4.1.4.8 AQ • 4.1.6.8 WR • 4.1.7.8 ER • 4.1.9.8 S • 4.1.10.8 NO • 4.1.11.8 FA • 4.1.14.8 WM • 5.1.1.8 GW • 5.1.2.8 HH • 5.1.3.8 LER	*Description* • 2.2.2.3 • 2.5.2.5 • D.1 • E.1	*Impacts* • 4.1.1.8 LR • 4.1.4.8 AQ • 4.1.6.8 WR • 4.1.7.8 ER • 4.1.11.8 FA • 4.1.12.8 T • 4.1.14 .8 WM • 5.1.1.8 GW • 5.1.2.8 HH • 5.1.3.8 LER	*Description* • 2.2.2.4 • 2.5.2.5 • E.1	*Impacts* • 4.1.4.8 AQ • 4.1.6.8 WR • 4.1.10.8 NO • 4.1.14.8 WM • 5.1.1.8 GW • 5.1.2.8 HH • 5.1.3.8 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-activity radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WM=Waste Management; WR=Water Resources; WTP=Waste Treatment Plant.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 6A: All Vitrification/No Separations; Clean Closure (Base and Option Cases)									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 84 new double-shell tanks (replacements)		*Key Features* • 99.9 percent tank waste retrieval • Liquid-based retrieval technologies and new retrieval technology • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2163 • 15 MTG/day (5 HLW melters) • No Tc-99 removal • No sulfate removal • No tank-derived TRU waste treatment • No supplemental treatment technology		*Key Features* • IHLW storage includes CSB + 65 additional vaults and 148 replacements • IHLW tank debris storage • PPF glass disposed of on site		*Key Features* • Clean closure of single-shell tank farms and landfill closure (modified RCRA Subtitle C barrier) of adjacent cribs and trenches (ditches) (option includes clean closure of adjacent cribs and trenches [ditches]) • Future use	
Potential Issues • Construction of 84 new double-shell tanks • Extended operating period		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank • Additional tank-cleaning process (chemical wash)		*Potential Issues* • Construction of additional IHLW Waste Treatment Plant capacity and replacements • All waste treated as HLW; large number of HLW containers • Extended operating period		*Potential Issues* • No waste acceptance criteria for HLW melters (stored indefinitely) • No waste acceptance criteria for HLW resulting from clean closure activities		*Potential Issues* • Clean closure	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.6.1 • D.1 • E.1	*Impacts* • 4.1.1.9 LR • 4.1.4.9 AQ • 4.1.7.9 ER • 4.1.9.9 S • 4.1.10.9 NO • 4.1.11.9 FA	*Description* • 2.2.2.1 • 2.5.2.6.1 • D.1 • E.1	*Impacts* • 4.1.4.9 AQ • 4.1.6.9 WR • 4.1.9.9 S • 4.1.10.9 NO • 4.1.11.9 FA • 5.1.1.9 GW • 5.1.2.9 HH • 5.1.3.9 LER	*Description* • 2.2.2.2 • 2.5.2.6.1 • D.1 • E.1	*Impacts* • 4.1.1.9 LR • 4.1.4.9 AQ • 4.1.6.9 WR • 4.1.7.9 ER • 4.1.9.9 S • 4.1.10.9 NO • 4.1.11.9 FA • 4.1.14.9 WM • 5.1.1.9 GW • 5.1.2.9 HH • 5.1.3.9 LER	*Description* • 2.2.2.3 • 2.5.2.6.1 • D.1 • E.1	*Impacts* • 4.1.1.9 LR • 4.1.4.9 AQ • 4.1.6.9 WR • 4.1.7.9 ER • 4.1.9.9 S • 4.1.11.9 FA • 4.1.12.9 T • 4.1.14.9 WM • 5.1.1.9 GW • 5.1.2.9 HH • 5.1.3.9 LER	*Description* • 2.2.2.4 • 2.5.2.6.1 • E.1	*Impacts* • 4.1.4.9 AQ • 4.1.6.9 WR • 4.1.9.9 S • 4.1.10.9 NO • 4.1.14.9 WM • 5.1.1.9 GW • 5.1.2.9 HH • 5.1.3.9 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; PPF=Preprocessing Facility; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=Transportation; Tc-99=technetium-99; TRU=transuranic; WM=Waste Management; WR=Water Resources.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 6B: All Vitrification with Separations; Clean Closure (Base and Option Cases)									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • No new double-shell tanks		*Key Features* • 99.9 percent tank waste retrieval • Liquid-based retrieval technologies and new retrieval technology • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2043 • 6 MTG/day (2 HLW melters) × 90 MTG/day (6 LAW melters) • No Tc-99 removal • No sulfate removal • No tank-derived TRU waste treatment • No supplemental treatment technology		*Key Features* • No ILAW disposal on site • ILAW storage facilities • IHLW storage includes CSB + 4 additional vaults • IHLW tank debris storage • PPF glass disposed of on site		*Key Features* • Clean closure of single-shell tank farms and landfill closure (modified RCRA Subtitle C barrier) of adjacent cribs and trenches (ditches) (option includes clean closure of adjacent cribs and trenches [ditches]) • Future use	
Potential Issues • Construction of 4 waste receiver facilities		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank • Additional tank-cleaning process (chemical wash)		*Potential Issues* • Construction of expanded Waste Treatment Plant • All waste treated as HLW; large number of ILAW containers		*Potential Issues* • No waste acceptance criteria for HLW and LAW melters (stored indefinitely) • No waste acceptance criteria for HLW resulting from clean closure activities • No ILAW disposition		*Potential Issues* • Clean closure	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.6.2 • D.1 • E.1	*Impacts* • 4.1.1.10 LR • 4.1.4.10 AQ • 4.1.7.10 ER • 4.1.9.10 S • 4.1.10.10 NO • 4.1.11.10 FA	*Description* • 2.2.2.1 • 2.5.2.6.2 • D.1 • E.1	*Impacts* • 4.1.4.10 AQ • 4.1.6.10 WR • 4.1.9.10 S • 4.1.10.10 NO • 4.1.11.10 FA • 5.1.1.10 GW • 5.1.2.10 HH • 5.1.3.10 LER	*Description* • 2.2.2.2 • 2.5.2.6.2 • D.1 • E.1	*Impacts* • 4.1.1.10 LR • 4.1.4.10 AQ • 4.1.6.10 WR • 4.1.7.10 ER • 4.1.9.10 S • 4.1.10.10 NO • 4.1.11.10 FA • 4.1.14.10 WM • 5.1.1.10 GW • 5.1.2.10 HH • 5.1.3.10 LER	*Description* • 2.2.2.3 • 2.5.2.6.2 • D.1 • E.1	*Impacts* • 4.1.1.10 LR • 4.1.4.10 AQ • 4.1.6.10 WR • 4.1.7.10 ER • 4.1.9.10 S • 4.1.11.10 FA • 4.1.12.10 T • 4.1.14.10 WM • 5.1.1.10 GW • 5.1.2.10 HH • 5.1.3.10 LER	*Description* • 2.2.2.4 • 2.5.2.6.2 • E.1	*Impacts* • 4.1.4.10 AQ • 4.1.6.10 WR • 4.1.9.10 S • 4.1.10.10 NO • 4.1.14.10 WM • 5.1.1.10 GW • 5.1.2.10 HH • 5.1.3.10 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CSB=Canister Storage Building; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; GW=Groundwater; HH=Human Health; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; PPF=Preprocessing Facility; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=transportation; Tc-99=technetium-99; TRU=transuranic; WM=Waste Management; WR=Water Resources.

Table 4. Roadmap to the Tank Closure Alternatives *(continued)*

TANK CLOSURE ALTERNATIVE 6C: All Vitrification with Separations; Landfill Closure									
STORAGE		**RETRIEVAL**		**TREATMENT**		**DISPOSAL**		**CLOSURE**	
Key Features • 4 waste receiver facilities • No new double-shell tanks		*Key Features* • 99 percent tank waste retrieval • Liquid-based retrieval technologies • Current leak detection technology • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Key Features* • Waste treatment: 2018–2043 • 6 MTG/day (2 HLW melters) × 90 MTG/day (6 LAW melters) • No Tc-99 removal • No sulfate removal • No tank-derived TRU waste treatment		*Key Features* • No ILAW disposal on site • ILAW storage facilities • IHLW storage includes CSB + 4 additional vaults		*Key Features* • Landfill closure (modified RCRA Subtitle C barrier) • Upper 4.6 meters (15 feet) of soil in BX and SX tank farms and ancillary equipment removed • 100-year postclosure care	
Potential Issues • Construction of 4 waste receiver facilities		*Potential Issues* • Retrieval leakage rate = 15,120 liters (4,000 gallons) per single-shell tank		*Potential Issues* • Construction of expanded Waste Treatment Plant • All waste treated as HLW; large number of ILAW containers		*Potential Issues* • No waste acceptance criteria for HLW and LAW melters (stored indefinitely) • No ILAW disposition		*Potential Issues* • Landfill closure of all single-shell tank farms with 1 percent residual waste	
Description • 2.2.1 • 2.2.2.1 • 2.5.2.6.3 • D.1 • E.1	*Impacts* • 4.1.1.11 LR • 4.1.4.11 AQ • 4.1.10.11 NO • 4.1.11.11 FA	*Description* • 2.2.2.1 • 2.5.2.6.3 • D.1 • E.1	*Impacts* • 4.1.4.11 AQ • 4.1.6.11 WR • 4.1.9.11 S • 4.1.10.11 NO • 4.1.11.11 FA • 5.1.1.11 GW • 5.1.2.11 HH • 5.1.3.11 LER	*Description* • 2.2.2.2 • 2.5.2.6.3 • D.1 • E.1	*Impacts* • 4.1.1.11 LR • 4.1.4.11 AQ • 4.1.6.11 WR • 4.1.7.11 ER • 4.1.9.11 S • 4.1.10.11 NO • 4.1.11.11 FA • 4.1.14.11 WM • 5.1.1.11 GW • 5.1.2.11 HH • 5.1.3.11 LER	*Description* • 2.2.2.3 • 2.5.2.6.3 • D.1 • E.1	*Impacts* • 4.1.1.11 LR • 4.1.4.11 AQ • 4.1.6.11 WR • 4.1.7.11 ER • 4.1.9.11 S • 4.1.11.11 FA • 4.1.12.11 T • 4.1.14 11WM • 5.1.1.11 GW • 5.1.2.11 HH • 5.1.3.11 LER	*Description* • 2.2.2.4 • 2.5.2.6.3 • E.1	*Impacts* • 4.1.4.11 AQ • 4.1.6.11 WR • 4.1.10.11 NO • 4.1.14.11 WM • 5.1.1.11 GW • 5.1.2.11 HH • 5.1.3.11 LER

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

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Table 5. Roadmap to the FFTF Decommissioning Alternatives

<table>
<tr><th colspan="5">FFTF DECOMMISSIONING ALTERNATIVE 1:
No Action</th></tr>
<tr><th colspan="2">FACILITY DISPOSITION</th><th colspan="2">DISPOSITION OF REMOTE-HANDLED SPECIAL COMPONENTS</th><th>DISPOSITION OF BULK SODIUM</th></tr>
<tr><td colspan="2">Key Features
FFTF Reactor Containment Building and buildings in Property Protected Area maintained under administrative control
Reactor vessel, piping systems, special components, and tanks left in place</td><td colspan="2">Key Features
Remote-handled special components left in place</td><td>Key Features
Bulk sodium from FFTF deactivation activities stored as a solid in tanks in the Sodium Storage Facility
Hallam Reactor and Sodium Reactor Experiment sodium remain in storage</td></tr>
<tr><td colspan="2">Potential Issues
FFTF Reactor Containment Building not decommissioned as planned</td><td colspan="2">Potential Issues
No final disposition of remote-handled special components</td><td>Potential Issues
No final disposition of stored sodium</td></tr>
<tr><td>Description
2.3.1
2.3.2
2.3.3.1
2.5.3.1
D.2.2
E.2</td><td>Impacts
4.2.1.1 LR
4.2.4.1 AQ
4.2.6.1 WR
4.2.7.1 ER
4.2.10.1 NO
4.2.11.1 FA
5.2.1.1 GW
5.2.2.1 HH
5.2.3.1 LER</td><td>Description
2.3.3.2
2.5.3.1
D.2.2
E.2</td><td>Impacts
None</td><td>Description
2.3.3.3
2.5.3.1
D.2.2
E.2</td><td>Impacts
None</td></tr>
</table>

Note: "Key Features" include alternative configurations and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; FFTF=Fast Flux Test Facility; GW=Groundwater; HH=Human Health**;** LER=Long-Term Ecological Risk; LR=Land Resources; NO=Normal Operations; WR=Water Resources.

Table 5. Roadmap to the FFTF Decommissioning Alternatives (*continued*)

<table>
<tr><th colspan="5">FFTF DECOMMISSIONING ALTERNATIVE 2:
Entombment</th></tr>
<tr><th colspan="2">FACILITY DISPOSITION</th><th colspan="2">DISPOSITION OF REMOTE-HANDLED SPECIAL COMPONENTS</th><th>DISPOSITION OF BULK SODIUM</th></tr>
<tr><td colspan="2">Key Features
• FFTF Reactor Containment Building and buildings in Property Protected Area decommissioned
• All above-grade structures dismantled and filled
• Special components and small-diameter pipes removed
• Reactor vessel left in place and grouted
• Modified RCRA Subtitle C barrier placed over filled area</td><td colspan="2">Key Features
• Remote-handled special components removed and processed for disposal
• Idaho Option: processing of remote-handled special components at Remote Treatment Project proposed at Idaho National Laboratory’s Materials and Fuels Complex
• Hanford Option: processing of remote-handled special components occurs at a new facility at the Hanford Site</td><td>Key Features
• Bulk sodium from FFTF deactivation activities, Sodium Reactor Experiment sodium, and Hallam Reactor sodium converted to a caustic (sodium hydroxide) solution for use in the Waste Treatment Plant pretreatment process
• Idaho Reuse Option: conversion of sodium at the Sodium Processing Facility at Idaho National Laboratory’s Materials and Fuels Complex
• Hanford Reuse Option: conversion of sodium at a new facility at the Hanford Site</td></tr>
<tr><td colspan="2">Potential Issues
• Reactor vessel left in place
• Postclosure care required after placement of barrier (not released for unrestricted use)</td><td colspan="2">Potential Issues
• Transportation of special components to Idaho
• Building of new facility at the Hanford Site</td><td>Potential Issues
• Transportation of sodium to Idaho
• Building new facility at the Hanford Site</td></tr>
<tr><td>Description
• 2.3.1
• 2.3.2
• 2.3.3.1
• 2.5.3.2
• D.2.3
• E.2</td><td>Impacts
• 4.2.1.2 LR
• 4.2.4.2 AQ
• 4.2.6.2 WR
• 4.2.7.2 ER
• 4.2.9.2 S
• 4.2.10.2 NO
• 4.2.11.2 FA
• 4.2.12.2 T
• 4.2.14.2 WM
• 5.2.1.2 GW
• 5.2.2.2 HH
• 5.2.3.2 LER</td><td>Description
• 2.3.3.2
• 2.5.3.2
• D.2.3
• E.2</td><td>Impacts
• 4.2.1.2 LR
• 4.2.10.2 NO
• 4.2.11.2 FA
• 4.2.12.2 T
• 4.4.14.2 WM
• 5.2.1.2 GW
• 5.2.2.2 HH
• 5.2.3.2 LER</td><td>Description
• 2.3.3.3
• 2.5.3.2
• D.2.3
• E.2</td><td>Impacts
• 4.2.1.2 LR
• 4.2.6.2 WR
• 4.2.10.2 NO
• 4.2.11.2 FA
• 4.2.12.2 T
• 4.2.14.2 WM
• 5.2.1.2 GW
• 5.2.2.2 HH
• 5.2.3.2 LER</td></tr>
</table>

Note: “Key Features” include alternative configurations and assumptions. “Potential Issues” include topics that may be environmental impact drivers or are expected to be of interest to readers. “Description” identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. “Impacts” identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; FFTF=Fast Flux Test Facility; GW=Groundwater; HH=Human Health**;** LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; RCRA=Resource Conservation and Recovery Act; S=Socioeconomics; T=Transportation; WM=Waste Management; WR=Water Resources.

Table 5. Roadmap to the FFTF Decommissioning Alternatives (*continued*)

FFTF DECOMMISSIONING ALTERNATIVE 3: Removal					
FACILITY DISPOSITION		**DISPOSITION OF REMOTE-HANDLED SPECIAL COMPONENTS**		**DISPOSITION OF BULK SODIUM**	
Key Features • FFTF Reactor Containment Building and buildings in Property Protected Area decommissioned • Reactor Containment Building and support facilities demolished to 0.91 meters (3 feet) below grade • Remote-handled special components and small diameter pipes removed • Remaining portion of buildings backfilled and area revegetated		*Key Features* • Remote-handled special components removed and processed for disposal • Idaho Option: processing of remote-handled special components at Remote Treatment Project proposed at Idaho National Laboratory's Materials and Fuels Complex • Hanford Option: processing of remote-handled special components at a new facility at the Hanford Site		*Key Features* • Bulk sodium from FFTF deactivation activities, SRE sodium, and Hallam Reactor sodium converted to a caustic (sodium hydroxide) solution for use in the Waste Treatment Plant pretreatment process • Hanford Reuse Option: conversion of sodium at a new facility at the Hanford Site • Idaho Reuse Option: conversion of sodium at the Sodium Processing Facility at Idaho National Laboratory's Materials and Fuels Complex	
Potential Issues • Reactor vessel disposed of on site • Revegetated area may still require postclosure care		*Potential Issues* • Transportation of special components to Idaho • Building new facility at the Hanford Site		*Potential Issues* • Transportation of sodium to Idaho • Building new facility at the Hanford Site	
Description • 2.3.1 • 2.3.2 • 2.3.3.1 • 2.5.3.3 • D.2.4 • E.2	*Impacts* • 4.2.1.3 LR • 4.2.4.3 AQ • 4.2.6.3 WR • 4.2.7.3 ER • 4.2.9.3 S • 4.2.10.3 NO • 4.2.11.3 FA • 4.2.12.3 T • 4.2.14.3 WM • 5.2.1.3 GW • 5.2.2.3 HH • 5.2.3.3 LER	*Description* • 2.3.1 • 2.3.2.2 • 2.3.3.2 • 2.5.3.3 • D.2.4 • E.2	*Impacts* • 4.2.1.3 LR • 4.2.4.3 AQ • 4.2.9.3 S • 4.2.10.3 NO • 4.2.11.3 FA • 4.2.12.3 T • 4.2.14.3 WM • 5.2.1.3 GW • 5.2.2.3 HH • 5.2.3.3 LER	*Description* • 2.3.3.3 • 2.5.3.3 • D.2.4 • E.2	*Impacts* • 4.2.1.3 LR • 4.2.4.3 AQ • 4.2.9.3 S • 4.2.10.3 NO • 4.2.11.3 FA • 4.2.12.3 T • 4.2.14.3 WM • 5.2.1.3 GW • 5.2.2.3 HH • 5.2.3.3 LER

Note: "Key Features" include alternative configurations and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; FFTF=Fast Flux Test Facility; GW=Groundwater; HH=Human Health**;** LER=Long-Term Ecological Risk; LR=Land Resources; MTG=metric tons of glass; NO=Normal Operations; S=Socioeconomics; SRE=Sodium Reactor Experiment; T=Transportation; WM=Waste Management; WR=Water Resources.

Table 6. Roadmap to the Waste Management Alternatives

<table>
<tr><th colspan="5">WASTE MANAGEMENT ALTERNATIVE 1:
No Action</th></tr>
<tr><th colspan="2">STORAGE AND TREATMENT</th><th colspan="2">DISPOSAL</th><th>CLOSURE</th></tr>
<tr><td colspan="2">Key Features
Continued storage/treatment of LLW, MLLW, and TRU waste at the CWC to process for disposal
Continued storage/treatment of LLW, MLLW, and TRU waste at WRAP and the T Plant complex
No offsite shipments of TRU waste or LLW/MLLW</td><td colspan="2">Key Features
Continued disposal of LLW and MLLW in lined trenches 31 and 34 in burial ground 218-W-5
Discontinued construction of IDF-East</td><td>Key Features
Administrative control for 100 years after operations cease</td></tr>
<tr><td colspan="2">Potential Issues
No additional storage capacity for onsite waste</td><td colspan="2">Potential Issues
No additional disposal capacity for on- or offsite waste</td><td>Potential Issues
No issues</td></tr>
<tr><td>Description
2.4.1
2.4.2
2.5.4.1
D.3.2
E.3</td><td>Impacts
4.3.1.1 LR
4.3.4.1 AQ
4.3.6.1 WR
4.3.9.11 S
4.3.10.1 NO
4.3.11.1 FA
4.2.12.3 T
4.3.14.1 WM
5.3.1.1 GW
5.3.2.1 HH
5.3.3.1 LER</td><td>Description
2.4.1
2.4.2
2.5.4.1
E.3</td><td>Impacts
4.3.1.1 LR
4.3.4.1 AQ
4.3.6.1 WR
4.3.10.1 NO
4.3.11.1 FA
4.2.12.3 T
4.3.14.1 WM
5.3.1.1 GW
5.3.2.1 HH
5.3.3.1 LER</td><td>Description
2.4.2.5
2.5.4.1</td><td>Impacts
4.3.4.1 AQ
4.3.6.1 WR
4.2.12.3 T
4.3.14.1 WM
5.3.1.1 GW
5.3.2.1 HH
5.3.3.1 LER</td></tr>
</table>

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; CWC=Central Waste Complex; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; FFTF=Fast Flux Test Facility; GS=Geology and Soil; GW=Groundwater; HH=Human Health**;** IDF=Integrated Disposal Facility; LER=Long-Term Ecological Risk; LLW=low-level radioactive waste; LR=Land Resources; MLLW=mixed low-level radioactive waste; NO=Normal Operations; RPPDF=River Protection Project Disposal Facility; S=Socioeconomics; T=Transportation; TRU=transuranic; WM=Waste Management; WR=Water Resources; WRAP=Waste Receiving and Processing Facility.

Table 6. Roadmap to the Waste Management Alternatives *(continued)*

<table>
<tr><th colspan="5">WASTE MANAGEMENT ALTERNATIVE 2:
Disposal in IDF, 200-East Area Only</th></tr>
<tr><th colspan="2">STORAGE AND TREATMENT</th><th colspan="2">DISPOSAL</th><th>CLOSURE</th></tr>
<tr><td colspan="2">Key Features
Continued storage/treatment of LLW, MLLW, and TRU waste at the CWC, WRAP, and T Plant
Construction of expansions of the CWC, WRAP, and T Plant complex
No offsite shipments of TRU waste
Offsite shipments of LLW and MLLW</td><td colspan="2">Key Features
Continued disposal of LLW and MLLW in lined trenches 31 and 34 in burial ground 218-W-5
IDF construction in 200-East Area for tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite LLW and MLLW
RPPDF construction in 200 Areas for lightly contaminated equipment and soils resulting from tank-related closure activities</td><td>Key Features
Modified RCRA Subtitle C barriers for IDF (200-East Area) and RPPDF and 100 years of postclosure care</td></tr>
<tr><td colspan="2">Potential Issues
Transportation of offsite waste</td><td colspan="2">Potential Issues
Disposal of offsite waste
Disposal of tank closure treated waste forms</td><td>Potential Issues
No issues</td></tr>
<tr><td>Description
2.4.1
2.4.2
2.5.4.2
D.3.3
E.3</td><td>Impacts
4.3.1.2 LR
4.3.4.2 AQ
4.3.5.2 GS
4.3.6.2 WR
4.3.7.2 ER
4.3.9.2 S
4.3.10.2 NO
4.3.11.2 FA
4.3.12.2 T
4.3.14.2 WM
5.3.1.2 GW
5.3.2.2 HH
5.3.3.2 LER</td><td>Description
2.4.1
2.4.2
2.5.4.2
E.3</td><td>Impacts
4.3.1.2 LR
4.3.4.2 AQ
4.3.5.2 GS
4.3.6.2 WR
4.3.7.2 ER
4.3.9.2 S
4.3.10.2 NO
4.3.11.2 FA
4.3.12.2 T
4.3.14.2 WM
5.3.1.2 GW
5.3.2.2 HH
5.3.3.2 LER</td><td>Description
2.4.2.5
2.5.4.2</td><td>Impacts
4.3.1.2 LR
4.3.4.2 AQ
4.3.5.2 GS
4.3.6.2 WR
4.3.7.2 ER
4.3.14.2 WM
5.3.1.2 GW
5.3.2.2 HH
5.3.3.3 LER</td></tr>
</table>

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

Key: AQ=Air Quality; CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; CWC=Central Waste Complex; EIS=environmental impact statement; ER=Ecological Resources; FA=Facility Accidents; FFTF=Fast Flux Test Facility; GS=Geology and Soil; GW=Groundwater; HH=Human Health**;** IDF=Integrated Disposal Facility; LER=Long-Term Ecological Risk; LLW=low-level radioactive waste; LR=Land Resources; MLLW=mixed low-level radioactive waste; NO=Normal Operations; RCRA=Resource Conservation and Recovery Act; RPPDF=River Protection Project Disposal Facility; S=Socioeconomics; T=Transportation; TRU=transuranic; WM=Waste Management; WR=Water Resources; WRAP=Waste Receiving and Processing Facility.

Table 6. Roadmap to the Waste Management Alternatives (*continued*)

<table>
<tr><th colspan="5">WASTE MANAGEMENT ALTERNATIVE 3:
Disposal in IDF, 200-East and 200-West Areas</th></tr>
<tr><th colspan="2">STORAGE AND TREATMENT</th><th colspan="2">DISPOSAL</th><th>CLOSURE</th></tr>
<tr><td colspan="2">Key Features
Continued storage/treatment of LLW, MLLW, and TRU waste at the CWC, WRAP, and T Plant
Construction of expansions of the CWC, WRAP, and T Plant complex
No offsite shipments of TRU waste
Offsite shipments of LLW and MLLW</td><td colspan="2">Key Features
Continued disposal of LLW and MLLW in lined trenches 31 and 34 in burial ground 218-W-5
IDF construction in 200-East Area for tank waste
IDF construction in 200-West Area for onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite LLW and MLLW
RPPDF construction in 200 Areas for lightly contaminated equipment and soils resulting from tank-related closure activities</td><td>Key Features
Modified RCRA Subtitle C barriers for IDF (200-East Area) and RPPDF and 100 years of postclosure care</td></tr>
<tr><td colspan="2">Potential Issues
Transportation of offsite waste</td><td colspan="2">Potential Issues
Two onsite disposal locations
Disposal of offsite waste
Disposal of tank closure treated waste forms</td><td>Potential Issues
No issues</td></tr>
<tr><td>Description
2.4.1
2.4.2
2.5.4.3
D.3.4
E.3</td><td>Impacts
4.3.1.2 LR
4.3.4.2 AQ
4.3.5.2 GS
4.3.6.2 WR
4.3.7.2 ER
4.3.9.2 S
4.3.10.2 NO
4.3.11.2 FA
4.2.12.2 T
4.3.14.2 WM
5.3.1.2 GW
5.3.2.2 HH
5.3.3.2 LER</td><td>Description
2.4.1
2.4.2
2.5.4.3
E.3</td><td>Impacts
4.3.1.12 LR
4.3.4.2 AQ
4.3.5.2 GS
4.3.6.2 WR
4.3.7.2 ER
4.3.9.2 S
4.3.10.2 NO
4.3.11.2 FA
4.2.12.2 T
4.3.14.2 WM
5.3.1.2 GW
5.3.2.2 HH
5.3.3.2 LER</td><td>Description
2.4.1
2.4.2
2.4.2.5
2.5.4.3</td><td>Impacts
4.3.1.12 LR
4.3.4.2 AQ
4.3.5.2 GS
4.3.6.2 WR
4.3.7.2 ER
4.3.14.2 WM
5.3.1.2 GW
5.3.2.2 HH
5.3.3.2 LER</td></tr>
</table>

Note: "Key Features" include alternative configurations, treatment dates, and assumptions. "Potential Issues" include topics that may be environmental impact drivers or are expected to be of interest to readers. "Description" identifies EIS Chapter 2 and Appendix D and E sections that further describe the Key Features, including the technologies evaluated. Chapter 2 provides an overview of the alternatives, while Appendix E provides more-detailed information. "Impacts" identify EIS Chapter 4 and 5 sections that describe the impacts of the Key Features and/or Potential Issues.

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ORGANIZATION OF THE *DRAFT TC & WM EIS*

This *Draft TC & WM EIS* is organized as described below.

- **Summary—**The Summary, a separate volume, summarizes the key information provided in this *TC & WM EIS* and includes background on, and regulatory history of, past activities at Hanford; the purpose and need for agency actions; a description and comparison of the alternatives; an overview of the tank farm systems, FFTF decommissioning activities, and solid waste operations complex; and a summary of potential short- and long-term impacts of the alternatives, key environmental findings, and costs of the alternatives.

- **Chapter 1—Proposed Actions: Background, Purpose, and Need.** Chapter 1 provides background information regarding preparation of this *TC & WM EIS*, including the purpose and need, for agency action regarding final waste disposition, SST system closure, and FFTF decommissioning; the anticipated decisions to be made based on the EIS analyses; a summary of the issues identified during scoping; the scope of this EIS, including brief summaries of the alternatives; the relationship of the proposed actions to other actions or programs; the cooperating agencies; and the organization of this *TC & WM EIS*.

- **Chapter 2—Proposed Actions and Alternatives.** Chapter 2 describes the alternatives evaluated in this EIS. This chapter also includes a description of the processes and facilities that could be used to implement each of the alternatives and a summary of the short- and long-term environmental impacts and cost estimates of each alternative.

- **Chapter 3—Affected Environment.** Chapter 3 describes the existing Hanford and INL environments that may be affected by the alternatives under consideration. In general, Hanford as a whole is described first, followed by the 200 and 400 Areas. The existing environments described include human, air, and surface and subsurface media that could be affected by activities related to tank waste retrieval, treatment, and disposal; SST system closure; interim storage, as applicable; FFTF decommissioning; and waste management.

- **Chapter 4—Short-Term Environmental Consequences.** Chapter 4 discusses the short-term environmental impacts associated with the various EIS alternatives for tank closure, FFTF decommissioning, and waste management. Impacts produced by construction, operations, decontamination, and decommissioning are considered.

- **Chapter 5—Long-Term Environmental Consequences.** Chapter 5 discusses the long-term environmental impacts associated with the various EIS alternatives for tank closure, FFTF decommissioning, and waste management, focusing on long-term environmental impacts on groundwater and human health, as well as ecological risks.

- **Chapter 6—Cumulative Impacts.** Chapter 6 discusses the cumulative impacts associated with the various EIS alternatives.

- **Chapter 7—Environmental Consequences Discussion.** Chapter 7 discusses possible measures to mitigate impacts identified in Chapters 4, 5, and 6; unavoidable adverse environmental impacts; the relationship between short-term use of the environment and long-term productivity; and any irreversible and irretrievable resource commitments.

- **Chapter 8—Potentially Applicable Laws, Regulations, and Other Requirements.** Chapter 8 describes the environmental laws, regulations, permits, and consultations that are potentially applicable to the various activities related to tank waste retrieval, treatment, and disposal and SST system closure; FFTF decommissioning; and waste management associated with the alternatives. Federal laws and regulations; Executive orders; DOE directives, orders, and guidance; and other compliance actions related to protection of the environment also are described.

- **Chapter 9—Glossary.** Chapter 9 contains definitions of important technical terms that may not be commonly used, including both discipline-specific and DOE- and Hanford-unique terms.

- **Chapter 10—List of Preparers.** Chapter 10 identifies the DOE and contractor preparers of this EIS. Information is provided for each preparer in the following areas: (1) name, (2) affiliation, (3) education, (4) experience, and (5) EIS responsibility.

- **Chapter 11—Distribution List.** Chapter 11 contains the external distribution list for this EIS, which includes Federal, state, and local elected and appointed officials and agencies; American Indian representatives; environmental and public interest groups; and organizations and individuals who requested/were sent a copy of the draft EIS.

- **Chapter 12—Index.** Chapter 12 contains the index of key words and terms found in this EIS.

In addition, the following appendices are provided to support these chapters:

- Appendix A—*Federal Register* and Other Public Notices
- Appendix B—Contractor and Subcontractor National Environmental Policy Act Disclosure Statements
- Appendix C—Cooperating Agency, Consultation, and Other Interaction Documentation
- Appendix D—Waste Inventories
- Appendix E—Descriptions of Facilities, Operations, and Technologies
- Appendix F—Direct and Indirect Impacts: Assessment Methodology
- Appendix G—Air Quality Analysis
- Appendix H—Transportation
- Appendix I—Workforce Estimates
- Appendix J—Environmental Justice
- Appendix K—Human Health Risk Analysis
- Appendix L—Groundwater Flow Field Development
- Appendix M—Release to Vadose Zone
- Appendix N—Vadose Zone Flow and Transport
- Appendix O—Groundwater Transport Analysis
- Appendix P—Ecological Resources and Risk Analysis
- Appendix Q—Human Health, Dose, and Risk Analysis
- Appendix R—Cumulative Impacts: Assessment Methodology

- Appendix S—Waste Inventories for Cumulative Impact Analyses
- Appendix T—Supporting Information for the Short-Term Cumulative Impact Analyses
- Appendix U—Supporting Information for the Long-Term Cumulative Impact Analyses
- Appendix V—Black Rock Reservoir Sensitivity Analysis

AVAILABILITY OF THE *DRAFT TC & WM EIS*

A complete copy of this *TC & WM EIS* and a list of reference documents are available in public reading rooms and other information locations. Copies can also be obtained as indicated below.

For copies of, or additional information regarding, this *Draft TC & WM EIS*, contact:

Mary Beth Burandt, Document Manager
Office of River Protection
U.S. Department of Energy
Post Office Box 1178
Richland, WA 99352
Attention: *TC & WM EIS*
Email: TC&WMEIS@saic.com
Fax: 509-372-7701
Telephone and voicemail: 888-829-6347

For general information regarding DOE's NEPA process, contact:

Carol M. Borgstrom, Director
Office of NEPA Policy and Compliance
(GC-20)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
Telephone: 202-586-4600, or leave a message at 800-472-2756

CHAPTER 1
PROPOSED ACTIONS: BACKGROUND, PURPOSE, AND NEED

Chapter 1 describes the background and purpose and need for the agency action presented in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*. Section 1.1 provides summary information on the size and distribution of the waste inventory at the Hanford Site (Hanford), the specific objectives of this *TC & WM EIS*, and the regulatory basis for the proposed actions. Section 1.2 details the operational history of Hanford, efforts to secure an agreement between Federal and state regulators on milestones for compliance with regulatory requirements, and the succession of environmental impact studies and Records of Decision consistent with that agreement. Section 1.3 presents the three major objectives of the U.S. Department of Energy (DOE) at Hanford, as well as specific objectives as part of the National Environmental Policy Act (NEPA) process. Provided in Section 1.4 are outlines of environmental impact statement–supported decisions relative to operation of DOE's Office of River Protection. Section 1.5 includes a brief description of the scoping process for the *TC & WM EIS* alternatives. Section 1.6 summarizes public comments and DOE responses on issues raised during the scoping processes for this *TC & WM EIS* and the earlier, unpublished "Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington" and "Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, Washington." Section 1.7 presents a breakdown of the *TC & WM EIS* alternatives as modified by DOE consistent with a review of public, stakeholder, and regulator comments generated during the scoping process. Section 1.8 contains brief discussions of a number of NEPA reviews, completed or ongoing, and their relationships with the proposed actions at Hanford. The organization of this *TC & WM EIS* is presented as Section 1.9.

1.1 INTRODUCTION

The U.S. Department of Energy (DOE) prepared this *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* to analyze and evaluate the potential environmental impacts of storing, retrieving, treating, and disposing of the waste inventory generated during defense production years at the Hanford Site (Hanford) in Washington State. This waste inventory of about 205 million liters (54.5 million gallons) of mixed radioactive and chemically hazardous waste, stored in 177 large and associated smaller underground storage tanks, presents a major source of potential public health and environmental risk. This *TC & WM EIS* revises and updates the analyses of the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement (TWRS EIS)* (DOE and Ecology 1996) and subsequent supplement analyses (SAs), which addressed retrieval, treatment, and disposal of the tank waste, by also evaluating the impacts of different scenarios for final closure of the single-shell tank (SST) system.

In addition, this *TC & WM EIS* evaluates the potential environmental impacts of proposed activities to decommission the Fast Flux Test Facility (FFTF), a nuclear test reactor, and associated auxiliary facilities at Hanford, including management of waste generated by the decommissioning process (such as certain waste designated as remote-handled special components [RH-SCs]) and disposition of Hanford's inventory of radioactively contaminated bulk sodium from FFTF and other onsite facilities.

Finally, this *TC & WM EIS* evaluates the potential environmental impacts of ongoing solid waste management operations at Hanford, as well as the proposed disposal of Hanford low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) and a limited volume of LLW and MLLW from other DOE sites in an Integrated Disposal Facility(ies) (IDF) located at Hanford.

This *TC & WM EIS* describes the potential environmental impacts and relative cost consequences of the proposed actions and reasonable alternatives for the major activities discussed above. This *TC & WM EIS* was prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.); DOE implementing procedures for NEPA (10 CFR 1021); and Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500–1508). Further, this *TC & WM EIS* implements a Settlement Agreement signed on

January 6, 2006, by DOE, the Washington State Department of Ecology (Ecology), and the Washington State Attorney General's Office. The agreement settles NEPA claims made in the case *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM), which addressed the January 2004 *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington (HSW EIS)* (DOE 2004a). Ecology is participating in this NEPA activity as a cooperating agency; as such, it is responsible for reviewing the content of the *TC & WM EIS* under authority of Washington's State Environmental Policy Act (SEPA) (RCW 43.21C) to ensure it satisfies the State of Washington's requirements and supports its proposed action to issue permits under its hazardous waste program. The information provided in this environmental impact statement (EIS) will be considered, along with other pertinent information, in the final decision process for DOE's proposed actions.

1.2 BACKGROUND

Hanford is located in southeastern Washington State along the Columbia River and is approximately 1,517 square kilometers (586 square miles) in size. Hanford's mission included defense-related nuclear research, development, and weapons production activities from the early 1940s to approximately 1989. During that period, Hanford operated a plutonium production complex with nine nuclear reactors and associated processing facilities.

To produce plutonium, uranium metal (fuel rods) was irradiated in plutonium production reactors located near the Columbia River. The irradiated uranium metal (spent nuclear fuel, or SNF) was cooled and then treated through chemical separation in reprocessing plants located in the central part of Hanford. At the reprocessing plants, the SNF was dissolved in acid and the plutonium was separated from the remaining uranium and byproducts, many of which are radioactive. The plutonium then was used for nuclear weapons production.

Hanford reprocessed SNF containing approximately 100,000 metric tons of irradiated uranium and generated several hundred thousand metric tons of chemical and radioactive waste during its production period. The waste included (1) high-level radioactive waste (HLW) as defined under the Nuclear Waste Policy Act (42 U.S.C. 10101 et seq.); (2) transuranic (TRU) waste (waste containing alpha emitting radionuclides with atomic numbers greater than uranium [92] and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram of waste); (3) LLW, which is radioactive waste that is neither HLW nor TRU waste; (4) MLLW, which is LLW containing hazardous constituents as defined under the Resource Conservation and Recovery Act (RCRA) of 1976 (42 U.S.C. 6901 et seq.); and (5) hazardous waste, as defined under RCRA.

For waste generated by the chemical reprocessing plants, the waste management process initially involved neutralizing the acidic waste with sodium hydroxide and sodium carbonate and storing the resulting caustic waste in large underground tanks until a long-term disposal solution could be found. From 1943 through early 1964, 149 SSTs were built to store waste in the 200 Areas of Hanford.

During the 1950s, uranium was extracted from some of the waste stored in SSTs, which introduced new chemicals to the tanks. Beginning in the 1960s, some waste was retrieved from SSTs and transferred to the B Plant at Hanford, where cesium and strontium were extracted, placed in capsules, and stored in a separate facility. This process removed approximately 40 percent of the fission product inventory from the tank waste. The remaining waste was returned to the tanks.

In the mid-1950s, leaks were suspected or detected in some SSTs. To address concerns about SST designs, Hanford adopted a new double-shell tank (DST) design—basically, a tank within a tank. The DST design would allow leaks to be detected and corrective actions to be taken before the waste could reach the soil surrounding the tanks. Between 1968 and 1986, 28 DSTs were constructed. Due to their

age, all SSTs were interim-stabilized by removing pumpable liquids to minimize the potential for future leaks. The interim stabilization program was completed in 2004. Newly generated waste and pumped SST interim stabilization waste are stored in the DSTs.

DOE is processing Hanford's contact-handled TRU waste (which does not require special protective shielding) for shipment to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, consistent with the 1998 Records of Decision (RODs) (63 FR 3629) for treatment and disposal of TRU waste under the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (WM PEIS)* (DOE 1997a) and the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement (WIPP SEIS-II)* (DOE 1997b). DOE is disposing of Hanford's LLW and MLLW on site, consistent with the ROD (65 FR 10061) for treatment and disposal of these wastes under the *Final WM PEIS*. The *Final WM PEIS* ROD also designates Hanford as a regional disposal site for LLW and MLLW from other DOE sites.

1.2.1 Hanford Regulatory Compliance Requirements

Throughout much of the history of plutonium production at Hanford, DOE regulated waste management and environmental protection under a set of orders implementing the Atomic Energy Act (42 U.S.C. 2011 et seq.), including DOE Order 435.1, *Radioactive Waste Management*. (For more detail, see the discussion on DOE Order 435.1 in Chapter 8 of this *TC & WM EIS*.) Although RCRA (42 U.S.C. 6901 et seq.) was enacted in 1976, giving other components of the Federal Government a major role in the regulation of hazardous waste, its applicability to the hazardous component of mixed waste (waste containing both radioactive and hazardous components) at DOE facilities was not recognized by DOE until 1987. In 1986, Ecology was authorized by the U.S. Environmental Protection Agency (EPA) to administer its own hazardous waste program (through the state's Hazardous Waste Management Act [RCW 70.105]) in lieu of the Federal RCRA program. Ecology has adopted "Dangerous Waste Regulations" (WAC 173-303) to regulate the management of hazardous waste.

To establish liability for cleanup of disposal sites for hazardous substances (radioactive materials and hazardous waste), Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) in 1980 (42 U.S.C. 9601 et seq.). In 1986, the Superfund Amendments and Reauthorization Act (P.L. 99-499) amended CERCLA, establishing Federal agencies' responsibility to investigate and remediate releases of hazardous substances, including radioactive contaminants, from their facilities.

Beginning in 1986, Ecology and EPA began working with DOE to examine how to bring Hanford into compliance with RCRA and CERCLA. The regulators and DOE agreed to develop one compliance agreement that set milestones for cleaning up past disposal sites under CERCLA and bringing operating facilities into compliance with RCRA. Negotiations concluded in late 1988, and the Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (TPA), was completed in 1988 and signed by the three agencies in 1989 (Ecology, EPA, and DOE 1989). Hanford's current mission is the cleanup of waste from defense-related nuclear research, development, and weapons production activities and, ultimately, the closure of Hanford. Because the TPA, which addresses DOE's mixed waste that is subject to the RCRA storage prohibition, preceded the Federal Facility Compliance Act of 1992 (P.L. 102-386), the TPA also satisfies the act's requirement for a site treatment plan addressing mixed waste in storage at Hanford.

1.2.2 *Tank Waste Remediation System Environmental Impact Statement* and Record of Decision

From 1991 to 1998, a DOE organization known as the Tank Waste Remediation System (TWRS) managed all aspects of Hanford's tank farms. In 1998, Congress created a new DOE organization, the Office of River Protection (ORP). Creation of this organization was required by the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (P.L. 105-261). The manager of ORP is responsible for all aspects of Hanford's tank farm operations. The ORP River Protection Project (RPP) carries out activities associated with storage, treatment, and disposal of Hanford's tank waste.

In 1996, DOE and Ecology coauthored the *TWRS EIS* (DOE and Ecology 1996) to be consistent with the requirements of NEPA (10 CFR 1021) and Washington's SEPA (RCW 43.21C). The *TWRS EIS* evaluated the range of reasonable alternatives feasible at that time to manage and dispose of radioactive, hazardous, and mixed wastes stored in the Hanford tanks. In February 1997, DOE published its decision in the "Record of Decision for the *Tank Waste Remediation System, Hanford Site, Richland, WA*" (62 FR 8693), hereafter referred to as the "*TWRS EIS* ROD."

DOE decided to implement the Preferred Alternative (Phased Implementation) identified in the *TWRS EIS* for retrieval, treatment, and disposal of tank waste. This alternative was based on a two-phase approach to tank waste treatment that included an initial demonstration phase lasting approximately 10 years, followed by Phase II, in which large production-level waste treatment plants would treat the remainder of the tank waste by 2028. DOE decided to chemically separate the tank waste into HLW and low-activity waste (LAW) streams. The LAW would be disposed of in a vitrified form on site at Hanford. The *TWRS EIS* ROD deferred the matter of tank closure pending development of further information. The Phased Implementation Alternative was selected because it would balance short- and long-term environmental impacts; meet regulatory requirements; address the technical uncertainties associated with remediation; and provide the flexibility necessary to accommodate future changes in remediation plans due to new information and technology development.

In the *TWRS EIS* ROD, DOE recognized that the conditions addressed in the *TWRS EIS* would likely require periodic reconsideration. Therefore, DOE committed in the *TWRS EIS* ROD to performing future evaluations of new information related to the tank waste remediation program. These evaluations were anticipated to occur at key points during implementation of the Phased Implementation Alternative, and DOE indicated that they would be performed under its NEPA regulations (10 CFR 1021), with appropriate public involvement. DOE committed to conducting NEPA evaluations as the information warranted to determine whether previous decisions should be changed.

As part of the *TWRS EIS*, a mitigation action plan was developed and implemented. This plan described three general actions to be performed. These included (1) creation of shrub-steppe habitat by transplanting sagebrush; (2) remediation of a transmission line corridor via seedlings of native grasses and sagebrush; and (3) research on native plant species.

In 2000 and 2001, sagebrush seedlings were planted on the Fitzner-Eberhardt Arid Lands Ecology Reserve. About a third of the seedlings were burned during the 24 Command Fire of June 2000 (more information on the fire is provided in Chapter 3 of this draft EIS). The surviving seedlings and subsequent replanting have resulted in about 91,000 seedlings that were planted across four general areas on the reserve. Remediation of the transmission line corridor was completed in March 2001. The mitigation action plan is complete (Durham and Sackschewsky 2004).

1.2.3 Developments Since Issuing the *Tank Waste Remediation System Environmental Impact Statement* Record of Decision

Publication of the *TWRS EIS* and ROD supported implementation of DOE's plans to proceed with the following:

- Design, construction, and operation of waste treatment facilities, including securing permits (e.g., air emissions, RCRA) supporting construction and operation of the treatment facilities
- Operation and maintenance of the tank farms
- Implementation of tank waste retrieval and transfer design and construction projects to support transferring the waste from the tanks to the waste treatment facilities

Consistent with DOE's commitment to conduct periodic evaluations under NEPA, an SA (DOE 1997c) was issued in May 1997. This analysis addressed the potential environmental impacts of proceeding with tank farm infrastructure upgrades, such as upgrading instrumentation and control, tank ventilation, waste transfer, and electrical distribution at existing tank farm facilities to support continued safe storage of tank waste until waste retrieval and disposal can be accomplished. DOE concluded that the potential impacts would be small in comparison to—and are bounded by—the impacts previously assessed under the Phased Implementation Alternative selected in the *TWRS EIS* ROD.

A second SA (DOE 1998) was issued in May 1998. This analysis addressed the impacts of emergent information on the design and construction of a new waste treatment plant under the privatization approach.[1] The new data included a revised tank waste inventory; emerging information on the level of contamination in the vadose zone; revised assessments on the potential for and consequences of accidents associated with management of the tank waste; ongoing technology development activities; and other engineering data. DOE concluded that the information developed since preparation of the *TWRS EIS* only minimally affected the impacts previously estimated in the *TWRS EIS*, and that the changes in environmental impacts were bounded by the impacts presented in the *TWRS EIS*.

A third SA (DOE 2001a) was issued in March 2001. This analysis considered information developed since approval of the *TWRS EIS* ROD relative to plans for treating Hanford tank waste. DOE concluded that new information regarding Phase I activities did not substantially change the proposed actions or present significant new circumstances relevant to environmental concerns, except for vitrified LAW disposal. Therefore, no further NEPA review was needed prior to starting construction of Phase I facilities (facilities capable of immobilizing approximately 10 percent of the tank waste through 2018).

However, changes in the vitrified LAW, including the change in waste form from cullet (small pieces of glass) to monoliths, the change from retrievable storage in vaults to disposal in shallow RCRA trenches, and the change in location within the 200-East Area, represented substantial changes to the scope of the Phased Implementation Alternative selected in the *TWRS EIS* ROD. While these changes in scope appeared to be bounded by the impacts previously analyzed in the *TWRS EIS*, the public had not had an opportunity to comment on the changes. Therefore, DOE determined that further NEPA analysis was

[1] "DOE started its privatization initiative in 1995 as a way to reduce the cost and speed the cleanup of its contaminated sites and to improve contractors' performance. The initiative was primarily an alternative contracting and financing strategy to foster open competition for fixed-price contracts; require the contractors to design, finance, build, own, and operate the facilities necessary to meet treatment requirements; and pay the contractors only for products or services delivered in accordance with the contracts." (GAO 2000).

warranted, and in 2003 these changes were included within the scope of the *Final HSW EIS* (DOE 2004a).[2]

The third SA also concluded that the Phase II waste treatment facilities (facilities capable of immobilizing the remaining tank waste through 2028) appeared to be substantially different from the facilities identified in the Phased Implementation Alternative selected in the *TWRS EIS* ROD. The impacts of revising the design of the Phase II treatment facilities to meet the SST retrieval key assumption made in the *TWRS EIS* (retrieval of all SSTs by 2018) appeared to exceed the bounds of the impacts analyzed in the *TWRS EIS*. Therefore, DOE determined that these changes would be included within the scope of a future NEPA analysis.

Since issuance of the *TWRS EIS* ROD and subsequent SAs, DOE has proceeded with plans to design, construct, and operate facilities that would separate waste into HLW and LAW streams, vitrify the HLW stream, and immobilize the LAW stream. These facilities are now under construction in the 200-East Area of the site and are collectively referred to as the "Waste Treatment Plant" (WTP). The WTP is the cornerstone of DOE's treatment capability for tank waste. The WTP will separate waste stored in Hanford's underground tanks into HLW and LAW fractions. HLW will be vitrified in the WTP and stored at Hanford until disposition decisions are made and implemented. Immobilized LAW would be produced at the WTP.

Design of and preliminary performance projections for the WTP support DOE's proposal to extend operations beyond the 10-year period (Phase I) originally planned in the *TWRS EIS* ROD. DOE also plans to enhance the throughput of the WTP rather than use a second, larger-scale treatment facility in 2012, as identified in the *TWRS EIS* ROD (Phase II). DOE determined that the original plan for a Phase II WTP was prohibitively expensive, and it was believed that the enhanced WTP would implement the *TWRS EIS* ROD. Based on this decision, DOE changed the mission of the WTP from demonstration plant to single, full-scale production facility.

Since issuance of the third SA and after evaluating changes to enhance the WTP, DOE began focusing on treatment methods tailored more to specific waste streams. Based on this evaluation, DOE decided to keep the enhanced WTP at its currently planned configuration and to use supplemental treatment for the remaining portion of the waste to meet the requirement to treat all tank waste. Based on the decision to pursue supplemental treatment and closure, in January 2003, DOE published a Notice of Intent (NOI) (68 FR 1052) in the *Federal Register* to prepare the "Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington" ("Tank Closure EIS") (DOE/EIS-0356). The proposed scope of the "Tank Closure EIS" included closure of the 149 underground SSTs and analysis of newly available information on supplemental treatment of a portion of the LAW from all 177 tanks, which contain a total of approximately 206 million liters (54.5 million gallons) of waste.

Another change since issuance of the third SA concerns the design of the WTP Pretreatment Facility. The Pretreatment Facility was originally designed to remove technetium from the HLW stream. However, based on reviews of technetium-99 in immobilized low-activity waste (ILAW) glass, DOE and Ecology agreed to delete technetium removal from the permit (Hedges 2008). The technetium removal capability was removed from the design of the Pretreatment Facility, which is currently being constructed without it. For analysis purposes, this *TC & WM EIS* assumes that technetium-99 removal capability could be added in the existing Pretreatment Facility. Design and construction modifications would be needed later to add the technetium-99 removal capacity if required.

[2] As stipulated in the Settlement Agreement, this scope is now included in this *TC & WM EIS*.

Issues facing DOE primarily result from uncertainties associated with the magnitude of waste retrieval required. DOE began retrieval activities on an SST in 2002 with the C-106 tank, consistent with TPA Milestone M-45-00. Since completion of waste retrieval from the C-106 tank, retrieval has been completed on the following tanks: C-103, C-201, C-202, C-203, C-204, and S-112. TPA Milestone M-45-00 specifies that closure will follow retrieval of as much tank waste as technically possible. Under this milestone, residual waste remaining in the tank is not to exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for 200-series tanks, corresponding to a 99 percent retrieval goal. Appendix H of the TPA, "Single Shell Tank Waste Retrieval Criteria Procedure," provides a procedure for DOE to request an exception to the retrieval criteria established under Milestone M-45-00 if DOE does not believe this criterion is achievable. This EIS will provide the environmental impact information needed to make informed decisions regarding the impacts of meeting or not meeting the 99 percent retrieval goal.

Additionally, requirements implementing DOE's Atomic Energy Act authority under DOE Order 435.1, *Radioactive Waste Management*, which was issued July 9, 1999, also identify retrieval goals as part of the HLW tank closure requirements.

1.2.4 Formal Evaluations of the Tank Waste Remediation Program

The RPP is very complex, and many technical uncertainties associated with implementation of the Phased Implementation Alternative were identified in the *TWRS EIS* ROD. To address these uncertainties and ensure that data developed during the various phases of the project would be incorporated into project planning, DOE committed in the *TWRS EIS* ROD to perform future analyses at three specific points in the program. Below is a description of the review commitments and how they have been fulfilled.

The first review was to occur "before proceeding into Privatization Phase I Part B (scheduled for May 1998)" (62 FR 8693). Phase I Part B consisted of detailed design, construction, and hot (radioactive) commissioning of the WTP demonstration facility. Completion of this review consisted of three parts.

- The first part was a detailed review of the Privatization Authorization to Proceed process, including a comprehensive assessment of the following:
  - The proposals submitted by the privatization contractors for Phase I Part B, including the technical and financial aspects of each proposal, and the options for proceeding with the next phase of the project
  - The Formal Readiness to Proceed reviews conducted by DOE, the management and operations contractor, and the privatization contractors to ensure that all policies, plans, procedures, equipment, facilities, and personnel are in place and each organization is ready to meet its responsibilities for Phase I Part B
- The second part was a programmatic review, including an assessment of the environmental reports submitted by the privatization contractors to address *TWRS EIS* and ROD commitments. This assessment included a review of the reports to verify the accuracy of the information submitted and preparation of an environmental critique (procurement-sensitive) and a publicly available synopsis (non-procurement-sensitive) of the potential impacts of the proposals, consistent with DOE NEPA regulations (10 CFR 1021.216).
- The third and last part included conducting a second SA (DOE 1998) to evaluate new data related to a re-evaluation of the tank waste inventory; emerging information on the level of contamination in the vadose zone; revised assessments of the potential for and consequences of

accidents associated with management of tank waste; and ongoing technology development activities.

The second review was to occur "prior to the start of hot operations of Privatization Phase I Part B (scheduled for December 2002/December 2003)"; the third review was to occur "before deciding to proceed with Privatization Phase II (scheduled for December 2005)" (62 FR 8693). As a result of the decision to terminate the privatization contract and rebid the WTP contract, as well as associated program delays and the decision to focus waste treatment on specific waste streams (identified as supplemental treatment), the second and third review commitments became part of the scope of this *TC & WM EIS*.

In 1996, DOE requested and received comments on the *Draft TWRS EIS* from the National Research Council in a report entitled *The Hanford Tanks: Environmental Impacts and Policy Choices* (National Research Council 1996). These comments were received after the *Final TWRS EIS* had been issued and were considered in preparing the *TWRS EIS* ROD. The National Research Council's principal findings were: (1) significant uncertainties exist concerning waste removal and treatment technologies, costs, environmental policy and regulatory requirements, sitewide integration and future land use, and long-term risks that limit DOE's ability to select a final disposal alternative for all tank waste; and (2) DOE needs to consider remediation alternatives that involve both ex situ (removal and treatment of waste) and in situ (in-place treatment and/or isolation) disposal to provide flexibility in the event that specific technologies do not perform as anticipated or new technologies emerge. The National Research Council recommended that DOE consider a phased decision strategy that incorporates multiple alternatives to allow the program to move forward.

Following issuance of the *TWRS EIS* ROD, DOE has made progress in a number of areas identified as issues/concerns in the National Research Council's report. For example, past leaks and spills are being characterized and contaminant fate and transport uncertainties are being addressed through RCRA facility investigations, and new data have been incorporated into the conceptual models used to evaluate environmental impacts in this *TC & WM EIS*. Additionally, significant advances have been made in the design, testing, construction, and estimates of costs associated with vitrification of tank waste in the WTP. Supplemental treatment technologies are also being considered in this EIS.

1.2.5 Fast Flux Test Facility Deactivation Decision and Record of Decision/Environmental Impact Statement for Deactivation Decision

FFTF is a DOE-owned, formerly operating 400-megawatt (thermal) liquid-metal (sodium)-cooled research and test reactor in the 400 Area of Hanford. Construction of FFTF was completed in 1978 and initial operation began in 1980. From April 1982 to April 1992, FFTF operated successfully as a national research facility to test advanced nuclear fuels, materials, and components; nuclear power plant operations and maintenance protocols; and reactor safety designs. During this time, FFTF also produced a wide variety of medical and industrial isotopes, made hydrogen-3 (tritium) for the U.S. fusion research program, and conducted cooperative international research work.

In December 1993, DOE ordered FFTF to be shut down due to a lack of economically viable missions at that time. An environmental assessment (EA) was prepared to evaluate the impacts of deactivating FFTF, which resulted in a Finding of No Significant Impact (FONSI) (DOE 1995a).

In 1994, Ecology, EPA, and the DOE Richland Office negotiated, under TPA authority, a set of transition phase milestones and targets for deactivating and shutting down FFTF as a first step toward decommissioning the facility (Ecology, EPA, and DOE 1995). From 1994 through 1997, fuel was removed from the reactor vessel for storage in aboveground dry storage casks, and some nonessential FFTF operating systems were deactivated.

In January 1997, the Secretary of Energy ordered FFTF to be maintained in a standby condition while its potential future role in DOE's tritium production strategy was evaluated. Consequently, FFTF transition work was limited to activities that would not inhibit a reactor restart. Additionally, the TPA agencies negotiated to revise (and potentially delete) the work schedules under the TPA M-81-00 series milestones, which cover the deactivation of FFTF. The proposed modifications and the agencies' "Tentative Agreement" were issued for public comment. As a result of the public comments received, the agencies agreed that, rather than delete the TPA M-81-00 series milestones and target dates, they would be held in abeyance (temporary suspension) until the Secretary of Energy issued a final decision regarding the potential restart of FFTF (Ecology, EPA, and DOE 1999). In December 1998, the Secretary of Energy announced that FFTF would not play a role in tritium production and that a decision on any other future FFTF missions would be made by spring 1999.

In May 1999, DOE initiated a two-phase process for finalizing a path forward for FFTF that included development and review of a program scoping plan. By August 1999, DOE initiated preparation of the *Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility (Nuclear Infrastructure PEIS [NI PEIS])* (DOE 2000a). The *NI PEIS* evaluated the potential environmental impacts resulting from DOE expanding domestic civilian nuclear energy research and development and isotope production using existing and new resources. In the *NI PEIS*, FFTF was evaluated as an alternative irradiation services facility to accomplish these missions. In the *NI PEIS* ROD, published in January 2001, DOE ruled out the use of FFTF for isotope production and research missions and reaffirmed its decision to permanently deactivate the facility (66 FR 7877).

From April 2001 to December 2001, DOE suspended its decision to resume permanent deactivation of FFTF to conduct additional reviews of the decision made in the *NI PEIS* ROD. Following these reviews, DOE decided in December 2001 that restarting FFTF was impractical and deactivation would proceed. Major deactivation activities consist of, but are not limited to, dry cask storage of irradiated fuel, dry storage of nonirradiated and sodium-bonded fuel, sodium draining and storage, and deactivation of the auxiliary plant systems.

In 2002, the TPA milestones were re-established and the M-81-00 series milestones were revised to reflect the new due dates for FFTF deactivation activities (Ecology, EPA, and DOE 2002). In late 2002, FFTF deactivation activities were temporarily suspended because of legal challenges by Benton County, which alleged it was not acceptable to address only deactivation of FFTF in the 1995 EA. The county asserted that a full NEPA EIS on the complete decommissioning process should have been done before any deactivation activities were performed. On February 28, 2003, the U.S. District Court of Eastern Washington ruled in favor of DOE's decision to address only deactivation of FFTF in the 1995 EA. Benton County subsequently appealed the U.S. District Court's ruling in favor of DOE to the U.S. Ninth Circuit Court of Appeals. On May 6, 2003, the county filed a motion with the Ninth Circuit Court dismissing its appeal.

In previous NEPA reviews and appropriate RODs, DOE evaluated transportation and storage of FFTF fuel at either Hanford or Idaho National Laboratory (INL) (formerly Idaho National Engineering and Environmental Laboratory [INEEL]) (DOE 1995a, 1995b, 1997d); transportation and treatment of FFTF sodium-bonded fuel at INL's Materials and Fuels Complex (MFC) (formerly Argonne National Laboratory-West [ANL-W]) (DOE 1995a, 2000b); storage and possible disposal or commercial use of surplus plutonium (including a small quantity of nonirradiated FFTF fuel) (DOE 1999a); and transportation and disposal of SNF and HLW at a geologic repository (DOE 2002a). Ongoing activities associated with management of the FFTF fuel are not evaluated in this EIS.

Numerous NEPA reviews were conducted that directly support ongoing FFTF deactivation activities. Additionally, numerous NEPA reviews that are either completed or under way support the FFTF

decommissioning activities addressed in this *TC & WM EIS*. These related NEPA reviews are enumerated and briefly described in Section 1.7 of this EIS.

1.2.6 *Hanford Solid Waste Environmental Impact Statement* and Record of Decision

In March 2003, prior to issuance of the *Final HSW EIS* and ROD, Ecology initiated litigation on issues related to importation, treatment, and disposal of radioactive and hazardous wastes generated off site as a result of nuclear defense and research activities. In response, the court enjoined shipment of offsite TRU waste to Hanford for processing and storage pending shipment to WIPP.

In January 2004, DOE issued the *Final HSW EIS*, which addressed ongoing solid waste management operations. In June 2004, DOE issued a ROD (69 FR 39449) that announced DOE's decision to dispose of Hanford LLW and MLLW and a limited volume of offsite LLW and MLLW in a new IDF in the 200-East Area (IDF-East) of Hanford. Two cells of IDF-East were constructed in April 2006. DOE also decided to continue sending Hanford's MLLW off site for treatment and to modify Hanford's T Plant for processing remote-handled TRU waste and MLLW.

1.2.7 Developments Since Issuing the *Hanford Solid Waste Environmental Impact Statement* Record of Decision

Ecology amended its March 2003 complaint in 2004, challenging the adequacy of the *HSW EIS* analysis of offsite waste importation. In May 2005, the court granted a limited discovery period and continued the injunction against shipping offsite waste to Hanford, including LLW and MLLW (*State of Washington v. Bodman* [Civil No. 2:03-cv-05018-AAM]). In July 2005, while preparing responses to discovery requests from Ecology, Battelle Memorial Institute, DOE's contractor who assisted in preparing the *HSW EIS*, advised DOE of several differences in groundwater analyses between the *HSW EIS* and its underlying data.

DOE promptly notified the court and the State of Washington and, in September 2005, convened a team of DOE experts in quality assurance, groundwater analysis, transportation, and human health and safety impacts analysis to conduct a quality assurance review of the *HSW EIS*. The team completed its *Report of the Review of the "Hanford Solid Waste Environmental Impact Statement (EIS)" Data Quality, Control and Management Issues (Quality Review)* in January 2006 (DOE 2006a). DOE, Ecology, and the Washington State Attorney General's Office signed a Settlement Agreement ending the NEPA litigation on January 6, 2006, which is intended to resolve Ecology's concerns about the *HSW EIS* groundwater analyses and to address other concerns about the *HSW EIS* that were identified in the *Quality Review*.

The agreement called for expanding the "Tank Closure EIS" to provide a single, integrated set of analyses that includes all waste types analyzed in the *HSW EIS* (LLW, MLLW, and TRU waste), which is now this *Draft TC & WM EIS*. Under the agreement, pending finalization of the *TC & WM EIS*, the *HSW EIS* remains in effect to support ongoing waste management activities at Hanford (including transportation of TRU waste to WIPP) in accordance with applicable regulatory requirements. The agreement also stipulates that, when the *TC & WM EIS* has been completed, it will supersede the *HSW EIS*. Until that time, DOE will not rely on *HSW EIS* groundwater analyses for decisionmaking and will not import offsite waste to Hanford, apart from certain limited exemptions specified in the agreement.

The agencies subsequently revised the original Memorandum of Understanding for the "Tank Closure EIS," effective March 25, 2003 (DOE and Ecology 2003) which identified Ecology as a cooperating agency in the preparation of this *TC & WM EIS*. The Memorandum of Understanding revision, signed January 6, 2006 (DOE and Ecology 2006), is consistent with the Settlement Agreement and provides for Ecology's continuing participation as a cooperating agency in preparing this *TC & WM EIS* to assist both agencies in meeting their respective responsibilities under NEPA and Washington's SEPA.

For example, concerning closure of the SSTs, Ecology regulates Hanford's tank systems under the provisions of WAC 173-303-640; specifically, that regulation requires DOE to close the tank system per WAC 173-303-640(8)(a). If DOE cannot clean-close the tanks per this regulation, then DOE must perform postclosure care to meet the WAC 173-303-665(6) requirements for closure and postclosure that apply to landfills. Ecology and DOE agreed that this *TC & WM EIS* would include alternatives for clean closure and landfill closure that would address the environmental impacts of either choice. If Ecology finds that the *Final TC & WM EIS* meets the criteria in the WAC 197-11 SEPA regulations, then Ecology may adopt the document in whole or in part. Ecology may then use this *TC & WM EIS* to satisfy its need to review any Hanford tank systems permit applications or modifications, including closure and postclosure plans, for their significant environmental impacts.

1.3 PURPOSE AND NEED FOR AGENCY ACTION

DOE needs to take action to accomplish the following objectives:

- Safely retrieve and treat radioactive, hazardous, and mixed tank waste; close the SST system; and store and/or dispose of the waste generated from these activities at Hanford. Further, DOE needs to treat the waste and close the SST system in a manner that complies with Federal and applicable Washington State laws and DOE directives to protect human health and the environment. Long-term actions are required to permanently reduce the risk to human health and the environment posed by waste in the 149 SSTs and 28 DSTs.

An environmental impact statement does not constitute a decision; rather, it is one of several sources of information that decisionmakers consider in making a decision on a proposed action. The final step in the National Environmental Policy Act process is issuing a Record of Decision (ROD), or possibly a series of RODs, to record a Federal agency's decision concerning a proposed action for which the agency has prepared an environmental impact statement. Decisions stated in a ROD sometimes may be broad in nature. Such decisions enable subsequent, more-detailed activities to move forward through implementing documents. Examples of implementing documents at Hanford include the Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement) milestones, closure plans, permit applications, contracts, and funding requests.

- Decommission FFTF and its support facilities at Hanford, manage waste associated with decommissioning the facilities, and manage disposition of the radioactively contaminated bulk sodium inventory at Hanford. These actions are necessary to facilitate cleanup at Hanford consistent with decisions reached by DOE as a result of previous NEPA reviews (DOE 1995a, 2000a; 66 FR 7877) and to comply with Federal, state, and local laws and regulations.

- Expand or upgrade existing waste treatment, storage, and disposal capacity at Hanford to support ongoing and planned waste management activities for on- and offsite waste. Some tank waste, LLW, and MLLW at Hanford, including waste resulting from FFTF decommissioning and waste from other DOE sites that do not have appropriate facilities, must be disposed of to facilitate cleanup of Hanford and other DOE sites.

1.4 DECISIONS AND REGULATORY FRAMEWORK

In support of the proposed actions to retrieve, treat, and dispose of tank waste; decommission FFTF; and expand waste disposal capacity at Hanford to provide disposal of on- and offsite waste, this EIS will support several decisions that DOE has to make related to the ORP mission. These potential decisions are outlined below.

1.4.1 Decisions to Be Made

- Storage of Tank Waste. Tank farm waste storage would be required under each of the Tank Closure alternatives evaluated in this *TC & WM EIS*. However, different lengths of time are considered, depending on the alternative. This EIS evaluates the construction and operation of waste transfer infrastructures, including waste receiver facilities (WRFs), which are below-grade storage and minimal waste treatment facilities; waste transfer line upgrades; and additional or replacement DSTs. This EIS also evaluates various waste storage facilities to manage the treated tank waste and the waste associated with closure activities. This includes construction and operation of additional immobilized high-level radioactive waste (IHLW) storage vaults, melter pads, TRU waste storage facilities, and ILAW storage facilities. This EIS also provides environmental impact information to assist in making informed decisions regarding continued storage of tank waste and storage to support treatment and disposal activities.

- Retrieval of Tank Waste. This *TC & WM EIS* evaluates various retrieval technologies and benchmarks. The four waste retrieval benchmarks considered are 0 percent, 90 percent, 99 percent, and 99.9 percent. These retrieval percentages address various aspects related to retrieval levels or activities. The 0 percent retrieval benchmark represents the No Action Alternative, which is required to be evaluated as part of the NEPA process; 90 percent retrieval represents a programmatic risk analysis for the tank farms as defined by Appendix H of the TPA, "Single Shell Tank Waste Retrieval Criteria Procedure"; 99 percent retrieval is the goal established by the TPA (Milestone M-45-00); and 99.9 percent retrieval reflects multiple uses of retrieval technologies to support clean closure requirements.

- Treatment of Tank Waste. Additional waste treatment capability can be achieved by building new treatment facilities that are either part of or separate from the WTP. DOE could also complete treatment sometime after 2028 by extending the current WTP operating period until all the waste is treated without supplemental treatment. The two primary choices that would comply with DOE's commitments are to treat all the waste in an expanded WTP or to provide supplemental treatment in conjunction with, but separate from, the WTP. DOE has conducted preliminary tests on three supplemental treatment technologies to determine whether one or more could be used to provide the additional capability needed to complete waste treatment. The decision of whether to treat all the waste in the WTP (as is or expanded) or to supplement its capacity by adding new treatment capability depends on the demonstration of supplemental treatment technology feasibility. (See Appendix E for more information on supplemental treatment.)

- Disposal of Treated Tank Waste. This *TC & WM EIS* addresses on- and offsite disposal, depending on the waste type. Onsite disposal includes disposal of treated tank waste and waste generated from closure activities that meet onsite disposal criteria. The decision to be made involves the onsite location of disposal facilities, specifically, one or two IDFs, which would manage treated tank waste, and the River Protection Project Disposal Facility (RPPDF), which would manage closure activity waste. This EIS will provide the environmental impact information needed to make informed decisions on tank waste that could be classified as TRU waste for disposal. Offsite disposal of tank waste determined to be TRU waste would occur at WIPP.

- Closure of the SST System. This *TC & WM EIS* addresses closure of the SST system under all Tank Closure alternatives except Tank Closure Alternatives 1 and 2A. Although DOE is committed to retrieving at least 99 percent of the waste, consistent with the TPA, the range of potential impacts in the cases considered includes the potential impacts of residual waste left in the tanks at different retrieval benchmarks (0, 90, 99, and 99.9 percent). Several types of closure

scenarios are also evaluated: clean closure, selective clean closure/landfill closure, and landfill closure with or without contaminated soil removal. In addition, two structurally different landfill barriers—an engineered modified RCRA Subtitle C barrier and a Hanford barrier—are considered to determine the effectiveness of the natural and engineered defense-in-depth barriers in minimizing any transport of waste over the long timeframes of interest. (See Appendix E for information on these two barriers.)

- Disposal of Hanford Waste and Offsite DOE LLW and MLLW. The decision to be made concerns the onsite location of disposal facilities for Hanford's waste and other DOE sites' LLW and MLLW. DOE committed in the *HSW EIS* ROD to disposing of LLW in lined trenches. Thus, the decision is whether to dispose of waste at IDF-East or at a new IDF located in the 200-West Area (IDF-West).

- Final Decommissioning of FFTF. This decision would determine the end state for FFTF's aboveground, belowground, and ancillary support structures.

This EIS is the next step in the process to close the tank farm waste management system, decommission FFTF, and expand waste management and disposal capacity at Hanford. The information provided in this EIS will be used both to identify a preferred alternative and to support (along with other data sources) future decisions regarding waste treatment and tank closure, FFTF decommissioning, and waste management and disposal capacity expansion. Public participation will continue throughout this process. Decisions based on the data presented in this EIS will be documented in a ROD or a series of RODs no sooner than 30 days after EPA's notice of the availability of the *Final TC & WM EIS* is published in the *Federal Register*. All project work resulting from the ROD that pertains to waste storage, treatment, or disposal facilities must undergo a permitting process with Ecology. Permit conditions will specify the safe handling and storage of the waste forms and will ensure any process air or liquid discharges are within regulatory limits. This permitting process offers additional opportunity for public input.

1.4.2 Decisions Not to Be Made

DOE will not make decisions on the following as part of this NEPA process:

- DST Closure. A closure configuration for the original 28 DSTs was evaluated in this EIS for engineering reasons related to the closure barrier placement. However, a decision on closure of DSTs is not part of the proposed actions because the DSTs are active components needed to complete waste treatment. Closure of the DSTs would need to be addressed at a later date subject to appropriate NEPA review.

- WTP Closure. The WTP is currently under construction in the 200-East Area of Hanford. As such, construction (and subsequent operations and deactivation) of the WTP from 2006 onward was analyzed under each Tank Closure alternative to establish a common reference point for use in comparing alternatives. However, closure of the WTP is not part of the proposed actions because it is a facility needed to complete waste treatment. Closure of the WTP would need to be addressed at a later date subject to appropriate NEPA review.

- Groundwater Remediation. Remediation of contaminated groundwater operable units is not part of the proposed actions for this EIS. Groundwater contamination in the non-tank-farm 200 Areas is being addressed under CERCLA, which will also satisfy substantive RCRA and Hazardous Waste Management Act corrective action requirements. NEPA values are integrated into the CERCLA analyses. However, contamination in the vadose zone resulting from tank farm past leaks is currently being evaluated under the RCRA facility investigation and corrective measures study process. Therefore, the vadose zone in the tank farms is part of an RCRA unit and is not

included in the CERCLA groundwater operable unit. As a result, the vadose zone as impacted by the tank farms is part of this *TC & WM EIS* scope.

- CERCLA Past-Practice Units. There are six sets of cribs and trenches (ditches) that are contiguous to the SSTs and would fall under the barriers placed over the SSTs during closure. They are evaluated in this EIS as part of a connected action because they would be influenced by barrier placement. However, closure of these CERCLA past-practice units is not part of the proposed actions for this EIS. Closure of these units would be addressed at a later date subject to appropriate NEPA review.

- Deactivation of FFTF. DOE does not intend to make any further decisions regarding deactivation of FFTF as a result of this EIS. Based on previous NEPA reviews (DOE 1995a, 2000a, 2006b), DOE decided to shut down and deactivate FFTF. Deactivation of FFTF as evaluated in those reviews consists of the following:

  - Removing fuel from the facilities
  - Storing fuel in either the 400 Area or the 200 Areas
  - Draining metallic sodium from the reactor cooling systems and support facilities
  - Storing metallic sodium from FFTF in the 400 Area
  - Removing and disposing of some radioactive and chemically hazardous materials
  - Deactivating plant systems as they are no longer required for safe operation
  - Placing the remaining plant systems in a radiologically and industrially safe condition for long-term surveillance and maintenance
  - Removal and packaging of the four RH-SCs for storage in the 400 Area

- Disposition of the Cesium and Strontium Capsules. Treatment of the cesium and strontium capsules, which are currently stored at the Waste Encapsulation and Storage Facility (WESF), is evaluated in this EIS based on the existing TPA milestone; however, the decision on final disposition of the cesium and strontium capsules will be determined at a later date subject to appropriate NEPA review.

- HLW Transportation and Disposition. The scope of this *TC & WM EIS* does not include making a decision on the ultimate disposition of HLW and transportation related to such disposition. The *TWRS EIS* ROD to treat the Hanford tank waste has not changed. Funding for the Yucca Mountain facility has been eliminated in the Administration's fiscal year 2010 budget request. Notwithstanding the decision to terminate the Yucca Mountain program, which was the development of a geologic repository for the disposal of HLW and SNF, DOE remains committed to meeting its obligations to manage and ultimately dispose of HLW and SNF. The Administration intends to convene a blue ribbon panel of experts to evaluate alternative approaches for meeting these obligations. Decisions reached through this process will need to be addressed at a later date subject to appropriate NEPA review.

1.5 SCOPING PROCESS AND DEVELOPMENT OF THE *DRAFT TC & WM EIS* ALTERNATIVES

Scoping is a process in which the public, regulators, and other interested parties provide comments directly to a Federal agency on the scope of an EIS. This process is initiated by publication of the NOI in the *Federal Register*. The NOI for this *TC & WM EIS* (71 FR 5655) was published on February 2, 2006. The NOI, as published, is provided in Appendix A of this document.

The NOI identified a set of preliminary alternatives that were presented to the public, regulators, and other interested parties for comment. The set included a No Action Alternative and a representative number of other alternatives to ensure analysis of the range of reasonable alternatives for waste treatment and tank closure, FFTF decommissioning, and waste management to assist in the decisionmaking process. Information collected from the NEPA scoping process was used to modify the scope of this *Draft TC & WM EIS*, as appropriate.

Ongoing dialogue with the public will continue as the *Draft TC & WM EIS* undergoes public review and comment (see Figure 1–1). A 140-day comment period will begin when EPA publishes a Notice of Availability in the *Federal Register*. Public hearings will be held during the comment period.

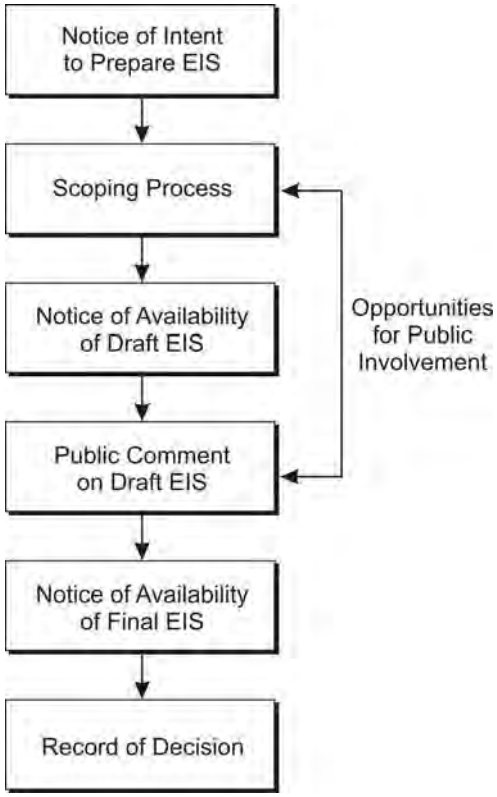


Figure 1–1. National Environmental Policy Act Process

1.6 PUBLIC COMMENTS ON THE PROPOSED *TC & WM EIS* SCOPE

The NOI to prepare this *TC & WM EIS* (71 FR 5655) initiated a 30-day scoping period that ended March 6, 2006. A later notice (71 FR 8569) extended the scoping period to April 10, 2006. In the NOI, DOE requested public comment on the proposed scope for the new *TC & WM EIS*. A number of ways to submit public comments were provided, including standard mail, electronic mail, fax, voicemail, and oral or written comments presented at formal public meetings. As stated in the NOI for this *TC & WM EIS*, DOE considered the comments previously submitted in response to the 2003 NOI for the "Tank Closure EIS" (68 FR 1052) and the 2004 NOI for the "Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, Washington" ("FFTF Decommissioning EIS") (69 FR 50176). Section 1.6.1 discusses the *TC & WM EIS* scoping process and the comments received. Sections 1.6.2 and 1.6.3 similarly discuss the "Tank Closure EIS" and "FFTF Decommissioning EIS" scoping processes and comments, respectively.

1.6.1 Public Meetings and Issues Identified During the *TC & WM EIS* Scoping Process

1.6.1.1 Public Meetings

DOE and Ecology, a cooperating agency, conducted four public meetings on the proposed scope of this *TC & WM EIS* at the following locations:

Seattle, Washington	March 21, 2006
Portland, Oregon	March 22, 2006
Hood River, Oregon	March 23, 2006
Tri-Cities, Washington	March 28, 2006

1.6.1.2 Issues Identified During the *TC & WM EIS* Scoping Process

As a result of the public scoping meeting and comment process, DOE considered each of the comments received and made corresponding changes to the alternatives as appropriate. DOE received comments from approximately 150 commentors during the *TC & WM EIS* scoping period. The issues presented below reflect the key concerns expressed by these commentors:

Issue: *DOE must do everything possible to avoid and/or mitigate contamination of the Columbia River and regional groundwater supplies due to the proposed actions.*

Response: This *TC & WM EIS* incorporates several mitigation measures into the proposed alternatives, including engineered barriers, contaminated soil removal, and waste treatment. This *TC & WM EIS* also explores other potential mitigation measures that could be pursued based on specific concerns.

Issue: *Complete Hanford waste cleanup activities as soon as possible, including removing both the waste and the tanks, as well as the waste currently buried in existing disposal facilities.*

Response: Retrieval of waste from the SSTs has been completed for seven tanks to date and is ongoing. The WTP is currently under construction to treat the tank waste. Removal of waste buried in existing disposal facilities is considered either as part of the alternatives or in the cumulative impacts section analyzed in this *TC & WM EIS*, depending on the waste stream.

Issue: *DOE should not consider an alternative for retrieving less than 99 percent of the tank waste, consistent with the TPA.*

Response: One *TC & WM EIS* alternative addresses a retrieval goal of 90 percent, less than the TPA Milestone M-45-00 minimum goal of 99 percent. Retrieval to 90 percent represents a range depicting the potential programmatic risk analysis process for the tank farms as defined by Appendix H of the TPA, "Single Shell Tank Waste Retrieval Criteria Procedure." This alternative evaluates the potential impacts that could occur from implementing that process. To date, Ecology and DOE have initiated the Appendix H process for one tank, 241-C-106.

Issue: *DOE needs more extensive, detailed data to complete this EIS; characterization data for all waste types is particularly lacking.*

Response: Both DOE and Ecology believe there is sufficient characterization information to support this *TC & WM EIS*. The goal of NEPA is to complete an impact analysis to support decisions that an agency needs to make related to a proposed Federal or state (in the case of Washington's SEPA) action early enough in the process to be useful. Additional

information may be necessary before a final permit decision can be issued. This *TC & WM EIS* describes uncertainties in the analysis of potential impacts.

Issue: *Preserve FFTF for potential future uses such as medical isotope production.*

Response: FFTF is not being considered for medical isotope production at this time. DOE has previously weighed FFTF's potential use in other applications (DOE 2000a; 72 FR 331). There is currently no proposed use. Irrespective of any proposed use, DOE needs to determine an appropriate end state for FFTF.

Issue: *Don't import waste from elsewhere to Hanford.*

Response: DOE is currently evaluating the potential for disposal of 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW at Hanford. This is the amount identified in the Settlement Agreement for disposal at Hanford.

Issue: *DOE should ensure that independent experts provide objective oversight, analysis, and review throughout the EIS preparation process.*

Response: Throughout the EIS preparation process, DOE has coordinated and consulted, as appropriate, with the U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, U.S. Advisory Council on Historic Preservation, American Indian tribes, and local agencies on matters within their technical expertise. In addition, a technical review group was formed to evaluate the conversion of the groundwater model from the previous models used on site to MODFLOW [modular three-dimensional finite-difference groundwater flow model]. This review group process is identified in Appendix L of this *TC & WM EIS*.

Issue: *DOE should address health risks to Hanford workers and the public from the proposed actions.*

Response: This *TC & WM EIS* addresses human health risks to workers and the public from actions proposed under the alternatives.

1.6.2 Public Meetings and Issues Identified During the "Tank Closure EIS" Scoping Process

The NOI to prepare the "Tank Closure EIS" (68 FR 1052) initiated a 60-day scoping period that ended March 10, 2003. In the NOI, DOE requested public comment and input on the proposed scope and the alternatives. A number of opportunities to submit public comments were provided, including standard mail, electronic mail, fax, voicemail, and oral or written comments presented at formal public meetings.

1.6.2.1 Public Meetings

DOE conducted four public meetings on the proposed "Tank Closure EIS" scope. Meetings were held at the following locations:

Richland, Washington	February 5, 2003
Hood River, Oregon	February 18, 2003
Portland, Oregon	February 19, 2003
Seattle, Washington	February 20, 2003

The public meetings were facilitated; DOE introduced the proposed activities, and Ecology and EPA were invited to make opening statements, as were a number of public interest groups. A court reporter and tape recorder captured the oral comments. In addition, DOE collected written comments.

1.6.2.2 Issues Identified During the "Tank Closure EIS" Scoping Process

DOE considered all comments received during the "Tank Closure EIS" public scoping period and made changes to the alternatives. The comments summarized below represent those that impacted a major component of the scope of an alternative.

Issue: *The alternatives are too complicated to understand and the titles need clarification.*

Response: Alternative titles and descriptions were clarified and, where possible, alternative descriptions were simplified. However, the multitude and combinations of retrieval/treatment/disposal/closure options make this an inherently complex assessment. For this reason, DOE prepared a Reader's Guide to help readers navigate the document.

Issue*:* *The proposed "No Action" alternative is not an accurate portrayal of what is typically considered as a "no action."*

Response: In CEQ's "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations" (46 FR 18026), two types of No Action Alternative are allowed. In one case, work is stopped and impacts are evaluated. In the second case, ongoing activities are evaluated as a "no change" and continuation of the present course of action.

In this EIS, DOE has chosen to show both types of no action. Under Tank Closure Alternative 1, the work would be stopped and impacts would be evaluated. Under Tank Closure Alternative 2A, DOE would evaluate retrieval from the tanks and treatment through the WTP, in accordance with the *TWRS EIS* ROD with modifications.

Issue: *No alternative is provided to address tank closure with the current all-vitrification waste treatment plans.*

Response: Tank Closure Alternative 2A retained implementation of the 1997 *TWRS EIS* ROD to address the current vitrification capacity of the existing WTP, which is currently under construction (i.e., Existing WTP Vitrification; No Closure).

Tank Closure Alternative 2B was developed to address an expanded LAW vitrification capacity for the existing WTP, which would provide vitrification of all tank waste, and to add a landfill closure of the SST system (i.e., Implement the *Tank Waste Remediation System EIS* Record of Decision with Modifications – Expanded WTP Vitrification; Landfill Closure).

Issue: *DOE is proposing to minimize the use of the WTP for tank waste treatment.*

Response: DOE is committed to completing construction of the WTP and operating the facility to vitrify all of the tank HLW and a portion of the LAW. Supplemental treatment technologies for LAW are part of the scope of this *TC & WM EIS*.

Issue: *DOE should stay the course on vitrifying all tank waste.*

Response: See previous response. With respect to the portion of the LAW that may not be treated in the WTP, DOE is evaluating supplemental treatment (supplemental to the WTP) for that

waste. This *TC & WM EIS* evaluates whether completing treatment of this waste with supplemental technologies faster could result in decreased impacts on the public and environment.

Issue: *None of the action alternatives address the possibility that separation of waste into HLW and LAW constituents may not be allowed under DOE directives.*

Response: Tank Closure Alternative 6A was created to address a scenario where separation of the tank waste into HLW and LAW components is not performed. Alternatives 6B and 6C were created to implement the current vitrification facility, supplemented with additional vitrification capacity. Under all three subalternatives, treated waste would be managed as HLW.

Issue: *Technetium-99, with its very long half-life, would impact the groundwater and Columbia River if allowed to remain in the ILAW disposed of at Hanford.*

Response: This *TC & WM EIS* evaluates the impacts on the groundwater and Columbia River resources of various waste treatment and disposal scenarios related to technetium-99. Projected impacts will be considered in making the decisions discussed in Section 1.4 of this document.

Issue: *Nuclear waste residuals would be abandoned inside the tanks and would impact the environment in the future.*

Response: NEPA requires consideration of all reasonable alternatives in EISs, as well as "no action," which serves as a baseline for comparison among alternatives. The No Action Alternative may not always be a reasonable alternative. To satisfy this requirement, DOE is evaluating the impacts of a range of waste retrieval benchmarks. The benchmarks considered are 0 percent of the tank volume (No Action Alternative), 90 percent, 99 percent, and 99.9 percent.

Issue: *Not enough information is available on supplemental treatment technology performance to make any decisions.*

Response: DOE is in the process of collecting available information on supplemental treatment technologies and is also funding additional studies where information gaps exist. Consistent with CEQ regulations, early evaluation is encouraged in an agency's planning process, when all information may not be available.

Issue: *Grout, or any similar waste form, does not have acceptable long-term performance.*

Response: DOE chose cast stone as a candidate nonthermal treatment technology to represent a lower-performing waste form for this assessment. WTP vitrification, bulk vitrification, and steam reforming were selected to represent a range of thermal waste form performance. The impacts of this treatment technology performance range will be considered in the decisions discussed in Section 1.4.

Issue: *Tank Closure alternatives are either landfill for all or total removal of all—no graded approach is considered.*

Response: Tank Closure Alternative 4 was revised to include selective clean closure of the BX tank farm (200-East Area) and SX tank farm (200-West Area) as representative tank farms and

landfill closure of the remaining tank farms. The range of closure alternatives represents landfill closure, selective clean closure, and clean closure.

Issue: *This process is being rushed. There is no driver for addressing closure at this time.*

Response: DOE needs to begin specific planning actions to treat the tank waste and to close the SST system. These actions are necessary to protect human health and the environment and to comply with several enforceable milestones in the TPA, specifically Milestone M-45-00, which requires complete closure of the SST system by September 30, 2024, and Milestone M-62-00, which requires completion of vitrification treatment of tank HLW and LAW by December 1, 2028.

1.6.3 Public Meetings and Issues Identified During the "FFTF Decommissioning EIS" Scoping Process

The NOI to prepare the "FFTF Decommissioning EIS" (69 FR 50176) initiated a 56-day scoping period that ended October 8, 2004. In the NOI, DOE requested public comment and input on the proposed scope and the alternatives. A number of opportunities to submit public comments were provided, including standard mail, electronic mail, fax, voicemail, and oral or written comments presented at formal public meetings.

1.6.3.1 Public Meetings

The NOI announced the schedule for the public scoping process and summarized the alternatives to be considered in the "FFTF Decommissioning EIS." Two scoping meetings were held at the following locations and dates:

Richland, Washington	September 22, 2004
Idaho Falls, Idaho	September 30, 2004

Opportunities were provided at each meeting for informal discussion, as well as formal comments, regarding DOE's proposed actions and the scope and content of the "FFTF Decommissioning EIS." Both oral and written comments were received at the public scoping meetings. Written comments were also accepted by conventional and electronic mail. All written and oral comments were considered in preparing this *TC & WM EIS*. Commentors provided comments on several topics, including additional alternatives and activities, waste management issues, transportation, and environmental consequences.

1.6.3.2 Issues Identified During the "FFTF Decommissioning EIS" Scoping Process

The following is a brief summary of the oral and written comments received by DOE during the "FFTF Decommissioning EIS" scoping period. DOE considered all comments received and made changes to the alternatives as appropriate.

Issue: *The EIS should evaluate each of the proposed alternatives, including suboptions, in a way that is complete and detailed. In particular, the alternative discussion should include a full evaluation of how each alternative would be implemented from beginning to end. The evaluation should include a full analysis of all impacts, including all impacts associated with transportation, handling, storage, and treatment of radioactive and hazardous materials; a detailed explanation of the workforce requirements; and a complete description of the ultimate disposal for all waste, including residuals. The information should be presented in a comparative format that will allow stakeholders to evaluate each alternative relative to the others.*

Response: This *Draft TC & WM EIS* provides a full evaluation of each alternative. It includes impacts associated with transportation, handling, storage, and treatment of radioactive and hazardous materials; details on the workforce requirements; and a complete description of the ultimate disposition of waste, including residuals. These impacts are discussed in Chapters 4 and 5 of this draft EIS. A comparison of the alternatives is provided in Chapter 4, Section 4.4, of this draft EIS for short-term impacts and in Chapter 5, Section 5.4, for long-term impacts. In addition, Chapter 2, Section 2.8, summarizes the short-term environmental impacts, and Section 2.9 summarizes the long-term impacts.

***Issue**: DOE should evaluate the environmental impacts of building a new facility at Hanford equivalent to the existing Sodium Processing Facility (SPF) at the MFC at INL. In particular, the cost savings and reduced risks caused by eliminating the need for transportation to INL should be evaluated.*

Response: This *Draft TC & WM EIS* provides options for the processing of bulk sodium at both the MFC (the Idaho Reuse Option) and Hanford. The Hanford Reuse Option would involve construction and operation of a new facility and eliminate the need for transportation to the INL's MFC.

***Issue:** DOE should evaluate the environmental impacts of construction and operation of a new facility at Hanford equivalent to the proposed Remote Treatment Project (RTP) at the MFC.*

Response: This *Draft TC & WM EIS* provides options for treating RH-SCs at both the MFC and Hanford. The Hanford Option would involve construction and operation of a new facility and eliminate the need for transportation to INL's MFC.

***Issue:** This EIS should include a Greenfield alternative that evaluates removal of all contaminated structures and equipment from the 400 Area. Cleanup should not result in a new waste site in the Hanford 400 Area that would require maintenance and monitoring for the foreseeable future.*

Response: FFTF Decommissioning Alternative 3: Removal is an alternative that looks at the (1) removal of all contaminated equipment while leaving small amounts of radioactivity in underground structures and (2) implementation of appropriate postclosure care, which may lead to unrestricted use of the site.

***Issue**: The No Action Alternative is clearly dangerous and should not be included as a reasonable alternative.*

Response: NEPA requires consideration of all reasonable alternatives in EISs, as well as "no action," which serves as a baseline for comparison among alternatives. The No Action Alternative may not always be a reasonable alternative. To satisfy this requirement, under the No Action Alternative, DOE is evaluating the impacts of completing only those actions consistent with previous DOE NEPA decisions. Final decommissioning would not occur. The site would be maintained under administrative control for 100 years following the ROD.

***Issue**: This draft EIS should evaluate all impacts of transportation associated with the radioactive sodium (in liquid and solid form), reactor components, and sodium-bonded SNF that would be shipped to the MFC for treatment, including estimates of the volumes and characteristics of all radioactive and hazardous materials and waste that would be produced at the MFC as a result of treatment of the incoming materials and waste.*

Response: This *Draft TC & WM EIS* evaluates the transportation impacts associated with the bulk sodium and the RH-SCs being considered for shipment to the MFC for processing or treatment. The impacts associated with these actions are provided in Chapter 4 of this draft EIS. In previous NEPA reviews, DOE evaluated transportation and storage of FFTF fuel at either Hanford or INL (formerly INEEL) (DOE 1995a, 1995b, 1997d); transportation and treatment of FFTF sodium-bonded fuel at INL's MFC (formerly ANL-W) (DOE 1995a, 2000b); storage and possible disposal or commercial use of surplus plutonium (including a small quantity of nonirradiated FFTF fuel) (DOE 1999a); and transportation and disposal of SNF and HLW at a geologic repository (DOE 2002a, 2008a). Ongoing activities associated with management of the FFTF fuel are not evaluated in this *Draft TC & WM EIS*.

Issue: *This EIS should consider alternatives that are economically sound and efficient.*

Response: Chapter 2, Section 2.11, of this *Draft TC & WM EIS* summarizes and compares the relative costs of the alternatives.

Issue: *This EIS should consider the effects of decommissioning activities on adjacent Hanford facilities and their programs. The Laser Interferometer Gravitational-Wave Observatory research facility is in close proximity to FFTF and is highly sensitive to vibration.*

Response: Chapter 6 of this *Draft TC & WM EIS* provides an analysis of the impacts on other Hanford activities, including the Laser Interferometer Gravitational-Wave Observatory.

Issue: *DOE is not complying with the spirit or the letter of the NEPA regulations in preparing the "FFTF Decommissioning EIS." The distinction between deactivation and decommissioning, as well as irreversible versus reversible actions, is unclear.*

Response: Chapter 1, Section 1.2.5, of this *Draft TC & WM EIS* provides a discussion of deactivation of FFTF, including the court decision in the Benton County case against DOE. Chapter 2, Section 2.3, of this *Draft TC & WM EIS* provides a discussion on the deactivation activities addressed by the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006b) and those proposed decommissioning activities under the scope of this *Draft TC & WM EIS*.

Issue: *This EIS should demonstrate that DOE intends to comply with Federal and state regulations and international (proliferation) and tribal agreements. Transportation and training agreements are not fully addressed.*

Response: Chapter 8 of this *Draft TC & WM EIS* discusses the Federal and state regulations that may be applicable to the proposed actions and consultations with tribes.

Issue: *FFTF should be preserved for various future missions. The decision to shut down FFTF is politically driven; political pressure may yet be able to reverse the process. FFTF should not be decommissioned.*

Response: Based on previous NEPA reviews (DOE 1995a, 2000a, 2006b), DOE decided to shut down and deactivate FFTF. DOE does not intend to make any further decisions regarding deactivation of FFTF.

1.7 ALTERNATIVES EVALUATED IN THIS *DRAFT TC & WM EIS*

1.7.1 Tank Closure Alternatives

DOE's review of the public's, regulators', and other interested parties' comments generated during the scoping process determined that revision of the proposed alternatives for tank closure was needed. In response to the comments, DOE modified the proposed alternatives as presented in the sections below. More-detailed discussions of the proposed alternatives are provided in Chapter 2.

In creating and modifying the alternatives, emphasis was placed on including all reasonable waste storage, retrieval, treatment, disposal, and tank closure components that could be selected. The goal was to give the public and decisionmakers sufficient information about each candidate component and allow maximum flexibility in selecting the technologies, methods, time periods, and locations of the treatment and closure activities. Developing alternatives that could be selected in their entirety was not a primary goal. Therefore, the alternatives described in this section and evaluated in the balance of this EIS are combinations of the treatment and closure decision options under consideration.

1.7.1.1 Tank Closure Alternative 1: No Action

In CEQ's "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations" (46 FR 18026), two types of No Action Alternative are allowed. In one case, work is stopped and impacts are evaluated. In the second case, ongoing activities are evaluated as a "no change" and continuation of the present course of action.

In this EIS, DOE has chosen to show both types of no action. Under this alternative, the work would be stopped and impacts would be evaluated. Under Tank Closure Alternative 2A, DOE would evaluate retrieval from the tanks and treatment through the WTP, in accordance with the *TWRS EIS* ROD.

Storage: DOE would continue to store and monitor waste in the SSTs and DSTs for 100 years. Tanks showing signs of deterioration affecting their structural integrity would be filled with grout or gravel as a corrective action or emergency response. The cesium and strontium capsules would remain in storage in the WESF.

Retrieval: Waste from the tanks would not be retrieved.

Treatment: No vitrification or treatment capacity would be built after 2008. The existing WTP construction would be terminated, and the WTP site would be isolated pending some future use, if any. No ILAW or IHLW would be produced.

Disposal: The waste in the SST and DST systems would remain in the tank farm indefinitely.

Closure: Tank closure would not be addressed under this alternative. DOE would maintain security and management of the site for a 100-year administrative control period (ending in 2107). During this period, DOE would continue to store and conduct routine monitoring of the waste in the SSTs, DSTs, and miscellaneous underground storage tanks.

1.7.1.2 Tank Closure Alternative 2: Implement the *Tank Waste Remediation System EIS* Record of Decision with Modifications

This alternative consists of two subalternatives: (1) Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure and (2) Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure. It represents the implementation of decisions made in the *TWRS EIS* ROD and considered in three SAs completed through 2001. Under this alternative, all waste retrieved from the tanks would be vitrified, resulting in either an ILAW or IHLW glass product.

Storage Under Tank Closure Alternative 2A: DOE would continue current waste management operations using existing tank storage facilities. Because all the DSTs will exceed their 40-year design life during the approximate 80-year period of waste retrieval, they would be replaced in a phased manner through 2054.

Storage Under Tank Closure Alternative 2B: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs, which are below-grade lag storage and minimal waste treatment facilities, would be constructed.

Retrieval Under Tank Closure Alternatives 2A and 2B: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval.

Treatment Under Tank Closure Alternative 2A: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a theoretical maximum capacity (TMC) of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in 2093. All the waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur. For analysis purposes, it was assumed that the WTP would need to be replaced after 60 years. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Treatment Under Tank Closure Alternative 2B: The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented with expanded LAW vitrification capacity (an addition of four LAW melters) to provide a vitrification TMC of 6 metric tons of glass IHLW per day and 90 metric tons of glass ILAW per day. Treatment would start in 2018 and end in approximately 2040 (for HLW) and 2043 (for LAW). All the waste streams routed to the WTP would be pretreated, including technetium-99 removal from the LAW stream. No facilities would need to be replaced. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal Under Tank Closure Alternatives 2A and 2B: LAW immobilized via the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented.

Closure Under Tank Closure Alternative 2A: Tank closure would not be addressed under this alternative. For analysis purposes, administrative control of the tank farms would cease following a 100-year period ending in 2193.

Closure Under Tank Closure Alternative 2B: As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent future

tank subsidence, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) for the BX and SX tank farms and replaced with clean soil from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the RPPDF, a new facility similar to an IDF. The closed tank systems and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years.

1.7.1.3 Tank Closure Alternative 3: Existing WTP Vitrification with Supplemental Treatment Technology; Landfill Closure

This alternative consists of three subalternatives: (1) Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure, (2) Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure, and (3) Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure. These subalternatives involve use of either thermal or nonthermal treatment technology to supplement the WTP treatment. TRU tank waste would be packaged and interim-stored pending shipment to WIPP for disposal.

Storage Under Tank Closure Alternatives 3A, 3B, and 3C: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed.

Retrieval Under Tank Closure Alternatives 3A, 3B, and 3C: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval.

Treatment Under Tank Closure Alternative 3A: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2040. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. WTP capacity would be supplemented with bulk vitrification treatment capacity to immobilize a portion of the LAW. Bulk vitrification supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas. In the 200-East Area, the waste feed would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and treated and packaged for disposal at WIPP.[3] The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Treatment Under Tank Closure Alternative 3B: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2040. All waste streams routed to the WTP would be pretreated, including technetium-99 removal from the LAW stream. WTP capacity would be supplemented with cast stone treatment capacity to immobilize a portion of the LAW. Cast stone supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas. In the 200-East Area, the waste feed would be pretreated in the WTP, including technetium-99 removal. In the 200-West Area, the waste feed would be

[3] DOE believes there may be certain HLW storage tanks that it could demonstrate should be classified as TRU waste based on the origin of the waste. This *Draft TC & WM EIS* evaluates the environmental impacts of managing this waste as TRU waste because it assumes the historical processing data support this classification. For Alternatives 3 through 5, this EIS evaluates treating the waste stream associated with the TRU waste portion as both TRU waste and HLW because this waste has not gone through the TRU waste confirmation and certification process.

pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Treatment Under Tank Closure Alternative 3C: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2040. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. WTP capacity would be supplemented with steam reforming treatment capacity to immobilize a portion of the LAW. The steam reforming supplemental treatment for the LAW would occur in both the 200-East and 200-West Areas. In the 200-East Area, the waste feed would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and treated and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal Under Tank Closure Alternatives 3A, 3B, and 3C: LAW immobilized via both the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be stored on site in a new storage facility pending disposal at WIPP.

Closure Under Tank Closure Alternatives 3A, 3B, and 3C: As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent future tank subsidence, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) for the BX and SX tank farms and replaced with clean soils from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the RPPDF, a new facility similar to an IDF. The closed tank systems and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years.

1.7.1.4 Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

This alternative involves the use of both thermal and nonthermal treatment technologies (bulk vitrification and cast stone, respectively) to supplement the WTP treatment. This alternative also evaluates treatment of 99.9 percent of the waste volume in the tank farms, clean closure of two representative (BX and SX) tank farms, and landfill closure of the remaining tank farms.

Storage: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed.

Retrieval: Using currently available liquid-based retrieval and leak detection systems along with a final chemical wash step, waste would be retrieved to a volume corresponding to 99.9 percent retrieval, equal to residual tank waste of no more than 1 cubic meter (36 cubic feet) for 100-series tanks or 0.08 cubic meters (3 cubic feet) for the smaller 200-series tanks.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would operate at a TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Treatment would start in 2018, and both HLW and LAW treatment would end in approximately 2043, which would

include treating the highly contaminated waste stream resulting from clean closure of the BX and SX tank farms. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. WTP capacity would be supplemented with additional waste treatment capacity to immobilize a portion of the LAW. Supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas and consist of a combination of cast stone treatment capacity in the 200-East Area and bulk vitrification treatment capacity in the 200-West Area. The waste stream feed for the 200-East Area cast stone supplemental treatment facility would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized via both the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be packaged and stored on site in an existing or new storage facility pending disposal at WIPP.

Closure: As operations are completed, the SST system at Hanford, except the BX and SX tank farms, would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. The closed tank systems, except the BX and SX tank farms, and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years. The BX and SX tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. The removed tanks, ancillary equipment, and soils would be treated, as appropriate, in the Preprocessing Facility (PPF), a new facility, resulting in MLLW and a highly contaminated liquid waste stream. The MLLW would be disposed of on site, and the highly contaminated liquid waste stream would be processed as HLW in the WTP, resulting in additional IHLW. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. Highly contaminated soils from deep soil excavation would be treated in the PPF. This process would generate a contaminated liquid waste stream that would be processed as LAW in the WTP, resulting in additional ILAW. The washed soils would be disposed of in the RPPDF, a new facility similar to an IDF. The BX and SX tank farms would be backfilled with clean soil.

1.7.1.5 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

This alternative involves the use of both thermal and nonthermal treatment technologies (bulk vitrification and cast stone, respectively) to supplement the WTP treatment. This alternative also evaluates retrieval and treatment of 90 percent of the tank waste volume in the tank farms, but on an accelerated schedule, as well as landfill closure of the SST system.

Storage: DOE would continue current waste management operations using existing tank storage facilities. Four new DSTs and four WRFs would be constructed.

Retrieval: Using currently available liquid-based retrieval and leak detection systems, waste would be retrieved to a volume corresponding to 90 percent retrieval, less than the TPA Milestone M-45-00 minimum goal of 99 percent. Retrieval to 90 percent represents a programmatic risk analysis process for the tank farms as defined by Appendix H of the TPA, "Single Shell Tank Waste Retrieval Criteria Procedure." The 90 percent retrieval level would be equal to residual tank waste of no more than

102 cubic meters (3,600 cubic feet) for 100-series tanks or 8.5 cubic meters (300 cubic feet) for the smaller 200-series tanks.

Treatment: The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented with expanded LAW vitrification capacity (an addition of one LAW melter) to provide a vitrification TMC of 6 metric tons of glass IHLW per day and 45 metric tons of glass ILAW per day. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. Treatment would start in 2018 and end in approximately 2034. This alternative considers implementation of a sulfate removal technology following WTP pretreatment that would potentially reduce the amount of glass produced in the WTP by increasing the waste loading in the ILAW glass. WTP capacity would be supplemented with additional waste treatment capacity to immobilize a portion of the LAW. Supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas and consist of a combination of cast stone treatment capacity in the 200-East Area and bulk vitrification treatment capacity in the 200-West Area. The waste stream feed for the 200-East Area cast stone supplemental treatment facility would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. A separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste and packaged for disposal at WIPP. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal: LAW immobilized both via the WTP and external to the WTP would be disposed of on site in an IDF. IHLW would be stored on site until disposition decisions are made and implemented. Mixed TRU waste would be packaged and stored on site in a new storage facility pending disposal at WIPP.

Closure: As operations are completed, the SST system would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and DOE Order 435.1, or decommissioned under DOE Order 430.1B. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Tank systems (tanks, ancillary equipment, and soils) and the six sets of adjacent cribs and trenches (ditches) would be closed in place and covered with the Hanford barrier (a barrier with performance characteristics that exceed RCRA requirements for disposal of hazardous waste). To support this schedule, SST system ancillary equipment outside the boundaries of the surface barriers would not be removed or decontaminated. Postclosure care would continue for 100 years.

1.7.1.6 Tank Closure Alternative 6: All Waste as Vitrified HLW[4]

This alternative consists of three subalternatives: (1) Alternative 6A: All Vitrification/No Separations; Clean Closure (Base and Option Cases), (2) Alternative 6B: All Vitrification with Separations; Clean Closure (Base and Option Cases), and (3) Alternative 6C: All Vitrification with Separations; Landfill Closure. These alternatives evaluate an all-vitrification case wherein all vitrified waste would be managed as HLW.

Storage Under Tank Closure Alternative 6A: DOE would continue current waste management operations using existing tank storage facilities that would be modified as needed to support SST waste retrieval and treatment. New DSTs would be required after the existing DSTs reach the end of their design life.

[4] Alternatives 6A, 6B, and 6C of this EIS evaluate the management of tank waste as HLW combined with different closure scenarios. The purpose of Alternative 6A is to evaluate the bounding case for no-separation scenarios. The DOE Manual 435.1-1 waste incidental to reprocessing evaluation determination process is not required for treatment of the waste under these alternatives.

Storage Under Tank Closure Alternatives 6B and 6C: DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed.

Retrieval Under Tank Closure Alternatives 6A and 6B: Using currently available liquid-based retrieval and leak detection systems along with a final chemical wash step, waste would be retrieved to a volume corresponding to 99.9 percent retrieval, equal to residual tank waste of no more than 1 cubic meter (36 cubic feet) for 100-series tanks or 0.08 cubic meters (3 cubic feet) for the smaller 200-series tanks.

Retrieval Under Tank Closure Alternative 6C: Using currently available liquid-based waste retrieval and leak detection systems, waste would be retrieved to the TPA minimum goal, i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for the smaller 200-series tanks, corresponding to 99 percent retrieval.

Treatment Under Tank Closure Alternative 6A: The existing WTP configuration would be modified to process all waste as HLW through expanded HLW vitrification capacity. This new WTP configuration (five HLW melters and no LAW melters) would provide a total vitrification TMC of 15 metric tons of glass IHLW per day. Treatment would start in 2018 and end in approximately 2163, requiring two WTP replacement facilities due to design-life constraints. There would be no pretreatment, LAW treatment, or technetium-99 removal. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Treatment Under Tank Closure Alternatives 6B and 6C: The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented with expanded LAW vitrification capacity (an addition of four LAW melters) to provide a vitrification TMC of 6 metric tons of glass IHLW per day and 90 metric tons of glass ILAW per day. Treatment would start in 2018 and end in approximately 2040 (for HLW) and 2043 (for LAW). All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. No supplemental or TRU waste treatment is proposed. The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated, and treated in the WTP.

Disposal Under Tank Closure Alternative 6A: IHLW canisters would be stored on site until disposition decisions are made and implemented. Replacement of the canister storage facilities would be required after a 60-year design life. The HLW debris from clean closure would be managed as HLW and stored on site.

Disposal Under Tank Closure Alternatives 6B and 6C: IHLW canisters would be stored on site until disposition decisions are made and implemented. ILAW glass canisters would be managed as HLW and stored on site. Under Alternative 6B, HLW debris from clean closure would be managed as HLW and stored on site.

Closure Under Tank Closure Alternatives 6A and 6B: These alternatives analyze clean closure of all twelve 200-East and 200-West Area SST farms following deactivation. Clean closure of the tank farms would involve removal of all tanks, associated ancillary equipment, and contaminated soil to a depth of 3 meters (10 feet) directly beneath the tank base. These materials would be packaged as HLW for onsite storage in shielded boxes. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The new PPF would process the highly contaminated deep soil to render it acceptable for onsite disposal. The liquid waste stream from the PPF soil washing would be thermally treated in the PPF and disposed of on site in an IDF. The washed soils would be disposed of in the RPPDF, a new facility similar to an IDF. Clean closure of the SST system would preclude the need for postclosure care. The six sets of adjacent cribs and trenches (ditches) would be covered with an

engineered modified RCRA Subtitle C barrier (Base Cases). Optional clean closure of these cribs and trenches (ditches) would occur under the Option Cases.

Closure Under Tank Closure Alternative 6C: As operations are completed, the SST system would be closed as an RCRA hazardous waste landfill unit under WAC 173-303, "Dangerous Waste Regulations," and under DOE Order 435.1, or decommissioned under DOE Order 430.1B. The tanks would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Soil would be removed down to 4.6 meters (15 feet) for the BX and SX tank farms and replaced with clean soils from onsite sources. The removed contaminated soils and ancillary equipment would be disposed of on site in the RPPDF, a new facility similar to an IDF. The closed tank systems and the six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Postclosure care would continue for 100 years.

1.7.2 FFTF Decommissioning Alternatives

The NOI for the "FFTF Decommissioning EIS" (69 FR 50176) identified the three alternatives listed below.

1.7.2.1 FFTF Decommissioning Alternative 1: No Action

As previously stated, CEQ NEPA regulations (40 CFR 1500–1508) and DOE NEPA regulations (10 CFR 1021) require analysis of a "no action" alternative. The FFTF Decommissioning No Action Alternative includes completion of actions in accordance with previous DOE NEPA decisions. Final decommissioning of FFTF would not occur. Specifically, only deactivation activities for the FFTF complex and support buildings, as described in the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006b), would be conducted. Deactivation activities would include removal and packaging of the RH-SCs for storage in the 400 Area, as described in the FONSI dated March 31, 2006. The FFTF Reactor Containment Building (RCB) (Building 405) and the rest of the buildings within the 400 Area Property Protected Area (PPA) would be maintained through 2107 (for 100 years after the *TC & WM EIS* ROD is published) under administrative controls such as site security and management. After 2107, administrative controls would cease and the remaining waste is assumed to become available for release to the environment.

1.7.2.2 FFTF Decommissioning Alternative 2: Entombment

Facility Disposition. The Entombment Alternative consists of removing all aboveground structures within the 400 Area PPA and minimal removal of below-grade structures, equipment, and materials as required to comply with regulatory standards. The RCB would be demolished and removed to grade, and auxiliary facilities would be removed to 0.91 meters (3 feet) below grade. Equipment, piping, and components containing hazardous and radioactive materials would be removed from below-grade structures only as needed for treatment to meet regulatory requirements. Any other necessary treatment of equipment or components would occur in place without removal from the facilities. After treatment, some of the components could be returned to below-grade spaces and grouted in place with the remaining structures and equipment to stabilize them and minimize void space. Most other equipment and materials removed from the facilities would be disposed of in the 200 Areas. An RCRA-compliant barrier would be constructed over the remains of the RCB and any other remaining below-grade structures (including the reactor vessel) that contain residual radioactive and treated hazardous materials. Equipment to be removed under this alternative includes the RH-SCs, which contain sufficient quantities of metallic sodium and radionuclides that they could not be treated and entombed in the RCB with the remaining materials.

Disposition of Remote-Handled Special Components. The RH-SCs consist of four large filter assemblies designed to remove radionuclides and other contaminants from the FFTF sodium coolant systems and the inert-cover gas systems. These components would require treatment to drain and stabilize residual metallic sodium prior to disposal, and they would contain sufficient quantities of radionuclides to require remote handling. Removal and storage of the RH-SCs in the 400 Area are covered in the FONSI dated March 31, 2006 (DOE 2006b). It would be necessary to treat these components in a specialized facility that is equipped to handle hazardous reactive materials and components with high radiological dose rates. Such a facility does not currently exist within the DOE waste management complex; however, most other waste generated during facility decommissioning could be managed using existing or proposed capabilities. Therefore, DOE needs to decide on an approach for treating and disposing of the FFTF RH-SCs. The two options discussed below are being considered for managing these components.

- **Hanford Option**. The RH-SCs would be shipped to an onsite treatment facility. The capability to treat these components does not currently exist at Hanford, nor has such a capability been previously proposed, although construction of a facility to treat RH- and oversized MLLW or TRU waste was evaluated in a previous NEPA review (DOE 2004a). Following treatment, the components and residuals would be disposed of with other Hanford waste in the 200 Areas. DOE is considering this option for management of the FFTF RH-SCs in response to scoping comments that recommended minimizing offsite transportation of these components and treatment residuals.

- **Idaho Option**. The RH-SCs would be shipped to the proposed RTP at the MFC at INL. The proposed RTP would treat remote-handled components containing comparable levels of radiological materials, as well as metallic sodium. An EA is being prepared at INL to evaluate this proposed treatment (DOE 2009a). Following treatment at the RTP, the FFTF components and residuals would be disposed of with other INL waste at an offsite facility, or they could be returned to Hanford for disposal. DOE is considering this option for the FFTF RH-SCs to utilize the existing sodium management expertise at the MFC and to consolidate waste management activities within the DOE complex at existing or proposed facilities.

Disposition of Bulk Sodium. The Hanford radioactive bulk sodium inventory consists of approximately 1.1 million liters (300,000 gallons) of metallic sodium, including sodium from the Hallam Reactor and the Sodium Reactor Experiment (SRE), in addition to sodium drained from the FFTF cooling systems during deactivation. Hallam and SRE sodium are currently stored in the Hanford 200-West Area Central Waste Complex (CWC). Sodium from FFTF is stored in the 400 Area within the RCB or adjacent storage facilities. The current DOE plan for this sodium is to convert it to a caustic for product reuse by ORP for the WTP. The two options discussed below are being considered for managing the Hanford radioactive bulk sodium inventory.

- **Hanford Reuse Option**. The bulk sodium would be stored in its current locations until it is shipped to an onsite facility for processing to a caustic (sodium hydroxide). The capability to process the bulk sodium does not currently exist at Hanford. The treated sodium (caustic) would be transferred to the 200-East Area for product reuse by ORP for the WTP. DOE is considering this option for processing the Hanford bulk sodium inventory in response to scoping comments that recommended minimizing the need for offsite transportation of the bulk sodium and caustic.

- **Idaho Reuse Option**. The bulk sodium would be stored in its current locations until it is shipped to the MFC for processing. The capability to process bulk metallic sodium currently exists at the MFC SPF, which previously has been used to process metallic sodium from the Experimental Breeder Reactor II (EBR-II) and other facilities. Following processing, the caustic would be returned to Hanford for use in the WTP. DOE is considering this option for processing the

Hanford bulk sodium inventory to utilize existing sodium management expertise and facilities at the MFC.

1.7.2.3 FFTF Decommissioning Alternative 3: Removal

Facility Disposition. The Removal Alternative consists of removing all above-grade structures within the 400 Area PPA, as well as contaminated below-grade structures, equipment, and materials. The RCB would be demolished and removed to grade, and all auxiliary facilities would be removed to 0.91 meters (3 feet) below grade. Most equipment, piping, and components containing chemically hazardous and radioactive materials, including the reactor vessel, lead shielding, depleted uranium shielding, and asbestos, would be removed from below-grade structures. Most equipment and materials removed from the facilities would be disposed of in the 200 Areas. The remaining structures and equipment, consisting mainly of the external RCB structure and associated components, as well as uncontaminated below-grade portions of auxiliary facilities, would be backfilled or grouted to minimize void space. The PPA would be backfilled to grade, contoured, and revegetated as necessary to stabilize the ground surface or to prepare the site for future industrial use.

Disposition of Remote-Handled Special Components. The two options being considered under FFTF Decommissioning Alternative 2 are the same options being considered under FFTF Decommissioning Alternative 3 for disposition of the RH-SCs.

Disposition of Bulk Sodium. The two reuse options being considered under FFTF Decommissioning Alternative 2 are the same options being considered under FFTF Decommissioning Alternative 3 for the disposition of the bulk sodium.

1.7.3 Waste Management Alternatives

Waste Management alternatives evaluated in this *TC & WM EIS* address the expansion of waste disposal capacity at Hanford to provide for the disposal of on- and offsite waste, thus to facilitate the cleanup of Hanford and other DOE sites. The major mission components include onsite storage and disposal of Hanford-generated and other sites' LLW and MLLW; onsite storage of Hanford-generated TRU waste; and eventual closure of the waste facilities.

1.7.3.1 Waste Management Alternative 1: No Action

Storage: LLW and MLLW would be stored at the CWC until processed for disposal in trenches 31 and 34 in low-level radioactive waste burial ground (LLBG) 218-W-5. TRU waste would be stored at the CWC and disposed of in WIPP. Processing of waste prior to disposal would continue to occur at existing facilities at the CWC, Waste Receiving and Processing Facility (WRAP), and T Plant. No offsite LLW, MLLW, or TRU waste would be received.

Disposal: LLW and MLLW would be disposed of in LLBG 218-W-5, trenches 31 and 34, through 2035. TRU waste would be disposed of in WIPP. Further construction at IDF-East would be discontinued in 2008, and the IDF site would be deactivated.

Closure: Administrative control would be implemented for 100 years.

1.7.3.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

Storage: LLW, MLLW, and TRU waste would be stored at the CWC until processed for disposal. Processing of waste prior to disposal would occur at existing and expanding facilities at the CWC, WRAP, and T Plant. No offsite TRU waste would be received. Offsite LLW and MLLW would be received from other DOE sites. A total volume of 62,000 cubic meters (81,000 cubic yards) of LLW and

20,000 cubic meters (26,000 cubic yards) of MLLW was assumed to be received, as identified in the Settlement Agreement for waste disposal at Hanford.

Disposal: LLBG 218-W-5, trenches 31 and 34, would continue to operate through 2050. Construction, operations, deactivation, closure, and postclosure care would take place at IDF-East. Waste from tank treatment operations, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-East. Waste from tank farm cleanup operations would be disposed of in the RPPDF. TRU waste would be disposed of in WIPP.

Closure: Disposal facilities would be covered with engineered modified RCRA Subtitle C barriers. Postclosure care would continue for 100 years.

1.7.3.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Storage: LLW, MLLW, and TRU waste would be stored at the CWC until processed for disposal. Processing of waste prior to disposal would occur at existing and expanding facilities at the CWC, WRAP, and T Plant. No offsite TRU waste would be received. Offsite LLW and MLLW would be received from other DOE sites. A total volume of 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW was assumed to be received.

Disposal: LLBG 218-W-5, trenches 31 and 34, would continue to operate through 2050. Construction, operations, deactivation, closure, and postclosure care would take place at IDF-East and IDF-West. Waste from onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-West. Waste from tank waste treatment operations would be disposed of in IDF-East. Waste from tank farm cleanup operations would be disposed of in the RPPDF. TRU waste would be disposed of in WIPP.

Closure: Disposal facilities would be covered with engineered modified RCRA Subtitle C barriers. Postclosure care would continue for 100 years.

1.8 RELATED NEPA REVIEWS

A number of related NEPA reviews have been completed or are ongoing. This section briefly discusses these activities and their relationships with this proposed activity.

***Environmental Statement, Fast Flux Test Facility, Richland, Washington* (WASH-1510, May 1972) (AEC 1972).** The U.S. Atomic Energy Commission prepared this environmental statement to assess the potential environmental impacts associated with constructing and operating FFTF, a liquid-metal-cooled research reactor in the Hanford 400 Area.

***Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington* (ERDA 1538, December 1975) (ERDA 1975).** The U.S. Energy Research and Development Administration prepared this environmental statement for use in planning and decisionmaking to ensure that future waste management practices would minimize adverse environmental consequences. Treatment and disposal of waste generated by nuclear defense production, research and development, and other activities at Hanford were addressed. This document was written for the Waste Management Operations Program at Hanford. Because this document predated the CEQ NEPA regulations, a formal ROD was not issued. To some extent, Hanford waste management programs still rely on the analyses conducted in this *Waste Management Operations Statement*. Note: This *TC & WM EIS* updates analysis of waste management activities conducted by DOE, including tank closure.

***Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants* (May 1984) (Navy 1984).** This EIS considered the disposal of defueled naval submarine reactor compartments in the Hanford LLW burial grounds. The EIS was prepared by the U.S. Department of the Navy and was adopted by DOE. The EIS analyzed preparation of the reactor compartments at the Puget Sound Naval Shipyard, transportation to Hanford, and disposal in the 200 Areas. The ROD was published in the *Federal Register* on December 6, 1984 (49 FR 47649).

***Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington (Hanford Defense Waste EIS)* (DOE/EIS-0113, December 1987) (DOE 1987).** DOE prepared this EIS to examine the potential impacts of processing TRU waste and tank waste stored at Hanford since 1943, as well as future waste, for disposal. Most LLW and waste associated with decommissioning of existing surplus or retired Hanford facilities were not considered in this EIS. In the 1988 ROD (53 FR 12449), DOE decided to dispose of or store DST waste and cesium and strontium capsules. Retrievably stored TRU waste in the 200 Area LLW burial grounds would be retrieved and disposed of with other newly generated TRU waste. A decision was also made to retrieve buried pre-1970 suspect TRU-contaminated waste from the 618-11 burial ground site. As part of that decision, DOE decided to construct and operate a facility for vitrification of HLW; facilities for grout stabilization and disposal of the LAW fraction resulting from processing tank waste; and WRAP for processing, certification, and shipment of TRU waste. Subsequent to preparation of this *Hanford Defense Waste EIS*, the TPA was established to implement many of the actions discussed in the ROD. The TPA also addresses compliance with RCRA and CERCLA requirements. Note: This *TC & WM EIS* updates analyses of Hanford waste associated with storage, retrieval, treatment, and disposal of tank waste.

***Environmental Assessment, Hanford Environmental Compliance Project, Hanford Site, Richland, Washington* (DOE/EA-0383, March 1992) (DOE 1992).** This EA included an evaluation of construction and operation of the Effluent Treatment Facility in the Hanford 200-East Area. This facility would receive wastewater collected from tank waste treatment facilities (in addition to other liquid waste generated at Hanford). The EA also evaluated construction of additional facilities at the CWC, where certain types of waste generated from the tank closure activities would be stored. Based on analyses in this EA, DOE determined the proposed actions were not major Federal actions significantly affecting the quality of the human environment and issued a FONSI on March 11, 1992.

***Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (SNF PEIS)* (DOE/EIS-0203-F, April 1995) (DOE 1995b).** The *SNF PEIS* was a DOE nationwide study examining the environmental impacts of managing more than 2,600 metric tons of SNF from past, present, and future DOE activities. The programmatic EIS analyzed the potential environmental consequences of alternatives related to the transportation, receipt, processing, and storage of SNF under the responsibility of DOE over the next 40 years, including no action, decentralization, regionalization, centralization, and the use of plans that existed in 1992 and 1993 for management of these materials. As a result, DOE decided to manage SNF according to the Regionalization Alternative by fuel type (60 FR 28680, 61 FR 9441). As part of that decision, Hanford would continue to store FFTF SNF, except for sodium-bonded fuel, until disposition decisions are made and implemented. The decision also included 12 shipments of sodium-bonded FFTF fuel to INL (formerly INEEL) for treatment and storage.

The waste management portion of the EIS evaluated various alternatives to manage radioactive and hazardous wastes at INL. Among the activities considered was operation of the SPF at the MFC to convert metallic sodium to a solid form suitable for reuse or disposal. Based on that evaluation, DOE decided to use the SPF to process sodium coolant from the EBR-II and other metallic sodium stored at INEEL. DOE also decided to proceed with a demonstration project for electrometallurgical treatment of sodium-bonded SNF (60 FR 28680). DOE has prepared two SAs for the INL portion of this EIS

(DOE/EIS-0203-SA-01, September 2002 [DOE 2002b], and DOE/EIS-0203-F-SA-02, June 2005 [DOE 2005]), concluding that the analyses remain valid and a supplemental NEPA documentation is not required.

***Environmental Assessment, Shutdown of the Fast Flux Test Facility, Hanford Site, Richland, Washington* (DOE/EA-0993, May 1995) (DOE 1995a).** This EA was prepared to assess the environmental impacts of shutting down FFTF. Deactivation, as evaluated in the EA, consisted of removing, cleaning, and storing fuel; draining sodium coolant; deactivating nonessential systems; removing some stored radioactive and hazardous materials; and performing other actions to place the facility in a safe surveillance and maintenance state for eventual decommissioning. Based on analyses in the EA, DOE determined the proposed actions were not major Federal actions that would significantly affect the quality of the human environment and issued a FONSI on May 1, 1995.

***Environmental Assessment, Solid Waste Retrieval Complex, Enhanced Radioactive and Mixed Waste Storage Facility, Infrastructure Upgrades, and Central Waste Support Complex, Hanford Site, Richland, Washington* (DOE/EA-0981, September 1995) (DOE 1995c).** In this EA, DOE proposed to construct and operate the Solid Waste Retrieval Complex and the Enhanced Radioactive Mixed Waste Storage Facility; expand the CWC; and upgrade the associated Hanford infrastructure. These facilities were to be located in the 200-West Area to support the Solid Waste Operations Complex. The proposed actions were to address retrieval of TRU waste, storage capacity for retrieved and newly generated TRU waste, and upgrades to the infrastructure network in the 200-West Area to enhance operational efficiencies and reduce the cost of operating the existing Solid Waste Operations Complex. Actions evaluated in the EA include the following:

- Construction and operations of the Solid Waste Retrieval Complex and the Enhanced Radioactive Mixed Waste Storage Facility
- Expansion of the CWC
- Upgrading associated infrastructure (utilities and roads) in the 200-West Area to support the Solid Waste Operations Complex
- Retrieval of post-1970 TRU waste in the LLW burial grounds and construction, operation, and maintenance of a complex of facilities to be used for the retrieval
- Construction of an RCRA-permitted storage facility for greater-than-Class C waste, retrieved TRU waste, and newly generated TRU waste awaiting processing in WRAP, as well as processed waste awaiting shipment to WIPP
- Construction of two pre-engineered metal solid waste management support buildings

Based on analyses in this EA, DOE determined the proposed actions were not major Federal actions that would significantly affect the quality of the human environment and issued a FONSI on September 28, 1995. This *TC & WM EIS* relies on a number of the waste management facilities analyzed in this EA.

***Final Environmental Impact Statement, Safe Interim Storage of Hanford Tank Wastes, Hanford Site, Richland, Washington* (DOE/EIS-0212, October 1995) (DOE and Ecology 1995).** DOE and Ecology prepared this EIS to assess the environmental and human health impacts associated with the construction and operation of facilities and systems to continue the safe management of tank waste. This EIS addressed only tank waste safety concerns that required action before implementing decisions based on the *TWRS EIS*. In the ROD, DOE decided to continue operation of the existing cross-site transfer system until its replacement had been constructed and begun operating (60 FR 61687). DOE and Ecology also determined that new storage tanks would not be necessary to mitigate the flammable gas safety issue, based on the demonstrated success of the mixer pumps.

***Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (DOE/EIS-0189, August 1996) (DOE and Ecology 1996).** In the *TWRS EIS*, DOE examined management and disposal of mixed, radioactive, and hazardous wastes currently stored or projected to be stored in 177 underground storage tanks, as well as cesium and strontium capsules. The *TWRS EIS* deferred analysis of alternatives for tank closure. In the ROD, DOE decided to retrieve, separate, vitrify, and dispose of the tank waste (62 FR 8693). The LAW fraction from the separation process would be retrievably stored on site. The HLW would be disposed of at an HLW geologic repository. A decision on disposition of cesium and strontium capsules was deferred. Note: This *TC & WM EIS* extends the assessment of alternatives for treatment and disposal of tank waste and assesses alternatives for closing the waste storage SSTs.

***Environmental Assessment, Management of Hanford Site Non-defense Production Reactor Spent Nuclear Fuel, Hanford Site, Richland, Washington* (DOE/EA-1185, March 1997) (DOE 1997d).** This EA evaluated the environmental impacts associated with actions necessary to place Hanford non-defense production reactor SNF, including FFTF fuel, in radiologically and industrially safe consolidated storage pending final disposition. The FFTF-irradiated SNF would be placed in interim storage areas in either the 400 Area or the 200 Areas, depending on the fuel characteristics. Irradiated FFTF fuel would be processed to remove sodium residuals in the 400 Area and loaded into dry storage casks in the 400 Area's interim storage area for eventual transfer to the Canister Storage Building in the 200-East Area. Nonirradiated or slightly irradiated FFTF fuel would be processed in the 400 Area as needed and transferred to secure storage in the 200-West Area. Based on analyses in the EA, DOE determined the proposed actions were not major Federal actions that would significant affect the quality of the human environment and issued a FONSI on March 28, 1997.

***Environmental Assessment, Shutdown of Experimental Breeder Reactor-II at Argonne National Laboratory-West* (DOE/EA-1199, September 1997) (DOE 1997e).** This EA addressed placement of EBR-II and its supporting facilities in an industrially and radiologically safe shutdown condition pending ultimate decommissioning, including draining the primary and secondary sodium coolant and processing it at the SPF. The EA did not evaluate final decontamination and decommissioning of EBR-II or the SPF. Based on analyses in the EA, DOE determined the proposed actions were not major Federal actions that would significantly affect the quality of the human environment and issued a FONSI on September 26, 1997.

***Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE/EIS-0200-F, May 1997) (DOE 1997a).** The *WM PEIS* is a DOE complex–wide study examining the environmental impacts of managing more than 2 million cubic meters (2.7 million cubic yards) of radioactive waste from past, present, and future DOE activities. Waste analyzed in the *WM PEIS* results primarily from nuclear weapons production and related activities. DOE's goal in preparing the *WM PEIS* was to develop a nationwide strategy to treat, store, and dispose of LLW, MLLW, HLW, TRU waste, and hazardous waste in a safe, responsible, and efficient manner that minimizes the impacts on workers and the public. The *WM PEIS* provides information on the impacts of using various alternatives and sites to consolidate or

decentralize treatment, storage, and disposal activities for each waste type. DOE would conduct further NEPA reviews regarding the specific location of new facilities at selected sites, as appropriate.

The *Final WM PEIS* was issued in May 1997, and decisions for each waste type analyzed in the *WM PEIS* have since been issued. The HLW storage ROD (64 FR 46661) stated that HLW should be stored at the generator sites pending disposal in an HLW geologic repository. The TRU waste treatment and storage ROD (63 FR 3624) stated that TRU waste at DOE sites would be treated and stored at the generator site prior to disposal at WIPP. The TRU waste treatment and storage ROD also stated that, in the future, DOE may decide to ship TRU waste from smaller sites that do not have the means to certify and package their waste for disposal at WIPP to larger sites, i.e., Savannah River Site, Oak Ridge Reservation, INL (formerly INEEL), and Hanford. The TRU waste treatment and storage ROD has been amended to this effect. The TRU waste treatment and storage ROD (69 FR 39446) was revised based on new information in the *HSW EIS* to confirm DOE's September 6, 2002, decision to ship its TRU waste from the Battelle West Jefferson North Site in Columbus, Ohio, to Hanford for storage, processing, and certification pending disposal at WIPP. DOE amended the TRU waste treatment and storage ROD to announce DOE's intent to send both contact- and remote-handled TRU waste from certain generator sites as needed to INL to be treated and characterized prior to shipment to WIPP for disposal (73 FR 12401). This would include shipping TRU waste from Hanford to INL. The hazardous waste treatment ROD (63 FR 41810) announced DOE's decision to continue using commercial facilities to treat nonwastewater hazardous waste generated at DOE sites. The LLW and MLLW ROD (65 FR 10061) states that DOE will minimally treat LLW at the generator sites, and that Hanford and the Nevada Test Site will be available to all DOE sites for LLW disposal. As part of this decision, DOE will treat MLLW at INL, the Oak Ridge Reservation, and the Savannah River Site; dispose of MLLW at the Nevada Test Site; and both treat and dispose of MLLW at Hanford.

Note: Analyses of alternatives in this *TC & WM EIS* are consistent with and tier from DOE complex–wide policies and practices that have been described in the various *WM PEIS* RODs for each waste type. The *Draft TC & WM EIS* alternatives assess the impacts of managing and disposing of the IHLW; ILAW; TRU waste; and process-generated LLW, MLLW, and hazardous waste associated with the proposed activities.

***Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE/EIS-0026-S-2, September 1997) (DOE 1997b).** This *WIPP SEIS-II* establishes the disposal and transportation pathway for TRU waste. DOE has decided on geologic disposal at WIPP for the TRU component of radioactive waste. TRU waste from Hanford, including that stored in SSTs, is designated for this disposal pathway. In June 2004, DOE issued an SA evaluating the proposal to dispose of up to 2,500 cubic meters (88,000 cubic feet) of TRU waste containing polychlorinated biphenyls (PCBs) at WIPP and to characterize and, if necessary, repackage TRU waste containing PCBs in storage at INL (formerly INEEL), Hanford, Oak Ridge Reservation, Rocky Flats Environmental Technology Site, Savannah River Site, and Knolls Atomic Power Laboratory for disposal at WIPP (DOE 2004b). Based on this SA, DOE determined that the proposed actions are not a substantial change to the proposal analyzed in the *WIPP SEIS-II* and, therefore, a supplement to the *WIPP SEIS-II* is not needed. As a result of this SA, DOE revised the *WIPP SEIS-II* ROD (69 FR 39456) to include disposal of TRU waste containing PCBs in concentrations of 50 parts per million or greater at WIPP.

***Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F, September 1999) (DOE 1999b).** As a result of public comments received and changes in DOE's NEPA/CERCLA/RCRA integration policies, DOE prepared this EIS, formerly named the *Hanford Remedial Action Environmental Impact Statement and Comprehensive Land-Use Plan*, to evaluate the potential environmental impacts associated with implementing a comprehensive land use plan for Hanford. Working with Federal, state, and local agencies and tribal governments, DOE evaluated six land use alternatives. In the ROD for this EIS (64 FR 61615), DOE decided to adopt a comprehensive

land use plan for Hanford. The purpose of this land use plan and its implementing policies and procedures is to facilitate decisionmaking about the site's uses and facilities over at least the next 50 years. As part of this plan, the 200 Areas were designated Industrial-Exclusive and the 400 Area was designated Industrial. Radioactive and hazardous waste treatment, storage, and disposal activities, as described in this *Draft TC & WM EIS*, are consistent with the Industrial-Exclusive and Industrial land use designations selected for the 200 and 400 Areas, respectively, in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)*.

***Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility* (DOE/EIS-0310, December 2000) (DOE 2000a).** This *NI PEIS* evaluated proposed expansion of nuclear irradiation capabilities for civilian nuclear energy research and development activities, production of medical and industrial isotopes to meet projected higher demand, and production of plutonium-238 to support future National Aeronautics and Space Administration space exploration missions. The *NI PEIS* also evaluated an alternative to permanently deactivate FFTF. The EIS concluded that "lack of clear commitments from likely users discouraged the Department from planning to build new facilities or to restart the FFTF." In the associated ROD (66 FR 7877), DOE decided FFTF would be permanently deactivated.

***Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (DOE/EIS-0306, July 2000) (DOE 2000b).** This EIS evaluated strategies to remove or stabilize the reactive sodium contained in a portion of DOE's SNF inventory to prepare the fuel for disposal in a geologic repository. The EIS analyzed six alternatives that employ one or more of the following technology options at nuclear fuel management facilities at the Savannah River Site or INL (formerly INEEL): electrometallurgical treatment; plutonium-uranium extraction; packaging in high-integrity cans; and melt-and-dilute treatment. DOE decided in the ROD (65 FR 56565) to implement the Preferred Alternative, electrometallurgically treating the EBR-II SNF and less than 0.5 metric tons of miscellaneous sodium-bonded SNF, including less than 0.3 metric tons of FFTF fuel at the MFC.

***Environmental Assessment, Use of Existing Borrow Areas, Hanford Site, Richland, Washington* (DOE/EA-1403, October 2001) (DOE 2001b).** This EA evaluated potential environmental consequences of operating existing borrow areas (including Borrow Area C) at Hanford to provide soil, sand, gravel, and rock for construction projects, site maintenance activities, and waste management activities. The EA specifically analyzed provision of an additional 7.6 million cubic meters (10 million cubic yards) of materials over a 10-year period (beginning in fiscal year 2001) to support site activities, including 690,000 cubic meters (905,000 cubic yards) to support WTP project activities. This rate of production (approximately 760,000 cubic meters [994,080 cubic yards] annually) analyzed in the EA would be adequate to support implementation of any of the alternatives considered in this *TC & WM EIS* if production were continued over the timeframe considered under each alternative. Based on analyses in this EA, DOE determined the proposed actions were not major Federal actions that would significantly affect the quality of the human environment and issued a FONSI on October 10, 2001.

Note: While this *Draft TC & WM EIS* evaluates the quantity of resource materials available and potentially consumed from the onsite borrow areas and assesses the environmental impacts of transporting the geologic resource materials to the point of use considered under each alternative, it does not further analyze the operational impacts of the onsite borrow areas.

***Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Yucca Mountain EIS)* (DOE/EIS-0250, February 2002) (DOE 2002a).** The *Yucca Mountain EIS* examined proposed actions to construct, operate, monitor, and eventually close a geologic repository for the disposal of SNF and HLW currently in storage or expected to be generated at 72 commercial and 5 DOE sites

across the United States. The *Yucca Mountain EIS* also analyzed transporting these materials, including the IHLW at Hanford considered in this *TC & WM EIS*, to the repository for disposal. The *Yucca Mountain EIS* accompanied the Secretary of Energy's recommendation to the President on February 14, 2002, for approval of the Yucca Mountain site for development as a repository. On July 23, 2002, the President signed into law (P.L. 107-200) a joint resolution of the U.S. House of Representatives and the U.S. Senate designating the Yucca Mountain site in Nye County, Nevada, for development as a geologic repository. DOE has submitted an application to the U.S. Nuclear Regulatory Commission for a construction authorization for the repository. An SA (DOE/EIS-0250-SA-01, March 2004) (DOE 2004c) and a supplemental EIS (DOE/EIS-0250F-S1, June 2008) (DOE 2008a) have been issued by DOE. The supplemental EIS addresses new and updated information that has been developed since the original EIS was issued in 2002 and includes views of Nye County, Nevada, concerning the proposed repository.

As indicated in the Administration's fiscal year 2010 budget request, the Administration intends to terminate the Yucca Mountain program while developing nuclear waste disposal alternatives. Notwithstanding the decision to terminate the Yucca Mountain program, DOE remains committed to meeting its obligations to manage and ultimately dispose of HLW and SNF. The Administration intends to convene a blue ribbon panel of experts to evaluate alternative approaches for meeting these obligations. The panel will provide the opportunity for a meaningful dialogue on how best to address this challenging issue and will provide recommendations that will form the basis for working with Congress to revise the statutory framework for managing and disposing of HLW and SNF.

***Environmental Assessment for the Accelerated Tank Closure Demonstration Project* (DOE/EA-1462, June 2003) (DOE 2003a).** ORP prepared this document to assess the environmental impacts of various SST system closure demonstration projects. Specifically, the assessment evaluated the physical response and behavior of a Phase I grout fill in an actual tank, the field use of actual grout production equipment, and the conduct of component closure activities for SST 241-C-106. The information collected from this demonstration project is expected to be applied to the design of future tank closure activities. The EA was approved in 2003 and a FONSI was issued on June 16, 2003.

***Categorical Exclusion for Treatability and Demonstration Testing of Supplemental Technologies, Hanford Site, Richland, Washington* (DOE/ORP-2003-24, December 2003) (DOE 2003b).** ORP prepared this document to construct, operate, and close a pilot-scale test and demonstration facility that would be used to evaluate the performance of supplemental technologies (bulk vitrification and steam reforming) using actual SST waste.

***Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (DOE/EIS-0286F, January 2004) (DOE 2004a).** The DOE Richland Operations Office prepared this *HSW EIS* regarding enhanced waste management programs at Hanford. The scope of this EIS covers management of LLW, MLLW, and post-1970 TRU waste at Hanford. This EIS includes the scope of the proposed, but not developed and published, Tank Waste Remediation System Supplemental EIS for the Disposal of Immobilized Low-Activity Wastes from Hanford Tank Waste Processing (68 FR 7110). The *HSW EIS* scope does not cover HLW, most liquid waste, SNF, naval reactor compartments, commercial LLW, nonradioactive hazardous solid waste, and other solid waste managed within Hanford boundaries. In the ROD for the *HSW EIS* (69 FR 39449), DOE decided to limit the volumes of LLW and MLLW received at Hanford from other sites for disposal to 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW. In addition, effective immediately, DOE will dispose of LLW in lined disposal facilities. As previously discussed in Section 1.2.7, DOE, Ecology, and the Washington State Attorney General's Office signed a Settlement Agreement ending the NEPA litigation related to the *HSW EIS* on January 6, 2006. The agreement is intended to resolve Ecology's concerns about *HSW EIS* groundwater analyses and to address other concerns about the *HSW EIS*.

The agreement called for an expansion of the "Tank Closure EIS" to provide a single, integrated set of analyses that will include all waste types analyzed in the *HSW EIS* (LLW, MLLW, and TRU waste), represented by this *Draft TC & WM EIS*. Pending finalization of this *Draft TC & WM EIS*, the *HSW EIS* remains in effect to support ongoing waste management activities at Hanford (including transportation of TRU waste to WIPP) in accordance with applicable regulatory requirements. The agreement also stipulates that, when this *TC & WM EIS* has been completed, it will supersede the *HSW EIS*. Until that time, DOE will not rely on *HSW EIS* groundwater analyses for decisionmaking and will not import offsite waste to Hanford, apart from certain limited exemptions as specified in the agreement.

***Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE/EA-1547F, March 2006) (DOE 2006b).** This EA addressed continuation of ongoing FFTF deactivation work that was not extensively discussed in the *Environmental Assessment, Shutdown of the Fast Flux Test Facility, Hanford Site, Richland, Washington* (DOE 1995a). The activities analyzed include removing radioactively contaminated sodium residuals left over from the drain of the Hanford radioactively contaminated sodium inventory (FFTF, Hallam Reactor, and SRE) by reacting the sodium metal with water to produce caustic sodium hydroxide; removing associated equipment/components to allow sodium removal; and removing, disposing of, and stabilizing miscellaneous hazards and waste streams left over from the sodium drains. The final FFTF decommissioning end state is addressed in this *Draft TC & WM EIS*.

***Hanford Reach National Monument Final Comprehensive Conservation Plan and Environmental Impact Statement, Adams, Benton, Grant and Franklin Counties, Washington (Final Comprehensive Conservation Plan and EIS)* (August 2008) (USFWS 2008).** The U.S. Fish and Wildlife Service prepared this *Final Comprehensive Conservation Plan and EIS* to provide guidance and management direction for the Hanford Reach National Monument (Monument) for the next 15 years. Once approved by DOE, the *Final Comprehensive Conservation Plan and EIS* will provide the framework for making decisions on protection of natural, cultural, and recreational resources; management of visitor use; development of facilities; and day-to-day Monument operations. The Monument was created from buffer lands that were no longer necessary for the Hanford mission. These buffer lands form a horseshoe around the lands still needed by DOE for its current missions. The U.S. Fish and Wildlife Service administers the Monument as an overlay national wildlife refuge.

***Final Planning Report/Environmental Impact Statement, Yakima River Basin Water Storage Feasibility Study, Yakima Project, Washington* (INT-FES-08-65, December 2008) (BOR 2008).** The U.S. Department of the Interior, Bureau of Reclamation, and Ecology, prepared a draft combined planning report and EIS on the Yakima River Basin Waste Storage Feasibility Study (BOR and Ecology 2008). This study evaluates alternatives that would create additional water storage for the Yakima River Basin and assess their potential to supply the water needed for ecosystems, aquatic habitat, and basin-wide agricultural and municipal demands. Ecology decided to separate from the joint NEPA/SEPA process and issued a supplement to the draft on December 10, 2008 (07-11-044A, December 2008, Ecology 2008), to incorporate an Integrated Water Resources Management Alternative in response to comments received on the January 2008 draft. The Bureau of Reclamation issued its *Final Planning Report/Environmental Impact Statement for the Yakima River Basin Water Storage Feasibility Study, Yakima Project, Washington* in December 2008 with Ecology as a cooperating agency. The Bureau of Reclamation identified the No Action Alternative, which includes activities currently planned or under construction, as the Preferred Alternative. The Bureau has informed Ecology that a formal Record of Decision is not required and will not be prepared.

***Environmental Impact Statement for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste (GTCC EIS)* (DOE/EIS-0375) (72 FR 40135).** DOE is preparing this *GTCC EIS* to address disposal of LLW generated by activities licensed by the U.S. Nuclear Regulatory Commission or

agreement states that contains radionuclides in concentrations exceeding Class C limits (10 CFR 61). The *GTCC EIS* will also consider DOE LLW and TRU waste having characteristics similar to GTCC LLW and that may not have an identified path to disposal. Hanford is being considered in the *GTCC EIS* as a candidate location for a new GTCC disposal facility.

***Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-SA-01, June 2008) (DOE 2008b).** DOE completed an SA to help determine whether the existing *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999b) remains adequate, or whether a new EIS, or a supplement to the existing EIS, should be prepared. In the SA, DOE did not identify significant changes in circumstances or substantial new information that have evolved since 1999 that would affect the basis for its decision as documented in the *Hanford Comprehensive Land-Use Plan EIS* ROD. DOE does not plan to prepare a new EIS or a supplement to the existing EIS at this time. An amended ROD was issued on September 26, 2008 (73 FR 55824).

***Revised Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE/EIS-0226-D [Revised], November 2008) (DOE and NYSERDA 2008).** This draft EIS analyzes alternatives for decommissioning the site and/or long-term stewardship, as well as a No Action Alternative as required by NEPA and New York's State Environmental Quality Review Act. The proposed actions are the completion of the West Valley Demonstration Project and the decommissioning and/or long-term management or stewardship of the Western New York Nuclear Service Center. This includes the decontamination and decommissioning of the waste storage tanks and facilities used in the solidification of HLW, and any material and hardware used in connection with the West Valley Demonstration Project. DOE needs to determine the manner in which facilities, materials, and hardware for which DOE is responsible will be managed or decommissioned in accordance with applicable Federal and state requirements. The New York State Energy Research and Development Authority needs to determine what material or structures for which it is responsible will remain on site, and what institutional controls, engineered barriers, or stewardship provisions would be needed.

***Final Environmental Assessment for the Remote-Handled Waste Disposition Project* (DOE/EA-01386, February 2009) (DOE 2009a).** This EA evaluated the potential environmental impacts related to processing RH waste at INL. This EA analyzed the impacts of treating the FFTF RH-SCs at INL as a reasonably foreseeable action. DOE issued a FONSI (February 18, 2009) for processing remote-handled waste at existing facilities at INL's Idaho Nuclear Technology and Engineering Center (INTEC). However, DOE will make a decision on the treatment of FFTF RH-SCs as part of the *TC & WM EIS* NEPA process.

***Environmental Assessment, Combined Community Communications Facility and Infrastructure Cleanup on the Fitzner-Eberhardt Arid Lands Ecology Reserve, Hanford Site, Richland, Washington* (DOE/EA-1660) (DOE 2009b).** This EA assessed the environmental impacts associated with consolidating existing communications operations and removing excess facilities and infrastructure within the Fitzner-Eberhardt Arid Lands Ecology Reserve located on Hanford. The proposed actions analyzed in the EA are within the scope of this *Draft TC & WM EIS* and are referred to as "interim actions." DOE prepared this interim-action EA before completing the *TC & WM EIS* process to take advantage of opportunities to accelerate remediation actions and reduce the physical footprint on the reserve. DOE issued a FONSI (July 20, 2009) on the proposed action to proceed with construction of the combined community communications facility, demolition of unneeded structures, and cleanup of abandoned debris at the reserve.

***American Recovery and Reinvestment Act of 2009* (P.L. 111-5).** Under the American Recovery and Reinvestment Act, DOE will conduct projects aimed at enhancing and accelerating its tank waste management program. These projects include construction of infrastructure and systems to transfer

radioactive liquid waste from aging underground tanks for waste treatment; accelerated design of the IHLW Interim Storage Facility; upgrade to the Effluent Treatment Facility to continue waste volume reduction; upgrade of the 222-S Analytical Laboratory to allow continued retrieval of waste from SSTs; and development of SST integrity programs for safe storage of waste. The projects are consistent with the *TWRS EIS*, the *Final Environmental Impact Statement, Safe Interim Storage of Hanford Tank Wastes, Hanford Site, Richland, Washington*, and this draft EIS. Additional NEPA reviews such as EAs may be conducted in the future as appropriate.

***Environmental Impact Statement for the Long-Term Management and Storage of Elemental Mercury* (DOE/EIS-0423) (74 FR 31723).** DOE is preparing this EIS to evaluate alternatives for a facility (or facilities) for the long-term management and storage of elemental mercury generated within the United States as required by the Mercury Export Ban Act of 2008 (P.L. 110-414). Hanford is being considered in this EIS as a candidate host site for the long-term management and storage of elemental mercury.

1.9 STRUCTURE OF THIS *TC & WM EIS*

This *Draft TC & WM EIS* is organized as described below.

- **Reader's Guide—**The Reader's Guide serves as an introduction and guide to the contents of this *TC & WM EIS*. It includes descriptions of the proposed actions; the scope of this EIS; the action alternatives evaluated; DOE's Preferred Alternatives for tank closure, FFTF decommissioning, and waste management at Hanford; and the organization of this EIS itself. It also provides information about the availability of this EIS.

- **Summary—**The Summary, a separate volume, summarizes the key information provided in this *TC & WM EIS* and includes background on, and regulatory history of, past activities at Hanford; the purpose and need for agency actions; a description and comparison of the alternatives; an overview of the tank farm systems, FFTF decommissioning activities, and solid waste operations complex; and a summary of potential short- and long-term impacts of the alternatives, key environmental findings, and costs of the alternatives.

- **Chapter 1—Proposed Actions: Background, Purpose, and Need.** Chapter 1 provides background information regarding preparation of this *TC & WM EIS*, including the purpose and need for agency action regarding final waste disposition, SST system closure, and FFTF decommissioning; the decisions to be made based on the EIS analyses; a summary of the issues identified during scoping; the scope of this EIS, including brief summaries of the alternatives; the relationship of the proposed actions to other actions or programs; the cooperating agencies; and the organization of this EIS.

- **Chapter 2—Proposed Actions and Alternatives.** Chapter 2 describes the alternatives evaluated in this EIS. This chapter also includes a description of the processes and facilities that could be used to implement each of the alternatives and a summary of the short- and long-term environmental impacts and cost estimates of each alternative.

- **Chapter 3—Affected Environment.** Chapter 3 describes the existing Hanford and INL environments that may be affected by the alternatives under consideration. In general, Hanford as a whole is described first, followed by the 200 and 400 Areas. The existing environments described include human, air, surface, and subsurface media that could be affected by activities related to tank waste retrieval, treatment, and disposal; SST system closure; FFTF decommissioning; and waste management.

- **Chapter 4—Short-Term Environmental Consequences.** Chapter 4 discusses the short-term environmental impacts associated with the various EIS alternatives for tank closure, FFTF decommissioning, and waste management. Impacts produced by construction, operations, decontamination, and decommissioning are considered.

- **Chapter 5—Long-Term Environmental Consequences.** Chapter 5 discusses the long-term environmental impacts associated with the various EIS alternatives for tank closure, FFTF decommissioning, and waste management, focusing on long-term environmental impacts on groundwater and human health, as well as ecological risks.

- **Chapter 6—Cumulative Impacts.** Chapter 6 discusses the cumulative impacts associated with the various EIS alternatives.

- **Chapter 7—Environmental Consequences Discussion.** Chapter 7 discusses possible measures to mitigate impacts identified in Chapters 4, 5, and 6; unavoidable adverse environmental impacts; the relationship between short-term use of the environment and long-term productivity; and any irreversible and irretrievable resource commitments.

- **Chapter 8—Potentially Applicable Laws, Regulations, and Other Requirements.** Chapter 8 describes the environmental laws, regulations, permits, and consultations that are potentially applicable to the various activities related to tank waste retrieval, treatment, and disposal and SST system closure; FFTF decommissioning; and waste management associated with the alternatives. Federal laws and regulations; Executive orders; DOE directives, orders, and guidance; and other compliance actions related to protection of the environment also are described.

- **Chapter 9—Glossary.** Chapter 9 contains definitions of important technical terms that may not be commonly used, including both discipline-specific and DOE- and Hanford-unique terms.

- **Chapter 10—List of Preparers.** Chapter 10 identifies the DOE and contractor preparers of this EIS. Information is provided for each preparer in the following areas: (1) name, (2) affiliation, (3) education, (4) experience, and (5) EIS responsibility.

- **Chapter 11—Distribution List.** Chapter 11 contains the external distribution list for this EIS, which includes Federal, state, and local elected and appointed officials and agencies; American Indian representatives; environmental and public interest groups; and organizations and individuals who requested/were sent a copy of this draft EIS.

- **Chapter 12—Index.** Chapter 12 contains the index of key words and terms found in this EIS.

In addition, the following appendices are provided to support these chapters:

- Appendix A *Federal Register* and Other Public Notices
- Appendix B Contractor and Subcontractor National Environmental Policy Act Disclosure Statements
- Appendix C Cooperating Agency, Consultation, and Other Interaction Documentation
- Appendix D Waste Inventories
- Appendix E Descriptions of Facilities, Operations, and Technologies
- Appendix F Direct and Indirect Impacts: Assessment Methodology
- Appendix G Air Quality Analysis

- Appendix H Transportation
- Appendix I Workforce Estimates
- Appendix J Environmental Justice
- Appendix K Human Health Risk Analysis
- Appendix L Groundwater Flow Field Development
- Appendix M Release to Vadose Zone
- Appendix N Vadose Zone Flow and Transport
- Appendix O Groundwater Transport Analysis
- Appendix P Ecological Resources and Risk Analysis
- Appendix Q Human Health, Dose, and Risk Analysis
- Appendix R Cumulative Impacts: Assessment Methodology
- Appendix S Waste Inventories for Cumulative Impact Analyses
- Appendix T Supporting Information for the Short-Term Cumulative Impact Analyses
- Appendix U Supporting Information for the Long-Term Cumulative Impact Analyses
- Appendix V Black Rock Reservoir Sensitivity Analysis

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WAC 173-303, Washington State Department of Ecology, "Dangerous Waste Regulations," Olympia, Washington, March 2003.

WAC 173-303-640, Washington State Department of Ecology, "Dangerous Waste Regulations: Tank Systems," Olympia, Washington, March 2003.

WAC 173-303-665, Washington State Department of Ecology, "Dangerous Waste Regulations: Landfills," Olympia, Washington, March 2003.

WAC 197-11, Washington State Department of Ecology, "SEPA Rules," Olympia, Washington, August 2003.

CHAPTER 2
PROPOSED ACTIONS AND ALTERNATIVES

Chapter 2 describes the processes and facilities that could be used to implement each of the alternatives proposed for this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*. Section 2.1 introduces the proposed actions addressed in this *TC & WM EIS* and outlines the contents of Chapter 2. Section 2.2 describes the existing and proposed tank farm operations and facilities and provides an overview of the various storage, retrieval, treatment, disposal, and closure technologies considered in the analyses of the tank closure proposed actions. Section 2.3 describes the existing Fast Flux Test Facility and auxiliary buildings; the status of ongoing deactivation activities, as well as proposed decommissioning activities and various technologies for dispositioning the facilities; disposal of remote-handled special components; and bulk sodium processing. Section 2.4 describes the existing Hanford Solid Waste Operations Complex and proposed solid waste management activities. Section 2.5 describes the range of alternatives evaluated in detail in this *TC & WM EIS*, including the No Action Alternatives. Section 2.6 summarizes the other technologies and options that were initially considered for the proposed actions, but were not evaluated in detail in this *TC & WM EIS*. Section 2.7 compares the *TC & WM EIS* alternatives and describes associated technical and programmatic uncertainties. Sections 2.8 and 2.9 summarize the short- and long-term environmental impacts of the alternatives, respectively. Section 2.10 presents the key environmental findings and conclusions drawn from the analyses. Section 2.11 provides a general discussion of the costs associated with each alternative. The chapter concludes with a brief discussion of preferred alternatives in Section 2.12.

2.1 INTRODUCTION

As discussed in Chapter 1, the U.S. Department of Energy (DOE) is proposing three sets of actions in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*. The first set of proposed actions is to retrieve, treat, and dispose of waste being managed in the high-level radioactive waste (HLW) single-shell tank (SST) and double-shell tank (DST) farms at the Hanford Site (Hanford) and to close the SST system, which includes disposition of the SSTs, ancillary equipment, and soils. The SST (149 tanks) and DST (28 tanks) systems contain both hazardous and radioactive waste (mixed waste). The second set of proposed actions analyzed in this environmental impact statement (EIS) is to decommission Hanford's Fast Flux Test Facility (FFTF) and auxiliary facilities; manage the waste from the decommissioning process, including certain waste designated as remote-handled special components (RH-SCs); and handle disposition of Hanford's inventory of radioactively contaminated bulk sodium from FFTF and other facilities on site. The third set of proposed actions involves various options for managing the waste resulting from tank closure and other Hanford activities, as well as limited volumes received from other DOE sites.

Proposed Actions

Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1508.18) define a proposed action as any "major Federal action" that may have major effects and is subject to Federal control and responsibility. Actions include new and continuing activities such as projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by Federal agencies. The proposed actions analyzed in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* focus on (1) closing the single-shell tank system; (2) decommissioning the Fast Flux Test Facility; and (3) managing solid waste at the Hanford Site.

DOE has developed various alternatives to address the three sets of proposed actions described above. As discussed in Chapter 1, Section 1.7, and throughout this chapter, there are 11 Tank Closure alternatives and subalternatives, 3 FFTF Decommissioning alternatives; and 3 Waste Management alternatives:

Tank Closure Alternatives

Tank Closure Alternative 1: No Action

Tank Closure Alternative 2: Implement the *Tank Waste Remediation System EIS* Record of Decision with Modifications

- Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure
- Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Tank Closure Alternative 3: Existing WTP Vitrification with Supplemental Treatment Technology; Landfill Closure

- Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

- Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

- Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Tank Closure Alternative 6: All Waste as Vitrified HLW

- Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure (Base and Option Cases)

- Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure (Base and Option Cases)

- Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

FFTF Decommissioning Alternatives

FFTF Decommissioning Alternative 1: No Action
FFTF Decommissioning Alternative 2: Entombment
FFTF Decommissioning Alternative 3: Removal

Waste Management Alternatives

Waste Management Alternative 1: No Action
Waste Management Alternative 2: Disposal in IDF, 200-East Area Only
Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

The following sections provide an overview of current and proposed tank farm, FFTF, and waste management activities and applicable technologies. Detailed descriptions of each Tank Closure, FFTF Decommissioning, and Waste Management alternative are presented in Section 2.5.

2.2 HANFORD TANK FARM SYSTEM CLOSURE ACTIONS

The waste being managed in the HLW tank system is the byproduct of producing plutonium and other defense-related materials. From 1944 through 1990, chemical processing facilities at Hanford reprocessed irradiated or spent nuclear fuel (SNF) use from defense reactors to separate and recover plutonium for weapons production. As new, improved reprocessing operations were developed over the last 50 years, processing efficiency improved, and the waste compositions sent to the tanks for storage have changed both chemically and radiologically. The B and T Plants were the first separations facilities built at the site. The separations processes carried out at these plants recovered only plutonium; consequently, all remaining components of the dissolved fuel elements, including uranium, were sent to the waste tanks (DOE and Ecology 1996:3–1).

Waste Types Analyzed in This Environmental Impact Statement

Hazardous waste: A category of waste regulated under the Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901 et seq.). To be considered hazardous, a waste must (1) be a solid waste under RCRA; (2) exhibit at least one of the four characteristics described in 40 CFR 261.20 through 261.24 (ignitability, corrosivity, reactivity, or toxicity); or (3) be specifically listed by the U.S. Environmental Protection Agency (EPA) in 40 CFR 261.31 through 261.33. Hazardous waste may also include solid waste designated as dangerous or extremely hazardous waste by the State of Washington (WAC 173-303-070 through 173-303-100).

High-level radioactive waste (HLW): Highly radioactive waste material resulting from reprocessing of spent nuclear fuel (SNF), including liquid waste produced directly from reprocessing; any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation (DOE Manual 435.1-1).

Low-activity waste (LAW): Waste that remains after as much radioactivity as technically and economically practical has been separated from HLW that, when solidified, may be disposed of as low-level radioactive waste (LLW) in a near-surface facility. In its final form, such solid LAW would not exceed 10 CFR 61.55 Class C radioisotope limits and would meet performance objectives comparable to those in 10 CFR Part 61, Subpart C. At the Hanford Site, this is mixed waste.

Low-level radioactive waste (LLW): Radioactive waste that is not HLW, SNF, transuranic (TRU) waste, byproduct material as defined in the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), or naturally occurring radioactive material.

Mixed waste: Waste that contains source, special nuclear, or byproduct material that is subject to the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), as well as a hazardous component subject to RCRA.

Transuranic (TRU) waste: Radioactive waste products containing more than 100 nanocuries (3,700 becquerels) of alpha-emitting TRU isotopes per gram of waste with half-lives greater than 20 years, except (1) HLW; (2) waste that does not need the degree of isolation required by the disposal regulations detailed in 40 CFR 191, as determined by the Secretary of Energy with the concurrence of the EPA Administrator; or (3) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

Processes were later developed to recover uranium, which was recycled back into the reactor fuel cycle. Many of the chemical processes associated with plutonium recovery from SNF involved dissolving the material in nitric acid. The resulting acidic waste streams were made alkaline by adding sodium hydroxide or calcium carbonate before being transferred to the tanks. These processing steps produced large volumes of sodium nitrate salts in the tanks (DOE and Ecology 1996:3–1).

The tank waste is categorized as liquid, sludge, or salt cake. Liquid tank waste is made up of water and organic compounds that contain dissolved salts. Depending on their type, the liquid organic compounds either are dissolved in the water or exist in separate phases of solution. Liquid is present in the tanks either as supernatant liquid (where the volume is relatively free of solid particles and present in larger pools) or as interstitial liquid (where the volume fills the interstitial spaces surrounding the sludge and salt cake particles). Sludge is a mixture of insoluble (i.e., will not dissolve in-tank liquid) metal salt compounds that have precipitated and settled out of solution after the waste was made alkaline. Salt cake

is primarily sodium and aluminum salts that have crystallized out of solution during evaporation (DOE and Ecology 1996:3-7, 3-8; Naiknimbalkar 2006:5).

These three types of waste exist in the tanks in numerous combinations and proportions, resulting in complex waste combinations with varied physical and chemical properties. Sludge has been found with consistencies from mud to hardened clay. Layers of organic compounds have been found in some tanks floating on top of solid waste. Crusts have formed in some tanks where a layer of solid waste has formed on top of the liquid (DOE and Ecology 1996:3-8).

DOE's strategy for retrieving, treating, and disposing of the tank waste and closing the SST farms has evolved based on information developed since issuance of the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement (TWRS EIS)* (DOE and Ecology 1996) Record of Decision (ROD) (62 FR 8693). The following items reflect this new information and the proposed changes to DOE's strategy.

- Changes in the design of, and preliminary performance projections for, the Waste Treatment Plant (WTP) (currently under construction) are being proposed to extend its operations beyond the original plan to operate the WTP for a 10-year period and to enhance its throughput compared to facilities that were proposed in the *TWRS EIS*.

- New information indicates that use of large-scale treatment facilities in approximately 2012 to immobilize waste not processed by the WTP, as identified in the *TWRS EIS* ROD, may be prohibitively expensive (68 FR 1052).

- DOE believes there may be certain HLW storage tanks that it could demonstrate should be classified as transuranic (TRU) waste based on the origin of the waste. This Draft *TC & WM EIS* evaluates the environmental impacts of managing this waste as TRU waste because it assumes the historical processing data support this classification. For Tank Closure Alternatives 3 through 5, this EIS evaluates treating the waste stream associated with the TRU waste portion as both TRU waste and HLW because this waste has not gone through the TRU waste confirmation and certification processes.

- DOE wants to consider nonvitrification treatment technologies for low-activity waste (LAW), if this waste can be immobilized and disposed of on site while providing protection to the human environment, comparable to LAW immobilized by vitrification (see Appendix E).

DOE's present management of the Hanford tank farm system is consisting of four major components:

SST system. This component includes 149 SSTs, ancillary equipment, and soils (from surface soils to the soil interface with groundwater) within the HLW tank farms and/or waste management area boundaries used to support Hanford waste retrieval and storage activities.

Ancillary Equipment

Ancillary equipment within the single-shell tank (SST) system, as established in the Resource Conservation and Recovery Act Part A permit, includes all subordinate tank systems, vaults, transfer pipelines, pump pits, valve pits, lift stations, catch tanks, unloading stations, and any other components that have been, are, or may be used to treat, store, or transfer hazardous and/or mixed waste within the boundary of the SST system. Appendix E, Section E.1.2.5.2, provides a detailed description of these components.

DST system.[1] This component includes 28 existing DSTs, ancillary equipment, and soils. It also includes new retrieval and delivery systems that are currently under construction and (potentially) any new DSTs needed to complete the DOE River Protection Project (RPP) mission.[2]

Waste treatment. This component includes existing and potential new pretreatment, vitrification, and supplemental treatment facilities used to treat Hanford tank waste prior to disposal.

Waste disposal. This component includes existing and potential new facilities required for interim storage and disposal of treated Hanford tank waste.

2.2.1 Tank Farm Operations and Facilities

The 149 SSTs, 28 DSTs, and ancillary equipment considered under the set of proposed actions for tank closure are distributed among 18 tank farms located in the 200 Areas of Hanford. The 200 Areas are divided into east and west components (200-East Area and 200-West Area), and each tank farm contains 2 to 18 tanks (see Figure 2–1 for a photograph of the tanks under construction). Figure 2–2 illustrates the key components of the tank farm system and the range of tank waste remediation approaches considered in this *TC & WM EIS*. As shown in Figures 2–3 and 2–4, the 200-West Area includes 6 SST farms (S, SX, T, TX, TY, and U) and 1 DST farm (SY); the 200-East Area includes 6 SST farms (A, AX, B, BX, BY, and C) and 5 DST farms (AN, AP, AW, AY, and AZ).

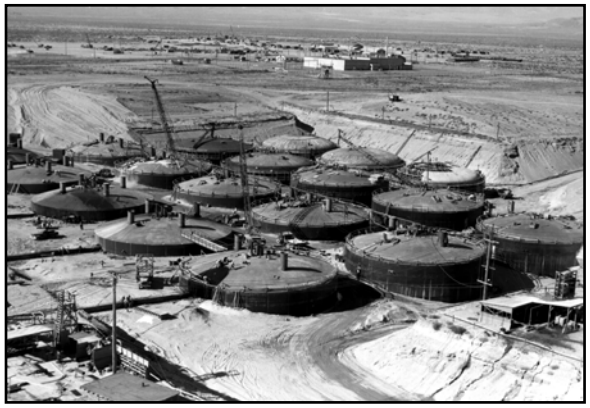


Figure 2–1. The Hanford Site's Waste Tanks Under Construction

Also included in the tank farm system are 66 miscellaneous underground storage tanks (MUSTs), most of which are inactive. These MUSTs are constructed of steel, concrete, or both, and range in capacity from approximately 3,000 to 190,000 liters (800 to 50,000 gallons). The inactive MUSTs, which are smaller than the SSTs and DSTs, were used for settling solids out of liquid waste before decanting the liquid to cribs and trenches (ditches), reducing the acidity of process waste, conducting uranium recovery operations, collecting waste transfer leakage, and performing waste handling activities and experiments. Active MUSTs are still used as receiver tanks during transfer activities or as catch tanks to collect potential spills and leaks. (DOE 2003a:Table 6–29; Hebdon 2001). The closure of 18 of these 66 MUSTs is not within the scope of this *TC & WM EIS* (see Appendix E, Section E.1.2.1.1.1).

[1] For analysis purposes, the DST system includes the 242-A Evaporator, which has a separate operating permit from the DSTs.

[2] A decision on closure of the DSTs is not part of the proposed actions because they are active components that are needed to complete waste treatment. Closure of the DSTs would need to be addressed at a later date subject to appropriate National Environmental Policy Act review. Some alternatives addressed by this EIS include closure of the SST system. Because DSTs may be located in an area of the SST system being closed under these alternatives, the impacts associated with closure of all of the DSTs (such as the impacts of filling the tanks and covering the tanks with a closure barrier) were evaluated.

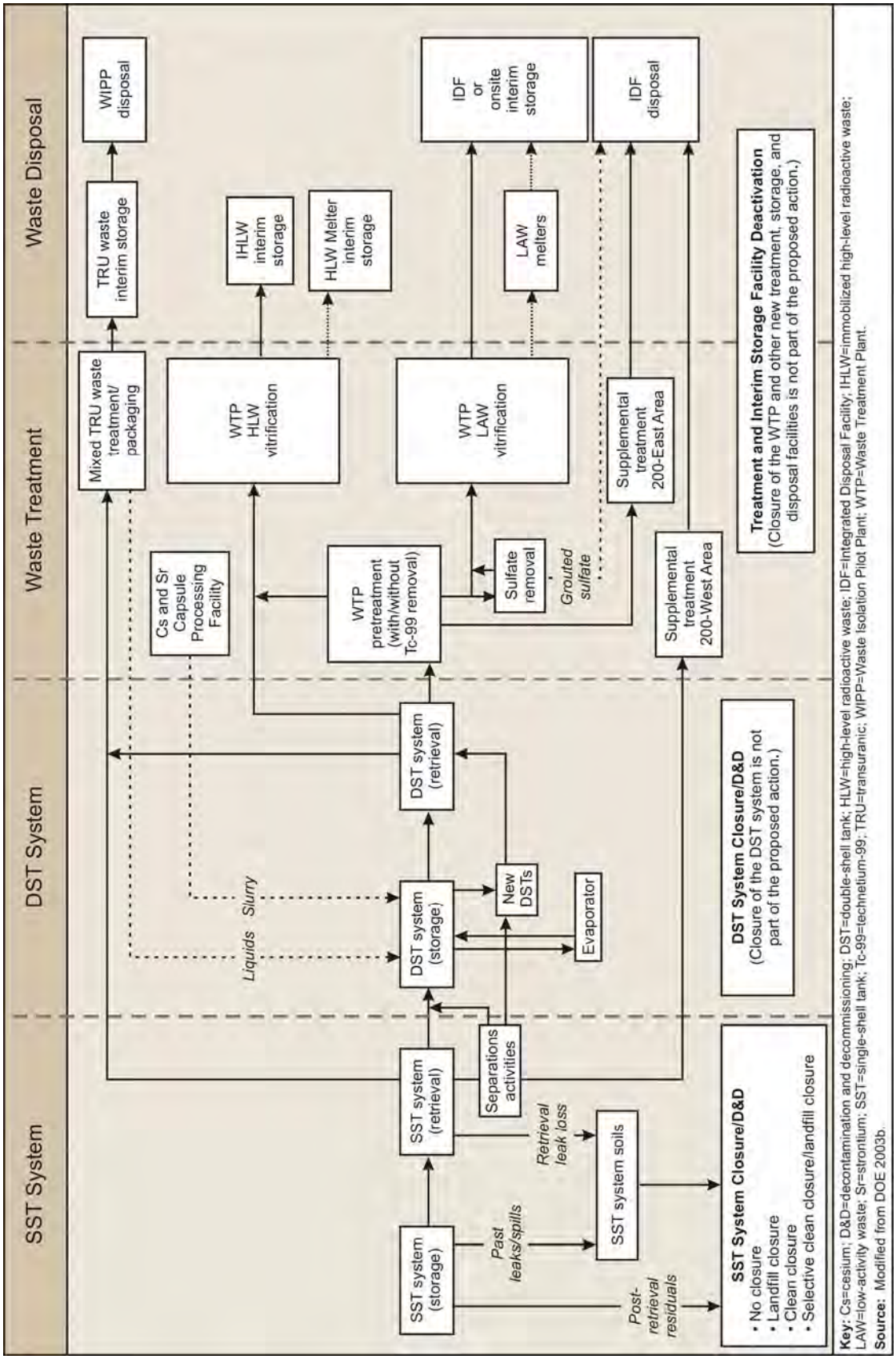


Figure 2–2. Hanford Site High-Level Radioactive Waste Tank Farm System and Remediation Approaches

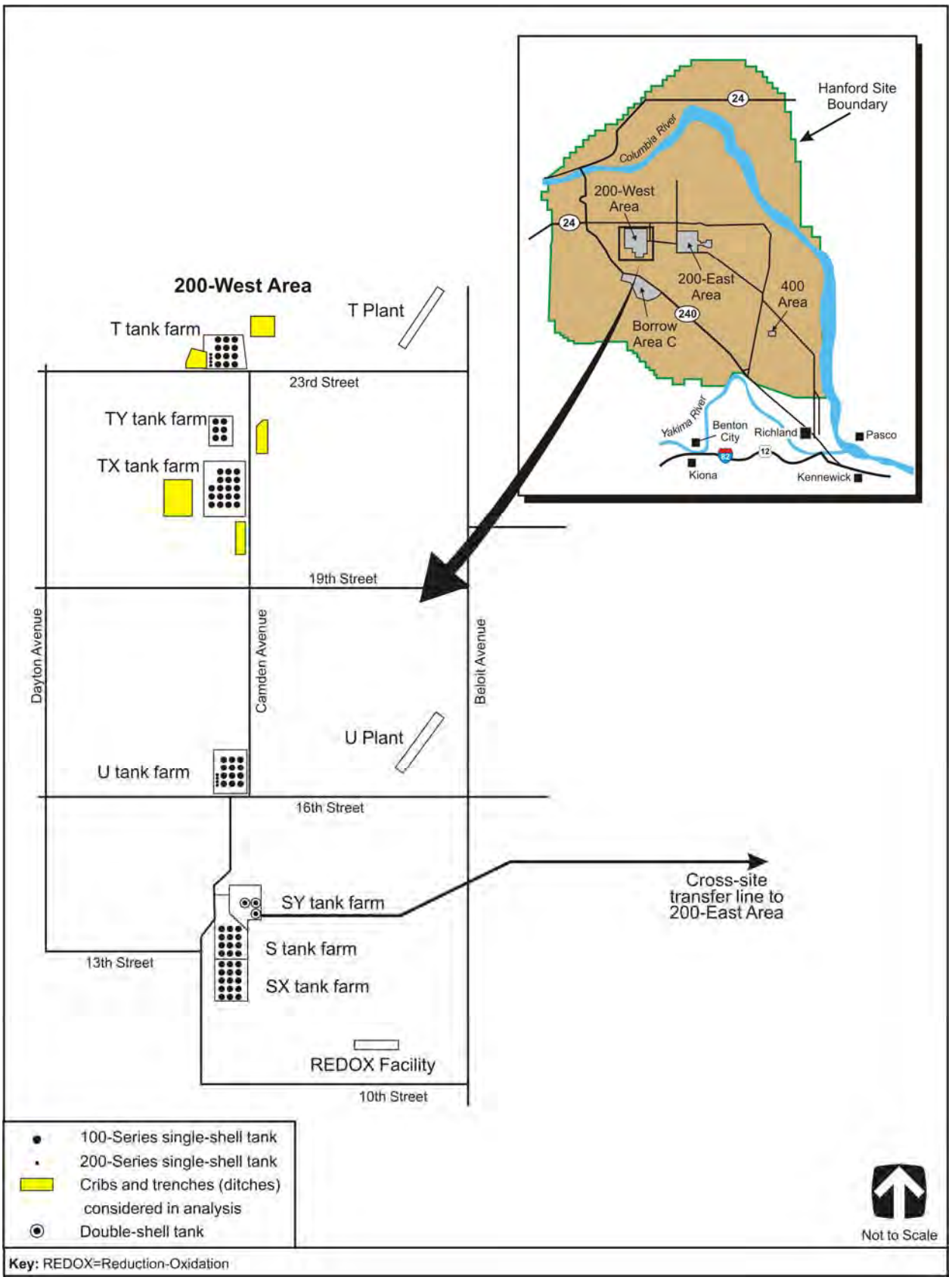


Figure 2–3. 200-West Area Tank Farm Location Map

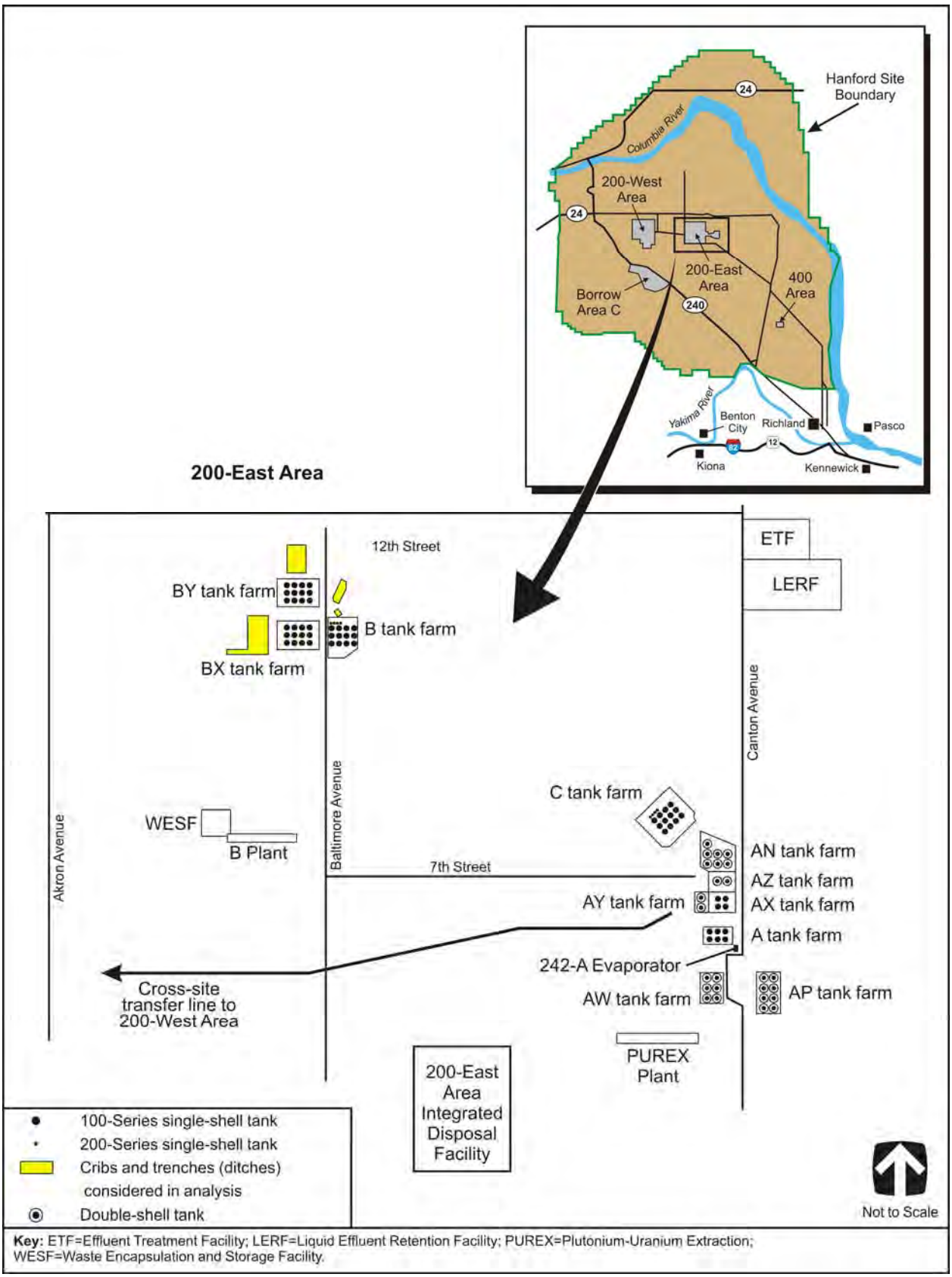


Figure 2–4. 200-East Area Tank Farm Location Map

Waste was discharged directly to the ground from SSTs during the 1940s and 1950s as part of the early plutonium and uranium recovery operations. Two types of disposal sites, cribs and trenches (ditches) were used. Cribs are underground structures designed to distribute liquid waste, usually through a perforated pipe, to the soil directly or to a connected tile field. Trenches (ditches) are depressions dug in the ground that are open to the atmosphere and are designed for disposal of low- or intermediate-level radioactive waste. Some of these cribs and trenches (ditches), specifically the B Cribs, BX Trenches, BY Cribs, T Cribs, T and TX Trenches, and TY Cribs, are close to the SST farms. Because of this proximity, it is sometimes difficult to clearly identify contamination sources in the groundwater and vadose zone (Waite 1991:6, A-1). Therefore, these cribs and trenches (ditches) are included in the tank farm analyses as a connected action under all of the Tank Closure alternatives considered in this *TC & WM EIS*. The balance of the cribs, trenches (ditches), 18 MUSTs, and other waste sites at Hanford are analyzed in Chapter 6.

The following sections describe the existing SST and DST farm facilities, as well as current DOE activities associated with routine operations and maintenance, tank farm upgrades, and WTP construction.

2.2.1.1 Single-Shell Tanks

The first 149 waste storage tanks constructed were SSTs. An SST is a single-wall underground storage tank with carbon steel sides and bottom surrounded by a reinforced-concrete shell. The SSTs were built from 1943 to 1964 to hold the liquid radioactive waste created by the production and separation of plutonium. The numbers and nominal capacities of the SSTs are as follows (DOE 2003c:6-7):

- 25 tanks of 3.8-million-liter[3] (1-million-gallon) capacity (100-series)
- 48 tanks of 2.9-million-liter (758,000-gallon) capacity (100-series)
- 60 tanks of 2.0-million-liter (530,000-gallon) capacity (100-series)
- 16 tanks of 208,000-liter (55,000-gallon) capacity (200-series)

A representative illustration of each of these SST types is presented in Figure 2–5.

The total nominal holding capacity of the SSTs is approximately 356 million liters (94 million gallons). The tanks currently contain approximately 120 million liters (32 million gallons) of radioactive and hazardous waste (DOE 2003c:6-7). These tanks contain salt cake and sludge; most of their free liquids were evaporated or transferred to the newer DSTs to reduce the potential consequences of leaks.

The tops of the tanks are buried approximately 2.5 meters (8 feet) below ground to provide radiation shielding. The larger tanks have multiple risers (shielded openings) that provide tank access from the surface. These risers provide access points for monitoring instrumentation, video observation, tank ventilation systems, and sampling. As analyzed in this *TC & WM EIS*, 67 of the SSTs are known or are suspected to have leaked liquid waste to the environment between the 1950s and the present, some of which has reached the groundwater. However, it is likely that some of the tanks have not actually leaked. Estimates of the total leak loss range from less than 2.8 million to as much as 3.97 million liters (750,000 to 1,050,000 gallons) (Hanlon 2003:B-13–B-15).

[3] To convert liters to cubic meters, divide by 1,000; cubic meters to cubic feet, multiply by 35.315.

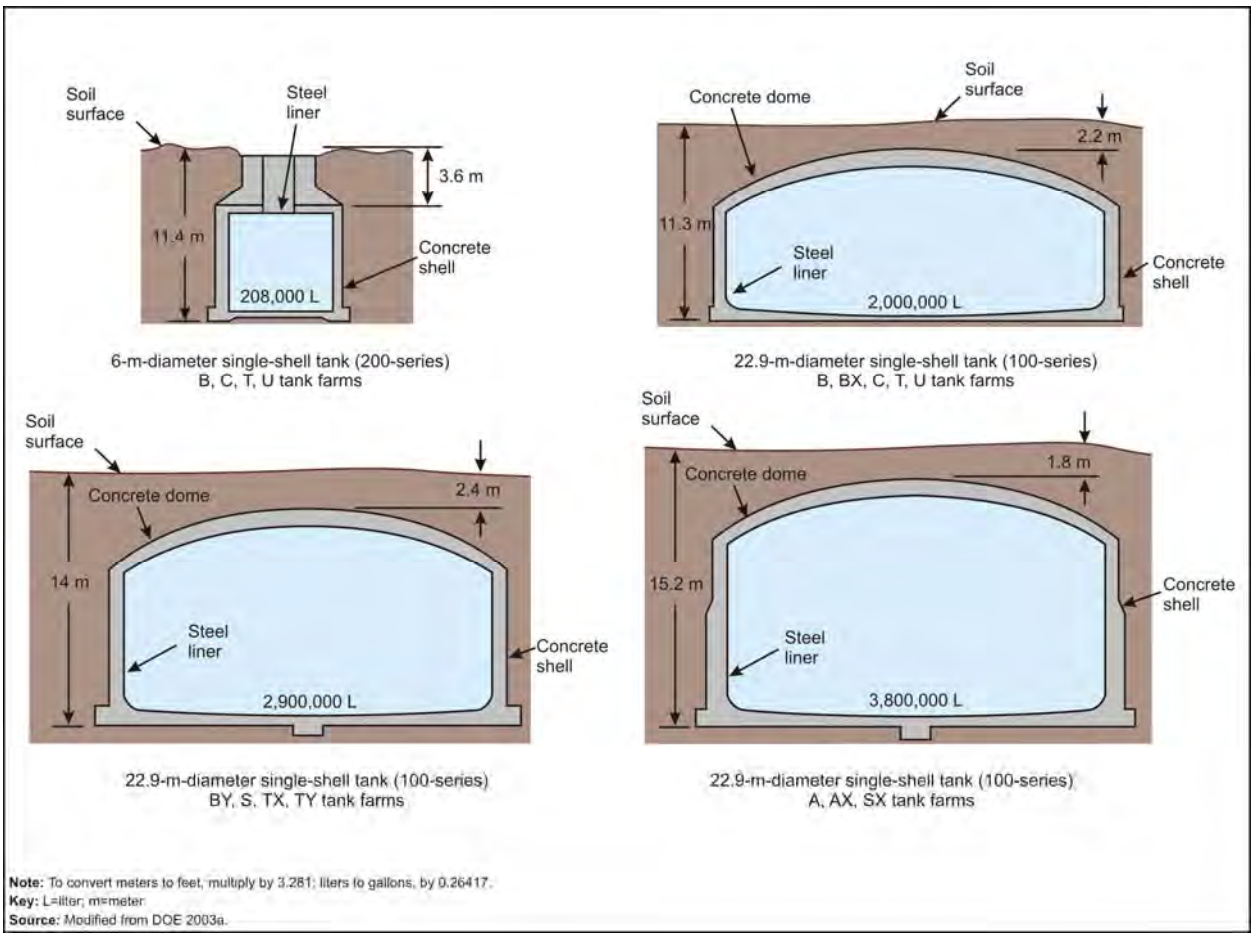


Figure 2–5. Cross-Sectional Views of Representative Hanford Site Single-Shell Tanks

2.2.1.2 Double-Shell Tanks

The last 28 waste tanks constructed at Hanford were DSTs built from 1968 to 1986. The DSTs contain a carbon steel tank inside a carbon steel-lined reinforced-concrete tank. This design provides improved leak detection and waste containment. To date, no leaks have been detected in the annulus, the space between the inner and outer tanks that houses equipment to detect and recover waste in the event of a leak from the inner tank. Like the SSTs, the DSTs are buried below ground and have risers for tank monitoring and access. The numbers and nominal capacities of the DSTs are as follows (DOE 2003c:6-7):

- 4 tanks of approximately 3.8-million-liter (1-million-gallon) capacity
- 24 tanks of approximately 4.4-million-liter (1.16-million-gallon) capacity

The DSTs have a total nominal holding capacity of 117 million liters (31 million gallons) and currently contain approximately 85 million liters (22.5 million gallons) of radioactive and hazardous waste, generally liquids and settled salts (DOE 2003c:6-8). Some tanks also contain a bottom layer of sludge. A representative DST is illustrated in Figure 2–6.

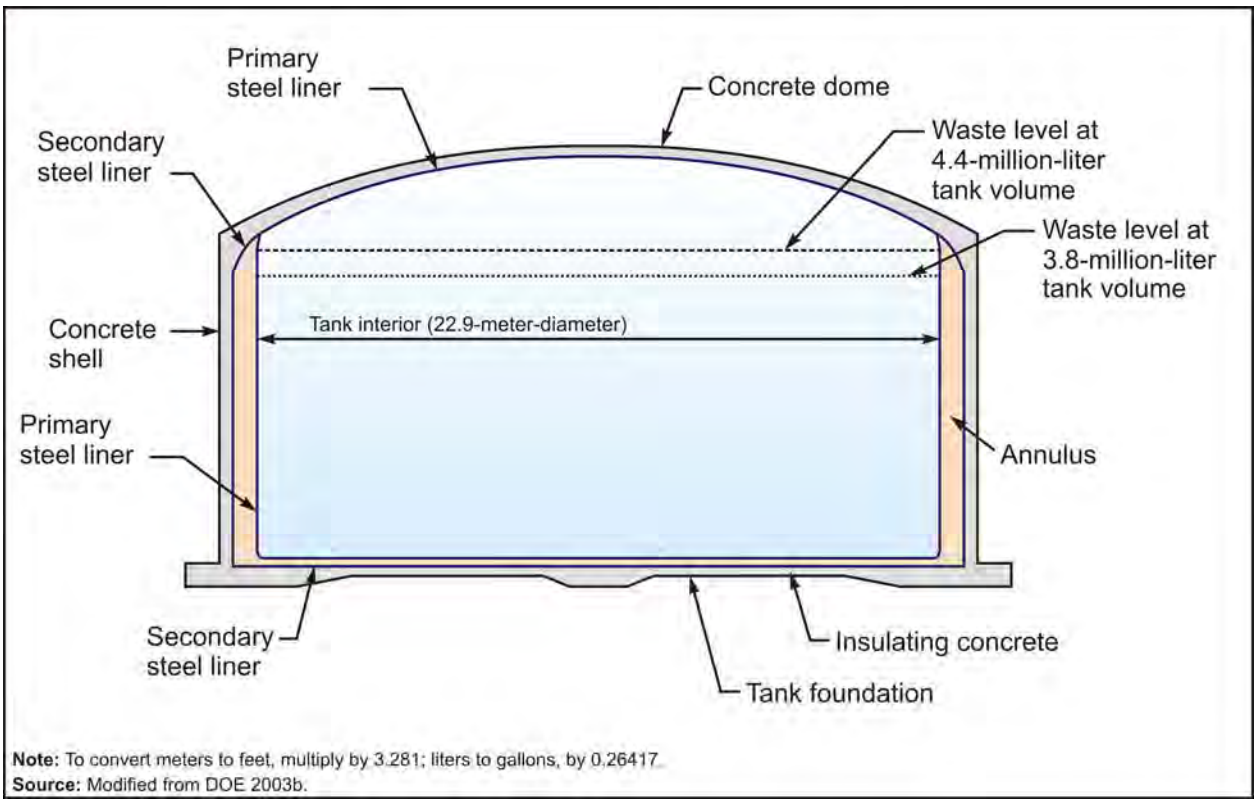


Figure 2–6. Cross-Sectional View of Representative Hanford Site Double-Shell Tank

2.2.1.3 DOE River Protection Project

Current RPP activities can be divided into three main areas: (1) routine operations and maintenance of the tank farm system, (2) tank farm upgrades and construction projects, and (3) WTP construction. The current program is based primarily on implementing Phase I of the Preferred Alternative identified in the *TWRS EIS*, as discussed in Chapter 1, Sections 1.2.2 and 1.2.3. The Tank Closure alternatives evaluated in this EIS (with the exception of the No Action Alternative) include the various activities needed to complete treatment of the tank waste and provide final disposition of the SST system. The following discussion presents an overview of current RPP activities. See Appendix E, Section E.1.1, for a more-detailed description of RPP activities.

2.2.1.3.1 Routine Tank Farm Operations and Maintenance

Routine tank farm system operations entail waste retrieval and transfer operations, evaporation, SST system closure activities, DST integrity assessments, and life extension activities. Included among these activities are nondestructive examination (NDE) of the tank system, chemical adjustments to tank contents to control corrosion, and upgrades to the 242-A Evaporator and 222-S Laboratory as needed to support RPP activities. Interim stabilization of the SST waste was completed in April 2004, except for tank S-102 (CH2M HILL 2004), and included stabilization pumping operations, transfer of waste to double-walled receiver tanks and DSTs, and transfer of waste from the 200-West Area tank farms to the 200-East Area tank farms (cross-site transfer activities).

Routine tank farm operations also include regular system monitoring to ensure compliance with safety basis, environmental, occupational safety and health, and other applicable regulatory requirements, as well as administrative and technical support. More discussion on potentially applicable requirements is provided in Chapter 8 of this EIS.

Routine maintenance activities consist primarily of preventive and corrective actions to ensure equipment remains operable and functional to support system operations. Such activities include maintenance of SST and DST system components and the waste feed delivery system that is currently being constructed to supply waste feed to the WTP.

2.2.1.3.2 Tank Farm Upgrades

Tank farm upgrade and construction projects are presently under way to provide systems for retrieval and transfer of waste to the WTP and for storage or disposal of waste produced by the treatment process. Additional projects include tank upgrades and completion of upgrades to the Canister Storage Building (CSB) to provide interim storage of immobilized high-level radioactive waste (IHLW).

2.2.1.3.3 Waste Treatment Plant Construction

The WTP is currently under construction in the 200-East Area of Hanford; to date, approximately 40 percent of construction is complete (Bechtel 2008). As configured, the WTP will have four main components: plants for pretreatment of tank waste, LAW vitrification, and HLW vitrification, as well as a large Analytical Laboratory. The WTP is designed to receive tank waste via pipelines from the tank farm systems, treat the waste, and convert the treated waste into a glass form for storage, pending disposal. Current WTP activities include design, regulatory permitting and licensing, and construction.

2.2.2 Proposed Retrieval, Treatment, and Disposal of Tank Waste and Closure of the Single-Shell Tank System

This section presents an overview of the key storage, retrieval, treatment, disposal, and closure technologies and facilities that would be used at Hanford to implement the tank closure proposed actions. The candidate locations of new facilities in the 200-West and 200-East Areas that are considered under the proposed actions are illustrated in Figures 2–7 and 2–8, respectively. Final site selection for technologies other than the WTP has not been implemented and would proceed only following the ROD for this *TC & WM EIS*. More-detailed descriptions of these proposed technologies and facilities are presented in Appendix E, Section E.1. These are representative technologies, and their evaluation in this EIS does not preclude the use of other retrieval approaches or modification of existing retrieval systems.

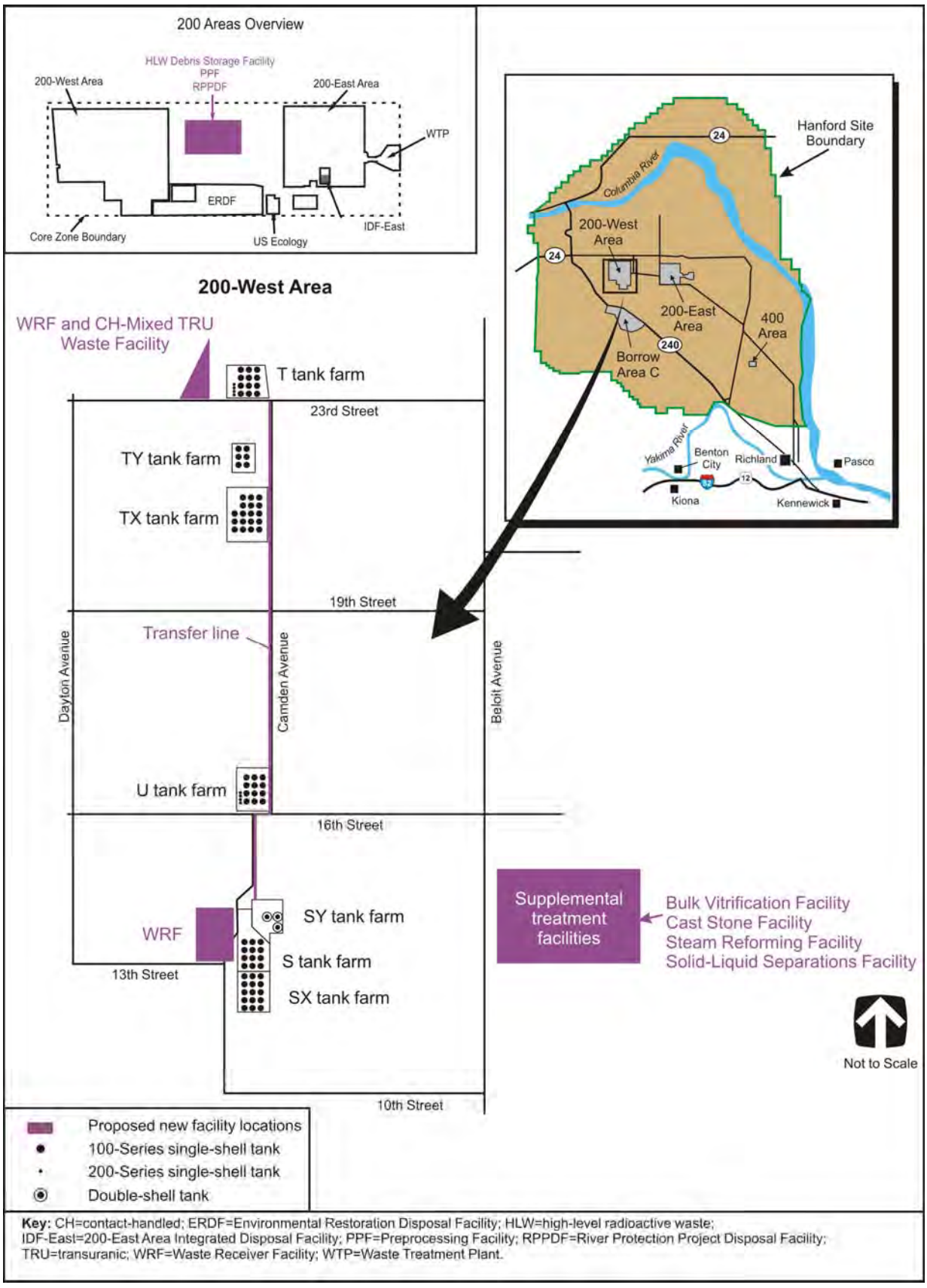


Figure 2–7. 200-West Area Proposed New Tank Closure Facility Locations

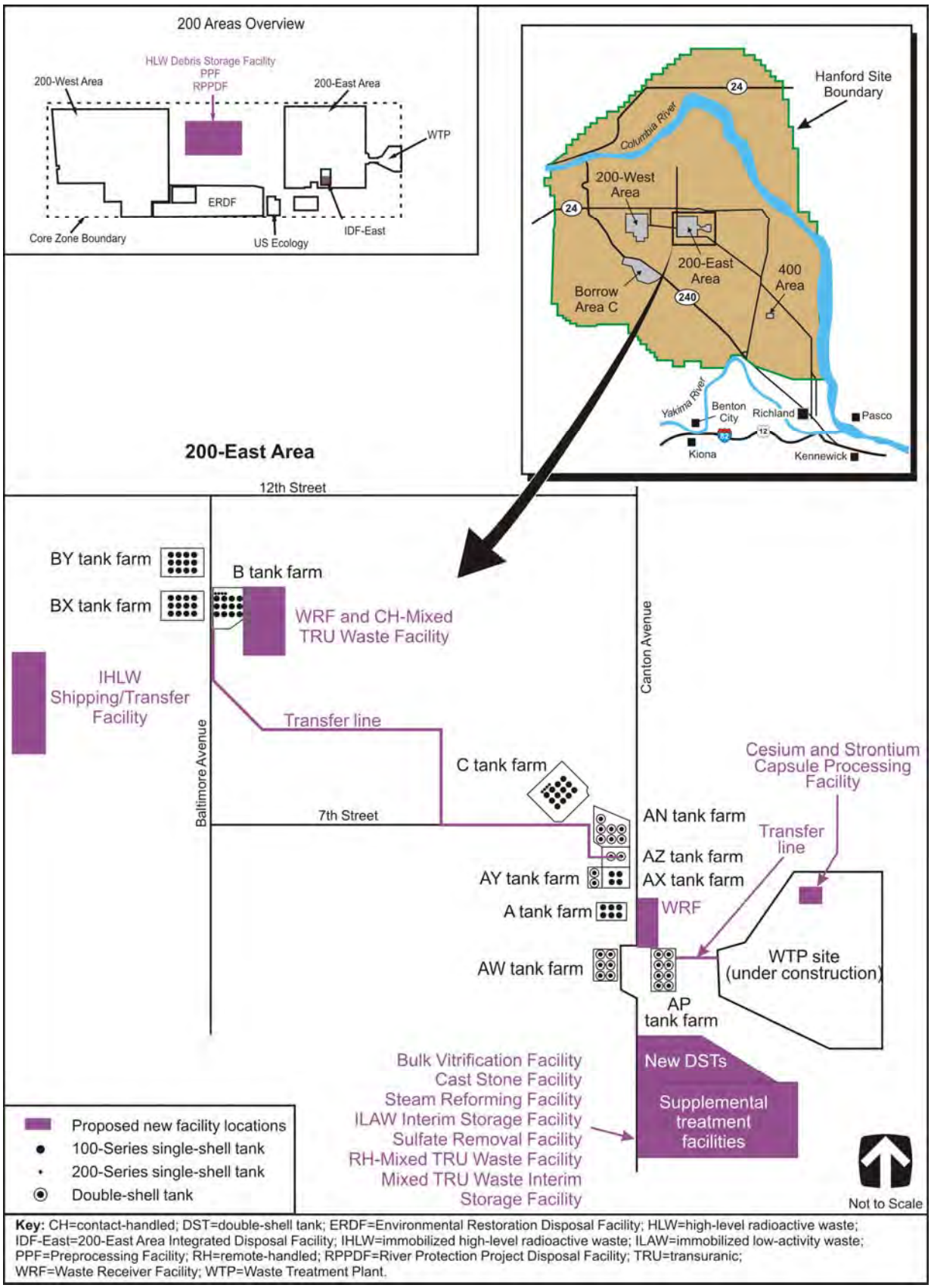


Figure 2–8. 200-East Area Proposed New Tank Closure Facility Locations

2.2.2.1 Waste Retrieval and Storage

This section describes the proposed technologies for retrieving and storing waste from the SST and DST systems that are analyzed in detail in this EIS. To support retrieval operations, these analyses also consider the existing, modified, and new systems (if required) that would be used to store and manage the waste pending retrieval.

2.2.2.1.1 Retrieval Systems

Various retrieval technologies were evaluated to determine their ability to achieve certain established waste retrieval benchmarks under the various Tank Closure alternatives. The four tank waste retrieval benchmarks considered in this *TC & WM EIS* are 0 percent (Alternative 1), 90 percent (Alternative 5), 99 percent (Alternatives 2A, 2B, 3A, 3B, 3C, and 6C), and 99.9 percent (Alternatives 4, 6A, and 6B). These waste retrieval benchmarks coincide with the following definitions for retrieval percentages, which were developed from Milestone M-45-00 and Appendix H, "Single Shell Tank Waste Retrieval Criteria Procedure," of the Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement [TPA]) (Ecology, EPA, and DOE 1989).

- A **0 percent retrieval** involves no removal of tank waste. The 0 percent retrieval was analyzed for the No Action Alternative.

- A **90 percent retrieval** involves removing tank waste to achieve a residual waste volume equal to 102 cubic meters (3,600 cubic feet) for the 100-series SSTs and 8.5 cubic meters (300 cubic feet) for the 200-series SSTs.

- A **99 percent retrieval** involves removing tank waste to achieve a residual waste volume equal to 10.2 cubic meters (360 cubic feet) for the 100-series SSTs and 0.85 cubic meters (30 cubic feet) for the 200-series SSTs.

- A **99.9 percent retrieval** involves removing tank waste to achieve a residual waste volume equal to 1 cubic meter (36 cubic feet) for the 100-series SSTs and 0.08 cubic meters (3 cubic feet) for the 200-series SSTs.

The four retrieval systems analyzed in this *TC & WM EIS* to attain these four benchmarks are modified sluicing, the mobile retrieval system (MRS), vacuum-based retrieval (VBR), and chemical wash tank cleaning. Other retrieval systems continue to be developed.

2.2.2.1.1.1 Modified Sluicing

Modified sluicing introduces liquid into the waste at low-to-moderate pressures and volumes. At lower pressures and flow rates, the retrieval action is primarily related to dissolution and retrieval of soluble materials. At higher pressures and flow rates, the retrieval action is related to both dissolution of soluble materials and the breaking apart of solid materials (such as the salt cake pictured in Figure 2–9) into a waste slurry. A transfer pump inside the tank pumps the waste to a receiver tank (either a DST or a waste receiver facility [WRF]) (DOE 2003b:4-2). See Appendix E, Section E.1.2.2.1, for a more-detailed discussion of modified sluicing.



Figure 2–9. Crystallized Salt Cake Inside One of Hanford Site's Waste Tanks

Modified sluicing differs from the past-practice sluicing previously used to remove waste from more than 50 tanks at Hanford. Past-practice sluicing introduced sluicing liquid from a single sluice nozzle in bulk fashion via a flooding action.

Modified sluicing, however, introduces sluice liquid from two to three sluicing nozzles in a controlled fashion and pumps out the resultant waste slurry at approximately the same rate as the sluice liquid being introduced. This operating strategy maintains minimal liquid inventories within the tank at all times (DOE 2003b:4-2).

2.2.2.1.1.2 Mobile Retrieval System

The MRS uses an articulated-mast system and an in-tank vehicle to retrieve waste. The articulated-mast system is located in the central region of the tank because the required, relatively large access riser does not exist in other locations of the tank. The mast contains a waste vacuum system on an articulated arm that can be rotated to reach the central portion of the tank and can support a sluice nozzle. The in-tank vehicle can be moved around the entire tank to physically push the waste, carry a sluice nozzle, and carry a vacuum hose-and-nozzle assembly. The waste is physically removed from the tank by first mobilizing it, either physically using the in-tank vehicle or by pumping in sluice liquid, and then pumping it out of the tank using a vacuum hose-and-nozzle assembly. At the end of the retrieval campaign, the in-tank vehicle can be used to rinse the tank walls and in-tank equipment (DOE 2003b:4-3). See Appendix E, Section E.1.2.2.2, for a more-detailed discussion of the MRS.

2.2.2.1.1.3 Vacuum-Based Retrieval

VBR uses little liquid; instead, it uses a vacuum system with air as the conveyance medium. The vacuum system is deployed on an articulated-mast system positioned in the central region of the tank. The vacuum system is similar to the MRS without the in-tank vehicle. The articulated-mast system has a 4.6-meter (15-foot) reach from the stationary mast and is capable of reaching the entire tank base of the 200-series SSTs (6-meter [20-foot] diameter), but only a portion of the tank base of the 100-series SSTs, which have a 22.9-meter (75-foot) internal diameter (DOE 2003b:4-5). See Appendix E, Section E.1.2.2.3, for a more-detailed discussion of VBR.

2.2.2.1.1.4 Chemical Wash Tank Cleaning

Following bulk waste removal and residual waste retrieval using the systems discussed above, additional measures may be required to meet the target waste retrieval performance objectives established by the closure criteria. These additional measures may be needed because (1) the base program retrieval method may not directly meet the performance objective; (2) use of the base program method would require significant operational time; or (3) continued use of the base program method would impact other tank farm operations. For example, the MRS option may not be able to meet the performance objectives because the in-tank equipment may not allow direct access to some regions within the tank (DOE 2003b:4-4).

If this is the case for the retrieval approach(es) selected for a tank, then chemical cleaning may be employed. An example of chemical cleaning would be the use of oxalic acid to dissolve the waste. Acids or other chemicals can dissolve the waste into a solution that can be more readily removed from the tank. The same methods used to deliver water or waste supernatant into a tank can be used to introduce other chemicals, provided the construction materials have been selected accordingly. Likewise, the same equipment used to remove waste can be used to remove the chemical cleaning solutions if the construction materials are properly selected (DOE 2003b:4-4).

Specific chemicals to be used for Hanford tank waste retrieval could range from weak acids to strong caustics and are likely to be selected on a tank-by-tank basis to optimize, among other factors,

effectiveness in retrieving the residual waste, compatibility with the tank waste and proposed treatment processes, and worker health and nuclear safety considerations (DOE 2003b:4-4, 4-5). See Appendix E, Section E.1.2.2.4, for a more-detailed discussion of the chemical wash system.

2.2.2.1.1.5 Retrieval Strategy

Any of the technologies described in Sections 2.2.2.1.1 through 2.2.2.1.4 could be used to retrieve waste from the SSTs and DSTs. All of the technologies are flexible with regard to the general configuration of the equipment, fluid velocities and flow rates, and methods of operation. As such, tank-specific considerations such as riser availability, waste condition, or in-tank interferences might advantage one retrieval technology over another, leading to selection of that technology to retrieve waste from a particular tank. For analysis purposes, the following waste retrieval technologies were evaluated in this *TC & WM EIS* for the SST system.

- Modified sluicing would be implemented for 100-series SSTs that are not classified as known or suspected leakers. Use would be limited to those tanks that are not classified as known or suspected leakers because of concerns about the potential for leakage during retrieval, as well as regulatory prohibitions against introducing liquids into leaking tanks. A number of tanks classified as known or suspected leakers may be candidates for use of modified sluicing after further evaluation of historical leak data. Based on current design information, modified sluicing is expected to be capable of retrieving waste to both the 90 percent and 99 percent retrieval benchmarks, but is not expected to be capable of achieving 99.9 percent retrieval.

- The MRS would be used to retrieve waste from 100-series SSTs that are classified as known or suspected leakers. This technology would retrieve the waste using lower liquid volumes, thereby reducing the potential volume of a retrieval leak, should one occur. Based on current design information, the MRS is expected to be capable of retrieving waste to both the 90 percent and 99 percent waste retrieval benchmarks, but is not expected to be capable of achieving 99.9 percent retrieval.

- VBR would be used to retrieve waste from the 200-series tanks, MUSTs, and WRFs. This technology is flexible because it can be operated as a dry vacuum retrieval method, but liquid also can be introduced near the vacuum head if necessary, depending on the type of waste to be retrieved. This technology is suited for use in small tanks, and it would minimize the potential for leakage in some of the 200-series tanks that are classified as known or suspected leakers. Based on current design information, the VBR system is expected to be capable of retrieving waste to both the 90 percent and 99 percent waste retrieval benchmarks, but is not expected to be capable of achieving 99.9 percent retrieval.

- Tank chemical cleaning (coupled with the MRS and the VBR system) is capable of retrieving 99.9 percent of the waste in the tanks. This technology was selected based on the uncertainty associated with achieving 99.9 percent retrieval using modified sluicing, the MRS, or the VBR system.

Retrieval systems for DSTs have been designed and installed in select DSTs to support waste feed delivery for the WTP. These retrieval systems consist of a combination of mixer and retrieval pumps that are designed to slurry the contents of the tank and pump the waste out of the tank into the transfer system. It was assumed that the current operational DST retrieval systems are capable of retrieving 90 percent of the waste. For retrieval of DST waste to 99 or 99.9 percent, installation of additional equipment was assumed necessary. To be consistent with the retrieval methodology selection process articulated for SSTs, the modified sluicing system was assumed to be used in DSTs where 99 percent waste retrieval is

required; the MRS with a chemical wash was assumed to be used in DSTs where 99.9 percent waste retrieval is required.

2.2.2.1.2 Leak Detection Monitoring

Detection, monitoring, and mitigation of liquid releases from SSTs during waste retrieval operations are problematic because of the physical limitations of the existing tank system. Currently available leak detection and monitoring technologies to support waste retrieval include dry-well monitoring, chemical process mass balance, static-liquid-level observation, and high-resolution resistivity. Performance limitations are associated with all four of these leak detection technologies, and current plans for near-term waste retrieval include the combined use of all. It is likely that SST leak detection strategies and technologies will continue to evolve. For the purpose of estimating the resources required to implement these leak detection technologies, the leak detection and monitoring system evaluated in this *TC & WM EIS* for use during SST waste retrieval consists of the following (DOE 2003b:4-6, 4-7):

- Dry-well monitoring
- Chemical process mass balance
- Static-liquid-level observation
- High-resolution resistivity

Dry-well monitoring, chemical process mass balance, and static-liquid-level observation have been previously used as leak detection methods at Hanford. High-resolution resistivity has been tested at Hanford and is now the primary leak detection system being used during tank waste retrieval. To conservatively estimate the potential impacts associated with use of SST leak detection and monitoring technologies, this *TC & WM EIS* assumes that each of these technologies would be used for each tank, even though some SST system tanks may require use of only a subset of these technologies. This approach also supports the Tank Closure Alternatives 4 and 6 analyses, which call for enhanced leak detection systems.

The DSTs have secondary containment, consisting of a primary steel liner and a secondary steel liner, separated by an annulus (see Figure 2–6). This annulus functions by detecting tank leaks, quantifying the liquid waste released in the event of a leak, and reducing the potential environmental impact should a leak occur. No leakage was assumed to occur from the DSTs during retrieval operations because the DSTs have provisions for leak containment and collection (DOE 2003b:4-11).

2.2.2.1.3 Internal Tank Interferences

Internal tank equipment/instrumentation could pose difficulties during tank retrievals. Figure 2–10 illustrates the general arrangement of this in-tank equipment in a typical SST. For modified sluicing, the equipment/instrumentation could create areas (shadows) behind the equipment that could not be reached with the sluice liquid. For the MRS, the equipment/instrumentation could create obstructions around which the in-tank vehicle would have to maneuver. Common in-tank equipment in SSTs that could potentially interfere with retrieval equipment includes the following (DOE 2003b:4-11):

- Temperature thermocouple assemblies
- Tank waste surface-level probes
- Liquid-observation wells
- Solids-level detectors
- Salt well screens

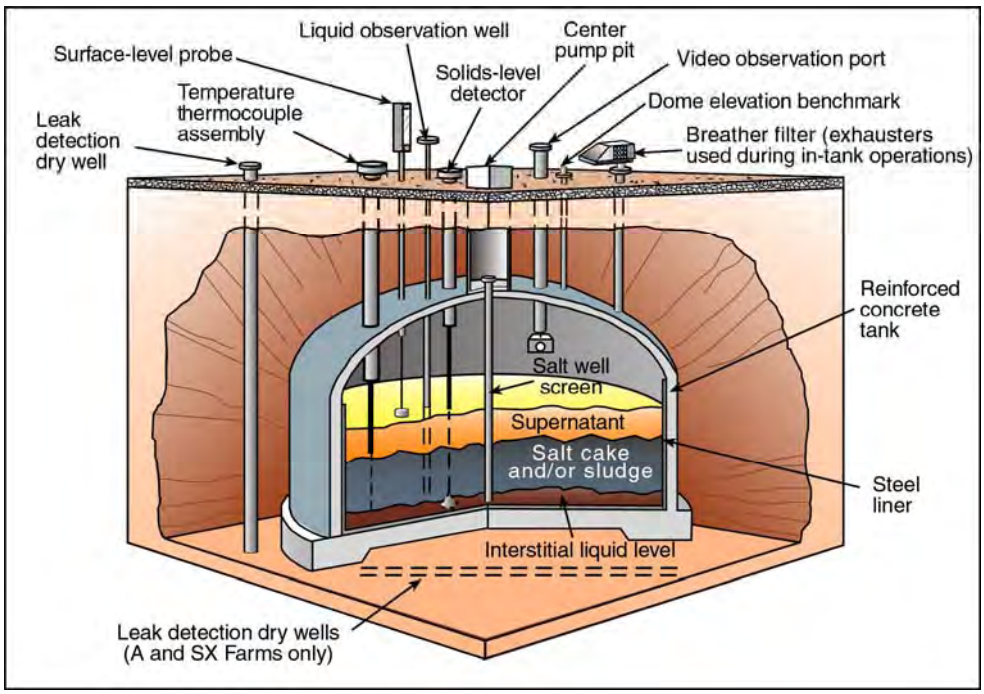


Figure 2–10. Representative Single-Shell Tank and In-Tank Equipment

Other in-tank interferences that may inhibit waste retrieval efforts include cement and bentonite, which were added to some tanks to absorb liquid, as well as other miscellaneous debris, including the following (DOE 2003b:4-13):

- Poly bottles (one tank in the SX tank farm)
- Plastic bottles (one tank in the SX tank farm)
- Ceramic balls, stainless steel capsules, and experimental fuel elements (one tank in the U tank farm)

Figure 2–11 illustrates the general arrangement of this in-tank equipment in a typical DST. Common in-tank equipment in DSTs that could potentially interfere with retrieval equipment includes the following (DOE 2003b:4-12):

- Surface-level probes
- Solids-level detectors
- Temperature thermocouple assemblies

In specific instances, other equipment (e.g., pumps, air-lift circulators) has been left in the SSTs and DSTs that could potentially create additional interferences during retrieval and closure operations.

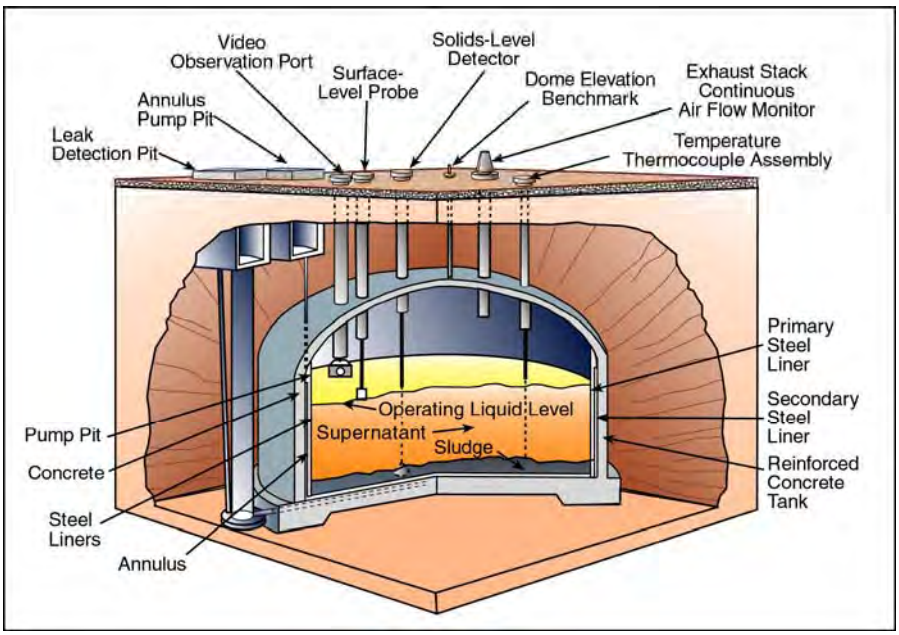


Figure 2–11. Representative Double-Shell Tank and In-Tank Equipment

2.2.2.1.4 Transfer Systems

The two approaches for transferring waste are as follows:

- Between tanks (e.g., from SSTs to DSTs and from DSTs to other DSTs)
- From tanks to treatment facilities (e.g., from SSTs, DSTs, or WRFs to treatment facilities)

This section addresses existing transfer approaches and their possible future augmentation, including piping, container transport, and WRFs. Waste transfer is discussed in more detail in Appendix E, Section E.1.2.2.7.

Existing transfer lines. None of the existing SST transfer piping would be used because (1) the pipelines are of single-wall construction and are noncompliant with current regulations; (2) some of the pipelines are plugged; (3) many of the pipelines leak; and (4) the pipelines are up to 60 years old.

An extensive existing system of underground piping connecting all of the DSTs is operated routinely. This piping would be used for final retrieval of DST waste. In particular, waste removed from DSTs in the 200-West Area would be transferred to selected DSTs in the 200-East Area through the existing underground cross-site transfer system that connects the DSTs in the 200-East Area to the SY tank farm in the 200-West Area (DOE 2003b:4-14, 4-15).

Waste from various DSTs in the 200-East Area also would be transferred through existing underground pipelines to DSTs in the AP tank farm, then through a new underground pipeline to the WTP. The DST transfer system would continue to service the DSTs through the end of the mission. Processes involved in operating underground waste transfer lines would include pumping waste from the source tank to the receiver tank; recycling supernatant back to the source tank if required; flushing the lines after the waste has been transferred; and verifying the volume transferred by material balance. In addition, monitoring and periodic leak testing of transfer lines would be conducted (DOE 2003b:4-15).

Use of hose-in-hose transfer lines. The Hanford Site utilizes a hose-in-hose transfer line (HIHTL) configuration on or near the surface. Interim stabilization project efforts have used this transfer line approach together with the single- and double-walled underground transfer lines (DOE 2003b:4-15).

Future waste transfer systems. Existing transfer lines would be used to retrieve waste from DSTs and WRFs to the extent practicable. Because the DST transfer system would continue to service the DSTs through the end of the mission and the SST transfer system offers limited utility, future transfer system upgrades would be oriented primarily to service the SSTs through the use of HIHTL. The two primary methods available for transferring tank waste are pipeline and container transport (DOE 2003b:4-15). For analysis purposes, this *TC & WM EIS* assumes the tank waste would be transferred predominantly by pipeline with no loss from leaks. This does not preclude, however, transfers via other safe means when appropriate.

The modified sluicing system, MRS, and VBR system would make extensive use of HIHTL. The MRS and VBR system previously engineered for tank 241-C-104 include approximately 457 meters (1,500 feet) of HIHTL; the modified sluicing system for tank 241-S-112 includes approximately 229 meters (750 feet) of HIHTL (DOE 2003b:4-15). These HIHTL lengths were assumed to be suitable for analyzing all applications of the modified sluicing system, MRS, and VBR system, as well as sufficient to transfer waste beyond the tank farm boundary or to nearby supplemental treatment facilities, but insufficient to deliver waste to more-distant locations.

New underground transfer lines would be used to transfer waste beyond the distances of the HIHTL. The general configuration of the SST farms suggests that the maximum distances for underground transfer lines would be from the B tank farm complex to the 200-East Area DSTs and from the T tank farm complex to the 200-West Area DSTs. For analysis purposes, the 200-East Area destination was designated as the AY/AZ DST farm because of its location relative to the B tank farm complex. The 200-West Area destination was designated as the SY DST farm because it is the only DST farm in the 200-West Area.

2.2.2.1.5 Waste Receiver Facilities

Storage and waste treatment facilities may be required to facilitate waste transfers. One option is the construction and operation of WRFs that contain the tanks and process piping needed to provide temporary storage and simple waste conditioning capabilities, including dissolution, dilution, and size reduction of particles suspended in the waste slurry. The general configuration of a WRF is depicted in Figure 2–12. WRFs accumulate waste during retrieval; condition waste by dissolution, dilution, or size reduction of particles; and provide batches of waste for subsequent transfer. The WRFs could also be used to recirculate sluicing liquids back to the SSTs. Not all SST retrievals were assumed to require the use of WRFs.

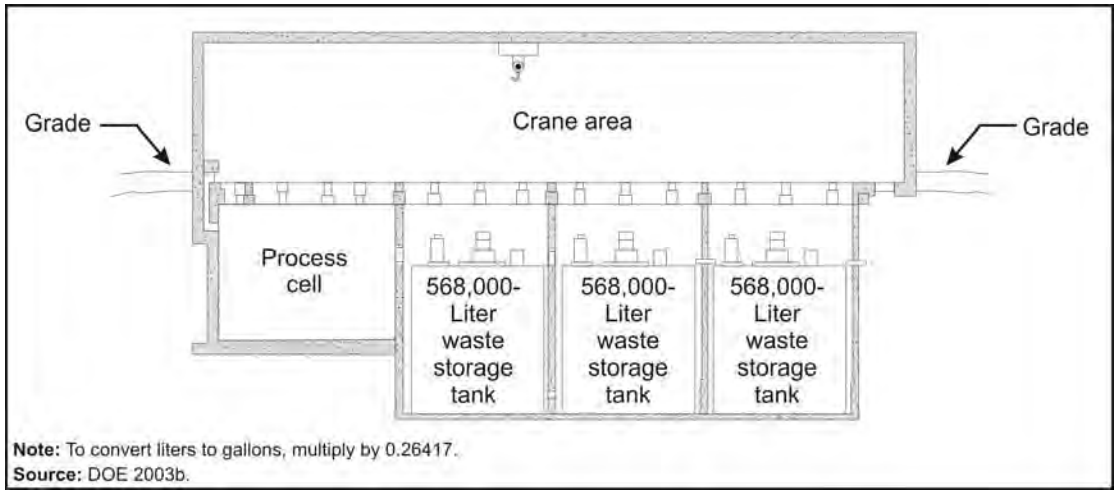


Figure 2–12. Cross-Sectional View of Representative Waste Receiver Facility

2.2.2.2 Waste Treatment

Waste treatment includes the methods, processes, and associated facilities used to change the physical or chemical character of the tank waste to render it less hazardous; make it safer to transport, store, or dispose of; or reduce its volume. This section describes the proposed technologies evaluated in this *TC & WM EIS* supporting WTP treatment and pretreatment, supplemental treatment of LAW, and supplemental treatment of tank mixed TRU waste.

Waste Treatment Technologies Analyzed in This Environmental Impact Statement

Waste Treatment Plant (WTP) pretreatment and vitrification. The WTP Pretreatment Facility would remove selected radionuclides and high-level radioactive waste (HLW) solids from retrieved tank waste to produce an HLW stream and a low-activity waste (LAW) stream. The HLW stream would be routed to the WTP HLW Vitrification Facility, and the LAW stream would be routed to the WTP LAW Vitrification Facility. At each vitrification facility, the pretreated waste would be combined with glass-forming materials and melted to produce a molten glass waste form that would be poured into stainless steel containers for cooling into a solid for storage, pending disposal. Hazardous and radioactive constituents would be removed or immobilized through this vitrification process.

Bulk vitrification. This thermal supplemental treatment process would convert LAW into a solid glass form by drying the waste, mixing it with soil, and applying electrical current to it within a large steel waste disposal container.

Steam reforming. This thermal supplemental treatment process would dilute LAW with water to transform it into a pumpable liquid. Using steam, this liquid would be converted to granular minerals suitable for packaging as a free-form granulated material.

Cast stone. This nonthermal supplemental treatment process would mix LAW with grout-formers (e.g., Portland cement, fly ash, slag) and -conditioners to produce a liquid-grout stream that would then be cast into containers for solidification into a cement matrix.

Mixed transuranic (TRU) waste supplemental treatment. Some types of Hanford tank waste are candidates for designation as mixed TRU waste. Under some alternatives, this waste would be packaged for eventual disposal at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, instead of being vitrified in the WTP HLW melter. Before packaging, the mixed TRU waste (both supernatants and sludges) would be dewatered. The resulting liquids would be sent for treatment in the WTP, while the solid waste would be packaged for eventual disposal at WIPP.

Separations processes. Some waste stored in the 200-West Area tank farms would not be pretreated in the WTP Pretreatment Facility. Instead, under some Tank Closure alternatives, the waste feed from 35 tanks that have been tentatively identified as containing low cesium-137 concentrations would be separated in a new Solid-Liquid Separations Facility in the 200-West Area to avoid the necessity of cross-site transport. Separations processes at this new facility may include selective dissolution and solid-liquid separations (gravity settling and/or decanting).

Sulfate removal. The presence of sulfate in the supernatant portion of the waste in many Hanford tanks poses potential technical and economic risks for the LAW vitrification process. If a separate, corrosive molten sulfur salt layer were to form and be allowed to accumulate, it could damage the LAW melter. Removal of sulfate from LAW after pretreatment, but before vitrification, could mitigate this problem and increase waste-loading, which would reduce the amount of immobilized low-activity waste (ILAW) glass produced in the WTP.

Technetium-99 removal. This WTP process would remove technetium-99 from the pretreated LAW stream via ion exchange. After removal, the technetium-99 would be blended with HLW solids for feed to HLW vitrification.

Cesium and strontium capsule treatment. Cesium and strontium would be extracted from storage capsules and prepared into a slurry waste stream. The slurry would then be treated in the WTP, resulting in an immobilized final waste form.

These waste treatment technologies are described in more detail in Appendix E, Section E.1.2.3.

2.2.2.2.1 Waste Treatment Plant

Waste Treatment Plant

The Waste Treatment Plant (WTP) is currently being constructed at the Hanford Site. Site work associated with the project began in late 2001. As of fall 2008, project construction was approximately 40 percent complete. When completed, the WTP will be the largest radiochemical processing facility in the world. It will occupy 26 hectares (65 acres) and be composed of 38,000 tons of steel, 300 kilometers (1 million feet) of piping, 1,500 kilometers (5 million feet) of electrical cable, and 203,000 cubic meters (265,000 cubic yards) of concrete. The WTP will consist of four major facilities: the Pretreatment Facility, Low-Activity Waste Vitrification Facility, High-Level Radioactive Waste Vitrification Facility, and an Analytical Laboratory.

The WTP is the cornerstone of tank waste treatment and is represented in each Tank Closure alternative in various configurations. The WTP is already under construction, having been analyzed in the 1996 *TWRS EIS* and three supplement analyses. However, under several of the alternatives evaluated in this *TC & WM EIS*, the WTP configuration and throughputs could change beyond those represented in the *TWRS EIS*. As such, construction, subsequent operations, and deactivation of the WTP from 2006 onward was analyzed under each *TC & WM EIS* alternative to establish a common reference point against which the impacts of other configurations and throughputs could be compared. Appendix E, Section E.1.2.3.1, provides an in-depth discussion of the WTP.

The WTP as it is currently being constructed includes four primary facilities: a Pretreatment Facility; an HLW Vitrification Facility housing two 3-metric-ton melters with a combined theoretical maximum capacity (TMC) of 6 metric tons of glass IHLW per day; a LAW Vitrification Facility housing two 15-metric-ton melters with a combined TMC of 30 metric tons of glass immobilized low-activity waste (ILAW) per day; and an Analytical Laboratory.[4]

The general configuration of the WTP is depicted in Figures 2–13 and 2–14. The WTP would receive HLW feed solutions and slurries transferred by pipeline for pretreatment and immobilization by vitrification. The pretreatment process would remove selected radionuclides (cesium, strontium, and transuranics), separate the HLW solids, and leach those solids to remove nonradioactive components that drive up total IHLW glass volume. The pretreated aqueous feed (referred to as the "LAW feed") would be routed to the LAW Vitrification Facility. The separated radionuclides and pretreated solids would be routed to the HLW Vitrification Facility.

[4] The LAW Vitrification Facility was originally designed to produce 30 metric tons of glass ILAW per day with three melters. Improvements in melter technology have demonstrated that a 30-metric-ton-of-glass-per-day vitrification capacity can be achieved with two melters. Construction of the LAW Vitrification Facility is proceeding; as presently designed, this facility will have two melters with a TMC of 30 metric tons of glass ILAW per day. Two approaches to providing the additional LAW vitrification capacity needed to accelerate treatment of the tank waste are addressed in this *TC & WM EIS*. The first approach is installation of additional melter capacity (e.g., a third LAW melter) in the LAW Vitrification Facility currently under construction as part of the WTP, bringing the total design capacity from a TMC of 30 metric tons of glass per day to a TMC of 45 metric tons of glass per day (Tank Closure Alternative 5). Installation of additional melter capacity in the LAW Vitrification Facility, though technically possible, would require design modifications for additional infrastructure tie-ins. The second approach includes installation of this additional melter capacity in the LAW Vitrification Facility now being constructed, as well as construction of a second LAW Vitrification Facility to achieve a total TMC of 90 metric tons of glass per day (Tank Closure Alternatives 2B, 6B, and 6C).

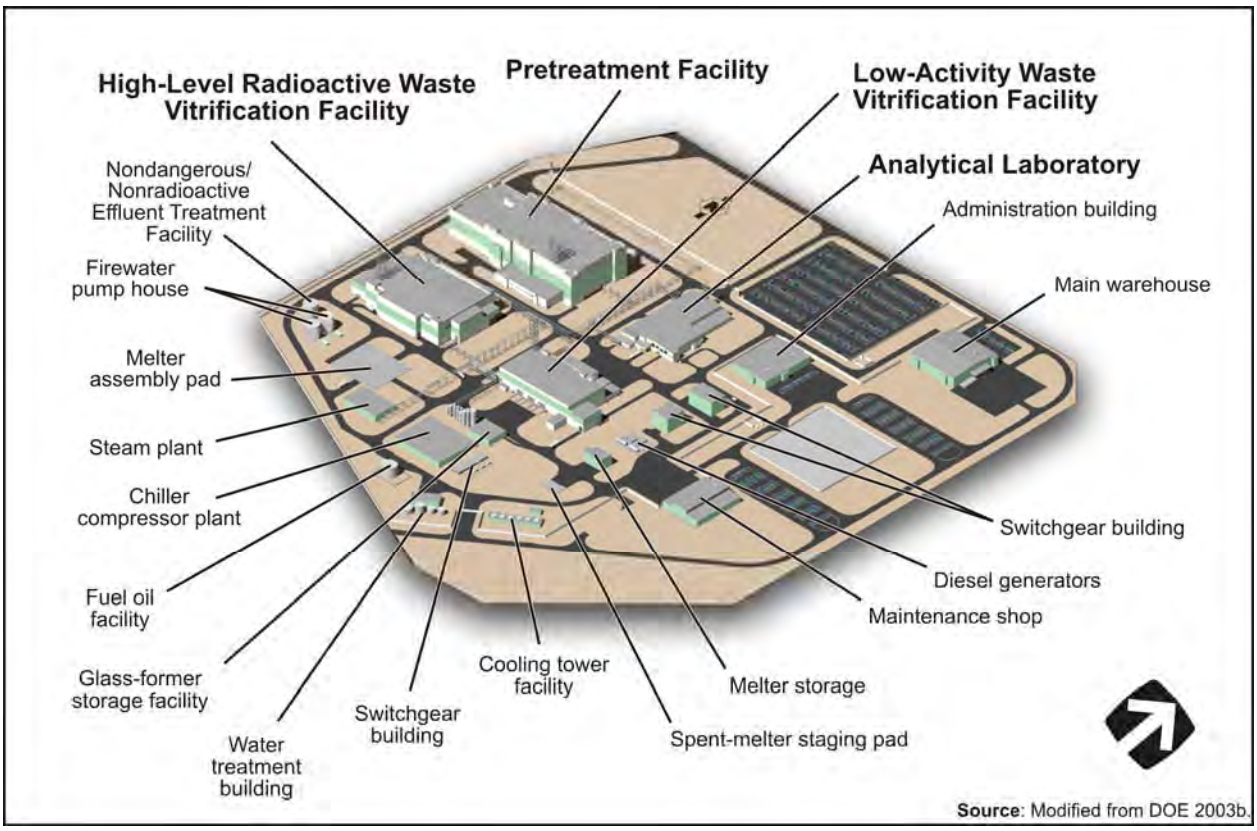


Figure 2–13. Waste Treatment Plant Facilities



Figure 2–14. Aerial View of Waste Treatment Plant Construction Site, February 2008

The vitrification process would combine the pretreated tank waste with glass-forming materials and melt the mixture at high temperatures (approximately 1,150 degrees Celsius [2,100 degrees Fahrenheit]) into a liquid that would be poured into stainless steel containers. After the glass cools and hardens, each container would be sealed and decontaminated in preparation for storage and permanent disposal. The dangerous waste and radioactive constituents would be either destroyed or immobilized in this durable glass matrix through the vitrification process. The offgas from the processes would be treated to a level compliant with regulations protecting human health and the environment. IHLW glass would be placed in canisters 0.6 meters (2 feet) in diameter by 4.6 meters (15 feet) long, each with a capacity of approximately 3.2 metric tons. ILAW glass would be placed in containers 1.2 meters in diameter by 2.3 meters long (4 feet in diameter by 7.5 feet long), each with a capacity of 6 metric tons.

Secondary Waste

Secondary waste is waste generated as a result of other activities, e.g., waste retrieval or waste treatment, that is not further treated by the WTP or supplemental treatment facilities, and includes liquid and solid wastes. Liquid waste sources could include process condensates, scrubber wastes, spent reagents from resins, offgas and vessel vent wastes, vessel washes, floor drain and sump wastes, and decontamination solutions. Solid waste sources could include worn filter membranes, spent ion exchange resins, failed or worn equipment, debris, analytical laboratory waste, HEPA filters, spent carbon adsorbent, and other process-related wastes. Secondary waste can be characterized as LLW, MLLW, TRU waste, or hazardous waste.

The various WTP processes (e.g., pretreatment, vitrification, and offgas treatment) would generate secondary waste. This secondary waste would be transferred to accumulation or storage facilities at the WTP and then either transferred to onsite storage facilities or transported to offsite facilities (e.g., TRU waste could be transported to the Waste Isolation Pilot Plant [WIPP] near Carlsbad, New Mexico), as appropriate. Nonradioactive dangerous waste could be generated by operations, laboratory, and maintenance activities. This waste would be managed at the WTP until it could be released for transfer to a permitted disposal facility. The secondary waste associated with each of the WTP processes is detailed in the Appendix E.

2.2.2.2.2 Thermal Supplemental Treatment: Bulk Vitrification

Thermal supplemental treatment would be used to treat a portion of the tank waste under Tank Closure Alternatives 3A, 4, and 5. Bulk vitrification is one of the two representative thermal supplemental treatment processes analyzed in this *TC & WM EIS* (the other is steam reforming) that may be used to immobilize LAW in a non-WTP vitreous waste form. Analysis of either of these representative processes (bulk vitrification and steam reforming) does not preclude potential consideration of other suitable thermal supplemental treatment technologies. However, if it were determined that the impacts of these other technologies were outside the envelope of impacts analyzed in this *TC & WM EIS*, further National Environmental Policy Act (NEPA) analyses would be required.

Waste feeds to the bulk vitrification process from the 200-East Area tank farms would consist of LAW resulting from pretreatment of waste in the WTP Pretreatment Facility. Waste feeds to the bulk vitrification process from the 200-West Area tank farms would consist of LAW separated in a new Solid-Liquid Separations Facility (see the discussion in Section 2.2.2.2.6). The bulk vitrification process would convert the LAW into a solid glass by drying the waste, mixing it with soils from onsite sources, and applying an electrical current within a large steel container. A temporary offgas hood would be placed over the LAW-filled steel container, and graphite electrodes would be inserted into the waste. The mixture of waste and soils and/or sand would then be melted into liquid glass by passing electrical current to the electrodes. Air emissions would be collected by the offgas hood and directed to an offgas treatment system.

Bulk Vitrification Facilities may be placed in both the 200-East and 200-West Areas. Construction and operation of a 200-East Area facility was analyzed under Tank Closure Alternative 3A. In addition, construction and operation of a 200-West Area facility was analyzed under Tank Closure Alternative 3A, 4, and 5.

Regardless of location, each Bulk Vitrification Facility is currently configured to have parallel processing lines that can process more than one vitrification container at a time. Two rectangular, steel roll-off boxes would typically be processed in parallel. The 2.4-meter-wide by 3.0-meter-high by 7.3-meter-long (8-foot-wide by 10-foot-high by 24-foot-long) boxes could be staged to accommodate approximately 42.6 metric tons of glass waste. The boxes would be allowed to cool for approximately 3 days before being transferred to a disposal site (DOE 2003d:4-10, 6-70; SAIC 2007).

The vitrified waste form contained inside the boxes would consist of a mixture of waste glass and crystalline materials and likely have an appearance similar to obsidian (a dark, volcanic glass). Generally, glass is one of the better-performing waste forms for containment of radioactive and hazardous waste because its high concentrations of silicon dioxide and aluminum oxide provide both durability and leach resistance. The waste vitrification process would result in an approximate net volume reduction of one-third to one-half due to the loss of volatile components and a reduction of void space from melting. Based on the assumptions used in this analysis, the estimated waste loading of the vitrified waste product would be 20 weight-percent sodium oxide (DOE 2003d:4-10). See Appendix E, Section E.1.2.3.6, for a more-detailed discussion of thermal supplemental treatment.

2.2.2.2.3 Thermal Supplemental Treatment: Steam Reforming

Steam reforming, the second of the two representative thermal supplemental treatment processes analyzed in this *TC & WM EIS* for immobilizing LAW, is proposed for treating a portion of the tank waste under Tank Closure Alternative 3C. Steam reforming is used extensively in nonradioactive processing in the petroleum industry and has recently been used to treat radioactive waste. The steam reforming process would begin with the receipt of pretreated waste or retrieved LAW and the dilution of this LAW stream with water. Dilution of the tank LAW is required to transform the waste feed into a pumpable liquid that can be introduced into a fluidized-bed vessel. Within this vessel, the water would be volatilized (heated into steam); the LAW material would be converted to granular minerals; and organic compounds, nitrate, and nitrite would decompose. The offgas from the steam reforming process would be treated to remove radionuclides and other pollutants before discharge. The mineralized product resulting from the steam reforming process is assumed to be suitable for packaging as a free-form granulated material. This steam reforming waste would be placed in 2.25-cubic-meter-volume (3.0-cubic-yard-volume) steel packages for disposal or storage. Based on the assumptions used in the *TC & WM EIS* analysis, the estimated waste loading of the steam reforming waste would be 19.8 weight-percent sodium oxide (SAIC 2007). Steam reforming facilities may be placed in both the 200-East and 200-West Areas. The 200-East Area Steam Reforming Facility would be located near the WTP and would accept a portion of the LAW generated from the WTP Pretreatment Facility (other portions would be treated in either the WTP LAW Vitrification Facility or the WTP HLW Vitrification Facility). The 200-West Area Steam Reforming Facility would accept LAW generated by the Solid-Liquid Separations Facility from separating the waste contained in the 35 SSTs with low cesium-137 concentrations via settling and decanting processes that would reduce the solids content of the waste.

2.2.2.2.4 Nonthermal Supplemental Treatment: Cast Stone

Cast stone, the representative nonthermal supplemental treatment process that is analyzed in this *TC & WM EIS*, would be used to treat a portion of the tank waste under Tank Closure Alternatives 3B, 4, and 5. The cast stone process would be used to immobilize LAW in a cementitious waste form. Analysis of this representative process does not preclude potential consideration of other suitable nonthermal

supplemental treatment technologies to treat this waste. However, if it were determined that the impacts of these other technologies were outside the envelope of impacts analyzed in this *TC & WM EIS*, further NEPA analysis would be required.

The cast stone supplemental treatment process involves mixing LAW with a Portland-cement-type grout, pumping it into disposal containers, and allowing it to solidify. Waste feeds to the cast stone process would consist of LAW separated in the new Solid-Liquid Separations Facility or LAW that has been pretreated in the WTP Pretreatment Facility. Storage vessels may be needed for Portland cement, fly ash, slag, and stabilizing chemicals if the dry blend mixture cannot be procured. Waste feeds would be directly transferred from retrieval operations or staged in a receiver tank. Waste and grout additives would be mixed and poured into 1.2-meter by 1.2-meter by 2.4-meter (4-foot by 4-foot by 8-foot) container boxes, each holding approximately 5.4 metric tons of cast stone waste. The cast stone waste containers would be managed using standard industrial handling equipment (DOE 2003d:4-11, 6-98).

The addition of grout-forming materials would increase the cast stone waste volume by approximately 1.4 times the feed volume. Based on the assumptions used in this analysis, the estimated waste loading of the cast stone product would be 7.8 weight-percent sodium oxide (DOE 2003d:6-96). It is possible that actual cast stone waste formulations would be tailored to adjust for batch-to-batch variations as waste is retrieved from different tanks. Use of grout on a wide variety of radioactive wastes has been documented for over 30 years. The cast stone process does not require development of any unique process equipment. See Appendix E, Section E.1.2.3.7, for a more-detailed discussion of nonthermal supplemental treatment.

Cast stone facilities may be placed in one or both of the 200-East and 200-West Areas. Construction and operation of a 200-East Area Cast Stone Facility are analyzed in Alternatives 3B, 4, and 5. Construction and operation of a 200-West Area Cast Stone Facility are analyzed under Tank Closure Alternative 3B.

2.2.2.2.5 Tank-Derived Mixed Transuranic Waste Supplemental Treatment

Presently, 20 Hanford underground storage tanks (17 SSTs and 3 DSTs) contain waste types that are candidates for classification as mixed TRU waste. Under Alternatives 3A, 3B, 3C, 4, and 5, approximately 11.8 million liters (3.1 million gallons) of waste that could be designated as mixed TRU waste would be retrieved from the tanks, treated, and packaged for eventual disposal at WIPP instead of being turned into a vitrified waste form in the WTP. As additional waste process records are reviewed, additional tanks may be identified as containing waste that can be designated as mixed TRU waste (DOE 2003d:6-118).

Contact-handled transuranic waste has a radiation level less than or equal to 200 millirem* per hour at the surface of a waste container and can be safely handled by direct contact.

Remote-handled transuranic waste is packaged transuranic waste whose external surface dose rate exceeds 200 millirem per hour. This waste requires special shielding and handling to protect workers and the public.

* A millirem (one-thousandth of a rem) is a unit of measure of absorbed ionizing radiation used to assess the biological effects of a given dose of any type of radiation.

For analysis purposes in this *TC & WM EIS* it was assumed that mixed TRU waste would be segregated into two categories: contact-handled (CH) and remote-handled (RH). Reviews of the process history and tank inventory data indicate that the waste in 11 of the SSTs may be processed using CH methods, but the waste in the remaining 6 SSTs and 3 DSTs would likely need to be processed using RH methods. These specific tanks and their associated waste volumes are detailed in Appendix E, Table E–6.

Mixed TRU waste (liquids and sludges) would first be retrieved from underground storage tanks and transferred to either the CH-Mixed TRU Waste Facilities or RH-Mixed TRU Waste Facility for dewatering and packaging. The liquids extracted during the dewatering process would be transferred to the DST system for treatment in the WTP. The resulting waste package configuration (drums or waste

boxes) would need to meet WIPP disposal requirements, as well as requirements for transportation and interim storage on site in a new TRU Waste Interim Storage Facility. For analysis purposes, this *TC & WM EIS* conservatively assumes that the mixed TRU solid tank waste would be packaged for disposal in 208-liter (55-gallon) drums, each filled with approximately 151 liters (40 gallons) of sludge and 57 liters (15 gallons) of absorbent material (DOE 2003d:4-13, 6-140, 6-143). After being filled, the containers would be closed with a bolted lid. The RH-mixed TRU waste and CH-mixed TRU waste process systems would be similar. The difference would be that all RH-mixed TRU waste packaging operations would be conducted remotely in the RH-Mixed TRU Waste Facility, which would be permanently located in the 200-East Area, while all CH-mixed TRU waste packaging operations would be conducted in mobile CH-Mixed TRU Waste Facilities that can relocate to each of the tank farms in both the 200-East and 200-West Areas.

Activities planned for the mixed TRU waste packaging systems would be similar in nature and facility scale to waste management activities practiced at other DOE facilities (e.g., the Rocky Flats Site in Colorado). See Appendix E, Section E.1.2.3.11, for a more-detailed discussion of mixed TRU waste processing.

2.2.2.2.6 Separations Processes

Each of the *TC & WM EIS* alternatives that consider use of supplemental treatment technologies in the 200-East Area of Hanford would use the capability provided by the WTP to pretreat the waste in 114 of the 149 SSTs and all 28 DSTs. In contrast, waste feeds for supplemental treatment technologies used in the 200-West Area would not undergo WTP pretreatment, but instead would be processed in the new Solid-Liquid Separations Facility in the 200-West Area. These waste feeds would include waste from the remaining 35 SSTs, which have tentatively been identified as containing low-cesium-137-concentration salt cake. The waste contained in many of these 35 tanks was previously treated in processing facilities that removed radionuclides such as cesium, strontium, and TRU radionuclides (see Appendix E, Section E.1.2.3.5.2, for a more-detailed discussion of these tanks). The extent of the separations processes conducted in the new Solid-Liquid Separations Facility would depend on the waste feed being processed and the immobilization operation being used.

The new Solid-Liquid Separations Facility would employ settling and decanting processes that are expected to return 50 percent of the entrained solids to the WTP for further processing. Strontium-90 and TRU radionuclides would be precipitated using a chemical addition during this settling process, resulting in a portion of the strontium-90 and TRU radionuclides being forwarded to the WTP and the balance being forwarded to the selected supplemental treatment (bulk vitrification, steam reforming, or cast stone) facility in the 200-West Area. Some precipitation, settling, and decanting could be conducted in the existing underground storage tanks. However, for analysis purposes, this *TC & WM EIS* assumes that all separations activities would occur in the new Solid-Liquid Separations Facility (DOE 2003d:4-6, 6-146).

2.2.2.2.7 Sulfate Removal

The sulfate removal pretreatment process is a representative technology that could be used to increase the waste loading in the ILAW glass. The sulfate removal approach involves sulfate precipitation using strontium nitrate addition, filtration, and solidification with grout-forming additives to create an immobilized waste form (grouted waste). As considered under Tank Closure Alternative 5 of this *TC & WM EIS*, sulfate removal would potentially increase waste loading, which would reduce the amount of ILAW glass produced in the WTP. The sulfate removal process is not proposed for use on waste provided as feed for supplemental technologies (bulk vitrification, cast stone, or steam reforming) because it would provide no added benefit for these technologies. Low-sulfate waste streams also may not need sulfate removal (DOE 2003d:4-3).

The sulfate removal process would require construction of two new facilities in the 200-East Area adjacent to the WTP—a Sulfate Removal Facility and an associated grout facility. The sulfate removal process would occur following pretreatment of waste at the WTP, but prior to treatment in the LAW Vitrification Facility. This process is expected to remove 90 to 95 percent of the sulfate present in the incoming pretreated LAW. From the perspective of waste form performance, sulfate removal is expected to increase waste loadings in the ILAW glass from approximately 14 percent to approximately 20 percent (sodium oxide basis) (DOE 2003d:4-4). Such an increase in waste loading would decrease the volume of ILAW glass produced over the life of the project by approximately 35 percent. See Appendix E, Section E.1.2.3.9, for a more-detailed discussion of the sulfate removal process.

The sulfate would be removed from the WTP LAW Vitrification Facility feed stream in the form of strontium sulfate precipitate. This precipitate would be immobilized in a grout waste form that is expected to exhibit improved performance characteristics relative to previous Hanford grouts for two reasons, as follows:

- Select radionuclides (e.g., TRU radionuclides and cesium) would be removed from the WTP LAW Vitrification Facility feed stream in the WTP Pretreatment Facility before the LAW is processed in the Sulfate Removal Facility.

- Other radionuclides and constituents of potential concern (COPCs) exhibit little affinity for the strontium sulfate precipitate. Accordingly, these radionuclides and COPCs would not be incorporated into the grout waste form; instead, they would be forwarded as components of the LAW Vitrification Facility feed stream for incorporation into ILAW glass (DOE 2003d:4-4).

In addition, high concentrations of sulfate in the LAW feed solutions would present problems for the current WTP LAW vitrification process. Preliminary testing of the LAW melter system indicated that a separate molten sulfur layer could form in the LAW melter at the maximum sulfate-to-sodium ratio in the LAW solutions. This molten sulfur layer would be highly corrosive to the LAW melter components. Formation of the sulfur layer can be avoided by reducing the amount of sulfate in the LAW melter feed stream.

2.2.2.2.8 Technetium-99 Removal

Technetium-99, a long-lived, mobile radionuclide present in the tank waste, is of particular interest with regard to long-term waste form performance. Tank Closure Alternatives 2B and 3B include removal of technetium-99 from the LAW stream during WTP pretreatment. For analysis purposes, it was assumed that technetium-99 removal would be conducted in the WTP Pretreatment Facility via ion exchange with a removal efficiency of approximately 99 percent.[5] Therefore, under Tank Closure Alternatives 2B and 3B, approximately 99 percent of the technetium-99 would be removed from the LAW stream, transferred to the HLW stream, and vitrified as IHLW glass. Under all other Tank Closure alternatives, this technetium-99 would remain in the LAW stream and be incorporated into an ILAW product. For a more-detailed discussion of the technetium removal process, see Appendix E, Section E.1.2.3.10.

[5] The WTP Pretreatment Facility evaluated in the *TWRS EIS* was originally designed to remove technetium-99. However, based on subsequent analysis of the ILAW glass, DOE and Ecology agreed to delete technetium removal from the WTP permit (Hedges 2008). Therefore, the detailed design of the Pretreatment Facility eliminated the technetium-99 removal capability from the LAW stream. However, under Tank Closure Alternatives 2B and 3B, this *TC & WM EIS* assumes that technetium-99 could be removed in the WTP Pretreatment Facility. Should DOE decide to implement technetium-99 removal, design modifications would be needed to add the technetium-99 removal capacity later, which could alter the assumed location of the unit.

2.2.2.2.9 Cesium and Strontium Capsule Treatment

There are currently 1,335 cesium capsules and 601 strontium capsules stored in the Waste Encapsulation and Storage Facility (WESF) pool cells in the 200-East Area. Most of the capsules are composed of an inner and outer capsule. The cesium capsules are 6.7 centimeters (2.6 inches) in diameter and 51.1 centimeters (20.1 inches) long, and the strontium capsules are 6.7 centimeters (2.625 inches) in diameter and 52.8 centimeters (20.8 inches) long (Jeppson 1973). Cesium and strontium waste would be extracted from the storage capsules prior to treatment in the WTP HLW melters. A new Cesium and Strontium Capsule Processing Facility would be constructed to extract and prepare the cesium and strontium waste into a slurry waste stream acceptable for treatment in the WTP. Under all Tank Closure alternatives except the No Action Alternative, immobilization of cesium and strontium capsule waste would take place during a separate campaign following treatment of all HLW from the tanks. It is estimated that an additional 340 canisters would be produced during this treatment campaign (CEES 2006a). For a more-detailed discussion of the cesium and strontium capsule treatment process, see Appendix E, Section E.1.2.3.4.

2.2.2.2.10 Interfacing Facilities

The following facilities would interface with storage, retrieval, and treatment of tank waste:

Liquid Waste Processing Facilities (LWPFs). The LWPFs include the Effluent Treatment Facility (ETF), Liquid Effluent Retention Facility (LERF), and Treated Effluent Disposal Facility (TEDF). The ETF and LERF process liquid effluents designated as radioactive and dangerous wastes. Operation of the ETF is planned to continue until fiscal year 2025. Replacement ETFs would need to be constructed and operated to support the Tank Closure alternatives. The LERF would need a life extension upgrade in 2015. After the life extension upgrade, the LERF was assumed to operate through the end of WTP operations. The 200 Area TEDF is permitted for disposal of nonradioactive, nondangerous liquid effluents. A life extension project is planned for fiscal year 2009, after which the facility was similarly assumed to operate through the end of WTP operations. Detailed descriptions of the ETF, LERF, and TEDF are presented in Appendix E, Section E.1.2.3.3.

242-A Evaporator. The continued operation of the 242-A Evaporator is required to support treatment of tank waste. The current and future mission of the evaporator is to support environmental restoration and remediation of Hanford by optimizing the 200 Area DST waste volumes in support of the tank farm management and WTP operations. To accomplish this mission, the 242-A Evaporator would require multiple replacements for some Tank Closure alternatives analyzed in this EIS. The 242-A Evaporator's estimated useful life is 25 years. The evaporator also depends on the continued operation of the ETF, LERF, and TEDF to accept and treat both contact (process condensate) and noncontact (steam condensate and cooling water) effluent waste streams. A detailed description of the 242-A Evaporator is presented in Appendix E, Section E.1.2.3.2.

222-S Analytical Laboratory. The 222-S Analytical Laboratory is a dedicated facility that provides analytical chemistry services in support of characterization. The laboratory is expected to operate as long as required to support tank waste characterization, tank waste retrieval, and waste feed delivery to the WTP. Upgrades or replacements to the 222-S Analytical Laboratory were not analyzed in this EIS because its use is expected to be limited following the start of operations of the WTP Analytical Laboratory.

2.2.2.3 Waste Disposal

Many waste disposal aspects of the proposed actions have been addressed in previous EISs. DOE evaluated the programmatic aspects of waste management across the DOE complex in the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and*

Disposal of Radioactive and Hazardous Waste (DOE 1997a). The *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement (WIPP SEIS-II)* (DOE 1997b) addressed transportation and disposal of given waste quantities at WIPP. These documents adopted assumptions and methodologies for assessing waste transportation and disposal and reported the anticipated environmental impacts. This *TC & WM EIS* was developed to be as consistent as possible with these adopted assumptions and methodologies to avoid contradictions in the anticipated impacts reported for overlapping activities.

This section addresses the disposal considerations associated with each of the waste types after completion of the proposed retrieval and, where applicable, treatment activities (see Appendix E, Section E.1.2.4, for a more-detailed discussion of waste disposal). This *TC & WM EIS* addresses the following key waste types and the activities proposed to support their transport, interim storage, and disposal.

IHLW. HLW, as defined in DOE Manual 435.1-1, *Radioactive Waste Management Manual*, would be immobilized (vitrified) in the WTP, resulting in IHLW glass. This tank IHLW glass would be mixed waste containing both radionuclides subject to the Atomic Energy Act of 1954 and hazardous components subject to the Resource Conservation and Recovery Act (RCRA).

IHLW glass canisters produced under the alternatives would be stored in the existing CSB and additional storage modules. (The analyses in this EIS are not affected by recent DOE plans to study alternatives for the disposition of the Nation's SNF and HLW because the EIS analysis shows that vitrified HLW can be stored safely at Hanford for many years until disposition decisions are made and implemented.)

Tank-derived mixed TRU waste. DOE proposes to designate waste in certain SSTs and DSTs as tank-derived mixed TRU waste in accordance with the TRU waste definition cited in DOE Manual 435.1-1 and the Waste Isolation Pilot Plant Land Withdrawal Act (P.L. 102-579). Prior to treatment in either the CH- or RH-Mixed TRU Waste Facilities, this tank-derived mixed TRU waste would be further subdivided into CH- and RH-mixed TRU waste streams to aid in defining packaging, transportation, and interim storage pathways.

Mixed TRU waste generated under the Tank Closure action alternatives would be stored in a new TRU Waste Interim Storage Facility pending shipment to WIPP. The mixed TRU waste would be placed in Type B containers certified by the U.S. Nuclear Regulatory Commission (NRC) (e.g., TRUPACT-II [transuranic package transporter model 2] containers) and shipped to WIPP by truck.

ILAW. This waste would be composed of LAW that has been immobilized by the WTP processes (ILAW glass) or by supplemental treatment (e.g., bulk vitrification glass, cast stone waste, or steam reforming waste) in other facilities. Under Tank Closure Alternatives 2A through 5, this ILAW would be managed as mixed low-level radioactive waste (MLLW) and disposed of on site. Under Tank Closure Alternatives 6B and 6C, the ILAW would be managed as HLW and stored on site pending disposition.

ILAW that is subject to disposal after treatment by one of the supplemental treatment processes would be disposed of on site at an Integrated Disposal Facility (IDF). The facility would include an RCRA-compliant liner and leachate collection system; upon closure, it would be capped with a modified RCRA Subtitle C barrier.

Grouted sulfate precipitate. This waste would result from the sulfate removal pretreatment process. The precipitate would be grouted, containerized, and managed as MLLW. Similar to ILAW, grouted sulfate precipitate would be sent directly to an IDF.

WTP melters. Melters taken out of service at the WTP would be disposed of based on their waste types. WTP melters used for LAW vitrification and determined to be MLLW would be disposed of on site in an

IDF. WTP melters used for HLW vitrification would be placed in interim storage on the new onsite melter storage pads.

In addition to the waste forms discussed above, secondary waste would be produced as a result of construction and operation of the facilities associated with the alternatives analyzed in this EIS. Secondary waste includes items such as protective clothing, construction materials, tools, liquids, and excess materials whose characterization as low-level radioactive waste (LLW), MLLW, mixed TRU waste, or hazardous waste depends on the characteristics of the waste. Secondary LLW and MLLW would be disposed of on site in an IDF. Secondary TRU waste would be stored in existing facilities at the Central Waste Complex (CWC) pending disposal at WIPP.

2.2.2.4 Tank System Closure and Facility Decontamination and Decommissioning

The final major component of the tank closure proposed actions evaluated in this *TC & WM EIS* is closure of the SST system.[6] Three approaches to closure were considered.

- Landfill closure
- Clean closure
- Selective clean closure/landfill closure

Tank Closure Alternatives 2B through 6C include a closure component. The specific closure approach proposed for each alternative varies in accordance with the specific objectives of that alternative or subalternative. The following sections describe the closure activities that would be included under each closure approach. Tank system closure is described in detail in Appendix E, Section E.1.2.5.

Closure Options Analyzed in This Environmental Impact Statement

Landfill Closure – Following tank waste retrieval, the single-shell tank (SST) system would be closed in accordance with state, Federal, and/or U.S. Department of Energy requirements for closure of a landfill. Landfill closure typically includes site stabilization and emplacement of a barrier followed by a postclosure care period.

Clean Closure – Following tank waste retrieval, the tanks, ancillary equipment, and contaminated soils would be removed as necessary to protect human health and the environment and to allow unrestricted use of the tank farm area.

Selective Clean Closure/Landfill Closure – This hybrid closure approach would implement clean closure of a representative tank farm in each of the 200-East and 200-West Areas (i.e., the BX and SX tank farms), while implementing landfill closure for the balance of the SST farm system.

2.2.2.4.1 Landfill Closure

Landfill closure of the SST system would generally include the following:

- Grout-filling of tanks
- Grouting of ancillary equipment and WRFs
- Removal of some ancillary equipment and near-surface contaminated soils
- Placement of a surface barrier
- Postclosure care

Grout-filling of tanks. Grout is formed from sand, cement, and fly ash to create a free-flowing material that would be used to fill the tanks after tank waste is removed. The grout would harden in the tanks to provide structural stability for completion of landfill

[6] WTP closure is not part of the proposed actions because it is an active facility needed to complete waste treatment. The existing 28 DSTs, which are also active components, are included in the closure scenario for each alternative presented in this *TC & WM EIS* that includes landfill closure. When the closure barrier is placed over the SSTs, it will need to cover nearby DSTs as well due to the engineering design and the proximity of the DSTs to the SSTs. Therefore, the decision was made to include the existing DSTs in the closure configuration. In contrast, new DSTs proposed for construction, along with other infrastructure needed to support certain alternatives, would not be closed because these new DSTs would be located away from the original 177 tanks (149 SSTs and 28 DSTs) built at Hanford and outside the areal extent of the SST closure barriers. Although a closure configuration for the DSTs is evaluated in this EIS, a decision on closure of the DSTs is not part of the proposed actions. Closure of both the DSTs and the WTP would need to be addressed at a later date subject to appropriate NEPA review.

closure of the tank farms. The tanks would be filled with grout in a series of "lifts" in two separate phases. Lifts are separate applications of grout applied over time to allow added grout to set. The first phase of the process would involve initial grout placement to stabilize the residual waste heel expected to remain following retrieval. Materials called sequestering agents would be added to immobilize specific COPCs (i.e., technetium and uranium) in residual waste. The second phase would involve filling the remaining tank void space to the tank dome to minimize water infiltration, prevent long-term degradation of the tank farm surface barrier due to subsidence, and discourage intruder access (DOE 2003a:6-1). The use of two mobile plants (one each in the 200-East and 200-West Areas) was assumed for this grouting activity.

Grouting of ancillary equipment and WRFs. Tank farm ancillary equipment includes MUSTs; the waste transfer system (diversion boxes, valve pits, and transfer piping); tank pits; tank risers; in-tank equipment; and miscellaneous facilities used to treat, transfer, or store tank waste. Above-grade ancillary equipment would be removed to grade. Below-grade ancillary equipment would be filled with grout produced at either of the two mobile grout plants located in the 200-East and 200-West Areas and trucked to the local site for placement into the ancillary equipment (DOE 2003a:6-35, 6-39). All SST system ancillary equipment and WRFs inside the projected closure barriers would be grouted under Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C. SST system ancillary equipment and WRFs outside the area covered by the surface barriers, except under Alternatives 1, 2A, and 5, would be removed or remediated. Under these three alternatives, the ancillary equipment would be left as is, with no remediation actions. Alternative 4 would involve grout-fill stabilization of ancillary equipment associated with landfill closure of all tank farms except the BX and SX tank farms.

Removal of ancillary equipment and near-surface contaminated soil. Ancillary equipment and near-surface contaminated soil removal is an additional remediation component considered under Tank Closure Alternatives 4, 6A, and 6B. Under Tank Closure Alternative 4, associated equipment in the BX tank farm in the 200-East Area and the SX tank farm in the 200-West Area would be removed and replaced with clean soils from onsite sources. This activity would require construction and operation of two containment structures, one over each farm. The removed materials would be disposed of on site in the new River Protection Project Disposal Facility (RPPDF), located between the 200-East and 200-West Areas. The RPPDF would be similar to an IDF. This additional level of remediation is proposed for the BX and SX tank farms to assess this activity's potential effectiveness at reducing long-term impacts on groundwater. The BX and SX tank farms were chosen for this option because (1) their tank waste inventories are well characterized and the nature and extent of past leaks and spills are documented; (2) their current in-tank inventories include substantial amounts of long-lived, highly mobile constituents and short-term health risks; and (3) they are in separate geographic locations, i.e., the BX tank farm is located in the 200-East Area and the SX tank farm is located in the 200-West Area.

Tank Closure Alternatives 6A and 6B would provide clean closure of all SST farms, including removal of ancillary equipment. The Alternative 6A and 6B Option Cases would also include removal of soils contaminated by liquid releases from the six sets of contiguous cribs and trenches (ditches). Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would partially remove soils from the tank farms along with ancillary equipment.

Placement of a surface barrier. An above-grade, multilayered engineered surface barrier would be placed over the tank farms and the six sets of contiguous cribs and trenches (ditches) under all of the alternatives involving landfill closure. This barrier would be designed to provide long-term containment and hydrologic protection of the waste site. Two types of surface barriers were considered in this *TC & WM EIS*: the modified RCRA Subtitle C barrier (under Alternatives 2B, 3A, 3B, 3C, 4, and 6C) and the Hanford barrier (under Alternative 5). The modified RCRA Subtitle C barrier would consist of 8 layers, with a combined thickness of approximately 2.7 meters (9 feet). It would be designed to provide protection for 500 years, with no need for maintenance following a 100-year postclosure care period. The

more-robust Hanford barrier would consist of 10 layers, with a combined thickness of approximately 4.6 meters (15 feet). For analysis purposes, it was assumed that the Hanford barrier would be designed to provide protection for 1,000 years without maintenance. The Hanford barrier would provide additional protection against wind and water erosion, as well as plant, animal, and human intrusion (DOE 2003a:6-64). Both types of surface barriers would be constructed as a set of five "lobes." Two large lobes would be constructed in the 200-East Area, and three lobes would be constructed in the 200-West Area (DOE 2003a:6-64). For more information on these barriers, see Appendix E, Section E.1.2.5.4.1.

Postclosure care. Under Alternatives 2B, 3A, 3B, 3C, 4, and 6C, which would use a modified RCRA Subtitle C barrier, monitoring during the postclosure care period would be consistent with RCRA landfill closure requirements (WAC 173-303) for 100 years after completion of the surface barrier. Under DOE's regulations implementing its Atomic Energy Act responsibilities (DOE Order 5400.5), postclosure care may exceed 100 years; however, for analysis purposes, it was assumed not to exceed 100 years. Monitoring activities would focus on air, groundwater, and the vadose zone. Air monitoring would be conducted under the existing air monitoring program and would concentrate on sampling for, detecting, and analyzing volatile compounds that may be moving up through the surface barrier. Groundwater monitoring would require installation and monitoring of new wells up- and downgradient of each barrier lobe. Monitoring of the vadose zone would require installation and monitoring of new boreholes along the perimeter of the barrier. Surface-barrier monitoring would include surveillance of structural integrity, animal burrowing, soil erosion and deposition, and vegetation status. For more information on postclosure care, see Appendix E, Section E.1.2.5.4.2.

2.2.2.4.2 Clean Closure

Alternatives 4, 6A, and 6B consider clean closure of all or parts of the SST system. Clean closure of the SST system would include the following:

- Removal of ancillary equipment, WRFs, and SSTs
- Deep soil removal
- Additional waste preprocessing/packaging

Removal of ancillary equipment, WRFs, and SSTs. Under the clean closure approach, ancillary equipment, WRFs, SSTs, and contaminated soils within the areal extent of a tank farm would be removed to a depth of 3 meters (10 feet) below the tank bases (approximately 20 meters [65 feet] below the ground surface). For analysis purposes, the removal of 3 meters (10 feet) of additional soils beneath the tank bases was assumed to be sufficient to remove contamination from retrieval leakage.

Tank farm removal activities would consist of removing cover soils, demolishing the tank domes, removing soils to the level of the tank bases, removing the tank sides, and, finally, removing the remaining base sections of the tanks (DOE 2003a:C-5). Ancillary equipment removal would consist of removing the equipment, reducing its size, and packaging it. This work would be conducted remotely whenever necessary.

Deep soil removal. Deep soil removal activities would include localized excavations to remove contaminated soils from past leaks to the depth necessary to protect human health and the environment and to allow unrestricted use of the tank farms. The clean closure approach would require installation of deep pilings for soil support and worker safety, as well as construction and operation of an overarching confinement structure or bubble over each tank farm prior to tank and deep soil removal. The exhaust from this structure would be filtered and would have at least two zones of negative pressure, each with personnel and equipment airlocks. The structure would be used to keep fugitive dusts containing hazardous or radioactive particles from escaping to the environment (DOE 2003e:8).

Under the Tank Closure Alternative 6A and 6B Option Cases, additional highly contaminated soils would be decontaminated at the Preprocessing Facility (PPF) and lightly contaminated soils would be disposed of at the RPPDF. This additional contaminated soils volume would come from the six sets of contiguous cribs and trenches (ditches) in the B and T Areas.[7]

Additional waste preprocessing and packaging. Lightly contaminated ancillary equipment, rubble, and removed soil would be disposed of on site in the RPPDF. Under Tank Closure Alternative 4, a portion of the tank debris, equipment, soils, and rubble recovered from ancillary equipment, tank, and deep soil removal activities is expected to be highly contaminated with tank waste. Because these materials would likely exceed the waste acceptance criteria for onsite disposal, they would be treated at a standalone, 4-hectare (10-acre) PPF using a strong acid wash (DOE 2003e:9). The washed tank debris, equipment, and soils would be packaged and disposed of on site in the RPPDF. The contaminated liquid waste stream from the acid wash would be neutralized and sent to the DSTs for treatment in the WTP. The contaminated soils from deep soil excavation would be treated in the PPF using a weak acid soil wash. The washed soils would be disposed of on site in the RPPDF, and the contaminated liquid waste stream from the soil acid wash would be neutralized and sent to the DSTs prior to treatment in the WTP.

Under Tank Closure Alternatives 6A and 6B, highly contaminated tank debris, equipment, soils, and rubble from tank removal activities would be considered HLW. These materials would be packaged in approximately 147,000 shielded storage boxes. To accommodate the shielded storage boxes, 35 covered, concrete pads would be constructed near the PPF (SAIC 2007). It was assumed that the boxed HLW would be stored on site until disposition decisions are made and implemented and that the radiological and nonradiological inventories in this waste would be contained during onsite storage. Therefore, this waste would not represent a contaminant source to groundwater. Highly contaminated soils removed from deep soil excavation would be treated in the PPF using a weak acid wash. The washed soils would be disposed of on site in the RPPDF, and the contaminated liquid waste stream from the soil acid wash would be further treated in the PPF using a glass melter. The melter would produce an immobilized waste form that would be equivalent to ILAW glass in waste form performance. Under the Alternative 6A and 6B Base Cases, the volume of PPF glass produced would fill approximately 670 canisters, while under the Alternative 6A and 6B Option Cases, the volume of PPF glass would fill approximately 18,300 canisters. This PPF glass would be disposed of on site in an IDF. Figure 2–15 depicts the movement of these highly contaminated materials through their preprocessing and disposal steps under Alternatives 4, 6A, and 6B. Appendix E, Section E.1.2.5.3.2, provides more detail on clean closure.

[7] The following 33 cribs and trenches (ditches) are analyzed in this *TC & WM EIS*: 2 cribs in the B tank farm, 8 trenches in the BX tank farm, 7 cribs in the BY tank farm, 2 cribs and 6 trenches in the T tank farm, 5 trenches in the TX tank farm, and 3 cribs in the TY tank farm. Additional information addressing these cribs and trenches (ditches) is presented in Appendix D, Section D.1.5. Note: The T and TX trenches are considered one set.

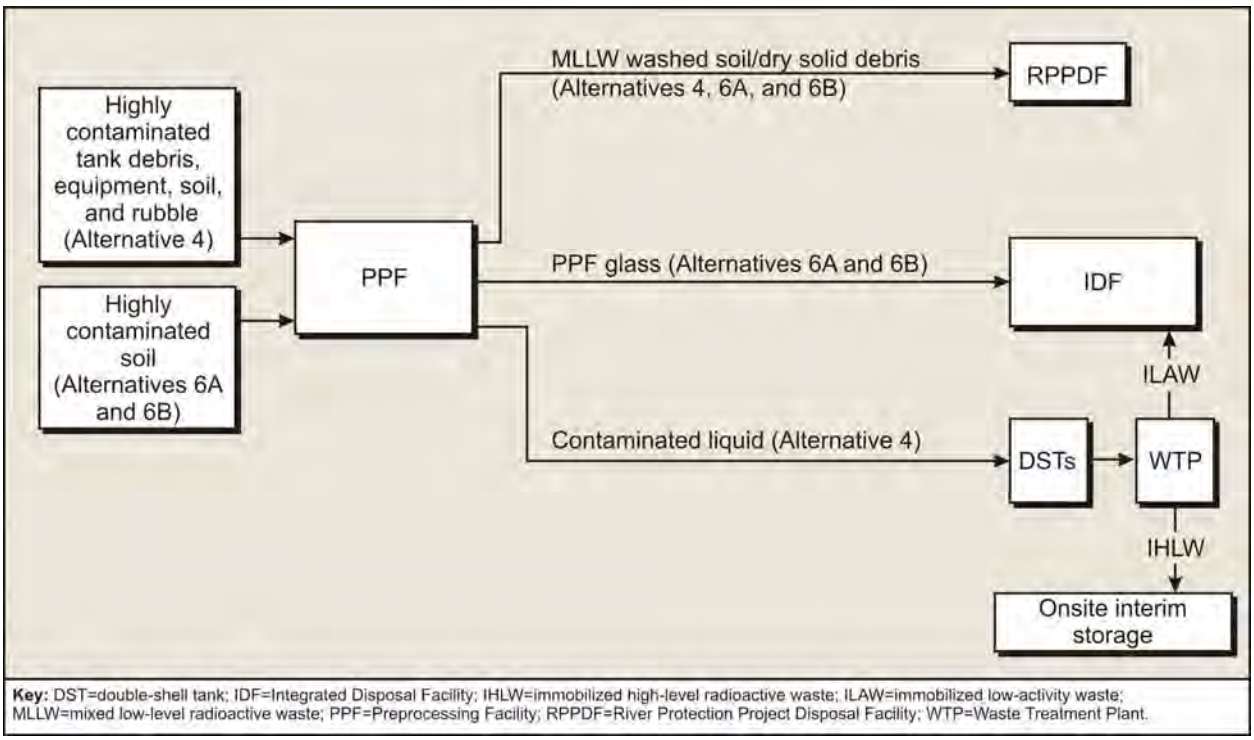


Figure 2–15. Preprocessing Waste Streams Associated with Tank Farm Clean Closure

2.2.2.4.3 Selective Clean Closure/Landfill Closure

This *TC & WM EIS* evaluates a hybrid closure approach under Alternative 4 that would implement clean closure of the BX and SX tank farms and landfill closure of the balance of the SST system. DOE proposes clean closure of the BX and SX tank farms to assess the potential effectiveness of this additional level of remediation to reduce long-term impacts on groundwater—i.e., to establish what might be gained from clean closure of a subset of SST farms (as under Alternative 4) compared to clean closure of the entire SST system (as under Alternatives 6A and 6B).

The BX and SX tank farms were chosen for selective clean closure to represent an intermediate case in the range of closure options. Analysis of Alternative 4 was designed to evaluate the impacts and potential benefits of a case where soil remediation and tank removal could be selectively performed. The purpose of this intermediate case was to examine the activities, impacts, and potential incremental benefit associated with clean closure of a single, moderately contaminated farm in each of the 200-East and 200-West Areas.

This information could be useful to a decisionmaker who wanted to clean-close a different farm or as a metric for scaling the potential impacts and benefits of remediating other single or multiple farms. However, selection of the BX and SX tank farms was not meant to preclude remediation of any different or additional tank farms or to suggest that these farms represent the only case for selective or clean closure. The final agency action could involve remediation of additional or different tank farms other than the BX and SX tank farms.

Selective clean closure, as presented under Alternative 4, was broadly designed to examine an intermediate concept of remediation and closure among alternatives, including waste retrieval without soil remediation or closure (Alternative 2A); landfill closure without soil removal (Alternative 5); landfill closure with surface soil remediation (Alternatives 2B, 3A, 3B, and 6C); and complete clean closure with tank removal (Alternatives 6A and 6B).

DOE anticipated that, if incremental benefits could be discerned at points of groundwater analysis within the sensitivity of the modeling, then decisionmakers would have a better range of options to consider, including selection of any, all, or none of the farms for remediation and/or clean closure. In addition, DOE expects that its analysis will conservatively estimate the potential impacts of selective or clean closure of some or all of the tank farms in question.

2.2.2.4.4 Borrow Area C Operations

Borrow Area C comprises approximately 930 hectares (2,300 acres) and is located south of the Hanford 200-West Area along State Route 240. It is a proposed supply site for the sand, soil, and gravel needed to support environmental remediation activities throughout Hanford. Specific alternatives discussed in this *TC & WM EIS* require the use of borrow materials from Borrow Area C. Resource material from Borrow Area C would be used primarily for construction of new facilities, backfilling and regrading where facilities and/or contaminated soils were removed from the ground, and creation of modified RCRA Subtitle C or Hanford barriers.

Conventional excavation, loading, and transportation equipment would be used at Borrow Area C. Conveyor systems may be employed to move excavated material to stockpile areas or load trucks. Conveying systems may be outfitted with crushing, sorting, and screening systems to segregate rock and fines according to Hanford's needs. Basalt, when encountered, would be blasted with controlled, subsurface detonations.

Borrow Area C was evaluated for use as a borrow area because it is relatively close to most of the proposed activities that would require borrow materials and because it could provide the variety of gravel, sand, and soil types necessary to support such activities. A detailed description of Borrow Area C is presented in Appendix E, Section E.1.2.5.5.

2.2.2.4.5 Facility Decontamination and Decommissioning

This *TC & WM EIS* specifically evaluates the decontamination and decommissioning (D&D) activities that would be required prior to final closure of the SST system for only the following 10 existing Hanford facilities[8]:

242-S Evaporator. Located north of the S tank farm, this facility was used to concentrate tank waste. Operation of the 242-S Evaporator began in 1973 and continued until 1980. The facility was shut down in 1980 and placed in a standby mode in 1981.

Deactivation is placing a facility in a stable and known condition, including removal of hazardous and radioactive materials, to ensure adequate protection of workers, public health and safety, and the environment, thereby limiting the long-term cost of surveillance and maintenance. Actions include removing fuel, draining and/or de-energizing nonessential systems, removing stored radioactive and hazardous materials, and related actions. Deactivation does not include all of the decontamination activities necessary for the dismantlement and demolition phase of decommissioning (e.g., removal of contamination remaining in the fixed structures and equipment after deactivation).

Decommissioning is the process of closing and securing a nuclear facility or nuclear materials storage facility to provide adequate protection from radiation exposure and to isolate radioactive contamination from the human environment. It takes place after deactivation and includes surveillance, maintenance, decontamination, and/or dismantlement. These actions are taken at the end of a facility's life to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment. The ultimate goal of decommissioning is unrestricted release or restricted use of the site.

Decontamination is the removal or reduction of residual chemical, biological, or radiological contaminants and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

[8] This *TC & WM EIS* evaluates deactivation of the WTP and other proposed waste treatment and interim storage facilities at the end of their operational lives. However, closure and D&D of these new facilities are not within the scope of the tank closure proposed actions.

242-T Evaporator. This facility is adjacent to the TX tank farm. Operation of the 242-T Evaporator began in 1952 and continued intermittently until 1980. In April 1981, a shutdown/standby plan was written, and a final waste transfer out of the facility was made in 1982.

204-AR Receiver Station. The 204-AR Receiver Station is located west of the AX tank farm. The facility was designed to receive liquid waste from rail tank cars or tank trailers and to pump the waste to a designated 200-East Area tank farm. The facility was constructed in 1981 and is still operational.

241-A-431 Vent Building. This facility was constructed in 1953 to provide offgas de-entrainment of the six tanks in the A tank farm and to receive drainage from the 296-A-11 stack. It began operation in 1955 and was shut down in 1969.

241-AX-IX Ion Exchange Facility. Designed and built in the late 1960s and located east of the A tank farm, this facility operated routinely from 1973 to 1976 to treat condensate from the waste facility exhauster between the A and AX tank farms.

241-BY-ITS1 In-Tank Solidification Facility. Located in the BY tank farm, this facility was constructed in the late 1950s and operated until the mid-1970s to concentrate waste in the BY tanks.

241-C-801 Cesium Loadout Facility. This cesium processing transfer facility, located in the C tank farm, operated from 1962 until 1976.

241-SX-401 and 241-SX-402 Condenser Shielding Buildings. Built in 1954, these condenser shielding buildings are located within the SX tank farm. Building 241-SX-401 was used as designed to cool some of the tanks in the SX tank farm until 1975, when use of the facility ended.

241-AX-WT-SP-137 Seal Pot. This facility is located underground in the AX tank farm. D&D of the 241-AX-WT-SP-137 Seal Pot would involve filling it with grout and abandoning it in place.

D&D of these facilities would occur under all Tank Closure alternatives, with the exception of the No Action Alternative. Activities would generally include decontamination of building surfaces and equipment; removal of major vessels from inside each facility; demolition of each facility to ground level (except for the 241-AX-WT-SP-137 Seal Pot); and transfer of waste, rubble, and debris into containers or shielded burial boxes for shipment to appropriate disposal locations (DOE 2003a:6-115).

2.3 FAST FLUX TEST FACILITY DECOMMISSIONING ACTIONS

FFTF is a DOE-owned, formerly operating, 400-megawatt (thermal) liquid-metal (sodium)-cooled research and test reactor located in the 400 Area of Hanford. The original purpose of the facility was to develop and test advanced fuels and materials for the Liquid Fast-Breeder Reactor Program; other missions were subsequently pursued. Construction of FFTF was completed in 1978, and initial criticality was achieved on February 9, 1980, with full power initiated on December 21, 1980. Following an additional year of acceptance testing, FFTF operated from 1982 to 1992, providing the nuclear industry with advances in fuel performance, medical isotope production, materials performance, and passive and active safety system testing. In December 1993, DOE decided not to continue operating FFTF due to a lack of economically viable missions at that time and issued a shutdown order. Figure 2–16 shows the location of the FFTF complex within the 400 Area. A detailed description of the FFTF complex is provided in Appendix E, Section E.2.

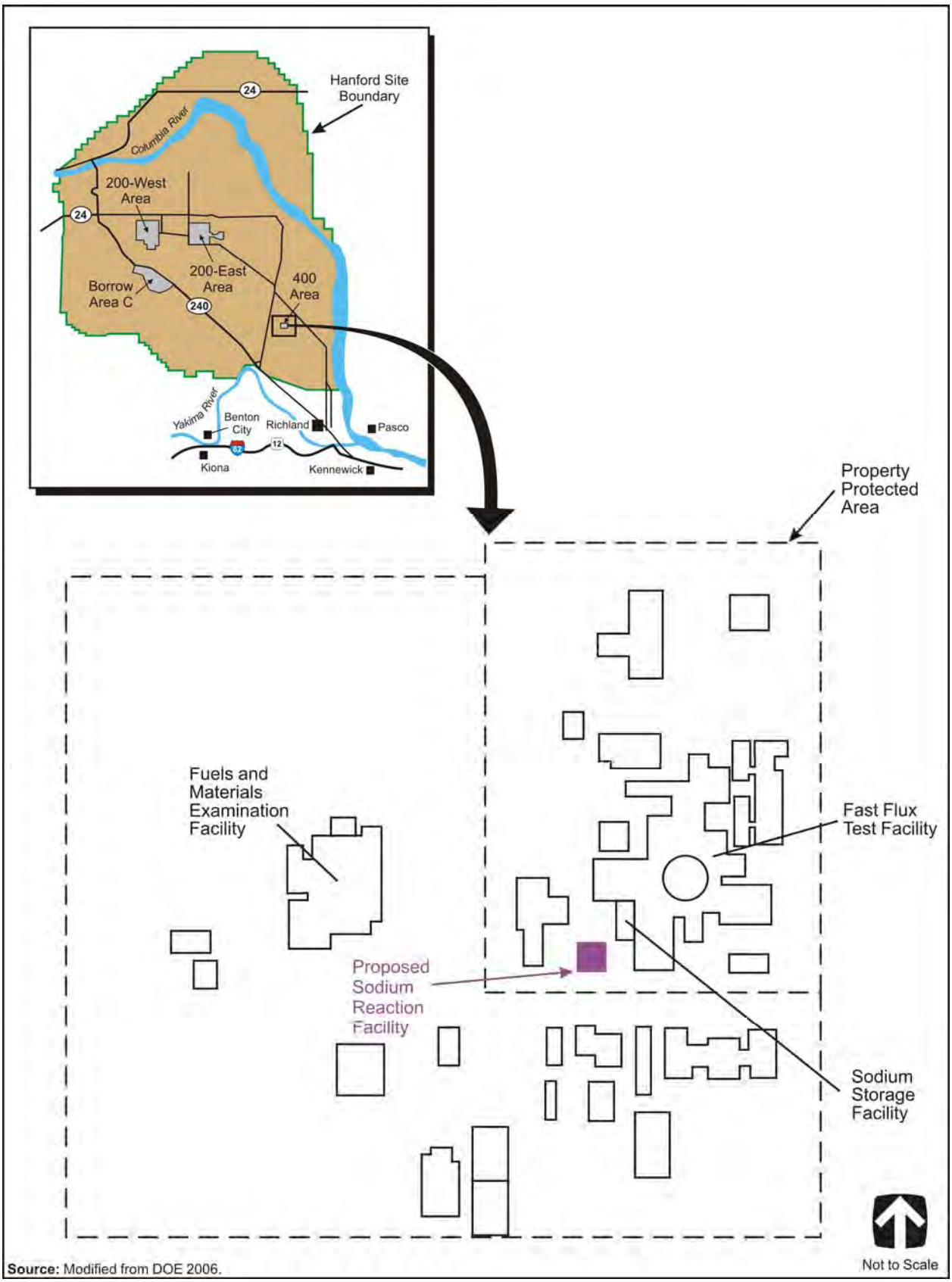


Figure 2–16. 400 Area Fast Flux Test Facility Complex Location Map

2.3.1 Decommissioning of Fast Flux Test Facility and Auxiliary Buildings

Forty-five structures or buildings within the FFTF Property Protected Area (PPA) would be decommissioned under the FFTF decommissioning set of proposed actions. These buildings fall under three general groups: the Reactor Containment Building (RCB), reactor support buildings (19 structures), and auxiliary buildings (25 structures).

Of the 45 facilities, 15 have basements or other below-grade structures, and 12 are potentially contaminated with radioactive materials. Because of the nature of the operations and maintenance work conducted in the area, most of the facilities are believed to contain hazardous materials as well.

2.3.1.1 Reactor Containment Building

The RCB is the major facility associated with the FFTF complex (see Figure 2–17) that would be decommissioned under the FFTF decommissioning proposed actions. The RCB consists of a cylindrical carbon steel reactor-containment vessel 56.7 meters high by 41.1 meters in diameter (186 feet high by 135 feet in diameter), as well as several principal structures and various equipment that are located inside the building. Reinforced-concrete cells occupy the lower portion of the containment vessel from grade level (elevation 158 meters [550 feet]) to approximately 24 meters (78 feet) below grade. Some areas near the sodium piping and vessels are steel-lined. Below-grade structures containing the greatest radionuclide inventories include the reactor vessel, the Interim Examination and Maintenance Cell, the Test Assembly and Conditioning Station, and the Interim Decay Storage Vessel (Fluor Hanford 2005a). Radionuclide and hazardous chemical inventories associated with FFTF decommissioning actions are presented in Appendix D, Section D.2.



Figure 2–17. Fast Flux Test Facility Complex

2.3.1.2 Reactor Support and Auxiliary Buildings

Various reactor support and auxiliary buildings surround the RCB. These buildings are structurally independent of the RCB, and their structural designs reflect specific requirements for resisting natural forces such as earthquakes, winds, and tornadoes. The reactor support and auxiliary buildings are listed in Table 2–1, which also summarizes the proposed decommissioning activities for each building under both the Entombment and Removal Alternatives.

Table 2–1. Fast Flux Test Facility and Support Facilities

Building Number	Building Name	Action Alternative	
		FFTF Decommissioning Alternative 2: Entombment	FFTF Decommissioning Alternative 3: Removal
405	FFTF Reactor Containment Building	F	E
491E	HTS Service Building, East	F	C
491W	HTS Service Building, West	F	C
4621E	Auxiliary Equipment Building, East	D	C
4621W	Auxiliary Equipment Building, West	D	C
4703	FFTF Control Building	D	C
4717	Reactor Service Building	D	C
491S	HTS Service Building, South	D	C
408A	Main Heat Dump, East	B	A
408B	Main Heat Dump, South	B	A
408C	Main Heat Dump, West	B	A
409A	Closed Loop Heat Dump, East 1	B	A
409B	Closed Loop Heat Dump, East 2	B	A
403	Fuel Storage Facility	C	C
402	Sodium Storage Facility	A	A
432A	ISA Covered Equipment Storage	A	A
436	Training Facility	A	A
437	Maintenance and Storage Facility	A	A
440	90-Day Covered Storage Pad	A	A
451A	Substation	A	A
453A	Transformer Station, East DHX A1, 2.4kV	A	A
453B	Transformer Station, South DHX A2, 2.4kV	A	A
453C	Transformer Station, West DHX A3, 2.4kV	A	A
4701	Former FFTF Guard Station	A	A
4710	FFTF Office Building	A	A
4713A	Riggers and Drivers Operations Facility	A	A
4713B	FFTF Maintenance Shop	A	A
4713C	Contaminated Storage Warehouse	A	A
4713D	Interim Maintenance and Storage Facility	A	A
4716	FFTF Rigging Loft	A	A
4718	400 Area Interim Storage Area Pad	A	A
4721	FFTF Emergency Generator Building	A	A
4734A	FFTF Argon/Nitrogen Pad	A	A
480A	Water Supply Well House (P-14)	A	A
480B	Water Supply Well House (P-15)	A	A
480D	Water Supply Well House (P-16)	A	A
481	Water Pump House	A	A
481A	Water Pump House	A	A
482A	Water Storage Tank (T-58)	A	A

Table 2–1. Fast Flux Test Facility and Support Facilities *(continued)*

Building No.	Building Name	Action Alternative	
		FFTF Decommissioning Alternative 2: Entombment	FFTF Decommissioning Alternative 3: Removal
482B	Water Storage Tank (T-87)	A	A
482C	Water Storage Tank (T-330)	A	A
483	Cooling Towers Chemical Addition Building	A	A
484	FFTF In-Containment Chiller Water Equipment Building	A	A
4842B	Switchgear Building for Pump Houses	A	A
SRF[a]	Sodium Reaction Facility (proposed)	A	A

[a] If DOE decides to process the bulk sodium at an existing INL (Idaho National Laboratory) facility, the SRF (Sodium Reaction Facility) would not be constructed. Decommissioning of the INL facility is not addressed in this *TC & WM EIS*.

Note: Gray shading indicates buildings with reinforced-concrete basements.

A = Demolish and remove building and soils, down to 0.91 meters (3 feet) below grade; if present, collapse subsurface floors and interior walls into the below-grade space (basement exterior walls below 0.91 meters [3 feet]; basement floor and foundations would remain). Backfill to grade with soil, then compact and contour surface and revegetate. Remove all radioactive and/or hazardous material, as well as wood and large steel components. Foundation rubble (e.g., concrete and rebar) could remain.

B = Same as A, except the building footprint would be partially covered by the engineered barrier system.

C = Demolish and remove building down to grade. Remove above- and below-grade components and systems, then collapse floors and walls into the below-grade space at least down to 0.91 meters (3 feet) below grade (basement exterior walls below 0.91 meters [3 feet]; basement floor and foundations would remain). Backfill to grade with soil, then compact and contour surface and revegetate. Remove all radioactive and/or hazardous material, as well as wood and large steel components. Foundation rubble (e.g., concrete and rebar) can remain.

D = Same as C, except the building footprint would be partially covered by the engineered barrier system.

E = Same as C, except small amounts of radioactive activation products in structural concrete and steel would remain.

F = Remove above-grade structures and systems. Contaminated equipment and systems below grade can remain. Consolidate waste and demolition debris below grade, then backfill with grout and cover entirely as part of the engineered barrier system. Radioactive and hazardous waste would remain entombed.

Key: DHX=Dump Heat Exchanger; FFTF=Fast Flux Test Facility; HTS=Heat Transport System; ISA=Interim Storage Area; kV=kilovolts.

2.3.2 Deactivation Activities

As discussed in Chapter 1, Section 1.2.4, and detailed in Appendix E, FFTF decommissioning will follow a series of facility deactivation actions specified by previous FFTF NEPA decisions; therefore these actions were not included as part of the *TC & WM EIS* analyses. Major deactivation activities under way since June 2007 include preparing fuel for shipment and processing and deactivating auxiliary plant systems. Approximately 916,000 liters (242,000 gallons) of a total 958,000 liters (253,000 gallons) of radioactively contaminated bulk sodium has been drained from the FFTF reactor vessel, three primary and three secondary heat transport system loops, the Fuel Storage Facility, and the Interim Decay Storage Vessel and associated auxiliary systems and transferred to the Sodium Storage Facility (SSF) located adjacent to FFTF. Associated trace heat systems have been de-energized (Chapin 2007).

2.3.3 Proposed Fast Flux Test Facility and Auxiliary Building Disposition Activities

This section presents an overview of the key technologies and facilities that would be used to implement the proposed FFTF decommissioning activities, i.e., disposition of facilities, RH-SCs, and bulk sodium. More-detailed descriptions of these proposed technologies and facilities are presented in Appendix E, Section E.2.

2.3.3.1 Facility Disposition

Table 2–1 in Section 2.3.1.2 summarizes the proposed decommissioning activities for FFTF and its support facilities under the Entombment and Removal Alternatives (FFTF Decommissioning Alternatives 2 and 3, respectively). Under both alternatives, all sodium residuals would be removed from the RCB systems or treated in place. The sodium would be drained from plant systems to the extent practicable, followed by in situ moist-gas passivation and/or flushing with water to stabilize the residuals. Sodium residuals in small-diameter piping would be treated in the 400 Area after the components are removed from the reactor plant.

Demolition debris, radioactive waste, and other regulated hazardous waste would be handled in the same manner under both action alternatives; only the volume of waste would change. Debris not placed in the RCB or other voids or used as backfill would be transported to an IDF for disposal. Radioactive liquid waste volume resulting from treatment of the sodium residuals would be reduced at FFTF, either through ion exchange and reuse or evaporation. The remaining liquids would be transported to the 200 Area ETF for processing and disposal. It was assumed for analysis purposes that a 90 percent reduction in volume could be achieved prior to shipment to the ETF. Volumes of other regulated waste, such as polychlorinated biphenyls (PCBs) and asbestos, are expected to be small and would be dispositioned in accordance with existing Hanford facility waste acceptance criteria

The FFTF facility disposition proposed actions evaluate various end-state approaches in accordance with the specific objectives of that alternative. Under the No Action Alternative, the facilities and infrastructure within the PPA, including the RCB, would undergo long-term surveillance with appropriate monitoring and controls to ensure that environmental and safety concerns are minimized for the foreseeable future. Under FFTF Decommissioning Alternative 2: Entombment, a regulatorily compliant engineered barrier, such as a modified RCRA Subtitle C barrier, would be constructed over the RCB and Buildings 491E and 491W, all of which contain radioactive and/or hazardous wastes. In addition, the barrier would extend over part or all of the immediately adjacent facility footprints.

The modified RCRA Subtitle C barrier would be circular with a radius of about 391 meters (128.5 feet), excluding the side slope used for drainage. It would be composed of eight layers of durable material with a combined minimum thickness of about 1.7 meters (5.7 feet). It would be designed to provide long-term containment and hydrologic protection for a performance period of 500 years. Like some of the Tank Closure alternatives, postclosure care would include monitoring of air, groundwater, and the vadose zone.

Under FFTF Decommissioning Alternative 3: Removal, no barrier would be built. Below-grade portions of structures would be backfilled with soil and compacted to eliminate void spaces, contoured to prevent natural settling resulting in depressions, and revegetated. Institutional controls or postclosure care may be established and continue for 100 years after revegetation of the area is complete.

2.3.3.2 Disposition of Remote-Handled Special Components

A number of components would require special handling and disposition because of high radiation levels and/or the inability to drain the component effectively. These components include a sodium cold trap, a cesium trap, and two sodium vapor traps. These components collected significant amounts of radioactive fission products during operation of the reactor. The resulting high radiation levels require these components to be handled remotely, which complicates removal and disposition. Removal of these RH-SCs from FFTF will be completed as part of the deactivation work and is evaluated in the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006). The removed components will be stored within the FFTF complex under all FFTF Decommissioning alternatives. Under FFTF Decommissioning Alternatives 2 and 3, the components would be sent to the selected treatment facility once it has been built and is ready to receive them.

2.3.3.2.1 Fast Flux Test Facility Remote-Handled Special Components

The following is a brief description of the four FFTF traps that are considered to be RH-SCs.

2.3.3.2.1.1 Sodium Cold Trap

When FFTF operated, the primary coolant system cold trap was cooled by a sodium-potassium cooling jacket around the outside of the sodium-containing crystallizer tank. The sodium and sodium-potassium system piping were interconnected and the sodium-potassium flushed into the sodium system, thus eliminating the sodium-potassium storage/disposal concern. However, sodium in both the tank and the cooling jacket is not fully drainable, and high dose rates make it impossible to enter the cold trap cell to do manual work. Therefore, DOE is proposing to flush the sodium-potassium from the cold trap cooling jacket with sodium. The sodium-potassium system would then be drained to the maximum extent possible and the sodium in the crystallizer tank, as well as the sodium residuals left in the cooling jacket, would be allowed to freeze. The cold trap would be removed using remote operations and special shielding.

2.3.3.2.1.2 Cesium Trap

The cesium trap is a reticulated vitreous carbon filter designed to remove radioactive cesium caused by fuel cladding failures from the primary sodium. It is located outside of containment in a shielded cell in the Heat Transport System Service Building South. The trap is not drainable; as with the cold trap, it would be removed using remote operations and special shielding.

2.3.3.2.1.3 Sodium Vapor Traps

The sodium vapor traps minimized sodium vapor transport into the primary cover-gas system piping. These components are located in isolated cells within the RCB. One vapor trap has large quantities of cesium-137, and considerable quantities have migrated beyond the trap into the downstream gas piping systems. Both of these traps would be remotely removed and shielded.

2.3.3.2.2 Processing Facility Options and Description

Sodium residuals would be left in the traps during their removal and transport to an interim storage facility. Currently, no facility exists within the DOE complex for handling or treating the traps or other Hanford RH-SCs. There are two options for treatment of these traps:

Hanford Option. DOE proposes constructing a new Remote Treatment Project (RTP) in the T Plant complex at Hanford. This new facility would be similar in design to Idaho National Laboratory's (INL's) proposed RTP, with the addition of a new high-bay cask-unloading area. RH-SCs would be removed from FFTF, stored on site at Hanford until the new RTP is permitted and built, then treated in the new RTP and disposed of in an IDF.

Idaho Option. The Idaho Option analyzed in this *TC & WM EIS* assumes shipment of RH-SCs to a new RTP at INL's Materials and Fuels Complex (MFC) for processing. Under the Idaho Option, RH-SCs from Hanford would be shipped to INL for treatment in this proposed facility (new RTP at MFC), then disposed of either at the Nevada Test Site (NTS) or in a Hanford IDF. The INL RTP is currently in the planning phase; an environmental assessment (DOE 2008) is being prepared that includes the impacts of receiving, storing, and treating the four FFTF RH-SCs analyzed in this *TC & WM EIS*.

The two primary design features of both proposed Hanford and INL RTPs are as follows:

- A waste processing cell used to prevent the release of radioactive and hazardous contaminants to the environment

- Waste processing equipment designed to handle and process the RH-waste received in liners, drums, and large waste boxes

The Hanford RTP would be a concrete and steel structure with planned dimensions of 22 meters by 29 meters (72 feet by 94 feet). The annex would consist of four floors: the service floor (basement), operating floor (grade level), utility floor, and high-bay floor. The total floor area would be approximately 2,600 square meters (28,000 square feet).

2.3.3.2.3 Process Flow Description

Handling of RH-SC waste packages in an RTP would begin when the waste shipments were received in trailer trucks carrying shielded casks or waste containers. After unloading the waste, it would be transferred into the waste processing cell, which would contain a variety of processing equipment for storing, sorting, sizing, processing, and repackaging the waste. Because the RH-SCs would enter the processing cell in some form of packaging (liners, drums, or boxes), the first step would be to open the packages and extract the RH-SCs. Specialized handling equipment would be used to open specific types of waste containers. CH-debris created during disassembly would be placed in large cans (drums), which would then be placed into standard waste boxes for transport and disposal at an appropriate CH-waste disposal facility, depending on the characteristics of the waste. RH-debris would be transferred to the RH-waste processing area, sorted at a waste sorter station, and reduced in size for packaging, removal, and disposal.

The following initial RH-SC waste package processing equipment and steps are proposed.

- A liner disassembly station would handle, unload, and disassemble liners and waste cans.

- Nondestructive assays (NDAs) would be used to quantify identifiable, separate items encountered in the repackaging process (item assays), as well as items that have been packaged for shipment (package assays). Both types of assays employ qualitative gamma-ray spectroscopy to identify isotopes and quantitative gamma-ray spectroscopy (such as segmented gamma scanning, tomographic gamma scanning, and whole-item corrected assays) to quantify isotopes whose gamma rays are detectable. Both types of assays also use passive and active neutron measurement methods to quantify fissile materials.

- A waste can size-reducing device would be used to compact CH-waste can tubes or cut the tubes into smaller pieces suitable for denser packing in waste containers such as 208-liter (55-gallon) drums.

- A sodium removal (melt-drain-evaporate) system would remove the sodium contained in some of the RH-waste. The RH-waste would be placed in an evaporation vessel and heated to melt and drain the sodium. The vessel would then be heated further under vacuum to remove sodium from the crevices. Test demonstrations have shown a removal rate greater than 99 percent.

- A waste sorting station would disassemble waste cans and remove, resize, and sort waste into various waste containers.

- An induction melter would consolidate irradiated and contaminated metal components that require deep geologic disposition, including zircaloy and stainless steel. The melter would

improve volumetric packaging in the waste containers without the particulate contamination created by other mechanical size-reduction techniques.

- After completion of melt processing, the crucible containing the waste ingot would be removed from the melter and transferred to the melter equipment–handling station, which would prepare and load the crucibles, dump and sample the ingots, and package the ingots into waste cans.

2.3.3.3 Sodium Processing

The FFTF reactor coolant systems and storage vessels contained about 980,000 liters (260,000 gallons) of radioactively contaminated sodium. This sodium is stored in solid form under an inert cover gas (argon or nitrogen) in four steel tanks located inside the 400 Area SSF. Management and disposition of this sodium, along with 128,700 and 26,500 liters (34,000 and 7,000 gallons) of radioactive sodium from the Hallam Reactor and the Sodium Reactor Experiment (SRE), respectively, are analyzed in this EIS. The Hallam Reactor sodium is stored in solid form under an inert cover gas in five stainless steel tanks inside the 200-West Area's 2727-W Facility, a Butler-type steel building. The SRE sodium is stored in solid form in 158 drums (208 liters [55 gallons] each) sealed within 322-liter (85-gallon) overpacks inside eight storage modules located in the 200 Area CWC (Burke 2007). All of this bulk sodium would undergo a sodium reaction process to produce a caustic sodium hydroxide solution at either a proposed Hanford Sodium Reaction Facility (SRF) or the Sodium Processing Facility (SPF) at INL's MFC. This caustic solution would then be available for reuse in processing tank waste at the WTP or for supporting Hanford tank corrosion controls. The following section provides a general process description that would apply to either facility option, as well as a brief description of each facility.

2.3.3.3.1 Sodium Reaction Process

Elemental sodium is a silver, soft, ductile alkali metal at room temperature with a density slightly less than that of water. It reacts vigorously with water and steam and oxidizes rapidly when exposed to air. The basic chemical reaction is an exothermic reaction with water that produces a caustic sodium hydroxide solution that yields hydrogen gas.

Liquid sodium would be transferred from a storage tank into the processing facility where the reaction would be controlled by adjusting the injection rate of the liquid reactants. The process would take place in a nickel pressure vessel. The entire system would use nitrogen as an inert cover and pressurizing gas. Offgases emitted during the process would contain hydrogen, nitrogen, water vapor, and caustic vapor. The gases would be exhausted from the vessel, dried, scrubbed, filtered through a high-efficiency particulate air filter, and monitored before venting as a nonflammable nitrogen-hydrogen mixture. The final caustic solution would be pumped from the reaction vessel to a fill station where transportation tanks or drums would be used to contain it for storage.

The following descriptions detail the bulk sodium processing steps proposed by DOE.

- Bulk sodium would be transported to either INL's SPF or Hanford's SRF, where a sodium barrel melt-and-drain system would remove the sodium from its packaging and transfer it into a sodium storage tank.

- A sodium transfer system would transfer the bulk sodium to two carbon steel sodium day tanks (so named because they will be sized to contain sufficient sodium for one day of processing), each with a working volume of 16,300 liters (4,300 gallons). A pressurized nitrogen blanket would be used to push the bulk sodium from the storage tank to fill one of the day tanks, while the other day tank is used for processing.

- The sodium reaction system would chemically convert the bulk sodium to a caustic sodium hydroxide solution using a reaction vessel consisting of a 76.2-centimeter-diameter by 4.6-meter-high (30-inch-diameter by 15-foot-high) corrosion-resistant vertical cylinder.

- A caustic transfer system would be used to pump (1) caustic sodium hydroxide solution from the bottom of the reaction vessel and cycle it back to the vessel; (2) some of the solution into a caustic cooling tank to reduce the temperature of the solution below the level necessary for caustic corrosion; (3) some of the solution to the product system.

- In the product system, the caustic sodium hydroxide solution would pass through a product fill line to be cooled prior to entering a product container. When filled, the container would be sampled, sealed, inspected, and moved to a storage bay.

2.3.3.3.2 Sodium Reaction Facility—Hanford Reuse Option

The sodium reaction process used by the SPF at INL forms the basis for the Hanford Reuse Option using the SRF. The SRF would be located directly adjacent to the existing SSF, as shown in Figure 2–18. This proposed location would reduce construction and operations costs through utilities sharing and operation integration. The SSF is located west of the FFTF Dump Heat Exchanger South and would be used to store the bulk sodium until it could be transferred to the SRF for processing. Like the SPF, the SRF would process the bulk sodium analyzed in this EIS to produce approximately 7,600 liters (2,000 gallons) of 50 weight-percent caustic sodium hydroxide solution each day (ANL-W and Fluor Hanford 2002).

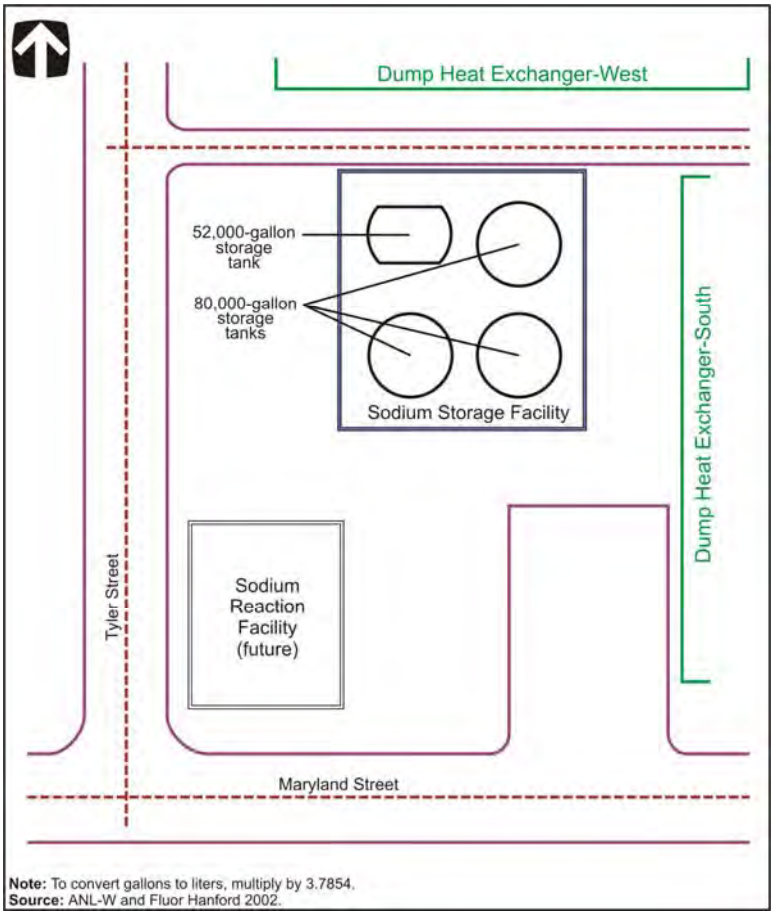


Figure 2–18. Location of the Hanford Site Sodium Reaction Facility and Sodium Storage Facility

2.3.3.3.3 Sodium Processing Facility—Idaho Reuse Option

The SPF is located within the MFC at INL and consists of several buildings, including the original SPF building (with a large addition), a caustic storage tank room, an operations support trailer, the Experimental Breeder Reactor II (EBR-II) sodium boiler building, and the sodium transfer system located in the yard area between the sodium boiler building and the SPF (see Figure 2–19).



Source: ANL-W and Fluor Hanford 2002.

Figure 2–19. Sodium Processing Facility at Idaho National Laboratory

The SPF is a 20.4-meter by 17.4-meter (67-foot by 57-foot) galvanized, structural-steel building containing the barrel melt-and-drain room, barrel holding room, and equipment and control room, as well as a carbon steel–lined concrete pad on which the process equipment is located. The barrel melt-and-drain room has reinforced-concrete block walls and a reinforced-concrete roof. A 7.6-meter by 22.6-meter (25-foot by 74-foot) addition to the SPF building was constructed to house the product area, and two storage bays with a combined outside dimension of 7.3 meters by 9.8 meters (24 feet by 32 feet) are also attached. A small metal-sided building, constructed over a lined-concrete secondary-containment basin and located west of the original SPF building, houses the caustic storage tank. An operation support trailer provides office space, a lunchroom, a locker room, and showers for the operating crews. The EBR-II sodium boiler building contains the secondary sodium drain tank, a recirculation system, and pumps to transfer sodium to the SPF.

The EBR-II/SPF complex was originally constructed in the mid-1980s to convert sodium from the Enrico Fermi Nuclear Generating Station (Fermi), a commercial power plant near Detroit, Michigan, into a 50 weight-percent caustic sodium hydroxide solution designated for use in the plutonium-uranium extraction (PUREX) process at Hanford. This designated use was abandoned after the SPF was constructed, but before SPF operations began. Once the EBR-II reactor was ordered to be shut down, defueled, and prepared for deactivation, the SPF was used to prepare the Fermi and EBR-II sodium for disposal. Production operations with radioactive sodium began in 1998 and were completed in 2001. The facility was then placed in a standby condition. To date, approximately 680,000 liters (180,000 gallons) of radioactive sodium have been processed in the SPF. The SPF would process the bulk sodium analyzed in this EIS to produce approximately 7,600 liters (2,000 gallons) of 50 weight-percent caustic sodium hydroxide solution each day (ANL-W and Fluor Hanford 2002).

2.4 SOLID WASTE MANAGEMENT ACTIONS

Each facility within the Hanford Solid Waste Operations Complex (SWOC) performs duties to achieve waste management goals. These duties are generally complementary, and each facility contributes to the overall process. However, some processes and activities are performed at more than one facility, either because it is necessary or because it maximizes flexibility and project efficiency. The primary processes for each facility include receipt, staging, storage, repackaging, treatment, and shipment of waste, all of which must comply with the waste acceptance criteria.

2.4.1 Existing Solid Waste Operations Complex

The existing SWOC consists of five components, which are depicted in Figures 2–20 and 2–21 and briefly described below. The SWOC units are currently operating under interim status standards as RCRA treatment, storage, and disposal (TSD) units. A detailed description of these facilities is presented in Appendix E, Section E.3.1.

2.4.1.1 Low-Level Radioactive Waste Burial Grounds

The low-level radioactive waste burial grounds (LLBGs) consist of eight separate waste disposal areas consolidated into a single radioactive waste unit. Two burial grounds are located in the 200-East Area, and six are located in the 200-West Area. The combined area of the burial grounds is about 220 hectares (544 acres) (DOE 1997c). The LLBGs contain lined and unlined trenches of varying size and depth that are used for disposal of LLW and MLLW and for retrievable storage of TRU waste.

Currently, LLW and MLLW are sent to RCRA-compliant trenches in LLBG 218-W-5 (trenches 31 and 34, the only lined trenches in the LLBGs) or the Environmental Restoration Disposal Facility. Figure 2–22 shows one of the lined disposal trenches in LLBG 218-W-5. Naval reactor compartments are sent to LLBG 218-E-12B (trench 94). Additional activities at the trenches include immobilization and macroencapsulation of difficult-to-handle packages and radioactive lead solids. In general, most types of waste packages are received, stored, or disposed of in the same manner. Active trenches are backfilled as needed to minimize exposure and dose rates to operators. Backfilling a trench also minimizes the amount of waste exposed to conditions that could cause package degradation and waste-handling accidents.

Ongoing TRU waste retrieval activities include uncovering and moving the waste containers that were retrievably stored in LLBGs 218-W-4C, 218-W-4B, and 218-W-3A. Preliminary site investigations are conducted in the burial grounds as needed to obtain in situ information regarding the current physical condition of buried TRU waste containers and to determine the status of the environmental conditions immediately surrounding the stored waste. Once stored waste locations are confirmed and conditions are assessed, a few selected waste containers may be retrieved and characterized to provide additional information for preliminary site investigations and prepare for the full-scale retrieval operations that will follow (Weidert 2003).

2.4.1.2 Central Waste Complex

The CWC provides storage and staging for waste containers awaiting waste processing operations at other waste management facilities. Primary activities include receiving and storing waste. The CWC's main buildings are shown in Figure 2–23, including Building 2403-WD, which has a radioactive waste storage capacity of 17,500 drums. Other structures include the Low-Flashpoint Mixed Waste Storage Modules, Alkali Mixed Waste Modules, South Alkali Metal Storage Modules, Mixed Waste Storage Modules, Waste Receiving and Staging Area, Mixed Waste Storage Pad, 2420-W Cask Storage Pad, and Outdoor Storage Area. The storage buildings and pads have physical features that provide segregated storage areas to maintain appropriate separation between groups of incompatible wastes. The total CWC drum capacity is 82,480 drums (Weidert 2003).

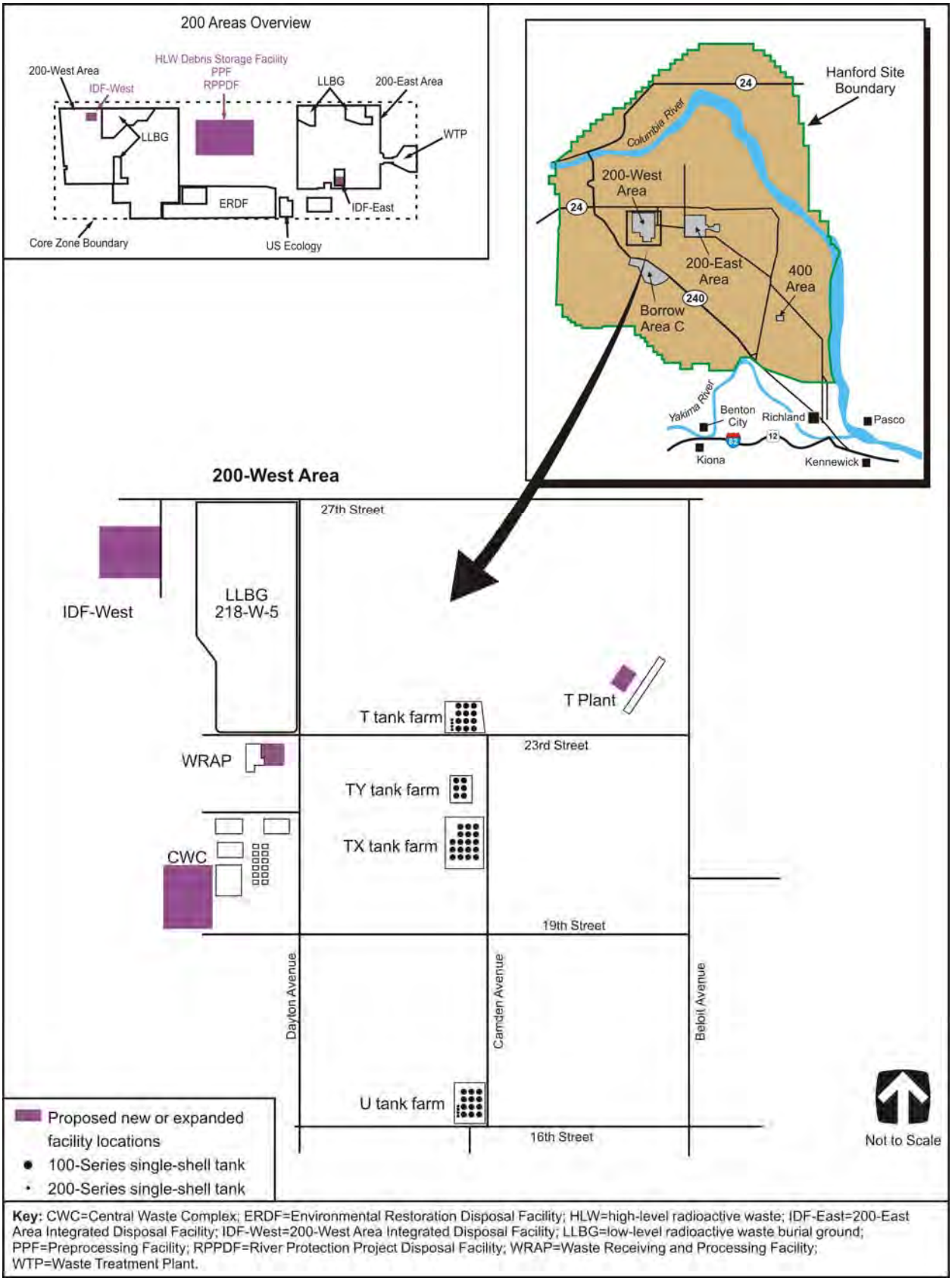
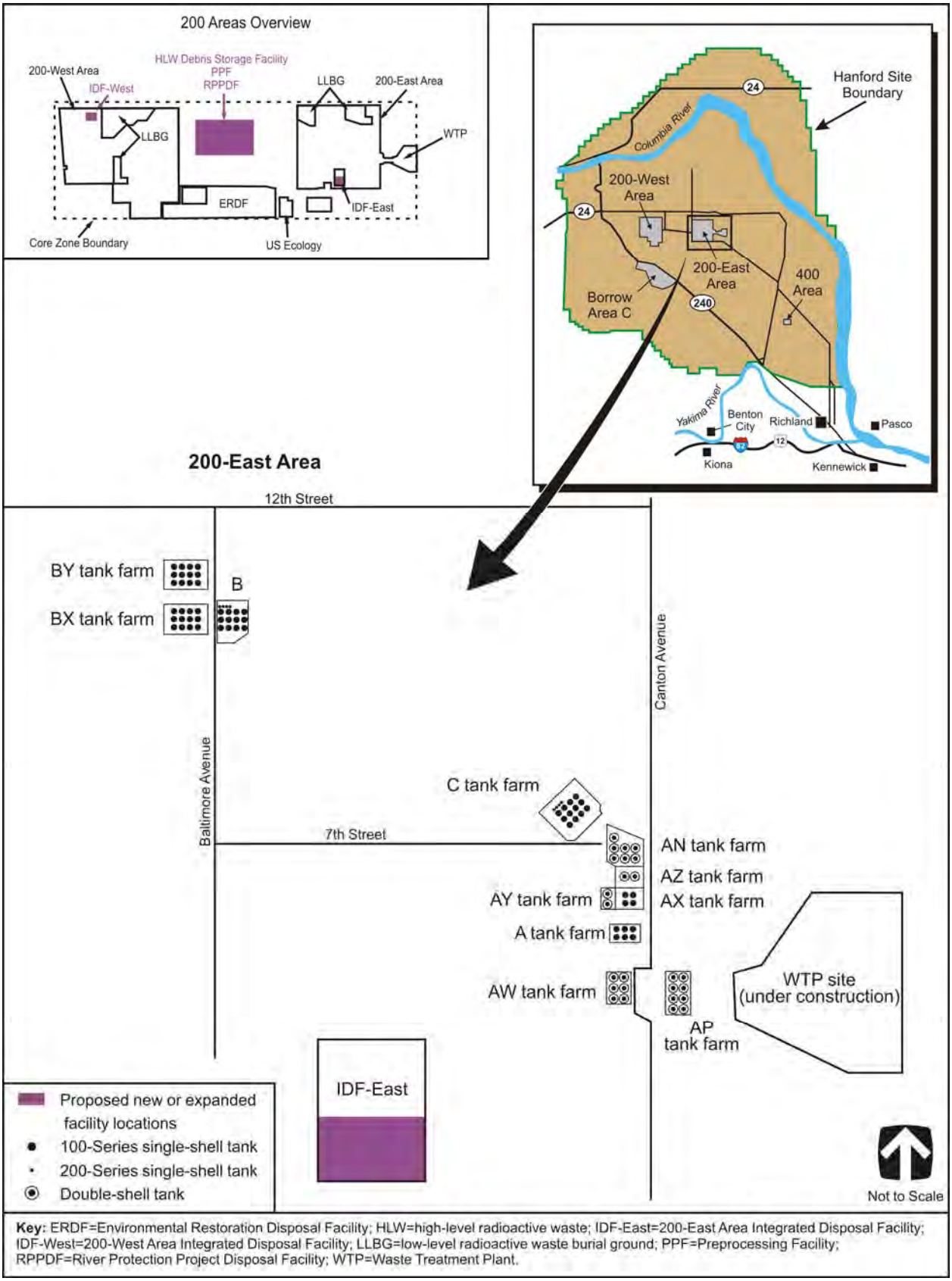


Figure 2–20. 200-West Area Waste Management Facility Locations



Key: ERDF=Environmental Restoration Disposal Facility; HLW=high-level radioactive waste; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; LLBG=low-level radioactive waste burial ground; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; WTP=Waste Treatment Plant.

Figure 2–21. 200-East Area Waste Management Facility Locations

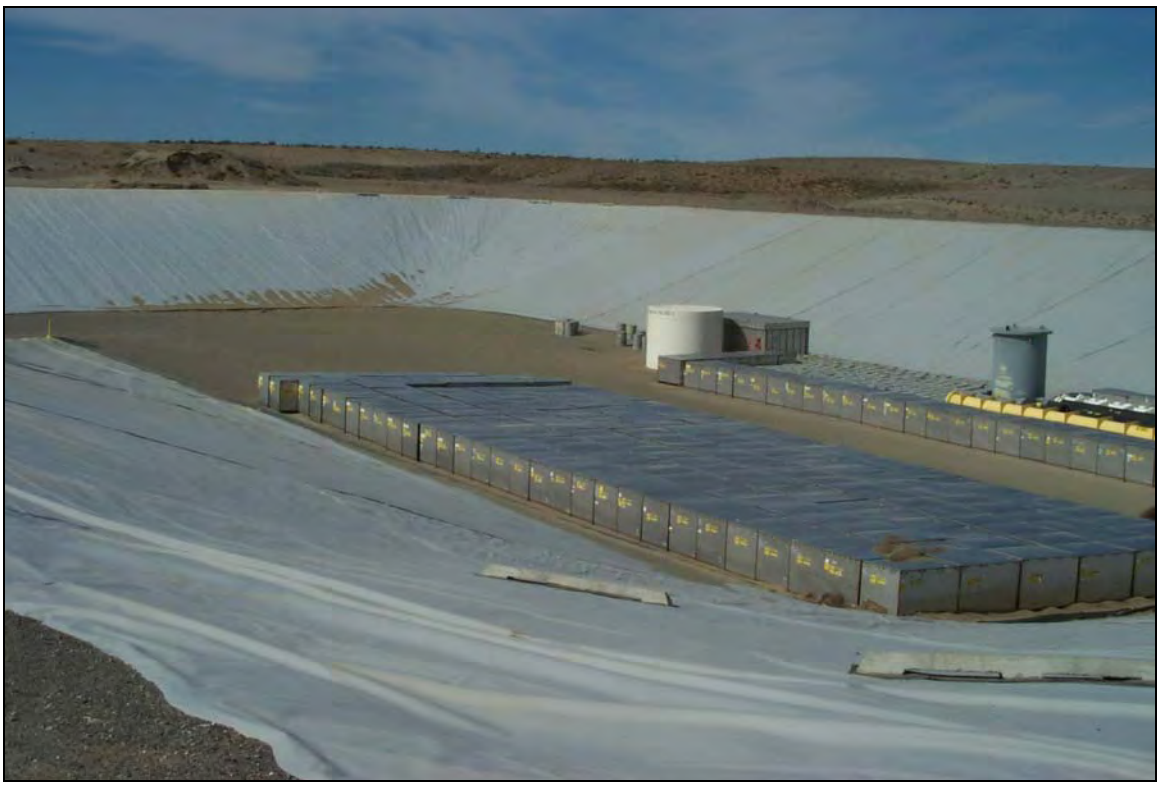


Figure 2–22. Lined Disposal Trench in Low-Level Radioactive Waste Burial Ground 218-W-5



Figure 2–23. Aerial View of the Central Waste Complex

2.4.1.3 T Plant

The T Plant operates under interim status as an RCRA TSD unit with no current RCRA permit capacity limit. Waste storage, decontamination, treatment, repackaging, and verification are the T Plant's primary activities. The T Plant complex, shown in Figure 2–24, includes the 221-T Canyon, which has RH-waste processing capabilities, and the 2706-T/TA/TB Facility. The 221-T Canyon is a heavily shielded, reinforced-concrete structure with an overall area of 5,370 square meters (57,800 square feet) (CEES 2006b). The 2706-T/TA/TB Facility, shown in the foreground of Figure 2–24, is a smaller, pre-engineered metal building with a concrete slab foundation. The overall area of the building is approximately 900 square meters (9,700 square feet).



Figure 2–24. Aerial View of the T Plant Complex

Solid waste processing at the T Plant consists of adding absorbent or grout material to the waste matrix, neutralization, and amalgamation of mercury or other metals. Additional services include sampling of drum headspace to support the TRU waste program and management of analytical samples returned from commercial laboratories.

2.4.1.4 Waste Receiving and Processing Facility

The primary activities at the Waste Receiving and Processing Facility (WRAP) are to confirm, sample, repackage, certify, store, and treat waste for shipment to a TSD unit. The facility, shown in Figure 2–25, measures 305 meters by 125 meters (1,000 feet by 410 feet), and consists of three buildings: 2336W, the main processing facility; 2740W, an administrative support building; and 2620W, a maintenance support building. WRAP receives containers of CH-waste from Hanford generators, including the CWC, waste retrieval operations, LLBGs, and T Plant, as well as from offsite generators. Radioactive waste is processed in three operational areas within the main processing facility: the shipping and receiving area, the NDE/NDA area, and the process area. Inspections include high-energy x-ray imaging of sealed waste



Figure 2–25. Waste Receiving and Processing Facility

containers (NDE), radiological emission measurement quantification of sealed waste containers (NDA), and visual examination of open waste containers in gloveboxes. Additional activities at WRAP include treating waste, intrusive sampling, packaging, repackaging, loading, headspace gas sampling, drum venting, and decontamination.

2.4.1.5 Integrated Disposal Facility

The primary mission of an IDF is to dispose of LLW and MLLW. In April 2006, an RCRA-permitted IDF in the 200-East Area (IDF-East) was partially completed at Hanford (shown in Figure 2–26). IDF-East measures 457 meters wide, 233 meters long by 12.8 meters deep (1,500 feet wide by 765 feet long by 42 feet deep); currently consists of two cells; and is expandable. As currently planned, one cell would be used to dispose of MLLW, including vitrified LAW from the WTP and 50 large containers of waste from the planned Demonstration Bulk Vitrification System Project. The second cell would be used to dispose of LLW from Hanford cleanup activities. Each cell has a 2.1-meter-thick (7-foot-thick) liner system consisting of a 0.9-meter (3-foot) clay liner topped by two separate, high-density polyethylene liners, a geosynthetic clay liner, and 0.3 meters (1 foot) of drain gravel. These layers are covered with a 0.9-meter (3-foot) earthen layer to protect the liners from heavy equipment during waste placement operations (CH2M HILL 2006).

2.4.1.6 Solid Waste Operations Complex Process Flow

The overall SWOC process flow follows each waste type through generation, storage, treatment, and disposal. LLW and MLLW can be generated either on or off site. Once generated, the waste can be staged or stored at the CWC, LLBGs, or T Plant until it is treated, analyzed, or directly disposed of at the LLBGs or offsite at a compliant facility. If the waste requires treatment, it would likely be conducted within the SWOC or at an offsite facility. After treatment, the waste would be staged or stored at a SWOC facility until disposal is completed.

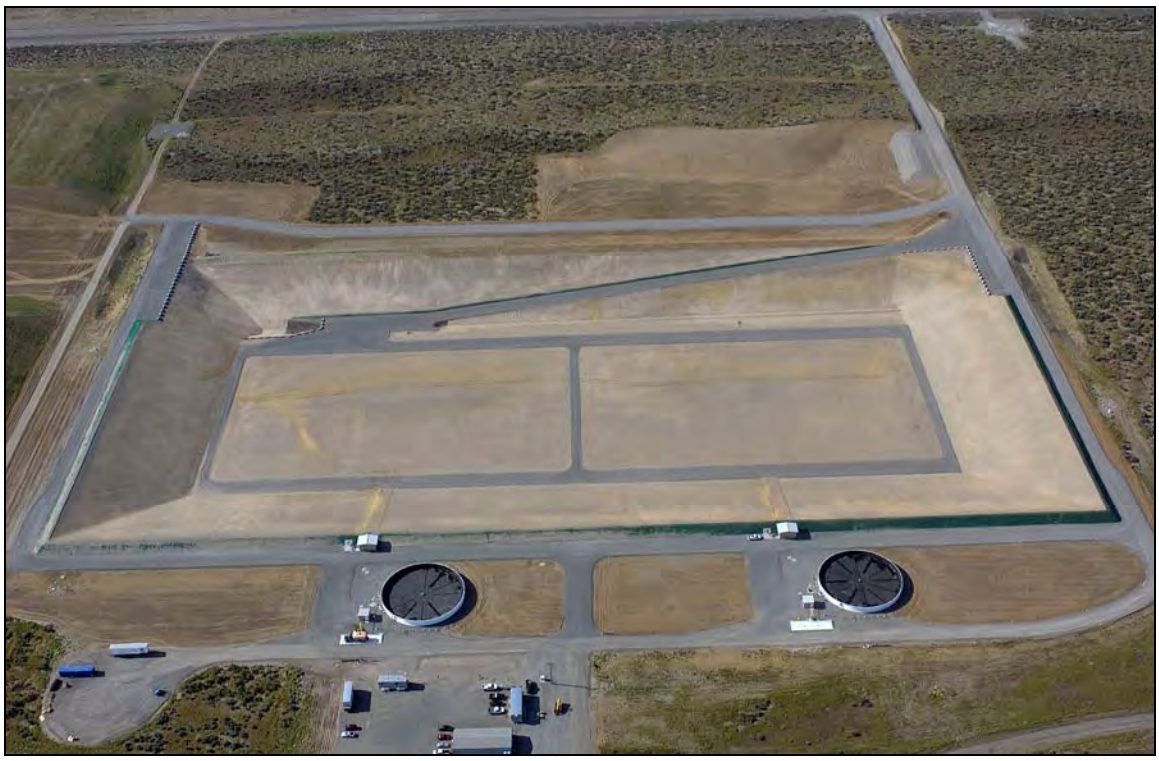


Figure 2–26. 200-East Area Integrated Disposal Facility

TRU waste and mixed TRU waste can also be generated on or off site. TRU waste can be either staged or stored within the SWOC until it is treated, or it can be sent directly from generation to treatment. Once the waste is treated, it can be disposed of at WIPP if it meets the WIPP Waste Acceptance Criteria, or it can be stored within the SWOC until disposal is complete (Weidert 2003).

2.4.2 Proposed Solid Waste Management Activities

This section presents an overview of the waste technologies and facilities that would be used to implement the proposed actions to dispose of both Hanford and DOE offsite LLW and MLLW. More-detailed descriptions of these proposed technologies and facilities are presented in Appendix E, Section E.3.

2.4.2.1 Use of Existing Low-Level Radioactive Waste Burial Grounds

Under the Waste Management No Action Alternative, the two lined LLBG 218-W-5 trenches 31 and 34 would continue to receive LLW and MLLW from onsite non–Comprehensive Environmental Response, Compensation, and Liability Act (non-CERCLA) generators through 2035. Under Waste Management Alternatives 2 and 3, trenches 31 and 34 would continue to receive LLW and MLLW from onsite non-CERCLA generators until they are filled. Currently, the remaining space in the two trenches totals approximately 17,215 cubic meters (22,520 cubic yards). At the projected emplacement rate, the trenches would be filled to capacity by no later than 2050. No construction activities would be necessary because the trenches are already in operation.

2.4.2.2 Expanded Central Waste Complex, T Plant, and Waste Receiving and Packaging Facility

Due to the uncertainty of the waste forecasts for Hanford, it was assumed for analysis purposes that additional solid waste storage capacity would be required at the CWC as soon as possible following

issuance of the ROD for this *TC & WM EIS*. Another 2403-WD Facility would be constructed at the CWC under Waste Management Alternatives 2 and 3. The drum storage capacity of 17,500 drums at the current 2403-WD Facility would therefore be duplicated, as would the footprint of 52 meters by 99 meters (170 feet by 325 feet) (Weidert 2003).

It was also assumed for analysis purposes that approximately 8,000 cubic meters (10,500 cubic yards) of high-dose (i.e., RH) or oversized waste packages may not meet the *Hanford Site Solid Waste Acceptance Criteria* for disposal (Fluor Hanford 2005b). Either a new facility or modifications to an existing facility may be required to process these waste volumes. To meet this need, under Waste Management Alternatives 2 and 3, DOE proposes constructing another 2706-T/TA/TB Facility-type building near the T Plant complex to allow processing of RH-waste in the 221-T Canyon, and shifting all other processing to the new 2706-T/TA/TB Facility-type buildings located near the T Plant.

The existing WRAP main processing facility has no vacant area for expansion of LLW, MLLW, and CH-mixed TRU waste processing, nor does it have an RH-mixed TRU waste processing capability. Thus, it was assumed for analysis purposes that a new WRAP Expansion CH Waste Facility would be constructed at the CWC, which would increase the throughput of LLW, MLLW, and CH-mixed TRU waste by approximately 40 percent, and that a new WRAP Expansion RH-TRU Waste Facility with approximately the same size and dimensions as the existing WRAP would be constructed as well.

Closure and postclosure care of the proposed CWC, T Plant, and WRAP expansions are not within the scope of the Waste Management alternatives, but are analyzed as part of the cumulative impacts addressed in Chapter 6.

2.4.2.3 Integrated Disposal Facility

Three different IDF configurations were analyzed in this *TC & WM EIS*. Under the Waste Management No Action Alternative, no additional construction would occur to expand IDF-East. The site would be deactivated, including removing the liner and backfilling the site to restore it to its natural grade. Under Waste Management Alternative 2, IDF-East would be either expanded from a planned capacity of 900,000 cubic meters (1.18 million cubic yards) to 1.2 million cubic meters (1.6 million cubic yards) or reduced to 425,000 cubic meters (556,000 cubic yards), depending on the disposal group analyzed (disposal groups are specific combinations of IDF and RPPDF waste capacities and operational timeframes that were grouped together for waste management analysis purposes in this EIS). Under Waste Management Alternative 3, two IDFs would be utilized: the existing IDF-East in the 200-East Area and a proposed second IDF in the 200-West Area (IDF-West). IDF-East would receive only waste generated under the Tank Closure alternatives. IDF-West would receive the balance of the waste, including FFTF decommissioning waste, onsite-generated non-CERCLA waste, and waste received from offsite DOE sources. As with Waste Management Alternative 2, IDF-East's capacity would vary, depending on the waste disposal group, from 340,000 cubic meters (445,000 cubic yards) to 1.1 million cubic meters (1.43 million cubic yards). IDF-West would have a capacity of 90,000 cubic meters (118,000 cubic yards) under all disposal groups analyzed.

2.4.2.4 River Protection Project Disposal Facility

Another new, onsite disposal facility, the RPPDF, would be constructed under the Waste Management action alternatives. Rubble, soils, and ancillary equipment that are not highly contaminated, but result from closure activities at various SST farms, would be disposed of at the RPPDF. For analysis purposes, it was assumed that the design, construction, and operations activities necessary for the RPPDF would be the same as those needed for IDF-West. However, the RPPDF's capacity would differ from the IDF capacities previously discussed. Under the Waste Management No Action Alternative, there would be no need for the RPPDF because no closure activities would take place. Under Waste Management

Alternatives 2 and 3, a single RPPDF would be constructed in the 200 Areas near IDF-East. Three disposal groups have been identified to support closure activities under the Tank Closure alternatives. Depending on the disposal group analyzed, the RPPDF could occupy from 30 to 228 hectares (74 to 563 acres) and have a capacity of 1.08 to 8.37 million cubic meters (1.41 to 10.9 million cubic yards).

2.4.2.5 Closure of Integrated Disposal Facility and River Protection Project Disposal Facility

Closure of IDF-East and the RPPDF were analyzed in this *TC & WM EIS* under Waste Management Alternatives 2 and 3. Closure activities for the CWC, WRAP, T Plant, and lined LLBGs are addressed in Chapter 6, "Cumulative Impacts." IDF-East and the RPPDF would be closed under a modified RCRA Subtitle C barrier over the landfill, similar to the barrier proposed under the Tank Closure alternatives. Postclosure care would consist of air, groundwater, and vadose zone monitoring.

2.5 DESCRIPTION OF THE ALTERNATIVES

This *TC & WM EIS* evaluates the impacts associated with 11 Tank Closure alternatives, 3 FFTF Decommissioning alternatives, and 3 Waste Management alternatives. For Tank Closure alternatives, impacts resulting from storage, retrieval, treatment, disposal, and closure activities at Hanford's HLW tank farms were evaluated, as well as the impacts of a No Action Alternative. The Tank Closure alternatives are:

Tank Closure Alternative 1: No Action

Tank Closure Alternative 2: Implement the *Tank Waste Remediation System EIS* Record of Decision with Modifications

- Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure
- Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Tank Closure Alternative 3: Existing WTP Vitrification with Supplemental Treatment Technology; Landfill Closure

- Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure
- Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure
- Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Tank Closure Alternative 6: All Waste as Vitrified HLW

- Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure (Base and Option Cases)

- Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure (Base and Option Cases)

- Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

These alternatives represent the range of reasonable approaches to removing waste from the tanks to the extent that is technically and economically feasible; treating the waste by vitrifying it in the WTP and/or using one or more supplemental treatment processes; packaging the waste for either offsite shipment and disposal or onsite disposal; and closing the SST system to permanently reduce the potential risk to human health and the environment.

This *TC & WM EIS* also evaluates the impacts associated with three alternatives for decommissioning FFTF and associated support buildings; managing the resulting waste using existing capabilities; managing designated RH-SCs for which waste management capabilities do not currently exist; closure of FFTF and its associated support buildings; and dispositioning the inventory of bulk sodium resulting from deactivation of FFTF, as well as bulk sodium from the Hallam Reactor and the SRE, which is now in storage at Hanford. FFTF Decommissioning alternatives include:

FFTF Decommissioning Alternative 1: No Action

FFTF Decommissioning Alternative 2: Entombment

FFTF Decommissioning Alternative 3: Removal

These alternatives represent the range of reasonable approaches to dismantling and removing the FFTF-related structures, equipment, and materials within the 400 Area PPA; treating and disposing of these components and equipment as necessary either in place or at other facilities; treating RH-SCs either at a new facility located at Hanford or the MFC at INL; converting Hanford bulk sodium to a caustic sodium hydroxide solution at Hanford or INL for use in the WTP; and closing the area (1) permanently to reduce the potential risk to human health and the environment or (2) to prepare the area for future industrial use.

This *TC & WM EIS* also provides analyses of the impacts associated with the following Waste Management alternatives for managing the storage, processing, and disposal of solid waste at Hanford, as well as subsequent closure of associated disposal facilities. The Waste Management alternatives are:

Waste Management Alternative 1: No Action

Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

These Waste Management alternatives represent the range of reasonable approaches to continued storage of LLW, MLLW, and TRU waste at Hanford; onsite waste processing using two expansions of WRAP; onsite disposal of onsite-generated non-CERCLA LLW and MLLW in trenches; disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW in new onsite facilities; and closure of disposal facilities to reduce water infiltration and the potential for intrusion.

Several hundred impacts scenarios could result from the potential combinations of the 11 Tank Closure, 3 FFTF Decommissioning, and 3 Waste Management alternatives when factored with their associated option cases and waste disposal groups. For analysis purposes, certain combinations of alternatives were chosen to represent key points along the range of actions and associated overall impacts that could result

from full implementation of the three sets of proposed actions. Selection of these three alternative combinations for detailed analysis in this EIS was done only to establish overall impact level reference cases for stakeholders and decisionmakers to consider, and does not preclude the selection and implementation of different combinations of the various alternatives in support of final agency decisions. These combinations and the associated potential short-term and long-term impacts are detailed in Chapter 4, Section 4.4, and Chapter 5, Section 5.4, respectively.

2.5.1 Development of the Alternatives

The alternatives presented in this *TC & WM EIS* were developed under NEPA to address the essential components of DOE's three sets of proposed actions (tank closure, FFTF decommissioning, and waste management) and to provide an understanding of the differences between the potential environmental impacts of the range of reasonable alternatives.

A No Action Alternative is required under the Council on Environmental Quality's NEPA-implementing regulations to provide a point of comparison against which the proposed actions and alternatives can be compared (40 CFR 1502.14[d]). Council on Environmental Quality and DOE NEPA guidance directs that the number of reasonable alternatives in an EIS should represent the full spectrum of alternatives for meeting the agency's purpose and need, but an EIS need not discuss every unique alternative when an unmanageably large number is involved (DOE 2004a).

2.5.1.1 Tank Closure Alternatives

The Tank Closure alternatives evaluated in this *TC & WM EIS* were constructed to address each of the primary tank closure components (storage, retrieval, treatment, disposal, and closure) and to consider a range of options for each component.

Storage. Tank farm storage operations would be required under each Tank Closure alternative and would include safe storage of the tank waste, necessary waste monitoring activities, routine maintenance activities, and waste transfers as required for tank space management and waste feed operations. Tank farm storage operations are considered a dependent function that varies based on changes in the duration of waste retrieval and treatment operations. If the tank waste is not retrieved and treated (the No Action Alternative), ongoing activities similar to those currently conducted (e.g., tank monitoring and security maintenance) would continue for a 100-year administrative control period.

Retrieval. Options range from retrieving none of the tank waste (the No Action Alternative) to retrieving the tank waste to the maximum extent that is both technically practical and required to support clean closure of the SST system. Based on the reasonable range of potential waste retrieval scenarios (from 90 percent, reflecting less than optimal waste retrieval system performance, to 99.9 percent, representing a retrieval end-state following multiple uses of retrieval systems), various technology configurations could be used for this purpose.

Treatment. Options range from treating none of the tank waste (the No Action Alternative) to treating all of the tank waste to the extent required to meet disposal requirements. A variety of technologies could be used for tank waste treatment, ranging from a single technology resulting in a single waste form for disposal to multiple technologies resulting in multiple waste forms for disposal. Due to prior NEPA analysis (DOE and Ecology 1996) and commitments made by DOE under agreements with the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (e.g., the TPA [Ecology, EPA, and DOE 1989]), all action alternatives assume, at a minimum, continued use of the WTP in its current configuration (including pretreatment and HLW and LAW vitrification), as well as immobilization at a TMC of 6 metric tons of glass IHLW per day (using two HLW melters) and 30 metric tons of glass ILAW per day (using two LAW melters). Some alternatives consider expansion

of the current WTP configuration. The one alternative that does not include continuing WTP construction and operations is the No Action Alternative.[9]

Disposal. Potential options include both on- and offsite disposal. Disposal is a dependent function that varies across the Tank Closure alternatives based on changes in the treatment of the tank waste. Onsite disposal would be influenced by the volume of waste produced and its ability to meet waste acceptance criteria for disposal in a near-surface onsite facility or in offsite disposal facilities such as WIPP. Onsite waste disposal also would be influenced by waste form performance issues, including the cumulative effects of waste disposal actions in proximity to other disposal and closure actions conducted in the Hanford 200 Areas (including closure of the SST system).

Closure. Options range from continuing tank farm operations (without closing the SST system) to closing the SST system under a landfill or clean closure configuration (or some combination of these two end-states). In addition, each of these options may include one or more end-state management activities (administrative controls, active institutional controls, postclosure care) that would take place at the completion of each action.

Because of the complexity of the RPP mission and its components (which are directly related to the proposed actions), the array of tank closure technologies that could be used is very large. In some cases, technologies were excluded from detailed analysis (see Section 2.6) because they were not practical (e.g., offsite disposal of ILAW). In other cases, technologies were excluded because they were characteristically similar to other technologies (e.g., the different types of melters used to vitrify HLW).

End-State Management of the Tank Farm Systems

Administrative controls: The provisions related to organization and management, procedures, record-keeping, assessment, and reporting necessary to ensure safe operation of a facility. For analysis purposes, it was assumed that administrative controls would be conducted at the single-shell tank (SST) system for those alternatives that do not include closure. Administrative controls would include monitoring the tanks for signs of deterioration that would threaten the structural integrity of the tanks. The period for administrative controls is the 100 years following the termination of Waste Treatment Plant construction under the No Action Alternative and the 100 years following retrieval of the waste from the SST system under Alternative 2A (applicable to Tank Closure Alternatives 1 and 2A).

Active institutional controls: The period when a site is under active governmental controls. Institutional controls may include administrative or legal controls, physical barriers or markers, and methods to preserve information and to inform current and future generations of hazards and risks. This would include controls necessary to ensure continued safe storage of waste following treatment. For analysis purposes, it was assumed that active institutional controls would be maintained for 100 years following final placement of waste in storage facilities (applicable to all Tank Closure alternatives except the No Action Alternative).

Postclosure care: The period following closure of a hazardous waste disposal system (e.g., a landfill) during which monitoring and maintenance activities must be conducted to preserve the integrity of the disposal system and continue preventing or controlling releases from the disposal unit. Under the hazardous waste regulations (WAC 173-303), postclosure care is typically 30 years. However, the regulator may extend this period as necessary to protect human health and the environment. For analysis purposes, it was assumed that the postclosure care period following landfill closure of the SST system would be extended to 100 years (applicable to Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C).

[9] In August 2007, DOE issued a study, the *Hanford River Protection Project Low Activity Waste Treatment: A Business Case Evaluation* (Wade et al. 2007), that considered the possibility of starting WTP LAW and/or supplemental LAW treatment earlier than scheduled under the *TC & WM EIS* alternatives. Appendix E, Section E.1.2.3.5.1, details the purpose and conclusions of this study.

Appendix E, Section E.1, includes a detailed discussion of the tank closure technologies analyzed in this EIS, and Section E.1.3 describes those technologies considered but not analyzed in detail because they were not technically or economically practical. The technology groupings were distilled into a limited number of viable technologies capable of supporting the range of reasonable Tank Closure alternatives in accordance with NEPA requirements (DOE 2004a).

As the tank closure technologies were grouped under the alternatives, reasonably conservative assumptions related to each technology and the associated alternatives were developed to ensure clear distinctions were made among the alternatives and to preserve sufficient flexibility for midcourse corrections as the selected alternative is implemented over an array of programmatic functions and a long timeframe. With the exception of the No Action Alternative, all of the Tank Closure alternatives would implement a wide variety of complex technologies. Some of these technologies have never been used in conditions similar to those of the tank farms or to treat waste similar to the Hanford tank waste. The assumptions associated with the Tank Closure alternatives and technologies are presented in Appendix E, Section E.1.

2.5.1.2 FFTF Decommissioning Alternatives

The FFTF Decommissioning alternatives evaluated in this *TC & WM EIS* were constructed to address disposition of facilities, RH-SCs, and bulk sodium. In constructing the FFTF Decommissioning alternatives, DOE considered a range of options for each component.

Facility disposition. Options include maintaining the deactivated FFTF and its associated facilities and components in a long-term surveillance and maintenance condition (No Action Alternative); dismantling and removing the RCB and immediately adjacent support facilities to grade, stabilizing associated below-grade contaminated components and equipment in place, and covering this area with a regulatorily compliant engineered barrier (Entombment Alternative); or dismantling and removing the RCB and immediately adjacent support facilities to grade, removing below-grade radioactively contaminated components and equipment (including the reactor vessel) and backfilling this area with either soil or grout (Removal Alternative). Under both action alternatives, all other ancillary buildings would be demolished and the area previously occupied by these facilities would be backfilled, compacted, contoured, and revegetated.

Disposition of remote-handled special components. Due to the inability to completely drain sodium from certain reactor system components with high radiation levels (primarily from cesium-137), these components would require remote handling, decontamination, and disposal. Options for disposition of these RH-SCs range from leaving the untreated materials on site (No Action Alternative), consistent with other Hanford NEPA activities, to treating the RH-SCs (removing the sodium residuals) and disposing of them either on or off site (Entombment and Removal Alternatives). No currently existing DOE facility can treat these RH-SCs. An RTP proposed for construction at INL's MFC to serve another project would have the capabilities to perform the required decontamination and sodium removal operations. Under this offsite treatment option, the RH-SCs would be transported from Hanford to INL for treatment. However, no U.S. Department of Transportation (DOT)-approved transport casks capable of holding such large components are currently available. A second option was developed under which an RTP capable of treating the RH-SCs would be constructed at Hanford, thus eliminating the need for intersite transport. Options for disposal of treated RH-SCs include disposal on site at Hanford in an IDF or disposal off site at NTS. Both these options were analyzed under the Entombment and Removal Alternatives.

Disposition of bulk sodium. Options for treatment and disposal of Hanford bulk sodium range from leaving the untreated materials on site in storage (No Action Alternative) to treating the bulk sodium for use in the WTP (Entombment and Removal Alternatives). DOE has determined that the FFTF sodium coolant, as well as other radioactively contaminated bulk sodium stored at Hanford, could be converted to

a concentrated caustic sodium hydroxide solution that could be reused to process tank waste at the WTP, or for Hanford tank corrosion control. Options for converting the sodium range from conducting conversion activities on site at Hanford in the proposed SRF (Hanford Reuse Option) to shipping the sodium to INL for conversion in the SPF at the MFC (Idaho Reuse Option). Both of these options were analyzed under the Entombment and Removal Alternatives.

2.5.1.3 Waste Management Alternatives

The Waste Management alternatives evaluated in this *TC & WM EIS* were constructed to address the essential components of the proposed actions: onsite storage and disposal of Hanford and other DOE sites' LLW and MLLW and closure of the waste disposal facilities. In constructing the Waste Management alternatives, DOE considered a range of options for each component.

Storage. Options range from continued storage of LLW, MLLW, and TRU waste at existing facilities, with no acceptance of offsite waste shipments (Waste Management Alternative 1: No Action) to expansion of Hanford facilities' storage capacity to accommodate limited shipments of LLW and MLLW from offsite DOE sources (Waste Management Alternatives 2 and 3). Hanford-generated LLW, MLLW, and TRU waste would continue to be processed on site in existing facilities (No Action) or in the expanded facilities (Waste Management Alternatives 2 and 3). Offsite-generated LLW and MLLW would be treated off site prior to shipment to Hanford under Waste Management Alternatives 2 and 3.

Disposal. Options include on- or offsite disposal. Disposal of waste on site would be influenced by the volume of waste produced and whether the waste could meet the criteria for disposal in a near-surface onsite facility or at an offsite facility (e.g., WIPP). The use of existing disposal facilities (e.g., the lined LLBG trenches), expansion of existing disposal facilities (IDF-East), and construction of new facilities (such as IDF-West and the RPPDF) were analyzed under the Waste Management alternatives. All three Waste Management alternatives include continued disposal of LLW and MLLW in lined trenches, with the timeframe for completing disposal activities varying from 2035 to 2050. Both of the two action alternatives include the construction of the proposed RPPDF (for disposal of equipment and soils that are not highly contaminated and result from closure activities), and use of the existing or expanded IDF-East (for disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, and waste management–produced wastes, as well as LLW and MLLW from offsite sources). The difference between the two action alternatives is that only IDF-East would be used to support Waste Management Alternative 2, but two IDFs would be used to support Waste Management Alternative 3 (IDF-East [for tank waste only] and IDF-West). Under Waste Management Alternative 1: No Action, any further construction of IDF-East would be discontinued.

Three disposal groups were analyzed under both action alternatives. The size, capacity, and number of facilities associated with each disposal group were developed based on the amounts and types of waste generated under each of the three sets of *TC & WM EIS* alternatives (Tank Closure, FFTF Decommissioning, and Waste Management). Facility timeframes would vary among the disposal groups, with the last year of operations ranging from 2050 to 2165.

Closure. Options range from operating the RPPDF and IDF(s) indefinitely using administrative controls to closing these disposal facilities followed by postclosure care. Closure type does not vary among the alternatives; both Waste Management Alternatives 2 and 3 include closing the RPPDF and IDF(s) under engineered modified RCRA Subtitle C barriers.

2.5.2 Tank Closure Alternatives

The Tank Closure alternatives are described in detail in this section. A summary of these alternatives by mission components is provided in Table 2–2.

Table 2–2. Tank Closure Alternatives – Summary by Mission Component

Mission Component	Range of Action	Alternative										
		1	**2A**	**2B**	**3A**	**3B**	**3C**	**4**	**5**	**6A**	**6B**	**6C**
Storage	None beyond 2004 (except administrative controls)	X										
	Existing system with minimum changes			X	X	X	X	X			X	X
	Existing system with extensive changes		X						X	X		
Retrieval	None	X										
	90 percent								X			
	99 percent		X	X	X	X	X					X
	99.9 percent							X		X	X	
Treatment	None	X										
	Existing WTP capacity		X									
	Expanded WTP LAW capacity only			X								
	Existing WTP capacity; supplement with mixed TRU waste and thermal treatment				X		X					
	Existing WTP capacity; supplement with mixed TRU waste and nonthermal treatment					X						
	Existing WTP capacity; supplement with mixed TRU waste, thermal, and nonthermal treatment							X				
	Replacement of WTP		X							X		
	Expanded WTP LAW capacity; supplement with mixed TRU waste, thermal, and nonthermal treatment								X			
	Expanded WTP HLW capacity; no LAW capacity									X		
	Expanded WTP LAW capacity (all HLW)										X	X
	Cesium and strontium capsule contents treated in WTP		X	X	X	X	X	X	X	X	X	X
Disposal	None	X										
	IHLW glass off site; ILAW glass on site		X	X								
	IHLW and TRU waste off site; ILAW (WTP and supplemental) on site				X	X	X	X	X			
	IHLW glass and ILAW glass managed as HLW and stored on site									X	X	X
Closure	None	X	X									
	Landfill closure (no soil removal)								X			
	Landfill closure (with soil removal)			X	X	X	X					X
	Selective clean closure/landfill closure							X				
	Clean closure/landfill closure of adjacent cribs and trenches (ditches)									X	X	

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; TRU=transuranic; WTP=Waste Treatment Plant.

2.5.2.1 Tank Closure Alternative 1: No Action

The Tank Closure No Action Alternative is based on the No Action Alternative presented in the 1996 *TWRS EIS*, updated to reflect actions taken and new information developed since the *TWRS EIS* was

issued, including additional consideration of the past leak inventory associated with the Hanford 200-East and 200-West Area tank farms. As shown in Figure 2–27, no retrieval, treatment, disposal, or closure operations would take place under the Tank Closure No Action Alternative.

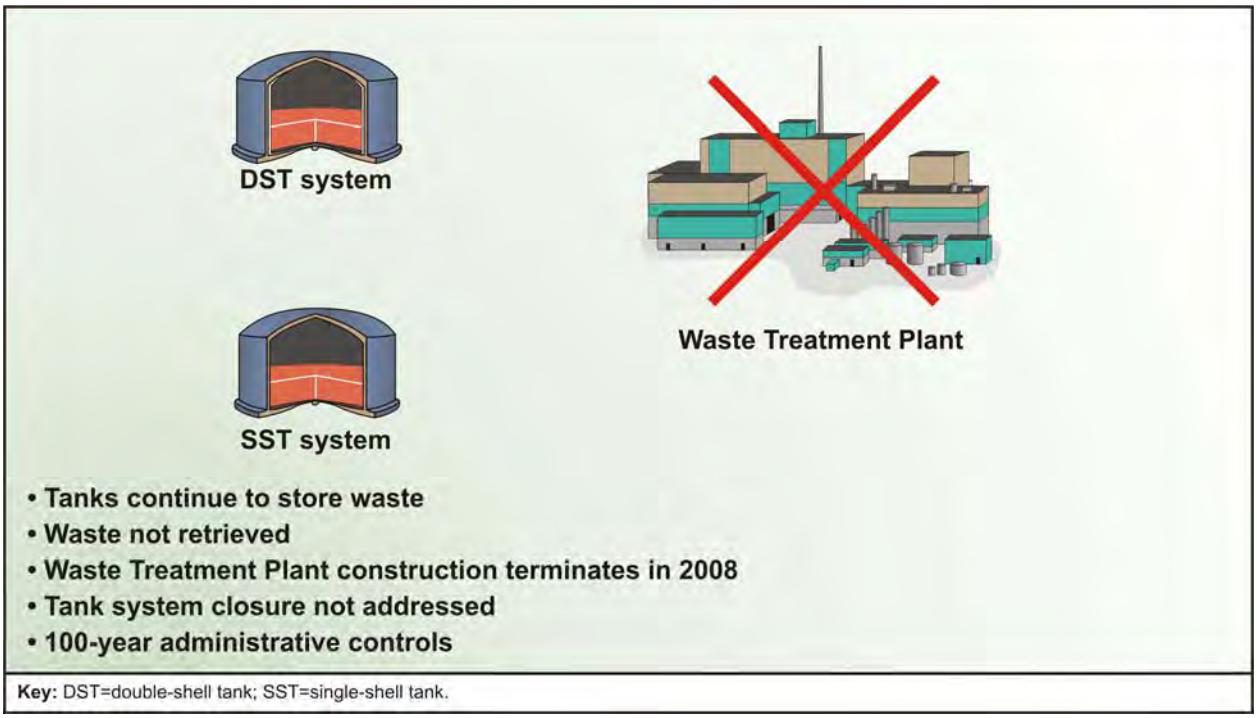


Figure 2–27. Tank Closure Alternative 1 Overview

Under the Tank Closure No Action Alternative, DOE would cease further construction of the WTP and any ongoing construction of upgrades to the tank farm systems in 2008, and the WTP site would be isolated pending some future use. No other waste would be retrieved from the tanks, and no IHLW glass or ILAW glass would be produced. DOE would maintain security and management of the site for a 100-year administrative control period (ending in 2107). During this administrative control period, DOE would continue to store and conduct routine monitoring of the waste in the SSTs, DSTs, and MUSTs. The cesium and strontium capsules would remain in storage in the WESF. The proposed schedule for implementing Alternative 1 is presented in Figure 2–28.

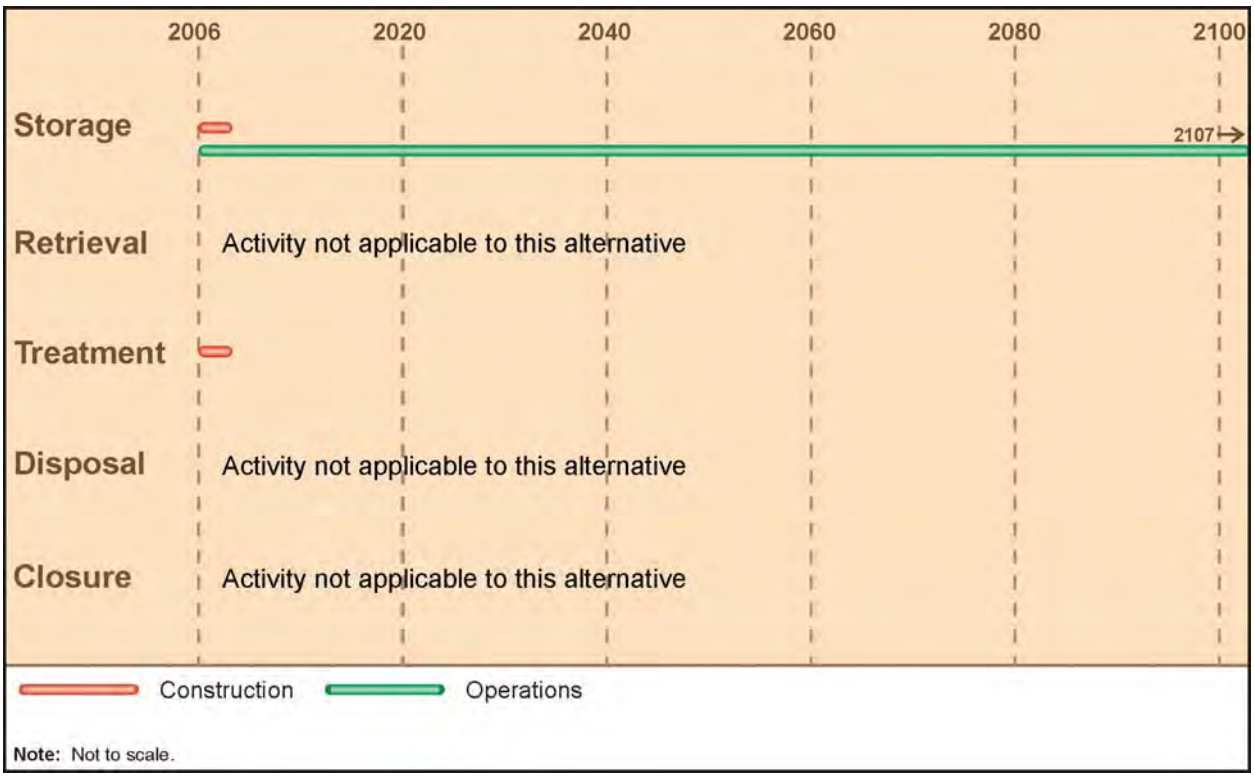


Figure 2–28. Tank Closure Alternative 1 Proposed Schedule

The waste in the SST and DST systems would remain in the tank farms indefinitely. SSTs showing signs of deterioration that would threaten the structural integrity of the tanks would be filled with grout or gravel as a corrective action or emergency response. Waste contained in DSTs showing similar signs of deterioration would be removed from the tanks and consolidated in existing DSTs to the extent possible. The deteriorated DSTs would then be filled with grout or gravel as a corrective action or emergency response. Figure 2–29 illustrates the primary components of the No Action Alternative.

2.5.2.2 Tank Closure Alternative 2: Implement the *Tank Waste Remediation System EIS* Record of Decision with Modifications

Tank Closure Alternative 2 considers all vitrification treatment with 99 percent retrieval of waste from the Hanford 200-East and 200-West Area tank farms in accordance with the *TWRS EIS* ROD and three supplement analyses completed through 2001. Two subalternatives were separately evaluated. Under Alternative 2A, waste would be treated using the existing WTP configuration and the SST system would not be closed. In contrast, under Alternative 2B, WTP capacity for producing ILAW glass would be expanded; technetium-99 would be removed from the WTP LAW stream during pretreatment; and the SST system would be closed (landfill closure). In addition, cesium and strontium capsules would be treated under both subalternatives.

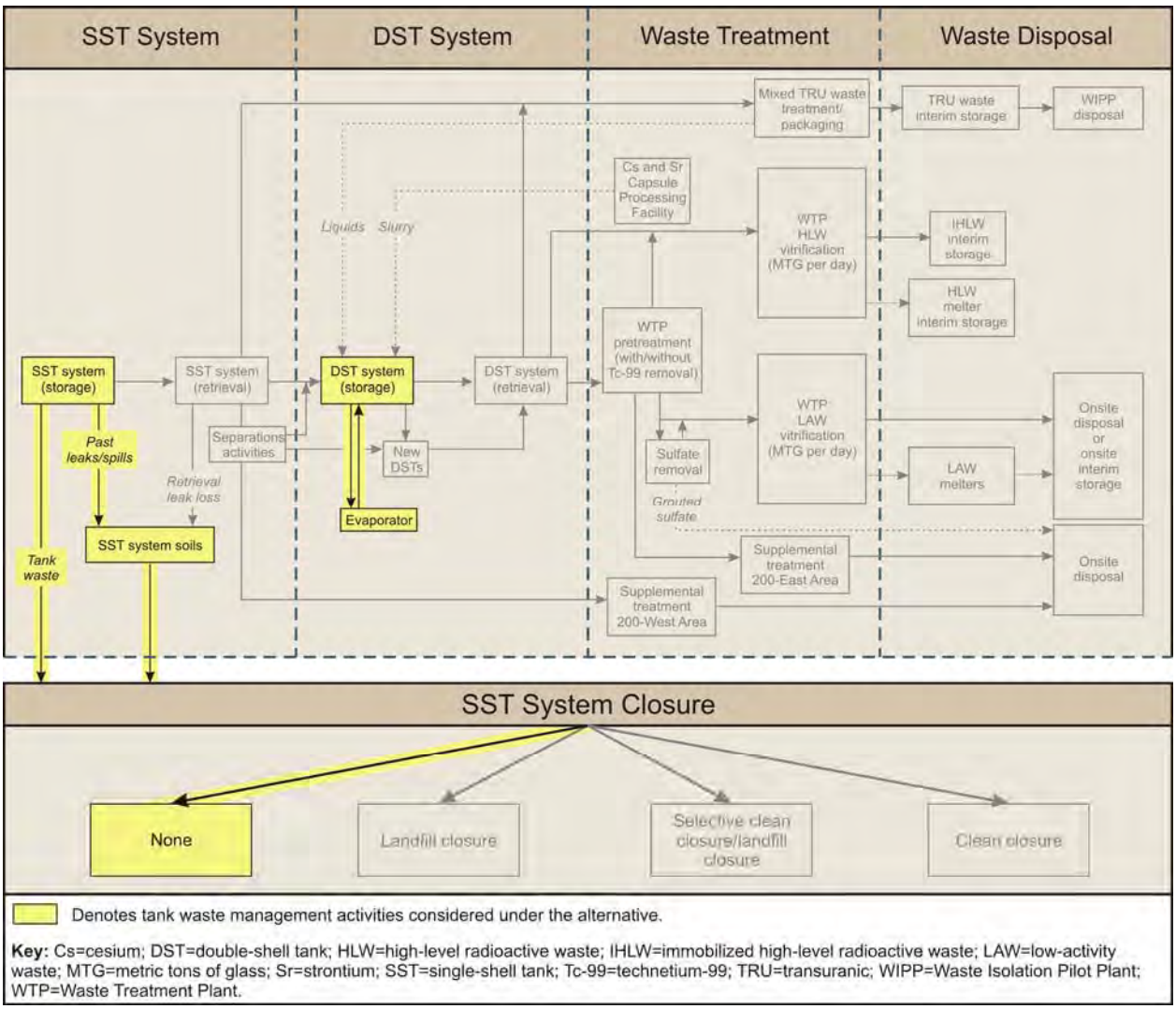


Figure 2–29. Tank Closure Alternative 1 Primary Components

2.5.2.2.1 Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure

As shown in Figure 2–30, under this subalternative, DOE would retrieve and treat 99 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms using only the currently planned WTP vitrification capacity. The waste retrieved from the tanks would be segregated into one of two waste streams during WTP pretreatment: (1) an HLW stream that would be vitrified to form IHLW glass or (2) a LAW stream that would be vitrified to form ILAW glass. Under Tank Closure Alternative 2A, technetium-99 removal would not occur as part of WTP pretreatment, and no supplemental technologies would be employed to treat the LAW.

Following completion of construction and a 2018 start, WTP vitrification operations under Tank Closure Alternative 2A would extend through 2093. No separate mixed TRU waste treatment capability would be provided under this alternative. Similarly, no tank or facility closure would be conducted under this alternative, although administrative controls would be maintained for 100 years (through 2193) following completion of vitrification operations. The proposed schedule for implementing Tank Closure Alternative 2A is presented in Figure 2–31.

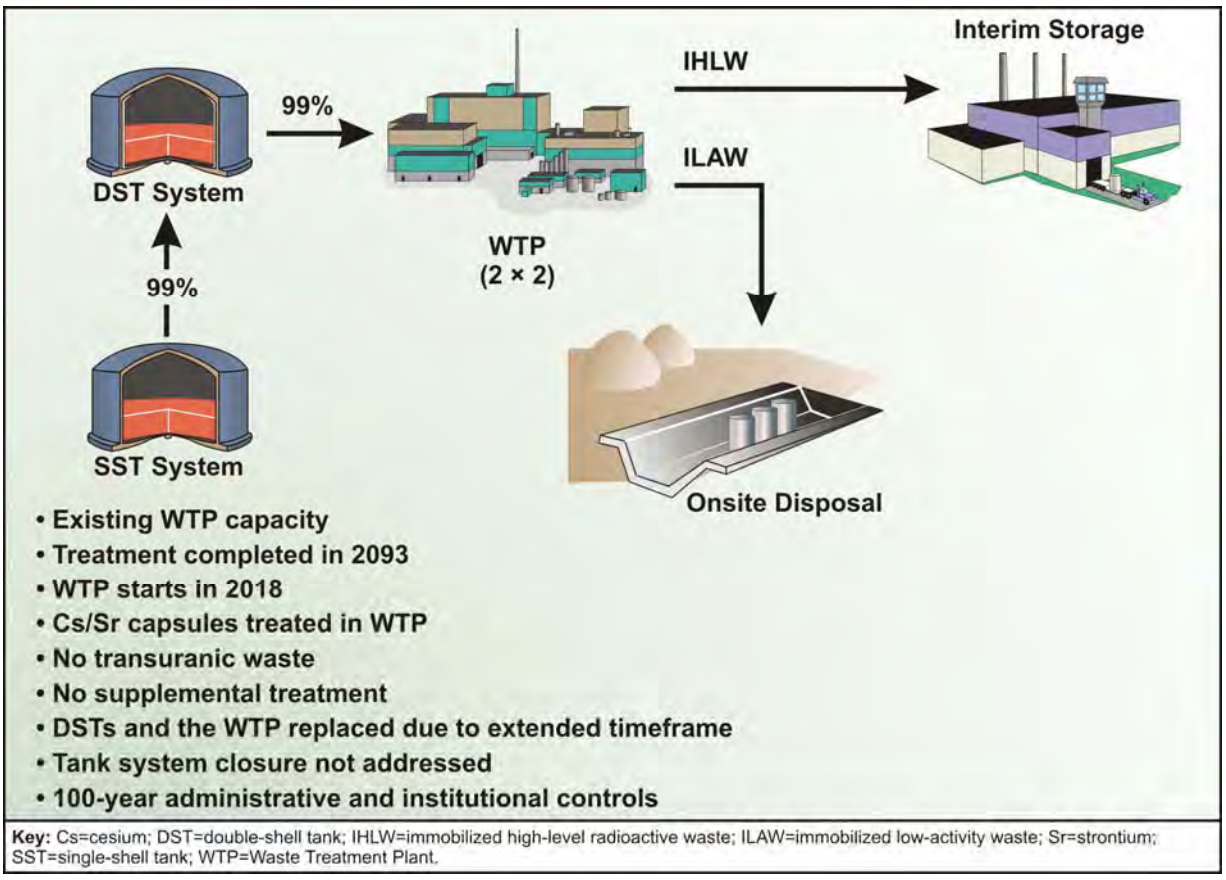


Figure 2–30. Tank Closure Alternative 2A Overview

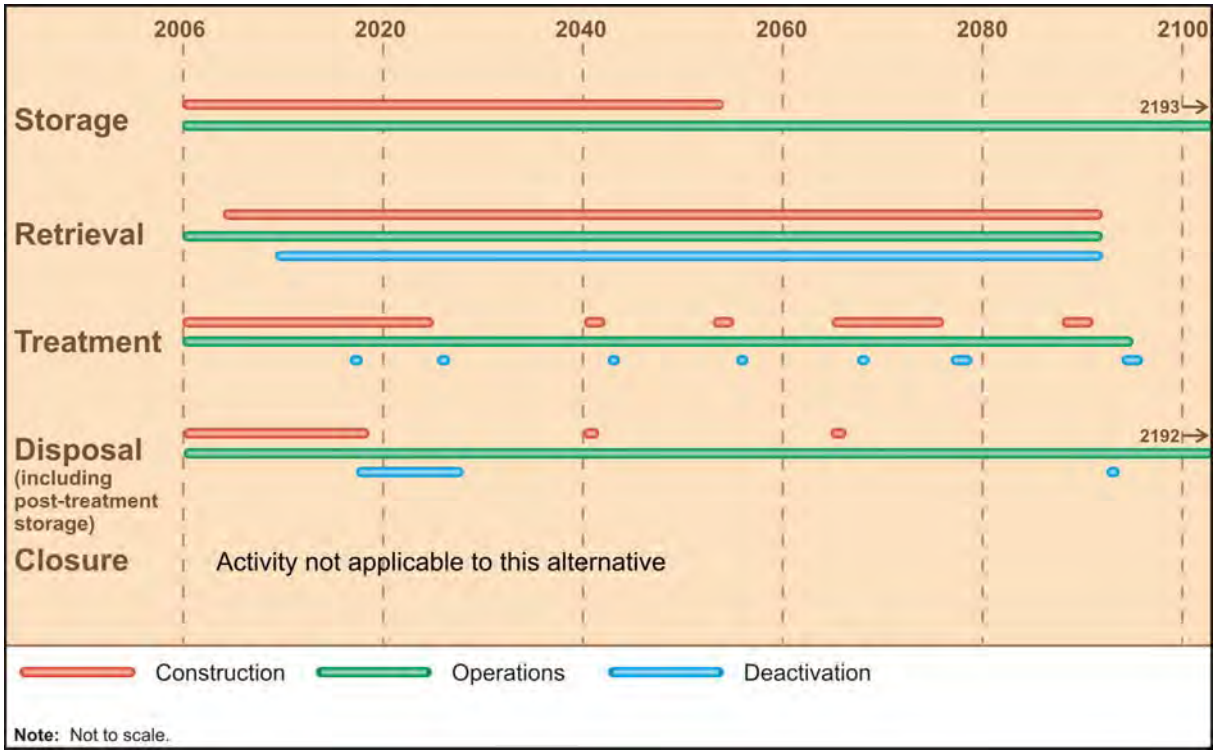


Figure 2–31. Tank Closure Alternative 2A Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–32, would occur under Tank Closure Alternative 2A.

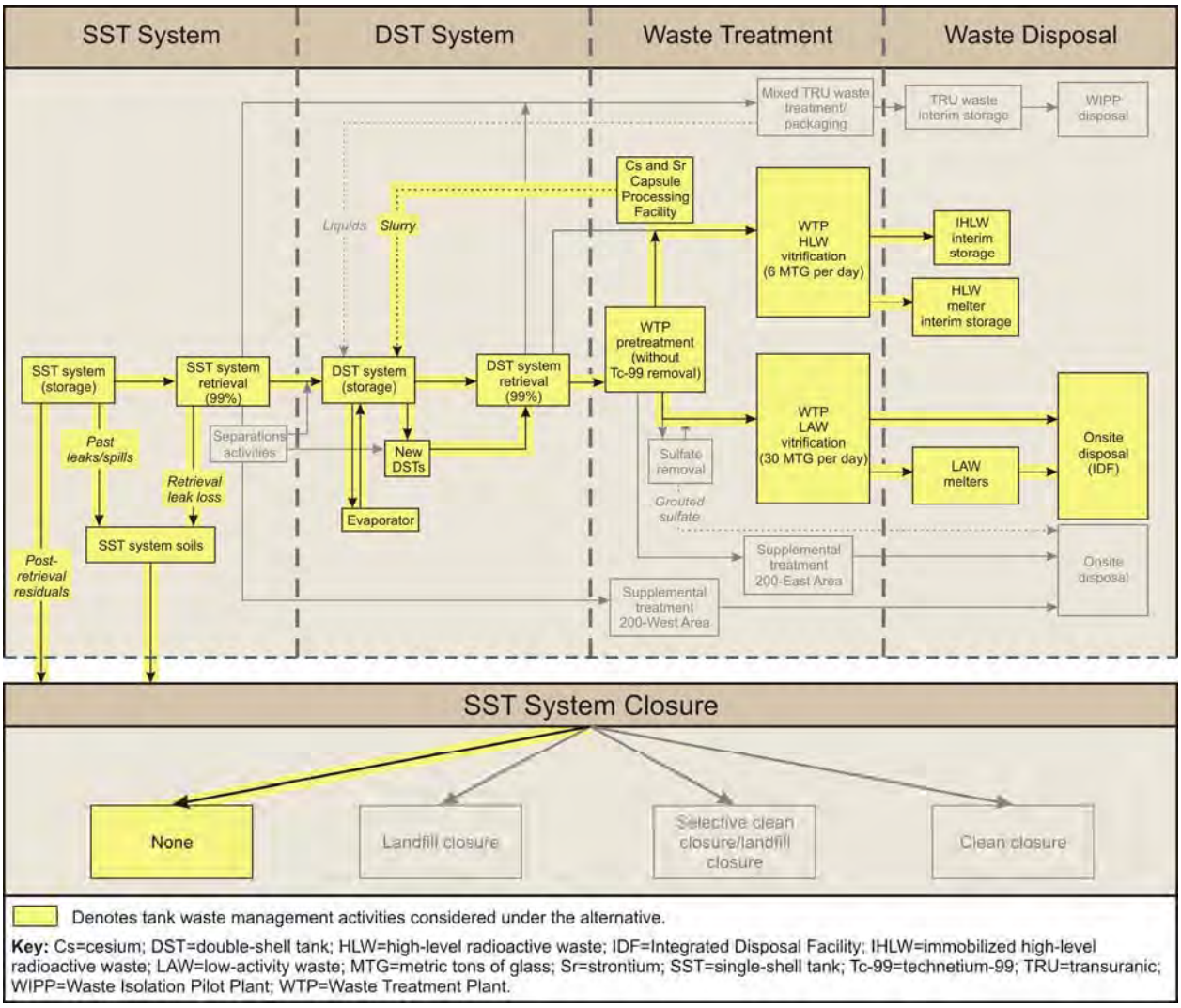


Figure 2–32. Tank Closure Alternative 2A Primary Components

Storage. DOE would continue current waste management operations using existing tank storage facilities. Because retrieval operations would be spread over an 80-year period, no WRFs would be required. However, all of the DSTs will exceed their 40-year design life by 2028, and all would be replaced in a phased manner through 2054.

Retrieval. Waste would be retrieved to the TPA Milestone M-45-00 minimum goal (Ecology, EPA, and DOE 1989), i.e., using currently available liquid-based waste retrieval and leak detection systems, residual waste would not exceed 10.2 cubic meters (360 cubic feet) for the 100-series tanks or 0.85 cubic meters (30 cubic feet) for the 200-series tanks, corresponding to 99 percent retrieval. Waste from 129 tanks (28 existing DSTs, 28 replacement DSTs, and 73 nonleaking 100-series SSTs) would be retrieved using the modified sluicing technology; waste from approximately 60 SSTs (100-series SSTs that are known or suspected leakers) would be retrieved using the MRS technology; and waste from 77 tanks (61 MUSTs and 16 SSTs [200-series], 7 of which are known or suspected leakers) would be retrieved using the VBR technology.

Treatment. The existing WTP configuration (two HLW melters and two LAW melters) would be used, representing a vitrification TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. All waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. The cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility located adjacent to the WTP; their contents would be treated in the WTP. Under Alternative 2A, the WTP would produce a total of 38,400 metric tons of glass IHLW (approximately 12,000 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and 553,500 metric tons of glass ILAW (approximately 92,250 containers). Due to the extended timeframe associated with this alternative, WTP pretreatment and vitrification facilities and the underground transfer lines that support staging of waste feed to the WTP would need to be replaced after they exceed their assumed maximum design lives (60 and 40 years, respectively). The ETF would be replaced twice, and the 242-A Evaporator would be replaced once.

Disposal. IHLW glass would be stored in the completed CSB, as well as in up to three new IHLW Interim Storage Modules until disposition decisions are made and implemented. ILAW glass would be disposed of on site in an IDF.

Closure. No tank farm system closure would occur under Tank Closure Alternative 2A. The tank farms and associated facilities would be maintained for 100 years (through 2193) following completion of waste treatment operations. DOE would maintain security and management of all tank system TSD facilities during this 100-year administrative and institutional control period, including surveillance, leak detection, and routine monitoring of residual waste in the SSTs, DSTs, and MUSTs. Tanks and associated facilities showing signs of deterioration threatening the integrity of the tanks would be filled with grout or gravel as a corrective action or emergency response. Any such actions would be designed to avoid precluding potential implementation of future closure actions. After 2193, administrative and institutional controls would end.

2.5.2.2.2 Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure

As shown in Figure 2–33, under this subalternative, DOE would retrieve and treat 99 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms using expand WTP vitrification capabilities. As under the previous subalternative, no supplemental technologies would be employed under Tank Closure Alternative 2B to treat LAW, and the tank waste would be segregated into one of two waste streams during WTP pretreatment: (1) an HLW stream that would be vitrified to form IHLW glass or (2) a LAW stream that would be vitrified to form ILAW glass. However, under Tank Closure Alternative 2B, technetium-99 would be removed from the LAW stream during WTP pretreatment and incorporated into the HLW stream for immobilization and offsite disposal.

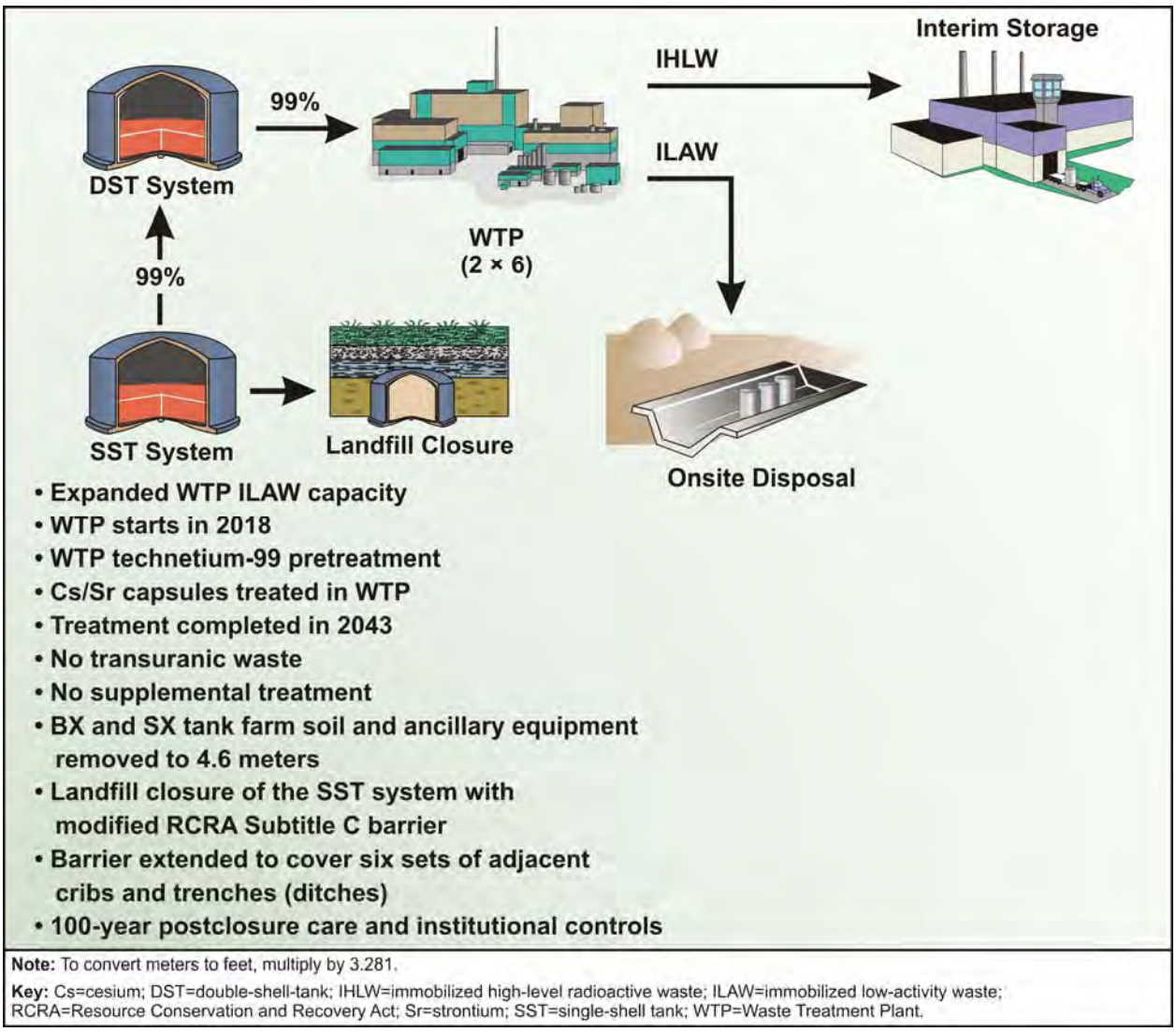


Figure 2–33. Tank Closure Alternative 2B Overview

Following WTP construction and a 2018 start, WTP vitrification operations under Tank Closure Alternative 2B would extend through 2043. No separate mixed TRU waste treatment capability would be provided under this alternative. Landfill closure of the SST system was evaluated under Tank Closure Alternative 2B, including completion of a modified RCRA Subtitle C barrier over the tank system by 2045, followed by a postclosure care period of 100 years through 2145. The proposed schedule for implementing Tank Closure Alternative 2B is presented in Figure 2–34.

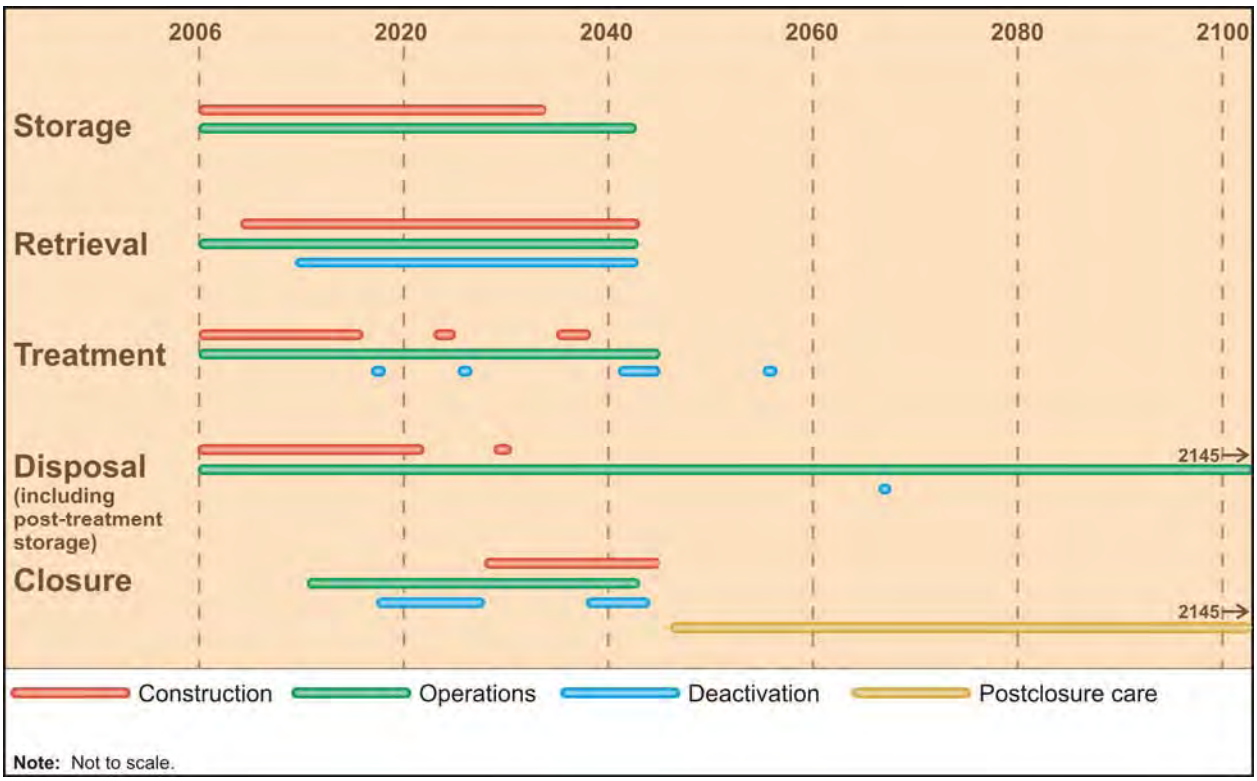


Figure 2–34. Tank Closure Alternative 2B Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–35, would occur under Tank Closure Alternative 2B.

Storage. DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four WRFs would be constructed. Each WRF would contain three 568,000-liter (150,000-gallon) tanks.

Retrieval. Waste would be retrieved to the TPA Milestone M-45-00 minimum goal (Ecology, EPA, and DOE 1989), i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for 200-series tanks, which would correspond to 99 percent retrieval using currently available liquid-based waste retrieval and leak detection systems (DOE 2003b:3-1). Under Tank Closure Alternative 2B, waste from 101 tanks (28 DSTs and 73 nonleaking 100-series SSTs) would be retrieved using the modified sluicing technology; waste from approximately 60 SSTs (100-series SSTs that are known or suspected leakers) would be retrieved using the MRS technology; and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology.

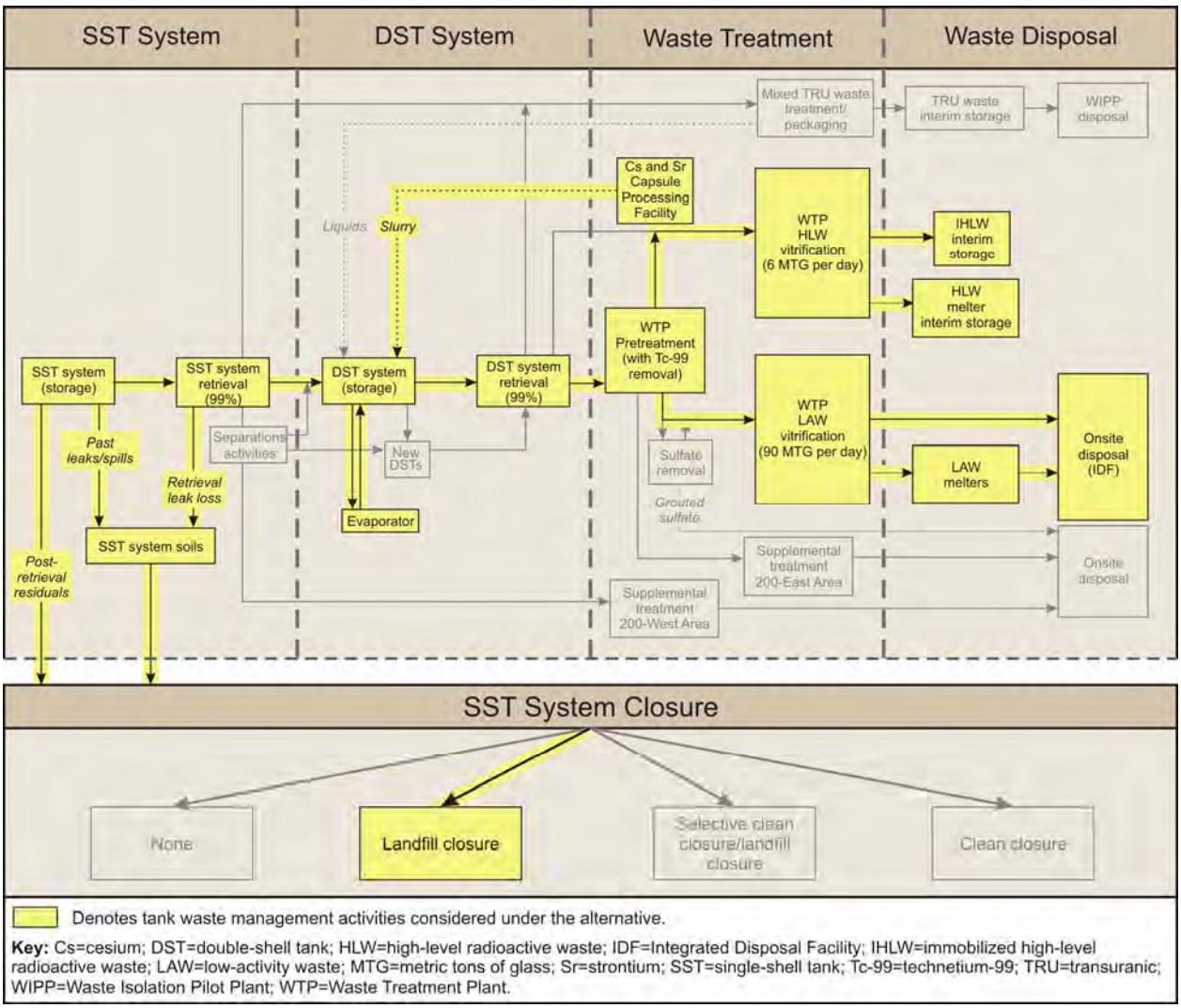


Figure 2–35. Tank Closure Alternative 2B Primary Components

Treatment. LAW vitrification capacity would be expanded by the addition of four more LAW melters to the existing WTP configuration of two HLW melters and two LAW melters. This new WTP configuration would provide a vitrification TMC of 6 metric tons of glass IHLW per day and an expanded vitrification TMC of 90 metric tons of glass ILAW per day. All of the waste streams routed to the WTP would be pretreated, including the stream in which technetium-99 removal from the LAW stream would occur. The cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility located adjacent to the WTP; their contents would be treated in the WTP. Under Alternative 2B, the WTP would produce a total of 38,400 metric tons of glass IHLW (approximately 12,000 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and 553,510 metric tons of glass ILAW (approximately 92,250 containers). Both the ETF and the 242-A Evaporator would be replaced once under this subalternative.

Disposal. IHLW glass would be stored in the completed CSB and in up to four new IHLW Interim Storage Modules until disposition decisions are made and implemented. This EIS assumes ILAW glass would be disposed of on site in an IDF.

Closure. As operations are completed, the SST waste system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303 and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B.[10] The tanks and ancillary equipment would be filled with grout to immobilize residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Contaminated soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soil from onsite sources. The 4.6-meter (15-foot) depth would allow removal of some of the ancillary equipment prior to closure. Contaminated soil and ancillary equipment would be disposed of on site in the RPPDF, a new disposal facility similar to an IDF. The closed tank system and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier, followed by postclosure care for 100 years. SST system ancillary equipment outside the boundary of the modified RCRA Subtitle C barrier would be remediated or removed to meet landfill closure requirements.

2.5.2.3 Tank Closure Alternative 3: Existing WTP Vitrification with Supplemental Treatment Technology; Landfill Closure

Under Tank Closure Alternative 3, removal of 99 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms would occur. Three subalternatives were separately evaluated. Under Tank Closure Alternative 3A, the waste would be treated using the existing WTP configuration supplemented with thermal treatment capacity (bulk vitrification) and separate treatment of the tank mixed TRU waste. Under Tank Closure Alternative 3B, the waste would be treated using the existing WTP configuration supplemented with nonthermal treatment capacity (cast stone) and separate treatment of the tank mixed TRU waste. Technetium-99 would be removed from the LAW stream during pretreatment and incorporated into the HLW stream for immobilization and offsite disposal. Under Tank Closure Alternative 3C, the waste would be treated using the existing WTP configuration supplemented with thermal treatment capacity (steam reforming) and separate treatment of the tank mixed TRU waste. Cesium and strontium capsules would be treated under all three subalternatives.

2.5.2.3.1 Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

As shown in Figure 2–36, this subalternative evaluates retrieval and treatment of 99 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms using a combination of WTP vitrification and supplemental technologies. A portion of the overall tank waste volume would be segregated into one of two waste streams during WTP pretreatment: (1) an HLW stream that would be vitrified to form IHLW glass or (2) a LAW stream that would be vitrified to form ILAW glass. Under Tank Closure Alternative 3A, technetium-99 removal would not occur as part of WTP pretreatment. The portion of the tank waste not vitrified in the WTP would be treated using the following supplemental technologies:

- Mixed TRU waste supplemental treatment
- Thermal supplemental treatment (bulk vitrification)

Mixed TRU waste supplemental treatment would be used to separately treat a select number of tanks believed to currently contain only mixed TRU waste by 2019. Bulk vitrification is the thermal supplemental treatment technology analyzed under this subalternative. The balance of the tank waste (i.e., the portion that would not be vitrified in the WTP or treated as mixed TRU waste) would be directed to the 200-East and 200-West Area Bulk Vitrification Facilities through 2039.

[10] DOE must submit a closure plan to Ecology for approval prior to undertaking any closure activities. The approved closure plan will become a condition of the Hanford RCRA permit. The Ecology permitting process includes opportunity for further public review and comment.

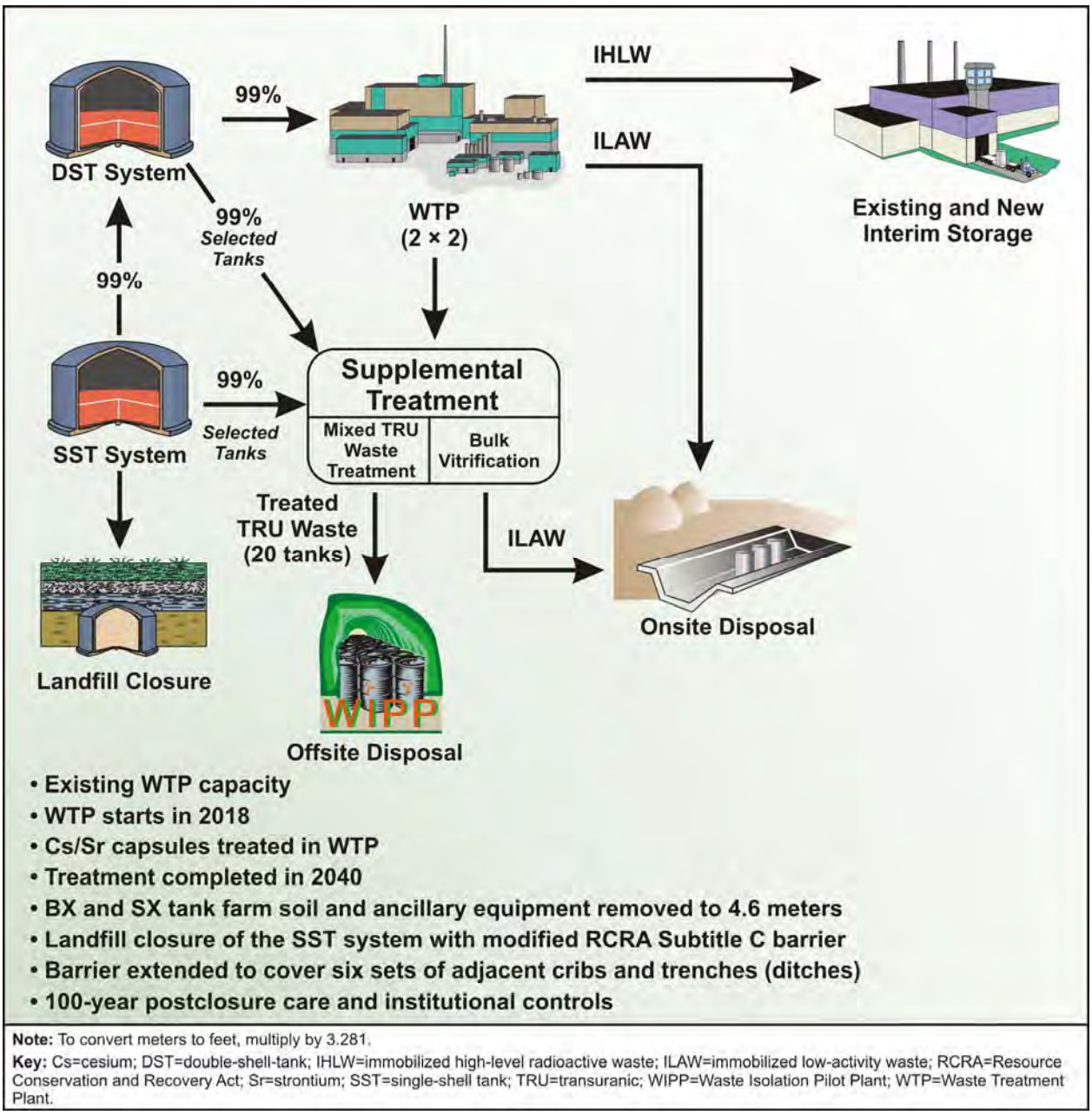


Figure 2–36. Tank Closure Alternative 3A Overview

Following construction and a 2018 start, WTP operations under Tank Closure Alternative 3A would extend through 2040. Landfill closure of the SST system was evaluated under Tank Closure Alternative 3A, including completion of a modified RCRA Subtitle C barrier over the tank system by 2041, followed by postclosure care for 100 years (through 2141). The proposed schedule for implementing Tank Closure Alternative 3A is presented in Figure 2–37.

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–38, would occur under Tank Closure Alternative 3A.

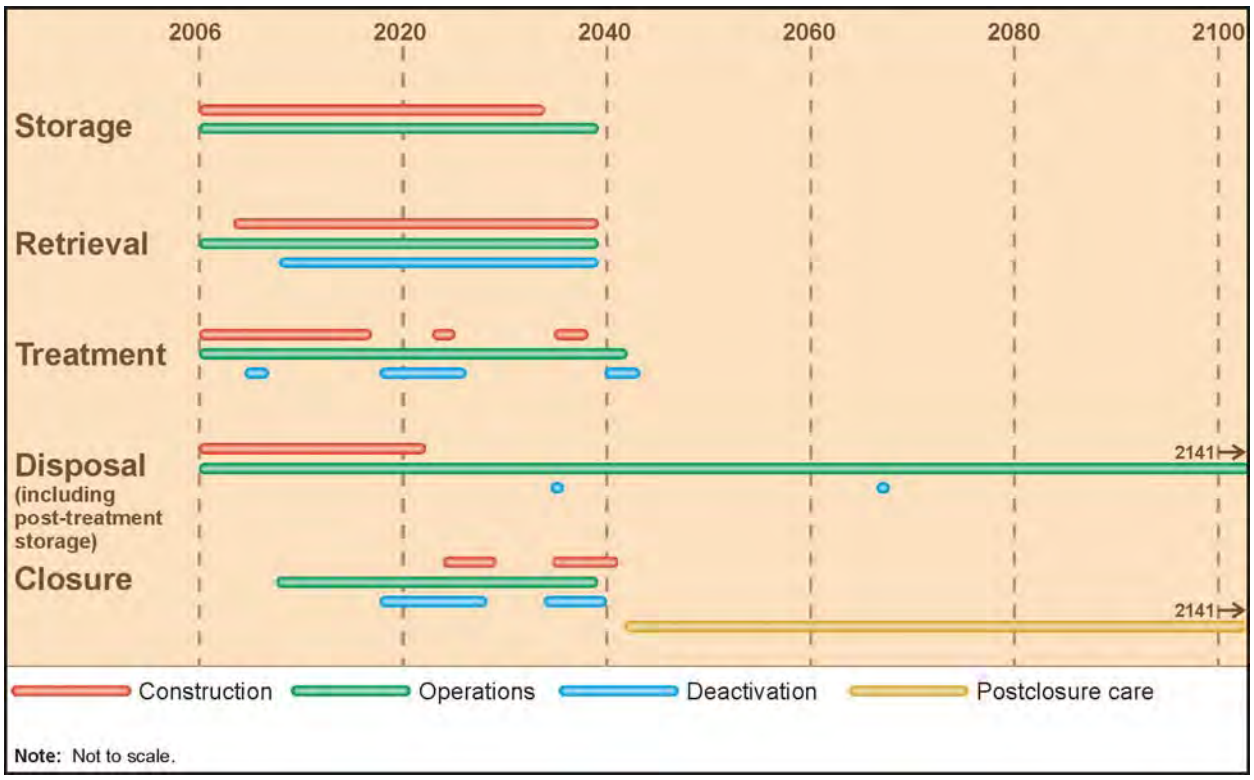


Figure 2–37. Tank Closure Alternative 3A Proposed Schedule

Storage. DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. Each WRF would contain three 568,000-liter (150,000-gallon) tanks. Treated mixed TRU waste would be stored in a separate new TRU Waste Interim Storage Facility.

Retrieval. Waste would be retrieved to the TPA Milestone M-45-00 minimum goal (Ecology, EPA, and DOE 1989), i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for 200-series tanks, which would correspond to 99 percent retrieval using currently available liquid-based waste retrieval and leak detection systems. Under Tank Closure Alternative 3A, waste from approximately 101 tanks (28 DSTs and 73 nonleaking 100-series SSTs) would be retrieved using the modified sluicing technology; waste from approximately 60 tanks (100-series SSTs that are known or suspected leakers) would be retrieved using the MRS technology; and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology.

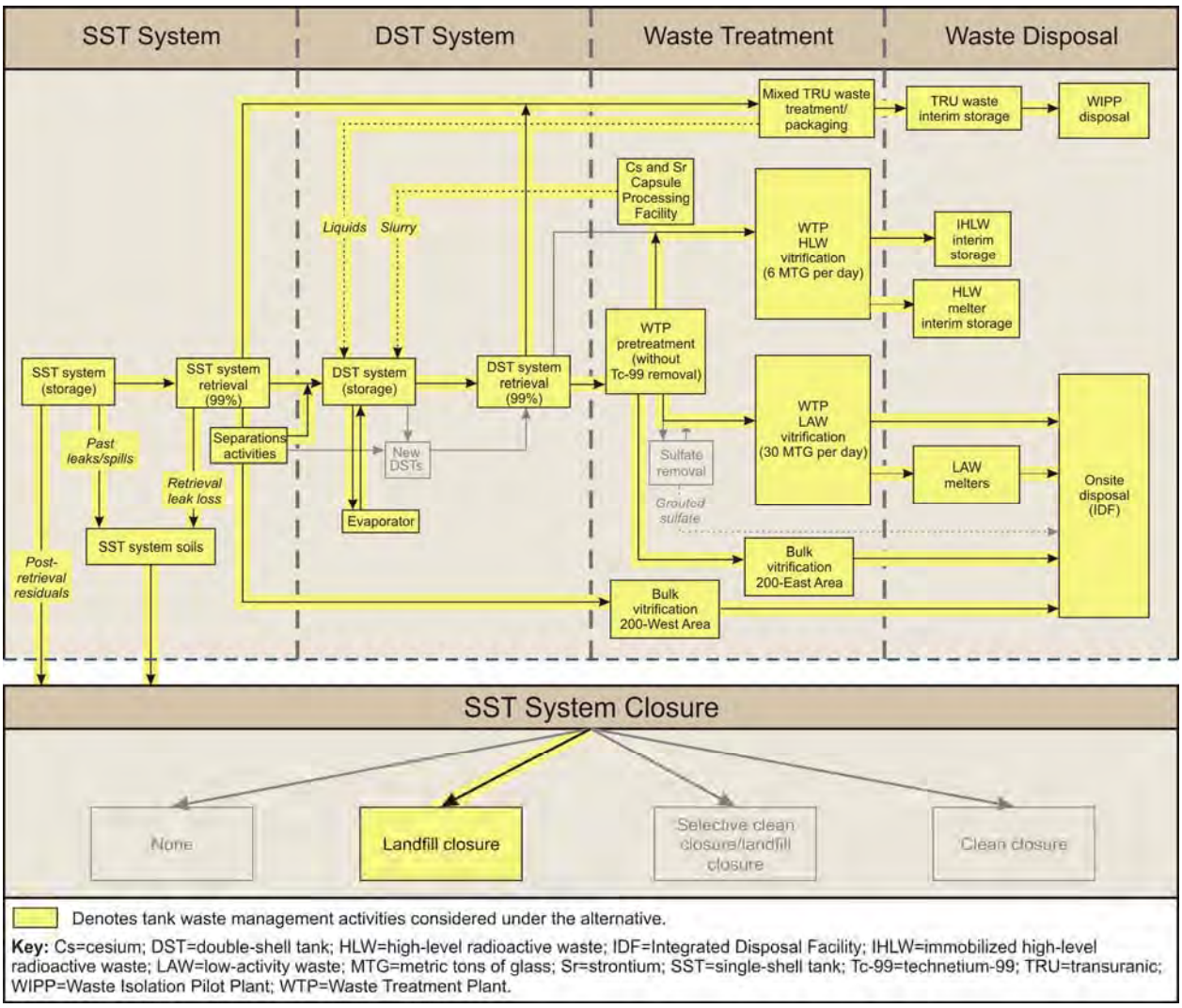


Figure 2–38. Tank Closure Alternative 3A Primary Components

Treatment. The existing WTP configuration (two HLW melters and two LAW melters) would be used, representing a vitrification TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. All of the waste streams routed to the WTP would be pretreated, although technetium-99 removal would not occur as part of WTP pretreatment. Under Tank Closure Alternative 3A, the WTP would produce a total of 27,840 metric tons of glass IHLW (approximately 8,700 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and 171,040 metric tons of glass ILAW (approximately 28,510 containers). The cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility located adjacent to the WTP; their contents would be treated in the WTP. Both the ETF and 242-A Evaporator would be replaced once under this subalternative.

WTP capacity under Tank Closure Alternative 3A would be supplemented by construction and operation of a thermal supplemental treatment facility to immobilize a portion of the LAW. This supplemental treatment of the LAW would occur in both the 200-East and 200-West Areas and would produce 256,840 metric tons of glass bulk vitrification waste (approximately 6,030 containers). In the 200-East Area, the waste feed would be pretreated, excluding technetium-99 removal, in the WTP. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. In addition, a separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons])

would be designated as mixed TRU waste. This mixed TRU waste would be treated and packaged using mobile CH-Mixed TRU Waste Facilities located in both the 200-East and 200-West Areas and a single, fixed RH-Mixed TRU Waste Facility in the 200-East Area.

Disposal. IHLW glass would be stored in the completed CSB and in up to four new IHLW Interim Storage Modules until disposition decisions are made and implemented. LAW immobilized at the WTP would be disposed of on site in an IDF, as would LAW immobilized external to the WTP through the bulk vitrification process. Mixed TRU waste would be packaged and stored on site in a new TRU Waste Interim Storage Facility pending disposal at WIPP.

Closure. As operations are completed, the SST system at Hanford would be either closed as an RCRA hazardous waste landfill unit under WAC 173-303 and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Contaminated soil at the BX and SX tank farms would be removed down to 4.6 meters (15 feet) and replaced with clean soil from onsite sources. The 4.6-meter (15-foot) depth would allow for removal of all ancillary equipment prior to closure of the BX and SX tank farms. Contaminated soil and ancillary equipment would be disposed of on site in the RPPDF, a new disposal facility similar to an IDF. The closed tank system and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier followed by postclosure care for 100 years. SST system ancillary equipment located outside the boundary of the modified RCRA Subtitle C barrier would be remediated or removed to meet landfill closure requirements.

2.5.2.3.2 Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

As shown in Figure 2–39, this subalternative evaluates retrieval and treatment of 99 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms using a combination of WTP vitrification and supplemental technologies. A portion of the overall tank waste volume would be segregated into one of two waste streams during WTP pretreatment: (1) an HLW stream that would be vitrified to form IHLW glass or (2) a LAW stream that would be vitrified to form ILAW glass. Under Tank Closure Alternative 3B, technetium-99 would be removed from the LAW stream during WTP pretreatment, and the portion of the tank waste not vitrified using the WTP would be treated using the following supplemental technologies:

- Mixed TRU waste supplemental treatment
- Nonthermal supplemental treatment (cast stone)

Mixed TRU waste supplemental treatment would be used to separately treat a select number of tanks that are currently believed to contain only mixed TRU waste by 2019. Cast stone is the nonthermal supplemental treatment technology analyzed under this subalternative. The balance of the tank waste (amounts not vitrified in the WTP or treated as mixed TRU waste) would be directed to the 200-East and 200-West Area Cast Stone Facilities for treatment through 2039.

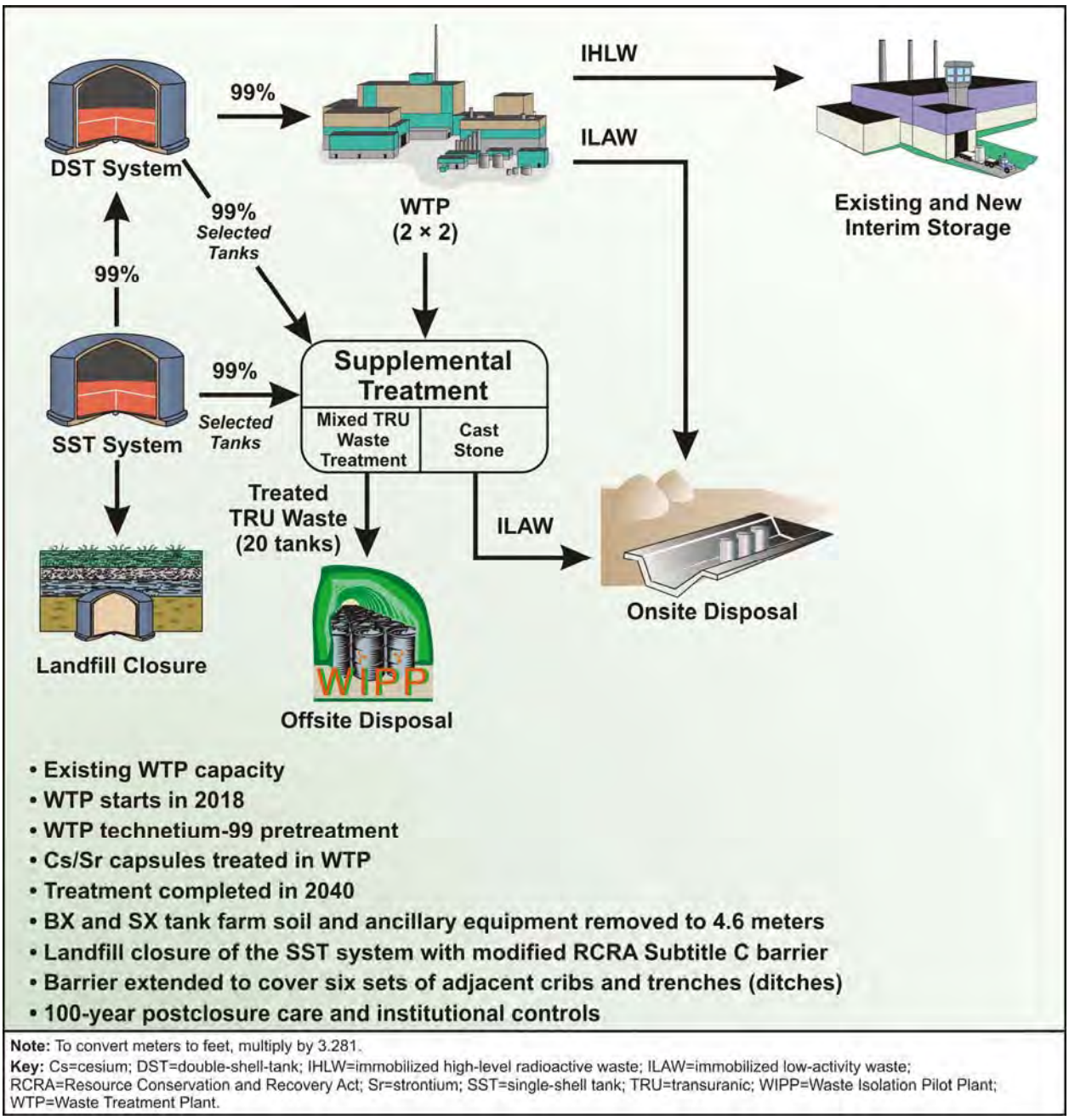


Figure 2–39. Tank Closure Alternative 3B Overview

Following construction and a 2018 start, WTP operations under Tank Closure Alternative 3B would extend through 2040. Landfill closure of the SST system was evaluated under this alternative, including completion of a modified RCRA Subtitle C barrier over the tank system by 2041, followed by postclosure care for 100 years (through 2141). The proposed schedule for implementing Tank Closure Alternative 3B is presented in Figure 2–40.

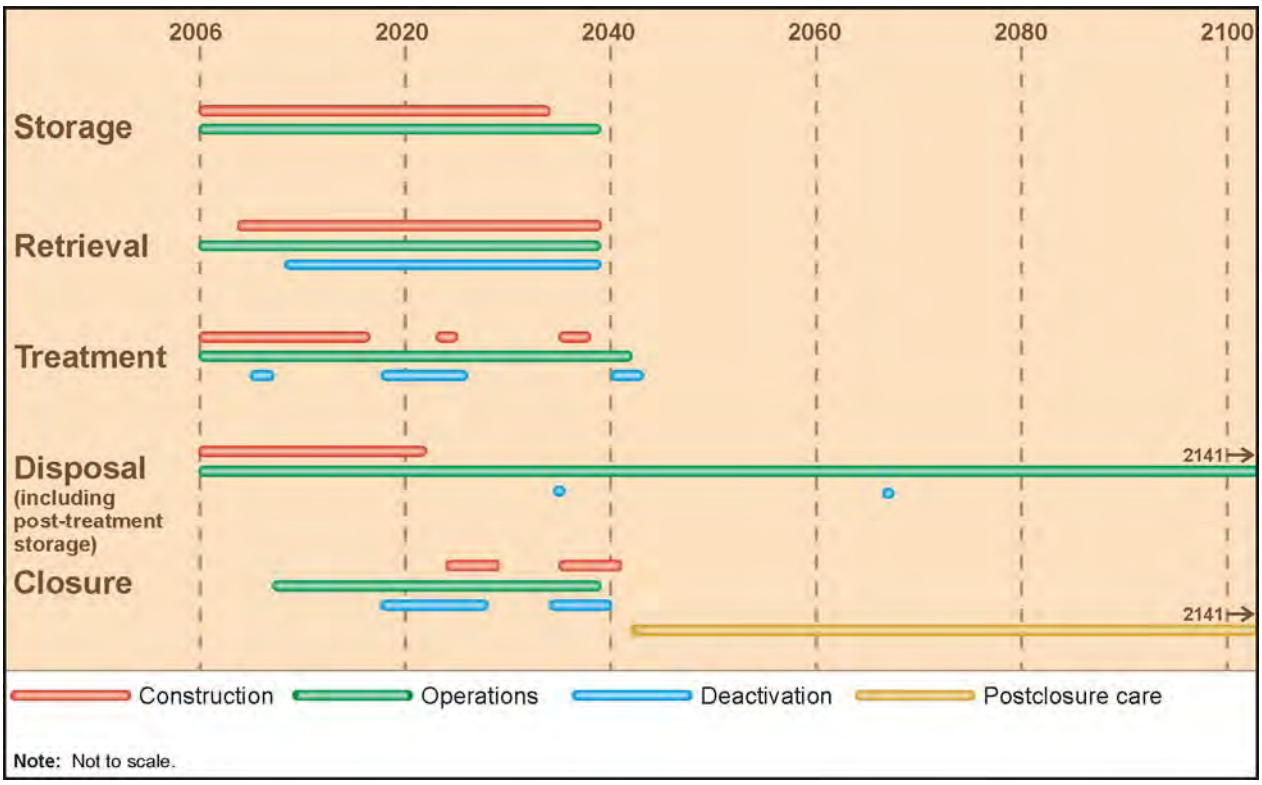


Figure 2–40. Tank Closure Alternative 3B Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–41, would occur under Tank Closure Alternative 3B.

Storage. DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four WRFs would be constructed. Each WRF would contain three 568,000-liter (150,000-gallon) tanks.

Retrieval. Waste would be retrieved to the TPA Milestone M-45-00 minimum goal (Ecology, EPA, and DOE 1989), i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for 200-series tanks, which would correspond to 99 percent retrieval using currently available liquid-based waste retrieval and leak detection systems. Under Tank Closure Alternative 3B, waste from approximately 101 tanks (28 DSTs and 73 nonleaking 100-series SSTs) would be retrieved using the modified sluicing technology; waste from approximately 60 tanks (100-series SSTs that are known or suspected leakers) would be retrieved using the MRS technology; and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology.

Treatment. The existing WTP configuration (two HLW melters and two LAW melters) would be used, representing a vitrification TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. All of the waste streams routed to the WTP would be pretreated, and technetium-99 would be removed from the LAW stream. Under Tank Closure Alternative 3B, the WTP would produce a total of 27,840 metric tons of glass IHLW (approximately 8,700 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and 171,040 metric tons of glass ILAW (approximately 28,510 containers). The cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility located adjacent to the WTP; their contents would be treated in the WTP. Both the ETF and 242-A Evaporator would be replaced once under this subalternative.

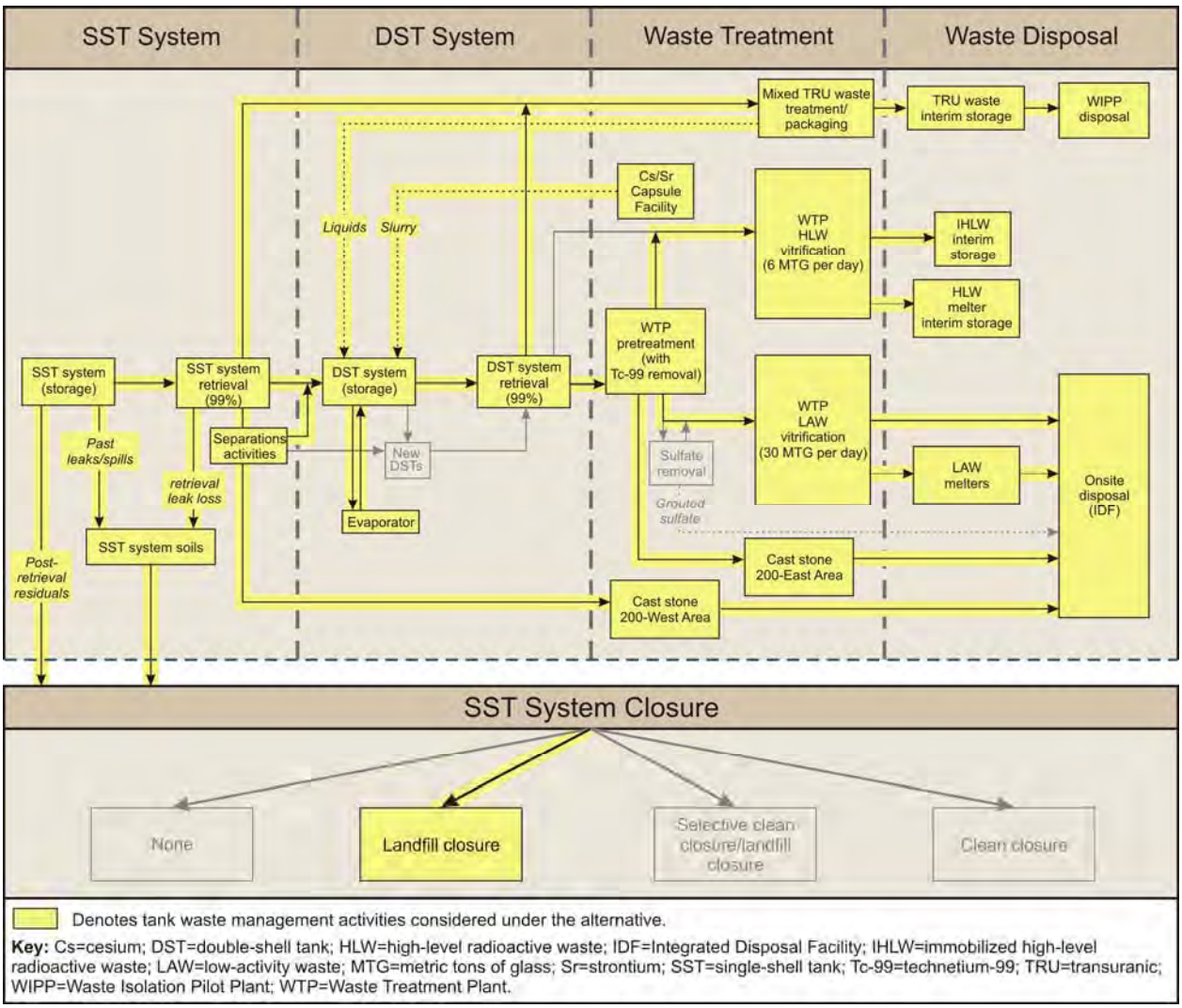


Figure 2–41. Tank Closure Alternative 3B Primary Components

WTP capacity under Tank Closure Alternative 3B would be supplemented by construction and operation of a new Cast Stone Facility in both the 200-East and 200-West Areas to immobilize a portion of the LAW. This supplemental treatment for the LAW would produce 465,560 metric tons of cast stone waste (approximately 23,270 containers). In the 200-East Area, the waste feed would be pretreated, including technetium-99 removal, in the WTP. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. In addition, a separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste. This mixed TRU waste would be treated and packaged using mobile CH-Mixed TRU Waste Facilities located in both the 200-East and 200-West Areas and a single, fixed RH-Mixed TRU Waste Facility in the 200-East Area.

Disposal. IHLW glass would be stored in the completed CSB and in up to four new IHLW Interim Storage Modules until disposition decisions are made and implemented. LAW immobilized via the WTP would be disposed of on site in an IDF, as would LAW immobilized external to the WTP through the cast stone treatment process. Mixed TRU waste would be packaged and stored on site in a new TRU Waste Interim Storage Facility pending disposal at WIPP.

Closure. As operations are completed, the SST system at Hanford would be either closed as an RCRA hazardous waste landfill unit under WAC 173-303 and DOE Order 435.1, as applicable, or

decommissioned under DOE Order 430.1B. The tanks would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Contaminated soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soil from onsite sources. The 4.6-meter (15-foot) depth would allow the removal of all ancillary equipment prior to closure of the BX and SX tank farms. Contaminated soil and ancillary equipment would be disposed of on site in the RPPDF, a new disposal facility similar to an IDF. The closed tank system and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier followed by postclosure care for 100 years. SST system ancillary equipment located outside the boundary of the modified RCRA Subtitle C barrier would be remediated or removed to meet landfill closure requirements.

2.5.2.3.3 Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

As shown in Figure 2–42, this subalternative evaluates retrieval and treatment of 99 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms using a combination of WTP vitrification and supplemental technologies. A portion of the overall tank waste volume would be segregated into one of two waste streams: (1) an HLW stream that would be pretreated in the WTP and vitrified to form IHLW glass or (2) a LAW stream that would be pretreated in the WTP and vitrified to form ILAW glass. Technetium-99 removal would not occur as part of WTP pretreatment. Under Tank Closure Alternative 3C, the portion of the tank waste not vitrified using the WTP would be treated using the following supplemental technologies:

- Mixed TRU waste supplemental treatment
- Thermal supplemental treatment (steam reforming)

Mixed TRU waste supplemental treatment would be used to separately treat a select number of tanks believed to currently contain only mixed TRU waste by 2019. Steam reforming is the thermal supplemental treatment technology analyzed under this subalternative. The balance of the tank waste (that waste not being vitrified in the WTP or treated as mixed TRU waste) would be directed to the new 200-East and 200-West Area Steam Reforming Facilities through 2039.

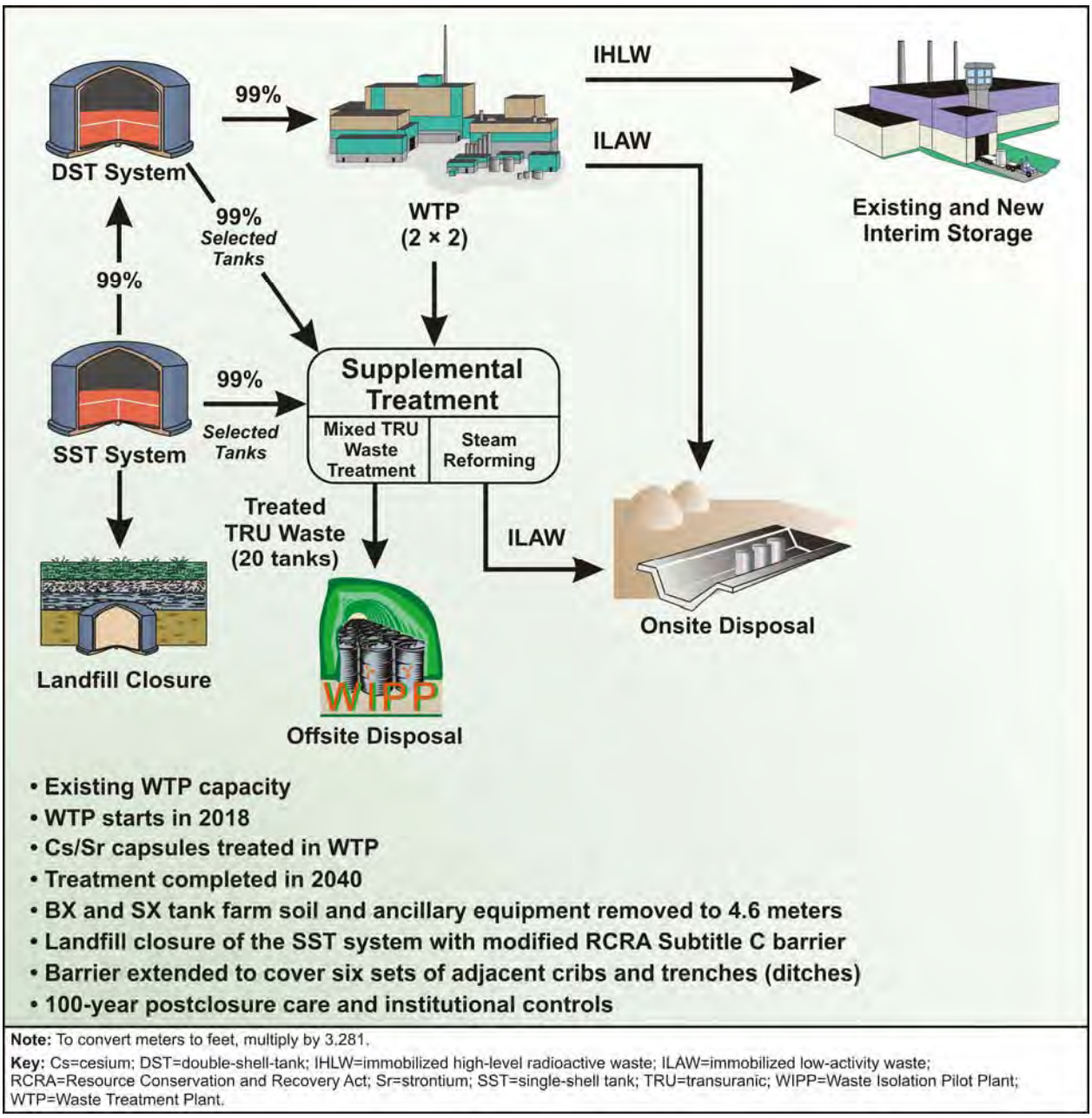


Figure 2–42. Tank Closure Alternative 3C Overview

Following construction and a 2018 start, WTP operations under Tank Closure Alternative 3C would extend through 2040. Landfill closure of the SST system was evaluated under this alternative, including completion of a modified RCRA Subtitle C barrier over the tank system by 2041, followed by postclosure care for 100 years (through 2141). The proposed schedule for implementing Tank Closure Alternative 3C is presented in Figure 2–43.

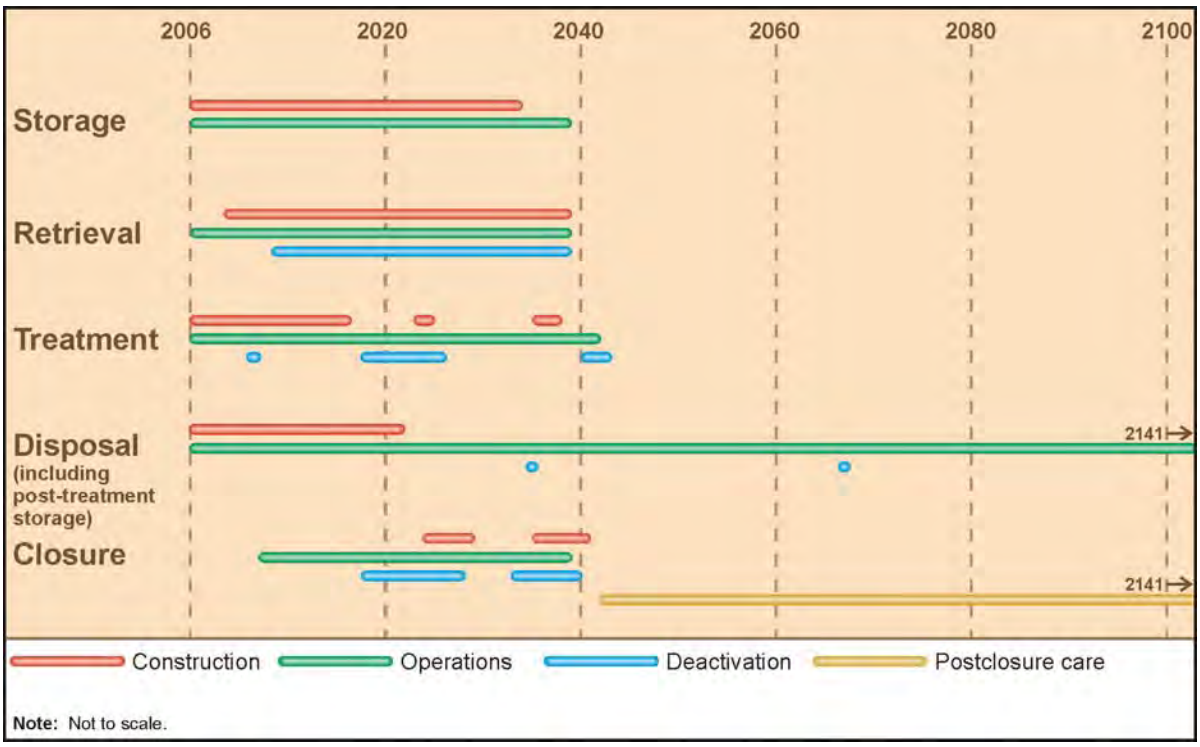


Figure 2–43. Tank Closure Alternative 3C Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–44, would occur under Tank Closure Alternative 3C.

Storage. DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. Each WRF would contain three 568,000-liter (150,000-gallon) tanks.

Retrieval. Waste would be retrieved to the TPA Milestone M-45-00 minimum goal (Ecology, EPA, and DOE 1989), i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for 200-series tanks, which would correspond to 99 percent retrieval using currently available liquid-based waste retrieval and leak detection systems. Under Alternative 3C, waste from approximately 101 tanks (28 DSTs and 73 nonleaking 100-series SSTs) would be retrieved using the modified sluicing technology; waste from approximately 60 tanks (100-series SSTs that are known or suspected leakers) would be retrieved using the MRS technology; and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology.

Treatment. The existing WTP configuration (two HLW melters and two LAW melters) would be used, representing a vitrification TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. All of the waste streams routed to the WTP would be pretreated, but no technetium-99 removal would occur. Under Tank Closure Alternative 3C, the WTP would produce a total of 27,840 metric tons of glass IHLW (approximately 8,700 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and 171,040 metric tons of glass ILAW (approximately 28,510 containers). The cesium and strontium capsules would be retrieved from the WESF, de-encapsulated in a new Cesium and Strontium Capsule Processing Facility located adjacent to the WTP; their contents would be treated in the WTP. Both the ETF and 242-A Evaporator would be replaced once under this subalternative.

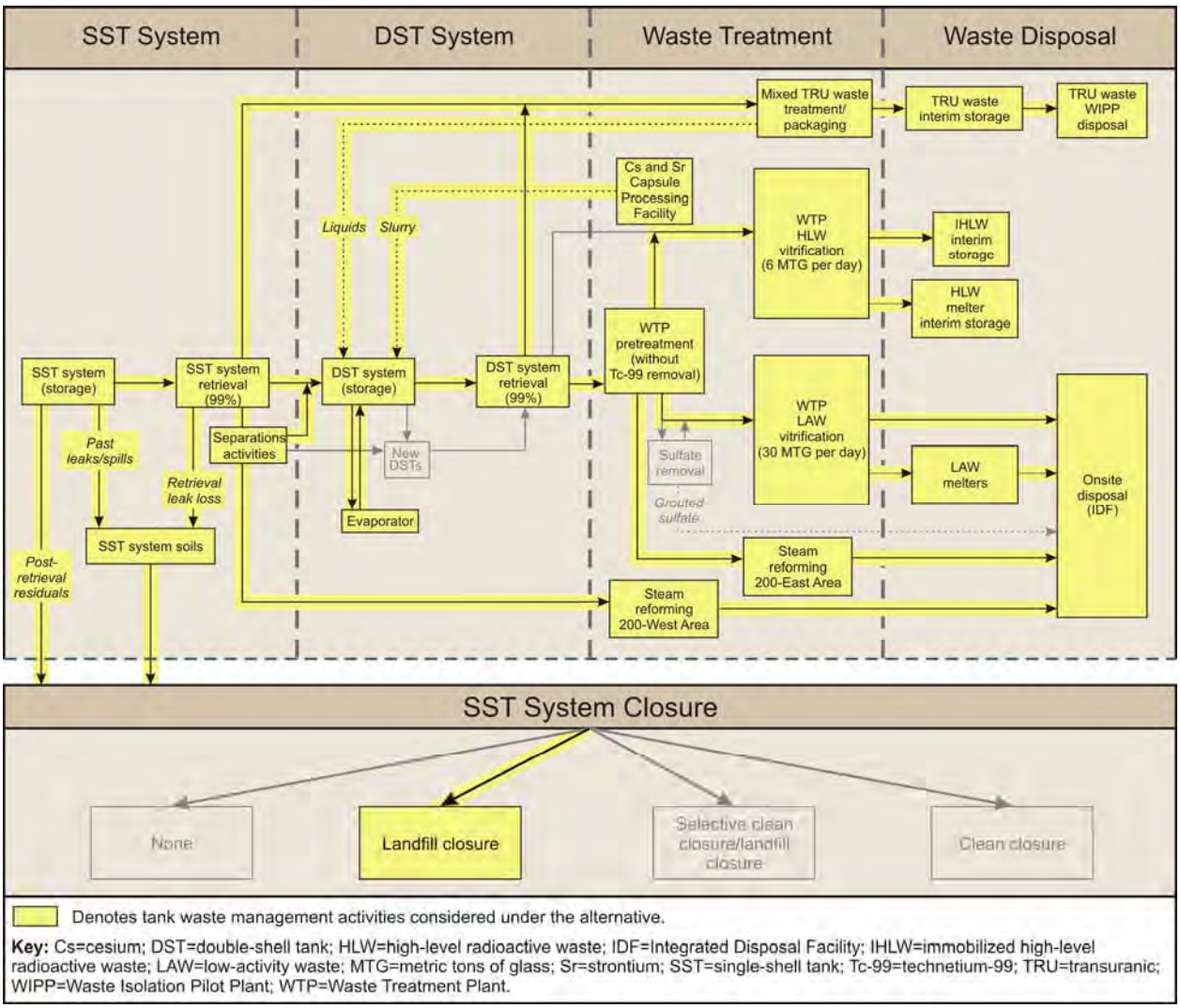


Figure 2–44. Tank Closure Alternative 3C Primary Components

WTP capacity under Tank Closure Alternative 3C would be supplemented by construction and operation of a Steam Reforming Facility in both the 200-East and 200-West Areas to immobilize a portion of the LAW. This supplemental treatment for the LAW would produce 260,920 metric tons of steam reforming waste (approximately 115,960 containers). In the 200-East Area, the waste feed would be pretreated in the WTP without removing technetium-99. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. In addition, a separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste that would be treated and packaged using mobile CH-Mixed TRU Waste Facilities located in both the 200-East and 200-West Areas and a single, fixed RH-Mixed TRU Waste Facility in the 200-East Area.

Disposal. IHLW glass would be stored in the completed CSB and in up to four new IHLW Interim Storage Modules until disposition decisions are made and implemented. LAW immobilized in the WTP would be disposed of on site in an IDF, as would LAW immobilized external to the WTP using the steam reforming process. Mixed TRU waste would be packaged and stored on site in a new TRU Waste Interim Storage Facility pending disposal at WIPP.

Closure. As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303 and DOE Order 435.1, as applicable, or

decommissioned under DOE Order 430.1B. The tanks and ancillary equipment would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Contaminated soil would be removed down to 4.6 meters (15 feet) for the BX and SX tank farms and replaced with clean soil from onsite sources. The 4.6-meter (15-foot) depth would allow removal of all of the ancillary equipment in the BX and SX tank farms prior to closure. Contaminated soil and ancillary equipment would be disposed of on site in the RPPDF, a new disposal facility similar to an IDF. The closed tank system and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier, followed by postclosure care for 100 years. SST system ancillary equipment outside the boundary of the modified RCRA Subtitle C barrier would be remediated or removed to meet landfill closure requirements.

2.5.2.4 Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

As shown in Figure 2–45, under Tank Closure Alternative 4, treatment of 99.9 percent of the waste volume in the Hanford 200-East and 200-West Area tank farms would occur using a combination of WTP vitrification and supplemental treatment technologies. A portion of the overall tank waste volume would be pretreated in the WTP and segregated into two waste streams during WTP pretreatment: (1) an HLW stream that would be vitrified to form IHLW glass and (2) a LAW stream that would be vitrified to form ILAW. Under this alternative, technetium-99 removal would not occur as part of WTP pretreatment; however, the cesium and strontium capsules would be treated. The portion of the tank waste not vitrified using the WTP would be treated using the following supplemental technologies:

- Mixed TRU waste supplemental treatment
- Bulk vitrification supplemental treatment
- Cast stone supplemental treatment

Mixed TRU waste supplemental treatment would be used to separately treat a select number of tanks believed to currently contain only mixed TRU waste by 2019. The balance of the tank waste (that waste not vitrified in the WTP or treated as mixed TRU waste) would be apportioned into two groups. One group would be routed to a Cast Stone Facility in the 200-East Area, and the other would be routed to a Bulk Vitrification Facility in the 200-West Area. The Cast Stone and Bulk Vitrification Facilities would operate through 2039.

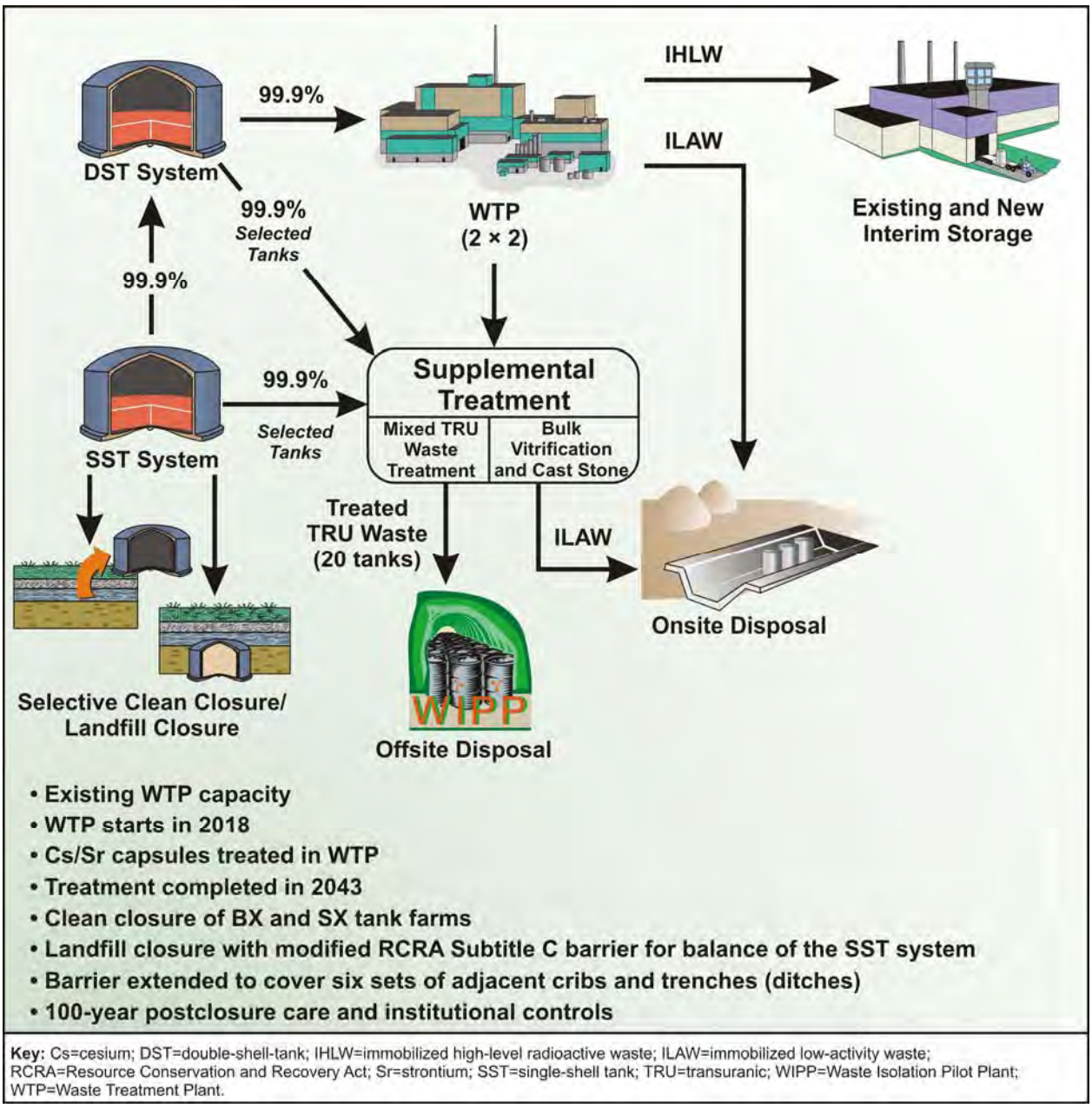


Figure 2–45. Tank Closure Alternative 4 Overview

Following completion of construction and a 2018 start, WTP operations under Tank Closure Alternative 4 are projected to be complete in 2043. This alternative evaluates the clean closure of two tank farms (BX and SX) and the landfill closure of the remaining 10 SST farms. Clean closure of the BX and SX tank farms would encompass tank, ancillary equipment, and contaminated soil removal and backfilling with clean fill. Landfill closure of the remaining tank farms and six adjacent cribs and trenches (ditches) would include the construction of a closure barrier (modified RCRA Subtitle C barrier) over these areas. The clean closure of the BX and SX tank farms and construction of the closure barrier would be completed in 2044, followed by postclosure care for 100 years, through 2144. The proposed schedule for implementing Alternative 4 is presented in Figure 2–46.

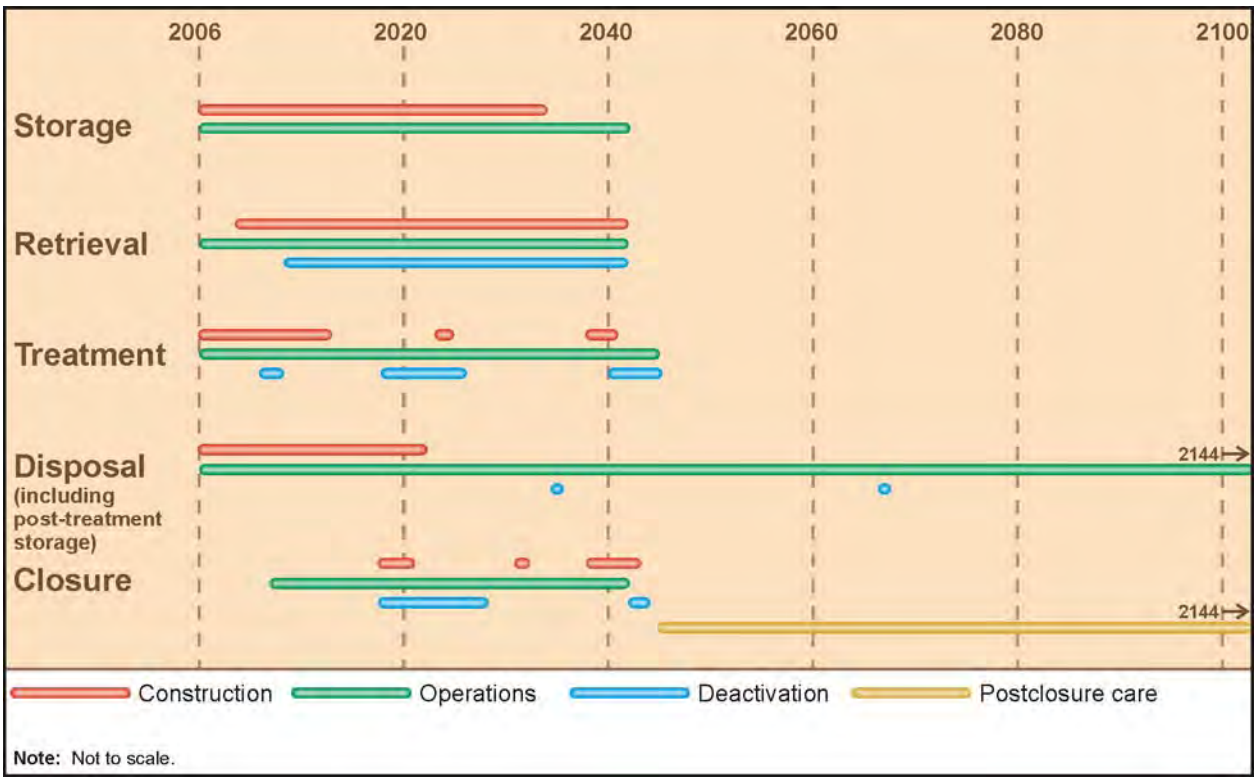


Figure 2–46. Tank Closure Alternative 4 Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–47, would occur under Tank Closure Alternative 4.

Storage. DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. Each WRF would contain three 568,000-liter (150,000-gallon) tanks.

Retrieval. Waste would be retrieved to 99.9 percent, exceeding the TPA Milestone M-45-00 minimum goal of 99 percent (Ecology, EPA, and DOE 1989). This level of retrieval would correspond to residual tank waste of no more than 1 cubic meter (36 cubic feet) for 100-series tanks or 0.08 cubic meters (3 cubic feet) for 200-series tanks. An additional tank chemical wash process and enhanced in-tank and ex-tank leak detection systems would be used to accomplish this higher percentage of waste volume retrieval. Under Tank Closure Alternative 4, waste from approximately 161 tanks (28 DSTs, 73 nonleaking 100-series SSTs, and 60 SSTs [100-series] that are known or suspected leakers) would be retrieved using the MRS technology, and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology. All 250 tanks would then undergo chemical washing to meet the 99.9 percent retrieval goal.

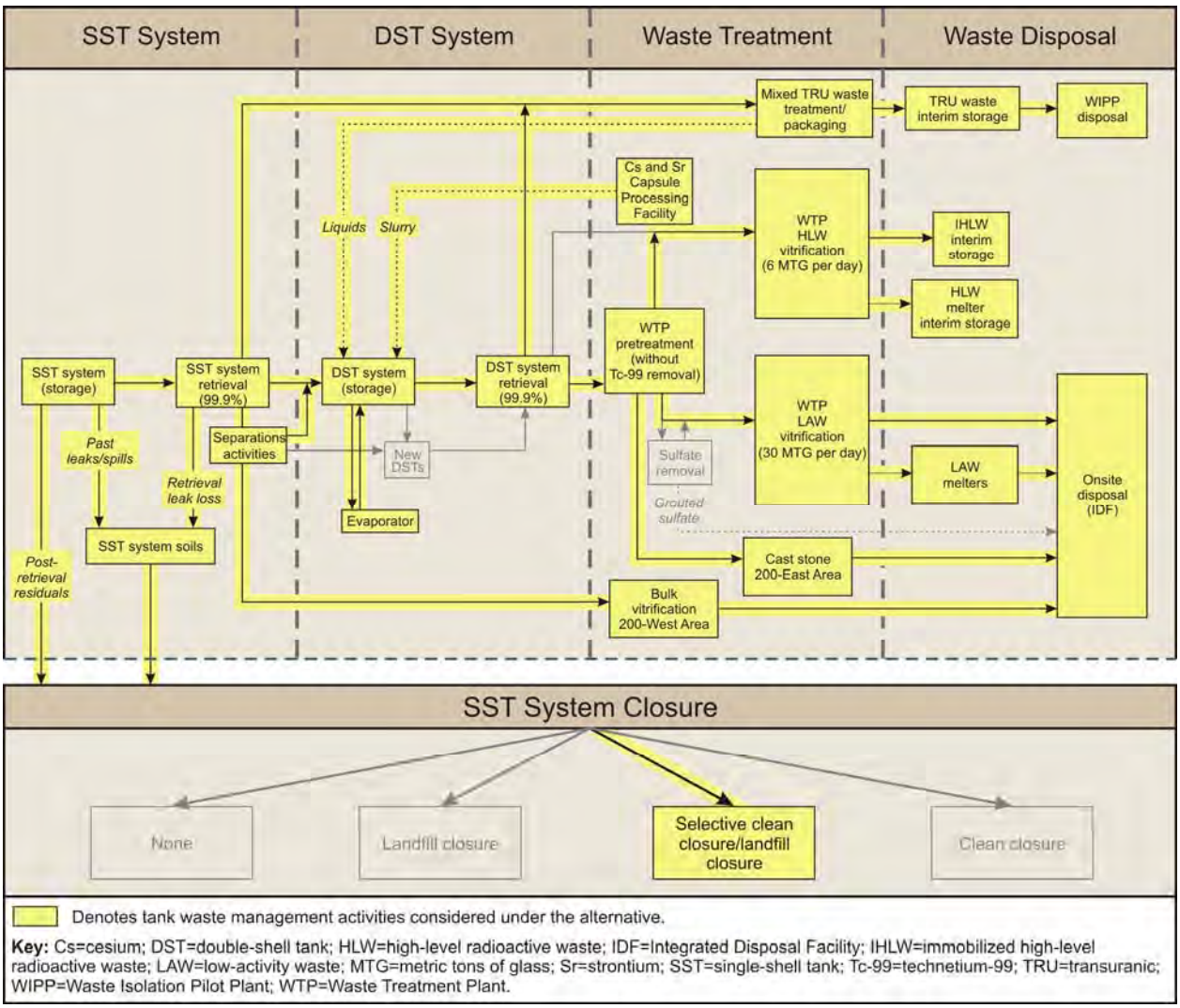


Figure 2–47. Tank Closure Alternative 4 Primary Components

Treatment. The existing WTP configuration (two HLW melters and two LAW melters) would be used, representing a vitrification TMC of 6 metric tons of glass IHLW per day and 30 metric tons of glass ILAW per day. Both HLW and LAW treatment would end in approximately 2037. However, the WTP would be required to operate through 2043 to treat the cesium and strontium capsules and the highly contaminated waste stream resulting from clean closure activities of the BX and SX tank farms. All of the waste streams routed to the WTP would be pretreated; technetium-99 would not be removed during WTP pretreatment. Under Tank Closure Alternative 4, the WTP would produce a total of 34,570 metric tons of glass IHLW (approximately 10,800 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and 172,320 metric tons of glass ILAW (approximately 28,730 containers). The cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility located adjacent to the WTP; their contents would be treated in the WTP. Both the ETF and the 242-A Evaporator would be replaced once under Tank Closure Alternative 4.

WTP capacity under Tank Closure Alternative 4 would be supplemented by construction and operation of Bulk Vitrification and Cast Stone Facilities to immobilize a portion of the LAW. Bulk vitrification would occur in the 200-West Area and produce 101,340 metric tons of glass bulk vitrification waste (approximately 2,380 containers). The waste feed for bulk vitrification would be pretreated in a new

Solid-Liquid Separations Facility. Cast stone treatment would occur in the 200-East Area and produce 287,540 metric tons of cast stone waste (approximately 14,380 containers). The waste feed for the 200-East Area Cast Stone Facility would be pretreated in the WTP, excluding technetium-99 removal. In addition, approximately 11.8 million liters (3.1 million gallons) of the tank waste would be designated as mixed TRU waste. This mixed TRU waste would be treated and packaged using mobile CH-Mixed TRU Waste Facilities located in both the 200-East and 200-West Areas and a single, fixed RH-Mixed TRU Waste Facility in the 200-East Area.

Disposal. IHLW glass would be stored in the completed CSB in up to six new IHLW Interim Storage Modules until disposition decisions are made and implemented. LAW immobilized via the WTP would be disposed of on site in an IDF, as would LAW immobilized external to the WTP through the bulk vitrification and cast stone supplemental treatment processes. Mixed TRU waste would be packaged and stored on site in a new TRU Waste Interim Storage Facility pending disposal at WIPP.

Closure. Tank Closure Alternative 4 includes clean closure of the BX tank farm (200-East Area) and the SX tank farm (200-West Area), as well as landfill closure of the remaining 10 SST farms and six sets of adjacent cribs and trenches (ditches). As described in Section 2.2.4.3, clean closure of the BX and SX tank farms was evaluated to determine the impacts of increased remediation at one representative tank farm in each of the 200-East and 200-West Areas. Clean closure at these tank farms would involve removal of the SSTs, ancillary equipment, and soil to a depth of 3 meters (10 feet) below the tank base. Removed tanks, ancillary equipment, and soil would be treated in the PPF, as appropriate, resulting in MLLW and a highly contaminated waste stream. The MLLW would be disposed of on site in the RPPDF, a new facility similar to an IDF that would be built between the 200-East and 200-West Areas. The highly contaminated liquid waste stream would be treated in the WTP, resulting in additional IHLW (approximately 2,100 canisters). Where necessary, deep soil excavation would be conducted to remove contamination plumes within the soil column. Highly contaminated soil from deep soil excavation would be treated in the PPF, which would generate a contaminated liquid waste stream that would be processed as LAW in the WTP, resulting in additional ILAW (approximately 220 containers). The washed soil would be disposed of in the RPPDF. The tank farms would then be backfilled with clean soil from onsite sources. Clean closure of these tank farms would preclude the need for postclosure care.

As operations at the balance of the tank farms are completed, the SST system and six sets of adjacent cribs and trenches (ditches) at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303 and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B. The tanks would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. The closed tank system and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier followed by postclosure care for 100 years through 2144. SST system ancillary equipment outside the boundary of the modified RCRA Subtitle C barrier would be remediated or removed to meet landfill closure requirements.

2.5.2.5 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

As shown in Figure 2–48, under Tank Closure Alternative 5, retrieval and treatment of 90 percent of the tank waste from the Hanford 200-East and 200-West Area tank farms was evaluated, but on an accelerated treatment schedule and using a combination of expanded WTP vitrification and supplemental technologies. A portion of the overall tank waste volume would be pretreated in the WTP and segregated into two waste streams: (1) an HLW stream that would be vitrified to form IHLW glass and (2) a LAW stream that would be vitrified to form ILAW glass. Under this alternative, no technetium-99 removal would occur as part of WTP pretreatment; however, a sulfate removal process would be employed following WTP pretreatment to allow higher waste loading in the ILAW glass.

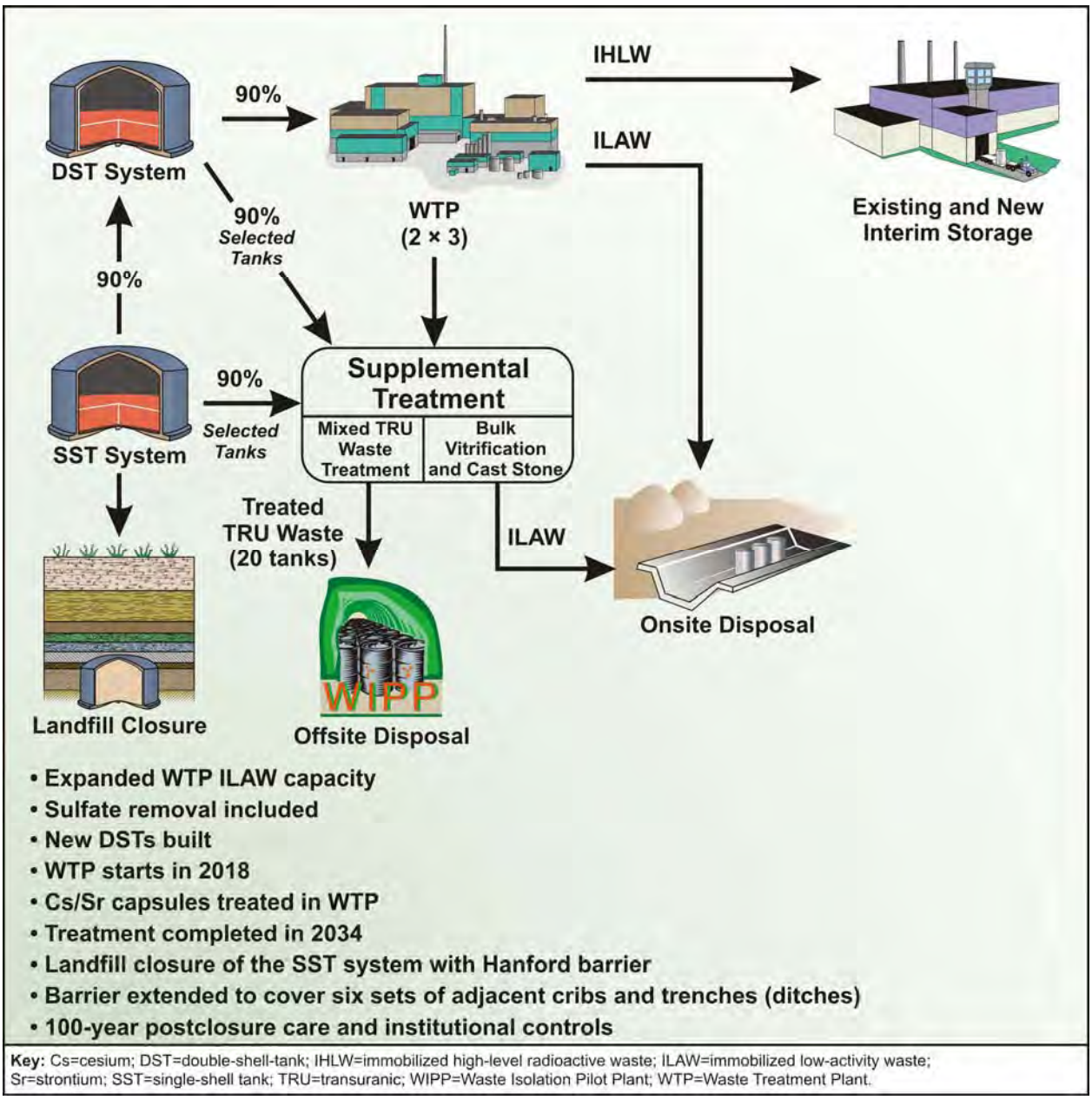


Figure 2–48. Tank Closure Alternative 5 Overview

Under Tank Closure Alternative 5, the portion of the tank waste not vitrified in the WTP would be treated using the following supplemental technologies:

- Mixed TRU waste supplemental treatment
- Thermal supplemental treatment (bulk vitrification)
- Nonthermal supplemental treatment (cast stone)

Mixed TRU waste supplemental treatment would be used to separately treat a select number of tanks believed to currently contain only mixed TRU waste by 2019. The balance of the tank waste (waste not being vitrified in the WTP or treated as mixed TRU waste) would be apportioned into two groups: one that would be routed to a Cast Stone Facility in the 200-East Area and the other that would be routed to a

Bulk Vitrification Facility in the 200-West Area. The Cast Stone and Bulk Vitrification Facilities would operate through 2033.

Following construction of the WTP and a 2018 start, WTP operations under Tank Closure Alternative 5 would extend through 2034. Landfill closure of the SST system was evaluated under Alternative 5, including completion of a more-robust Hanford barrier over the tank system by 2039, followed by postclosure care for 100 years through 2139. The proposed schedule for implementing Alternative 5 is presented in Figure 2–49.

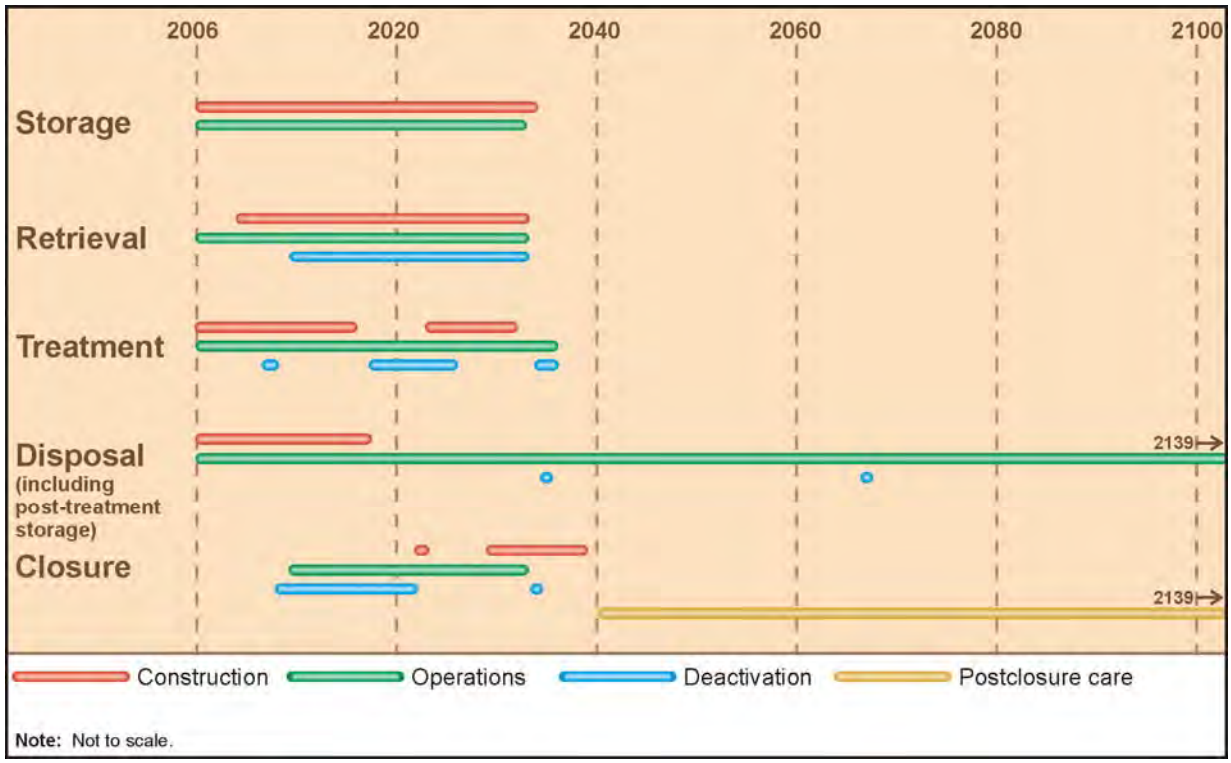


Figure 2–49. Tank Closure Alternative 5 Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–50, would occur under Tank Closure Alternative 5.

Storage. DOE would continue current waste management operations using existing tank storage facilities. The accelerated treatment schedule associated with Alternative 5 would require the construction and operation of four new DSTs and four new WRFs to facilitate waste retrieval operations.

Retrieval. Waste would be retrieved to 90 percent, less than the TPA Milestone M-45-00 minimum goal of 99 percent, which represents a programmatic risk analysis process for the tank farms as defined by Appendix H of the TPA, "Single Shell Tank Waste Retrieval Criteria Procedure" (Ecology, EPA, and DOE 1989). This level of retrieval would correspond to residual tank waste of no more than 102 cubic meters (3,600 cubic feet) for the 100-series tanks or 8.5 cubic meters (300 cubic feet) for the 200-series tanks. Waste would be retrieved using currently available liquid-based waste retrieval and leak detection systems. A study of the feasibility of tank closure supports this aggressive retrieval schedule, which assumes retrieval completion in 2033 (CEES 2003). Under Tank Closure Alternative 5, waste would be retrieved from approximately 73 tanks (nonleaking 100-series SSTs) using the modified sluicing technology; waste from approximately 60 tanks (100-series SSTs that are known or suspected leakers) would be retrieved using the MRS technology; and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology. Existing in-tank

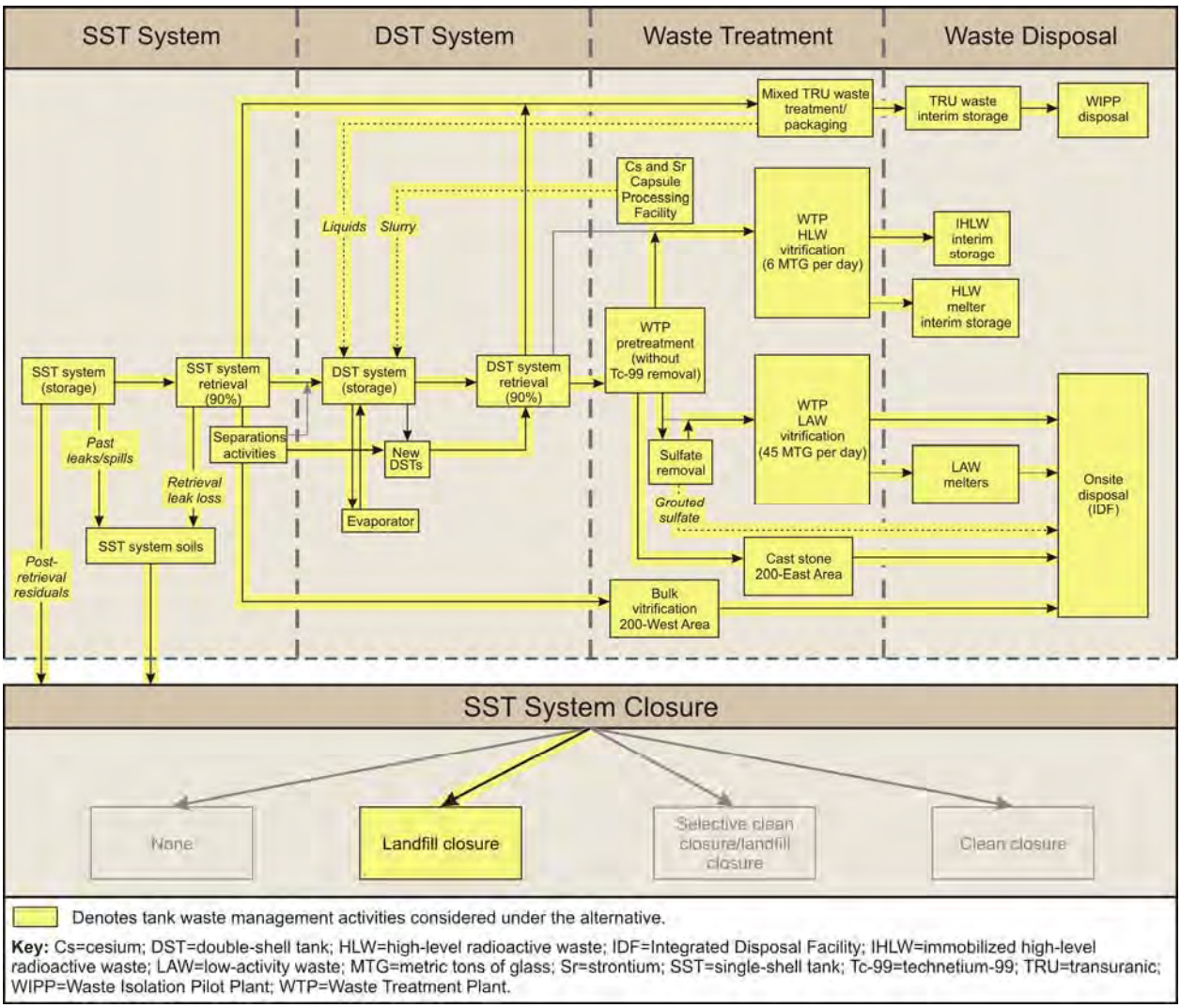


Figure 2–50. Tank Closure Alternative 5 Primary Components

mixer pumps would accomplish 90 percent retrieval of waste from the DSTs, making additional waste retrieval from those tanks unnecessary.

Treatment. An additional LAW melter would be added to the existing WTP configuration (two HLW melters and two LAW melters) to expand LAW vitrification capacity. This new WTP configuration would provide a vitrification TMC of 6 metric tons of glass IHLW per day and an expanded vitrification TMC of 45 metric tons of glass ILAW per day. All of the waste streams routed to the WTP would be pretreated, but without technetium-99 removal. However, this alternative would implement a sulfate removal technology following WTP pretreatment, which would reduce the amount of glass produced in the WTP by increasing the waste loading in the ILAW glass. Under Tank Closure Alternative 5, the WTP would produce 24,960 metric tons of glass IHLW (approximately 7,800 canisters, as well as 340 canisters from treatment of cesium and strontium capsules); 186,590 metric tons of glass ILAW (approximately 31,100 containers); and 35,700 metric tons of grouted sulfate waste (approximately 6,120 containers).

WTP capacity under Tank Closure Alternative 5 would be supplemented by construction and operation of a Cast Stone Facility in the 200-East Area and a Bulk Vitrification Facility in the 200-West Area to immobilize a portion of the LAW. Cast stone supplemental treatment would produce 100,080 metric tons of cast stone waste (approximately 5,000 containers). Bulk vitrification supplemental treatment would

produce 91,490 metric tons of glass bulk vitrification waste (approximately 2,150 containers). The waste stream feed for the 200-East Area Cast Stone Facility would be pretreated in the WTP, excluding technetium-99 removal. In the 200-West Area, the waste feed would be pretreated in a new Solid-Liquid Separations Facility. Under Tank Closure Alternative 5, cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility located adjacent to the WTP; their contents would be treated in the WTP. Both the ETF and the 242-A Evaporator would be replaced once under Tank Closure Alternative 5.

In addition, a separate portion of the tank waste (approximately 11.8 million liters [3.1 million gallons]) would be designated as mixed TRU waste. This mixed TRU waste would be treated and packaged using mobile CH-Mixed TRU Waste Facilities located in both the 200-East and 200-West Areas and a single, fixed RH-Mixed TRU Waste Facility in the 200-East Area.

Disposal. IHLW glass would be stored in the completed CSB and in up to three new IHLW Interim Storage Modules until disposition decisions are made and implemented. LAW immobilized via the WTP would be disposed of on site in an IDF, as would LAW immobilized external to the WTP through the bulk vitrification and cast stone supplemental treatment processes. Mixed TRU waste would be packaged and stored on site in a new TRU Waste Interim Storage Facility pending disposal at WIPP. The strontium sulfate precipitate would be immobilized in grout and disposed of as MLLW on site in an IDF.

Closure. As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303 and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B. The tanks would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. The closed tank system and the six sets of adjacent cribs and trenches (ditches) would be covered with an engineered Hanford barrier, followed by postclosure care for 100 years.

To support the schedule for this alternative, no contaminated soil would be removed at the BX or SX tank farm. Similarly, SST system ancillary equipment outside the boundary of the Hanford barrier would be neither remediated nor removed.

2.5.2.6 Tank Closure Alternative 6: All Waste as Vitrified HLW

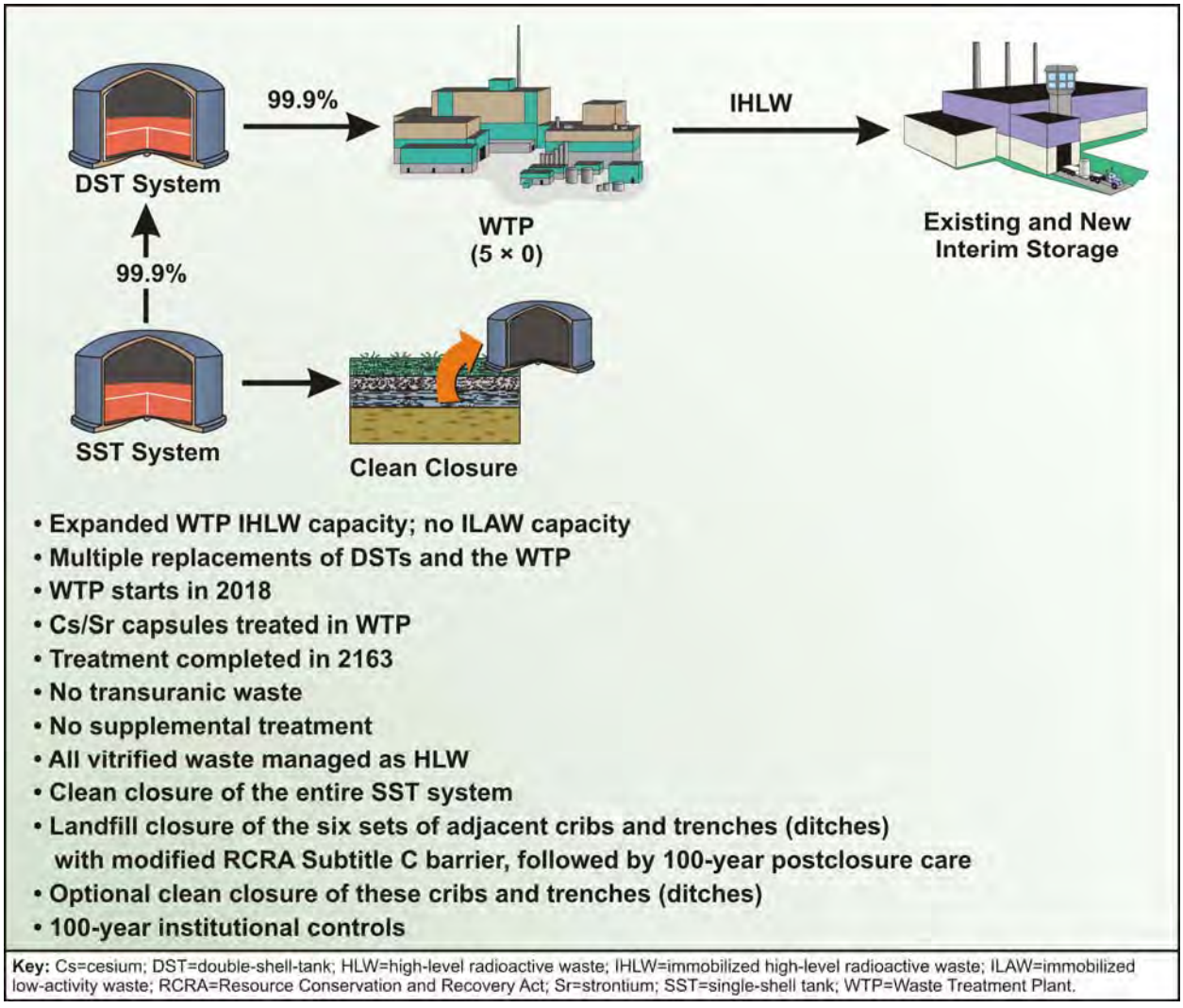
Under Tank Closure Alternative 6, all vitrified waste produced in the WTP would be managed as HLW (IHLW) under various retrieval and treatment scenarios. Three subalternatives were separately evaluated. Under Tank Closure Alternative 6A, 99.9 percent of the waste volume would be retrieved from Hanford's 200-East and 200-West Area tank farms and vitrified in the WTP using an expanded IHLW production capacity. The resulting IHLW glass would be stored in IHLW Interim Storage Modules and managed as IHLW pending further disposition. Under Tank Closure Alternative 6B, 99.9 percent of the waste volume would be retrieved from the tank farms, pretreated in the WTP, separated into HLW and LAW streams, and vitrified into IHLW and ILAW glass. Both vitrified waste streams would be stored on site and managed as IHLW pending further disposition. Under Tank Closure Alternative 6C, only 99 percent of the waste volume would be retrieved from the tank farms. Like Alternative 6B, this waste volume would be pretreated in the WTP, separated into HLW and LAW streams, and vitrified into IHLW and ILAW glass. Both vitrified waste streams would be stored on site and managed as IHLW pending further disposition. No technetium-99 removal would occur under Tank Closure Alternatives 6A, 6B, or 6C, but the contents of the cesium and strontium capsules would be treated in the WTP under all three subalternatives.

Note that a higher waste volume percentage (99.9 percent) would be retrieved from the tank farms under both Alternatives 6A and 6B than under Alternative 6C and most of the other alternatives. Removal of this higher waste volume would be accomplished by using various retrieval technologies, including an additional in-tank chemical wash process during retrieval operations.

Regarding closure of the SST system, Tank Closure Alternatives 6A and 6B would employ clean closure, and Tank Closure Alternative 6C would employ landfill closure. Landfill closure of the six sets of cribs and trenches (ditches) located adjacent to the SST system also is evaluated under all three of these subalternatives. In addition, Tank Closure Alternatives 6A and 6B each evaluate an Option Case that would employ clean closure of the six sets of adjacent cribs and trenches (ditches).

2.5.2.6.1 Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure (Base and Option Cases)

As shown in Figure 2–51, under Tank Closure Alternative 6A, 99.9 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms would be retrieved and treated using a modified WTP with expanded HLW vitrification capacity. All of the retrieved tank waste would be vitrified in the WTP to form IHLW glass. No WTP pretreatment or technetium-99 removal would occur, and no supplemental treatment technologies would be employed.



Key: Cs=cesium; DST=double-shell-tank; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; RCRA=Resource Conservation and Recovery Act; Sr=strontium; SST=single-shell tank; WTP=Waste Treatment Plant.

Figure 2–51. Tank Closure Alternative 6A Overview

Following construction and a 2018 start, WTP vitrification operations under Tank Closure Alternative 6A would extend through 2163. Institutional controls would be maintained for 100 years (through 2262) after completion of vitrification operations. The SST system would be clean-closed, meaning most tanks

and ancillary equipment would be removed and disposed of as HLW. Contaminated soil plumes would be removed (to the depth of groundwater, where necessary) from tank farms showing evidence of deep soil contamination, and the soil would be treated to support onsite disposal. Under the Base Case of Tank Closure Alternative 6A, the six sets of adjacent cribs and trenches (ditches) would undergo landfill closure (see Section 2.2.2.4.1 for a description) and be covered with an engineered modified RCRA Subtitle C barrier, followed by postclosure care for 100 years. Under the Option Case, these cribs and trenches (ditches) would be clean-closed (see Section 2.2.2.4.2). The proposed schedule for implementing Alternative 6A is presented in Figure 2–52.[11]

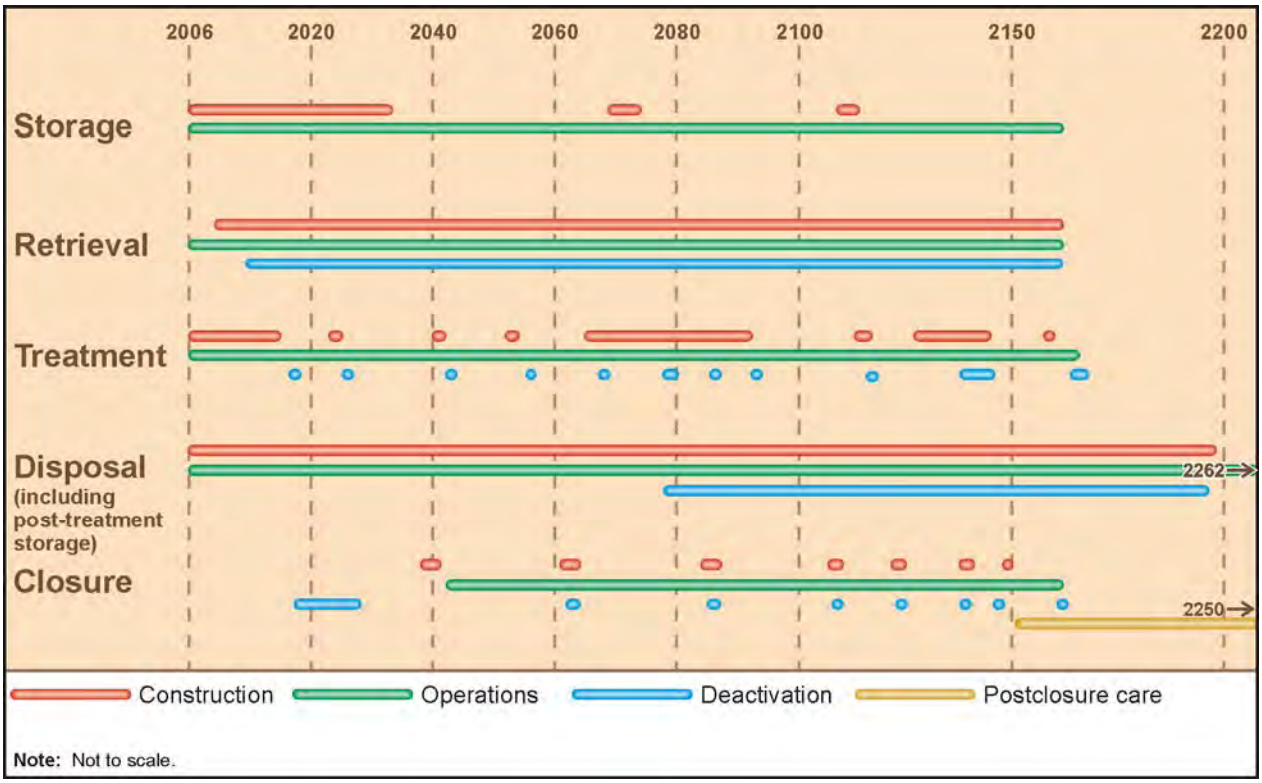


Figure 2–52. Tank Closure Alternative 6A Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–53, would occur under Tank Closure Alternative 6A.

Storage. DOE would continue its current waste management operations using existing tank storage facilities. Because retrieval operations would be spread over a 150-year period, no WRFs would be required. However, the extended timeframe associated with this alternative would exceed the 40-year design life of each of the 28 existing DSTs operating in the tank farms and require three phased replacements (beginning in 2029, 2069, and 2109), for a total of 84 new DSTs.

Retrieval. Waste would be retrieved to 99.9 percent, exceeding the TPA Milestone M-45-00 minimum goal of 99 percent (Ecology, EPA, and DOE 1989). This level of retrieval would correspond to residual tank waste of no more than 1 cubic meter (36 cubic feet) for 100-series tanks or 0.08 cubic meters (3 cubic feet) for 200-series tanks. An additional tank chemical wash process and enhanced in-tank and ex-tank leak detection systems would be used to accomplish this higher percentage of waste volume

[11] Some activities under this alternative could possibly be completed in a shorter timeframe as DOE becomes more proficient and efficient at tank retrieval, treatment, and closure operations. However, additional NEPA analyses might be required.

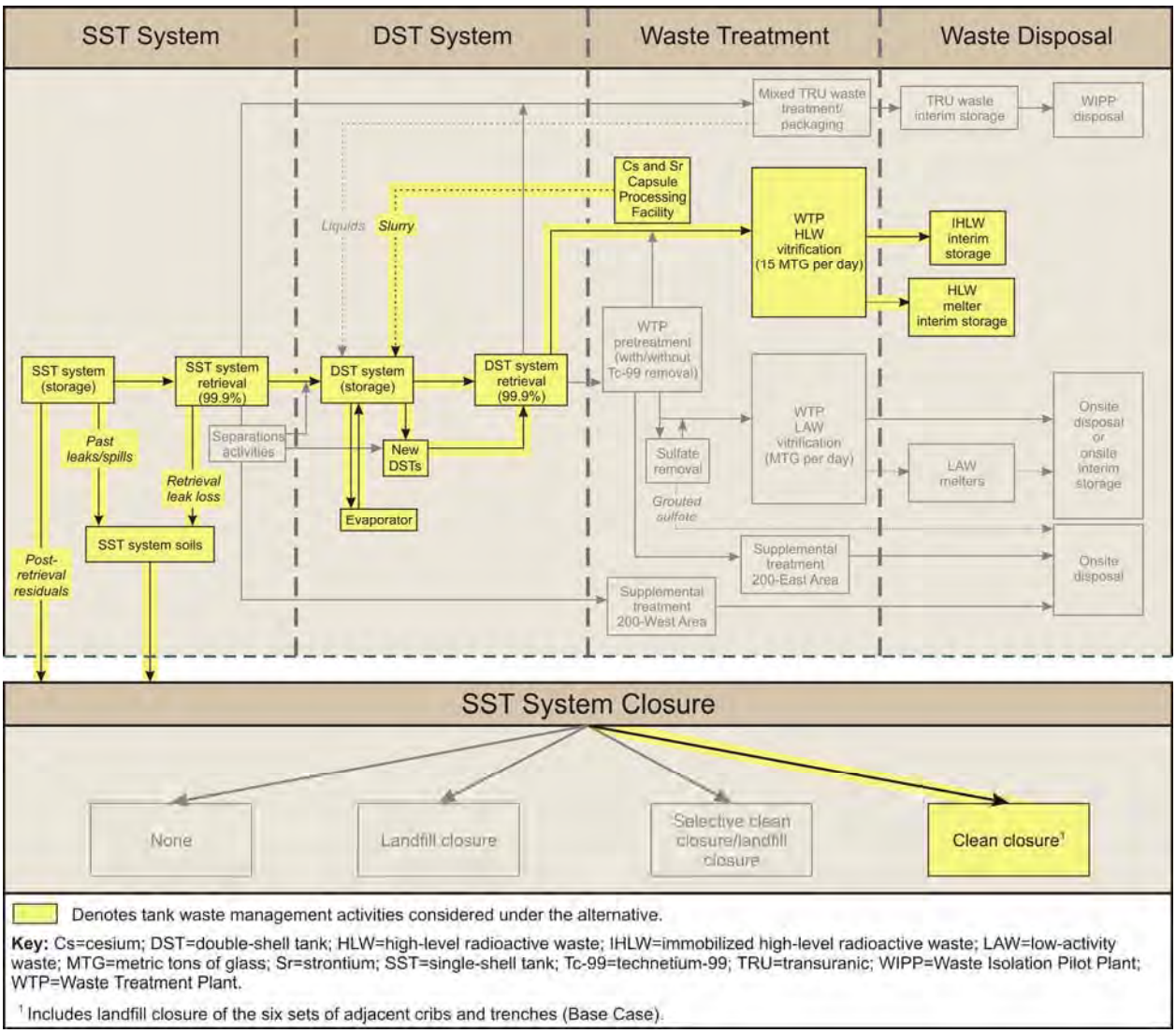


Figure 2–53. Tank Closure Alternative 6A Primary Components

retrieval. Under Tank Closure Alternative 6A, waste from approximately 245 tanks (28 existing DSTs, 84 replacement DSTs, 73 nonleaking 100-series SSTs, and 60 SSTs [100-series] that are known or suspected leakers) would be retrieved using the MRS technology, and waste from 77 tanks (61 MUSTs and 16 SSTs [200-series]) would be retrieved using the VBR technology. All 322 tanks would then undergo chemical washing to meet the 99.9 percent retrieval goal.

Treatment. WTP HLW vitrification capacity would be expanded by changing the existing melter configuration (two HLW and two LAW melters) to five HLW melters and no LAW melters. This new WTP configuration would provide a total vitrification TMC of 15 metric tons of glass IHLW per day.[12] Because none of the tank waste would be separated into a LAW component, there would be no need to produce ILAW glass. Similarly, there would be no need to pretreat any of the tank waste or employ

[12] The HLW vitrification TMC initially considered for Tank Closure Alternatives 6A and 6B was 6 metric tons of glass per day (using two melters). This capacity matched the existing HLW configuration of the WTP. However, analysis indicated that, with this throughput, operations would be required to continue for over 300 years, and facility upgrades/replacements would be required every 60 years. This was considered unreasonable, so the alternative was revised to analyze implementing a vitrification TMC of 15 metric tons of glass per day (using five melters).

supplemental treatment technologies. Under Tank Closure Alternative 6A, the WTP would produce a total of 548,260 metric tons of glass IHLW (approximately 171,330 canisters, as well as 340 canisters from treatment of cesium and strontium capsules). Due to the extended timeframe (150 years) associated with this alternative, the WTP would exceed its 60-year design life and would have to be replaced twice. The underground transfer lines that support staging of waste feed to the WTP would need to be replaced once during this timeframe. Under this alternative, the cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new facility adjacent to the WTP; their contents would be treated in the WTP. The ETF would be replaced five times and the 242-A Evaporator would be replaced six times.

Under the Base Case of Tank Closure Alternative 6A, the highly contaminated deep soil waste stream generated from PPF soil washing would be thermally treated in the PPF. Approximately 4,010 metric tons of glass waste (670 containers) would be produced. The additional clean closure of the six adjacent cribs and trenches (ditches) that would occur under the Option Case would not require extension of the PPF operation schedule. However, throughput would be increased and 109,750 metric tons of glass waste (18,290 containers) would be produced.

Disposal. IHLW glass would be stored in the completed CSB and in up to 65 new IHLW Interim Storage Modules until disposition decisions are made and implemented. Due to the extended timeframe associated with this alternative, the canister storage facilities would require two partial replacements and one full replacement as the modules exceed their 60-year design life. The HLW shielded boxes (147,000) would be stored on site in 35 HLW Debris Storage Facilities. Should these HLW Debris Storage Facilities be required beyond 60 years, facility life extension measures would be required. Such measures are beyond the scope of this *TC & WM EIS*. Contaminated deep soils would be disposed of on site. PPF-generated glass that would perform equivalent to ILAW glass would also be disposed of on site.

Closure. Tank Closure Alternative 6A includes clean closure of all 12 SST farms in the 200-East and 200-West Areas following deactivation. This alternative assumes that clean closure activities would be conducted at two tank farms simultaneously and would continue at this rate until clean closure of all the SST farms is completed. Clean closure of the tank farms would involve removing all SSTs, associated ancillary equipment, and contaminated soil to a depth of 3 meters (10 feet) below the tank base, all of which would be managed as HLW. These materials would be packaged for onsite storage in shielded boxes, resulting in approximately 0.83 million cubic meters (1.09 million cubic yards) of HLW packaged in approximately 147,000 shielded boxes. Where necessary, deep soil excavation would be conducted to remove contamination plumes within the soil column. Highly contaminated soil from deep soil excavation would be treated in the PPF to make it acceptable for onsite disposal. The liquid waste stream from PPF soil washing would be thermally treated in the PPF to produce a glass waste form (approximately 670 containers under the Base Case and 18,290 containers under the Option Case) with a long-term performance equivalent to ILAW glass. This PPF waste glass would be disposed of on site in an IDF. The washed soils would be disposed of in the RPPDF, a new facility similar to an IDF. The tank farms would then be backfilled with clean soil from onsite sources. Clean closure of the SST system would preclude the need for conducting postclosure care. Under the Base Case of Tank Closure Alternative 6A, the six sets of adjacent cribs and trenches (ditches) would undergo landfill closure and be covered with an engineered modified RCRA Subtitle C barrier, followed by postclosure care for 100 years. Under the Option Case, these cribs and trenches (ditches) would be clean-closed.

2.5.2.6.2 Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure (Base and Option Cases)

As shown in Figure 2–54, under Tank Closure Alternative 6B, 99.9 percent of the waste volume from the Hanford 200-East and 200-West Area tank farms would be retrieved and separated into two waste streams

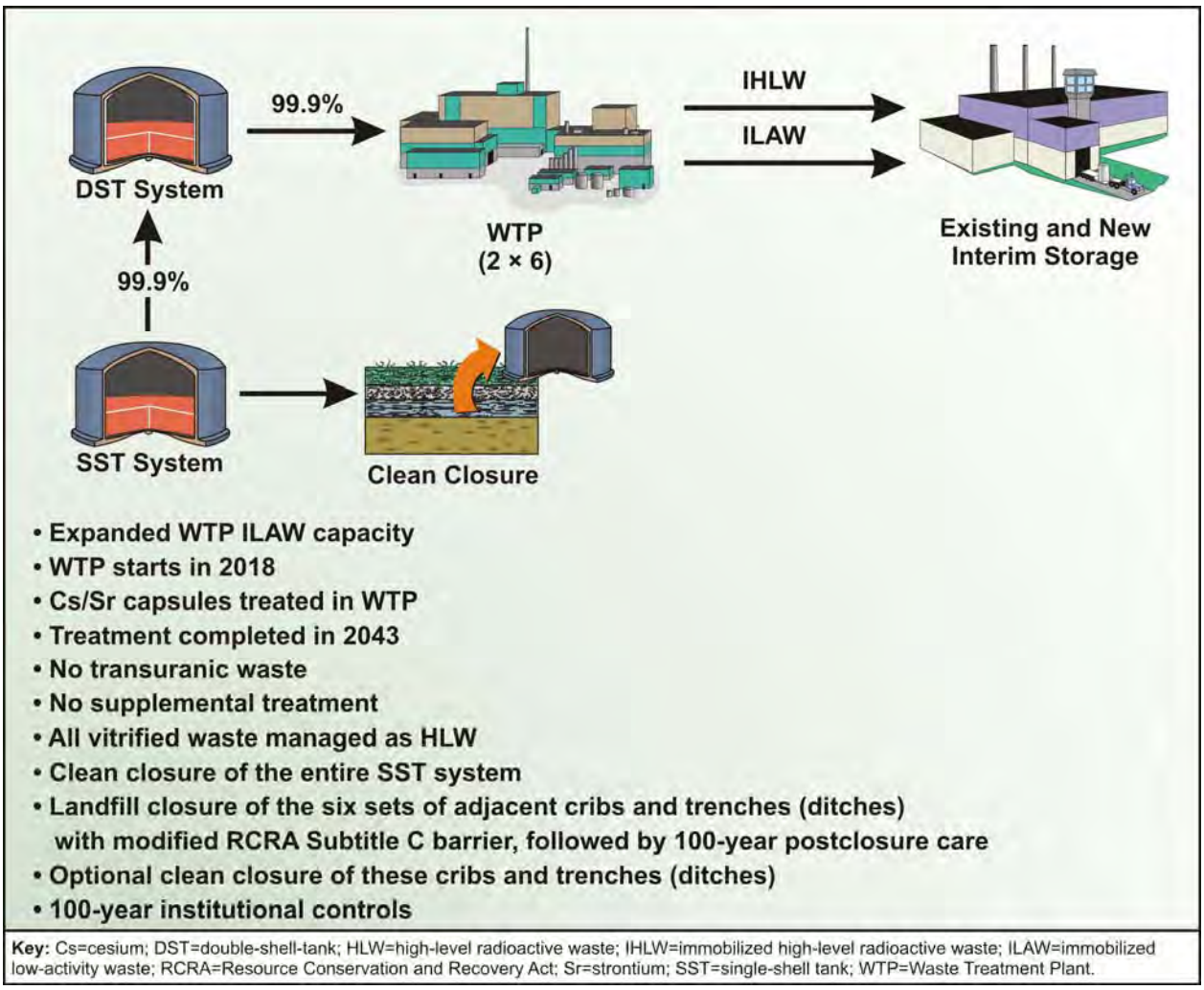


Figure 2–54. Tank Closure Alternative 6B Overview

during WTP pretreatment: (1) an HLW stream that would be vitrified to form IHLW glass and (2) a LAW stream that would be vitrified to form ILAW glass. All vitrified waste (IHLW and ILAW) would be managed as HLW and stored on site until disposition decisions are made and implemented. Technetium-99 would not be removed during WTP treatment, and no supplemental treatment technologies would be employed. Like Alternative 6A, Alternative 6B would employ clean closure of the SST system.

Following construction and a 2018 start, WTP vitrification operations under Tank Closure Alternative 6B would extend through 2043 (HLW processing would be completed in 2040, and ILAW processing would be completed in 2043). Institutional controls would be maintained for 100 years following completion of PPF operations in 2099. No separate tank mixed TRU waste treatment capability would be provided under this alternative. The SST system would be clean-closed, which would include removing all tanks, ancillary equipment, and soils within 3 meters (10 feet) of the bottom of the tanks. Highly contaminated deep soils or rubble would be removed and washed in the PPF to help meet closure standards, and the tank farms would be backfilled with clean fill. Clean closure of the tank farms would preclude the need for postclosure care. Under the Base Case of Tank Closure Alternative 6B, the six sets of adjacent cribs and trenches (ditches) would undergo landfill closure (see Section 2.2.2.4.1 for a description) and be covered with an engineered modified RCRA Subtitle C barrier, followed by postclosure care for 100 years. Under the Option Case, these cribs and trenches (ditches) would be clean-closed (see Section 2.2.2.4.2). The proposed schedule for implementing Alternative 6B is presented in Figure 2–55.

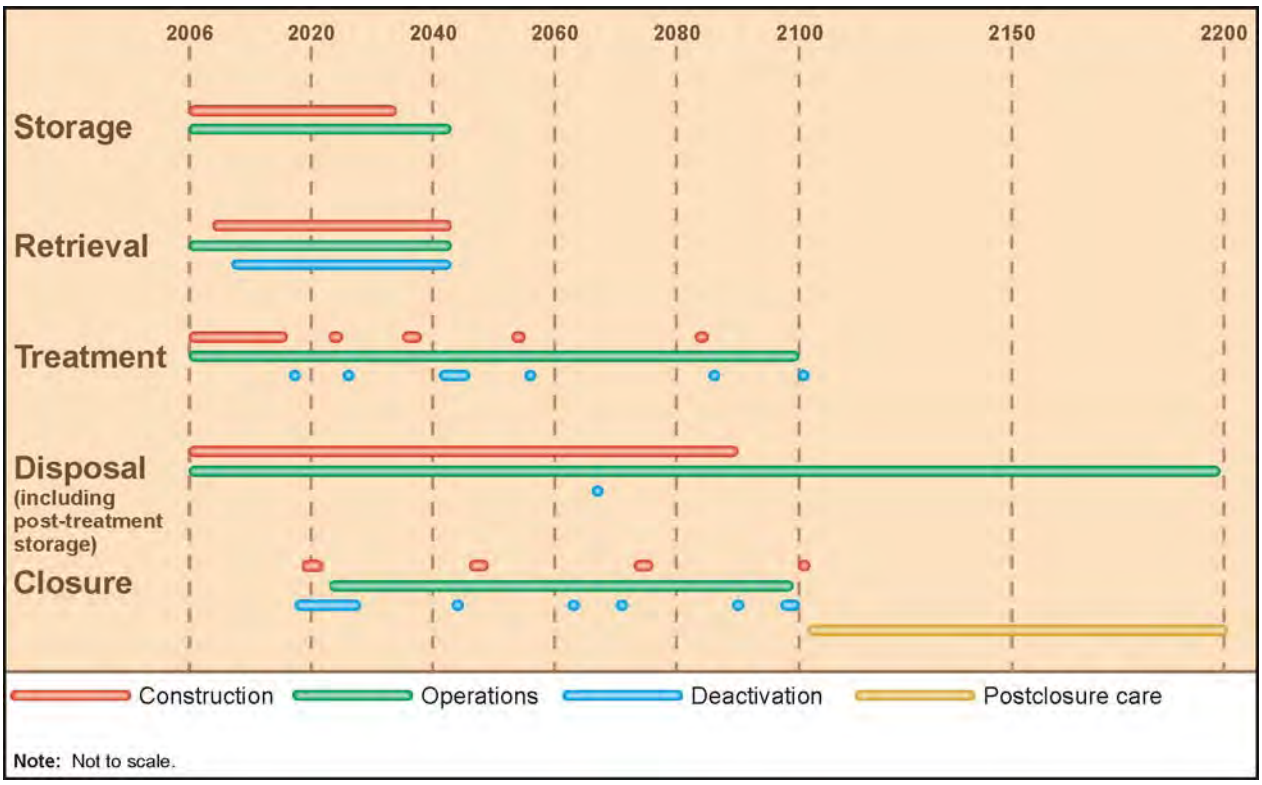


Figure 2–55. Tank Closure Alternative 6B Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–56, would occur under Tank Closure Alternative 6B.

Storage. DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. Each WRF would contain three 568,000-liter (150,000-gallon) tanks.

Retrieval. Waste would be retrieved to 99.9 percent, exceeding the TPA Milestone M-45-00 minimum goal of 99 percent (Ecology, EPA, and DOE 1989). This level of retrieval would correspond to residual tank waste of no more than 1 cubic meter (36 cubic feet) for 100-series tanks or 0.08 cubic meters (3 cubic feet) for 200-series tanks. This higher percentage of waste volume retrieval would be accomplished by using an additional tank chemical wash process and enhanced in-tank and ex-tank leak detection systems. Under Tank Closure Alternative 6B, waste from approximately 161 tanks (28 existing DSTs, 73 nonleaking 100-series SSTs, and 60 SSTs [100-series] that are known or suspected leakers) would be retrieved using the MRS technology, and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology. All 250 tanks would then undergo chemical washing to meet the 99.9 percent retrieval goal.

Treatment. The existing WTP configuration (two HLW melters and two LAW melters) would be supplemented by the addition of four new LAW melters to expand LAW vitrification capacity. This new WTP configuration would provide a vitrification TMC of 6 metric tons of glass IHLW per day and an expanded vitrification TMC of 90 metric tons of glass ILAW per day. All waste streams routed to the WTP would be pretreated, but technetium-99 would not be removed from the LAW stream. Under Tank Closure Alternative 6B, the WTP would produce 38,400 metric tons of glass IHLW (approximately 12,000 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and

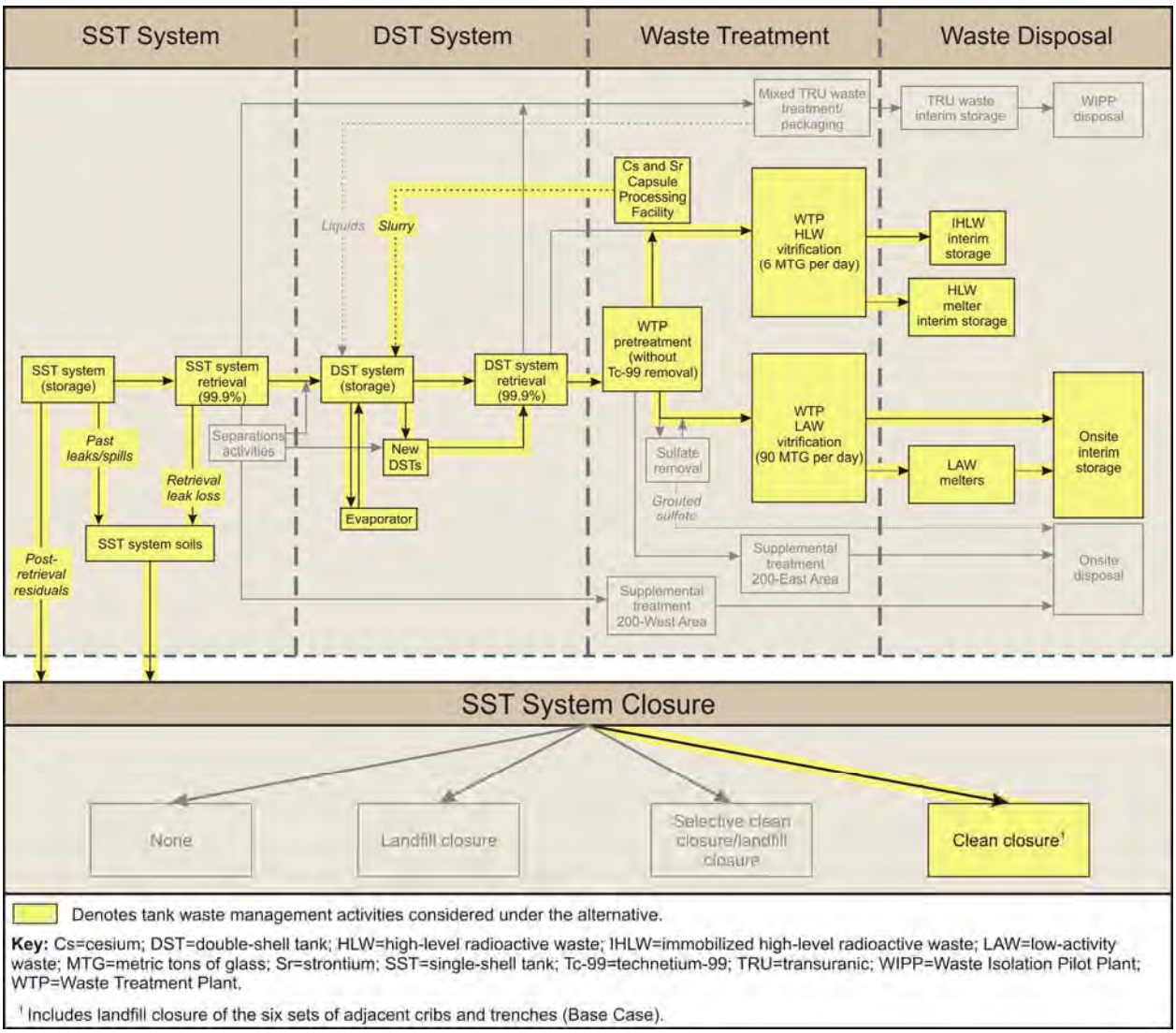


Figure 2–56. Tank Closure Alternative 6B Primary Components

557,990 metric tons of glass ILAW (approximately 93,000 containers). The cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility adjacent to the WTP; their contents would be treated in the WTP. The ETF would be replaced twice and the 242-A Evaporator would be replaced once.

Under the Tank Closure Alternative 6B Base Case, the highly contaminated deep soil waste stream generated from PPF soil washing would be thermally treated in the PPF. Approximately 4,010 metric tons of glass waste (670 containers) would be produced. The additional clean closure of the six adjacent cribs and trenches (ditches) that would occur under the Option Case would not require extension of the PPF operation schedule. However, throughput would be increased and 109,750 metric tons of glass waste (18,290 containers) would be produced.

Disposal. IHLW glass would be stored in the existing CSB and in four additional IHLW Interim Storage Modules until disposition decisions are made and implemented. ILAW glass would be managed as HLW and stored on site in 46 new ILAW Interim Storage Facilities. Should these IHLW or ILAW Interim Storage Facilities be required beyond 60 years, facility life extension measures that are beyond the scope of this *TC & WM EIS* would be considered. Approximately 147,000 HLW shielded boxes would be

stored on site in 35 other new HLW Debris Storage Facilities. Should these HLW Debris Storage Facilities be required beyond 60 years, facility life extension measures that are beyond the scope of this *TC & WM EIS* would be required. Contaminated deep soils would be disposed of on site. PPF-generated glass that would perform equivalent to ILAW glass would also be disposed of on site.

Closure. Under Tank Closure Alternative 6B, all 12 SST farms in the 200-East and 200-West Areas would be clean-closed following deactivation. This alternative assumes that clean closure activities would be conducted at four tank farms simultaneously and would continue at this rate until clean closure of the SST farms is completed. Clean closure of the tank farms would involve removal of all SSTs, associated ancillary equipment, and contaminated soil to a depth of 3 meters (10 feet) below the tank base, all of which would be dispositioned as HLW. These materials would be packaged for long-term onsite storage in shielded boxes, resulting in approximately 0.83 million cubic meters (1.09 million cubic yards) of HLW packaged in approximately 147,000 shielded boxes. Where necessary, deep soil excavation would be conducted to remove contamination plumes within the soil column. Highly contaminated soil from deep soil excavation would be treated in the PPF to make it acceptable for onsite disposal. The liquid waste stream from the PPF soil washing would be thermally treated in the PPF to produce a glass waste form (approximately 670 containers in the Base Case and 18,290 containers in the Option Case) with a long-term performance equivalent to ILAW glass. This PPF glass would be disposed of on site in an IDF. The washed soils would be disposed of in the RPPDF, a new disposal facility similar to an IDF. The tank farms would then be backfilled with clean soil from onsite sources. Clean closure of these tank farms would preclude the need for postclosure care. Under the Base Case of Tank Closure Alternative 6B, the six sets of adjacent cribs and trenches (ditches) would undergo landfill closure and be covered with an engineered modified RCRA Subtitle C barrier, followed by postclosure care for 100 years. Under the Option Case, these cribs and trenches (ditches) would be clean-closed.

2.5.2.6.3 Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

Under Tank Closure Alternative 6C, 99 percent of the waste volume would be retrieved from the Hanford 200-East and 200-West Area tank farms and separated into two waste streams during WTP pretreatment: (1) an HLW stream that would be vitrified to form IHLW glass and (2) a LAW stream that would be vitrified to form ILAW glass. The ILAW glass would be managed as HLW and stored on site. Technetium-99 would not be removed from the LAW stream during WTP pretreatment, and no supplemental treatment technologies would be employed. As shown in Figure 2–57, Alternative 6C would employ landfill closure of the SST system and the six sets of adjacent cribs and trenches (ditches).

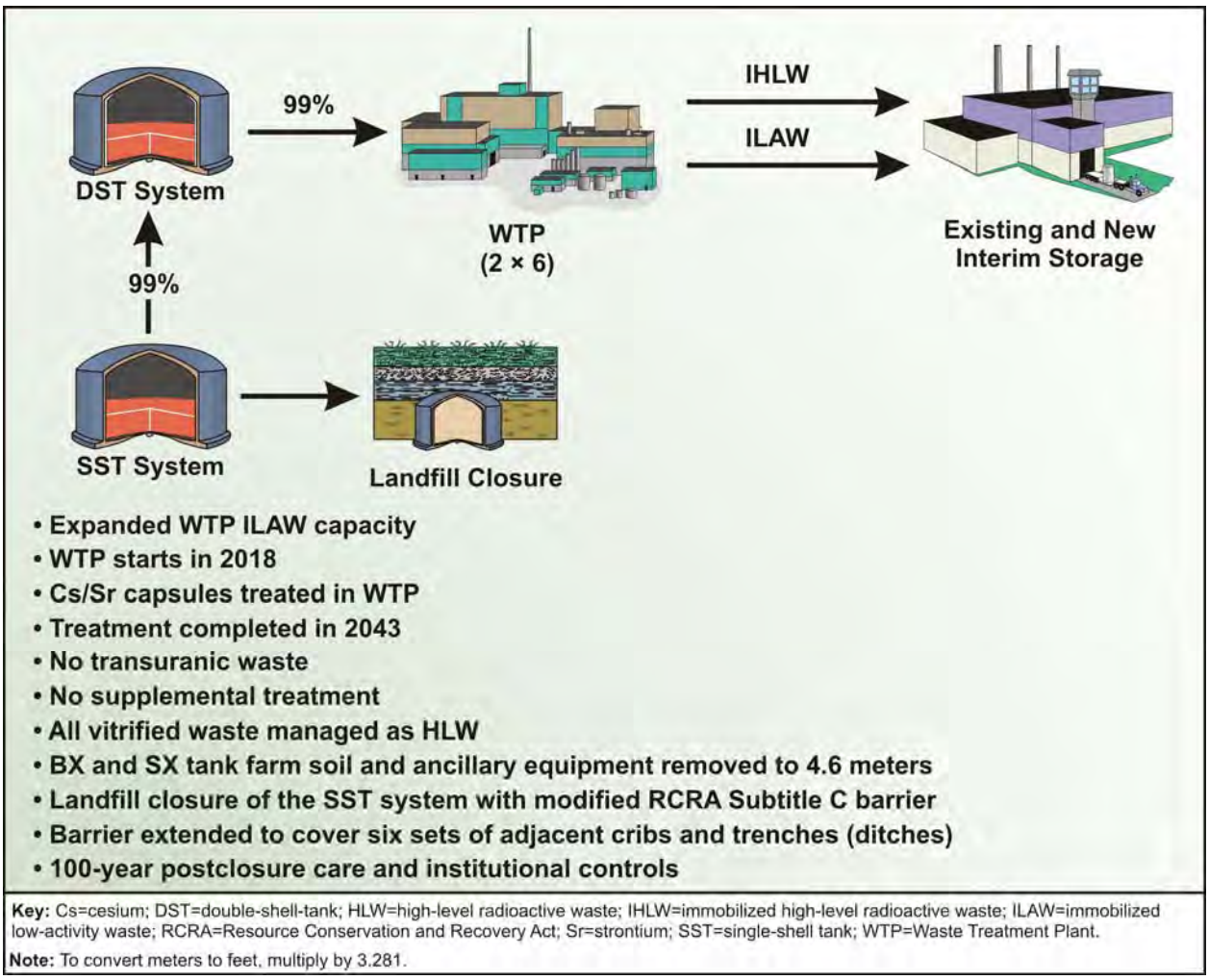


Figure 2–57. Tank Closure Alternative 6C Overview

Following construction and a 2018 start, WTP vitrification operations under Tank Closure Alternative 6C would extend through 2043. No separate tank mixed TRU waste treatment capability would be provided under this alternative. Alternative 6C also includes landfill closure of the SST farms, including completion of a modified RCRA Subtitle C barrier over these areas and the six adjacent cribs and trenches (ditches) by 2045, followed by postclosure care for 100 years (through 2145). The proposed schedule for implementing Alternative 6C is presented in Figure 2–58.

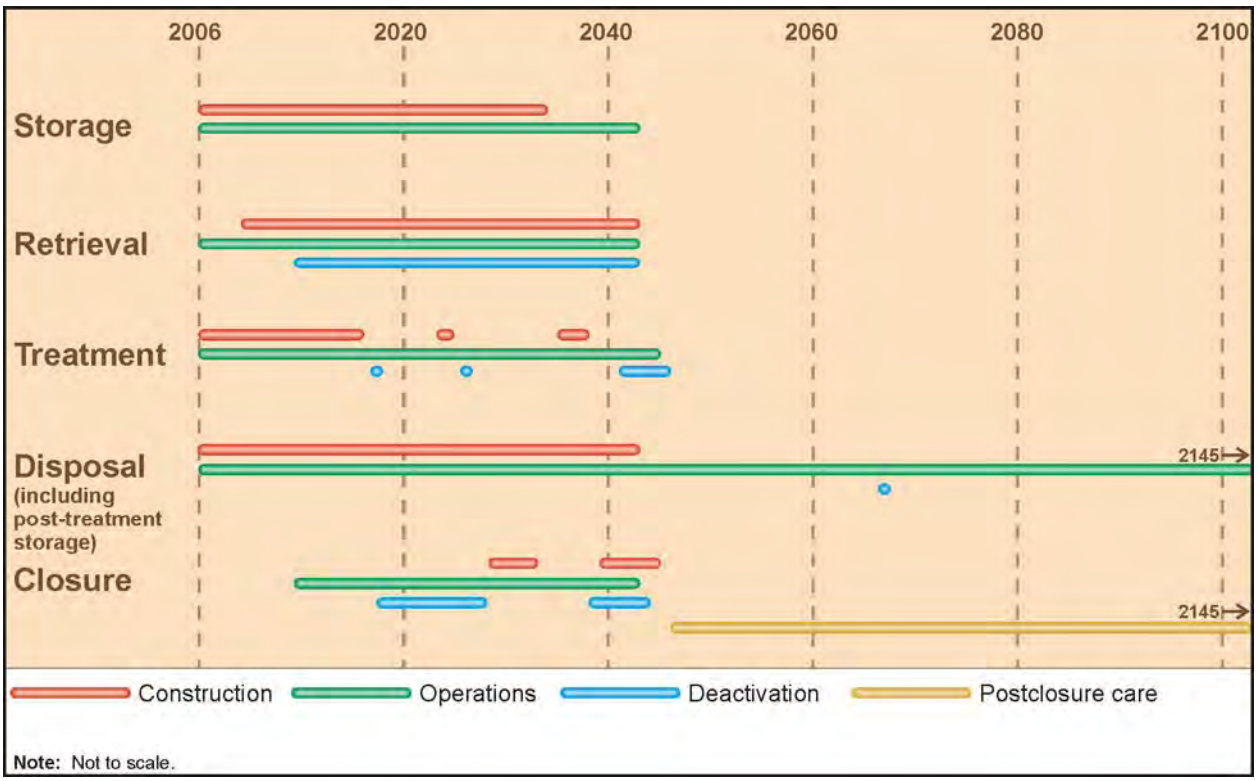


Figure 2–58. Tank Closure Alternative 6C Proposed Schedule

The following storage, retrieval, treatment, disposal, and closure actions, as depicted in Figure 2–59, would occur under Tank Closure Alternative 6C.

Storage. DOE would continue current waste management operations using existing tank storage facilities. No new DSTs would be required, but four new WRFs would be constructed. Each WRF would contain three 568,000-liter (150,000-gallon) tanks.

Retrieval. Waste would be retrieved to the TPA Milestone M-45-00 minimum goal (Ecology, EPA, and DOE 1989), i.e., residual waste would not exceed 10.2 cubic meters (360 cubic feet) for 100-series tanks or 0.85 cubic meters (30 cubic feet) for 200-series tanks, corresponding to 99 percent retrieval using currently available liquid-based waste retrieval and leak detection systems. Under Alternative 6C, waste from approximately 101 tanks (28 DSTs and 73 nonleaking, 100-series SSTs) would be retrieved using the modified sluicing technology; waste from approximately 60 SSTs (100-series SSTs that are known or suspected leakers) would be retrieved using the MRS technology; and waste from 89 tanks (61 MUSTs, 16 SSTs [200-series], and 12 WRF tanks) would be retrieved using the VBR technology.

Treatment. LAW vitrification capacity would be expanded by adding four new LAW melters to the existing WTP configuration (two HLW melters and two LAW melters). This new WTP configuration would provide a vitrification TMC of 6 metric tons of glass IHLW per day and an expanded vitrification TMC of 90 metric tons of glass ILAW per day. All waste streams routed to the WTP would be pretreated, but technetium-99 would not be removed from the LAW stream. Under Tank Closure Alternative 6C, the WTP would produce a total of 38,400 metric tons of glass IHLW (approximately 12,000 canisters, as well as 340 canisters from treatment of cesium and strontium capsules) and 553,510 metric tons of glass ILAW (approximately 92,250 containers). The cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in a new Cesium and Strontium Capsule Processing Facility adjacent to the WTP; their contents would be treated in the WTP. Both the ETF and the 242-A Evaporator would be replaced once.

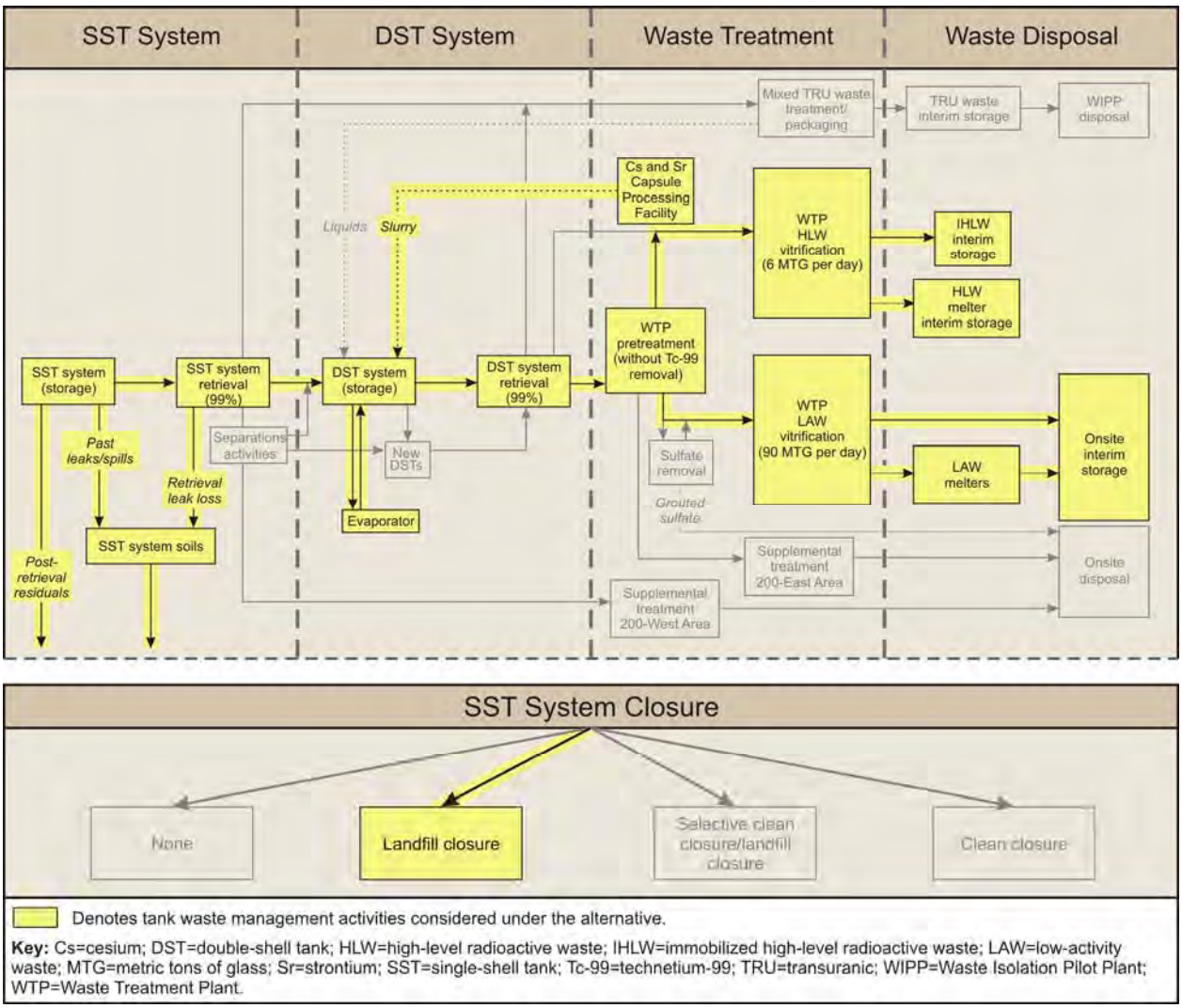


Figure 2–59. Tank Closure Alternative 6C Primary Components

Disposal. IHLW glass would be stored in the completed CSB and in four additional IHLW Interim Storage Modules until disposition decisions are made and implemented. ILAW glass would be managed as HLW and stored on site in 46 new ILAW Interim Storage Facilities. Should these IHLW or ILAW Interim Storage Facilities be required beyond 60 years, facility life extension measures that are beyond the scope of this *TC & WM EIS* would be considered.

Closure. Tank Closure Alternative 6C assumes that residual tank waste and contaminated facilities would be managed and closed as non-HLW. As operations are completed, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC 173-303 and DOE Order 435.1, as applicable, or decommissioned under DOE Order 430.1B. The tanks would be filled with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Contaminated soil would be removed down to 4.6 meters (15 feet) for the BX and SX tank farms and replaced with clean soils from onsite sources. The 4.6-meter (15-foot) depth would allow removal of all of the ancillary equipment prior to closure. Contaminated soil and ancillary equipment would be disposed of on site in the RPPDF, a new facility similar to an IDF. The closed tank system and the six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier, followed by postclosure care for 100 years. SST system ancillary equipment outside the

boundary of the modified RCRA Subtitle C barrier would be remediated or removed to meet landfill closure requirements.

2.5.3 FFTF Decommissioning Alternatives

The FFTF Decommissioning alternatives are described in detail in this section. A summary of these alternatives by mission components is provided in Table 2–3.

Table 2–3. FFTF Decommissioning Alternatives – Summary by Mission Component

Mission Component	Range of Action	Alternative		
		1	2	3
Facility disposition	Reactor vessel, piping systems, and tanks left in place under inert gas blanket	X		
	Dismantlement of RCB and adjacent support buildings		X	X
	Removal of reactor vessel, internal piping and equipment, and attached depleted-uranium shield			X
	Onsite disposal of reactor vessel, internal piping and equipment, and attached depleted-uranium shield			X
	Removal and onsite disposal of radioactive or chemical waste	X	X	X
	Ancillary facility areas backfilled and revegetated		X	
	Property Protected Area backfilled and revegetated			X
	RCRA Subtitle C barrier over RCB		X	
	Administrative controls for 100 years	X		
	Postclosure care and/or institutional controls for 100 years		X	X
Disposition of remote-handled special components	Onsite removal and storage per FONSI	X	X	X
	Treatment at the Hanford Site		X	X
	Treatment at Idaho National Laboratory		X	X
	Onsite disposal		X	X
	Offsite disposal		X	X
Disposition of bulk sodium	Onsite storage	X	X	X
	Onsite conversion to a caustic sodium hydroxide solution		X	X
	Offsite conversion to a caustic sodium hydroxide solution		X	X
	Caustic shipped to the Waste Treatment Plant for use in processing tank waste		X	X

Key: FFTF=Fast Flux Test Facility; FONSI=Finding of No Significant Impact; RCB=Reactor Containment Building; RCRA=Resource Conservation and Recovery Act.

2.5.3.1 FFTF Decommissioning Alternative 1: No Action

As shown in Figure 2–60, the FFTF Decommissioning No Action Alternative would complete ongoing activities that are consistent with previous DOE NEPA decisions. Final decommissioning of FFTF would not occur. Deactivation activities for the FFTF complex and support buildings, as described in the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006), would be conducted through 2016. Deactivation activities would include removal and packaging of the four RH-SCs (the sodium cold trap, cesium trap, and two sodium vapor traps), followed by storage in the

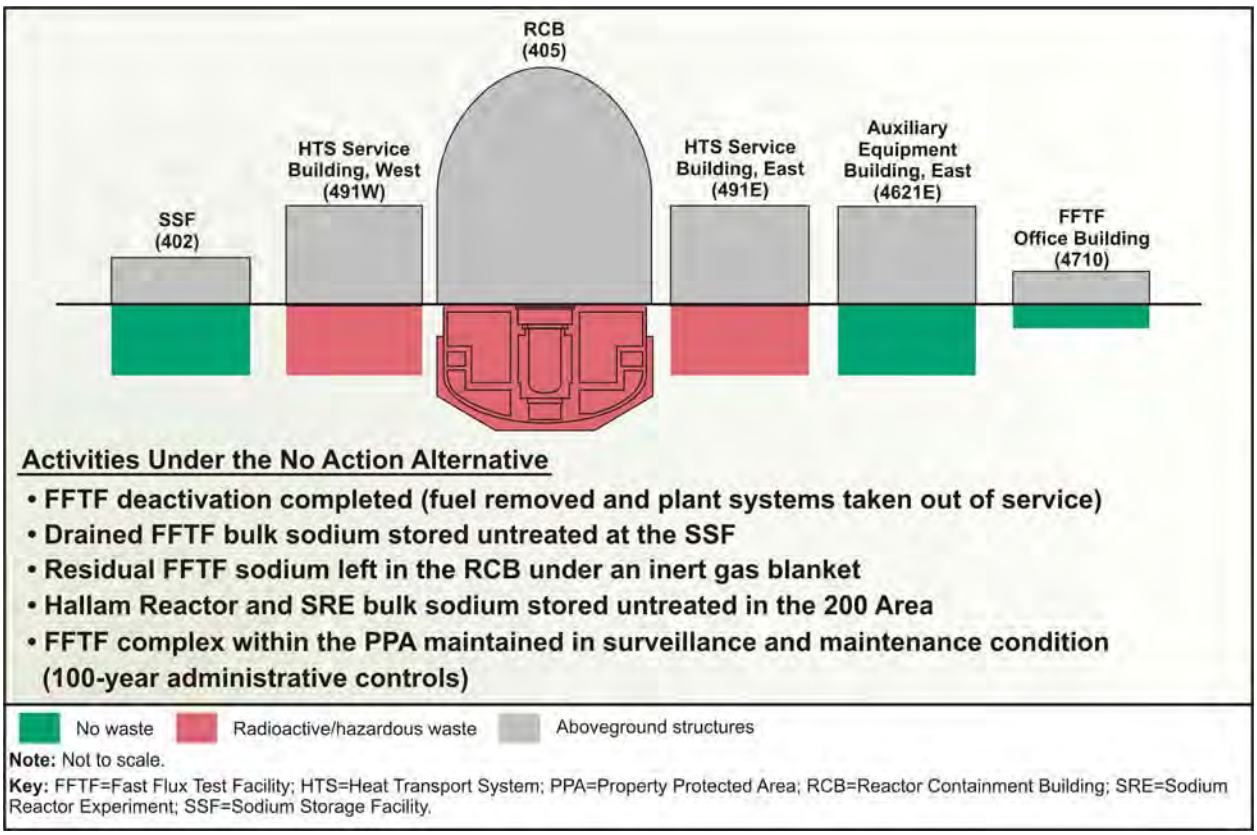


Figure 2–60. FFTF Decommissioning Alternative 1 Overview

400 Area, as described in the Finding of No Significant Impact (FONSI) dated March 31, 2006 (DOE 2006:Appendix B).

The FFTF RCB (Building 405), along with the rest of the buildings within the 400 Area PPA, would be maintained through 2107 (100 years following the ROD for this EIS) under administrative controls (site security and management). After 2107, administrative controls would cease and the remaining waste was assumed to become available for release to the environment. The reactor vessel, piping systems, and tanks would be left in place under an inert gas blanket. SNF would have been removed, and systems not associated with maintaining safety-related functions would be deactivated or de-energized and isolated according to the deactivation plans. Other radioactive or chemical waste and materials would have been removed under the deactivation activities. Small amounts of waste generated during the surveillance and monitoring activities would be disposed of in an IDF. The proposed schedule for implementing the FFTF Decommissioning No Action Alternative is presented in Figure 2–61.

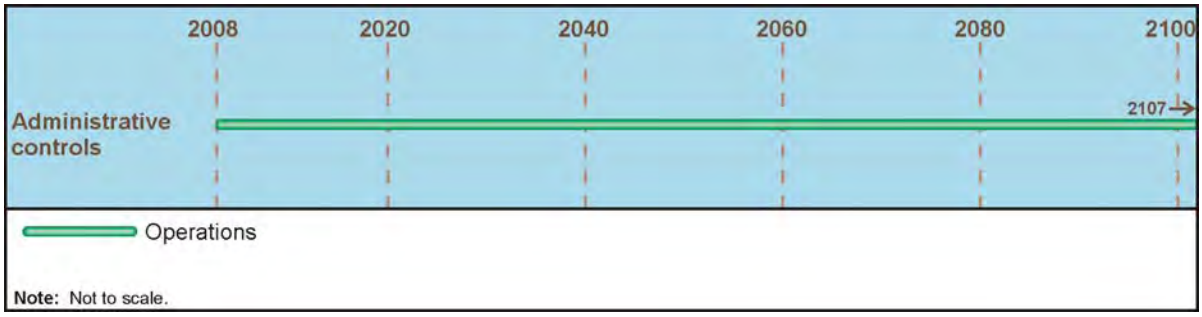


Figure 2–61. FFTF Decommissioning Alternative 1 Proposed Schedule

FFTF bulk sodium (approximately 980,000 liters [260,000 gallons]) removed from reactor systems during deactivation activities would be stored as a solid in tanks in the SSF in the 400 Area. The small amount of sodium potassium alloy would be blended with the contents of the bulk sodium storage containers. After 2107, administrative controls would cease and the FFTF bulk sodium was assumed to become available for release to the environment. Similarly, the Hallam and SRE sodium stored in the 200-West Area would remain there and was likewise assumed to become available for release into the environment after 2107 when administrative controls would cease. Figure 2–62 illustrates the primary components of the FFTF Decommissioning No Action Alternative.

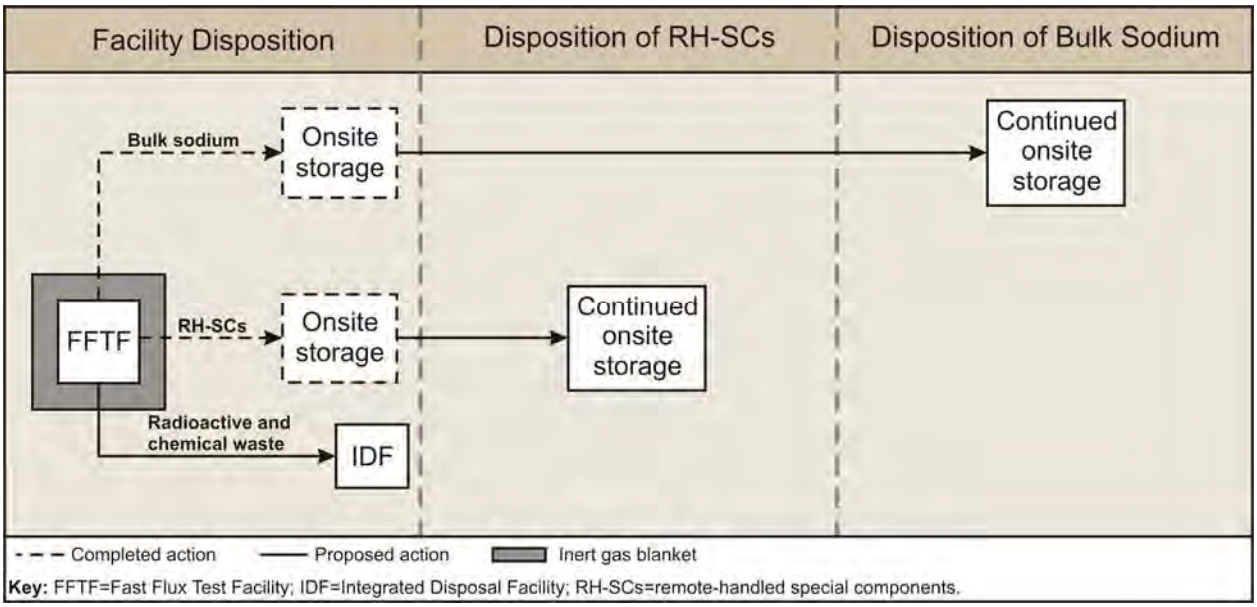


Figure 2–62. FFTF Decommissioning Alternative 1 Primary Components

2.5.3.2 FFTF Decommissioning Alternative 2: Entombment

As shown in Figure 2–63, under FFTF Decommissioning Alternative 2, all of the above-grade (168 meters [550 feet] above mean sea level) structures that are part of the main FFTF reactor building and two adjacent support facilities would be dismantled. Demolition waste would be consolidated in below-grade spaces and stabilized with grout. Small-diameter piping and any sodium residuals would be removed or treated in place. RH-SCs would be removed and treated at either Hanford or INL, and then be disposed of in a Hanford IDF or at NTS, depending on the treatment option selected. Completion of decommissioning activities is projected in 2020. Under FFTF Decommissioning Alternative 2, the FFTF site would be regraded and revegetated. A modified RCRA Subtitle C barrier would be constructed over the filled area (projected to be complete in 2021), followed by postclosure care for 100 years (through 2121).

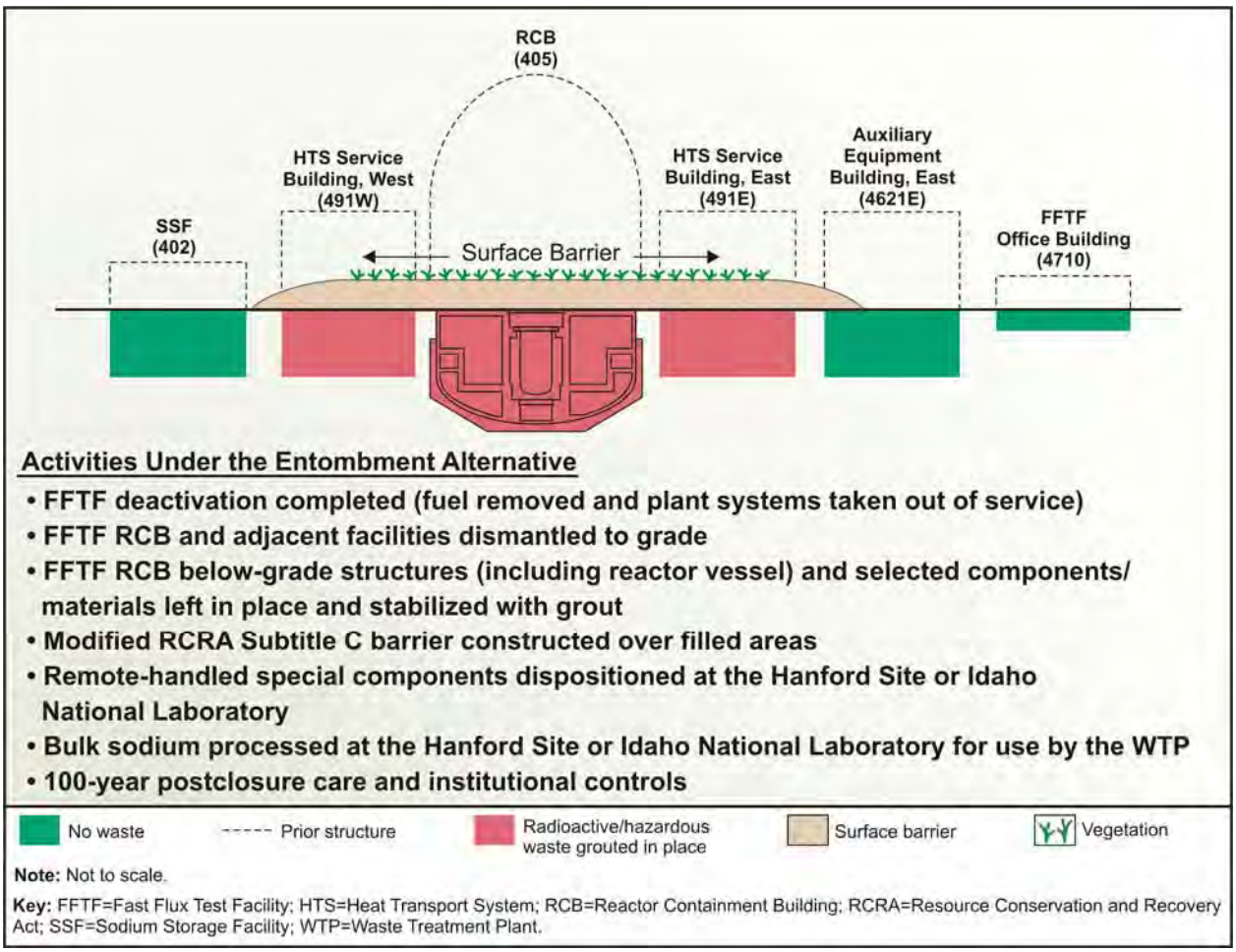


Figure 2–63. FFTF Decommissioning Alternative 2 Overview

Under FFTF Decommissioning Alternative 2, Hanford's bulk sodium inventory would be converted to a caustic sodium hydroxide solution for reuse at Hanford. This inventory includes approximately 980,000 liters (260,000 gallons) from FFTF, 128,700 liters (34,000 gallons) from the Hallam Reactor, and 26,500 liters (7,000 gallons) from the SRE. Options for converting the sodium include using an existing RTP at the MFC at INL, with completion scheduled in 2016, or using a new RTP proposed for construction at Hanford, with completion scheduled in 2018. The proposed schedule for implementing FFTF Decommissioning Alternative 2 is presented in Figure 2–64.

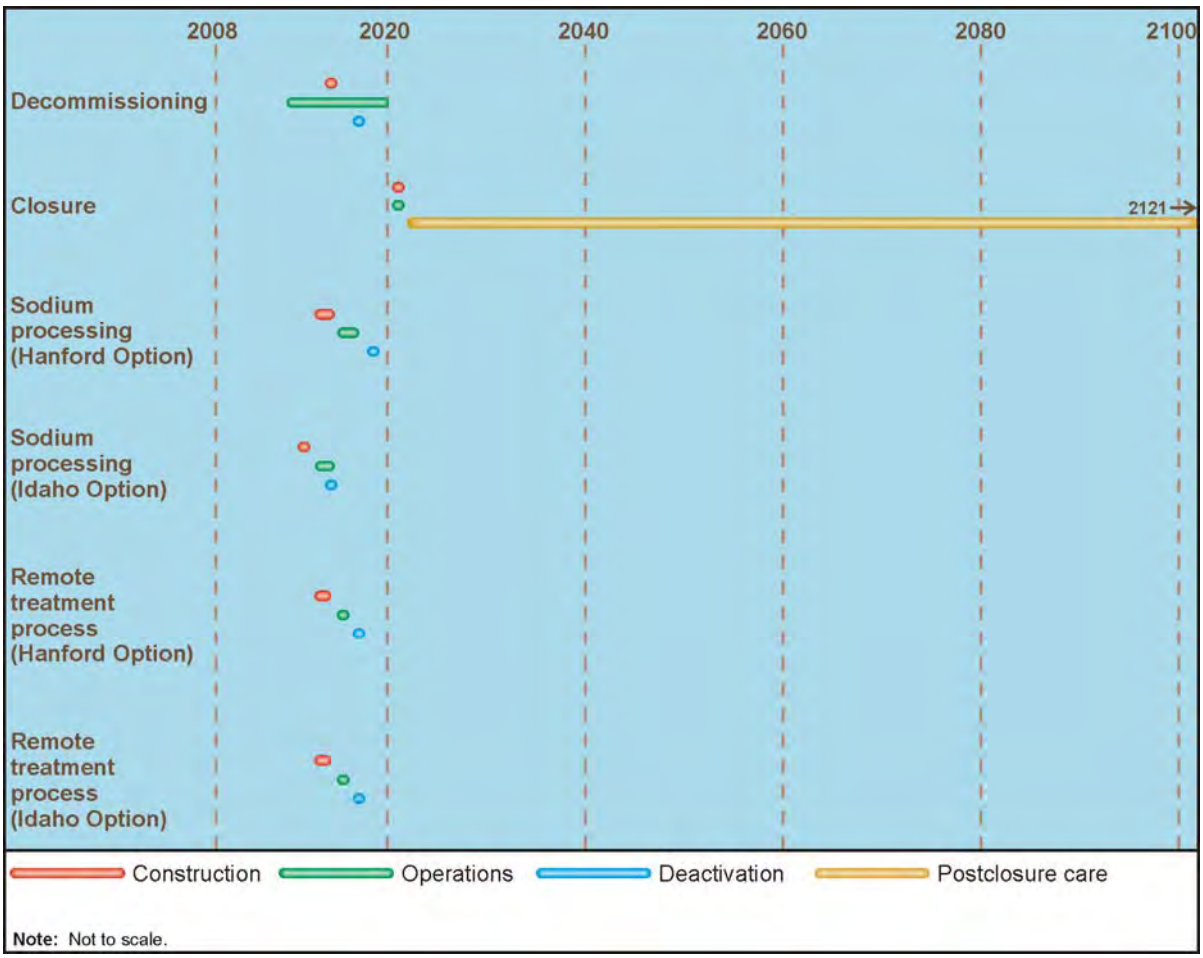


Figure 2–64. FFTF Decommissioning Alternative 2 Proposed Schedule

The following activities associated with facility disposition, disposition of RH-SCs, and disposition of bulk sodium, as depicted in Figure 2–65, would occur under FFTF Decommissioning Alternative 2.

Facility disposition. All of the aboveground structures of the RCB and the two immediately adjacent support facilities (Buildings 491E and 491W) would be dismantled. Minimal removal of below-grade structures, equipment, and materials would occur to comply with regulatory standards. The RCB would be demolished and removed to grade, and auxiliary facilities would be removed to 0.91 meters (3 feet) below grade. Equipment, piping, and components containing hazardous and radioactive materials would be removed from below-grade structures only as necessary for treatment to meet regulatory requirements. Any other necessary treatment of equipment or components would occur in place (without removing them from the facilities). Some of the components removed for treatment could be returned to below-grade spaces and be grouted in place with the remaining structures and equipment to stabilize them and minimize void space. Contaminated demolition debris would be disposed of in an IDF. A modified RCRA Subtitle C barrier would be constructed over the RCB and any other remaining below-grade structures (including the reactor vessel) that contain residual radioactive and treated hazardous materials. The area previously occupied by the ancillary facilities would be backfilled, compacted, contoured, and revegetated. Equipment to be removed under this alternative would include RH-SCs, which contain sufficient quantities of metallic sodium and radionuclides to prevent their treatment and entombment in the RCB with the remaining materials.

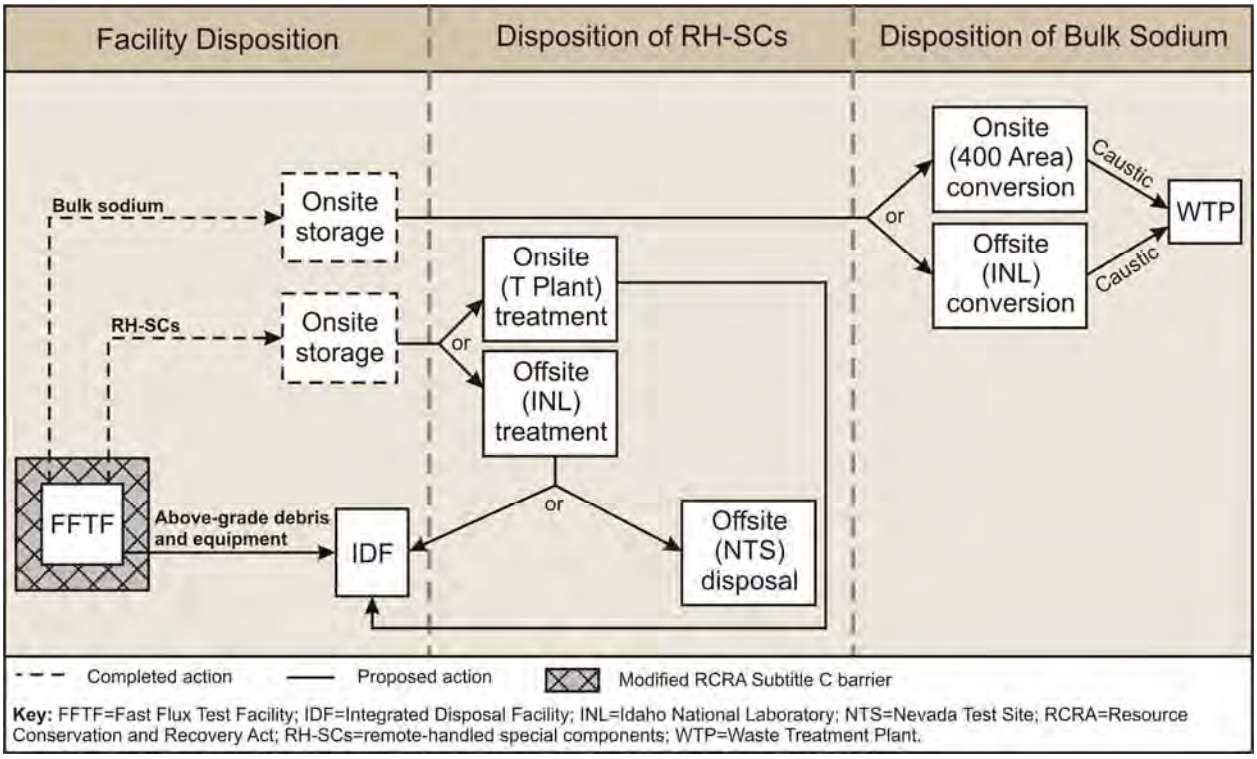


Figure 2–65. FFTF Decommissioning Alternative 2 Primary Components

Disposition of remote-handled special components. RH-SCs, including the primary sodium cold trap, a cesium trap, and two sodium vapor traps, would be removed, treated, and disposed of in an IDF. Removal and storage of these four RH-SCs in the SSF in the 400 Area are covered in the FONSI dated March 31, 2006 (DOE 2006:Appendix B). These RH-SCs would be treated either in a large hot cell such as the RTP planned for construction at the MFC at INL or in a similar RTP proposed for construction at Hanford's T Plant in the 200-West Area. These two options are described below.

- **Hanford Option.** The RH-SCs would be stored in the Hanford 400 Area pending construction of the proposed RTP at Hanford's T Plant. After construction is complete, the RH-SCs would be shipped to the new RTP via truck. Following treatment, the RH-SCs and sodium residuals would be disposed of in an IDF.

- **Idaho Option.** The RH-SCs would be stored in the Hanford 400 Area pending construction of the planned RTP at INL. When this RTP is complete, the RH-SCs would be shipped to INL via truck and/or rail. Construction of the INL RTP is planned to treat RH components that contain comparable levels of radiological materials as well as metallic sodium. An environmental assessment is being prepared at INL to evaluate this proposed treatment (DOE 2008). Following treatment at this RTP, the FFTF RH-SCs and sodium residuals would be either disposed of with other INL waste at NTS or returned to Hanford for disposal in an IDF.

Disposition of bulk sodium. Hanford's radioactively contaminated bulk sodium inventory consists of approximately 1.1 million liters (300,000 gallons) of metallic sodium, including sodium from the Hallam Reactor and the SRE, as well as sodium drained from the FFTF cooling systems during deactivation. The Hallam and SRE sodium are currently stored in solid form in the Hanford 200-West Area's 2727-W Building and the CWC, respectively. FFTF sodium from the FFTF is stored in liquid form in the 400 Area within the RCB or adjacent storage facilities. The bulk sodium would be converted to a caustic sodium hydroxide solution for product reuse in processing tank waste at the WTP, or for supporting

Hanford tank corrosion controls. Two options are being considered for managing Hanford's bulk sodium inventory, as follows:

- **Hanford Reuse Option.** The bulk sodium inventory would be stored in its current locations until it is shipped to the proposed 400 Area SRF for processing. Following processing, the resulting caustic sodium hydroxide solution would be transferred to the WTP in the 200-East Area.

- **Idaho Reuse Option.** The bulk sodium would be stored in its current locations until it is shipped via truck and/or rail to INL for processing. The Hallam sodium would be transported from the 200-West Area to the 400 Area, where it would be transferred into shipping tanks at the SSF before being transported to INL. The capability to process bulk metallic sodium currently exists at INL's SPF, which was previously used to process metallic sodium from EBR-II and other facilities. Following processing, the caustic sodium hydroxide solution would be returned to Hanford.

2.5.3.3 FFTF Decommissioning Alternative 3: Removal

As shown in Figure 2–66, under FFTF Decommissioning Alternative 3, all above-grade structures around the main RCB and the two adjacent support facilities would be dismantled. The RCB would be demolished to grade and the support facilities to 0.91 meters (3 feet) below grade. Contaminated demolition waste would be disposed of in an IDF. The reactor vessel, its internal piping and equipment, and its attached depleted-uranium shielding would be filled with grout, removed, packed, and disposed of in an IDF. All other radioactively contaminated equipment and hazardous materials, including asbestos and lead shielding, also would be removed for disposal.

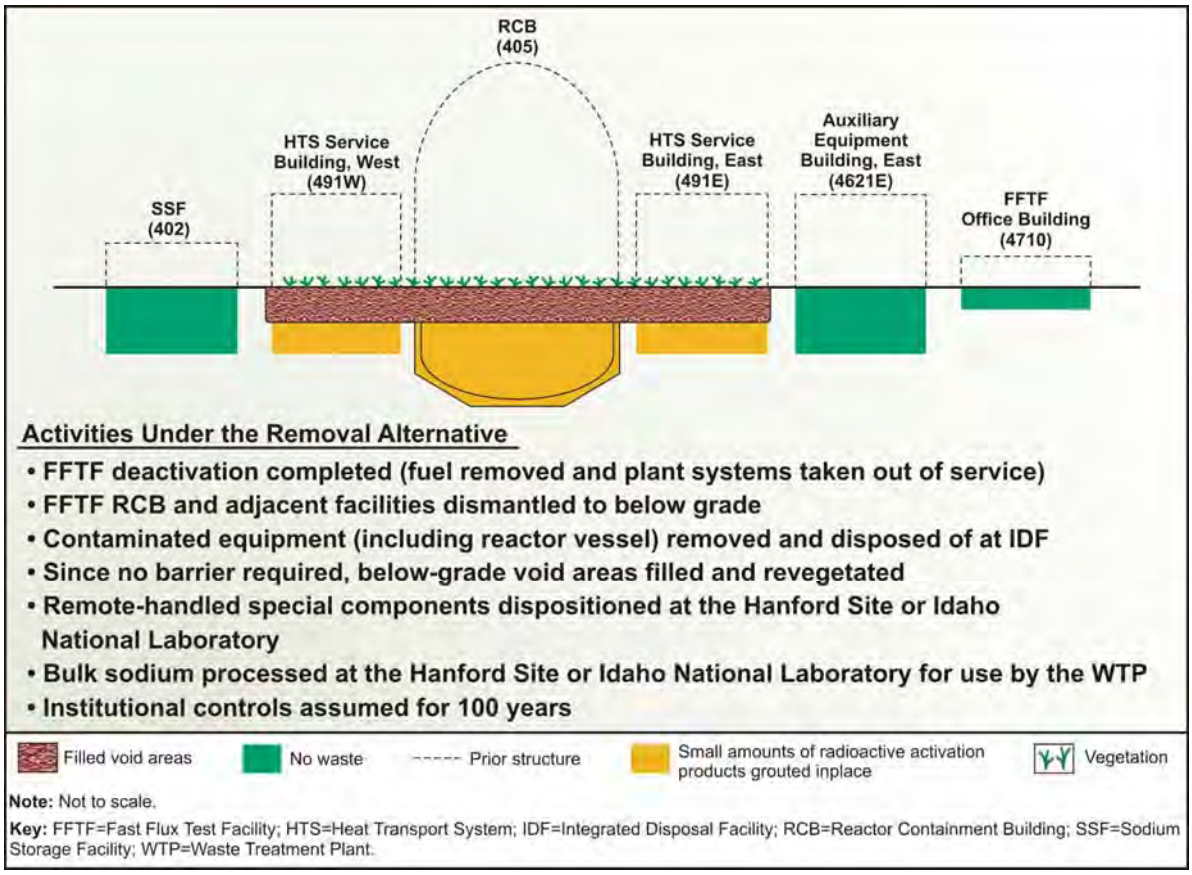


Figure 2–66. FFTF Decommissioning Alternative 3 Overview

In addition, all small-diameter piping would be removed, treated in the 400 Area to remove sodium residuals, and disposed of on site in an IDF. Similar to FFTF Decommissioning Alternative 2, the RH-SCs would be removed and treated at either Hanford or INL and be disposed of in an IDF at Hanford or at NTS, depending on the treatment option. The remaining lower portion of the RCB concrete shell would be backfilled with either soil or grout to minimize void space. Decommissioning activities are projected to be complete in 2020. Under FFTF Decommissioning Alternative 3, the FFTF site would be regraded and revegetated in 2021, with no barrier required. Institutional controls, which potentially could include postclosure care, may be established and continue for 100 years (through 2121) after revegetation of the area is complete.

Under FFTF Decommissioning Alternative 3, Hanford's bulk sodium inventory would be converted to a caustic sodium hydroxide solution for use in the WTP. As under FFTF Decommissioning Alternative 2, options for converting the sodium include modifying the SPF at INL (construction scheduled for completion in 2014) or using the SRF proposed for construction at Hanford (construction scheduled for completion in 2016). The proposed schedule for implementing FFTF Decommissioning Alternative 3 is presented in Figure 2–67.



Figure 2–67. FFTF Decommissioning Alternative 3 Proposed Schedule

The following activities associated with facility disposition, disposition of RH-SCs, and disposition of bulk sodium, as depicted in Figure 2–68, would occur under FFTF Decommissioning Alternative 3.

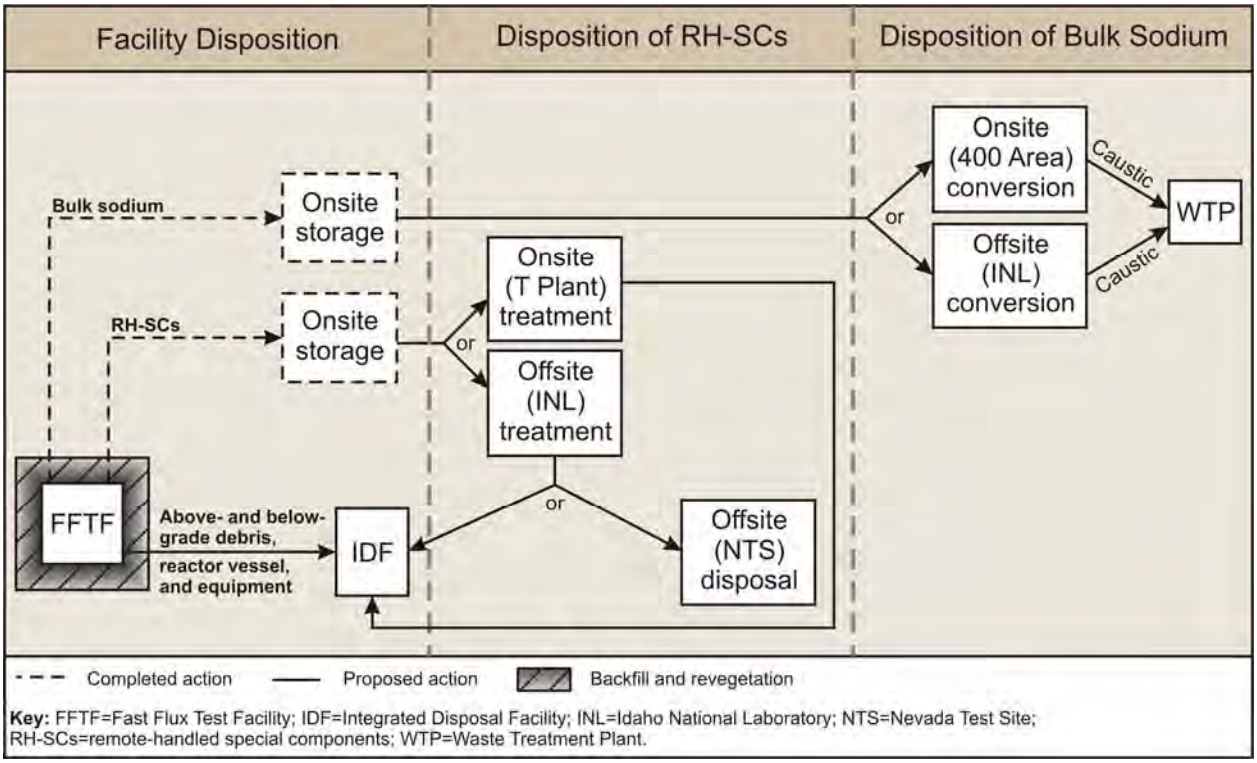


Figure 2–68. FFTF Decommissioning Alternative 3 Primary Components

Facility disposition. All of the aboveground structures of the RCB and the two adjacent support facilities (Buildings 491E and 491W) would be dismantled. The reactor vessel, as well as any internal piping and equipment and attached depleted-uranium shielding, would be filled with grout, removed, packaged, and disposed of in an IDF. All other radioactively contaminated equipment and hazardous materials down to 0.91 meters (3 feet) below grade, including asbestos and lead shielding and contaminated demolition debris, would also be removed and disposed of in an IDF. The remaining structures and equipment, consisting mainly of the external RCB structure and associated components, as well as uncontaminated below-grade portions of the auxiliary facilities, would be backfilled or grouted to minimize void space. The PPA would be backfilled to grade, contoured, and revegetated as necessary to stabilize the ground surface or to prepare the site for future industrial use. Institutional controls would be maintained for 100 years after revegetation is complete.

Disposition of remote-handled special components. The two options considered under FFTF Decommissioning Alternative 2 are also considered under FFTF Decommissioning Alternative 3. The RH-SCs would be removed, treated, and disposed of in an IDF. Removal and storage of the four RH-SCs in the SSF in the 400 Area are covered in the FONSI dated March 31, 2006 (DOE 2006:Appendix B). These RH-SCs would be treated either in a large hot cell such as the RTP planned for construction at the MFC at INL or in a similar RTP proposed for construction at Hanford's T Plant in the 200-West Area. These two options are described below.

- **Hanford Option.** The RH-SCs would be stored in the Hanford 400 Area pending construction of the proposed RTP at Hanford's T Plant. After construction is complete, the RH-SCs would be shipped to the new RTP via truck. Following treatment, the RH-SCs and sodium residuals would be disposed of in an IDF.

- **Idaho Option.** The RH-SCs would be stored in the Hanford 400 Area pending construction of the planned RTP at INL. When this RTP is complete, the RH-SCs would be shipped to INL via

truck and/or rail. Construction of the INL RTP is planned to treat EBR-II components that contain comparable levels of radiological materials as well as metallic sodium. Following treatment at this RTP, the FFTF RH-SCs and sodium residuals would be either disposed of with other INL waste at NTS or returned to Hanford for disposal in an IDF.

Disposition of bulk sodium. The two options considered for disposition of radioactively contaminated bulk sodium under FFTF Decommissioning Alternative 2 are also considered under FFTF Decommissioning Alternative 3. Hanford's bulk sodium inventory would be converted to a caustic sodium hydroxide solution for product reuse in processing tank waste at the WTP or for supporting Hanford tank corrosion controls. The two options being considered for managing Hanford's bulk sodium inventory are as follows:

- **Hanford Reuse Option.** The bulk sodium inventory would be stored in its current locations until it can be shipped to the proposed 400 Area SRF for processing. Following processing, the caustic sodium hydroxide solution would be transferred to the WTP in the 200-East Area.

- **Idaho Reuse Option.** The bulk sodium would be stored in its current locations until it can be shipped via truck and/or rail to INL for processing in the SPF. The Hallam sodium would be transported from the 200-West Area to the 400 Area, where it would be transferred into shipping tanks at the SSF before being transported to INL. The capability to process bulk metallic sodium currently exists at INL's SPF, which was previously used to process metallic sodium from the EBR-II and other facilities. Following processing, the caustic sodium hydroxide solution would be returned to Hanford.

2.5.4 Waste Management Alternatives

The Waste Management alternatives are described in detail in this section. A summary of these alternatives by mission components is provided in Table 2–4.

Table 2–4. Waste Management Alternatives – Summary by Mission Component

Mission Component	Range of Action	Alternative		
		1	2	3
Storage	Existing storage at CWC for LLW, MLLW, and TRU waste	X		
	Expanded storage at CWC for LLW, MLLW, and TRU waste		X	X
	Existing storage of onsite-generated LLW, MLLW, and TRU waste on site at WRAP and T Plant	X		
	Expanded storage of onsite-generated LLW, MLLW, and TRU waste on site at WRAP and T Plant		X	X
Treatment	Existing CWC treatment (LLW, MLLW, and TRU waste)	X		
	Expanded CWC treatment (LLW, MLLW, and TRU waste)		X	X
	Existing WRAP and T Plant treatment (LLW, MLLW, and TRU waste)	X		
	Expanded WRAP and T Plant treatment (LLW, MLLW, and TRU waste)		X	X

Table 2–4. Waste Management Alternatives – Summary by Mission Component *(continued)*

Mission Component	Range of Action	Alternative		
		1	2	3
Disposal	Continued onsite disposal of onsite-generated non-CERCLA, nontank LLW and MLLW in LLBG 218-W-5 trenches 31 and 34	X	X	X
	200-East Area IDF construction terminated and facility deactivated	X		
	Disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW at 200-East Area IDF		X	
	Disposal of tank waste only at 200-East Area IDF and onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW at 200-West Area IDF			X
	Disposal of rubble, ancillary equipment, and soils (not highly contaminated) from closure activities in RPPDF		X	X
Closure	None	X		
	Landfill closure of IDF(s) and RPPDF		X	X
	Administrative control for 100 years	X		
	Postclosure care for 100 years		X	X

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; CWC=Central Waste Complex; FFTF=Fast Flux Test Facility; IDF=Integrated Disposal Facility; LLBG=low-level radioactive waste burial ground; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WRAP=Waste Receiving and Processing Facility.

2.5.4.1 Waste Management Alternative 1: No Action

The scope of the Waste Management No Action Alternative is based on the requirements of the TPA (Ecology, EPA, and DOE 1989); the Memorandum of Understanding between DOE and Ecology (dated January 6, 2006) (DOE and Ecology 2006); and the ROD (69 FR 39449; June 30, 2004) for the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington (HSW EIS)* (DOE 2004b). As shown in Figure 2–69, the Waste Management No Action Alternative includes continued storage of LLW, MLLW, and TRU waste at the CWC (Building 2403-WD) in the 200-West Area, with no expanded storage capacity required. At the CWC, the LLW and MLLW would be processed for disposal in LLBG 218-W-5, trenches 31 and 34. These trenches are the only lined trenches in the LLBGs and would receive onsite-generated non-CERCLA, nontank LLW and MLLW until this waste stream is no longer generated (until 2035).[13] TRU waste would be shipped to and disposed of in WIPP. The proposed schedule for implementing Waste Management Alternative 1 is presented in Figure 2–70.

Onsite-generated LLW, MLLW, and TRU waste would continue to be stored and treated at WRAP and the T Plant complex. No offsite shipments of LLW, MLLW, or TRU waste would be received except as allowed as part of the Settlement Agreement among DOE, the Washington State Department of Ecology

[13] Retrieval, treatment, storage, and packaging of retrievably stored radioactive waste buried before 1970 was not analyzed as a discrete component of the *TC & WM EIS* Waste Management alternatives; however, this waste was addressed in the cumulative impacts analyses. Shipment of TRU waste to WIPP was analyzed in the *WIPP SEIS-II* (DOE 1997b).

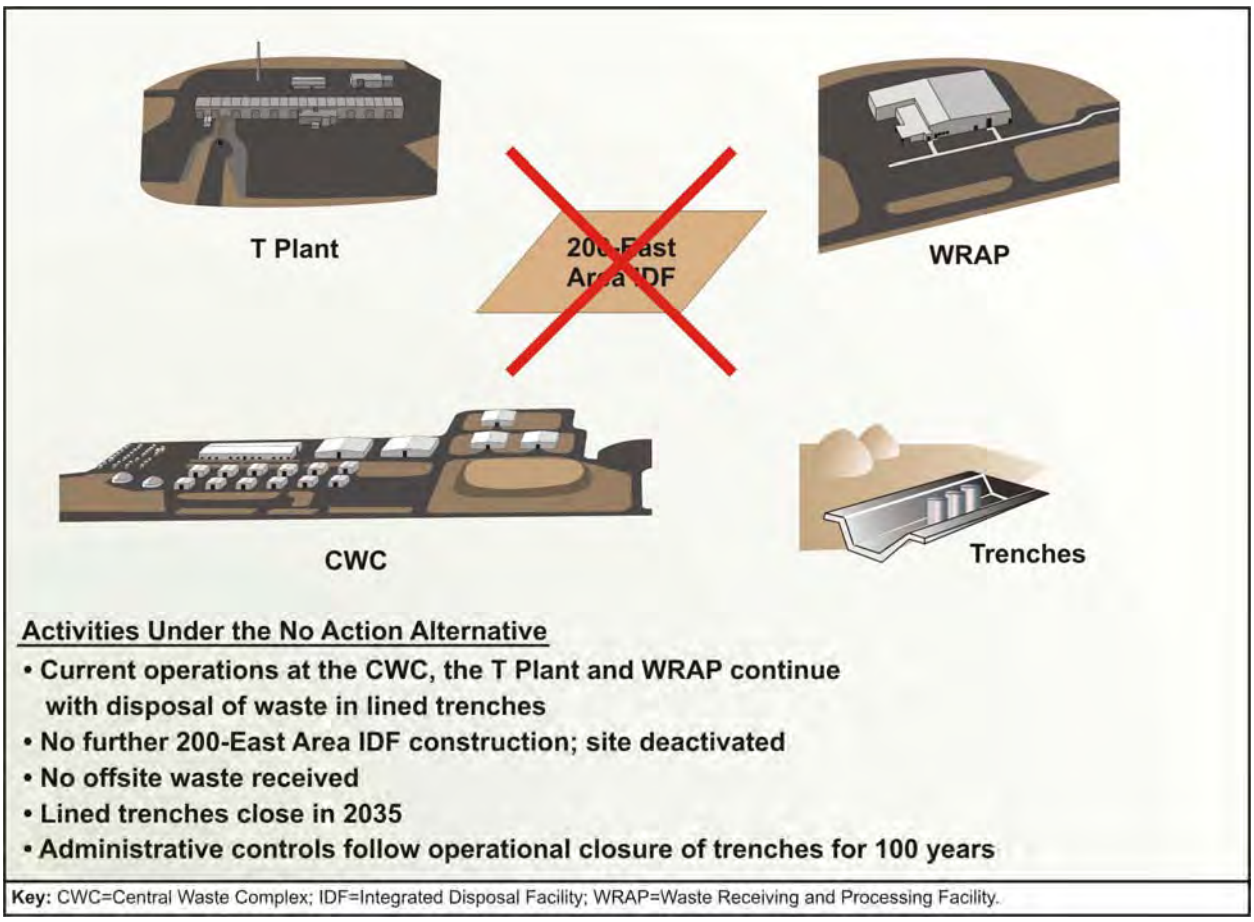


Figure 2–69. Waste Management Alternative 1 Overview

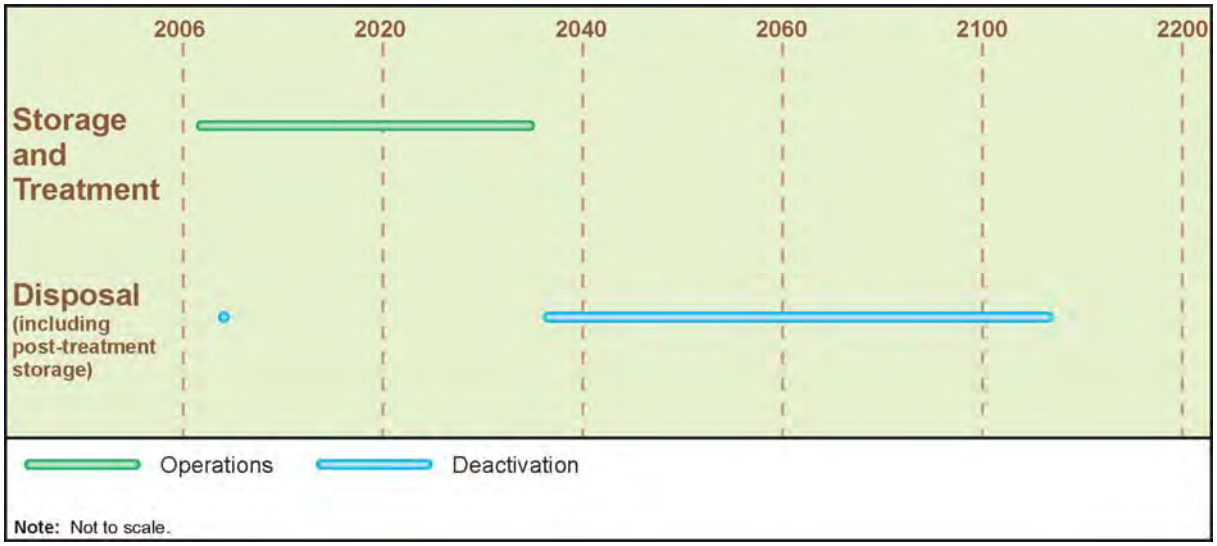


Figure 2–70. Waste Management Alternative 1 Proposed Schedule

and the Washington State Attorney General's Office (*State of Washington v. Bodman* [Civil No. 2:03-cv-05018-AAM, January 6, 2006]) (See Chapter 8, Section 8.1.1). Under the Waste Management No Action Alternative, further construction of IDF-East would discontinue in 2008, and IDF-East would be deactivated in 2009. Deactivation would include removing the liner and backfilling the excavated site.

No barriers would be constructed over LLBG 218-W-5 trenches 31 and 34 or the CWC, WRAP, or T Plant complex. There would be a 100-year administrative control period through 2135. Figure 2–71 illustrates the primary components of the Waste Management No Action Alternative.

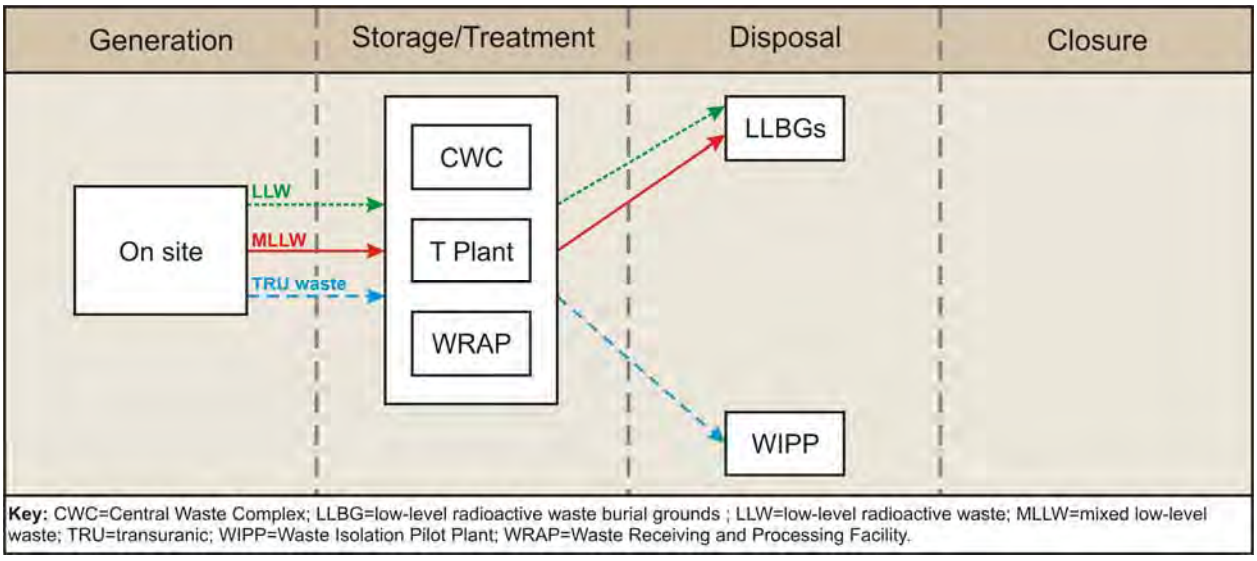


Figure 2–71. Waste Management Alternative 1 Primary Components

2.5.4.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

As shown in Figure 2–72, Waste Management Alternative 2 evaluates continued storage and processing of LLW, MLLW, and TRU waste through 2050 using existing and expanded capabilities at the CWC, T Plant complex, and WRAP. Construction of expanded storage/processing facilities would be completed by 2018, and these facilities would be deactivated in 2051. Under Waste Management Alternative 2, disposal of LLW and MLLW in LLBG 218-W-5 trenches 31 and 34 would continue until they are filled in 2050. IDF-East and the RPPDF would accept waste for disposal until as late as 2165, after which these disposal facilities would be covered with modified RCRA Subtitle C barriers, followed by postclosure care for 100 years (through as late as 2267). The proposed schedule for implementing Waste Management Alternative 2 is presented in Figure 2–73.

The following storage, disposal, and closure activities, as depicted in Figure 2–74, would occur under Waste Management Alternative 2.

Storage. DOE would continue to store and process LLW, MLLW, and TRU waste at the CWC until disposal. A new storage facility with a capacity of 17,500 drums of waste would be constructed in Building 2403-WD. Two expansions of WRAP would be constructed and operated: (1) additional CH-LLW, CH-MLLW, and CH-TRU waste processing capability at the CWC to match the current WRAP's existing capability and (2) an RH-TRU waste processing capability at the WRAP site. The T Plant also would be expanded to handle oversized CH-LLW and CH-MLLW packages (duplicating the capabilities of the 2706-T/TA/TB Facility).

Offsite-generated LLW and MLLW would be treated off site by the generator or commercial treatment operations prior to shipment to Hanford. No offsite TRU waste would be shipped to Hanford. Offsite waste shipments would be limited to a total volume of 82,000 cubic meters (107,000 cubic yards), including 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW.

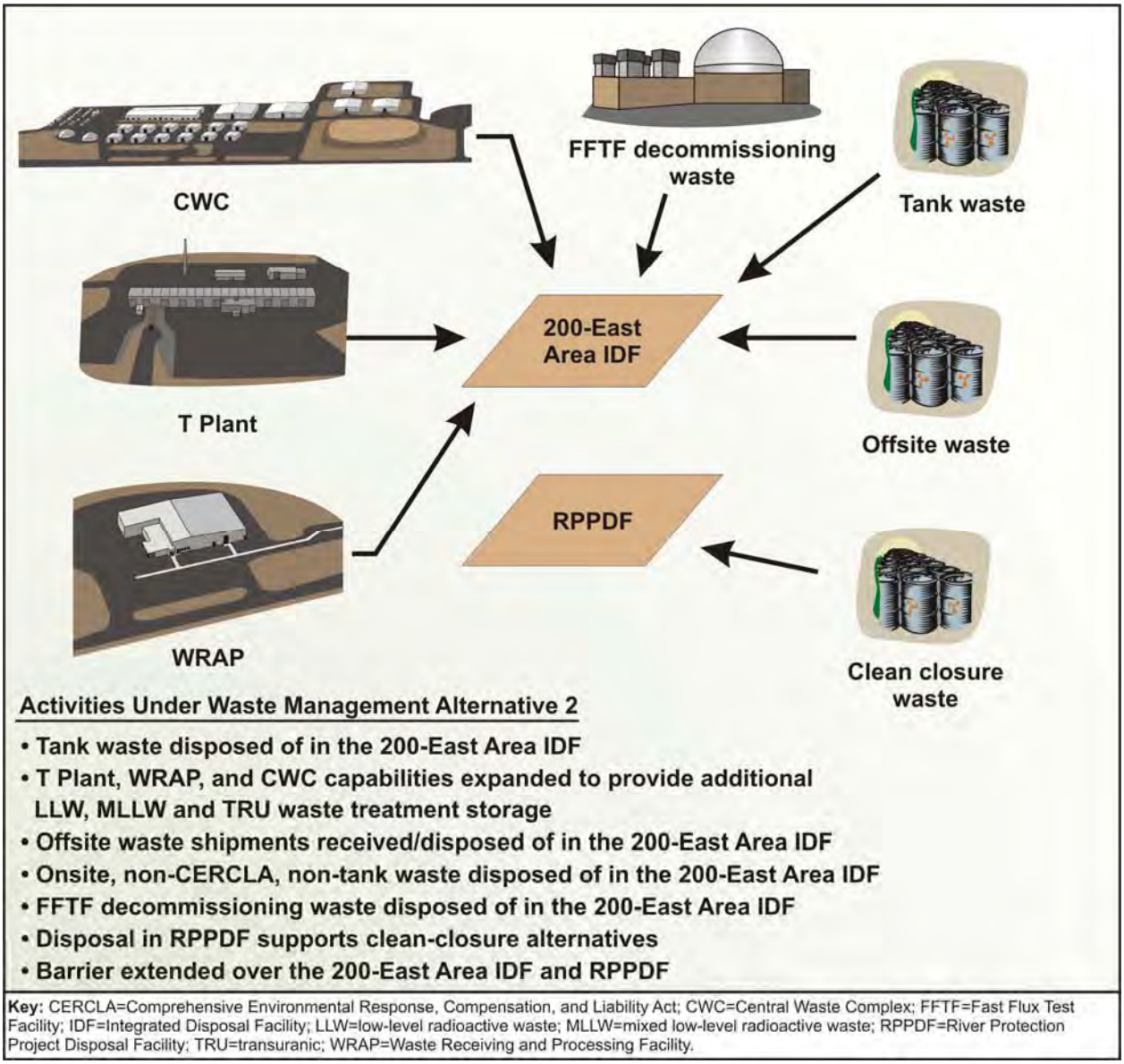


Figure 2–72. Waste Management Alternative 2 Overview

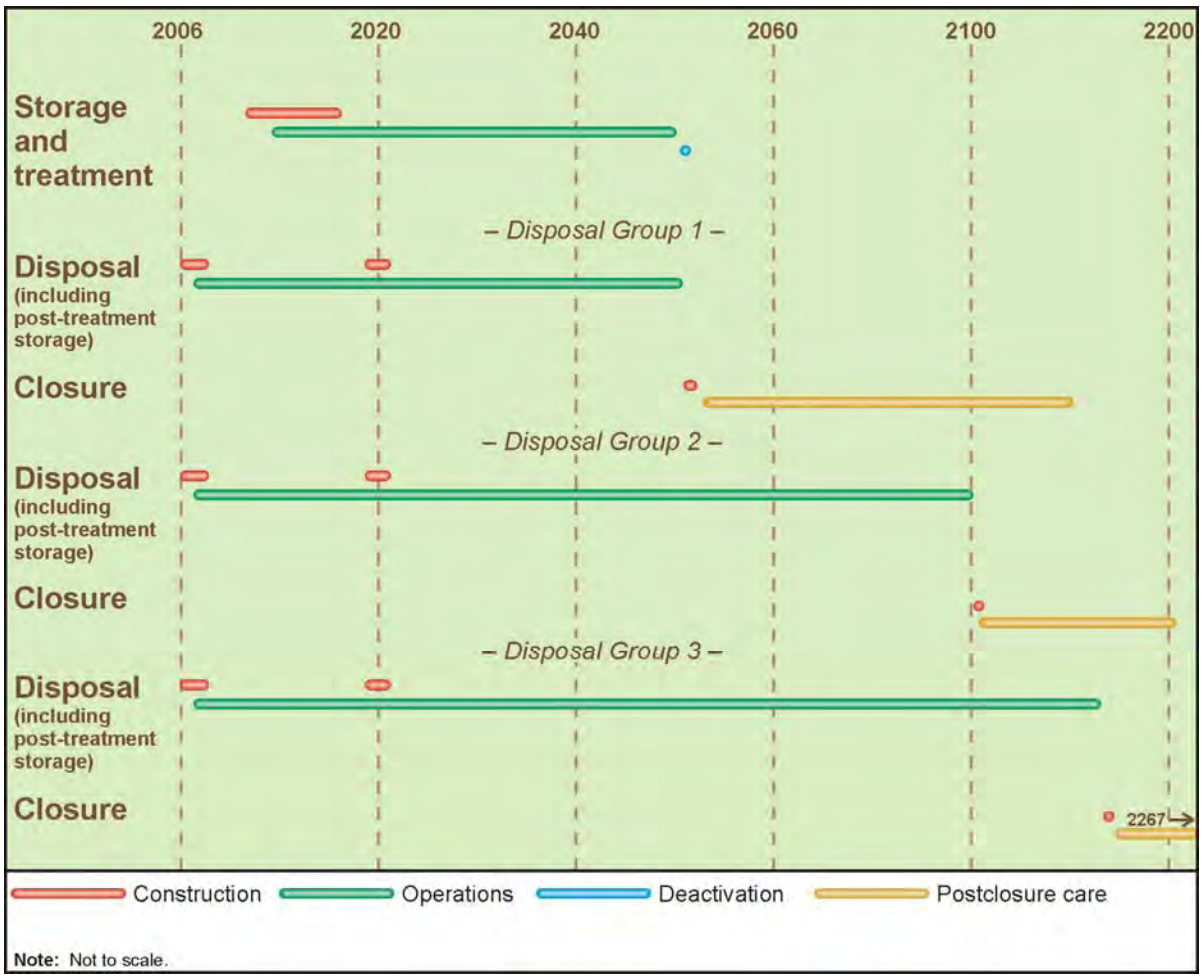


Figure 2–73. Waste Management Alternative 2 Proposed Schedule

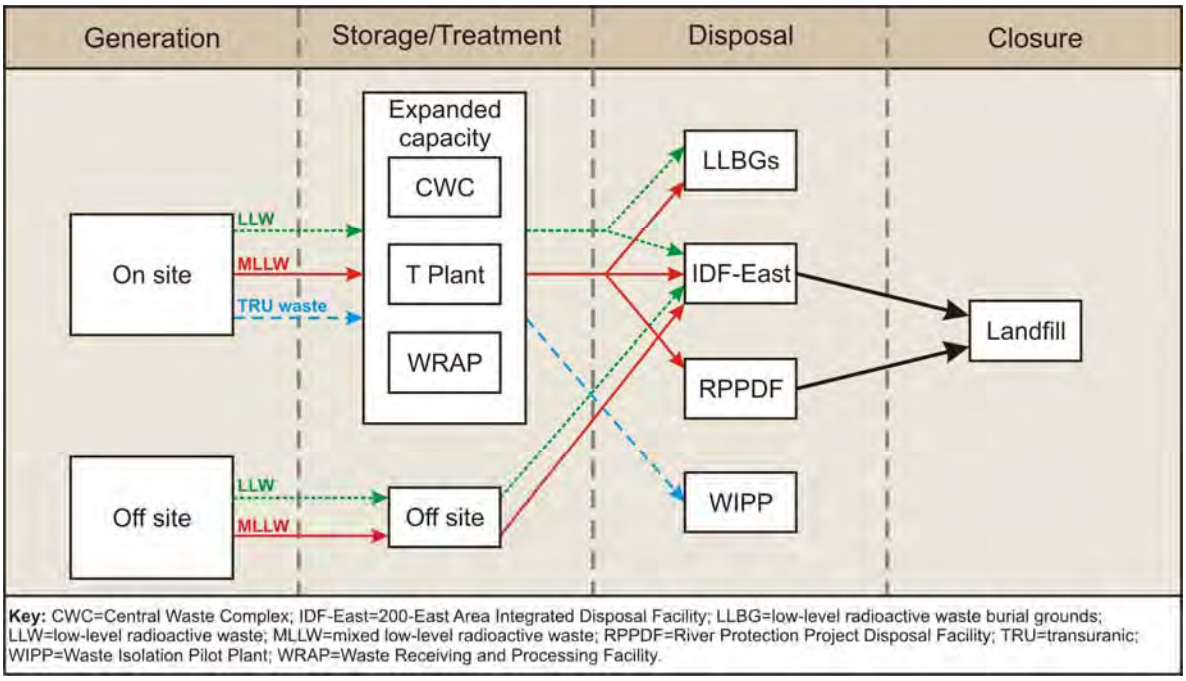


Figure 2–74. Waste Management Alternative 2 Primary Components

Disposal. DOE would continue disposing of onsite-generated non-CERCLA, nontank LLW and MLLW in LLBG 218-W-5 trenches 31 and 34 until they are filled in 2050. IDF-East would be used for disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW. RPPDF would be used for disposal of lightly contaminated equipment and soils resulting from closure activities. TRU waste would be disposed of in WIPP. Three disposal groups were analyzed under Waste Management Alternative 2, as follows:

1. Disposal Group 1: IDF-East would have a capacity of 1.2 million cubic meters (1.57 million cubic yards), and the RPPDF would have a capacity of 1.08 million cubic meters (1.41 million cubic yards). Both facilities would operate through 2050. The following alternatives are associated with this disposal group: Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C; and FFTF Decommissioning Alternatives 2 and 3.

2. Disposal Group 2: IDF-East would have a capacity of 425,000 cubic meters (556,000 cubic yards), and the RPPDF would have a capacity of 8.37 million cubic meters (10.9 million cubic yards). Both facilities would operate through 2100. The following alternatives are associated with this disposal group: Tank Closure Alternatives 2A and 6B; and FFTF Decommissioning Alternatives 2 and 3.

3. Disposal Group 3: IDF-East would have a capacity of 425,000 cubic meters (556,000 cubic yards), and the RPPDF would have a capacity of 8.37 million cubic meters (10.9 million cubic yards). Both facilities would operate through 2165. The following alternatives are associated with this disposal group: Tank Closure Alternative 6A, and FFTF Decommissioning Alternatives 2 and 3.

Closure. IDF-East and the RPPDF would be covered with engineered modified RCRA Subtitle C barriers to reduce water infiltration and the potential for intrusion. A 100-year postclosure care period would follow.

2.5.4.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Waste Management Alternative 3 is similar to Waste Management Alternative 2 in that it would continue storage and processing of LLW, MLLW, and TRU waste through 2050 using existing and expanded capabilities at the CWC, T Plant complex, and WRAP. As shown in Figure 2–75, expanded storage and processing facilities would be constructed by 2018 and deactivated in 2051. Under Waste Management Alternative 3, disposal of LLW and MLLW would continue in LLBG 218-W-5 trenches 31 and 34 until they are filled in 2050. Both IDF-East and the RPPDF would accept waste for disposal until as late as 2165. Under Waste Management Alternative 3, however, IDF-West would also be constructed and operated. IDF-East would be used for disposal of tank waste only; IDF-West would be used for disposal of onsite-generated non-CERCLA and offsite-generated LLW and MLLW, as well as FFTF decommissioning and waste management wastes. When closed, these disposal facilities would be covered with engineered modified RCRA Subtitle C barriers, followed by a postclosure care period of 100 years (through as late as 2267). The proposed schedule for implementing Waste Management Alternative 3 is presented in Figure 2–76.

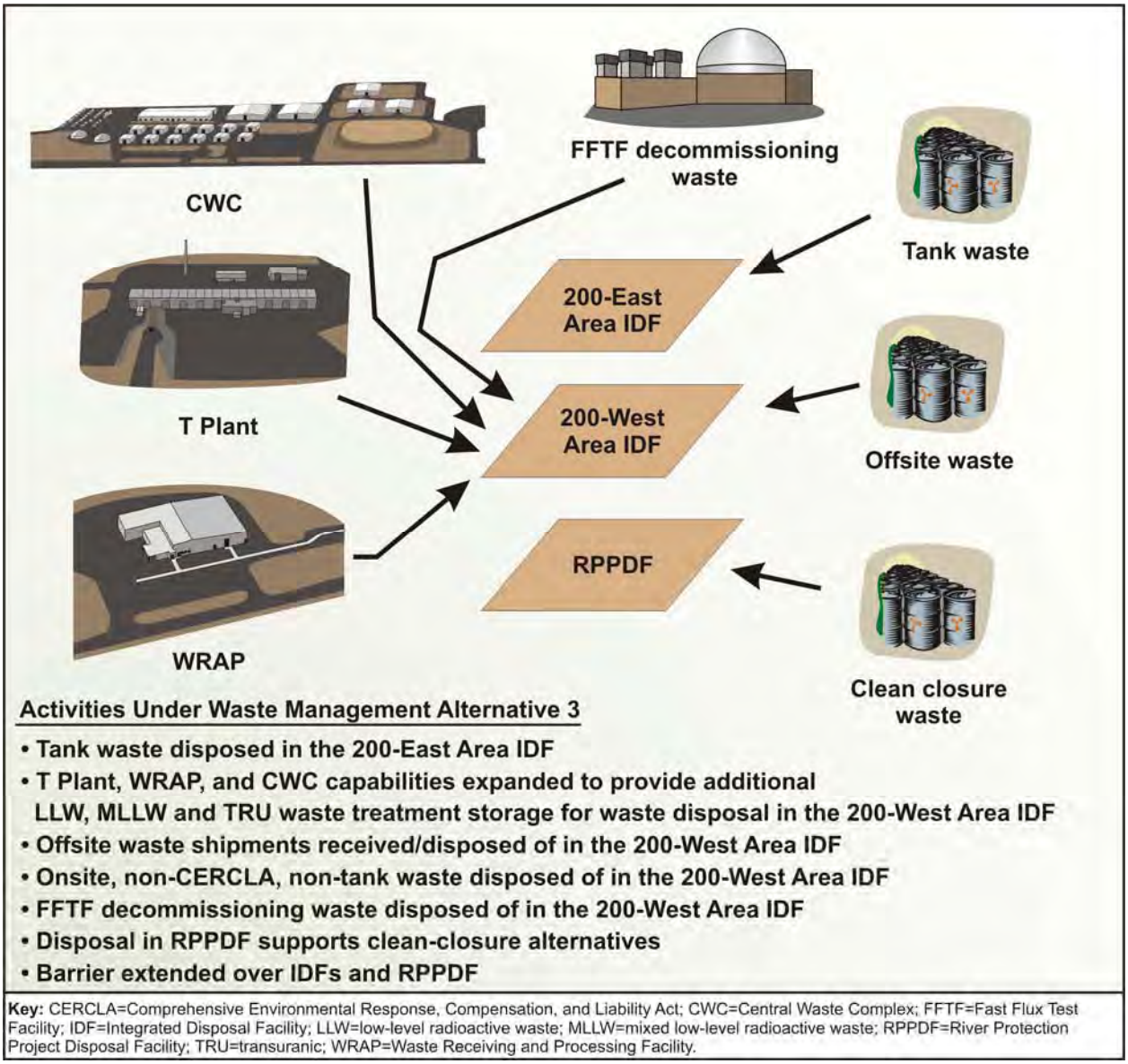


Figure 2–75. Waste Management Alternative 3 Overview

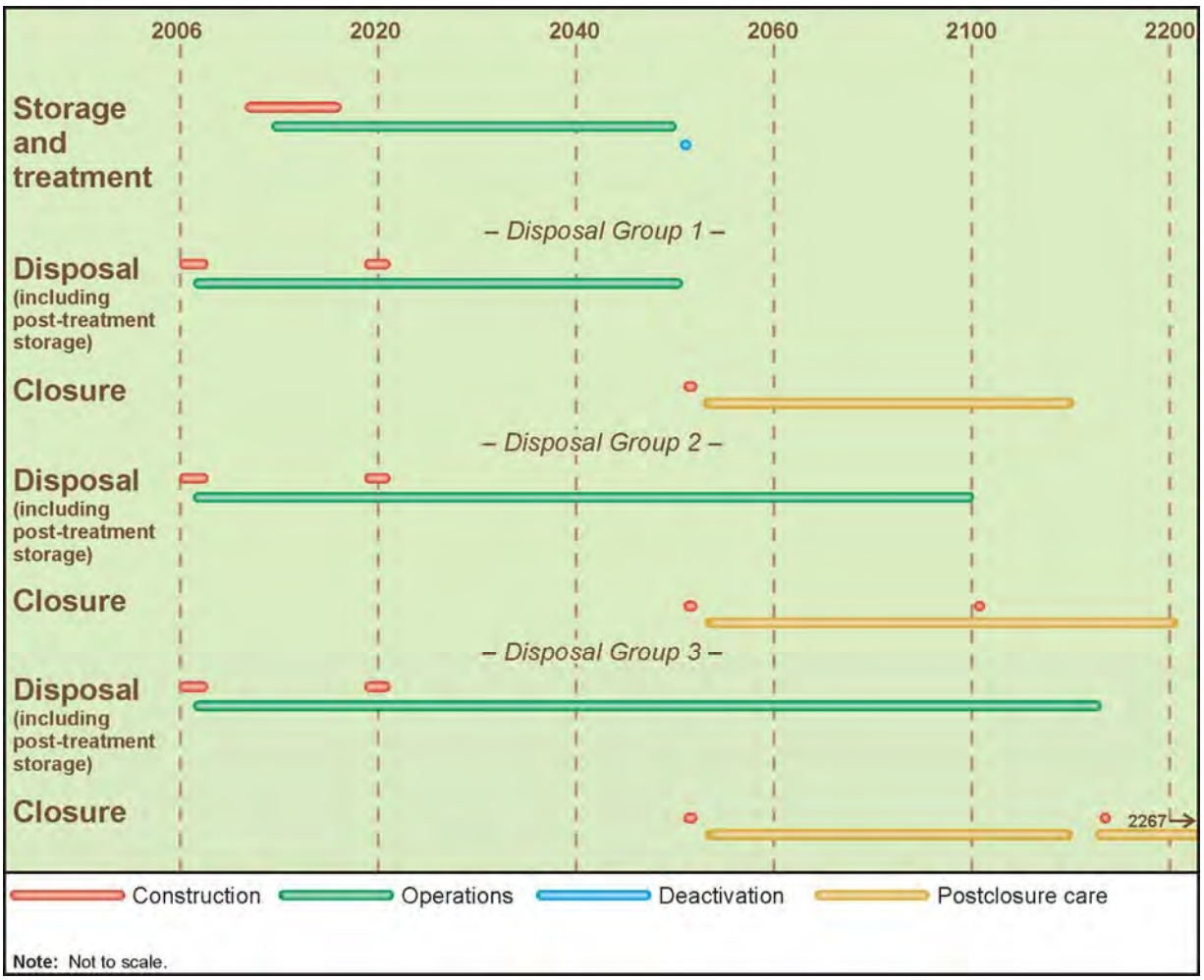


Figure 2–76. Waste Management Alternative 3 Proposed Schedule

The following storage, disposal, and closure activities, as depicted in Figure 2–77, would occur under Waste Management Alternative 3.

Storage. DOE would continue storing and processing LLW, MLLW, and TRU waste at the CWC until disposal. A new storage facility with a capacity of 17,500 drums of waste would be constructed in Building 2403-WD. WRAP would be expanded to provide additional LLW, MLLW, and CH-TRU waste processing capabilities at the CWC to match the existing capability at the current WRAP, as well as an RH-TRU waste processing capability at the WRAP site. Under Waste Management Alternative 3, the T Plant also would be expanded to accommodate oversized CH-LLW and CH-MLLW packages (a duplication of the 2706-T/TA/TB Facility).

Offsite-generated LLW and MLLW would be treated off site by the generator or commercial treatment operations prior to shipment to Hanford. No offsite TRU waste would be shipped to Hanford. Offsite waste shipments would be limited to a total volume of 82,000 cubic meters (107,000 cubic yards), including 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW.

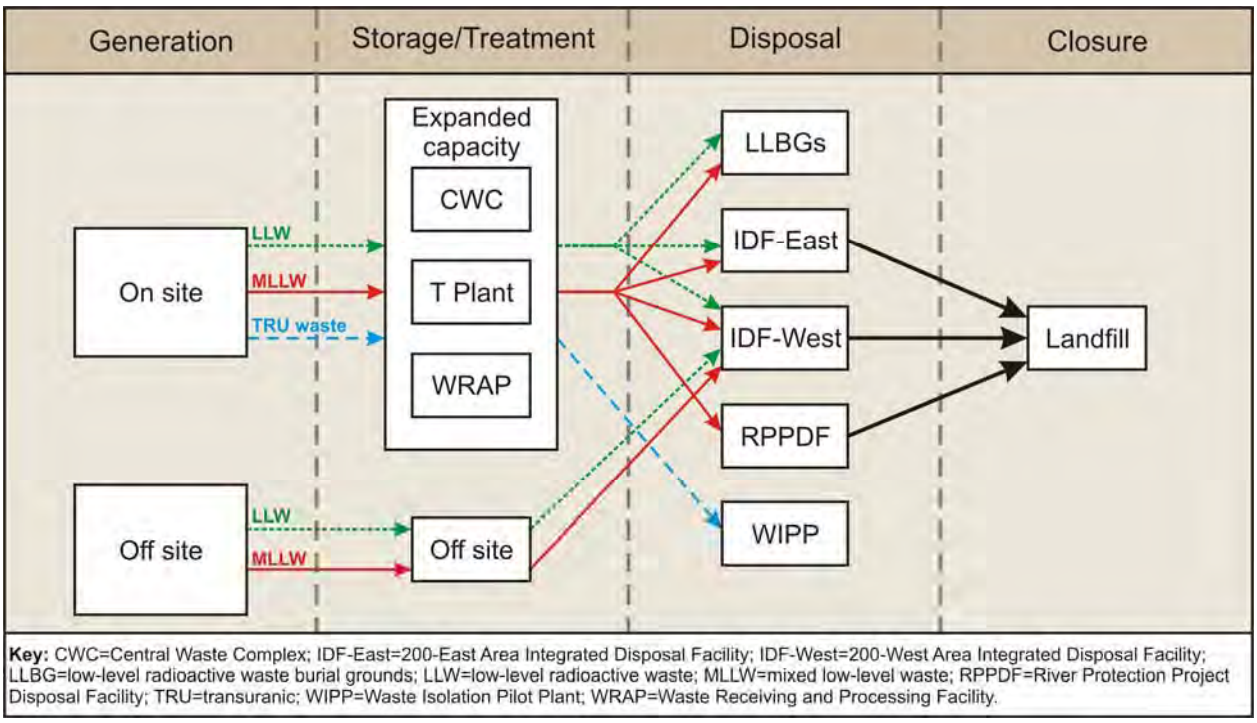


Figure 2–77. Waste Management Alternative 3 Primary Components

Disposal. DOE would continue disposing of onsite-generated non-CERCLA, nontank LLW and MLLW in LLBG 218-W-5 trenches 31 and 34 until they are filled in 2050. After construction, IDF-East and IDF-West would undergo operations, deactivation, closure, and postclosure care. IDF-East would be used for disposal of waste from tank treatment operations. Onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated waste would be disposed of in IDF-West cells. RPPDF would be constructed and operated for disposal of lightly contaminated equipment and soils resulting from closure activities. TRU waste would be disposed of in WIPP. Three disposal groups were analyzed under Waste Management Alternative 3, as follows:

1. Disposal Group 1: IDF-East would have a capacity of 1.1 million cubic meters (1.43 million cubic yards); IDF-West would have a capacity of 90,000 cubic meters (118,000 cubic yards); and the RPPDF would have a capacity of 1.08 million cubic meters (1.41 million cubic yards). All three facilities would operate through 2050. The following alternatives are associated with this disposal group: Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C; and FFTF Decommissioning Alternatives 2 and 3.

2. Disposal Group 2: IDF-East would have a capacity of 340,000 cubic meters (445,000 cubic yards); IDF-West would have a capacity of 90,000 cubic meters (118,000 cubic yards); and the RPPDF would have a capacity of 8.37 million cubic meters (10.9 million cubic yards). IDF-East and the RPPDF would operate through 2100. IDF-West would operate through 2050. The following alternatives are associated with this disposal group: Tank Closure Alternatives 2A and 6B, and FFTF Decommissioning Alternatives 2 and 3.

3. Disposal Group 3: IDF-East would have a capacity of 340,000 cubic meters (445,000 cubic yards); IDF-West would have a capacity of 90,000 cubic meters (118,000 cubic yards); and the RPPDF would have a capacity of 8.37 million cubic meters (10.9 million cubic yards). IDF-East and the RPPDF would operate through 2165. IDF-West would operate through 2050. The following alternatives are associated with this disposal group: Tank Closure Alternative 6A, and FFTF Decommissioning Alternatives 2 and 3.

Closure. When closed, these disposal facilities would be covered with engineered modified RCRA Subtitle C barriers. Closure activities would occur at the two IDFs and RPPDF only and would include a 100-year postclosure care period.

2.6 TECHNOLOGIES AND OPTIONS CONSIDERED BUT NOT EVALUATED IN DETAIL

In developing the range of reasonable alternatives for tank closure, FFTF decommissioning, and waste management, DOE examined numerous technologies and options. The technologies and options discussed in this section were initially considered, but were subsequently dismissed as reasonable alternatives under NEPA for meeting DOE's purpose and need. The following sections provide a brief discussion of these technologies and options as applicable to the three sets of proposed actions, as well as the bases for why they were deemed unreasonable and were not considered further.

2.6.1 Tank Closure

Evaluation of tank waste disposal alternatives has been ongoing since waste storage in underground tanks was first recognized as a temporary solution to a long-term problem. Numerous technologies and approaches have been examined for the storage, retrieval, treatment, and disposal of tank waste, as well as closure of the SST system. This section summarizes the alternatives and technologies that were considered but not evaluated in detail in this *TC & WM EIS*. The following criteria were used to determine whether an alternative or technology would be appropriate for detailed evaluation.

- Is the alternative or technology relevant to the purpose and need for agency action in this EIS?
- Is the alternative or technology technically viable and practicable?
- Can the alternative or technology be designed to be protective of human health and the environment, with practicable mitigative measures?
- Is the technology sufficiently mature to allow detailed evaluation? Would the costs and time required to develop the technology for application at Hanford be feasible?
- Is the technology appreciably different from an alternative already included in this EIS, or does it offer potential advantages in terms of effectiveness, costs, or impacts on human health and the environment?

If the answer to any of the above questions was no, DOE determined that the alternative or technology was not reasonable for further consideration and evaluation in this *TC & WM EIS*.[14] Therefore, the following waste storage, retrieval, treatment, and disposal and tank closure approaches were deemed unreasonable and were not evaluated in detail. A more-indepth discussion of these technologies is provided in Appendix E, Section E.1.3.

Waste storage. Some alternatives may require additional storage capacity above and beyond the current DST capacity. The selected storage arrangement is the construction of new below-grade DSTs. The following storage options were considered but not evaluated:

- Modification of existing canyon facilities – This option was not evaluated in detail because (1) the existing canyon facilities are not designed for storage of large volumes of liquid waste;

[14] Additionally, in 2007, DOE conducted a Technology Readiness Assessment to determine the maturity level of the LAW treatment technologies considered for use under the *TC & WM EIS* alternatives (WTP vitrification, bulk vitrification, cast stone, and steam reforming). Appendix E, Section E.1.3.4, summarizes this assessment.

(2) the existing radiation and contamination levels would result in elevated personnel exposure; (3) the low volume of storage space would not be cost-effective; and (4) environmental permitting is highly uncertain.

- New above-grade DSTs – This option was not evaluated in detail because (1) there are technical disadvantages associated with shielding large (3.8-million-liter [1-million-gallon]) aboveground tanks and (2) the resources required for construction and operation of new aboveground tanks would be similar to those associated with below-grade tanks.

Waste retrieval. A number of technologies were initially considered to retrieve waste from the SSTs. Each of these technologies is flexible regarding the general equipment configuration, fluid velocities and flow rates, and methods of operation. Some are better suited to tank-specific considerations such as riser availability, waste condition, or in-tank interferences. Although the following technologies were not considered reasonable for detailed analysis in this *TC & WM EIS*, that does not preclude their future consideration as potentially viable approaches for retrieving waste from the SSTs.

- Past-practice sluicing, fluidic mixing, and salt cake dissolution – These retrieval technologies were addressed in the *TWRS EIS*. However, they are very similar to and are effectively encompassed by the retrieval technologies evaluated in this *TC & WM EIS*.

- Staging waste in SSTs – This option was not evaluated in detail in this *TC & WM EIS* primarily because the SSTs cannot be made compliant with current regulations. In addition, this option would likely require extra DST space to be held in reserve in the event a leak was detected in one of the waste-staging SSTs. This would potentially decrease the available space in the DSTs by the volume of the largest SST used.

Treatment technologies. The following treatment and pretreatment technologies were initially considered but were eliminated from detailed consideration in this *TC & WM EIS*.

- Active metal reduction – This LAW treatment technology was not evaluated in detail in this *TC & WM EIS* primarily due to its relative technical immaturity and complexities, as well as operational safety issues related to flammable gas generation.

- Fractional crystallization – This technology was not evaluated in detail as a supplemental pretreatment process due to concerns over waste form performance with respect to nitrate, difficulty of operations, complexity of the process, and lack of data demonstrating applicability to actual tank waste.

- HLW and LAW vitrification with phosphate glass – This technology was not evaluated in detail because the phosphate glass formula has not been proven compatible with production-scale melters, and the resulting product glass has not been shown to meet the waste acceptance technical requirements for DOE's Civilian Radioactive Waste Management System (DOE 2007). Other WTP melter configurations and waste forms were not evaluated in detail in this *TC & WM EIS* because of DOE's intention to construct and operate the WTP as currently designed, using current melter technology and glass formulations.

- Preprocessing tank waste with a plasma mass separator – This technology was not evaluated in detail in this *TC & WM EIS* due to its present immaturity and the need for further testing and demonstration of its applicability to managing Hanford tank waste.

Disposal. The following disposal approaches were initially considered, but were eliminated from detailed evaluation in this *TC & WM EIS*.

- The *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (WM PEIS)* (DOE 1997a) provided analysis of potential environmental impacts of broad alternatives for DOE's waste management program to provide a basis for DOE decisions on programmatic configurations of sites for waste management activities. One of DOE's decisions based on the *WM PEIS* addressed disposal of LLW and MLLW, and DOE decided that Hanford would dispose of its own LLW and MLLW on site (65 FR 10061). There is no new information that would compel reconsideration of this decision. Therefore, the option of disposing of these wastes off site was eliminated from further consideration in this EIS.

- An option considered for the disposal of the HLW melters taken out of service was onsite disposal.

  As the HLW melters have not been installed or operated, a high degree of uncertainty exists about their operation, lifespan, waste characterization, and waste classification. As a result, this *TC & WM EIS* assumed a conservative (i.e., economically and with consideration of the human health impacts of melter storage, transportation, and disposal) disposition of the melters; the HLW melters would be stored on site until disposition decisions are made and implemented. Thus, onsite disposal was eliminated from further consideration in this EIS.

Tank system closure and facility D&D. The following technologies, each of which could provide in situ soil remediation and offer alternatives to support tank farm closure, were considered but not selected for detailed analysis in this *TC & WM EIS*.

- Subsurface barriers – This option was not evaluated in detail because (1) use of subsurface barriers would reduce only a small amount of the risk associated with waste retrieval, tank stabilization, and surface-barrier technologies; (2) the performance of subsurface barriers is highly uncertain, so their use is expected to have a limited impact on risk, but would carry a high cost–benefit ratio; and (3) the potential risks to workers involved in implementing subsurface barrier approaches would increase substantially compared to the risks associated with using surface barriers and waste retrieval.

- In situ soil remediation – A variety of in situ soil remediation technologies were initially considered but were not evaluated in detail in this *TC & WM EIS* because of the difficulties and uncertainties associated with placement of treatment zones and their performance verification. In situ treatment generally requires long periods of time and provides questionable uniformity of treatment because of the variability in soil and aquifer characteristics. The overall efficacy of in situ processes is also relatively difficult to verify.

- Gravel filling of tanks – Although gravel or grout could be used to adequately stabilize waste tanks structurally and both are considered viable as a potential corrective action or emergency response, this *TC & WM EIS* does not evaluate this option in detail for closure purposes, primarily because the gravel would not prevent water intrusion and possible mobilization of contaminants from stabilized residual waste. In addition, the use of grout, rather than gravel, represents a more conservative estimate for commitment of resources.

2.6.2 Fast Flux Test Facility

This section describes the potential alternatives that were considered, but not evaluated in detail, for decommissioning the FFTF complex, managing and disposing of one or more of the FFTF waste streams, or disposing of Hanford's radioactively contaminated bulk sodium inventory. These alternatives were not evaluated in detail because DOE determined they are not reasonable due to current Hanford activities,

likely environmental impacts, public and worker safety considerations, and implementation issues and concerns.

Restart FFTF to support isotope production or research missions. On the basis of previous NEPA evaluations, DOE decided to shut down and deactivate FFTF (DOE 1995, 2000). Deactivation of the facility is currently in progress; therefore, restart is not considered to be a reasonable alternative.

Turn the FFTF complex into a museum or find another alternative use. During the public scoping meetings for this *TC & WM EIS*, some of the comments received suggested cleaning out the FFTF facility and turning it into a publicly accessible museum. Because the structures would need to be maintained for an indefinite period of time, this approach would be closely analogous to the No Action Alternative. This suggestion was not considered a reasonable alternative due to the radiological and unique chemical hazards associated with the facility, the age of the buildings, and the lack of a financial sponsor. However, any documentation necessary to preserve information regarding FFTF's historic aspects will be developed in conjunction with the State Historic Preservation Officer and applicable regulations

Interim safe storage. The production reactors along the Columbia River are undergoing a cleanout process, referred to as "interim safe storage." As part of that process, all SNF is being removed, surrounding buildings are being demolished, the main reactor building is being cleaned and partially dismantled (to the shield walls), and a new roof is being installed. In the interim safe storage configuration, storage and maintenance costs are very low and the reactor can be left for up to 75 years, allowing radionuclides to decay before further action would be needed, thus reducing worker exposure during waste dispositioning. With respect to decommissioning FFTF, the interim safe storage approach would be closely analogous to the No Action Alternative, with enhanced isolation of the RCB. Because of the chemical hazards associated with the reactive sodium coolant and the relatively low doses associated with the proposed decommissioning activities, as well as DOE's desire to accelerate and complete the required cleanup actions, this approach was not deemed a reasonable alternative.

Recycle debris. One option for disposal of some of the demolition debris would be to recycle the steel and concrete. The potential presence of radioactivity and hazardous chemicals and the expense required to decontaminate the debris and ensure its suitability for unrestricted release made this option impractical. Therefore, it was not considered a reasonable alternative.

Convert bulk sodium to a solid waste. DOE previously decided to convert Hanford's bulk sodium to a caustic sodium hydroxide solution for use in tank waste processing at the WTP (Ecology, EPA, and DOE 2002), thus avoiding the expense of converting the reactive sodium to a solid form and disposing of it as radioactive waste, as well as the cost of procuring additional resources needed to treat Hanford's tank waste. DOE did not consider this option, primarily based on the loss of a beneficial use of the sodium, to be a reasonable alternative that required further evaluation.

Alternative barrier concepts. Under the Entombment Alternative, an engineered closure barrier would be constructed over the FFTF buildings in accordance with applicable regulations. Because the final design of the barrier is still to be determined, various design options were considered. For the *TC & WM EIS* analysis, the modified RCRA Subtitle C barrier was assumed.

2.6.3 Waste Management

As discussed in Chapter 1, Section 1.1, DOE and Washington State executed a Settlement Agreement on January 6, 2006, ending the NEPA litigation (*State of Washington v. Bodman* [Civil No. 2:03-cv-05018-AAM]) regarding the state's concerns about the groundwater-related and other analyses presented in the *HSW EIS* (DOE 2004b). This agreement and the concurrent Memorandum of Understanding between DOE and Ecology (DOE and Ecology 2006) directed DOE to revise or update analyses from the *HSW EIS*, as appropriate, in the new *TC & WM EIS*. The new EIS would also ensure all waste types

addressed in the *HSW EIS* alternatives and cumulative impact analyses are integrated. The alternatives evaluated in this *TC & WM EIS* represent the range of reasonable alternatives covering a full spectrum of tank closure, FFTF decommissioning, and waste management activities. In addition, any combination of the Waste Management No Action Alternative with waste-generating Tank Closure or FFTF Decommissioning alternatives was considered unreasonable, and therefore activities necessary to support such alternative combinations were not evaluated in this *TC & WM EIS*.

2.7 COMPARISON OF ALTERNATIVES

The following sections present an overview of the key parameters associated with each of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives, including the methodology for developing the alternatives so as to provide comparisons of how parameter differences may affect potential impacts. A discussion of specific technical and programmatic uncertainties associated with the alternatives is also presented.

Detailed discussions of the short- and long-term environmental impacts associated with each of the alternatives are presented in Chapters 4 and 5 of this *TC & WM EIS*, respectively. Summaries of these respective impact discussions are presented in Sections 2.8 and 2.9.

2.7.1 Tank Closure Alternatives

The Tank Closure action alternatives described in this *TC & WM EIS* represent the range of reasonable approaches to storing Hanford tank waste; removing the waste from the tanks to the extent technically and economically feasible; treating the waste through vitrification in the existing WTP, in an expanded WTP, and/or in conjunction with one or more supplemental treatment technologies; packaging the waste for onsite storage or disposal or offsite shipment and disposal; and closing the SST system to permanently reduce the potential risk to human health and the environment. Table 2–5 outlines the key technical parameters under each of the five RPP mission components (storage, retrieval, treatment, disposal, and closure) and compares these parameters by alternative.

The Tank Closure action alternatives were developed in part to allow comparisons of the short-term impacts of the construction, operations, and deactivation of the additional facilities proposed for storage, retrieval, treatment, and disposal of waste from the SST system and closure of the SST system. These action alternatives were also developed to allow similar comparisons of the long-term water quality, human health, and ecological risk impacts resulting from completion of these activities. Following is a brief comparative discussion of the Tank Closure alternatives (by RPP mission component).

Tank farm storage. Tank farm storage operations would be required under each Tank Closure alternative. Tank Closure Alternative 1 would continue storage of the tank waste in the existing SST system without treating the waste. Tank Closure Alternatives 2A and 6A would require construction of new DSTs to replace the existing DSTs to provide safe storage over the extended time period needed for tank waste treatment. Tank Closure Alternative 5 would require construction of new DSTs to facilitate a shorter time period for waste treatment. Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, 6B, and 6C would require the construction of WRFs to facilitate waste treatment.

Table 2–5. Comparison of the Tank Closure Alternatives

	Alternative 1: No Action	Alternative 2A: Existing WTP Vitrification; No Closure	Alternative 2B: Expanded WTP Vitrification; Landfill Closure	Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	Alternative 6A: All Vitrification/No Separations; Clean Closure	Alternative 6B: All Vitrification with Separations; Clean Closure	Alternative 6C: All Vitrification with Separations; Landfill Closure
Storage											
Existing	✓										
New WRFs			✓	✓	✓	✓	✓	✓		✓	✓
New DSTs		✓						✓	✓		
Retrieval											
90 percent								✓			
99 percent		✓	✓	✓	✓	✓					✓
99.9 percent							✓		✓	✓	
Treatment											
WTP											
Existing vitrification only		✓		✓	✓	✓	✓				
Expanded LAW vitrification			✓					✓		✓	✓
Expanded HLW vitrification									✓		
Replacement of WTP		✓							✓		
Technetium-99 removal			✓		✓						
Sulfate removal								✓			
Cesium and strontium capsules		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Non-WTP											
Tank mixed TRU waste supplemental treatment				✓	✓	✓	✓	✓			
Thermal supplemental treatment				✓		✓	✓	✓			
Nonthermal supplemental treatment					✓		✓	✓			
Disposal (including post-treatment storage)											
On Site											
ILAW		✓	✓	✓	✓	✓	✓	✓		a	a
IHLW[b]		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grouted sulfate								✓			
Contaminated soil			✓	✓	✓	✓	✓		✓	✓	✓
SSTs							c		d	d	
Off Site											
Tank mixed TRU waste to WIPP				✓	✓	✓	✓	✓			
Closure											
Clean closure									✓	✓	
Selective clean closure/landfill closure							✓				
Landfill closure			✓	✓	✓	✓		✓			✓
Modified RCRA Subtitle C barrier			✓	✓	✓	✓	✓		e	e	✓
Hanford barrier								✓			

a Under Alternatives 6B and 6C, ILAW glass would be interim-stored on site and managed as IHLW glass.

b Although disposition decisions have not been made and implemented, these alternatives do not assume the inventory in the IHLW canisters remains on site. However, the number of storage facilities needed to store all the IHLW is one more than the number of canister storage facilities analyzed under Tank Closure Alternative 2B.

c Under Alternative 4, SSTs at the BX and SX tank farms would be removed and treated in the Preprocessing Facility.

d Under Alternatives 6A and 6B, all SSTs would be removed and packaged in shielded boxes for onsite storage pending disposition.

e Base Case: Construct modified RCRA Subtitle C barrier over six sets of cribs and trenches (ditches) in B and T Areas. Option Case: Remove six sets of cribs and trenches (ditches) in the B and T Areas and remediate their deep-soil plumes.

Key: DST=double-shell tank; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; RCRA=Resource Conservation and Recovery Act; SST=single-shell tank; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WRF=waste receiver facility; WTP=Waste Treatment Plant.

Tank waste retrieval. The Tank Closure alternatives allow a range of retrieval options to be evaluated. Under Tank Closure Alternative 1, the tank waste would not be retrieved. Under Tank Closure Alternative 5, retrieval of 90 percent of the waste would occur. Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, and 6C would achieve 99 percent retrieval. Tank Closure Alternatives 4, 6A, and 6B would retrieve 99.9 percent of the tank waste.

Tank waste treatment. Use of the WTP would be required under each of the Tank Closure action alternatives. The configuration of the WTP would vary among the action alternatives, however, and different combinations of supplemental treatment technologies would be combined with waste treatment in the WTP under some alternatives.

The various WTP configurations under each of the Tank Closure action alternatives are as follows:

- Under Tank Closure Alternative 1, construction of the WTP would not be completed and no tank waste would be treated.

- Tank Closure Alternatives 2A, 3A, 3B, 3C, and 4 would use the existing WTP configuration, which would provide a TMC of 6 metric tons of glass IHLW per day (using two HLW melters) and 30 metric tons of glass ILAW per day (two LAW melters).

- Tank Closure Alternatives 2B, 5, 6B, and 6C would use the existing WTP configuration supplemented with expanded ILAW capacity. Under Alternatives 2B, 6B, and 6C, the expanded WTP configuration would provide a vitrification TMC of 6 metric tons of glass IHLW per day (using two HLW melters) and 90 metric tons of glass ILAW per day (using six LAW melters). Under Alternative 5, the expanded WTP configuration would provide a vitrification TMC of 6 metric tons of glass IHLW per day (using two HLW melters) and 45 metric tons of glass ILAW per day (using three LAW melters).

- Tank Closure Alternative 6A would require modification of the WTP to provide a vitrification TMC of 15 metric tons of glass IHLW per day (using five HLW melters) and no LAW vitrification capacity.

As discussed above, under some of the alternatives, supplemental treatment technologies would be combined with the WTP treatment.

- Tank Closure Alternatives 2A, 2B, 6A, 6B, and 6C are all-vitrification scenarios that would not use any supplemental treatment technologies.

- Tank Closure Alternatives 3A, 3B, 3C, 4, and 5 would add various supplemental treatment technologies to WTP treatment of the tank waste.

The Tank Closure alternatives also were developed to evaluate a range of supplemental thermal and nonthermal treatment choices and their associated project impacts. The thermal supplemental treatment technologies are represented in this EIS by bulk vitrification and steam reforming; the nonthermal supplemental treatment technology is represented by cast stone. In addition, analysis of treatment in the 200-West Area as well as the 200-East Area was desired. As proposed under some alternatives, tank waste treatment in the 200-West Area would target tanks that had undergone previous treatment to remove cesium-137 and strontium-90. An additional Solid-Liquid Separations Facility would be used

prior to supplemental treatment in the 200-West Area. The various supplemental treatment technology configurations for each of the alternatives that utilize these technologies are as follows:

- Tank Closure Alternative 3A – Thermal (bulk vitrification) supplemental treatment in both the 200-East and 200-West Areas

- Tank Closure Alternative 3B – Nonthermal (cast stone) supplemental treatment in both the 200-East and 200-West Areas

- Tank Closure Alternative 3C – Thermal (steam reforming) supplemental treatment in both the 200-East and 200-West Areas

- Tank Closure Alternatives 4 and 5 – Thermal (bulk vitrification) supplemental treatment in the 200-West Area and nonthermal (cast stone) supplemental treatment in the 200-East Area

Under Tank Closure Alternative 5, an additional sulfate removal technology would be used after pretreatment to increase the waste loading of ILAW glass, thereby reducing the amount of ILAW glass produced in the WTP and allowing earlier completion of treatment. This alternative was developed to determine the environmental impact of a shorter treatment timeframe.

Under Tank Closure Alternatives 3A, 3B, 3C, 4, and 5, the waste in some selected tanks would be managed as mixed TRU waste. These alternatives were developed to determine the environmental impacts related to that approach.

The Tank Closure action alternatives were also developed to compare WTP pretreatment with or without technetium-99 removal. Tank Closure Alternatives 2B and 3B include technetium-99 removal during WTP pretreatment, but Tank Closure Alternatives 2A, 3A, 3C, 4, 5, and 6A through 6C do not.

Tank waste disposal. No tank waste would be disposed of under the No Action Alternative (Tank Closure Alternative 1). However, tank waste disposal is required under all Tank Closure action alternatives. The waste disposal options and the amount of waste vary among these alternatives based on the type of waste generated, the specific program (i.e., treatment method, closure), and the assumptions made regarding disposal requirements. The tank waste disposal options are summarized below.

- Under all Tank Closure action alternatives, IHLW glass would be stored on site until disposition decisions are made and implemented.

- Under Tank Closure Alternatives 6B and 6C, ILAW glass would be managed as HLW and stored on site until disposition decisions are made and implemented.

- Under Tank Closure Alternatives 3A, 3B, 3C, 4, and 5, tank mixed TRU waste would be disposed of at WIPP.

- Under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5, ILAW would be disposed of on site in an IDF.

- Under Tank Closure Alternatives 3A, 3C, 4, and 5, LAW treated using thermal supplemental treatment technologies (bulk vitrification or steam reforming) would be disposed of on site in an IDF.

- Under Tank Closure Alternatives 3B, 4, and 5, LAW treated using nonthermal supplemental treatment technology (cast stone) would be disposed of on site in an IDF.

- Under Tank Closure 5, grouted sulfate from the sulfate removal process would be disposed of on site in an IDF.

- Under Tank Closure Alternatives 6A and 6B, PPF glass from soil washing would be disposed of on site in an IDF.

- Under Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, and 6A through 6C, contaminated soils would be disposed of on site in the proposed RPPDF.

Several Tank Closure action alternatives were developed in part to compare the performance of thermal and nonthermal supplemental treatment waste forms to be disposed of on site at Hanford. The waste forms evaluated under each of these alternatives are summarized below.

- Tank Closure Alternative 3A would produce an all-thermally treated waste form after WTP pretreatment and bulk vitrification.

- Tank Closure Alternative 3B would produce an all-nonthermally treated waste form after WTP pretreatment and cast stone treatment.

- Tank Closure Alternative 3C would produce an all-thermally treated waste form after WTP pretreatment and steam reforming.

- Tank Closure Alternatives 4 and 5 would produce both thermally and nonthermally treated waste forms after WTP pretreatment and bulk vitrification and cast stone treatment.

Another issue considered in the development of the Tank Closure action alternatives was onsite versus offsite waste disposal, particularly to better understand the potential impacts on groundwater due to waste form performance (assuming onsite disposal) and the potential impacts on groundwater resulting from past releases (contamination in the vadose zone), retrieval of sodium residuals, and closure of the SST system. Tank Closure Alternatives 6A through 6C assume that the treated waste form would be managed as HLW and would not be disposed of on site. Tank Closure Alternatives 2A, 2B, 3A through 3C, 4, and 5 assume that the treated waste forms would be disposed of on site.

The Tank Closure action alternatives were also developed to compare the long-term performance of different treated waste forms with or without technetium-99 removal. A brief discussion of this issue under the various Tank Closure action alternatives is provided below.

- Under Tank Closure Alternatives 2A and 2B, the waste streams would be treated in the WTP. Tank Closure Alternative 2A assumes technetium-99 removal would not occur during WTP pretreatment; as a result, the ILAW glass would contain most of the technetium-99. In contrast, Tank Closure Alternative 2B assumes that technetium-99 removal would be conducted as part of the WTP pretreatment process; as a result, a large fraction (approximately 99 percent) of the technetium-99 would be removed from the ILAW glass waste stream and treated as part of the IHLW glass waste stream. Under both of these alternatives, the ILAW glass would be disposed of on site in an IDF. These alternatives would allow a demonstration of the long-term impacts on groundwater of ILAW glass with or without technetium-99.

- Under Tank Closure Alternatives 3A and 3C, the waste streams would be treated in the WTP and/or using a thermal supplemental treatment (bulk vitrification or steam reforming). Both of these alternatives assume that technetium-99 removal would not be conducted in the WTP pretreatment process; as a result, the WTP and bulk vitrification glass or steam reforming waste would contain most of the technetium-99, which would be disposed of on site in an IDF. These

alternatives would allow a demonstration of the long-term impacts on groundwater of supplemental treatment waste forms that include technetium-99.

- Under Tank Closure Alternative 3B, the waste streams would be treated in the WTP and/or using a nonthermal supplemental treatment (cast stone). Because previous grout data showed that technetium-99 removal would be required for long-term waste form performance, Tank Closure Alternative 3B assumes that technetium-99 removal would be conducted as part of the WTP pretreatment process; as a result, a large fraction (approximately 99 percent) of the technetium-99 would be removed from the ILAW glass and the cast stone waste treated in the 200-East Area. Conversely, no technetium-99 would be removed from the cast stone waste treated in the 200-West Area. Both the ILAW glass and cast stone waste would be disposed of on site in an IDF. This alternative would allow a demonstration of the long-term impacts on groundwater of a cast stone waste form, portions of which would or would not include technetium-99.

- Under Tank Closure Alternatives 4 and 5, the waste streams would be treated in the WTP and/or using a thermal or nonthermal supplemental treatment (bulk vitrification or cast stone). These alternatives assume that technetium-99 removal would not be conducted as part of the WTP pretreatment process; as a result, the ILAW glass, bulk vitrification glass, and cast stone waste would contain most of the technetium-99 and would be disposed of on site in an IDF. These alternatives would allow a comparison of a range of closure conditions relative to the long-term impacts on groundwater of bulk vitrification and cast stone waste forms that include technetium-99.

Under all of the Tank Closure action alternatives, cesium and strontium capsules would be retrieved from the WESF and de-encapsulated in the new Cesium and Strontium Capsule Processing Facility adjacent to the WTP; their contents would be treated in the WTP.

A comparison of the total waste volumes and waste containers associated with each of the Tank Closure alternatives is presented in Appendix E, Table E–10.

Tank farm closure. Tank farm closure is evaluated under all Tank Closure alternatives except Tank Closure Alternatives 1 and 2A. These alternatives were partially developed to compare the long-term impacts on groundwater relative to the range of retrieval benchmarks and the type of closure barrier used (engineered modified RCRA Subtitle C barrier or Hanford barrier).

- Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C assume a retrieval benchmark of 99 percent and that the SST system would be closed as a landfill under an engineered modified RCRA Subtitle C barrier.

- Tank Closure Alternative 4 assumes a retrieval benchmark of 99.9 percent and that the SST system, except for two representative tank farms, would be closed as a landfill under an engineered modified RCRA Subtitle C barrier. The two representative tank farms (BX and SX) would be clean-closed.

- Tank Closure Alternative 5 assumes a retrieval benchmark of 90 percent and that the SST system would be closed, without ancillary equipment removal, as a landfill under a Hanford barrier.

- Tank Closure Alternatives 6A and 6B assume a retrieval benchmark of 99.9 percent and clean closure of the SST system. Under the Base Case for 6A and 6B, a modified RCRA Subtitle C barrier would be built over the six sets of cribs and trenches (ditches) in the B and T Areas. Under the Option Case, these cribs and trenches (ditches) would be removed and the deep-soil plumes would be remediated.

The Tank Closure alternatives were also developed to compare the long-term impacts on groundwater of closing the SST system. Proposed closure options range from clean closure or selective clean closure/landfill closure to landfill closure with or without any contaminated soil removal. The relationships of these closure scenarios to Tank Closure alternatives are summarized below.

- Tank Closure Alternatives 1 and 2A assume no closure of the SST system.
- Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C assume landfill closure using an engineered modified RCRA Subtitle C barrier and removal of 4.6 meters (15 feet) of contaminated soils (which includes ancillary equipment) from two tank farms (BX and SX).
- Tank Closure Alternative 4 assumes selective clean closure of two tank farms (BX and SX) and landfill closure of the remaining tank farms using an engineered modified RCRA Subtitle C barrier.
- Tank Closure Alternative 5 assumes landfill closure using a Hanford barrier without removal of contaminated soils or ancillary equipment.
- Tank Closure Alternatives 6A and 6B assume clean closure of the SST system. The Base Cases would place an engineered modified RCRA Subtitle C barrier over the six sets of cribs and trenches (ditches) in the B and T tank farms, and the Option Cases include deep soil removal and remediation.

2.7.2 FFTF Decommissioning Alternatives

The FFTF Decommissioning alternatives represent the range of reasonable approaches to dismantling and removing structures, equipment, and materials within the 400 Area PPA; treating and disposing of these components and equipment as necessary; treating RH-SCs; converting Hanford bulk sodium to a caustic sodium hydroxide solution for use in the WTP; and closing the area to permanently reduce the potential risk to human health and the environment and/or to prepare the area for future industrial use. Table 2–6 outlines the key technical parameters under each of the three mission components (disposition of facilities, RH-SCs, and bulk sodium) and compares these parameters by alternative. A brief comparison discussion of the alternatives by mission component follows the table.

Facility disposition. The FFTF Decommissioning alternatives were structured to allow a range of facility disposition options. Under FFTF Decommissioning Alternative 1: No Action, the facilities would be left in place and stabilized under a blanket of inert gas. In contrast, under FFTF Decommissioning Alternatives 2 and 3, radioactive materials would be removed, but in varying degrees. FFTF Decommissioning Alternative 2 would remove and dispose of a minimal amount of radioactive materials and entomb the rest. All above-grade RCB and adjacent support facilities would be dismantled and either consolidated and entombed in below-grade spaces, or disposed of in an IDF. FFTF Decommissioning Alternative 3 would remove nearly all radioactive materials, including the reactor vessel, internal piping and equipment, and attached depleted-uranium shield, and dispose of these materials on site in an IDF.

Small-diameter pipes would be treated before disposal under both FFTF Decommissioning Alternatives 2 and 3. Under FFTF Decommissioning Alternative 2: Entombment, some materials would be treated in place and used to fill void space in the below-grade spaces, while some materials would be treated in the 400 Area and disposed of in an IDF. In contrast, under FFTF Decommissioning Alternative 3: Removal, all materials would be removed and treated in the 400 Area, then disposed of in an IDF. No components would be left in place under Alternative 3.

Table 2–6. Comparison of FFTF Decommissioning Alternatives

	Alternative 1: No Action	Alternative 2: Entombment	Alternative 3: Removal
Facility Disposition			
Facility equipment and components left in place under inert gas blanket	X		
Dismantlement of RCB and adjacent support buildings		X	X
Removal of reactor vessel (internal piping and equipment, attached depleted-uranium shield)			X
Onsite disposal of reactor vessel (internal piping and equipment, attached depleted-uranium shield)			X
Removal and onsite disposal of radioactive or chemical waste	X	X	X
Backfill and revegetation of ancillary facility areas		X	
Backfill and revegetation of PPA			X
Modified RCRA Subtitle C barrier over RCB		X	
Administrative controls for 100 years	X		
Postclosure care and/or institutional controls for 100 years		X	X
Disposition of Remote-Handled Special Components			
Removal and storage on site per FONSI	X	X	X
Treatment at the Hanford Site		X	X
Treatment at Idaho National Laboratory		X	X
Onsite disposal		X	X
Offsite disposal		X	X
Disposition of Bulk Sodium			
Onsite storage	X	X	X
Onsite conversion to caustic sodium hydroxide solution		X	X
Offsite conversion to caustic sodium hydroxide solution		X	X
Caustic sodium hydroxide solution shipped to the Waste Treatment Plant		X	X

Key: FFTF=Fast Flux Test Facility; FONSI=Finding of No Significant Impact; PPA=property protected area; RCB=Reactor Containment Building; RCRA=Resource Conservation and Recovery Act.

Both FFTF Decommissioning Alternatives 2 and 3 include backfilling, compacting, contouring, and revegetation of the area. Alternative 2, would require construction of an engineered modified Subtitle C barrier, followed by postclosure care for 100 years. Alternative 3, however, would not need a barrier constructed because all structures and equipment would be removed. Because no barrier would be constructed under FFTF Decommissioning Alternatives 1 and 3, administrative or institutional controls would be put in place for 100 years.

Disposition of remote-handled special components. Under FFTF Decommissioning Alternative 1, the RH-SCs that would have been removed and packaged for storage under deactivation activities would be left in place in the 400 Area under an inert gas blanket. No treatment or disposal would occur under this alternative. Under FFTF Decommissioning Alternatives 2 and 3, however, two options are proposed for treatment (decontamination and sodium removal) and disposal, as follows:

- **Hanford Option.** RH-SCs would be stored in the 400 Area pending construction of the proposed RTP at Hanford's T Plant. After construction is complete, the RH-SCs would be shipped to the

new RTP via truck. Following treatment, the RH-SCs and sodium residuals would be disposed of in an IDF.

- **Idaho Option.** RH-SCs would be stored in the 400 Area pending construction of the planned RTP at the INL MFC. When this RTP is complete, the RH-SCs would be shipped to INL via truck and/or rail. Following treatment in the INL RTP, the FFTF RH-SCs would be either disposed of with other INL wastes at NTS or returned to Hanford for disposal in an IDF.

Disposition of bulk sodium. Under FFTF Decommissioning Alternative 1, FFTF bulk sodium would be left untreated as a solid in onsite storage tanks in the 400 Area SSF under deactivation activities, while Hallam and SRE sodium would remain stored in the 200-West Area. Under FFTF Decommissioning Alternatives 2 and 3, the bulk sodium would be converted into a caustic sodium hydroxide solution for use in the WTP. Both Alternatives 2 and 3 analyze the same reuse options for conversion, as follows:

- **Hanford Reuse Option.** The bulk sodium inventory would be stored in its current locations until it is shipped to the proposed 400 Area SRF for processing. Following processing, the resulting caustic sodium hydroxide solution would be transferred for use at the WTP.

- **Idaho Reuse Option.** The bulk sodium would be stored in its current locations until it is shipped via truck and/or rail to INL for processing. The capability to process bulk metallic sodium currently exists at INL's SPF. Following processing, the caustic sodium hydroxide solution would be returned to Hanford for use in tank waste processing at the WTP.

2.7.3 Waste Management Alternatives

The Waste Management alternatives described in this *TC & WM EIS* represent the range of reasonable approaches to storing and treating onsite-generated LLW, MLLW, and TRU waste; disposing of onsite- and offsite-generated LLW and MLLW (at Hanford); and shipping and disposing of onsite-generated TRU waste (at WIPP); and closing the disposal facilities to reduce water infiltration and the potential for intrusion. Table 2–7 outlines the key technical parameters under each of the RPP mission components (storage, treatment, disposal, and closure) and compares these parameters by alternative.

The Waste Management alternatives were developed partly to compare the short-term impacts of the expansion of existing facilities and construction of new facilities, as well as the operation and deactivation of facilities used to store, treat, and dispose of waste. The Waste Management alternatives were also developed to compare the long-term water quality, human health, and ecological risk impacts resulting from these activities. The following is a brief comparison discussion of the alternatives by mission component.

Waste storage and treatment. Storage and processing of LLW, MLLW, and TRU waste until disposal would be required under each Waste Management alternative. Waste Management Alternative 1 would continue storage and processing of wastes at the existing CWC, WRAP, and T Plant. Waste Management Alternatives 2 and 3 would require construction, expansion, and continued operation of these existing storage facilities. Both Waste Management Alternatives 2 and 3 include construction and operation of a new storage facility in Building 2403-WD, as well as two expansions of WRAP: one that would increase the capability to process LLW, MLLW, and CH-TRU waste and another to process RH-TRU waste. Waste Management Alternatives 2 and 3 also include construction and operation of a duplicate of the 2706-T/TA/TB Facility (a T Plant expansion) for oversized CH-LLW and CH-MLLW packages.

Table 2–7. Comparison of Waste Management Alternatives

	Alternative 1: No Action	Alternative 2: Disposal in IDF, 200-East Area Only	Alternative 3: Disposal in IDF, 200-East and 200-West Areas
Storage			
Existing storage of LLW, MLLW, and TRU waste at CWC	X		
Expanded storage of LLW, MLLW, and TRU waste at CWC		X	X
Existing storage of LLW, MLLW, and TRU waste at WRAP and T Plant	X		
Expanded storage of LLW, MLLW, and TRU waste at WRAP and T Plant		X	X
Treatment			
Existing treatment of LLW, MLLW, and TRU waste at CWC	X		
Expanded treatment of LLW, MLLW, and TRU waste at CWC		X	X
Existing treatment of LLW, MLLW, and TRU waste at WRAP and T Plant	X		
Expanded treatment of LLW, MLLW, and TRU waste at WRAP and T Plant		X	X
Disposal			
Continued disposal of onsite-generated non-CERCLA, nontank LLW and MLLW in onsite lined trenches	X	X	X
Construction of 200-East Area IDF terminated and facility deactivated	X		
Disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW at 200-East Area IDF		X	
Disposal of tank waste only at 200-East Area IDF and onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW at 200-West Area IDF			X
Disposal of rubble, ancillary equipment, and soils (not highly contaminated) from closure activities at RPPDF		X	X
Closure			
None	X		
Landfill closure of IDF(s) and RPPDF		X	X
Administrative control for 100 years	X		
Postclosure care for 100 years		X	X

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; CWC=Central Waste Complex; FFTF=Fast Flux Test Facility; IDF=Integrated Disposal Facility; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WRAP=Waste Receiving and Processing Facility.

No offsite TRU waste would be received under any of the Waste Management alternatives. No shipments of LLW or MLLW would be received under Waste Management Alternative 1. Under Waste Management Alternatives 2 and 3, offsite shipments of up to 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW would be received. However, under both alternatives, this offsite waste would be treated off site by either the generator or a commercial treatment facility.

Disposal. Waste disposal would be required under all three Waste Management alternatives. The disposal options for waste and the amount of waste vary among the alternatives. Waste Management Alternative 1 would continue disposal of onsite-generated non-CERCLA, nontank LLW and MLLW in lined trenches 31 and 34 until the waste is no longer generated (by about 2035). For conservative analysis purposes, both Waste Management Alternatives 2 and 3 would continue operation of these trenches through 2050, though the waste would be sent to an onsite IDF.

Construction of new, onsite facilities for waste disposal would occur under Waste Management Alternatives 2 and 3. No new construction would occur under Waste Management Alternative 1: No Action, and ongoing construction of IDF-East would be discontinued in 2008, with deactivation activities (e.g., removal of the liner and backfilling of the site) occurring in 2009. Under Waste Management Alternatives 2 and 3, IDF construction would continue. However, the number and location of IDFs constructed and the types of waste disposed of in each facility would be different based on the particular alternative. Waste Management Alternative 2 would complete IDF-East for disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW. Waste Management Alternative 3 would dispose of these waste types in two IDF facilities: IDF-East and IDF-West. Only waste from tank treatment operations would be disposed of in IDF-East. All other wastes would be disposed of in IDF-West. Both Waste Management Alternatives 2 and 3 would construct and operate the RPPDF for disposal of lightly contaminated equipment and soils from closure activities.

Because of the large number of combinations of IDF and RPPDF configurations, three waste disposal groups were analyzed under Waste Management Alternatives 2 and 3. Table 2–8 depicts the similarities and differences among the disposal groups and between Waste Management Alternatives 2 and 3. As shown in Table 2–8, the same disposal group would support the same Tank Closure and FFTF Decommissioning alternatives under Waste Management Alternative 2 or 3. Because the number of IDFs analyzed differs between Waste Management Alternatives 2 and 3, the amounts, types of waste disposed of, and facility operations schedules differ under the disposal groups. The RPPDF capacities and operations schedules under each of the disposal groups are the same for both Waste Management Alternatives 2 and 3.

Closure. Closure activities would take place under both Waste Management Alternatives 2 and 3. Under Waste Management Alternative 1: No Action, there would be a 100-year administrative control period, but no barriers would be constructed over disposal facilities or trenches. Both Waste Management Alternatives 2 and 3 analyze covering the IDF(s) (IDF-East under Waste Management Alternative 2 and both IDF-East and -West under Waste Management Alternative 3) and the RPPDF with engineered modified RCRA Subtitle C barriers. Both alternatives also include a 100-year postclosure care period.

Table 2–8. Comparison of Disposal Groups by Waste Management Alternative

	Waste Management Alternative 2: Disposal in IDF, 200-East Area Only	Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas
Disposal Group 1		
Alternatives Supported		
Tank Closure	2B, 3A, 3B, 3C, 4, 5, and 6C	2B, 3A, 3B, 3C, 4, 5, and 6C
FFTF Decommissioning	2 or 3	2 or 3
Total Capacity		
IDF	1,200,000 m^3	1,100,000 m^3 (IDF-East) 90,000 m^3 (IDF-West)
RPPDF	1,080,000 m^3	1,080,000 m^3
Operations Schedule (Year Operations are Completed)		
IDF	2050	2050
RPPDF	2050	2050
Disposal Group 2		
Alternatives Supported		
Tank Closure	2A and 6B	2A and 6B
FFTF Decommissioning	2 or 3	2 or 3
Total Capacity		
IDF	425,000 m^3	340,000 m^3 (IDF-East) 90,000 m^3 (IDF-West)
RPPDF	8,370,000 m^3	8,370,000 m^3
Operations Schedule (Year Operations are Completed)		
IDF	2100	2100 (IDF-East) 2050 (IDF-West)
RPPDF	2100	2100
Disposal Group 3		
Alternatives Supported		
Tank Closure	6A	6A
FFTF Decommissioning	2 or 3	2 or 3
Total Capacity		
IDF	425,000 m^3	340,000 m^3 (IDF-East) 90,000 m^3 (IDF-West)
RPPDF	8,370,000 m^3	8,370,000 m^3
Operations Schedule (Year Operations are Completed)		
IDF	2165	2165 (IDF-East) 2050 (IDF-West)
RPPDF	2165	2165

Note: Waste Management Alternative 1 would support only Tank Closure Alternative 1. To convert cubic meters to cubic yards, multiply by 1.308.

Key: FFTF=Fast Flux Test Facility; IDF=Integrated Disposal Facility; IDF-East=200-East Area IDF; IDF-West=200-West Area IDF; m^3=cubic meters; RPPDF=River Protection Project Disposal Facility.

2.7.4 Uncertainties

The following sections describe the technical and regulatory uncertainties inherent in the analysis of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives evaluated in this *TC & WM EIS*. The individual analyses of environmental impacts in Chapters 4 and 5 and the corresponding appendices provide additional details regarding the uncertainties unique to each resource area, where applicable.

TANK CLOSURE

Even with the knowledge and experience gained over the past decade of managing Hanford's tank system, there are still many technical and regulatory uncertainties. Some of these uncertainties cannot be fully resolved until tank waste storage, retrieval, treatment, and disposal and tank closure activities have

been demonstrated. A major focus of the RPP is managing these uncertainties while making progress toward tank closure. The following is a brief discussion, by mission activity, of the overarching technical and programmatic uncertainties facing the RPP in its tank waste management program.

Storage. There is uncertainty associated with tank waste inventories in terms of both chemical and radioactive contaminants. A prioritized sampling and estimation process, termed the "Best-Basis Inventory" process, was developed for estimation of the inventories present in the HLW tanks. However, in some cases the number of available measurements was limited and estimates of the tank inventories for some waste constituents were supplemented by process modeling techniques. Thus, due to the spatial variability in the characteristics and concentrations of the waste, as well as gaps in knowledge of separations processes and waste management conditions, uncertainty exists regarding the estimated waste inventories in the HLW tanks. In addition, records that were kept on the waste that was put into the tanks, waste that was transferred between tanks, and waste that was decanted off and discharged into shallow subsurface cribs and trenches (ditches) were not always complete. Although the overall quantities of radionuclides generated at Hanford are relatively well known, the actual amounts in specific waste sites are more uncertain. Also, the tank waste contains a complex mix of chemical and radiological constituents that is constantly changing as chemical reactions and radioactive decay occur. This results in an uncertain and continuously changing inventory of waste. This *TC & WM EIS* addresses this uncertainty by making conservative assumptions regarding the waste inventories based on process knowledge, assay results of sampled waste, or other available information from waste generators.

Retrieval. The efficiency and effectiveness of current methods for retrieving waste from the tanks (e.g., modified sluicing) and the quantity of liquid waste that might be released to the environment during retrieval are uncertain. For example, it is not certain whether the modified sluicing technique can retrieve all types of sludge or the dense, highly compacted waste on the tank bottom. Using large volumes of liquids during modified sluicing also may cause liquids to be released through cracks in the tanks. Other retrieval techniques such as the MRS, VBR, and chemical washing have been used on only a limited basis at Hanford and other DOE sites, so those technologies carry potential uncertainties as well.

Treatment. Separation of waste into HLW and LAW streams and vitrification of these waste streams have been conducted at other DOE sites and in Europe. However, these treatment processes have not been performed on Hanford tank waste on a production scale; therefore, the impacts and operating efficiencies are uncertain. Full-scale production of ILAW using the bulk vitrification, cast stone, and steam reforming processes has not been conducted anywhere within the DOE complex. As a result, uncertainties exist regarding waste loading and waste form quality and performance. The adequacy of the ETF to treat anticipated secondary waste from the WTP and supplemental treatment facilities is also uncertain.

Disposal. The final waste classifications of certain waste streams have not been determined due to regulatory uncertainties that could affect implementation of tank management actions. For example, DOE Manual 435.1-1 provides a process for determining whether waste resulting from processing SNF (e.g., ILAW, tank residual waste at closure) can be considered both "waste incidental to reprocessing" (WIR) and non-HLW, which would allow the waste to be managed as LLW or TRU waste, as appropriate. However, in July 2003, the parts of DOE Order 435.1 that deal with the procedures for determining WIR were declared invalid by the U.S. District Court for the District of Idaho. In November 2004, the court's decision was reversed on appeal by the U.S. Court of Appeals for the Ninth Circuit and remanded to the District Court, which in turn dismissed the case in March 2006. For analysis purposes, this *TC & WM EIS* assumes for some of the alternatives that historical processing data will support management of some of the tank waste as non-HLW. For other alternatives (e.g., Alternatives 6A and 6B), the opposite is assumed (i.e., all tank waste is assumed to be HLW).

An IHLW glass disposal location has not been established at this time. This EIS assumed the use of a thin-wall IHLW glass canister to maximize the volume of HLW put into each canister and minimize the number of canisters needed. Due to uncertainties regarding final canister design and capacity, as well as offsite shipping schedules, the EIS analysis included assumptions for onsite (interim) storage of IHLW glass until disposition decisions are made and implemented.

The impacts associated with disposal of ILAW are also uncertain at this time. Because the release rates for ILAW glass are low and are supported by experiment, there is less uncertainty regarding this waste form compared to bulk vitrification glass, cast stone waste, and steam reforming waste. Of these supplemental treatment ILAW forms, the least amount of characterization and testing has been performed for steam reforming waste. Thus, the greatest degree of uncertainty relative to waste form performance is associated with the steam reforming waste.

Closure. Clean closure of the tank farms would require construction and use of containment structures during the removal of 149 SSTs, ancillary equipment, and deep soil. There is substantial uncertainty associated with the technical feasibility, schedules, costs, and worker impacts associated with these clean closure activities. This *TC & WM EIS* evaluated the use of engineering structures, including shielding and remote equipment, to minimize worker exposure when removing the tanks. Even with these mitigation measures, the worker radiological dose would be an order of magnitude higher than that under landfill closure. Containment of air releases would be needed to mitigate impacts due to tank, ancillary equipment, and soil removal requiring construction of movable containment structures. Although the technology for installation of such containment structures is understood, there is a large degree of uncertainty concerning the feasibility of installing these structures over a large area the size of a tank farm and, under some alternatives, of constructing and using multiple structures. There is also uncertainty related to the pathway identified for disposition of the tanks, which would need to be cut up and packaged. This EIS assumed that the tanks would be packaged and disposed on site; however, they would have to go through the DOE Manual 435.1-1 process to determine the appropriate disposition pathway (i.e., whether waste is HLW, TRU waste, or LLW).

Selective clean closure/landfill closure, as evaluated in Tank Closure Alternative 4, would remove two of the tank farms, one in the 200-East Area and one in the 200-West Area, there by reducing the volume of material that would be removed. However, this volume reduction would not lessen the high degree of technical uncertainties related to how soils would be removed and treated, or the infrastructure and additional capability needed to manage the new waste generated from the removal. Although not to the same levels as clean closure, the following technical uncertainties exist: characteristics of borrow material, land and terrestrial resource disturbances, waste generation, and worker safety and health issues.

The technical uncertainties associated with tank removal and deep soil remediation beneath the tanks, under the selective clean closure and clean closure alternatives, would need to be weighed against the order(s) of magnitude increase in short-term impacts on resource areas that would result by implementing these alternatives.

The *TC & WM EIS* analyses rely on various modeling approaches to predict the consequences of RPP mission activities that DOE may undertake in the future. Some of these models are complex and rely on assumptions that are subject to a large degree of uncertainty, particularly when trying to predict potential impacts out to 10,000 years. One such uncertainty is how waste moves in the vadose zone and groundwater. The *TC & WM EIS* analyses assume that both the groundwater flow field and infiltration rate will remain constant over 10,000 years, and that the location of the river channel will remain the same over the same period. These assumptions affect the ability to accurately predict when groundwater impacts will reach their peak. Long-term impact analysis indicates that the largest potential impact on human health may be due to past-practice discharges to cribs and trenches (ditches) and past leaks from SSTs. Contaminant movement rates through the vadose zone for such releases strongly depend on the

area saturated by the initial release and subsequent horizontal spreading of the released volume of liquid. These two sensitive variables cannot be known with certainty and, coupled with natural variability in precipitation, recharge, and vadose zone hydraulic conditions, make any estimates of a rate of release to the unconfined aquifer highly uncertain. Contaminant movement rates in the unconfined aquifer were projected with greater certainty by measuring past and current contaminant concentrations and calibrating the water-movement models to hydraulic-head measurements.

FFTF DECOMMISSIONING

It was assumed under FFTF Decommissioning Alternatives 2 and 3 that Hanford's bulk sodium inventory would be converted to a caustic solution for use in processing tank waste at the WTP or for Hanford tank corrosion control. However, there is uncertainty regarding whether these processing or corrosion control demands would require reuse of the entire available inventory or whether an alternative disposition pathway for this material would be necessary. There is also uncertainty regarding the potential shipment of RH-SCs for processing, as no NRC-licensed transportation cask currently exists with the capacity to handle these components for shipment. For analysis purposes, this EIS assumes that a suitable transportation cask or other shielded container would be available at the time of removal to transport these components.

WASTE MANAGEMENT

There is substantial uncertainty associated with the sources, volumes, and potential long-term performance of radiological and chemical offsite waste inventories forecast for disposal at Hanford. Because similar uncertainties also exist regarding potential volumes and characteristic of the waste to be generated onsite, it was assumed for analysis purposes that proposed expansions to the Hanford waste management facilities (e.g., the CWC, T Plant, or WRAP) would be required as soon as possible following issuance of the ROD for this *TC & WM EIS*.

2.8 SUMMARY OF SHORT-TERM ENVIRONMENTAL IMPACTS

The following sections provide a summary-level comparison of the potential short-term environmental impacts of implementing each of the *TC & WM EIS* alternatives. Short-term impacts of Tank Closure alternatives are summarized in Section 2.8.1 and Table 2–9; of FFTF Decommissioning alternatives in Section 2.8.2 and Table 2–10; and of Waste Management alternatives in Section 2.8.3 and Table 2–11. Short-term impacts are associated with the active project phase during which construction, operations, deactivation, and closure activities would take place, and extend through the applicable 100-year administrative control, institutional control, or postclosure care period. The comparison of impacts is presented to aid the decisionmakers and public in understanding the potential short-term environmental consequences of proceeding with each of these alternatives. The information presented in the following discussions and tables is based on the detailed information on potential impacts presented in Chapter 4.

2.8.1 Tank Closure Alternatives: Short-Term Environmental Impacts

2.8.1.1 Land Resources

Land use includes the land on and adjacent to Hanford, the physical features that influence current or proposed uses, pertinent land use plans and regulations, and land ownership and availability. Under the No Action Alternative, there would be no additional impact on land use during the administrative control period. However, the 17 hectares (42 acres) of land comprising the existing 18 tank farms would be committed to waste management use indefinitely, as no tank farm closure would be performed. For the action alternatives, project activities would impact the land within the 200 Areas and Borrow Area C. These areas are designated as Industrial-Exclusive and Conservation (Mining), respectively. Implementation of Alternatives 2 through 5 and 6C would necessitate a total land commitment within the

200 Areas and Borrow Area C ranging from 76.9 hectares (190 acres) under Alternative 2A to 222 hectares (549 acres) under Alternative 5. Considerably more land would be required to implement Alternative 6, with the land needed ranging from 381 hectares (942 acres) under the Base Case of Alternative 6B to as much as 781 hectares (1,930 acres) under the Option Case of Alternative 6A. Under both the Base and Option Cases of Alternatives 6A and 6B, it would be necessary to utilize 86.2 hectares (213 acres) to the east of the WTP. This land is not within the Industrial-Exclusive land use designation and is presently designated as Conservation (Mining) consistent with the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (and supplement analysis) (DOE 1999, 2008) and Records of Decision (64 FR 61615; 73 FR 55824).

Visual resources are the natural and manmade features that give a particular landscape its character and aesthetic quality. There would be little change in the overall visual setting, both within the 200 Areas and Borrow Area C under the No Action Alternative. Under Alternatives 2 through 5, there would also be little change to the visual character of the 200 Areas due to their present highly developed state. However, the greater land area affected under the Alternative 6 options would result in a noticeable increase in the industrial nature of the 200 Areas as viewed from nearby higher elevations (i.e., Gable Mountain, Gable Butte, and Rattlesnake Mountain). With respect to visual impacts resulting from mining activities at Borrow Area C, Alternative 2 would result in a moderate change to the area as viewed from nearby higher elevations (principally Rattlesnake Mountain) and State Route 240. Due to the greater acreage affected, the remaining alternatives would result in a highly noticeable change to the appearance of Borrow Area C.

2.8.1.2 Infrastructure

Site infrastructure includes physical resources encompassing the utility systems required to support the construction, operations, and deactivation of facilities associated with tank waste storage, retrieval, treatment, and disposal and tank closure. It includes the electric power supply system; natural gas and liquid fuel (i.e., fuel oil, diesel fuel, and gasoline) availability and delivery capacity (see Table 2–9); and water supply system capacity. From the standpoint of total resource use, Alternative 6A would have the highest demand for all utility infrastructure resources, with the Alternative 6A Option Case having slightly higher total demands for electricity and diesel fuel than the Base Case. This is because this alternative would have the highest construction demands coupled with the longest period of WTP operations, 145 years, as well as clean closure of the SST system. It would be necessary to construct replacement WTP facilities twice as the predecessor facilities reach the end of their operational lifetimes. Other activities that support the waste retrieval and treatment activities would likewise be extended for longer time periods than would be the case under the other alternatives. In total, the active project phase would span 161 years.

Of Alternatives 1 through 5, Alternative 2A would have the highest demand for all utility infrastructure resources. Demands would be driven by 75 years of WTP operations, with a 90-year active project phase during which WTP and other facilities would be replaced once. Consequently, total electricity and water usage, for example, would be about two times greater under Alternative 2A on average than under Alternatives 1 through 5. The projected resource requirements among Alternatives 2B, 3A–3C, 4, 5, and 6C fall within relatively narrow ranges for most utilities. Total projected electricity requirements range between 12.1 and 20.1 million megawatt-hours. For electricity, projected peak annual demands under both Alternative 6A Base and Option Cases would exceed the current capacity of the Hanford transmission system. Projected water usage ranges between 77,000 million and 92,500 million liters (20,340 million and 24,440 million gallons). Peak annual water demand would not exceed the capacity of the Hanford export water system under any alternative and would be substantially less than the 200 Areas' historical average annual water use. Total diesel fuel consumption would range from 1,860 million to 4,110 million liters (491 million to 1,086 million gallons). Liquid fuels are not considered to be a limiting resource, as additional supplies can be trucked to the point of use as needed

from offsite suppliers. Overall, compared to Alternative 1, Alternative 3B would have the lowest total electricity requirement, and Alternatives 3A and 3B would have the lowest total diesel fuel requirement and the lowest water requirements. Under Alternatives 2B, 3A–3C, 4, 5, and 6C, the WTP would operate for 26, 22, 25, 16, and 26 years, respectively. Alternative 2A would not implement SST system closure, while Alternatives 2B, 3A, 3B, and 5 evaluate landfill closure of the SST system. Alternative 4 evaluates selective clean closure/landfill closure.

2.8.1.3 Noise and Vibration

Noise is undesirable sound that interferes negatively with the human or natural environment. Noise may disrupt normal activities (e.g., hearing, sleep), damage hearing, or diminish the quality of the environment. Noise impacts may result from construction, operations, deactivation, and closure activities, including increased traffic. Noise impacts of onsite activities under all alternatives would be negligible. Following the end of WTP construction under the No Action Alternative, some reduction in noise levels could result, and traffic noise levels could decrease. Noise impacts of traffic would be highest under the Alternative 6B Option Case, which would have the highest peak employment and employee vehicle traffic associated with WTP operation and PPF construction. The increase in employee traffic noise along the road to the site during peak hours (shift changes) could be noticeable to residents along these routes. Alternative 3C would have the highest offsite truck traffic associated with steam reforming operations. Noise impacts of onsite activities and traffic under other alternatives would be negligible to minor.

2.8.1.4 Air Quality

Air pollution refers to any substance in the air that could harm human or animal populations, vegetation, or structures or that unreasonably interferes with the comfortable enjoyment of life and property. As modeled, nonradiological air pollutant concentrations under all alternatives would exceed the applicable 24-hour ambient standards for particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) and 10 micrometers (PM_{10}) and, under Alternatives 2A, 3A, 3B, 3C, and 5, would exceed the carbon monoxide applicable 1-hour ambient standard. Nonradiological air quality impacts of $PM_{2.5}$ and PM_{10} would be highest under Alternatives 6A Base and 6B Base Cases. Under these alternatives, $PM_{2.5}$ and PM_{10} (24-hour averaging) concentrations in the peak year would be attributable primarily to fugitive dust from heavy-equipment operations during modified RCRA Subtitle C barrier construction.

Particulate matter emissions estimated for construction-type activities include fugitive dust emissions from construction areas and account for dust suspended by equipment and vehicle activity and by wind. The emission factor used for these estimates is intended to provide a gross estimate of total suspended particulate emissions when more-detailed engineering data of a construction activity are not available that would allow for a more-refined estimate of dust emissions. For the purpose of this analysis, $PM_{2.5}$ and PM_{10} emissions from general construction activities were assumed to be the same as the total suspended particulate emissions. This results in a substantial overestimate of $PM_{2.5}$ and PM_{10} emissions. Further, the analysis did not consider appropriate emission controls that could be applied in the construction areas, as discussed in Chapter 4, Section 4.9.2. A refined analysis of emissions, based on more-detailed engineering data of the construction activities and application of appropriate control technologies, is expected to result in substantially lower projected emissions and ambient concentrations from the major construction activities under these alternatives. Maximum air quality impacts of particulate matter are expected to occur along State Route 240, along or near the Hanford boundary to the east to southeast, or along the Hanford boundary to the southwest.

The Clean Air Act, as amended (40 U.S.C. 7401 et seq.), requires that Federal actions conform to the host state's "state implementation plan." A state implementation plan provides for the implementation,

maintenance, and enforcement of National Ambient Air Quality Standards (NAAQS) for the six criteria pollutants: sulfur dioxide, PM_{10}, carbon monoxide, ozone, nitrogen dioxide, and lead. Its purpose is to eliminate or reduce the severity and number of NAAQS violations and to expedite the attainment of these standards. "No department, agency, or instrumentality of the Federal Government shall engage in or support in any way or provide financial assistance for, license or permit, or approve any activity that does not conform to an applicable implementation plan." The final rule for "Determining Conformity of General Federal Actions to State or Federal Implementation Plans" (40 CFR 51.850–51.860) took effect on January 31, 1994. Hanford is within an area currently designated as attainment for criteria air pollutants. Therefore, the alternatives considered in this EIS do not require a conformity determination under the provisions of this rule (40 CFR 81.348).

Maximum concentrations of nonradiological toxic air pollutants off site and in areas to which the public has access would be less than 70 percent of the state's acceptable source impact levels. Maximum concentrations of carcinogenic toxic pollutants would be less than 8 percent of the state's acceptable source impact levels. Acceptable source impact levels are used during the permitting process to demonstrate that emissions from a new toxic air pollutant source are sufficiently low to protect human health and safety from potential carcinogenic and/or other toxic effects. Comparison of the estimated concentrations to acceptable source impact levels indicates that emissions under all Tank Closure alternatives would be sufficiently low to protect human health and safety. Impacts of radiological air emissions are summarized in Section 2.8.1.10.

2.8.1.5 Geology and Soils

Geologic resources include consolidated and unconsolidated earth materials, including rock and mineral assets such as ore and aggregate materials (e.g., sand, gravel) and fossil fuels such as coal, oil, and natural gas. Soil resources include the loose surface materials of the earth in which plants grow. Impacts on geology and soils under the Tank Closure alternatives would generally be directly proportional to the total area of land disturbed by site grading and soil compaction and by the depth of excavation associated with construction of new facilities and to support tank farm closure. Consumption of geologic resources would constitute the major indirect impact on geology and soils. Incremental impacts on geology and soils under Alternative 1 would be negligible, as ongoing facility construction and tank farm upgrades would be confined to previously disturbed areas. Somewhat similarly to that described above for land use, new permanent land disturbance would be similar under Alternatives 2B through 5, ranging from 111 hectares (274 acres) to 138 hectares (341 acres) (see Table 2–9), with short-term construction impacts on geology and soils resulting principally from wind and water erosion expected to be small. Impacts associated with Alternatives 2A and 6C would fall below and beyond the range described, respectively. Alternatives 6A and 6B would result in the greatest land disturbance and potential for impacts on geology and soils, with new permanent land disturbance ranging from 356 hectares (879 acres) under the Alternative 6B Base Case to 781 hectares (1,930 acres) under the Alternative 6A Option Case. Potential impacts on geology and soils would be greatest under Alternatives 6A and 6B due to the larger facility construction demands and the extensive excavation work required for clean closure of all tank farms, requiring multiple deep soil excavations ranging from 20 meters (65 feet) to as much as 78 meters (255 feet) in depth. Projected requirements for geologic resources, including rock/basalt, sand, gravel, and soil for such uses as concrete aggregate or grout materials and borrow material for backfill and landfill barrier construction, as appropriate, would be relatively similar under Alternatives 2B through 5, ranging from 4,280,000 cubic meters (5,600,000 cubic yards) under Alternative 3B to 5,380,000 cubic meters (7,037,000 cubic yards) under Alternative 5. Geologic resource requirements would be highest under the Alternative 6A Option Case at 26,000,000 cubic meters (34,000,000 cubic yards) due to extensive facility construction combined with clean closure requirements. While the volume of aggregate and other borrow materials would be very large under some alternatives, the demands are not expected to deplete Hanford reserves of these materials under any alternative, as they are widely available in the Hanford region.

2.8.1.6 Water Resources

Water resources are the surface and subsurface waters that are suitable for human consumption, aquatic or wildlife use, agricultural purposes, irrigation, or industrial/commercial purposes. No additional impacts on availability or quality of surface-water or groundwater resources are expected in the short term under Alternative 1. No direct disturbance to surface-water features, including the Columbia River, is expected to occur in the short term under any alternative, as there are no natural, perennial surface-water drainages on the Central Plateau of Hanford. Construction-related land disturbance would expose soils and sediments to possible erosion, and stormwater runoff from exposed areas could convey soil, sediments, and other pollutants from construction sites. Adherence to appropriate soil erosion and sediment control measures would serve to minimize any potential water quality impacts, as described in the water resources sections of Chapter 4, Section 4.1.6. There would be no direct discharge of effluents to either surface waters or groundwater during construction, operations, deactivation, or closure activities under any alternative. Effluents would be managed by appropriate Hanford treatment facilities. Water would be required during all project phases. Under all action alternatives, peak annual water demands would be substantially less than the production capacity of the Hanford export water system that withdraws water from the Columbia River. Demand is not expected to have a substantial impact on the availability of surface water from the Columbia River for downstream users.

With the exception of Alternatives 4, 6A, and 6B, facility construction, operations, deactivation, and landfill closure would be unlikely to have any impact on groundwater hydrology or existing contaminant plumes under any alternative. Deep excavation to effect clean closure of the BX and SX tank farms under Alternative 4 and clean closure of all 12 tank farms under Alternatives 6A and 6B may require construction dewatering and could locally affect groundwater flow and existing contaminant plumes beneath the tank farms. During normal operations in the short term, impacts on the vadose zone and groundwater in the 200 Areas would be due to leaks from the tank system during retrieval operations and from effluent disposal. These additional retrieval releases would be essentially recovered under Alternatives 6A and 6B, but would add to other historical releases under all other alternatives. Landfill barriers constructed under Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C would delay, but not prevent, downgradient movement of contaminants over the long term to the unconfined aquifer system and ultimately to the Columbia River, as further summarized in Section 2.9.1.

While portions of the probable maximum flood zone associated with Cold Creek lie within the confines of Borrow Area C, production operations associated with material extraction to support tank closure and waste management activities would be conducted to avoid impacting the watercourse and associated floodplain. Any changes in the extent and nature of predicted mining that could impact the floodplain would be evaluated, and a floodplain assessment would be prepared as required by Executive Order 11988, *Floodplain Management*, and Federal regulations (10 CFR 1022).

2.8.1.7 Ecological Resources

Ecological resources include terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Sagebrush habitat is an important regional community that is considered a priority habitat within Washington State and a Level III resource under the *Hanford Site Biological Resources Management Plan* (DOE 2001). In most cases, mitigation in the form of replacement at a rate of from 1:1 to 3:1 would be required. Sagebrush habitat would not be disturbed within the 200 Areas under the No Action Alternative; however, it would be impacted under the remaining alternatives. Under Alternative 2A, 14.2 hectares (35 acres) would be affected, while Alternatives 2B through 5 would impact from 1.2 hectares (3 acres) to 4.9 hectares (12.1 acres). The Alternative 6 subalternatives would disrupt the greatest area of sagebrush habitat—182 hectares (450 acres) under Alternative 6A (both options); 98.3 hectares (243 acres) under Alternative 6B (both options); and 46.1 hectares (114 acres) under

Alternative 6C. Because there is no sagebrush habitat within Borrow Area C, it would not be disturbed under any of the alternatives.

Because at present no federally or state-listed threatened or endangered species are recorded as occurring within the 200 Areas or Borrow Area C, this group of species would not be affected under any alternative. Under the No Action Alternative, no state-listed special status species would be affected within the 200 Areas; however, the potential exists to impact four such species within Borrow Area C. In fact, each of the remaining alternatives has the potential to impact the same four species within Borrow Area C, with those alternatives requiring more acreage having the greater potential. Within the 200 Areas, two state-listed special status species could be affected under Alternative 2B, four under Alternatives 6B (both Base and Option Cases), and six under the remaining alternatives.

Due to the lack of wetlands and aquatic resources within the 200 Areas and Borrow Area C, there would be no impact on these resources under any of the alternatives.

2.8.1.8 Cultural and Paleontological Resources

Cultural resources are the indications of human occupation and use of property, as defined and protected by a series of Federal laws, regulations, and guidelines, and are categorized as prehistoric resources, historic resources, and American Indian interests. Prehistoric resources are the physical remains of human activities that predate written records. Historic resources consist of physical remains that postdate the emergence of written records. American Indian interests include sites, areas, and materials important to American Indians for religious or heritage reasons. Paleontological resources are the physical remains, impressions, or traces of plants or animals from a former geologic age and may be sources of information on ancient environments and the evolutionary development of plants and animals.

Under the Tank Closure alternatives, there would be no impact on prehistoric or paleontological resources, as none are located in the project area. None of the proposed alternatives would have an impact on prehistoric or historic resources at Hanford that are either listed or eligible for listing on the National Register of Historic Places. Sites containing early historic resources (i.e., cans and bottles) could be impacted under the Alternative 6 subalternatives; however, these sites are not eligible for listing on the National Register of Historic Places. The viewscape from nearby higher elevations (i.e., Gable Mountain, Gable Butte, and Rattlesnake Mountain) is important to American Indians with cultural ties to Hanford. There would be little change in the overall visual setting under the No Action Alternative. The greater the land area affected, the more-noticeable increase there would be in industrial appearance as viewed from these higher elevations. Alternatives 6A, 6B, and 6C would have the greatest impact on the viewshed.

2.8.1.9 Socioeconomics

Socioeconomic impacts are defined in terms of changes to demographic and economic characteristics of a region. The socioeconomic environment is generally made up of regional economic indicators and demographic characteristics of the area. Economic indicators include employment, the civilian labor force, and unemployment rates. Demographic characteristics include population, housing, education, and health information. In addition, the projected workforce and work activities could potentially impact the local transportation and result in level-of-service impacts on the roads in the region of influence (ROI) (i.e., the Tri-Cities).

Except for the No Action Alternative, all other alternatives have a potential for socioeconomic impacts in the ROI. The impacts would be greatest under the Alternative 6B Option Case (10,300 full-time equivalents [FTEs] annually in 2021 and 2022) and similar under the Alternative 6A Option Case (10,100 FTEs annually in 2041). These peak year workforce requirements would be primarily in support of WTP operations and PPF construction needed for clean closure. Under Alternative 3C, the number of

daily offsite truck loads could potentially be higher in support of the steam reforming supplemental treatment activities. The increase in direct employment at Hanford under these alternatives and associated indirect employment in the region would result in appreciable changes in the socioeconomic ROI, including increases in population, demand and cost for housing and community services, and level-of-service impacts on local transportation systems in the Tri-Cities area.

2.8.1.10 Public and Occupational Health and Safety—Normal Operations

A description of the radiological releases resulting from construction, operations, deactivation, and closure activities under each alternative is provided in Chapter 4 of this *TC & WM EIS*. The impacts on both the public and workers are estimated. For the public, impacts on the population near Hanford, the maximally exposed individual (MEI), and an onsite MEI are evaluated; for workers, the focus is on impacts to on site radiation workers. The measure of impact is the number or risk of health effects (e.g., latent cancer fatalities [LCFs]) among the public or workers. Potential impacts to workers from exposure to chemicals are also addressed.

Maximally Exposed Individual (MEI)

A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure). As used in this environmental impact statement, the MEI refers to an individual located off site, unless characterized otherwise in terms of time or location.

Latent Cancer Fatalities

Deaths from cancer resulting from, and occurring sometime after, exposure to ionizing radiation or other carcinogens.

Rem

A rem is a unit of dose equivalent that allows comparison of the biological effects of radionuclides that emit different types of radiation.

Person-rem

A person-rem is a unit of collective radiation dose applied to populations or groups; it is a unit for expressing dose when summed across all persons in a specified population or group.

The largest radiological impact on the public within 80 kilometers (50 miles) of the 200 Areas over the life of the project is estimated to be under Alternative 2A (1,100 person-rem). The estimated dose is higher for this alternative because of the continuing radiological air emissions from residual material in tanks during the 100 years of administrative control following the removal and processing of tank waste. Alternative 3B would result in the smallest radiological impact on the public (380 person-rem). The smaller impact compared to other action alternatives is due to the use of the nonthermal cast stone process for treating a portion of the tank waste and the associated low emissions. Public doses over the life of the project from the remaining alternatives would range from a little less than 500 person-rem (Alternatives 2B, 4, 5, and 6C) up to about 760 person-rem (Alternative 6A). Under Alternatives 6A and 6B, the option to retrieve and process contaminated soils from six sets of cribs and trenches (ditches) would add about 100 to 200 person-rem to the public dose. The projected number of LCFs calculated to occur in the population would be either 0 or 1 under all alternatives. Projections of an LCF in the population surrounding Hanford are based on a large number of people receiving small doses over many years—for some alternatives, the doses are received over several generations.

Risk to individual members of the public would be less than the calculated dose and risk to an MEI. The estimated dose to an MEI in the year of peak impact under all alternatives is less than the National Emission Standards for Hazardous Air Pollutants limit of 10 millirem per year (40 CFR 61.90–61.97). The smallest impact (0.13 millirem per year) would be associated with Alternative 1, under which no waste processing would occur; impacts of the other alternatives would be nominally the same (1.4 to 1.7 millirem per year), with the peak occurring in the year that materials from the cesium and strontium capsules are processed through the WTP. The largest annual incremental risk of an LCF to an MEI would be about 1 in 1 million. Impacts of nonradiological air emissions are summarized in Section 2.6.3.4.

Impacts on an onsite MEI, defined as a member of the public who spends a normal workday at a facility on Hanford that is not under the auspices of DOE, were also evaluated. The maximum annual impact on an onsite MEI, assumed to be at the Columbia Generating Station or the Laser Interferometer Gravitational-Wave Observatory, would be 0.018 millirem under Alternative 1 (annual risk of an LCF of about 1 in 93 million) and about 0.058 millirem (annual risk of an LCF of about 1 in 29 million) under the other alternatives except Alternatives 2B, 6B, and 6C. Under Alternatives 2B, 6B, and 6C, the maximum annual dose would be about 0.097 millirem per year (annual risk of an LCF of about 1 in 17 million).

The collective radiation dose to workers over the life of the project would be lowest (280 person-rem) under Alternative 1. Collective worker doses for about half of the alternatives (2B, 3A, 3B, 3C, 5, and 6C) would range from 8,800 to 11,000 person-rem. Based on the dose-to-risk factor of 0.0006 LCFs per person-rem, these doses could result in 5 to 7 LCFs in the worker population. Alternative 2A would result in a collective worker dose of about 23,000 person-rem due to the longer time period during which waste processing would occur; this dose could result in 13 LCFs among the workers. The largest collective worker doses would be associated with alternatives that include removal of tanks and contaminated soil—Alternative 4 (43,000 person-rem), Alternative 6A (120,000 person-rem), and Alternative 6B (82,000 person-rem for the Base Case, 85,000 person-rem for the Option Case). Statistically, applying the risk coefficient of 0.0006 LCFs per person-rem would result in additional LCFs of 26, 72, and 49, respectively. It should be noted that for the larger doses and risks, the project extends over several generations of workers and that individual worker doses would be maintained less than the Administrative Control Level of 500 millirem per year (DOE Standard 1098-99).

Estimated average annual radiation worker doses are based on 2,080 hours per year of radiation work, but do not necessarily represent expected doses to individual radiation workers; a larger number of workers may be employed to complete work than the worker years imply, resulting in lower average doses to the actual workers. Estimated average doses per radiation worker per year range from 140 to 170 millirem under all alternatives except Alternatives 4, 6A, and 6B. The average annual risk of an individual developing an LCF from these doses would be 1 in 10,000 to 11,000. Alternative 4 (520 millirem per year), Alternative 6A (420 millirem per year), and Alternative 6B (870 millirem per year), which involve tanks and soil removal, would have the highest average annual radiation worker doses. The corresponding annual risks to an individual of developing an LCF would be 1 in 2,000 to 5,000. DOE and its contractors would employ engineering and administrative controls to manage individual radiation worker doses and ensure that they remain below the administrative control level.

Calculated doses to a noninvolved worker in the year of peak impact would be low under all alternatives. The conservatively calculated annual doses to the noninvolved workers would be less than 1 millirem, well below the DOE Administrative Control Level of 500 millirem per year (DOE Standard 1098-99).

Occupational hazards and possible exposure agents associated with work activities under the EIS alternatives are generally considered to be typical of DOE operations. No unique or extra-hazardous operations were identified during this evaluation. There have been, however, concerns about, and investigations into, exposure of tank farm workers to chemicals emitted from the tanks, as further discussed in Appendix K.

2.8.1.11 Public and Occupational Health and Safety—Facility Accidents

Processing any hazardous material creates a risk of accidents impacting involved workers (workers directly involved in facility processes), noninvolved workers (workers on the site but not directly involved in facility processes), and members of the public. The consequences of such accidents could involve the release of radioactive materials, toxic chemicals, or hazardous (e.g., explosive) energy, beyond the intended confines of the process. Risk is determined by the development of a representative spectrum of postulated accidents, each of which is conservatively characterized by a likelihood

(i.e., expected frequency of occurrence) and a consequence. For the Tank Closure alternatives presented in Table 2–9, the projected accident consequences are conditional on an accident's occurrence and therefore do not reflect an accident's frequency of occurring. Shown in this table is the accident with the highest projected consequences under each alternative. For Tank Closure Alternative 1, the event selected to represent a severe accident is the seismically induced waste tank dome collapse, whereas for all other alternatives it is a seismically induced collapse and failure of the WTP. For this latter accident, the contents of the HLW Vitrification Facility's melter feed-preparation vessels would be the largest contributors to consequences under the action alternatives. As a result, action Tank Closure Alternatives 2A through 5, 6B, and 6C, each of which is based on an HLW Vitrification Facility TMC of 6 metric tons of glass per day, would have the highest (identical) consequences. Tank Closure Alternative 6A would have considerably lower consequences for this accident, because there would be no pretreatment of the waste and therefore no Pretreatment Facility or LAW Vitrification Facility contributions to the accident source term. In addition, the contents of the HLW melter feed-preparation vessels would be diluted with LAW. The frequency of this accident is estimated to be 0.0005 per year (once in 2,000 years).

The accident risks shown in Table 2–9 take into account an accident's frequency. The annual risk value reflects the annual frequency of the accident. The risk over the life of the project reflects the duration of WTP operations, ranging from 16 to 145 years, during which that accident could occur. The risk over the life of the project from the seismically induced WTP collapse would be highest under Alternative 2A and lowest under Alternative 6A.

In accordance with DOE orders, DOE protects against intentional destructive acts aimed at its facilities and materials. Regardless of those protections, this EIS evaluates the potential impacts of intentional destructive acts in addition to conventional facility accident scenarios. Detonation of explosives in an underground storage tank was hypothesized; the radiological impacts of this scenario would be about 4 times greater than the impacts of the most severe accident scenario that involves the same inventory of radioactive material (seismically induced waste tank dome collapse—unmitigated). An aircraft or ground vehicle crash or explosions initiated by an insider at the HLW Vitrification Facility would result in radiological impacts about one-tenth of those calculated for the most severe accident scenario that involves the same inventory of radioactive material (seismically induced WTP collapse and failure—unmitigated). An intentional explosion causing massive damage to the WTP ammonia tank could result in life-threatening health effects or death at distances about 10 times farther than for the accident scenario that involves the same chemical inventory (tank failure with release of entire contents in 30 minutes). The potential for and consequences of the intentional destructive act scenarios are essentially the same under each of the alternatives, with the exception of Alternative 1: No Action, for which the scenarios involving the WTP would not apply. More-detailed discussion of intentional destructive act impacts associated with Tank Closure alternatives is provided in Chapter 4, Section 4.1.11.12.

2.8.1.12 Public and Occupational Health and Safety—Transportation

Transportation of any commodity involves a risk to both transportation crewmembers and members of the public. The risk results directly from transportation-related accidents and indirectly from the levels of pollution from vehicle emissions, regardless of the cargo. The transportation of certain materials, such as hazardous or radioactive waste, can pose additional risk due to the unique nature of the material itself. Except for the No Action Alternative, all other alternatives would generate various radioactive waste materials that would require their transport for disposition to offsite locations, such as WIPP, and onsite locations within Hanford. In addition, all alternatives would require transport of various nonradioactive materials for construction and operational support. Table 2–9 summarizes the transportation risks to the workers (transport drivers) and the public in terms of traffic fatalities and LCFs. Based on the results presented in this table, the following observations can be made:

- It is unlikely that the transportation of radioactive waste would cause an additional fatality as a result of radiation from either incident-free operations or postulated transportation accidents.

- The highest risk to the public would be under Tank Closure Alternative 4, where about 3,600 truck shipments of TRU waste would be transported to WIPP, and about 143,000 shipments of various radioactive waste materials would be transported to onsite waste burial and storage locations over a period of about 30 years.

- The lowest risk to the public would be under Tank Closure Alternative 2A, where about 105,000 shipments of various radioactive wastes would be transported to onsite waste burial and storage locations over a period of about 75 years.

- Tank Closure Alternatives 3 through 6 have risk estimates between those of Tank Closure Alternatives 2A and 4.

- The nonradiological accident risks (the potential for fatalities as a direct result of traffic accidents) present the greatest risks. The number of projected traffic accident fatalities ranges from 1 to 7 for the action alternatives. Considering that the transportation activities analyzed in this *TC & WM EIS* would occur from about 20 to over 150 years and the average number of traffic fatalities in the United States is about 40,000 per year, the traffic fatality risks under all alternatives would be relatively small.

2.8.1.13 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of their programs, policies, and activities on minority and low-income populations. Potential risks to human health from normal facility operations and postulated facility accidents are not expected to pose disproportionately high and adverse effects on minority or low-income populations surrounding Hanford under any Tank Closure alternative.

2.8.1.14 Waste Management

Tank waste retrieval, treatment, and disposal and tank closure would generate several types of waste: HLW, mixed TRU waste, LLW, MLLW, hazardous waste, and nonhazardous waste. The generation of waste could have an impact on existing Hanford facilities devoted to TSD. As described in Chapter 4, either the current waste management capacity is sufficient or the new infrastructure would be constructed under the alternative. Projected waste generation rates for the proposed activities were compared with Hanford's capacity to manage the waste, including the additional waste disposal capacity that is proposed to be constructed. Projected waste generation rates for the proposed activities were compared with site processing rates and capacities of those TSD facilities likely to be involved in managing the additional waste. Potential impacts of waste generated as a result of site environmental restoration activities unrelated to Tank Closure, FFTF Decommissioning, or Waste Management alternatives are not within the scope of this analysis. Where additional disposal capacity would be needed, the land use impacts are addressed in the appropriate sections of Chapter 4. The estimated full inventories of waste forms disposed of on site are included in the analyses of long-term impacts presented in Chapter 5 of this *TC & WM EIS*.

IHLW. Under all the alternatives, the IHLW glass canisters would be stored in new onsite facilities. Onsite canister storage capacity would be constructed under these alternatives, so there would be no impacts on the existing Hanford waste management system.

Other HLW. Under Tank Closure Alternatives 6A and 6B, other HLW would be generated. Under both alternatives, other HLW would consist of tank parts, equipment, and debris arising from the demolition and removal of all the SSTs. Under Alternative 6B, other HLW would also consist of vitrified waste in canisters that would come from the LAW Vitrification Facility. Because sufficient onsite storage capacity would be constructed under these alternatives, there would be no additional impacts on the existing Hanford waste management system.

Cesium and strontium capsules. Under all Tank Closure alternatives except Alternative 1, the cesium and strontium capsules would be processed for de-encapsulating and preparing the waste into a suitable WTP slurry feed. The waste slurry would then be stored in a DST prior to treatment through the WTP. This EIS analyzes the immobilization of the cesium and strontium slurry feed as a separate, 1-year-long WTP campaign; however, the cesium and strontium slurry feed could be mixed with the late-stage tank waste feed for consistency.

Under Tank Closure Alternative 1, the cesium and strontium capsules would be stored indefinitely in the WESF, in a manner similar to the present; therefore, construction of a new Cesium and Strontium Capsule Processing Facility would be unnecessary. Under all other alternatives analyzed in this EIS, the cesium and strontium waste would be vitrified in the WTP. It is estimated that an additional 340 canisters would be produced during the cesium and strontium treatment campaign.

WTP melters. Under all Tank Closure alternatives except Alternative 1, WTP HLW melters and LAW melters (and, in the case of Alternatives 6A, 6B, and 6C, PPF melters) would become a waste stream following service.

It is anticipated that the HLW melters would be stored on site. The LAW melters would be disposed of as MLLW under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5 and as HLW under Alternatives 6B and 6C. Storage of HLW melters is expected to result in no releases to the environment. Impacts of constructing and operating facilities with sufficient storage capacity under these Tank Closure alternatives for the WTP HLW and LAW melters are evaluated in the appropriate sections of this *TC & WM EIS*.

The LAW melters that are disposed of as MLLW would be disposed of in an RCRA-compliant, onsite IDF. The impacts of providing disposal capacity in an IDF are included in the disposal capacities of the corresponding Waste Management alternatives.

The PPF melters generated from processing soils contaminated by past tank leaks would be disposed of on site in an IDF. Disposal of the PPF melters is included in the disposal capacity of the corresponding Waste Management alternatives.

CH- and RH-mixed TRU waste. Sources of CH- and RH-mixed TRU waste would include secondary waste and, under Alternatives 3A, 3B, 3C, 4, and 5, waste forms derived from supplemental treatment of mixed TRU waste retrieved from the underground storage tanks.

The CH-mixed TRU waste would be treated and packaged using mobile units. The remainder of the mixed TRU waste has a high level of activity, necessitating use of a shielded facility and remote processing for treatment. A single facility for remotely processing the high-activity waste would be constructed in the 200-East Area. Impacts of constructing and operating facilities with additional mixed TRU waste treatment and certification capacity are evaluated in the appropriate sections of this *TC & WM EIS*.

For analysis purposes, it was assumed that all of the TRU waste would be disposed of at WIPP. The *WIPP SEIS-II* evaluated the receipt and disposal of 57,000 cubic meters (74,600 cubic yards) of CH- and 29,000 cubic meters (37,900 cubic yards) of RH-mixed TRU waste from Hanford (DOE 1997b). The

waste generated under all alternatives would be within the capacities allocated to Hanford in the *WIPP SEIS-II*. As reported in the *WIPP SEIS-II*, the Consultation and Cooperation Agreement with the State of New Mexico currently limits the volume of RH-TRU waste shipped to WIPP from all DOE sites to 7,080 cubic meters (9,260 cubic yards) (DOE 1997b:S-7).

LLW and MLLW. Secondary LLW (e.g., personal protective equipment, tools, filters, empty containers) would be generated during routine operations and the administrative control period. LLW is typically not treated or only minimally treated (e.g., compacted) before disposal. Therefore, this waste treatment would cause no impacts on the Hanford waste management system. The LLW would be sent directly to disposal. Therefore, long-term storage facilities would not be required.

Secondary MLLW (e.g., personal protective equipment, tools, job waste, and soil in the case of closure activities) would be generated during operations, deactivation, and closure. Using a combination of on- and offsite capabilities, secondary MLLW would be treated to meet RCRA land-disposal-restriction treatment standards prior to disposal.

Also included as MLLW are the PPF glass canisters generated from treatment of soils in the PPF under Tank Closure Alternatives 6A and 6B. The process would generate a liquid waste stream containing radionuclides and chemicals removed from the soils. A melter cell would be installed in the PPF to process this liquid waste into a PPF glass suitable for onsite disposal. This waste would be disposed of as MLLW on site in an IDF.

Under Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C, Waste Management Alternative 2, Disposal Group 1, or Waste Management Alternative 3, Disposal Group 1, would be chosen for the disposal of tank waste and all other LLW and MLLW. As described under Waste Management Alternative 2, IDF-East would be constructed and operated for the disposal of tank waste and all other LLW and MLLW; under Waste Management Alternative 3, two IDFs would be constructed and operated: IDF-East for tank waste only and IDF-West for the other LLW and MLLW. The RPPDF would be constructed and operated for disposal of lightly contaminated equipment and soils resulting from closure activities. Under Waste Management Alternative 2, Disposal Group 1, IDF-East and RPPDF operations would be completed in 2050, with IDF-East capacity at 1.2 million cubic meters (1.57 million cubic yards) and RPPDF capacity at 1.08 million cubic meters (1.41 million cubic yards). Under Waste Management Alternative 3, Disposal Group 1, IDF-East, IDF-West, and RPPDF operations would be completed in 2050. IDF-East's capacity would be at 1.1 million cubic meters (1.43 million cubic yards); IDF West's at 90,000 cubic meters (118,000 cubic yards); and the RPPDF's at 1.08 million cubic meters (1.41 million cubic yards). Under Waste Management Alternatives 2 and 3, the IDF(s) and RPPDF would be covered with engineered modified RCRA Subtitle C barriers to reduce water infiltration and potential for intrusion. A 100-year postclosure care period would follow.

Under Tank Closure Alternatives 2A and 6B, Waste Management Alternative 2, Disposal Group 2, or Waste Management Alternative 3, Disposal Group 2, would be chosen for disposal of tank waste and all other LLW and MLLW. As described under Waste Management Alternative 2, IDF-East would be constructed and operated for the disposal of tank waste and all other LLW and MLLW; under Waste Management Alternative 3, two IDFs would be constructed and operated: IDF-East for tank waste only and IDF-West for the other LLW and MLLW. Under Alternative 6B, the RPPDF would be constructed and operated for disposal of lightly contaminated equipment and soils resulting from clean closure activities. Under Waste Management Alternative 2, Disposal Group 2, IDF-East and RPPDF operations would be completed in 2100, with IDF-East capacity at 425,000 cubic meters (556,000 cubic yards) and RPPDF capacity at 8.37 million cubic meters (10.9 million cubic yards). Under Waste Management Alternative 3, Disposal Group 2, IDF-East and RPPDF operations would be completed in 2100, and IDF-West operations in 2050. IDF-East's capacity would be at 340,000 cubic meters (445,000 cubic yards); IDF-West's at 90,000 cubic meters (118,000 cubic yards); and the RPPDF's at 8.37 million cubic

meters (10.9 million cubic yards). Under both Waste Management action alternatives, the IDF(s) and RPPDF would be covered with engineered modified RCRA Subtitle C barriers to reduce water infiltration and potential for intrusion. A 100-year postclosure care period would follow.

Under Tank Closure Alternative 6A, Waste Management Alternative 2, Disposal Group 3, or Waste Management Alternative 3, Disposal Group 3, would be chosen for disposal of tank waste and all other LLW and MLLW. As described under Waste Management Alternative 2, IDF-East would be constructed and operated for the disposal of tank waste and all other LLW and MLLW; under Waste Management Alternative 3, two IDFs would be constructed and operated: IDF-East for tank waste only and IDF-West for the other LLW and MLLW. Under Alternative 6C, the RPPDF would be constructed and operated for disposal of lightly contaminated equipment and soils resulting from closure activities. Under Waste Management Alternative 2, Disposal Group 3, IDF-East and RPPDF operations would be completed in 2100, with IDF-East capacity at 425,000 cubic meters (556,000 cubic yards) and RPPDF capacity at 8.37 million cubic meters (10.9 million cubic yards). Under Waste Management Alternative 3, Disposal Group 3, IDF-East and RPPDF operations would be completed in 2165, and IDF-West operations in 2050. IDF-East's capacity would be at 340,000 cubic meters (445,000 cubic yards); IDF-West's at 90,000 cubic meters (118,000 cubic yards); and the RPPDF's at 8.37 million cubic meters (118,000 cubic yards). Under both Waste Management Alternatives 2 and 3, the IDF(s) and RPPDF would be covered with engineered modified RCRA Subtitle C barriers to reduce water infiltration and potential for intrusion. A 100-year postclosure care period would follow.

Under Tank Closure Alternatives 1, 2, and 3, trenches 31 and 34 and the existing LLBGs would continue to receive LLW and MLLW from onsite non-CERCLA generators. Under Tank Closure Alternative 1, waste would be received until 2035, and under Tank Closure Alternatives 2 and 3, waste would be received until filled to capacity but not later than 2050. No construction activities would be necessary because the trenches are in current operation.

Hazardous waste. Hazardous waste is dangerous waste as defined in the *Washington Administrative Code* (WAC 173-303). Hazardous waste generated during construction and operations would be packaged in DOT-approved containers and shipped off site to permitted commercial recycling, treatment, and disposal facilities. Under all Tank Closure alternatives except Alternative 1, during the period of active construction, operations, and closure, the average annual hazardous waste generation rate would include two peak years with generation of approximately 31,500 cubic meters (41,200 cubic yards). Management of the additional waste generated under the Tank Closure alternatives would require additional planning, coordination, and establishment of satellite accumulation areas, but because the waste would be treated and disposed of at offsite commercial facilities, the additional waste load would have a minor impact at Hanford.

Nonhazardous waste. Any nonhazardous solid waste generated during facility construction, operations, deactivation, and closure under the Tank Closure alternatives would be packaged and transported in conformance with standard industrial practice. Solid waste such as office paper, metal cans, and plastic and glass bottles that can be recycled would be sent off site for that purpose. The remaining nonhazardous solid waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

Liquid process waste. Process waste, including liquid secondary LLW, would be generated by the activities performed to retrieve, separate, and treat tank waste. Process waste and dilute process waste, such as cooling waters or steam condensates, would be routed to the Hanford facilities, whose mission it is to manage such wastes, as applicable. It is assumed that the ETF and the TEDF, or their equivalents, would continue to be available to manage process liquids generated under the Tank Closure alternatives.

2.8.1.15 Industrial Safety

In addition to facility accident risks, estimates of potential industrial safety impacts on workers during construction, operations, deactivation, and closure activities under each alternative were evaluated based on the DOE complex–wide computerized Accident/Incident Reporting System database (see Appendix K, Section K.4). These impacts correlate with the number of labor hours required to support each Tank Closure alternative and are classified into two groups: total recordable cases (TRCs) and fatalities. A recordable case includes work-related deaths, illnesses, or injuries leading to loss of consciousness, lost workdays, transfer to another job, and/or requiring medical treatment beyond first aid.

Table 2–9 summarizes the potential number of TRCs and fatalities resulting from the construction, operations, deactivation, and closure activities that would be conducted under each Tank Closure alternative. The fewest projected industrial safety impacts would occur under Tank Closure Alternative 1, as the No Action Alternative would require the least amount of worker labor. Under the Tank Closure action alternatives, the fewest projected impacts would occur under Tank Closure Alternative 5, which is expected to result in approximately 3,300 TRCs and no worker fatalities. In contrast, the highest projected impacts would occur under the Tank Closure Alternative 6A Option Case, which could result in more than 26,200 TRCs and three fatalities.

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Land Resources											
Land Use (percent of total land commitment within either the Industrial-Exclusive Zone or Borrow Area C, as appropriate)	17 hectares (0.3 percent) committed to tank closure within the Industrial-Exclusive Zone. 2 hectares (0.2 percent) affected within Borrow Area C	49.4 hectares (1 percent) committed to tank closure within the Industrial-Exclusive Zone. 27.5 hectares (3 percent) affected within Borrow Area C.	100 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 94.7 hectares (10 percent) affected within Borrow Area C.	102 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 101 hectares (11 percent) affected within Borrow Area C.	102 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 93.5 hectares (10 percent) affected within Borrow Area C.	102 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 93.9 hectares (10 percent) affected within Borrow Area C.	78.6 hectares (1.6 percent) committed to tank closure within the Industrial-Exclusive Zone. 102 hectares (11 percent) affected within Borrow Area C.	104 hectares (2.1 percent) committed to tank closure within the Industrial-Exclusive Zone. 118 hectares (13 percent) affected within Borrow Area C.	236 hectares (4.7 percent) committed to tank closure within the Industrial-Exclusive Zone. 86.2 hectares required outside of Industrial-Exclusive Zone. 494 hectares (53 percent) affected within Borrow Area C. *Option Case* 210 hectares (4.1 percent) committed to tank closure within the Industrial-Exclusive Zone. 86.2 hectares required outside of Industrial-Exclusive Zone. 571 hectares (62 percent) affected within Borrow Area C.	142 hectares (2.8 percent) committed to tank closure within the Industrial-Exclusive Zone. 86.2 hectares required outside of Industrial-Exclusive Zone. 239 hectares (26 percent) affected within Borrow Area C. *Option Case* 117 hectares (2.3 percent) committed to tank closure within the Industrial-Exclusive Zone. 86.2 hectares required outside of Industrial-Exclusive Zone. 316 hectares (34 percent) affected within Borrow Area C.	145 hectares (2.9 percent) committed to tank closure within the Industrial-Exclusive Zone. 104 hectares (11 percent) affected within Borrow Area C.

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Land Resources *(continued)*											
Visual resources	Little change in the overall visual character of the 200 Areas and Borrow Area C.	Little change in the overall visual character of the 200 Areas and moderate change to Borrow Area C.	Little change in the overall visual character of the 200 Areas and a highly noticeable change to Borrow Area C, especially as seen from State Route 240 and nearby higher elevations.						Highly noticeable change in the visual character of both the 200 Areas and Borrow Area C, especially as seen from State Route 240 and nearby higher elevations.	Noticeable change to the visual character of the 200 Areas and a highly noticeable change to Borrow Area C, especially as seen from State Route 240 and nearby higher elevations.	
Infrastructure											
Total Requirements											
Electricity (million megawatt-hours)	0.12	35.6	17.9	14.1	12.1	20.1	14.8	12.2	186 *188*	21.1 *23.8*	17.9
Diesel fuel (million liters)	35.9	4,950	4,040	1,860		1,980	2,050	4,110	23,100 *23,200*	4,360 *4,440*	4,040
Gasoline (million liters)	4.61	218	156	116			133	124	723 *720*	216 *212*	156
Water (million liters)	3,300	208,000	86,300	77,000		77,300	82,200	92,500	644,000 *644,000*	92,600 *92,800*	86,300
Peak Annual Demand											
Electricity (million megawatt-hours)	0.035	0.56	1.16	0.78	0.47	0.83	0.55	0.62	1.94 *1.97*	1.24 *1.28*	1.16
Diesel fuel (million liters)	11.8	112	271	80.8	81.2	86.1	76.2	229	234 *237*	255 *259*	271

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Infrastructure *(continued)*											
Peak Annual Demand (continued)											
Gasoline (million liters)	1.0	5.33	8.18	5.03			10.9	5.89	8.95 *7.54*	6.56 *6.58*	8.18
Water (million liters)	1,090	3,720	3,560	2,180		2,190	2,180	3,800	6,580 *6,580*	3,500 *3,500*	3,560
Noise and Vibration											
	Current noise levels reduced following WTP construction.	Negligible offsite impact of onsite activities. Minor traffic noise impacts.									
Air Quality											
Peak Year Incremental Criteria Pollutant Concentrations as Compared to Most Stringent Guideline or Standard (micrograms per cubic meter)[a]											
Carbon monoxide (1-hour) standard=40,000	23,300	**40,600**	36,300	**56,600**	**57,700**	**57,600**	35,700	**47,300**	31,900 *22,400*	34,200 *34,200*	33,600
Nitrogen oxides (annual) standard=100	8.56	18.4	20.4	17.9	18.1		13.1	21.1	19.3 *14.9*	14.2 *14.7*	20.4
PM_{10} (24-hour) standard=150	**546**	**1,600**	**4,510**				**2,960**	**4,920**	**5,040** ***3,650***	**5,110** ***1,690***	**4,570**
Sulfur oxides (1-hour) standard=660	24.0	64.6	99.4	126	82.1	81.6	71.8	106	53.3 *41.6*	65.4 *70.3*	99.5
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[a]											
Ammonia (24-hour) ASIL[b]=100	26.1	19.6	11.7	11.9		12.0	11.8	12.0	10.2 *9.91*	11.9 *11.9*	11.4
Benzene (annual) ASIL[b]=0.12	0.00264	0.00592	0.00456	0.00602	0.00627	0.00602	0.00344	0.00594	0.00479 *0.00278*	0.00460 *0.00355*	0.00458

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Air Quality *(continued)*											
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[a] (continued)											
Toluene (24-hour) ASIL[b]=400	1.69	4.07	3.40	5.78	6.03	5.78	2.77	5.19	3.50 *2.34*	3.73 *2.58*	3.40
Xylene (24-hour) ASIL[b]=1,500	0.51	1.22	1.03	1.71	1.78	1.71	0.82	1.55	1.07 *0.68*	1.13 *0.77*	1.03
Geology and Soils											
Construction impacts	Negligible, incremental impact on geology and soils.	Small impact from construction, including potential for short-term soil erosion. Excavation depths limited to 12 meters.					Similar to Alternatives 2A through 3C, except extensive excavation work required for clean closure of BX and SX tank farms, with excavation depths of 20 meters to as much as 78 meters.	Similar to Alternatives 2A through 3C.	Similar to Alternatives 2A through 3C, except extensive excavation work required for clean closure of all tank farms, with excavation depths of 20 meters to as much as 78 meters.		Similar to Alternatives 2A through 3C.
New permanent land disturbance (hectares)	2	59.8	111	118	112	112	120	138	704 *781*	356 *433*	165
Geologic resource requirements, i.e., fill from Borrow Area C (cubic meters)	92,800	1,250,000	4,330,000	4,610,000	4,280,000	4,290,000	4,660,000	5,380,000	22,500,000 *26,000,000*	10,900,000 *14,400,000*	4,750,000

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Water Resources											
Surface water	No additional impact on surface water in the short term. Water use and wastewater generation and discharges would decrease from current levels.	Short-term increase in stormwater runoff during construction, but no direct disturbance to surface-water features. No direct, routine discharge of effluents during operations to surface waters or to the subsurface. Water use would not exceed site capacity. Activities in Borrow Area C could encroach on the probable maximum flood zone associated with Cold Creek, especially under Alternatives 6A and 6B.									
Vadose zone and groundwater	No additional impact in the short term.	Potential for SST retrieval leaks in the short term without any recovery once in the subsurface. Groundwater mounds could begin to re-expand due to increased discharge of sanitary wastewater, nonhazardous process wastewater, and treated radioactive liquid effluents to onsite treatment and disposal facilities during waste treatment.					Potential for retrieval leaks similar to Alternatives 2A through 3B. Deep soil excavation for selective clean closure would require dewatering and could locally affect groundwater flow and contaminant plumes.	Similar to Alternatives 2A through 3C.	Potential for SST retrieval leaks in the short term. Deep soil excavation for clean closure would require dewatering and could locally affect groundwater flow and contaminant plumes.		Similar to Alternatives 2A through 3C.

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Ecological Resources											
Terrestrial resources	No additional disturbance to sagebrush habitat in the 200 Areas.	14.2 hectares of sagebrush habitat affected in the 200 Areas.	1.2 hectares of sagebrush habitat affected in the 200 Areas.	4 hectares of sagebrush habitat affected in the 200 Areas.	4.9 hectares of sagebrush habitat affected in the 200 Areas.	4.8 hectares of sagebrush habitat affected in the 200 Areas.	4.4 hectares of sagebrush habitat affected in the 200 Areas.		182 hectares of sagebrush habitat affected within the 200 Areas under both Base and Option Cases.	98.3 hectares of sagebrush habitat affected within the 200 Areas under both Base and Option Cases.	46.1 hectares of sagebrush habitat affected in the 200 Areas.
	No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.		No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.	No sagebrush habitat affected within Borrow Area C.
Wetlands	No impact on wetlands within 200 Areas or Borrow Area C.										
Aquatic resources	No impact on aquatic resources within 200 Areas or Borrow Area C.										
Threatened and endangered species	No impact on any federally or state-listed threatened or endangered species.	No impact on any federally or state-listed threatened or endangered species.	No impact on any federally or state-listed threatened or endangered species.	No impact on any federally or state-listed threatened or endangered species.					No impact on any federally or state-listed threatened or endangered species under both Base and Option Cases.		No impact on any federally or state-listed threatened or endangered species.
	No impact on state-listed species within the 200 Areas.	Potential impacts on 4 state-listed species.	Potential impacts on 2 state-listed species.	Potential impacts on 6 state-listed special status species.					Potential impacts on 6 state-listed special status species under both Base and Option Cases.		Potential impacts on 4 state-listed special status species.
	Minimum potential for impact on 4 state-listed species within Borrow Area C.	Potential impacts on 4 state-listed species within Borrow Area C.	Potential impacts on 4 state-listed species within Borrow Area C.	Potential impacts on 4 state-listed special status species within Borrow Area C.					Potential impacts on 4 state-listed special status species within Borrow Area C under both Base and Option Cases.		Potential impacts on 4 state-listed special status species within Borrow Area C.

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Cultural and Paleontological Resources											
Prehistoric resources	No impact on prehistoric resources.										
Historic resources	No impact on historic resources.								Impact on National Register–ineligible resources (i.e., areas where old cans and bottles were disposed of).		
American Indian interests	The 2 hectares (5 acres) of Borrow Area C that would be excavated would be noticeable from higher elevations but would not dominate the view.	The 27.5 hectares (68 acres) excavated from Borrow Area C would be readily visible from Rattlesnake Mountain and higher elevations. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	The 200-East and 200-West Area containment structures and closure barriers would be visible from higher elevations. 94.7 hectares (234 acres) of Borrow Area C would be excavated. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	Impacts would be similar to Alternative 2B. An additional 6.1 hectares (15 acres) of land would be disturbed within Borrow Area C.	Impacts would be similar to Alternative 2B. Excavated land in Borrow Area C would be slightly less (1.2 hectares [3acres]) but the visual impacts would be similar.	Impacts would be similar to Alternative 2B. Nearly the same amount of geologic material would be required from Borrow Area C (93.9 hectares [232 acres]).	Impacts would be similar to Alternative 2B. An additional 7.3 hectares (18 acres) of land would be disturbed.	Impacts would be similar to Alternative 2B. 118 hectares (291 acres) of Borrow Area C would be excavated. This would be readily visible from Rattlesnake Mountain and higher elevations. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	Construction of facilities would noticeably add to the industrial nature of the 200 Areas; 494 hectares (1,220 acres) of Borrow Area C would be excavated. This would be readily visible from Rattlesnake Mountain. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	Impacts would be similar to, but less than, those under Alternative 6A, Base Case. Land impact of construction of facilities and material excavated from Borrow Area C would be approximately half as much as under 6A. This would be readily visible from Rattlesnake Mountain. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	There would be an overall increase to the industrial appearance of the 200 Areas. 61.1 hectares (151 acres) of land would be converted to industrial use. 104 hectares (257 acres) of Borrow Area C would be excavated. These areas would be visible from nearby higher elevations.

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Cultural and Paleontological Resources *(continued)*											
American Indian interests *(continued)*									*Option Case* Impacts would be similar to those under the Base Case. An additional 76.5 hectares (189 acres) would be excavated from Borrow Area C, further impacting the viewshed.	*Option Case* Impacts would be similar to those under the Base Case. An additional 76.5 hectares (189 acres) would be excavated from Borrow Area C, further impacting the viewshed.	
Paleontological Resources	No impact on paleontological resources.										
Socioeconomics											
Peak annual workforce (FTEs)	1,730	4,920	6,860	5,330	5,260	5,460	8,000	6,100	8,500 *10,100*	7,870 *10,300*	6,870
Peak daily commuter traffic (vehicles per day)	1,400	4,000	5,500	4,300	4,200	4,300	6,400	4,900	6,800 *8,100*	6,300 *8,200*	5,500
Peak daily truck loads – off site	4	15	48	24	37	142	64	57	58 *71*	66 *83*	50
Impact on the ROI	Potential for immediate decrease in FTEs.	Potential for change in the socioeconomic ROI, including increases in population, demand and cost for housing and community services, and level-of-service impacts on local transportation.									

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Public and Occupational Health and Safety – Normal Operations											
Offsite Population Impact – Life of the Project											
Dose (person-rem)	600	1,100	460	570	380	570	490	460	560 *760*	600 *710*	460
LCF[C]	0 (4×10^{-1})	1 (6×10^{-1})	0 (3×10^{-1})		0 (2×10^{-1})	0 (3×10^{-1})			0 (3×10^{-1}) *1* *(5×10^{-1})*	0 (4×10^{-1}) *0* *(4×10^{-1})*	0 (3×10^{-1})
Peak Year Maximally Exposed Individual Impact											
Dose (millirem per year)	0.13	1.4	1.7	1.4					1.4 *1.4*	1.7 *1.7*	1.6
Increased risk of an LCF	8×10^{-8}	8×10^{-7}	1×10^{-6}	8×10^{-7}					8×10^{-7} *8×10^{-7}*	1×10^{-6} *1×10^{-6}*	1×10^{-6}
Peak Year Onsite Maximally Exposed Individual Impact											
Dose (millirem per year)	0.018	0.058	0.097	0.058					0.059 *0.059*	0.096 *0.098*	0.094
Increased risk of an LCF	1×10^{-8}	4×10^{-8}	6×10^{-8}	4×10^{-8}					4×10^{-8} *4×10^{-8}*	6×10^{-8} *6×10^{-8}*	6×10^{-8}
Radiation Worker Population Impact – Life of the Project											
Dose (person-rem)	280	23,000	11,000	10,000		11,000	43,000	8,800	120,000 *120,000*	82,000 *85,000*	11,000
LCF[C]	0 (2×10^{-1})	13	7	6			26	5	72 *75*	49 *51*	7
Average Annual Impact per Radiation Worker											
Dose (millirem per year)	140	170	160				520	150	420 *400*	870 *790*	160
Increased risk of an LCF	9×10^{-5}	1×10^{-4}			9×10^{-5}	1×10^{-4}	3×10^{-4}	9×10^{-5}	2×10^{-4} *2×10^{-4}*	5×10^{-4} *5×10^{-4}*	1×10^{-4}
Peak Year Noninvolved Worker Impact											
Dose (millirem per year)	0.71		0.29	0.18	0.17	0.18	0.20	0.18	0.18 *0.20*	0.33 *0.40*	0.28
Increase risk of an LCF	4×10^{-7}		2×10^{-7}	1×10^{-7}						2×10^{-7}	

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Public and Occupational Health and Safety – Facility Accidents											
Offsite Population Consequences											
Dose (person-rem)	0.96	58,000							780	58,000	
Number of LCFs[c]	0 (6×10^{-4})	35							0 (5×10^{-1})	35	
Maximally Exposed Offsite Individual Consequences											
Dose (rem)	0.00021	4.3							0.058	4.3	
Increased risk of an LCF	1×10^{-7}	3×10^{-3}							4×10^{-5}	3×10^{-3}	
Noninvolved Worker Consequences											
Dose (rem)	0.22	13,000							180	13,000	
Increased risk of an LCF[d]	1×10^{-4}	1							2×10^{-1}	1	
Offsite Population Risk											
Annual number of LCFs[c]	0 (3×10^{-7})	0 (2×10^{-2})							0 (2×10^{-4})	0 (2×10^{-2})	
Number of LCFs over life of the project[c]	0 (3×10^{-5})	1	0 (4×10^{-1})					0 (3×10^{-1})	0 (3×10^{-2})	0 (4×10^{-1})	
Maximally Exposed Offsite Individual Risk											
Annual increased risk of an LCF	6×10^{-11}	1×10^{-6}							2×10^{-8}	1×10^{-6}	
Increased risk of an LCF over life of the project	6×10^{-9}	1×10^{-4}	3×10^{-5}					2×10^{-5}	3×10^{-6}	3×10^{-5}	
Noninvolved Worker Risk											
Annual increased risk of an LCF	7×10^{-8}	8×10^{-3}							1×10^{-4}	8×10^{-3}	
Increased risk of an LCF over life of the project	7×10^{-6}	6×10^{-1}	2×10^{-1}					1×10^{-1}	2×10^{-2}	2×10^{-1}	

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Public and Occupational Health and Safety – Transportation											
Traffic Accidents (nonradiological fatalities)	0 (0.009)	0 (0.44)	1 (0.57)	1 (0.75)	1 (1.02)	4 (3.63)	1 (1.26)	1 (0.94)	3 (3.3) *6* *(6.47)*	1 (1.26) *2* *(2.37)*	1 (0.62)
Offsite Population											
Dose (person-rem)	0	73		347	266	337	306	257	60 *74*	90 *102*	73
LCFs	0	4.4×10^{-2}		2.1×10^{-1}	1.6×10^{-1}	2.1×10^{-1}	1.8×10^{-1}	1.5×10^{-1}	3.6×10^{-2} *4.4×10^{-2}*	5.4×10^{-2} *6.1×10^{-2}*	4.4×10^{-2}
Worker											
Dose (person-rem)	0	260	262	842	1,089	1,224	1,086	790	450 *498*	560 *608*	262
LCFs	0	1.6×10^{-1}		5.1×10^{-1}	6.5×10^{-1}	7.3×10^{-1}	6.5×10^{-1}	4.7×10^{-1}	2.7×10^{-1} *3.0×10^{-1}*	3.4×10^{-1} *3.6×10^{-1}*	1.6×10^{-1}
Environmental Justice											
Human health impacts	No disproportionately high and adverse human health impacts on minority or low-income populations due to normal facility operations or postulated facility accidents.										
Waste Management (all values are in cubic meters unless otherwise noted; values rounded to no more than three significant digits)											
Disposed of Off Site and/or Stored On Site											
IHLW glass (No. of canisters)	N/A	14,200 (12,000)		10,300 (8,700)			12,800 (10,800)	9,200 (7,800)	203,000 (171,000) *203,000* *(171,000)*	14,200 (12,000) *14,200* *(12,000)*	14,200 (12,000)
IHLW cesium and strontium glass (No. of canisters)	N/A	400 (340)							400 (340) *400* *(340)*	400 (340) *400* *(340)*	400 (340)
Other HLW	N/A								337,000 *337,000*	337,000 *337,000*	N/A

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Waste Management (all values are in cubic meters unless otherwise noted; values rounded to no more than three significant digits) *(continued)*											
Disposed of Off Site and/or Stored On Site (continued)											
HLW melters (No. of melters)	N/A	3,670 (30)	1,350 (11)	1,100 (9)			1,230 (10)	858 (7)	17,800 (145) *17,800 (145)*	1,350[e] (11) *1,350 (11)*	1,350[e] (11)
Mixed TRU waste (includes tank and secondary, CH and RH)	N/A	219	206	3,850			4,080	3,480	530 *530*	412 *412*	206
Hazardous waste	12	79,200	79,300			79,700	79,900	79,200	83,000 *83,100*	80,900 *81,000*	79,700
Disposed of On Site											
ILAW glass (No. of canisters)	N/A	213,000 (92,300)		65,800 (28,500)			63,800 (28,700)	71,800 (31,100)	N/A	215,000[f] (93,000) *215,000 (93,000)*	213,000[f] (92,300)
PPF Melters (No. of melters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,060 (25) *17,900 (146)*	1,960 (16) *11,400 (93)*	N/A
Bulk vitrification glass	N/A			103,000	N/A		40,500	36,600	N/A		
Cast stone waste	N/A				232,000	N/A	144,000	50,000	N/A		
Sulfate grout waste	N/A							19,800	N/A		

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Waste Management (all values are in cubic meters unless otherwise noted; values rounded to no more than three significant digits) *(continued)*											
Disposed of On Site (continued)											
Steam reforming waste	N/A					261,000	N/A				
PPF glass (No. of canisters)	N/A								1,540 (670) *42,200 (18,300)*		N/A
LAW melters (No. of melters)	N/A	7,700 (30)	8,000 (31)	2,260 (9)			2,570 (10)	2,460 (10)	N/A	8,000[e] (31) *8,000 (31)*	8,000[e] (31)
LLW (secondary)	35	34,300	37,700	28,600	22,100	21,900	42,000	20,700	93,000 *138,000*	99,800 *144,000*	34,700
Liquid LLW (liters)	N/A	9,690					2,370,000,000	9,690	9,690 *4,640,000,000*	9,691 *4,630,000,000*	9,690
Closure LLW	N/A		679				2,400	N/A	4,070 *5,430*		525,000
MLLW (secondary)	21	39,500	37,000	42,000	35,200	21,330	43,600	22,800	110,000 *153,000*	105,000 *148,000*	40,100
Closure MLLW	N/A		525,000				1,010,000	3,060	2,410,000 *8,310,000*		53

Table 2–9. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Industrial Safety											
Worker Population Impact – Total Project											
Total recordable cases (fatalities)	163 (0)	7,040 (0.92)	3,940 (0.52)	3,570 (0.46)	3,530 (0.46)	3,650 (0.47)	4,550 (0.58)	3,320 (0.43)	25,500 (3.3) *26,200* *(3.4)*	5,190 (0.67) *5,760* *(0.75)*	3,950 (0.52)

[a] Concentrations exceeding applicable standards, discussed in the air quality sections of Chapter 4 of this *TC & WM EIS*, are presented in **bold** text. The Federal standard for $PM_{2.5}$ is 35 micrograms per cubic meter (24-hour average). No specific data for $PM_{2.5}$ were available, but for the purposes of analysis, concentrations were assumed to be the same as for PM_{10}. Radiological air quality impacts are included separately under the public and occupational health and safety sections.

[b] Acceptable Source Impact Levels (ASILs) are used by the state in the permitting process and represent concentrations sufficiently low to protect human health and safety from potential carcinogenic and other toxic effects (WAC 173-460).

[c] The number of LCFs in a population is presented as an integer; where the value is 0, the calculated value (dose × 0.0006 LCFs per person-rem) is presented in parentheses.

[d] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[e] Under Alternatives 6B and 6C, HLW and LAW melters from the WTP would be managed as HLW.

[f] Under Alternatives 6B and 6C, ILAW glass would be produced but would be managed as HLW.

Note: To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471; liters to gallons, by 0.26417; meters to yards, by 1.0936.

Key: ASIL=Acceptable Source Impact Level; CH=contact-handled; FTE=full-time equivalent; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LCF=latent cancer fatality; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; National Register=National Register of Historic Places; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; PPF=Preprocessing Facility; RH=remote-handled; ROI=region of influence; SST=single-shell tank; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Chapter 4 of this *TC & WM EIS*.

2.8.2 FFTF Decommissioning Alternatives: Short-Term Environmental Impacts

2.8.2.1 Land Resources

Land use includes the land on and adjacent to Hanford, the physical features that influence current or proposed uses, pertinent land use plans and regulations, and land ownership and availability. Under the FFTF Decommissioning No Action Alternative there would be no change in land use within either the 400 Area or 200 Areas. Also, there would be no need to excavate geologic material from Borrow Area C. Under FFTF Decommissioning Alternative 2, facility disposition would lead to 2.1 hectares (5.3 acres) of land within the 400 Area becoming available for future development; the Industrial designation of the area would not change. To support actions taken under this alternative, 2.8 hectares (7 acres) within Borrow Area C would be mined. Disposition of RH-SCs and bulk sodium would have minimal impact on land use within the 200 Areas, 400 Area, or the MFC at INL. Impacts on land use under FFTF Decommissioning Alternative 3 would be similar to FFTF Decommissioning Alternative 2, although slightly more land would be affected within the 400 Area and slightly less within the MFC.

Visual resources are the natural and manmade features that give a particular landscape its character and aesthetic quality. Under the No Action Alternative there would be no change in the visual character of either the 400 Area or 200 Areas. Facility disposition under both Alternatives 2 and 3 would lead to an overall improvement in the visual character of the 400 Area. However, it is possible that the area could be developed in the future. Due to the need to mine a limited volume of geologic material from Borrow Area C, there would be a minor change in the visual character of the area as seen from nearby higher elevations and State Route 240.

2.8.2.2 Infrastructure

Site infrastructure includes physical resources encompassing the utility systems required to support necessary construction, operations, deactivation, closure, and decommissioning activities associated with the alternatives and options for implementation of the FFTF Decommissioning alternatives. Utility infrastructure resources considered include electricity, liquid fuels, and water (see Table 2–10). For the FFTF Decommissioning No Action Alternative, utility resource demands would be associated with those necessary to maintain the safety- and environmental protection–related systems of the FFTF complex and support buildings during a 100-year administrative control period. In particular, water demands would remain high due to the need to keep active and periodically test fire protection and other systems, with annual demands of 79.8 million liters (21.1 million gallons). Of the action alternatives for FFTF decommissioning, the Entombment Alternative would have the highest total and peak demands for diesel fuel and water. This is mainly attributable to the requirements associated with final grading of the site following grouting of below-grade structures and final construction of the modified RCRA Subtitle C barrier over the site. For the Removal (see Alternative 3) and Entombment (see Alternative 2) Alternatives, projected total diesel fuel requirements are 3.76 and 4.02 million liters (0.99 to 1.06 million gallons) and total water requirements are 18.9 and 19.6 million liters (4.99 and 5.17 million gallons), respectively. Overall, these demands would be a very small fraction of the capacity of the utility systems that supply these utility resources. Liquid fuels are not considered to be a limiting resource, as additional supplies can be trucked to the point of use as needed from offsite suppliers, but peak requirements to support decommissioning would be comparable to Hanford's current total annual liquid fuel consumption (see Chapter 3, Section 3.2.2).

Utility demands associated with the options for disposition of RH-SCs and bulk sodium would generally result in a small, incremental increase in utility resource requirement to those for facility disposition, regardless of the option selected. Utility infrastructure requirements, total and peak, for the Hanford and Idaho Options for disposition of RH-SCs would be essentially identical (see Table 2–10). Incremental demands for implementation of the Hanford Reuse Option for disposition (processing) of bulk sodium

would be substantially greater than those for the Idaho Reuse Option, as a new SRF would have to be constructed at Hanford in lieu of modifications to the existing SPF at INL.

2.8.2.3 Noise and Vibration

Noise is undesirable sound that interferes negatively with the human or natural environment. Noise may disrupt normal activities (e.g., hearing, sleep), damage hearing, or diminish the quality of the environment. Noise impacts may result from construction, operations, deactivation, and closure activities, including increased traffic. Noise impacts of onsite activities under each FFTF Decommissioning alternative would be negligible. Under the No Action Alternative there would be negligible noise impacts of employee vehicles traffic. Noise impacts of traffic would be highest under Alternative 3, which would have the highest peak year employment and employee vehicle traffic. The increase in employee traffic noise along the road to the site during peak hours (shift changes) is not expected to be noticeable to residents along these routes. FFTF Decommissioning Alternative 2 would have the highest offsite truck traffic associated with grout facility operation.

2.8.2.4 Air Quality

Air pollution refers to any substance in the air that could harm human or animal populations, vegetation, or structures or that unreasonably interferes with the comfortable enjoyment of life and property. As modeled, nonradiological air pollutant concentrations under all FFTF Decommissioning alternatives would meet the applicable 24-hour ambient standards for $PM_{2.5}$ and PM_{10} except under Alternatives 2 and 3 for $PM_{2.5}$. Nonradiological air quality impacts for $PM_{2.5}$ and PM_{10} would be highest under Alternative 3 for facility disposition. Under these alternatives, $PM_{2.5}$ and PM_{10} concentrations in the peak year would be attributable primarily to fugitive dust from heavy-equipment operations during Hanford RTP construction and grout facility deactivation.

Particulate matter emissions estimated for construction-type activities include fugitive dust emissions from construction areas and account for dust suspended by equipment and vehicle activity and by wind. The emission factor used for these estimates is intended to provide a gross estimate of total suspended particulate emissions when more-detailed engineering data of a construction activity are not available that would allow for a more-refined estimate of dust emissions. For the purpose of this analysis, $PM_{2.5}$ and PM_{10} emissions from general construction activities were assumed to be the same as the total suspended particulate emissions. This results in a substantial overestimate of PM_{10} emissions. Further, the analysis did not consider appropriate emission controls that could be applied in the construction areas, as discussed in Chapter 4, Section 4.9.2. A refined analysis of emissions based on more-detailed engineering data of the construction activities and application of appropriate control technologies is expected to result in substantially lower projected emissions and ambient concentrations from the major construction activities under these alternatives. Maximum air quality impacts of particulate matter are expected to occur along State Route 240, along or near the Hanford boundary to the east to southeast, or along the Hanford boundary to the southwest.

The Clean Air Act, as amended (40 U.S.C. 7401 et seq.), requires that Federal actions conform to the host state's "state implementation plan." A state implementation plan provides for the implementation, maintenance, and enforcement of NAAQS for the six criteria pollutants: sulfur dioxide, PM_{10}, carbon monoxide, ozone, nitrogen dioxide, and lead. Its purpose is to eliminate or reduce the severity and number of NAAQS violations and to expedite the attainment of these standards. "No department, agency, or instrumentality of the Federal Government shall engage in or support in any way or provide financial assistance for, license or permit, or approve any activity that does not conform to an applicable implementation plan." The final rule for "Determining Conformity of General Federal Actions to State or Federal Implementation Plans" (40 CFR 51.850–51.860) took effect on January 31, 1994. Hanford and INL are within areas currently designated as attainment for criteria air pollutants (40 CFR 81.348 and

81.313, respectively). Therefore, the alternatives considered in this EIS do not require a conformity determination under the provisions of this rule.

Maximum concentrations of nonradiological toxic air pollutants off site and in areas to which the public has access would be less than 33 percent of the state's acceptable source impact levels. Maximum concentrations of carcinogenic toxic pollutants would be less than 33 percent of the state's acceptable source impact levels. Acceptable source impact levels are used during the permitting process to demonstrate that emissions from a new toxic air pollutant source are sufficiently low to protect human health and safety from potential carcinogenic and/or other toxic effects. Comparison of the estimated concentrations to acceptable source impact levels indicates that emissions under all FFTF Decommissioning alternatives would be sufficiently low to protect human health and safety. Impacts of radiological air emissions are summarized in Section 2.8.1.10.

2.8.2.5 Geology and Soils

Geologic resources include consolidated and unconsolidated earth materials, including rock and mineral assets such as ore and aggregate materials (e.g., sand, gravel) and fossil fuels such as coal, oil, and natural gas. Soil resources include the loose surface materials of the earth in which plants grow. Impacts on geology and soils would generally be directly proportional to the total area of land disturbed by facility decommissioning and demolition, site grading, excavation work, and construction of facilities to support facility disposition and related waste treatment options under the FFTF Decommissioning alternatives and options (see Table 2–10). Consumption of geologic resources would constitute the major indirect impact on geology and soils. Under the FFTF Decommissioning No Action Alternative, there would be no incremental impact on geology and soils because there would be no new, ground-disturbing activities and no geologic resources would be required to support surveillance and monitoring activities. Under the Removal (see Alternative 3) and Entombment (see Alternative 2) Alternatives, impacts would generally be minimal and would vary in relation to the nature of the excavation and exhumation work and associated ground disturbance necessary to support the decommissioning objectives of each alternative. Under the Entombment Alternative, following completion of above-grade facility demolition to a depth of 0.91 meters (3 feet) and backfill and grouting of remaining below-grade spaces, an approximately 0.7-hectare (1.7-acre) modified RCRA Subtitle C barrier would be constructed over the FFTF RCB and adjacent facilities. The potential for short-term wind and water erosion would exist in disturbed areas but would be minimized via the application of best management practices, as further discussed in Chapter 7, Section 7.1.5. Total permanent land disturbance associated with implementation of the Entombment Alternative would include the engineered barrier and excavation of a 2.8-hectare (6.9-acre) area of Borrow Area C to provide necessary geologic and soil resources, for a total of about 3.5 hectares (8.6 acres). Under the Removal Alternative, impacts would be similar to, but greater than, those described for the Entombment Alternative, as the RCB reactor vessel would be grouted and removed for disposal, rather than left in place. While no barrier would be constructed, geologic resource requirements would be higher than under the Entombment Alternative (143,000 cubic meters [187,000 cubic yards] versus 122,000 cubic meters [160,000 cubic yards]) due to the need for additional soil for use in backfilling exhumations and grading the entire site. Permanent land disturbance associated with the Removal Alternative would total 3.2 hectares (4.2 acres) associated with excavation in Borrow Area C to provide necessary geologic and soil resources (see Table 2–10).

Impacts on geology and soils associated with the Hanford Option under FFTF Decommissioning Alternative 2 or 3 for disposition of RH-SCs would be associated with construction of a new RTP in a previously disturbed part of the 200-West Area. Construction would permanently disturb only about 0.1 hectares (0.3 acres) of land, but excavation to a depth of 6 meters (20 feet) within Hanford formation sediments would be necessary. Impacts of implementing the Idaho Option would be very similar to those for the Hanford Option, as the RTP would also be constructed in a developed and previously disturbed portion of the MFC at INL. Nevertheless, due to the occurrence of near-surface basalt outcrops at the

MFC, blasting may be required to excavate the site for the below-grade service level of the RTP. Under both options for disposition of RH-SCs, demands for geologic and soil resources, ranging from 4,580 to 4,670 cubic meters (5,990 to 6,100 cubic yards) would be relatively small as compared to the FFTF Decommissioning alternative facility disposition requirements (see Table 2–10).

Implementation of the Hanford Reuse Option under FFTF Decommissioning Alternative 2 or 3 for disposition of bulk sodium would have minimal effects on geology and soils in the Hanford 400 Area. Construction of the new SRF with a reinforced-concrete slab adjacent to the existing SSF would require minimal excavation work. The new SRF would permanently occupy about 0.1 hectares (0.2 acres) of land. Impacts on geology and soils within the MFC at INL and demands for geologic and soil resources would be less under the Idaho Reuse Option, as activities would be limited to modifications to the existing SPF to receive and process Hanford sodium, as reflected in Table 2–10.

2.8.2.6 Water Resources

Water resources are the surface and subsurface waters that are suitable for human consumption, aquatic or wildlife use, agricultural purposes, irrigation, or industrial/commercial purposes. Under FFTF Decommissioning Alternative 1: No Action, no additional impacts on availability or quality of surface-water or groundwater resources are expected in the short term following FFTF deactivation. Water use would be reduced following completion of deactivation and limited to that necessary to maintain critical systems as part of surveillance and monitoring of the FFTF complex. Any wastewater generated would be discharged to the existing systems that serve the 400 Area. No impacts on surface water are expected from implementation of either the Entombment or Removal Alternatives for FFTF decommissioning. While stormwater runoff could convey pollutants from demolition-related and other work sites, the potential to impact runoff quality beyond the 400 Area would be small. Also, appropriate soil erosion and sediment control measures, spill prevention and waste management practices, and National Pollutant Discharge Elimination System and state waste-discharge permitting requirements would be implemented to minimize any impacts on surface water, the vadose zone, and groundwater. The potential for short-term impacts on surface-water runoff quality and on the vadose zone would be somewhat greater under the Removal Alternative, as the FFTF reactor vessel would be removed and a slightly larger area would be regraded and revegetated following facility demolition than under the Entombment Alternative. Regardless, water use to support decommissioning and site closure activities under each alternative would be limited to that required to provide dust control and possibly to aid soil compaction in backfilled areas, to mix concrete grout, and possibly for equipment washdown. These water demands could be easily supplied by trucking water to the point of use or via temporary utility service connections to the 400 Area's water supply wells. Water use would be somewhat greater under the Entombment Alternative to support construction of the modified RCRA Subtitle C barrier (see Section 2.8.2.2).

Under the Removal Alternative, the removal of the FFTF reactor vessel and other contaminated equipment would have positive impacts on the vadose zone and groundwater quality in the short-and-long term. In contrast, under the Entombment Alternative, installation of the modified RCRA Subtitle C barrier over the FFTF RCB and adjacent facilities would delay, but not prevent, contamination migration from the 400 Area over the longer term (see Section 2.9.1).

Construction of an RTP to treat RH-SCs under either the Hanford or Idaho Option would likely have no impact on surface-water features or quality, as no surface-water features would be directly disturbed and construction activities would occur in previously developed areas of the Hanford 200-West Area and of the MFC at INL, respectively. Process wastewater generated during facility operations would be discharged to existing treatment facilities that already service the Hanford 200 Areas and MFC at INL. There would be no direct discharge of effluent to the vadose zone or groundwater.

Impacts of construction and operation of the new SRF under the Hanford Reuse Option for disposition of bulk sodium would be unlikely to have any impact on surface-water features or quality. This is due to the fact that there are no surface-water features that could be impacted in the Hanford 400 Area and there would be no direct discharge of effluents during operations to the vadose zone or groundwater. Effluents would be disposed of at appropriate onsite facilities. Potential impacts on water resources associated with implementing the Idaho Reuse Option would be negligible, as activities would be limited to modifications to the existing SPF to receive and process Hanford sodium. Similar to bulk sodium processing operations at Hanford, effluents from processing Hanford sodium at the SPF would be discharged to existing treatment facilities that already service the MFC.

2.8.2.7 Ecological Resources

Ecological resources include terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Under the FFTF Decommissioning No Action Alternative, there would be no impact on ecological resources within the 400 Area or Borrow Area C. Because of the developed nature of the 400 Area, 200 Areas, and the MFC, actions taking place under either Alternative 2 or 3 would not impact ecological resources, including threatened and endangered species, within those areas. While the mining of 2.8 hectares (7 acres) of land within Borrow Area C would impact the existing habitat of the site, no sagebrush habitat would be affected. Also, although no federally or state-listed threatened or endangered species would be affected by mining activities, there is minimal potential to disturb four state-listed special status species.

Due to the lack of wetlands and aquatic resources within the 200 Areas, Borrow Area C, and the MFC, there would be no impact on these resources under any of the alternatives.

2.8.2.8 Cultural and Paleontological Resources

Cultural resources are the indications of human occupation and use of property, as defined and protected by a series of Federal laws, regulations, and guidelines, and are categorized as prehistoric resources, historic resources, and American Indian interests. Prehistoric resources are the physical remains of human activities that predate written records. Historic resources consist of physical remains that postdate the emergence of written records. American Indian interests include sites, areas, and materials important to American Indians for religious or heritage reasons. Paleontological resources are the physical remains, impressions, or traces of plants or animals from a former geologic age and may be sources of information on ancient environments and the evolutionary development of plants and animals. Under the FFTF Decommissioning alternatives and options, there would be no impact on prehistoric, historic, or paleontological resources. Under the No Action Alternative and the disposition of RH-SCs (both Hanford and Idaho Options) and bulk sodium (both Hanford Reuse and Idaho Reuse Options), there would be no impact on American Indian interests. Facility disposition under both FFTF Decommissioning Alternative 2: Entombment, and Alternative 3: Removal, would impact the view from higher elevations, including Rattlesnake Mountain.

2.8.2.9 Socioeconomics

Socioeconomic impacts are defined in terms of changes to demographic and economic characteristics of a region. The socioeconomic environment is generally made up of regional economic indicators and demographic characteristics of the area. Economic indicators include employment, the civilian labor force, and unemployment rates. Demographic characteristics include population, housing, education, and health information. In addition, the projected workforce and work activities could potentially impact the local transportation and result in level-of-service impacts on the roads in the ROI (i.e., the Tri-Cities). Under all FFTF Decommissioning alternatives, any socioeconomic impacts on the ROI would be limited to the period from approximately 2013 through 2021. None of the peak workforce requirements would be

more than 100 FTEs in a given year. The impacts on the region's economics, demographics, and housing and community services from this projected workforce would be small. In addition, the level of service on offsite roads is not expected to change.

2.8.2.10 Public and Occupational Health and Safety—Normal Operations

A description of the radiological releases that would result from FFTF decommissioning activities, including the disposition of RH-SCs and bulk sodium, is provided in Chapter 4 of this *TC & WM EIS*. The impacts on both the public and workers are estimated. For the public, impacts are presented for the population near Hanford, an MEI, and an onsite MEI. Public impacts would be negligible under the No Action Alternative and the facility disposition portion of the FFTF Decommissioning Removal Alternative. In addition to impacts at Hanford, options for dispositioning RH-SCs and bulk sodium could result in impacts on the population and an MEI near INL. For workers, the focus is on impacts on site radiation workers at both Hanford and INL.

Table 2–10 shows the radiological impacts of the three activities—facility disposition, disposition of RH-SCs, and disposition of bulk sodium—that compose the FFTF Decommissioning alternatives. Of the three activities, disposition of the bulk sodium would have the largest impact on members of the public. Disposition of RH-SCs and/or bulk sodium could occur at Hanford or INL; the impacts of either activity would be slightly higher if conducted at Hanford. In all cases, the impacts on the population and the MEI would be very low. The largest radiological impact on the population within 80 kilometers (50 miles) over the life of the project would result under FFTF Decommissioning Alternative 2: Entombment, facility disposition accompanied by the Hanford options for disposition of the RH-SCs and bulk sodium. The sum of the population doses for these three activities would be 0.0073 person-rem. Based on this dose, no LCFs are expected in the offsite population. Dispositioning the RH-SCs and bulk sodium at INL would result in a dose to the population within 80 kilometers (50 miles) of INL of 0.00043 person-rem; no LCFs are expected as a result of this dose.

The largest annual MEI dose, under FFTF Decommissioning Alternative 2 with the Hanford options for disposition of the RH-SCs and bulk sodium, would be 0.00012 millirem. The annual risk of an LCF from this dose would be extremely unlikely, less than 1 in 13 billion. The dose and risk to an onsite MEI, assumed to be at the Columbia Generating Station, would be less than for the offsite MEI because the onsite MEI would be exposed for a shorter duration and through fewer pathways (e.g., no ingestion). Dispositioning the RH-SCs and bulk sodium at INL would result in a maximum annual MEI impact of 4.6×10^{-5} millirem, with a corresponding annual risk of an LCF of less than 1 in 30 billion.

Considering the doses for the duration of the project, facility disposition under the Removal Alternative would have the largest collective worker dose and under the Entombment Alternative would have the smallest collective dose. The No Action Alternative dose would be higher than the Entombment Alternative facility disposition dose because of the continued exposure of workers charged with facility monitoring and maintenance. The worker dose from disposition of RH-SCs would be the same regardless of whether the activity was performed at Hanford (Hanford Option) or INL (Idaho Option). The Hanford Reuse Option for disposition of bulk sodium would result in a slightly higher worker dose than the Idaho Reuse Option because it includes an additional work element. Whereas the facility for processing bulk sodium would remain available for use by others at INL under the Idaho Reuse Option, under the Hanford Reuse Option, the facility would be decommissioned, resulting in additional worker dose. The maximum project collective dose to workers—Removal Alternative facility disposition using the Hanford Option for dispositioning the RH-SCs and the Hanford Reuse Option for bulk sodium—would be 11 person-rem. No additional LCFs are expected in the worker population as a result of this dose. The average annual dose to individual radiation workers would be 100 millirem or less for all activities; the corresponding annual risk of an LCF would be less than 1 in 17,000. Impacts on a noninvolved worker would be extremely small, with essentially no additional risk of an LCF.

2.8.2.11 Public and Occupational Health and Safety—Facility Accidents

Processing any hazardous material creates a risk of accidents impacting involved workers (workers directly involved in facility processes), noninvolved workers (workers on the site but not directly involved in facility processes), and members of the public. The consequences of such accidents could involve the release of radioactive materials, toxic chemicals, or hazardous (e.g., explosive) energy, beyond the intended confines of the process. Risk is determined by the development of a representative spectrum of postulated accidents, each of which is conservatively characterized by a likelihood (i.e., expected frequency of occurrence) and a consequence. For the FFTF Decommissioning alternatives presented in Table 2–10, the projected accident consequences are conditional on an accident's occurrence and therefore do not reflect an accident's frequency of occurrence. Shown in this table is the accident with the highest projected consequences under each alternative. Under all three alternatives, the accident involving sodium inventories that would have the highest consequences if it were to occur is the Hanford sodium storage tank failure. The frequency of this accident is estimated to be 0.00001 per year (once in 100,000 years). All three alternatives have the potential for accidents involving the sodium inventories stored in the Hanford sodium storage tank and elsewhere on Hanford. In addition, Alternatives 2 and 3 involve the removal and treatment of the FFTF RH-SCs, which contain sodium residuals and significant amounts of radionuclides. A fire involving an RH-SC could occur under either the Hanford Option or the Idaho Option and would have much higher consequences than the Hanford sodium storage tank failure. The frequency of the RH-SC fire accident is estimated to be 0.01 per year (once in 100 years). Under the Hanford Option, the RH-SC fire could occur only at Hanford. Under the Idaho Option, it could occur at Hanford during removal and preparation of the RH-SCs for shipment or at the INL site during storage or handling.

The accident risks shown in Table 2–10 take into account an accident's frequency. The annual risk value reflects the annual frequency of the accident. The risk over the life of the project reflects the duration of the activity that produces the accident potential, ranging from 5 to 100 years, during which that accident could occur. For bulk sodium, the risk over the life of the project would be highest under Alternative 1 due to the risk of a sodium inventory accident during 100 years of storage. Under FFTF Decommissioning Alternatives 2 and 3 in which the sodium is processed for reuse, a longer storage time results in higher life-of-project risks for the Hanford Reuse Option than for the Idaho Reuse Option. Risks over the life of the project for disposition of RH-SCs at Hanford are also slightly higher than for disposition under the Idaho Option.

In accordance with DOE orders, DOE protects against intentional destructive acts aimed at its facilities and materials. Regardless of those protections, this EIS evaluates the potential impacts of intentional destructive acts in addition to conventional facility accident scenarios. An intentional destructive act was postulated whereby the FFTF primary cold trap, containing cesium-137 and cobalt-60, is destroyed by an explosive or incendiary device during removal or handling. All of the radioactive material was assumed to aerosolize and be released to the atmosphere. Analysis results indicate that the radiological impacts would be about three times those calculated for the accident scenario that involves the same inventory of radioactive material (remote-handled special component fire). The scenario would apply to both action alternatives. More-detailed discussion of intentional destructive act impacts associated with FFTF Decommissioning alternatives is provided in Chapter 4, Section 4.2.11.4.

2.8.2.12 Public and Occupational Health and Safety—Transportation

Transportation of any commodity involves a risk to both transportation crewmembers and members of the public. The risk results directly from transportation-related accidents and indirectly from the levels of pollution from vehicle emissions, regardless of the cargo. The transportation of certain materials, such as hazardous or radioactive waste, can pose additional risk due to the unique nature of the material itself. Except for the No Action Alternative, FFTF decommissioning activities would generate various

radioactive materials that would require transport to both off- and onsite locations for treatment and/or disposal. Radioactive materials would need to be transported off site if DOE decides to treat sodium or RH-SCs at INL. Table 2–10 summarizes the transportation risks to the workers (transport drivers) and the public in terms of traffic fatalities and LCFs. Based on the results presented in this table, the following conclusions have been reached:

- It is unlikely that transportation of radioactive waste would cause an additional fatality due to radiation resulting from either incident-free operations or postulated transportation accidents.

- The highest risk to the public would be under options that treat the sodium and RH-SCs at INL. Alternative 3 would add additional risks for transport of radioactive materials for disposal in an IDF and transport of nonradioactive materials for disposal at a sanitary and hazardous waste landfill.

- The lowest risk to the public would be under options that treat the sodium and RH-SCs at Hanford. FFTF Decommissioning Alternative 2 would add some risks for transport of the nonradioactive materials for disposal at a sanitary and hazardous waste landfill.

- Under Alternative 2, the waste would be entombed, with the option of treating sodium at Hanford (Hanford Reuse Option) and RH-SCs at INL (Idaho Option).

2.8.2.13 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of their programs, policies, and activities on minority and low-income populations. Potential risks to human health from normal facility operations and postulated facility accidents are not expected to pose disproportionately high and adverse effects on minority or low-income populations surrounding Hanford under any FFTF Decommissioning alternative.

2.8.2.14 Waste Management

FFTF Decommissioning alternatives for facility disposition and options for disposition of RH-SCs and Hanford bulk sodium would generate several types of waste: LLW, MLLW, hazardous waste, nonhazardous waste, and liquid process waste. The generation of this waste could have little or minimal impact on existing Hanford facilities devoted to TSD. As described in Chapter 4, either the current waste management capacity is sufficient or the new infrastructure would be constructed as part of the alternative. Projected waste generation rates for the proposed activities were compared with Hanford's capacity to manage the waste, including the additional waste disposal capacity that is proposed to be constructed. Projected waste generation rates for the proposed activities were compared with site processing rates and capacities of those TSD facilities likely to be involved in managing the additional waste. Potential impacts of waste generated as a result of site environmental restoration activities unrelated to Tank Closure, FFTF Decommissioning, or Waste Management alternatives are not within the scope of this analysis. Where additional disposal capacity would be needed, the land use impacts are addressed in the appropriate sections of Chapter 4. The estimated full inventories of waste forms disposed of on site are included in the analyses of long-term impacts presented in Chapter 5 of this *TC & WM EIS*.

LLW and MLLW. LLW and MLLW (e.g., personal protective equipment, tools, filters, and empty containers) would be generated during routine operations, deactivation, decommissioning, and disposition activities associated with the action alternatives and options, as well as during routine surveillance and maintenance under FFTF Decommissioning Alternative 1: No Action. LLW is typically not treated or

only minimally treated (e.g., compacted) before disposal. Using a combination of on- and offsite capabilities, secondary MLLW would be treated to meet RCRA land-disposal-restriction treatment standards prior to disposal. Therefore, this waste treatment would cause no or only minimal impacts on the Hanford waste management system. The LLW would be sent directly to disposal. The MLLW would be sent to disposal after treatment. All LLW and MLLW would be disposed of in an IDF.

Hazardous waste. Hazardous waste is dangerous waste as defined in the *Washington Administrative Code* (WAC 173-303). Hazardous waste generated during operations, deactivation, or monitoring would be packaged in DOT-approved containers and shipped off site to permitted commercial recycling, treatment, and disposal facilities. Management of the additional waste generated under the FFTF Decommissioning alternatives and options would require little, if any, additional planning. The waste would be treated and disposed of at offsite commercial facilities.

Nonhazardous waste. Any nonhazardous solid waste generated related to facility disposition activities or treatment facility construction, operations, or deactivation would be packaged and transported in conformance with standard industrial practice. Solid waste such as office paper, metal cans, and plastic and glass bottles that can be recycled would be sent off site for that purpose. The remaining nonhazardous solid waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

Liquid process waste. Process waste would be generated by FFTF facility disposition activities and would possibly be generated in association with RH-SC treatment, bulk sodium processing, and facility deactivation. Process waste, and dilute process waste such as cooling waters or steam condensates would be routed to the Hanford or INL facilities, as applicable, whose mission it is to manage such wastes. It is assumed that the ETF and TEDF, or their equivalents, would continue to be available to manage process liquids generated under the FFTF Decommissioning alternatives.

2.8.2.15 Industrial Safety

In addition to facility accident risks, estimates of potential industrial safety impacts on workers during construction, operations, deactivation, and closure activities under each FFTF Decommissioning alternative were evaluated based on the DOE complex–wide computerized Accident/Incident Reporting System database (see Appendix K, Section K.4). These impacts correlate with the number of labor hours required to support each FFTF Decommissioning alternative and are classified into two groups: TRCs and fatalities. A recordable case includes work-related deaths, illnesses, or injuries leading to loss of consciousness, lost workdays, transfer to another job, and/or requiring medical treatment beyond first aid.

Table 2–10 summarizes the potential number of TRCs and fatalities resulting from the construction, operations, deactivation, and closure activities that would be conducted under each FFTF Decommissioning alternative. The fewest projected industrial safety impacts would occur under FFTF Decommissioning Alternative 1; the No Action Alternative would require the least amount of worker labor. Under the action alternatives for FFTF decommissioning, the fewest projected impacts would occur under Alternative 2: Entombment, in conjunction with the Idaho options for disposition of RH-SCs and bulk sodium. The highest projected impacts would occur under Alternative 3: Removal, in conjunction with the Hanford options for disposition of RH-SCs and bulk sodium, which could result in approximately 20 TRCs, but no fatalities.

Table 2–10. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Land Resources							
Land Use (total land commitment)	No change in land use in the 400 Area, 200 Areas, or Borrow Area C.	2.1 hectares affected within the 400 Area. 2.8 hectares (0.3 percent) affected within Borrow Area C.	2.4 hectares affected within the 400 Area. 3.2 hectares (0.3 percent) affected within Borrow Area C.	0.1 hectares affected in 200-West Area.	0.1 hectares affected within the MFC.	0.1 hectares affected in 400 Area.	No change in land use within the MFC.
Visual resources	No change in the visual character of the 400 Area or 200 Areas.	Overall improvement in visual character of 400 Area. Minor change in visual character of Borrow Area C.		No meaningful change in the visual character of the 200-West Area.	No meaningful change in the visual character of the MFC.	No meaningful change in the visual character of the 400 Area.	No change in the visual character of the MFC.
Infrastructure							
Total Requirements							
Electricity (million megawatt-hours)	0.60	0.0032	0.0064	0.0000011		0.0013	
Diesel fuel (million liters)	0.0	4.02	3.76	0.24		1.09	0.12
Gasoline (million liters)	0.11	0.36	0.37	0.090		0.42	0.012
Water (million liters)	7,980	19.6	18.9	8.53		2.92	2.72
Peak Annual Demand							
Electricity (million megawatt-hours)	0.006	0.0032		0.00000071		0.00069	
Diesel fuel (million liters)	0.0	1.74	1.11	0.12		0.47	0.058
Gasoline (million liters)	0.0011	0.098	0.050	0.045		0.18	0.0088
Water (million liters)	79.8	11.4	10.5	3.75	3.74	1.36	

Table 2–10. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Noise and Vibration: Negligible offsite impact of onsite activities. Minor traffic noise impacts.							
Air Quality							
Peak Year Incremental Criteria Pollutant Concentrations as Compared to Most Stringent Guideline or Standard (micrograms per cubic meter)[a]							
Carbon monoxide (1-hour) standard=40,000	31.3	435	381	39.3	0	5,160	66.6
Nitrogen oxides (annual) standard=100	0.0006	2.84	2.04	Does not occur in peak year	0	Does not occur in peak year	0.772
PM_{10} (24-hour) standard=150	0.0027	31.3	72	41.9	0	22.5	13.5
Sulfur oxides (1-hour) standard=660	0.042	30.6	50.4	0.062	0	6.97	N/A
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[a]							
Ammonia (24-hour) ASIL=100	0.00013	0.196	0.026	0.0157	0	14.0	0.007
Benzene (annual) ASIL=0.12	0.00000319	0.0106		Does not occur in peak year	0	Does not occur in peak year	0.0008
Toluene (24-hour) ASIL=400	0.0034	11.3		Does not occur in peak year	0	Does not occur in peak year	0.0517
Xylene (24-hour) ASIL=1,500	0.00095	3.18		Does not occur in peak year	0	Does not occur in peak year	0.0147

Table 2–10. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Geology and Soils							
Construction impacts	No incremental impact on geology and soils.	Minimal impact associated with facility demolition in previously disturbed area. Potential for short-term soil loss from wind and water erosion during demolition, backfilling, and barrier construction. Excavation depths generally limited to 0.91 meters (3 feet) in the 400 Area.	Similar to, but somewhat greater than, Alternative 2: Entombment, due to reactor vessel removal and greater demands for geologic and soil resources from Borrow Area C.	Impacts of construction limited to previously disturbed area in 200-West Area. Excavation depths to 6 meters (20 feet) within the Hanford formation.	Similar to, but somewhat greater than, the Hanford Option due to the potential for blasting at the MFC to excavate the subgrade portion of the RTP in near-surface basalt.	Limited impact on geology and soils in the Hanford 400 Area.	Minimal impact on geology and soils within the MFC at INL.
New permanent land disturbance (hectares)	0.0	3.5	3.2	0.1			<0.1
Geologic resource requirements (cubic meters)	0.0	122,000	143,000	4,670	4,580	202	35.5
Water Resources							
Surface water	No additional impacts on surface water in the short term. Wastewater generation and discharges would decrease from current levels.	No impact expected on surface-water features. Potential for contaminated runoff from demolition and work areas with no effect expected beyond the 400 Area.	Similar to, but somewhat greater than, Alternative 2: Entombment, due to reactor vessel removal and slightly larger area of disturbance and associated runoff.	Little or no impact on surface-water features or quality in the 200-West Area.	Little or no impact on surface-water features or quality within the MFC.	Limited impact on surface-water features or quality in the Hanford 400 Area.	No impacts on surface-water resources from construction and operations within the MFC at INL.

Table 2–10. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Water Resources *(continued)*							
Vadose zone and groundwater	No additional impact in the short term. Groundwater use would decrease following deactivation.	Barrier emplacement would delay contaminant migration from the 400 Area.	Short-term, positive impact of removal of sources of residual contamination associated with the FFTF RCB.	No direct discharge of effluents from facility operations to the vadose zone or groundwater.			
Ecological Resources							
Terrestrial resources	No impact within 400 Area or Borrow Area C.	No impact within 400 Area. No disturbance to sagebrush habitat within Borrow Area C.		No impact within the 200-West Area.	No impact within the MFC.	No impact within the 400 Area.	No impact within the MFC.
Wetlands	No impact within 400 Area or Borrow Area C.			No impact within the 200-West Area.	No impact within the MFC.	No impact within the 400 Area.	No impact within the MFC.
Aquatic resources	No impact within 400 Area or Borrow Area C.			No impact within the 200-West Area.	No impact within the MFC.	No impact within the 400 Area.	No impact within the MFC.
Threatened and endangered species	No impact on federally or state-listed threatened or endangered species within the 400 Area or Borrow Area C.	No impact on any federally or state-listed threatened or endangered species. No impact on state-listed special status species within the 400 Area. Minimal potential for impact on 4 state-listed special status species within Borrow Area C.		No impact on federally or state-listed threatened, endangered, or special status species within the 200-West Area.	No impact on federally or state-listed threatened, endangered, or special status species within the MFC.	No impact on federally or state-listed threatened, endangered, or special status species within the 400 Area.	No impact on federally or state-listed threatened, endangered, or special status species within the MFC.
Cultural and Paleontological Resources							
Prehistoric resources	No impact on prehistoric resources.						
Historic resources	No impact on historic resources.						
American Indian interests	No impact on American Indian interests.	Excavation activities would impact the view from State Route 240 and higher elevations, including Rattlesnake Mountain.		No impact on American Indian interests.			
Paleontological resources	No impact on paleontological resources.						

Table 2–10. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Socioeconomics							
Peak annual workforce (FTEs)	1	50	85	53	46	65	55
Peak daily commuter traffic (vehicles per day)	1	40	68	43	46	52	55
Peak daily truck loads – off site	Less than 1	3	2	1	Less than 1	Less than 1	Less than 1
Impact on the ROI	Little or no impact on socioeconomic ROI.	The impact on the Hanford and INL socioeconomic ROIs would be small.					
Public and Occupational Health and Safety – Normal Operations[a]							
Offsite Population Impact – Life of the Project							
Dose (person-rem)	b	0.000001	b	0.00014	0.000011	0.0072	0.00042
LCF[c]	b	0 (6×10^{-10})	b	0 (8×10^{-8})	0 (7×10^{-9})	0 (4×10^{-6})	0 (3×10^{-7})
Peak Year Maximally Exposed Individual Impact							
Dose (millirem per year)	b	0.00000003	b	0.0000016	0.0000014	0.00012	0.000045
Increased risk of an LCF	b	2×10^{-14}	b	1×10^{-12}	8×10^{-13}	7×10^{-11}	3×10^{-11}
Peak Year Onsite Maximally Exposed Individual Impact							
Dose (millirem per year)	b	0.0000000019	b	0.000000034	N/A	0.000011	N/A
Increased risk of an LCF	b	1×10^{-15}	b	2×10^{-14}	N/A	7×10^{-12}	N/A
Radiation Worker Population Impact – Life of the Project							
Dose (person-rem)	1	0.37	6.3	1.2		3.7	3.6
LCF[c]	0 (6×10^{-4})	0 (2×10^{-4})	0 (4×10^{-3})	0 (7×10^{-4})		0 (2×10^{-3})	
Average Annual Impact per Radiation Worker							
Dose (millirem per year)	50	100	100	20		39	
Increased risk of an LCF	3×10^{-5}	6×10^{-5}	6×10^{-5}	1×10^{-5}		2×10^{-5}	
Peak Year Noninvolved Worker Impact							
Dose (millirem per year)	b	0.00000000066	b	0.00019	0.0000011	0.0000037	0.000055
Increased risk of an LCF	b	4×10^{-16}	b	1×10^{-10}	7×10^{-13}	2×10^{-12}	3×10^{-11}

Table 2–10. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Public and Occupational Health and Safety – Facility Accidents							
Offsite Population Consequences							
Dose (person-rem)	0.048	d		4.4	0.25[e]	0.048	0.0002[e]
Number of LCFs[c]	0 (3×10^{-5})	d		0 (3×10^{-3})	0 (2×10^{-4})[e]	0 (3×10^{-5})	0 (1×10^{-7})[e]
Maximally Exposed Offsite Individual Consequences							
Dose (rem)	0.000001	d		0.00011	0.0001[e]	0.000001	0.000000055
Increased risk of an LCF	6×10^{-10}	d		7×10^{-8}	6×10^{-8}[e]	6×10^{-10}	3×10^{-11}[e]
Noninvolved Worker Consequences							
Dose (rem)	0.00000087	d		0.0009	0.0036[e]	0.00000087	0.00000034
Increased risk of an LCF	5×10^{-10}	d		5×10^{-7}	2×10^{-6}[e]	5×10^{-10}	2×10^{-10}[e]
Offsite Population Risk							
Annual number of LCFs[c]	0 (3×10^{-10})	d		0 (3×10^{-5})	0 (2×10^{-6})[e]	0 (3×10^{-10})	0 (1×10^{-12})[e]
Number of LCFs over the life of the project[c]	0 (3×10^{-8})	d		0 (1×10^{-4})	0 (8×10^{-6})[e]	0 (4×10^{-9})	0 (2×10^{-12})[e]
Maximally Exposed Offsite Individual Risk							
Annual increased risk of an LCF	6×10^{-15}	d		7×10^{-10}	6×10^{-10}[e]	6×10^{-15}	3×10^{-16}[e]
Increased risk of an LCF over the life of the project	6×10^{-13}	d		3×10^{-9}	3×10^{-9}[e]	8×10^{-14}	6×10^{-16}[e]
Noninvolved Worker Risk							
Annual increased risk of an LCF	5×10^{-15}	d		5×10^{-9}	2×10^{-8}[e]	5×10^{-15}	2×10^{-15}[e]
Increased risk of an LCF over the life of the project	5×10^{-13}	d		3×10^{-8}	1×10^{-7}[e]	7×10^{-14}	4×10^{-15}[e]
Public and Occupational Health and Safety – Transportation							
Traffic accidents[c] (nonradiological fatalities)	0 (0.0003)	0 (0.019)	0 (0.021)	0 (0.0026)	0 (0.0013)	0 (0.0004)	0 (0.0053)
Offsite Population							
Dose (person-rem)	0	f	0.0025	0.0048	0.330	0.0112	0.945
LCFs	0	N/A	1.5×10^{-6}	2.9×10^{-6}	2.0×10^{-4}	6.7×10^{-6}	5.7×10^{-4}

Table 2–10. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Public and Occupational Health and Safety – Transportation *(continued)*							
Worker							
Dose (person-rem)	0	[f]	0.033	0.032	0.839	0.115	3.52
LCFs	0	N/A	2×10^{-5}	1.9×10^{-5}	5×10^{-4}	6.9×10^{-5}	2.1×10^{-3}
Environmental Justice							
Human health impacts	No disproportionately high and adverse human health impacts on minority or low-income populations due to normal facility operations or postulated facility accidents.						
Waste Management (cubic meters unless otherwise noted; values rounded to no more than three significant digits)							
Disposed of Off Site and/or Stored On Site							
LLW	1,700	7	692	68		10	N/A
MLLW	57	N/A	8	7		400	275
Hazardous	396	N/A	73	N/A			
Liquid LLW (liters)	623,000	182,000	324,000	N/A			
Industrial Safety							
Worker Population Impact – Total Project							
Total recordable cases (fatalities)	0.42 (0)	8.1 (0)	9.5 (0)	4.7 (0)	3.2 (0)	5.8 (0)	2.0 (0)

[a] Concentrations associated with FFTF Decommissioning alternatives and options are not projected to exceed applicable standards. The Federal standard for $PM_{2.5}$ is 35 micrograms per cubic meter (24-hour average). No specific data for $PM_{2.5}$ were available, but for the purposes of analysis, concentrations were assumed to be the same as for PM_{10}. Radiological air quality impacts are included separately under the public and occupational health and safety sections.

[b] Impacts on remote receptors would be negligible under Alternatives l and 3.

[c] The number of LCFs in a population is presented as an integer; where the value is 0, the calculated value (dose × 0.0006 LCFs per person-rem) is presented in parentheses.

[d] Impacts of accidents associated with facility disposition (building entombment or removal) would be less than those for disposition of RH-SCs or bulk sodium.

[e] Impacts are only for accidents that could occur at INL. Impacts identified for disposition of RH-SCs or bulk sodium at Hanford could also occur under the Idaho options during removal and preparation of material for shipment.

[f] All materials are sanitary and hazardous waste, not radioactive.

Note: To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471; liters to gallons, by 0.26417; meters to yards, by 1.0936.

Key: ASIL=acceptable source impact level; FFTF=Fast Flux Test Facility; FTE=full-time equivalent; INL=Idaho National Laboratory; LCF=latent cancer fatality; LLW=low-level radioactive waste; MFC=Materials and Fuels Complex; MLLW=mixed low-level radioactive waste; N/A=not applicable; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; RCB=Reactor Containment Building; rem=Röentgen equivalent man; RH-SCs=remote-handled special components; ROI=region of influence; RTP=Remote Treatment Project; wt=weight.

Source: Chapter 4 of this *TC & WM EIS*.

2.8.3 Waste Management Alternatives: Short-Term Environmental Impacts

2.8.3.1 Land Resources

Land use includes the land on and adjacent to Hanford, the physical features that influence current or proposed uses, pertinent land use plans and regulations, and land ownership and availability. Under the Waste Management No Action Alternative, there would be no change in land use within the 200 Areas or Borrow Area C. Under Alternative 2, the total land commitment within the 200 Areas would range from about 67 hectares (165 acres) under Disposal Group 1 to 250 hectares (618 acres) under Disposal Groups 2 and 3. Under Alternative 3, the total acreage required within the 200 Areas would be similar to that under Alternative 2 for all disposal groups. Because it would be necessary to mine geologic material under all alternative/disposal group combinations, land use within Borrow Area C would vary. Under Alternative 2, land commitment within Borrow Area C would range from 41.7 hectares (103 acres) under Disposal Group 1 to 159 hectares (392 acres) under Disposal Groups 2 and 3. Land commitment within Borrow Area C under Alternative 3 would range from 36.8 hectares (91 acres) under Disposal Group 1 to 157 hectares (388 acres) under Disposal Groups 2 and 3.

Visual resources are the natural and manmade features that give a particular landscape its character and aesthetic quality. Visual resources would not be affected under the No Action Alternative. However, there would be a noticeable change in the visual character of the 200 Areas and Borrow Area C under all alternative/disposal group combinations when viewed from nearby higher elevations and, in the case of Borrow Area C, State Route 240. In addition, ongoing construction, consolidation, operations, maintenance and deactivation of new or existing facilities on Rattlesnake and Gable Mountains would occur under each Waste Management alternative. These activities would result in short-term adverse impacts to land and visual resources, including the development or use of previously undisturbed land. However, the eventual consolidation or removal of unnecessary facilities/infrastructure on Rattlesnake and Gable Mountains would tend to improve the visual profile of the features, allow restoration of natural habitat, and enhance tribal religious and cultural experiences.

2.8.3.2 Infrastructure

Site infrastructure includes physical resources encompassing the utility systems required to support facility construction, operations, and closure activities associated with the Waste Management alternatives for waste storage, treatment, and disposal at Hanford (see Table 2–11). Utility infrastructure resources considered include electricity, liquid fuels, and water. Under Waste Management Alternative 1: No Action, ongoing waste storage, treatment, and disposal activities in LLBG 218-W-5 coupled with peak demands for deactivation of IDF-East would drive utility resource demands. Common to the action alternatives for waste management (see Alternatives 2 and 3) would be utility demands associated with construction, operations, and deactivation of new facility expansions to support ongoing Hanford waste treatment and storage activities. Otherwise, the magnitude of utility demands would vary primarily in direct relation to the size, number, and required lifespan of disposal facilities (i.e., the IDF(s) and RPPDF) that would be constructed, operated, and ultimately closed under each disposal group scenario. Nevertheless, peak and total utility resource requirements would be very similar within a disposal group between Waste Management Alternatives 2 and 3, with the division of disposal capacity using one IDF under Alternative 2 versus two IDFs under Alternative 3, resulting in little change in overall total and peak annual utility demands. One exception is the demand for electricity, which is projected to be the same regardless of the disposal configuration, with a relatively constant demand of 0.00019 million megawatt-hours. However, this demand is mainly attributable to ongoing disposal operations in LLBG 218-W-5. Regardless, this requirement is minimal compared to the current capacity (1.74 million megawatt-hours annually) of the Hanford electric power distribution system. While not considered to be a limiting resource, as additional supplies of liquid fuels can be trucked to the point of use as needed from offsite suppliers, liquid fuel requirements to supply mobile equipment associated with

disposal facility construction, operations, and closure would be substantial under the action alternatives compared to current Hanford consumption. Under Waste Management Alternatives 2 and 3, projected total diesel fuel requirements range from 215 million liters (56.8 million gallons) under Disposal Group 1 to 2,170 and 2,180 million liters (573 and 576 million gallons) under Alternative 3, Disposal Group 3, and Alternative 2, Disposal Group 3, respectively (see Table 2–11). Peak annual diesel fuel consumption would range from about 39.0 million liters (10.3 million gallons) under Disposal Group 1 to 151 million liters (39.9 million gallons) under Waste Management Alternative 2, Disposal Groups 2 and 3. Projected total water usage ranges from about 2,610 million liters (697 million gallons) under Alternative 3, Disposal Group 1, to 36,800 million liters (9,720 million gallons) under Alternative 2, Disposal Group 3. Peak annual water demand would range from about 66.7 million liters (17.6 million gallons) under Alternative 3, Disposal Group 1 up to 259 million liters (68.4 million gallons) under Alternative 2, Disposal Groups 2 and 3. The projected peak water demand of 259 million liters (68.4 million gallons) would be about 1.4 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 32 percent of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford (see Chapter 3, Section 3.2.2).

2.8.3.3 Noise and Vibration

Noise is undesirable sound that interferes negatively with the human or natural environment. Noise may disrupt normal activities (e.g., hearing, sleep), damage hearing, or diminish the quality of the environment. Noise impacts may result from construction, operations, deactivation, and closure activities, including increased traffic. Noise impacts of onsite activities under all Waste Management alternatives would be negligible. Under the No Action Alternative, there would be negligible noise impact of employee vehicles. Noise impacts of traffic would be highest under Alternative 2, Disposal Groups 2 and 3, which would have the highest peak year employment and employee vehicle traffic. The increase in employee traffic noise along the road to the site during peak hours (shift changes) could be noticeable to residents along these routes. Alternative 2, Disposal Group 2, would have the highest offsite truck traffic associated with RPPDF closure. Noise impacts of onsite activities and traffic under the other alternatives would be negligible to minor.

2.8.3.4 Air Quality

Air pollution refers to any substance in the air that could harm human or animal populations, vegetation, or structures or that unreasonably interferes with the comfortable enjoyment of life and property. As modeled, nonradiological air pollutant concentrations under all Waste Management alternatives would exceed the applicable 24-hour ambient standard for $PM_{2.5}$ and PM_{10} and the annual standard under Alternative 2, Disposal Groups 2 and 3, and Alternatives 2 and 3, Disposal Groups 2 and 3. The annual standard would also be exceeded under Alternatives 2 and 3, Disposal Group 1, for $PM_{2.5}$. Nonradiological air quality impacts of $PM_{2.5}$ and PM_{10} would be highest under Alternative 3, Disposal Groups 2 and 3. Under this alternative and disposal group, $PM_{2.5}$ and PM_{10} concentrations in the peak year would be attributable primarily to fugitive dust from heavy-equipment operations during IDF-East operations and RPPDF construction.

Particulate matter emissions estimated for construction-type activities include fugitive dust emissions from construction areas and account for dust suspended by equipment and vehicle activity and by wind. The emission factor used for these estimates is intended to provide a gross estimate of total suspended particulate emissions when more-detailed engineering data of a construction activity are not available that would allow for a more-refined estimate of dust emissions. For the purpose of this analysis, $PM_{2.5}$ and PM_{10} emissions from general construction activities were assumed to be the same as the total suspended particulate emissions. This results in a substantial overestimate of $PM_{2.5}$ and PM_{10} emissions. Further, the analysis did not consider appropriate emission controls that could be applied in the construction areas, as discussed in Chapter 4, Section 4.9.2. A refined analysis of emissions based on more-detailed

engineering data of the construction activities and application of appropriate control technologies is expected to result in substantially lower emissions and ambient concentrations from the major construction activities under these alternatives. Maximum air quality impacts of particulate matter are expected to occur along State Route 240, along or near the Hanford boundary to the east to southeast, or along the Hanford boundary to the southwest.

The Clean Air Act, as amended (40 U.S.C. 7401 et seq.), requires that Federal actions conform to the host state's "state implementation plan." A state implementation plan provides for the implementation, maintenance, and enforcement of NAAQS for the six criteria pollutants: sulfur dioxide, PM_{10}, carbon monoxide, ozone, nitrogen dioxide, and lead. Its purpose is to eliminate or reduce the severity and number of NAAQS violations and to expedite the attainment of these standards. "No department, agency, or instrumentality of the Federal Government shall engage in or support in any way or provide financial assistance for, license or permit, or approve any activity that does not conform to an applicable implementation plan." The final rule for "Determining Conformity of General Federal Actions to State or Federal Implementation Plans" (40 CFR 51.850–51.860) took effect on January 31, 1994. Hanford is within an area currently designated as attainment for criteria air pollutants (40 CFR 81.348). Therefore, the alternatives considered in this EIS do not require a conformity determination under the provisions of this rule.

Maximum concentrations of nonradiological toxic air pollutants off site and in areas to which the public has access would be less than 38 percent of the state's acceptable source impact levels. Maximum concentrations of carcinogenic toxic pollutants would be less than 38 percent of the state's acceptable source impact levels. Acceptable source impact levels are used during the permitting process to demonstrate that emissions from a new toxic air pollutant source are sufficiently low to protect human health and safety from potential carcinogenic and/or other toxic effects. Comparison of the estimated concentrations to acceptable source impact levels indicates that emissions under all Waste Management alternatives would be sufficiently low to protect human health and safety. Impacts of radiological air emissions are summarized in Section 2.8.1.10.

Chapter 6, Section 6.5.2, "Global Climate Change," summarizes the estimated annual carbon dioxide emissions by *TC & WM EIS* alternative.

2.8.3.5 Geology and Soils

Geologic resources include consolidated and unconsolidated earth materials, including rock and mineral assets such as ore and aggregate materials (e.g., sand, gravel) and fossil fuels such as coal, oil, and natural gas. Soil resources include the loose surface materials of the earth in which plants grow. Impacts on geology and soils would generally be directly proportional to the total area of land disturbed by facility construction, operations, deactivation, and closure associated with the Waste Management alternatives for waste treatment, storage, and disposal (see Table 2–11). Consumption of geologic resources, including rock, mineral, and soil resources, would constitute the major indirect impact on geologic and soil resources. As for other areas of the impacts analysis, Hanford waste treatment and storage activities and commensurate geologic resource requirements would be identical under Waste Management Alternatives 2 and 3. Under Waste Management Alternative 1: No Action, interim waste storage, treatment, and disposal activities would have little additional impact on geology and soils. Deactivation of IDF-East under this alternative would involve backfilling the facility with stockpiled material. No new facilities would be constructed or expanded under Alternative 1, but geologic resources totaling 6,230 cubic meters (8,150 cubic yards), would be required from Borrow Area C to support ongoing waste disposal operations in trenches 31 and 34 in LLBG 218-W-5. Under both Alternatives 2 and 3, limited impacts on geology and soils would occur associated with the construction of new facilities or facility expansion in support of ongoing Hanford waste treatment and storage activities. Construction activities would permanently disturb about 2.7 hectares (6.7 acres), with excavations of up to 3 meters (10 feet) in

depth. Work would occur in previously disturbed areas in the 200-West Area. Geologic resource requirements would total 10,600 cubic meters (13,860 cubic yards) (see Table 2–11).

For the three disposal groupings under each action alternative (Waste Management Alternatives 2 and 3), impacts on geology and soils and associated demand for geologic resources would be relatively substantial and would vary primarily in direct relation to the size, number, and required lifespan of disposal facilities (i.e., the IDF(s) and RPPDF) that would be constructed, operated, and ultimately closed under each disposal scenario. New permanent land disturbance would range from 104 hectares (257 acres) under Waste Management Alternative 2, Disposal Group 1, to a high of 398 hectares (983 acres) under Waste Management Alternative 3, Disposal Groups 2 and 3. Permanent land disturbance includes that projected for the construction of new disposal facilities plus area excavated in Borrow Area C to supply geologic resources. The potential for short-term wind and water erosion would exist in disturbed areas but would be minimized via the application of best management practices. Disposal facility construction would require excavations to a depth of about 14 meters (45 feet), but the need for blasting is not expected due to the depth of the Hanford formation sediments across the areas in which new facilities would be constructed. Projected geologic resource requirements range from a total of 1,760,000 cubic meters (2,300,000 cubic yards) under Waste Management Alternative 3, Disposal Group 1, to 7,610,000 cubic meters (9,950,000 cubic yards) under Waste Management Alternative 2, Disposal Groups 2 and 3 (see Table 2–11). These requirements would consist primarily of materials needed for construction of a modified RCRA Subtitle C barrier over the IDF(s) and RPPDF(s) to effect final closure.

2.8.3.6 Water Resources

Water resources are the surface and subsurface waters that are suitable for human consumption, aquatic or wildlife use, agricultural purposes, irrigation, or industrial/commercial purposes. Implementation of Waste Management Alternative 1 would have no additional impacts on surface water, the vadose zone, or groundwater. Increased stormwater runoff could occur during deactivation of IDF-East but any effects would be confined to the 200 Areas. Under both Waste Management Alternatives 2 and 3, impacts on surface-water resources and quality associated with construction of expanded Hanford waste treatment and storage facilities would be negligible. The expanded facilities would be constructed in previously developed portions of the 200-West Area with any effect on stormwater runoff quality likely to be very localized and of short duration, with no incremental impacts on groundwater. Water would be required during construction, operations, and deactivation of new/expanded facilities (see Table 2–11). Effluents, generated from operation of the new/expanded facilities, would be discharged to existing treatment facilities that already service the 200 Areas.

For the three disposal groupings under each action alternative (Waste Management Alternatives 2 and 3), impacts on surface water from new disposal facility construction would be limited to the very poorly defined drainage features that are present where the RPPDF would be constructed between the 200-East and 200-West Areas. The potential exists for site clearing, grading, and facility excavation work during construction to expose soils and sediments to possible erosion by infrequent, heavy rainfall or by wind. This potential would be greater under Disposal Groups 2 and 3, where larger land areas would be affected, but any impacts would be localized and of short duration. Nevertheless, appropriate soil erosion and sediment control measures, spill prevention and waste management practices, and National Pollutant Discharge Elimination System and state waste-discharge permitting requirements would be implemented to minimize any impacts on surface water, the vadose zone, and groundwater. Construction also is not expected to affect groundwater flow in the vicinity of any disposal facilities.

Normal disposal facility operations, including the continued operation of trenches 31 and 34 in LLBG 218-W-5, are not expected to have any additional impact on water resources in the short term. The trenches are lined, RCRA-compliant disposal facilities equipped with a leachate collection system.

Leachate would continue to be collected and disposed of at ETF. The new IDF(s) and RPPDF would incorporate appropriate stormwater management engineering and operational controls to collect, detain, and convey stormwater away from disposal areas, so as to minimize water quality impacts during operations. The new facilities would include a redundant (double) liner system, a leachate collection and removal system, and a leak detection system to protect subsurface-water quality. Collected leachate would be similarly detained and trucked to the ETF for treatment and disposal. Potential impacts of normal operations of the IDF(s) and RPPDF would only increase relative to the longer operational lifespans from Disposal Group 1 to Disposal Group 2. Nevertheless, following completion of disposal activities in the IDF(s) and the RPPDF under each disposal grouping, each facility would be closed with a modified RCRA Subtitle C barrier to minimize infiltration through emplaced waste in the short term, and each facility would be subject to a DOE-administered 100-year postclosure care period.

Water would be required to support waste management disposal activities, including dust control, soil compaction, and other activities, during disposal facility construction, operations, and closure, with demands generally varying based on the total size of the disposal facilities under each scenario. While water demands would be relatively substantial under all disposal scenarios, demands would not exceed site capacity (see Section 2.8.3.2).

2.8.3.7 Ecological Resources

Ecological resources include terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. There would be no impact on ecological resources, including sagebrush habitat and threatened and endangered species, within the 200 Areas or Borrow C under the Waste Management No Action Alternative. However, sagebrush habitat within the 200 Areas would be affected under Waste Management Alternatives 2 and 3, and the total affected acreage would be similar under each alternative and waste disposal combination (i.e., ranging from about 63.9 hectares to 76.9 hectares [158 acres to 190 acres] under Disposal Group 1 and from about 247 hectares to 253 hectares [611 acres to 624 acres] under Disposal Groups 2 and 3 for Alternatives 2 and 3, respectively). While grassland habitat within Borrow Area C would be disturbed under all alternative and waste disposal combinations, no sagebrush habitat within that area would be affected.

No federally or state-listed threatened or endangered species would be affected under any alternative/disposal combination within either the 200 Areas or Borrow Area C. However, there is potential to impact a number of state-listed special status species under Alternatives 2 and 3. All disposal groups under Alternative 2 have the potential to impact four state-listed special status species in the 200 Areas and four in Borrow Area C; however, due to the greater acreage of habitat disturbed, the potential is greater under Disposal Groups 2 and 3. Under all disposal groups under Alternative 3, the potential exists to disturb five state-listed special status species within the 200 Areas and four within Borrow Area C. There is greater potential to impact these species under Disposal Groups 2 and 3 also, due to the greater acreage of habitat disturbed.

Due to the lack of wetlands and aquatic resources within the 200 Areas and Borrow Area C, there would be no impact on these resources under any of the alternatives.

2.8.3.8 Cultural and Paleontological Resources

Cultural resources are the indications of human occupation and use of property, as defined and protected by a series of Federal laws, regulations, and guidelines, and are categorized as prehistoric resources, historic resources, and American Indian interests. Prehistoric resources are the physical remains of human activities that predate written records. Historic resources consist of physical remains that postdate the emergence of written records. American Indian interests include sites, areas, and materials important to American Indians for religious or heritage reasons. Paleontological resources are the physical remains, impressions, or traces of plants or animals from a former geologic age and may be sources of information on ancient environments and the evolutionary development of plants and animals. Under the Waste

Management alternatives and disposal groups, there would be no impact on prehistoric, historic, or paleontological resources. There would be no impact on American Indian interests under the No Action Alternative. There would be an impact on the viewshed from higher elevations, including Rattlesnake Mountain, under Alternatives 2 and 3 treatment and storage. Alternatives 2 and 3, Disposal Groups 1, 2, and 3, would all affect the viewshed from Rattlesnake Mountain and higher elevations. The greater the land disturbance, the more the viewshed would be affected. Alternatives 2 and 3, Disposal Groups 2 and 3, would disturb the greatest area of land for the expansion or construction of the IDF(s), construction of the RPPDF, and excavation of Borrow Area C, thus having the most impact on the viewshed.

2.8.3.9 Socioeconomics

Socioeconomic impacts are defined in terms of changes to demographic and economic characteristics of a region. The socioeconomic environment is generally made up of regional economic indicators and demographic characteristics of the area. Economic indicators include employment, the civilian labor force, and unemployment rates. Demographic characteristics include population, housing, education, and health information. In addition, the projected workforce and work activities could potentially impact the local transportation and result in level-of-service impacts on the roads in the ROI (i.e., the Tri-Cities). Under Waste Management Alternatives 2 and 3, there would be potential for similar socioeconomic impacts in the ROI, merely in different time periods. The impacts would be greatest under Disposal Groups 2 and 3, where the projected workforce would be needed for construction of the barriers over IDF-East and the RPPDF as late as 2101 and 2166, respectively. The near-term (less than 100 years) impacts would be minimal.

2.8.3.10 Public and Occupational Health and Safety—Normal Operations

A description of the radiological releases associated with Waste Management alternatives is provided in Chapter 4 of this *TC & WM EIS*. Radiological impacts on both the public and workers are estimated. For the public, impacts are presented for the population within 80 kilometers (50 miles) of the 200-West Area, an MEI, and an onsite MEI. Public impacts associated with the No Action Alternative are from existing, permitted facilities and are accounted for in currently reported dose impacts. Offsite impacts of the action alternatives would be dominated by radiological air emissions from the treatment activities. Because waste handled during disposal operations would be packaged or have very low radioactivity, the contribution to remote receptors would be negligible compared to the emissions associated with treatment activities.

The incremental dose to the public (in addition to the dose from current waste management operations) would be the same under Waste Management Alternatives 2 and 3. The population dose over the life of the project would be 0.00067 person-rem; no additional LCFs are expected as a result of this dose. The incremental dose received by the MEI in the year of maximum impact would be 0.00000021 millirem; the increased risk of an LCF from this dose is negligible. The dose and risk to an onsite MEI, assumed to be at the Laser Interferometer Gravitational-Wave Observatory, would be less than for the offsite MEI because the onsite MEI would be exposed for a shorter duration and through fewer pathways (e.g., no ingestion).

Doses to radiation workers would result from TSD operations. Under Waste Management Alternative 1: No Action, the worker population dose from continuing operations for 29 years would be 37 person-rem; no LCFs are expected as a result of this dose. Under Alternatives 2 and 3, worker radiation doses would be the same for treatment and storage activities, as well as for each of the three disposal groups analyzed. Under Waste Management Alternative 2 or 3, Disposal Group 1, the collective worker dose over the life of the project (for TSD) would be about 3,400 person-rem; only 360 person-rem of this dose would be from the 44 years of disposal operations. Statistically, this collective dose could result in two LCFs in the worker population. Alternative 2 or 3, Disposal Group 2, would result in a collective worker dose over the life of the project of 6,600 person-rem; about half of this dose would be from 94 years of disposal operations. Statistically, this collective dose could result in four LCFs in the

worker population. Alternative 2 or 3, Disposal Group 3, would result in a collective worker dose over the life of the project of 9,400 person-rem; about 6,400 person-rem of this dose would be from 159 years of disposal operations. Statistically, this collective dose could result in six LCFs in the worker population. The risk of LCFs occurring as a result of these doses should be considered in terms of the timeframe over which the doses occur and DOE's guidance for maintaining individual worker doses below the Administrative Control Level of 500 millirem per year (DOE Standard 1098-99). Some of these doses would accrue over several generations of workers. Additionally, the estimated average annual dose to a radiation worker under any of the Waste Management alternatives would be 200 millirem per year. If this dose were received over a 40-year career, a worker would receive a dose of 8,000 millirem and the associated individual risk of an LCF would be 1 in 200.

Under Alternatives 2 and 3, the maximum annual dose to a nearby noninvolved worker assumed to be 100 meters (330 feet) from the treatment facility would be 0.00023 millirem. The risk of an LCF from this exposure would be negligible.

2.8.3.11 Public and Occupational Health and Safety—Facility Accidents

Processing any hazardous material creates a risk of accidents impacting involved workers (workers directly involved in facility processes), noninvolved workers (workers on the site but not directly involved in facility processes), and members of the public. The consequences of such accidents could involve the release of radioactive materials, toxic chemicals or hazardous (e.g., explosive) energy, beyond the intended confines of the process. Risk is determined by the development of a representative spectrum of postulated accidents, each of which is conservatively characterized by a likelihood (i.e., expected frequency of occurrence) and a consequence. For the alternatives presented in Table 2–11, the accident consequences are conditional on an accident's occurrence and therefore do not reflect an accident's frequency of occurrence.

All three Waste Management alternatives have the potential for accidents involving the waste inventories stored at the SWOC. Under Waste Management Alternative 1, construction of IDF-East would be discontinued in 2008. Therefore, accidents associated with the onsite disposal of ILAW are not applicable to Waste Management Alternative 1. Under Waste Management Alternatives 2 and 3, new facilities or expansions of existing facilities would be required and there would be limited shipments of LLW and MLLW from other DOE sites to Hanford.

Under all three Waste Management alternatives, the accident that would have the highest consequences if it were to occur is the aircraft crash with ensuing fire at the Hanford SWOC. The frequency of this accident is estimated to be 0.00003 per year (once in 33,000 years). The consequences of a large fire (from other origins) involving waste containers stored outside at the SWOC would be only about 30 percent lower than for the aircraft crash accident; however, the estimated frequency of that fire is significantly greater than for the aircraft crash (0.01 compared to 0.00003 per year). As a result, the annual LCF risk to individuals and the population from the large waste-container fire would be greater than for the fire initiated by an aircraft crash. Accordingly, the accident scenario titled "large fire of waste containers outside facility (SWOC FIR-4)" is used as the basis for this summary comparison of alternatives.

The accident risks shown in Table 2–11 take into account an accident's frequency. The annual risk value reflects the annual frequency of the accident. The risk over the life of the project reflects the duration of the activity that produces the accident potential, ranging from 29 to 159 years, during which that accident could occur. Under the Waste Management action alternatives, the risk over the life of the project from the large fire scenario would be highest under Alternatives 2 and 3, Disposal Group 3, which have the longest duration, and lowest under Alternatives 2 and 3, Disposal Group 1.

In accordance with DOE orders, DOE protects against intentional destructive acts aimed at its facilities and materials. Regardless of those protections, this EIS evaluates the potential impacts of intentional destructive acts in addition to conventional facility accident scenarios. The intentional crashing of a large

aircraft into a SWOC storage building was assumed to damage all of the containers in the building. The radiological impacts would be about 18 times greater than those calculated for the aircraft crash accident scenario. This scenario applies to all Waste Management alternatives. More-detailed discussion of intentional destructive act impacts associated with Waste Management alternatives is provided in Chapter 4, Section 4.3.11.4.

2.8.3.12 Public and Occupational Health and Safety—Transportation

The various wastes generated at Hanford from tank closure and FFTF decommissioning activities, along with the waste transported from offsite DOE sources, are managed and disposed of in an IDF. Offsite waste would be accepted at Hanford only under Waste Management Alternatives 2 and 3. The onsite-generated LLW and MLLW, excluding waste from tank closure and FFTF decommissioning activities, would be common to all alternatives. Transport and disposition of all other waste considered under the Waste Management alternatives were already evaluated under the Tank Closure and FFTF Decommissioning alternatives. Table 2–11 summarizes the transportation risks to the workers (transport drivers) and the public in terms of traffic fatalities and LCFs. Based on the results presented in this table, the following conclusions have been reached:

- It is unlikely that transportation of radioactive waste would cause an additional fatality as a result of radiation from either incident-free operations or postulated transportation accidents. It should be noted that the maximum annual dose to a transportation worker would be 100 millirem per year, unless the individual is a trained radiation worker, which would administratively limit the annual dose to 2 rem (DOE Standard 1098-99). Exposure to a maximum annual dose of 2 rem per year would lead to an LCF risk of 1.2×10^{-3}. Assuming that an individual is exposed for 20 years to the same annual exposure, the cumulative LCF risk would be 2×10^{-2}.
- The highest risk to the public would occur under Waste Management Alternative 2 or 3, where about 16,600 shipments of waste would be transported to Hanford from various DOE facilities.
- The lowest risk to the public would occur under Waste Management Alternative 1, where no waste from other DOE facilities would be shipped to Hanford.

2.8.3.13 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of their programs, policies, and activities on minority and low income populations. Potential risks to human health from normal facility operations and postulated facility accidents are not expected to pose disproportionately high and adverse effects on minority or low-income populations surrounding Hanford under any Waste Management alternative.

2.8.3.14 Waste Management

Waste Management alternatives and disposal groups developed to manage the various waste volumes would generate several types of waste associated with the construction, operations, deactivation, and closure of expanded waste treatment and storage facilities and new waste disposal, including LLW, MLLW, and hazardous waste. Common to Waste Management Alternatives 2 and 3 is that Hanford waste treatment and storage activities would be expanded at the CWC, T Plant, and WRAP to provide greater capacity and throughput. Also common to all three Waste Management alternatives is the continued operation of trenches 31 and 34 for disposal of LLW/MLLW until filled. The generation of waste could have little or minimal impact on existing Hanford facilities devoted to TSD. As described in Chapter 4, the current waste management capacity is either sufficient or the new infrastructure would be constructed as part of the alternative. Projected waste generation rates for the proposed activities were compared with Hanford's capacity to manage the waste, including the additional waste disposal capacity

that is proposed to be constructed. Projected waste generation rates for the proposed activities were compared with site processing rates and capacities of those TSD facilities likely to be involved in managing the additional waste. Potential impacts of waste generated as a result of site environmental restoration activities unrelated to Tank Closure, FFTF Decommissioning, or Waste Management proposed actions and alternatives are not within the scope of this analysis, but are included in the cumulative impacts analysis. Where additional disposal capacity would be needed, the land use impacts are addressed in the appropriate sections of Chapter 4. The projected full inventories of waste forms disposed of on site are included in the analyses of long-term impacts presented in Chapter 5 of this *TC & WM EIS*.

LLW. LLW would be generated during routine operations at the two MLLW trenches (trenches 31 and 34) in LLBG 218-W-5 and during operations of WRAP and the T Plant. LLW is typically not treated or only minimally treated (e.g., compaction) before disposal. Therefore, this waste treatment would cause no impacts on the Hanford waste management system. The LLW would be sent directly to disposal. Therefore, long-term storage facilities would not be required. All LLW would be disposed of in an IDF.

MLLW. MLLW would be generated during routine operations at WRAP and the T Plant. Using a combination of on- and offsite capabilities, MLLW would be treated to meet RCRA land-disposal-restriction treatment standards prior to disposal. All MLLW would be disposed of in an IDF.

Hazardous waste. Hazardous waste is dangerous waste as defined in the *Washington Administrative Code* (WAC 173-303). Hazardous waste generated during operations at the two MLLW trenches (trenches 31 and 34) in LLBG 218-W-5 and for postclosure care of the IDF(s) would be packaged in DOT-approved containers and shipped off site to permitted commercial recycling, treatment, and disposal facilities. Management of the additional waste generated under the Waste Management alternatives would require little, if any, additional planning. The waste would be treated and disposed of at offsite commercial facilities.

2.8.3.15 Industrial Safety

In addition to facility accident risks, estimates of potential industrial safety impacts on workers during construction, operations, deactivation, and closure activities under each Waste Management alternative were evaluated based on the DOE complex–wide computerized Accident/Incident Reporting System database (see Appendix K, Section K.4). These impacts correlate with the number of labor hours required to support each Waste Management alternative and are classified into two groups: TRCs and fatalities. A recordable case includes work-related deaths, illnesses, or injuries leading to loss of consciousness, lost workdays, transfer to another job, and/or requiring medical treatment beyond first aid.

Table 2–11 summarizes the potential number of TRCs and fatalities resulting from the construction, operations, deactivation, and closure activities that would be conducted under each Waste Management alternative. There would be no worker fatalities under any of the Waste Management alternatives. The fewest projected industrial safety impacts would occur under Waste Management Alternative 1; the No Action Alternative would require 1 million labor hours and would generate only 10 TRCs. Under the action alternatives for waste management, the fewest projected impacts would occur under Alternative 3, Disposal Group 1, which is expected to result in approximately 214 TRCs. The highest projected impacts would occur under Alternative 3, Disposal Group 3, which could result in more than 2,000 TRCs.

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a]

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Land Resources								
Land Use (total land commitment)	No change in land use within the 200 Areas or Borrow Area C.	2.7 hectares affected within the 200-West Area.	63.9 hectares affected within and adjacent to the 200-East Area. 41.7 hectares affected within Borrow Area C.	247 hectares affected within and adjacent to the 200-East Area. 159 hectares affected within Borrow Area C.		76.9 hectares of land affected within and adjacent to the 200 Areas. 36.8 hectares affected within Borrow Area C.	253 hectares affected within and adjacent to the 200 Areas. 157 hectares affected within Borrow Area C.	
Visual resources	No change in the visual character of the 200 Areas.	No meaningful change in the visual character of the 200-West Area.	Noticeable change in the visual character of the 200 Areas and Borrow Area C, especially from nearby higher elevations, or, in the case of Borrow Area C, State Route 240.					
Infrastructure								
Total Requirements								
Electricity (million megawatt-hours)	0.0056	0.55	0.0085					
Diesel fuel (million liters)	13.9	42.0	215	1,420	2,180	215	1,410	2,170
Gasoline (million liters)	1.23	8.48	13.2	74.6	100	13.2	74.6	100
Water (million liters)	35.7	430	2,620	20,800	36,800	2,610	20,700	36,500
Peak Annual Demand								
Electricity (million megawatt-hours)	0.00019	0.018	0.00019					
Diesel fuel (million liters)	3.46	2.60	39.0	151		38.9	149	
Gasoline (million liters)	0.012	1.01	3.68	14.2		3.66	14.1	
Water (million liters)	25.5	23.9	67.0	259		66.7	256	

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Noise and Vibration: Negligible offsite impact of onsite activities. Minor traffic noise impacts.								
Air Quality								
Peak Year Incremental Criteria Pollutant Concentrations as Compared to Most Stringent Guideline or Standard (micrograms per cubic meter)[b]								
Carbon monoxide (1-hour) standard=40,000	451	12,200	**49,800**	**257,000**		**51,200**	**256,000**	
Nitrogen oxides (annual) standard=100	1.24	3.47	19.2	92.1		20.1	92.0	
PM_{10} (24-hour) standard=150	**507**	**717**	**3,360**	**17,200**		**3,420**	**17,300**	
Sulfur oxides (1-hour) standard=660	0.71	16.5	68.4	353		70.5	352	
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[b]								
Ammonia (24-hour) ASIL=100	0.210	8.74	3.84	20.0		4.09	20.0	
Benzene (annual) ASIL=0.12	0.000264	0.001	0.007	0.033		0.007	0.033	
Toluene (24-hour) ASIL=400	0.027	1.84	6.00	31.2		6.20	31.1	
Xylene (24-hour) ASIL=1,500	0.01	0.526	1.78	9.27		1.84	9.25	

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Geology and Soils								
Construction impacts	Little additional impact on geology and soils.	Limited impact on geology and soils from construction of new/expanded facilities in previously disturbed areas. Excavation depths up to 3 meters.	Small-to-moderate impact of construction, including potential for short-term soil erosion. Excavation depths to 14 meters.	Impacts similar in nature to, but greater than, those under Alternative 2, Disposal Group 1. Excavation depths to 14 meters.	The impacts would be identical to those under Alternative 2, Disposal Group 2.	Similar to those under Alternative 2, Disposal Group 1, but impacts more dispersed across the 200 Areas.	Similar to those under Alternative 2, Disposal Group 2, but impacts more dispersed across the 200 Areas.	Similar to those under Alternative 2, Disposal Group 3, but impacts more dispersed across the 200 Areas.
New permanent land disturbance (hectares)	0.0	2.7	104	398		98.7	397	
Geologic resource requirements (cubic meters)	6,230	10,600	1,980,000	7,610,000		1,760,000	7,550,000	
Water Resources								
Surface water	No additional impacts on surface water in the short term.	Negligible potential impact on surface water from stormwater runoff.	Short-term increase in stormwater runoff during construction, but little-to-no impact on surface-water features. Water use would not exceed site capacity.	Similar to those under Alternative 2, Disposal Group 1, with greater potential for stormwater runoff during construction. Longer period of operations than under Alternative 2, Disposal Group 1. Water use would not exceed site capacity.	Potential construction impacts would be similar to those under Alternative 2, Disposal Group 2. Longer period of operations than under Alternative 2, Disposal Group 2. Water use would not exceed site capacity.	Similar to those under Alternative 2, Disposal Group 1.	Similar to those under Alternative 2, Disposal Group 2.	Similar to those under Alternative 2, Disposal Group 3.

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Water Resources *(continued)*								
Vadose zone and groundwater	No additional impact in the short term.	No direct discharge of effluents from facility operations to the vadose zone or groundwater.	No impact on groundwater flow from construction. No impact on groundwater in the short term from collection and treatment of leachate.	Similar to those under Alternative 2, Disposal Group 1.	The potential for impacts during operations would increase proportionally to the lifespan of the disposal facilities.	Similar to those under Alternative 2, Disposal Group 1.	Similar to those under Alternative 2, Disposal Group 2.	Similar to those under Alternative 2, Disposal Group 3.
Ecological Resources								
Terrestrial resources	No impact within the 200 Areas or Borrow Area C.	0.4 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	63.9 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	247 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.		76.9 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	253 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	
Wetlands	No impact on wetlands within the 200 Areas or Borrow Area C.							
Aquatic resources	No impact on aquatic resources within the 200 Areas or Borrow Area C.							
Threatened and endangered species	No impact on federally or state-listed threatened, endangered, or special status species.	No impact on federally or state-listed threatened, endangered, or special status species within the 200 Areas.	No impact on federally or state-listed threatened or endangered species. Potential impact on 4 state-listed special status species within the 200 Areas. Potential impact on 4 state-listed special status species within Borrow Area C.	No impact on federally or state-listed threatened or endangered species. Somewhat greater potential to impact 4 state-listed special status species within the 200 Areas than under Disposal Group 1, as more sagebrush habitat would be disturbed. Potential impact on 4 state-listed special status species within Borrow Area C.		No impact on federally or state-listed threatened or endangered species. Potential impact on 5 state-listed special status species within the 200 Areas. Potential impact on 4 state-listed special status species within Borrow Area C.	No impact on federally or state-listed threatened or endangered species. Somewhat greater potential impact on 5 state-listed special status species within the 200 Areas than under Disposal Group 1, as more sagebrush habitat would be disturbed. Potential impact on 4 state-listed special status species within Borrow Area C.	

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Cultural and Paleontological Resources								
Prehistoric resources	No impact on prehistoric resources.							
Historic resources	No impact on historic resources.							
American Indian interests	No impact on American Indian interests.	Impacts on viewshed from higher elevations, including Rattlesnake Mountain.	Expansion of IDF-East and construction of the RPPDF would affect 62.3 hectares. Excavation of Borrow Area C would involve 41.7 hectares. This would change the viewscape from Rattlesnake Mountain and higher elevations.	Expansion of IDF-East and construction of the RPPDF would affect 240 hectares. Excavation of Borrow Area C would involve 159 hectares. This would change the viewscape from Rattlesnake Mountain and higher elevations.		The impact would be similar to those under Alternative 2, Disposal Group 1.	The impact would be similar to those under Alternative 2, Disposal Groups 2 and 3.	
Paleontological resources	No impact on paleontological resources.							
Socioeconomics								
Peak annual workforce (FTEs)	109	449	1,180	4,540		1,170	4,500	
Peak daily commuter traffic (vehicles per day)	88	360	943	3,640		940	3,600	
Peak daily truck loads – off site	Less than 1	2	28	34		28	33	
Impact on the ROI	Little impact on socioeconomic ROI.	Potential for change in the socioeconomic ROI, including level-of-service impacts on local transportation. Impacts would be similar under both alternatives.						

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Public and Occupational Health and Safety – Normal Operations[c]								
Offsite Population Impact – Life of the Project								
Dose (person-rem)	d	0.00067	e					
LCF[f]	d	0 (4×10^{-7})	e					
Peak Year Maximally Exposed Individual Impact								
Dose (millirem per year)	d	0.00000021	e					
Increased risk of an LCF	d	1×10^{-13}	e					
Peak Year Onsite Maximally Exposed Individual Impact								
Dose (millirem per year)	d	0.000000057	e					
Increased risk of an LCF	d	3×10^{-14}	e					
Radiation Worker Population Impact – Life of the Project								
Dose (person-rem)	37	3,000	360	3,600	6,400	360	3,500	6,400
LCF[f]	0 (2×10^{-2})	2	0 (2×10^{-1})	2	4	0 (2×10^{-1})	2	4
Average Annual Impact per Radiation Worker								
Dose (millirem per year)	200		200					
Increased risk of an LCF	1×10^{-4}		1×10^{-4}					
Peak Year Noninvolved Worker Impact								
Dose (millirem per year)	d	0.00023	e					
Increased risk of an LCF	d	1×10^{-10}	e					

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Public and Occupational Health and Safety – Facility Accidents								
Offsite Population Consequences								
Dose (person-rem)	1,100	h	1,100					
Number of LCFs	1		1					
Maximally Exposed Offsite Individual Consequences								
Dose (rem)	0.25	h	0.25					
Increased risk of an LCF	2×10^{-4}		2×10^{-4}					
Noninvolved Worker Consequences								
Dose (rem)	260	h	260					
Increased risk of an LCF	3×10^{-1}		3×10^{-1}					
Offsite Population Risk								
Annual number of LCFs[f]	0 (7×10^{-3})	h	0 (7×10^{-3})					
Number of LCFs over the life of the project[f]	0 (2×10^{-1})		0 (3×10^{-1})	1 (6.3×10^{-1})	1 (1.1)	0 (3×10^{-1})	1 (6.3×10^{-1})	1 (1.1)
Maximally Exposed Offsite Individual Risk								
Annual increased risk of an LCF	2×10^{-6}	h	2×10^{-6}					
Increased risk of an LCF over the life of the project	4×10^{-5}		6×10^{-5}	1×10^{-4}	2×10^{-4}	6×10^{-5}	1×10^{-4}	2×10^{-4}
Noninvolved Worker Risk								
Annual increased risk of an LCF	3×10^{-3}	h	3×10^{-3}					
Increased risk of an LCF over the life of the project	9×10^{-2}		1×10^{-1}	3×10^{-1}	5×10^{-1}	1×10^{-1}	3×10^{-1}	5×10^{-1}

Table 2–11. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/Resource	Waste Management Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Public and Occupational Heath and Safety – Transportation								
Traffic accidents[g] (nonradiological fatalities)	0 (0.003)	0 (0.03)	0 (0.07)	0 (0.25)	0 (0.32)	0 (0.06)	0 (0.25)	0 (0.32)
Offsite Population								
Dose (person-rem)	0.083	352	i					
LCFs	5×10^{-5}	2.2×10^{-1}	i					
Worker								
Dose (person-rem)	2.62	2,621	i					
LCFs	1.6×10^{-3}	1.57	i					
Environmental Justice								
Human health impacts	No disproportionately high and adverse human health impacts on minority or low-income populations due to normal facility operations or postulated facility accidents.							
Waste Management (all values are in cubic meters unless otherwise noted; values rounded to no more than three significant digits)								
LLW	38	1,460	58					
MLLW	N/A	98	N/A					
Hazardous	38	N/A	58					
Industrial Safety								
Worker Population Impact – Total Project								
Total recordable cases (fatalities)	10 (0)	379 (0.05)	199 (0.03)	1,280 (0.16)	2,050 (0.26)	214 (0.03)	1,290 (0.17)	2,050 (0.26)

[a] Total impacts associated with each action alternative would be equal to the sum of the (1) treatment and storage and (2) disposal group values.
[b] Concentrations exceeding applicable standards, discussed in the air quality sections of Chapter 4 of this *TC & WM EIS* are presented in **bold** text. The Federal standard for $PM_{2.5}$ is 35 micrograms per cubic meter (24-hour average). No specific data for $PM_{2.5}$ were available, but for the purposes of analysis, concentrations were assumed to be the same as for PM_{10}. Radiological air quality impacts are included separately under the public and occupational health and safety sections.
[c] Disposal group radiological impacts of normal operations are additive to the treatment and storage impacts under Alternatives 2 and 3.
[d] Impacts of the Waste Management No Action Alternative are from existing, permitted facilities and are included in current annual dose estimates.
[e] Regardless of disposal group, emissions from burial ground operations would have negligible impact on distant receptors.
[f] The number of LCFs in a population is presented as a whole number; where the value is less than 0, the calculated value (dose × 0.0006 LCFs per person-rem) is presented in parentheses.
[g] Nearest whole integer (calculated value in parentheses).
[h] Treatment and storage accident consequences and risks are encompassed in the values presented for disposal.
[i] The impacts of transporting the materials under these disposal groups have already been considered under the Tank Closure and FFTF Decommissioning alternatives.

Note: To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471; liters to gallons, by 0.26417; meters to yards, by 1.0936.

Key: ASIL=acceptable source impact level; FTE=full-time equivalent; IDF-East=200-East Area Integrated Disposal Facility; LCF=latent cancer fatality; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; ROI=region of influence; RPPDF=River Protection Project Disposal Facility.

Source: Chapter 4 of this *TC & WM EIS*.

2.9 SUMMARY OF LONG-TERM ENVIRONMENTAL IMPACTS

This section provides a summary-level comparison of the potential long-term environmental impacts on water quality, human health, ecological risk, and environmental justice associated with implementing each of the *TC & WM EIS* Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Long-term impacts would occur following the active project phase defined for each alternative and the assumed end of the associated 100-year administrative control, institutional control, or postclosure care period, as appropriate. This comparison of impacts is presented to aid decisionmakers and the public in understanding the potential long-term environmental consequences of proceeding with each of the *TC & WM EIS* alternatives. Note that, for analysis purposes, three disposal groups were identified to support Hanford waste management needs. These groupings (Disposal Groups 1, 2, and 3) were developed to limit the number of iterations of analysis; support reader understanding; and encompass the sizing and associated construction, operations, and closure requirements for IDF-East, IDF-West, and the RPPDF that would be necessary to accommodate the various waste volumes considered under each disposal configuration. These disposal groupings were further separated into subgroups (see Chapter 5, Section 5.3) reflecting the different types and volumes of waste generated by activities under the 10 Tank Closure action alternatives and 2 FFTF Decommissioning action alternatives to better analyze the long-term impacts associated with disposal of the various waste types and volumes. The information presented in the following discussion and tables is based on the detailed information presented in Chapter 5 and supporting appendices. Information on the primary radiological constituent inventory associated with each *TC & WM EIS* alternative is provided in Appendix D.

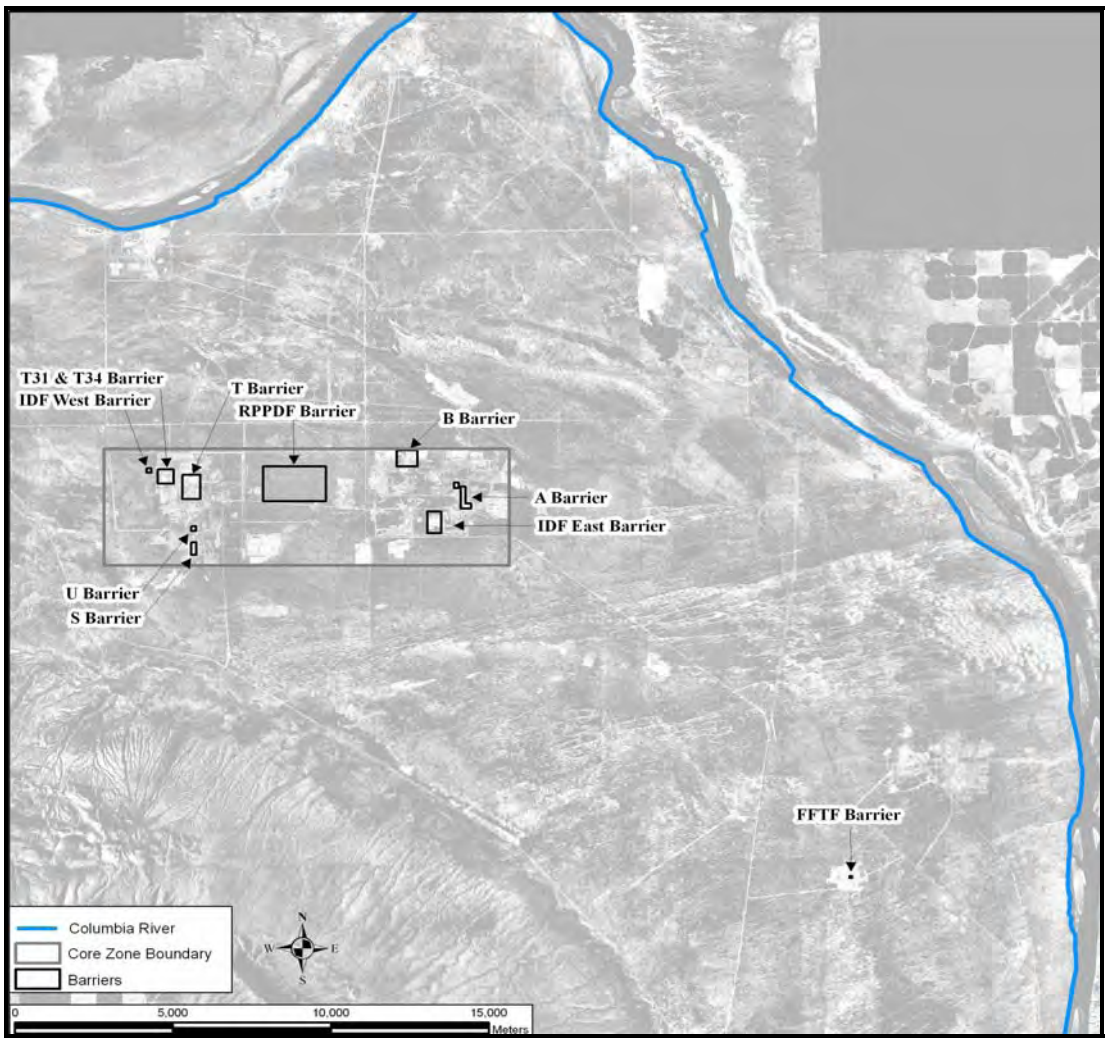
2.9.1 Tank Closure Alternatives: Long-Term Environmental Impacts

2.9.1.1 Water Quality

This section discusses the long-term impacts on groundwater quality from tank closure sources (i.e., tank farm past leaks, discharges to cribs and trenches (ditches) closely associated with the tank farms, tank farm residuals, retrieval losses, and ancillary equipment). Long-term impacts on groundwater quality from FFTF and waste management sources are discussed in Sections 2.9.2.1 and 2.9.3.1, respectively. Three assessment boundaries were selected for the groundwater analysis based on a combination of regulatory, permit, and land-use requirements. For Tank Closure alternatives, the innermost (i.e., closest to the source) area of analysis comprises the engineered barriers that would be installed above the tank farms (see Figure 2–78). Very little groundwater transport would occur between the time the contaminants encounter the aquifer and the time they pass beneath the outer perimeter of the barriers; in general, the greatest water quality impacts would occur at these innermost assessment boundaries.

The second area of analysis is established by the location of the Core Zone Boundary. The Core Zone Boundary is approximated by a rectangle encompassing the entire area that would be directly affected by project facilities. The Core Zone Boundary represents the "fence line" of the projected tank closure operational facilities for each of the alternatives. Groundwater beneath the western portions of the northern and southern Core Zone Boundary would be impacted by contaminants released at the S, T, and U Barriers; because the western portion of the aquifer has relatively low groundwater flux, these impacts would be relatively high (although lower than at the barriers themselves). The eastern portion of the Core Zone Boundary is in an area of high groundwater flux, and peak groundwater impacts along the eastern part of the Core Zone Boundary would be correspondingly lower.

The third area of analysis is the Columbia River nearshore (shoreline closest to Hanford). It approximates the location where contaminants in the groundwater system discharge into the surface-water system. Water quality impacts at the Columbia River reflect the superposition of releases from individual sources.



Key: FFTF=Fast Flux Test Facility; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility; T31 & T34=trenches 31 and 34.

Figure 2–78. Core Zone and Barriers Boundaries

Groundwater impacts are described in terms of the concentrations of the COPC drivers at the assessment boundaries under the alternatives considered. The COPC drivers are hydrogen-3 (tritium), iodine-129, technetium-99, uranium-238, chromium, nitrate, and total uranium. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is less than 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

Tables 2–12 through 2–16 present the maximum concentrations of the COPC drivers under each of the Tank Closure alternatives at the tank farm barriers (A and B Barriers in the 200-East Area and S, T, and U Barriers in the 200-West Area); Table 2–17, at the Core Zone Boundary; and Table 2–18, at the Columbia River nearshore.

Table 2–12. Maximum Concentrations in Groundwater at the A Barrier

Contaminant	Tank Closure Alternative									
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	4,186 (2112)	3,531 (1999)	3,634 (1999)			3,577 (1999)		3,609 (1999)		20,000
Technetium-99	**70,050** (2114)	**11,891** (1999)	**11,600** (1999)		**12,353** (1999)	**11,954** (1999)		**12,380** (1999)		900
Iodine-129	**71.2** (2114)	**23.2** (1999)	**23.6** (1999)		**23.2** (1999)	**23.3** (1999)		**23.9** (1999)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	**23** (11,789)	3 (11,707)	1 (11,755)	0.42 (11,814)	1 (11,845)	0 N/A				15
Chemical (micrograms per liter)										
Chromium	**284** (2114)	59 (1999)	61 (1999)		62 (1999)	61 (1999)		63 (1999)		100
Nitrate	**69,566** (2119)	11,617 (2068)	5,650 (2057)	5,531 (2056)	6,509 (4099)	4,335 (1999)		4,193 (1999)		45,000
Total uranium	5 (11,769)	1 (11,805)	0.20 (11,795)	0.16 (11,819)	0.40 (11,795)	0.00001 (2160)		0 N/A		30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–13. Maximum Concentrations in Groundwater at the B Barrier

Contaminant	Tank Closure Alternative									
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	**2,855,631** (1956)	**2,955,633** (1956)	**2,823,299** (1956)				**2,835,466** (1956)	**2,823,299** (1956)	**2,843,651** (1956)	20,000
Technetium-99	**175,426** (3837)	**148,565** (1956)	**144,196** (1956)				**144,526** (1956)	**144,196** (1956)	**143,823** (1956)	900
Iodine-129	**397.6** (3801)	**194.6** (1956)	**187.0** (1956)				**188.4** (1956)	**187.0** (1956)	**187.3** (1956)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	**490** (11,749)	**142** (11,814)	**55** (11,739)	**36** (11,742)	**67** (11,739)	**34** (11,742)	1 (1981)	**34** (11,742)	1 (1981)	15
Chemical (micrograms per liter)										
Chromium	**50,531** (1955)	**45,892** (1955)	**50,842** (1955)				**50,965** (1955)	**50,842** (1955)	**51,235** (1955)	100
Nitrate	**17,182,820** (1955)	**18,103,786** (1955)	**17,418,627** (1955)				**17,327,249** (1955)	**17,418,627** (1955)	**17,805,762** (1955)	45,000
Total uranium	**695** (11,762)	**190** (11,836)	**46** (11,792)	14 (11,678)	**83** (11,798)	10 (11,678)	1 (1981)	10 (11,678)	1 (1981)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Table 2–14. Maximum Concentrations in Groundwater at the S Barrier

Contaminant	Tank Closure Alternative									
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	2,458 (2117)	479 (2011)	466 (2013)	469 (2008)	466 (2013)	467 (2011)		478 (2013)		20,000
Technetium-99	**38,734** (3238)	**3,942** (2028)	**4,096** (2026)	**3,837** (2022)	**4,053** (2030)	**3,963** (2027)		**3,897** (2030)		900
Iodine-129	**67.0** (3312)	**7.6** (2029)	**7.7** (2026)		**7.6** (2030)	**8.0** (2027)		**7.6** (2030)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	**259** (11,730)	7 (11,714)	6 (11,765)	1 (11,795)	15 (11,727)	0.001 (2166)		0 N/A		15
Chemical (micrograms per liter)										
Chromium	**1,651** (3172)	**407** (2026)	**413** (2030)	**397** (2030)	**421** (2026)	**397** (2026)		**407** (2029)		100
Nitrate	**107,499** (3138)	11,889 (2023)	12,112 (2030)	11,964 (2030)	13,211 (3586)	11,732 (2030)		11,766 (2028)		45,000
Total uranium	**281** (11,762)	8 (9863)	8 (11,602)	1 (11,828)	**33** (11,473)	0.001 (2166)		0 N/A		30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–15. Maximum Concentrations in Groundwater at the T Barrier

Contaminant	Tank Closure Alternative									
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	**12,350,369** (1975)	**12,264,731** (1975)	**12,499,854** (1974)			**12,499,843** (1974)	**12,350,331** (1975)	**12,499,843** (1974)	**12,440,094** (1974)	20,000
Technetium-99	**23,161** (2029)	**22,812** (2026)	**22,665** (2029)		**23,632** (2027)	**22,802** (2026)	**22,799** (2026)	**23,505** (2026)	**23,500** (2026)	900
Iodine-129	**71.1** (3756)	**44.9** (2026)	**45.3** (2028)		**23.1** (2041)	**44.0** (2028)		**45.1** (2027)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	**102** (11,820)	**42** (11,799)	**27** (11,780)	**26** (11,780)	**25** (11,780)	13 (11,780)	2 (1980)	13 (11,780)	1 (1980)	15
Chemical (micrograms per liter)										
Chromium	**9,007** (1961)	**9,116** (1961)	**9,325** (1961)				**8,860** (1961)	**9,325** (1961)	**9,139** (1961)	100
Nitrate	**2,099,621** (1961)	**2,115,355** (1961)	**2,112,423** (1961)				**2,097,467** (1961)	**2,112,423** (1961)	**2,135,491** (1961)	45,000
Total uranium	**96** (11,836)	20 (11,709)	11 (11,840)		15 (11,815)	4 (11,755)	3 (1980)	4 (11,755)	3 (1980)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Table 2–16. Maximum Concentrations in Groundwater at the U Barrier

Contaminant	Tank Closure Alternative									
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	61 (2011)	60 (2009)	62 (2011)			61 (2011)		64 (2011)		20,000
Technetium-99	**14,824** (3536)	546 (2096)	284 (3499)	180 (2060)	**1,776** (4022)	150 (2064)		142 (2049)		900
Iodine-129	**29.2** (3536)	**1.1** (2089)	0.4 (3708)	0.3 (2052)	0.8 (4694)	0.3 (2040)		0.3 (2054)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	**40** (11,758)	11 (11,763)	8 (11,441)		9 (11,750)	0 N/A				15
Chemical (micrograms per liter)										
Chromium	**308** (3587)	17 (2086)	14 (2028)		36 (3847)	13 (2024)		14 (2026)		100
Nitrate	34,949 (3654)	5,796 (2083)	1,379 (2068)	1,233 (2067)	4,507 (3794)	684 (2026)		683 (2040)		45,000
Total uranium	**51** (11,739)	15 (10,978)	12 (11,599)		15 (11,821)	0.000004 (2167)		0 N/A		30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–17. Maximum Concentrations in Groundwater at the Core Zone Boundary

Contaminant	Tank Closure Alternative									
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	**2,855,631** (1956)	**2,955,633** (1956)	**2,823,299** (1956)				**2,835,466** (1956)	**2,823,299** (1956)	**2,843,651** (1956)	20,000
Technetium-99	**349,996** (3837)	**148,565** (1956)	**144,196** (1956)				**144,526** (1956)	**144,196** (1956)	**143,823** (1956)	900
Iodine-129	**682.2** (3801)	**194.6** (1956)	**187.0** (1956)				**188.4** (1956)	**187.0** (1956)	**187.3** (1956)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	**1,066** (11,683)	**148** (11,828)	**73** (11,691)	**48** (11,529)	**102** (11,735)	10 (11,758)	1 (1981)	10 (11,758)	1 (1981)	15
Chemical (micrograms per liter)										
Chromium	**28,686** (1956)	**27,172** (1956)	**28,041** (1956)				**28,382** (1956)	**28,041** (1956)	**28,338** (1956)	100
Nitrate	**13,364,821** (1956)	**13,492,655** (1956)	**12,890,767** (1956)				**13,367,907** (1956)	**12,890,767** (1956)	**13,709,300** (1956)	45,000
Total uranium	**1,220** (11,648)	**196** (11,624)	**103** (11,683)	**63** (11,690)	**204** (11,805)	7 (11,678)	1 (1981)	7 (11,678)	1 (1981)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Table 2–18. Maximum Concentrations in Groundwater at the Columbia River Nearshore

Contaminant	Tank Closure Alternative									
	1	**2A**	**2B, 3A, 3B, 3C, 6C**	**4**	**5**	**6A, Base Case**	**6A, Option Case**	**6B, Base Case**	**6B, Option Case**	**Benchmark Concentration**
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	1,723 (1998)	1,384 (1998)	1,280 (1994)				1,268 (2016)	1,280 (1994)	1,607 (1997)	20,000
Technetium-99	**5,231** (4032)	204 (3464)	205 (2480)	191 (2480)	724 (5017)	169 (2515)	181 (2502)	168 (2214)	162 (2304)	900
Iodine-129	**13.0** (4411)	0.4 (3355)	0.4 (2876)	0.3 (2181)	0.5 (7030)	0.3 (2579)	0.3 (2308)	0.3 (2319)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	6 (11,918)	1 (11,783)	1 (11,871)	1 (11,891)	1 (11,594)	0.4 (11,844)	0.002 (4077)	0.4 (11,844)	0.001 (3268)	15
Chemical (micrograms per liter)										
Chromium	**165** (4019)	32 (2603)	34 (2695)		35 (2695)	33 (2695)	29 (2256)	33 (2695)	28 (2166)	100
Nitrate	23,484 (3911)	9,102 (2400)	8,576 (2450)	8,490 (2450)	8,748 (2450)	8,409 (2450)	7,933 (2460)	8,420 (2450)	7,107 (2056)	45,000
Total uranium	8 (11,591)	1 (11,809)	1 (11,146)	1 (11,577)	1 (11,935)	0.1 (11,508)	0.003 (4581)	0.1 (11,508)	0.002 (3972)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

The location where the maximum concentrations would occur varies with time, contaminant, and alternative. The benchmark concentration for each contaminant is provided for comparison. The benchmark concentrations include EPA maximum contaminant levels (MCLs) (i.e., primary drinking water standards), EPA interim drinking water standards, DOE-derived concentration guides, and other standards known or accepted to be associated with a specific level of effect. Concentrations that would exceed the benchmark concentrations are indicated in bold text.

Under all Tank Closure alternatives, the mobile constituents exceed their benchmarks at the Core Zone Boundary. These exceedances occur early during the period of analysis and are driven primarily by past releases to cribs and trenches (ditches) and past leaks (note that the period of analysis begins in 1944). For the less-mobile uranium-238 and total uranium, benchmark exceedances occur later in the period of analysis under the Tank Closure alternatives that do not include removal of contaminated soil from the closely associated cribs and trenches (ditches) in addition to clean closure (i.e., all Tank Closure alternatives except Alternatives 6A, Option Case, and 6B, Option Case).

The magnitude of the impacts can be represented in terms of the total amounts of the COPC drivers released to the vadose zone from all sources related to a particular alternative. Releases of radionuclides are totaled in curies over the 10,000-year period of analysis. The total amounts of iodine-129 and technetium-99 released to the vadose zone under the Tank Closure alternatives are presented in Figures 2–79 and 2–80, respectively. Under the Tank Closure alternatives, the magnitude of the impact is governed by waste inventory (which is the same for all Tank Closure alternatives), retrieval (which is zero percent under Tank Closure Alternative 1; 90 percent under Alternative 5; 99 percent under Alternatives 2A, 2B, 3A, 3B, 3C, and 6C; and 99.9 percent under Alternatives 4, 6A, and 6B), and removal of tanks and soil during closure (which is none under Tank Closure Alternatives 1, 2A, 2B, 3A, 3B, 3C, 5, and 6C; selective clean closure under Alternative 4; and clean closure under Alternatives 6A and 6B). Retrieval of waste from the tank farms is the dominant factor determining the differential magnitudes of impact among the Tank Closure alternatives, followed by removal of contaminated soil during closure activities.

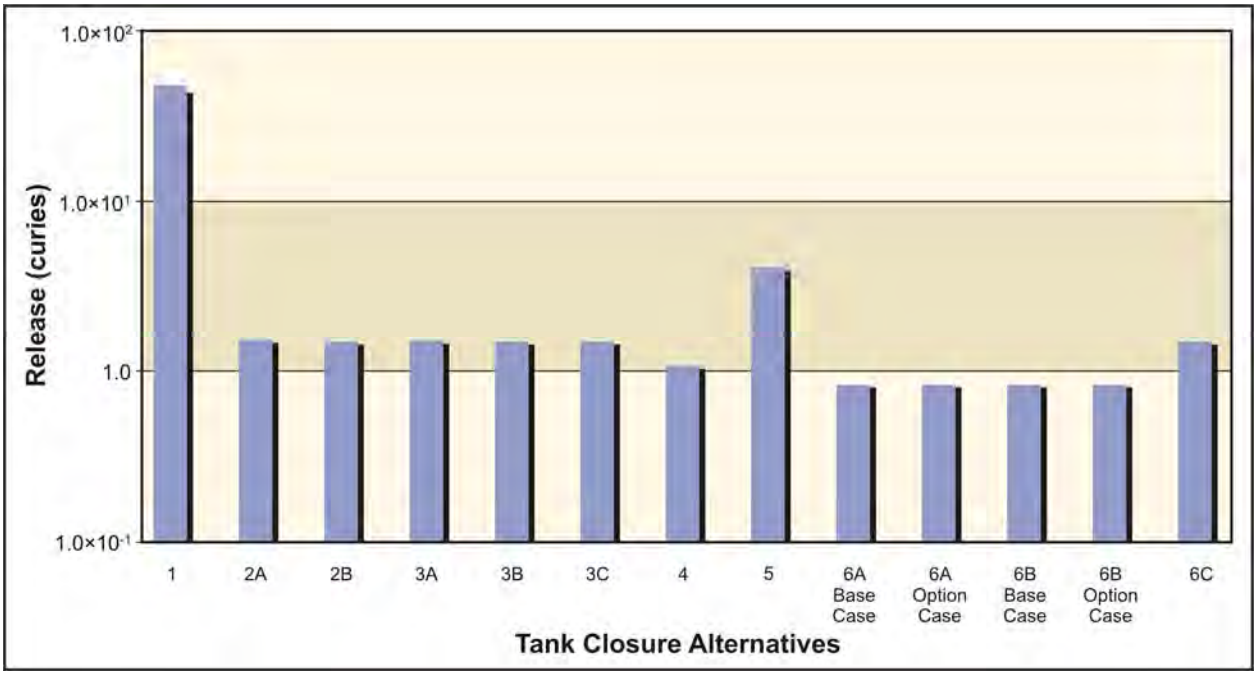


Figure 2–79. Tank Closure Alternatives – Total Iodine-129 Released to the Vadose Zone

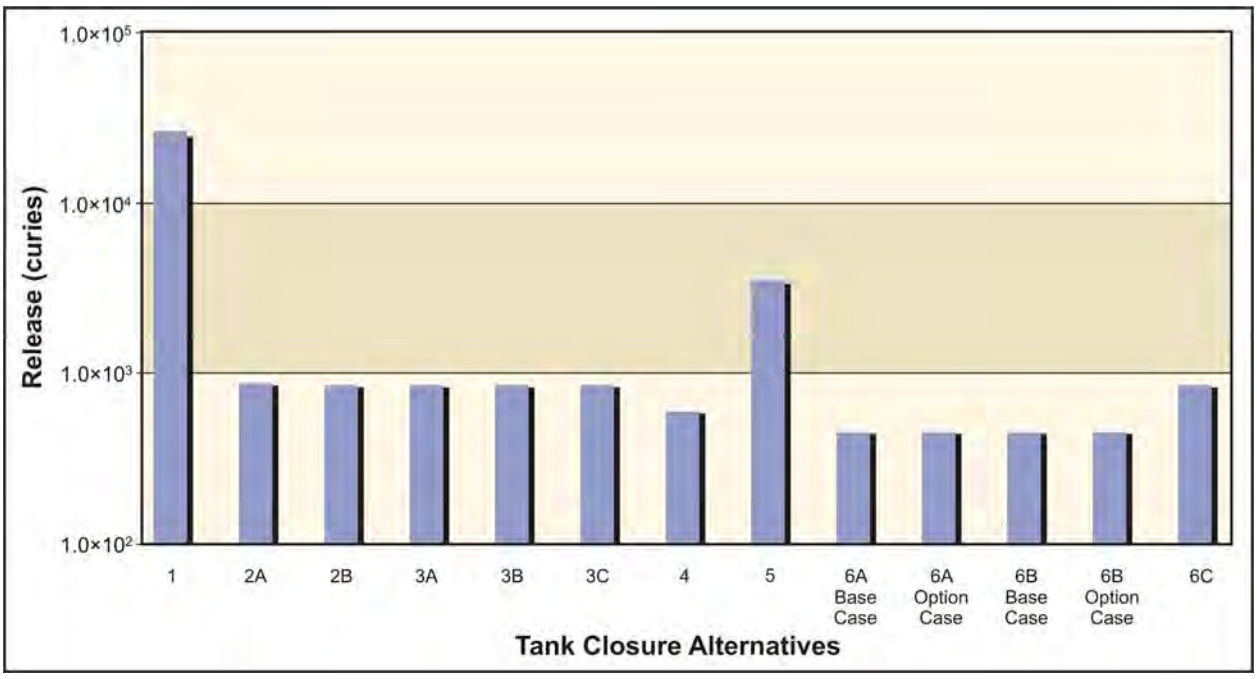


Figure 2–80. Tank Closure Alternatives – Total Technetium-99 Released to the Vadose Zone

The peak impact can be represented in terms of the peak concentrations of the COPC drivers at the Core Zone under each of the Tank Closure alternatives. The peak concentrations of iodine-129 and technetium-99 at the Core Zone Boundary presented in tabular form above (see Table 2–17) are depicted in Figures 2–81 and 2–82, respectively. For the Tank Closure alternatives the peak impact is governed by past discharges to cribs and trenches (ditches), except for Tank Closure Alternative 1, which is dominated by tank farm residuals.

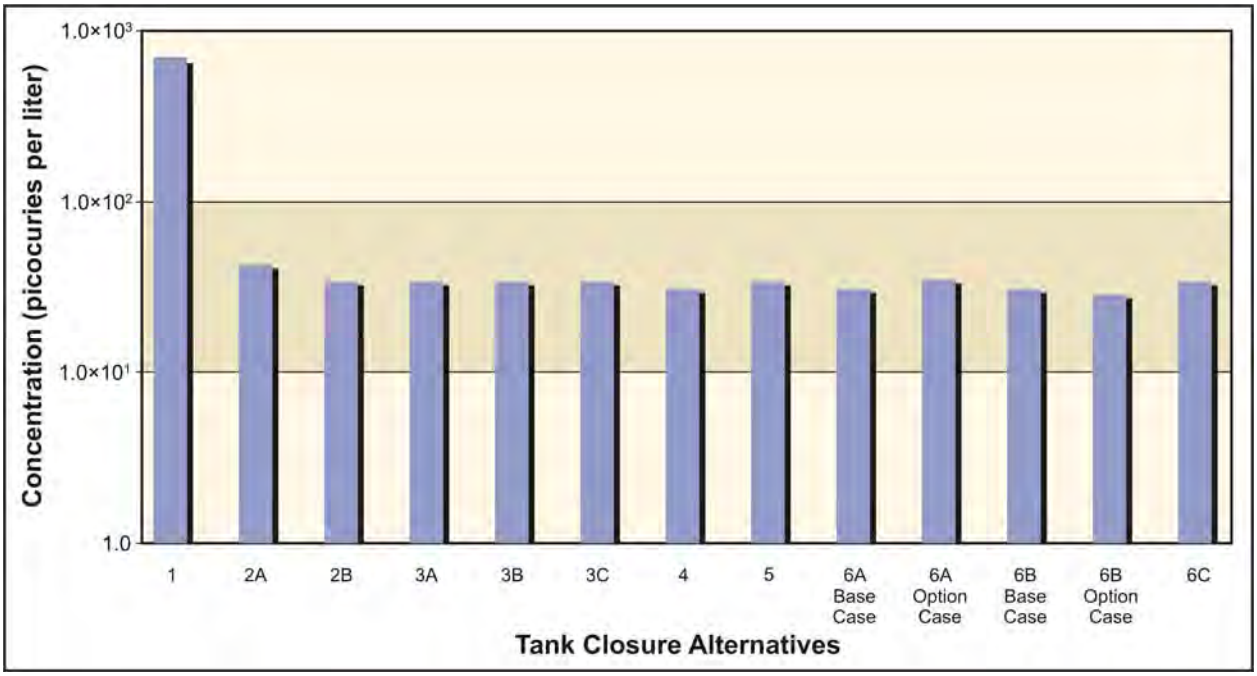


Figure 2–81. Tank Closure Alternatives – Peak Iodine-129 Concentrations at the Core Zone Boundary

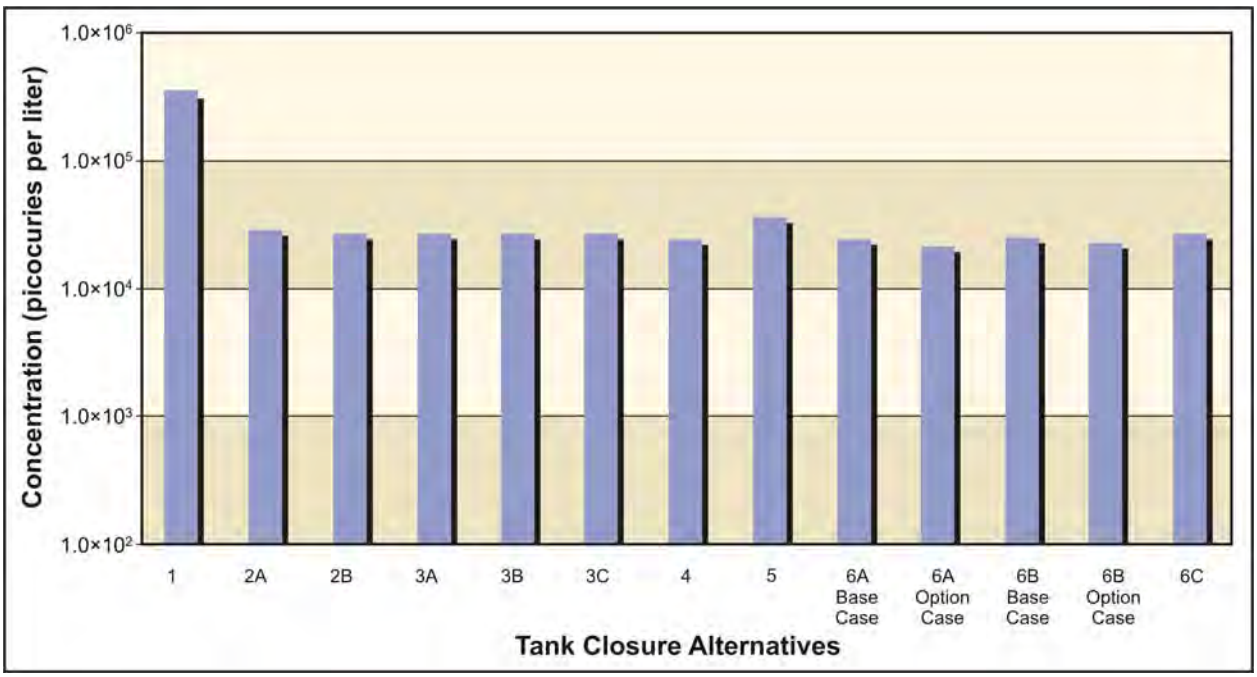


Figure 2–82. Tank Closure Alternatives – Peak Technetium-99 Concentrations at the Core Zone Boundary

2.9.1.2 Human Health

Implementation of activities defined for the Tank Closure alternatives could lead to releases of radiological and chemical constituents to the environment over long periods of time. In the case of Tank Closure Alternatives 1 and 2A, these releases would not be controlled by engineered closure of the tanks, but under Tank Closure Alternative 2A wastes generated by retrieval activities would be stabilized. Under the other Tank Closure alternatives, releases would be controlled by stabilization of the tanks and the wastes generated by retrieval and closure activities. Potential human health impacts due to releases of radiological constituents are estimated as dose and as lifetime risk of incidence of cancer. Potential human health effects due to releases of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as a Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as a Hazard Index, the sum of the Hazard Quotients of a group of chemicals.

The four measures of human health impacts considered for the EIS analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radionuclides, and Hazard Index from chemical constituents—were calculated for each year for 10,000 years for each receptor at eight locations. The locations are the disposal facility barriers (A, B, S, T, and U), the Core Zone Boundary, the Columbia River nearshore, and the Columbia River surface water.

Consistent with DOE guidance (DOE Guide 435.1-1), the potential consequences of loss of administrative or institutional control are considered by estimation of impacts on onsite receptors. Because DOE does not anticipate loss of control of the site, these onsite receptors are considered hypothetical and are applied to develop estimates for past and future periods of time.

Four types of receptor were considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking water consumption and irrigation of crops. Garden size and crop yield were assumed to be adequate to produce

approximately 25 percent of average requirements for crops and animal products. The third type, an American Indian resident farmer, also uses groundwater for drinking water consumption and irrigation of crops. Garden size and crop yield were assumed to be adequate to produce the entirety of average requirements for crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because surface water is used for drinking water consumption and wild plant materials, which use groundwater, and game, which use surface water, are consumed. A summary of the results for the drinking-water well user at the Core Zone Boundary is provided below. Impacts on other types of receptors vary in proportion to the impacts on the drinking-water well user and do not provide additional information to discriminate among alternatives. Further discussion of these receptors is provided in Appendix Q, Section Q.2.

A large amount of information must be summarized to allow interpretation of results. The method chosen was to present the dose for the year of maximum dose, the risks for the year of maximum risks, and the Hazard Index for the year of maximum Hazard Index. This choice was based on regulation of radiological impacts as dose and observations from the analysis results that the peak risks and peak noncarcinogenic impacts expressed as a Hazard Index may occur at times other than that of peak dose. The significance of the dose impacts was evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. Population doses were compared with the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The significance of noncarcinogenic chemical impacts is evaluated by comparison against a Hazard Index guideline value of less than unity. Impacts related to tank farm operations, tank waste retrieval, and tank closure would be due to three types of release. The first type is the past practice of directly discharging waste liquid to cribs and trenches (ditches). The second type is past leaks from damaged tanks. The third type results from other tank farm sources such as leaks during tank waste retrieval and long-term leaching of waste material from tanks and ancillary equipment.

The results of the analysis for each Tank Closure alternative for the drinking-water well user at the Core Zone Boundary are summarized in the sections below. Impacts that depend upon, or would be affected by, Tank Closure alternative activities would be evident after calendar year 2050, the approximate time assumed for placement of engineered barriers. However, releases to the vadose zone associated with past practices such as planned discharges to cribs and trenches (ditches) and past leaks from tanks occurring after calendar year 1940 but before calendar year 2050 may continue to produce impacts into the future. Because of uncertainty in estimates of the time of occurrence of impacts and the perspective that could be added by knowledge of past impacts, estimates of peak impacts are provided for time periods beginning in calendar year 1940 and in calendar year 2050. In addition, a time series of estimates of radiological risk for the drinking-water well user at the Core Zone Boundary is presented to provide a view of evolution of impacts over the entire period of analysis. Tables 2–19 and 2–20 provide the maximum dose and maximum Hazard Index for the drinking-water well user by alternative according to the groundwater analysis results.

Table 2–19. Tank Closure Alternatives – Summary of Radiological Dose at Year of Peak Dose for the Drinking-Water Well User

Location	Tank Closure Alternatives (millirem per year)								
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case
A Barrier	1.43×10^{2} (2114)	3.60 (2055)	3.27 (2058)	3.28 (2058)	5.46 (4338)	3.03 (2058)		3.21 (2050)	
B Barrier	3.69×10^{2} (3837)	6.83×10^{1} (2076)	6.31×10^{1} (2050)	5.92×10^{1} (2050)	4.96×10^{1} (2050)	6.15×10^{1} (2050)	5.61×10^{1} (2057)	6.17×10^{1} (2050)	5.79×10^{1} (2058)
S Barrier	8.33×10^{1} (3238)	6.31 (2050)	6.09 (2050)	4.77×10^{-1} (2060)	6.04 (3931)	6.14 (2050)		5.86 (2050)	
T Barrier	3.52×10^{1} (2051)	3.53×10^{1} (2051)	3.55×10^{1} (2050)		3.26×10^{1} (2051)	3.53×10^{1} (2051)	3.54×10^{1} (2050)	3.61×10^{1} (2051)	
U Barrier	3.43×10^{1} (3536)	1.33 (11,763)	1.04 (11,441)	1.02 (11,441)	3.24 (4022)	3.39×10^{-1} (2064)		3.23×10^{-1} (2060)	
Core Zone Boundary	7.44×10^{2} (3837)	5.92×10^{1} (2076)	5.42×10^{1} (2050)	5.02×10^{1} (2050)	6.50×10^{1} (4326)	5.14×10^{1} (2050)	4.51×10^{1} (2057)	5.16×10^{1} (2050)	4.79×10^{1} (2058)
Columbia River nearshore	1.19×10^{1} (4106)	4.39×10^{-1} (2406)	4.28×10^{-1} (2541)	3.91×10^{-1} (2480)	1.37 (5017)	3.55×10^{-1} (2520)	3.73×10^{-1} (2502)	3.38×10^{-1} (2214)	3.38×10^{-1} (2304)

Note: Calendar year of peak impact shown in parentheses.

Table 2–20. Tank Closure Alternatives – Summary of the Hazard Index at Year of Peak Hazard Index for Drinking-Water Well User

Location	Tank Closure Alternative (unitless)								
	1	2A	2B, 3A, 3B, 3C, 6C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case
A Barrier	4.13 (2119)	3.16×10^{-1} (2070)	1.84×10^{-1} (2057)	1.79×10^{-1} (2057)	4.06×10^{-1} (4094)	8.36×10^{-2} (2050)		7.68×10^{-2} (2050)	
B Barrier	6.95×10^{1} (2087)	6.89×10^{1} (2085)	5.79×10^{1} (2050)	5.77×10^{1} (2050)	5.79×10^{1} (2050)	5.77×10^{1} (2050)	6.46×10^{1} (2091)	5.78×10^{1} (2050)	6.37×10^{1} (2087)
S Barrier	1.73×10^{1} (3172)	2.94 (2050)	2.74 (2050)	3.61×10^{-1} (2057)	2.91 (2050)			2.85 (2050)	
T Barrier	1.18×10^{1} (2050)	9.90 (2050)	9.63 (2050)	9.63 (2051)	9.77 (2050)	9.56 (2050)	9.64 (2051)	9.65 (2050)	9.58 (2051)
U Barrier	3.42 (3577)	2.60×10^{-1} (2083)	1.18×10^{-1} (11,599)	1.15×10^{-1} (11,599)	4.01×10^{-1} (3869)	1.03×10^{-1} (2050)		9.89×10^{-2} (2050)	
Core Zone Boundary	1.31×10^{2} (3524)	3.78×10^{1} (2066)	3.39×10^{1} (2050)	3.36×10^{1} (2050)	3.38×10^{1} (2050)		3.67×10^{1} (2056)	3.38×10^{1} (2050)	3.52×10^{1} (2053)
Columbia River nearshore	1.88 (4019)	4.36×10^{-1} (2527)	4.35×10^{-1} (2695)	4.31×10^{-1} (2695)	4.43×10^{-1} (2695)	4.20×10^{-1} (2695)	3.91×10^{-1} (2303)	4.22×10^{-1} (2695)	3.79×10^{-1} (2166)

Note: Calendar year of peak impact shown in parentheses.

2.9.1.2.1 Tank Closure Alternative 1

Under Tank Closure Alternative 1, the tank farms would be indefinitely maintained in their current condition; however, for analysis purposes, the tank farms were assumed to fail after an institutional control period of 100 years. At that time, the salt cake in the SSTs was assumed to be available for leaching into the vadose zone, and the liquid contents of the DSTs were assumed to be discharged directly to the vadose zone.

Due to the large magnitude of the liquid release, transport through the vadose zone would be rapid, and the resulting impacts would exceed the dose standard and Hazard Index guideline for the onsite locations. The largest contributors would be the cribs and trenches (ditches), due to the presence of tritium, technetium-99, iodine-129, uranium-238, chromium, nitrates, and total uranium. The population dose was estimated to be 3.5 person-rem for the year of maximum impact, approximately 2×10^{-4} percent of the background dose.

Figure 2–83 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user due to releases from cribs and trenches (ditches), past leaks, and other sources, as well as the total risk from all three sources. The peak radiological risk from the cribs and trenches (ditches) under this alternative occurred around the year 1956 at the Core Zone Boundary and was dominated by tritium, technetium-99, and iodine-129. The peak radiological risk from past leaks for the period beginning in calendar year 1940 would occur around the year 2300 at the Core Zone Boundary and would be dominated by tritium, technetium-99, and iodine-129. For the period beginning in calendar year 2050, the peak radiological risk from all three sources combined would occur around the year 3800 and would be dominated by tritium, technetium-99, and iodine-129, all of which move at the same velocity as groundwater.

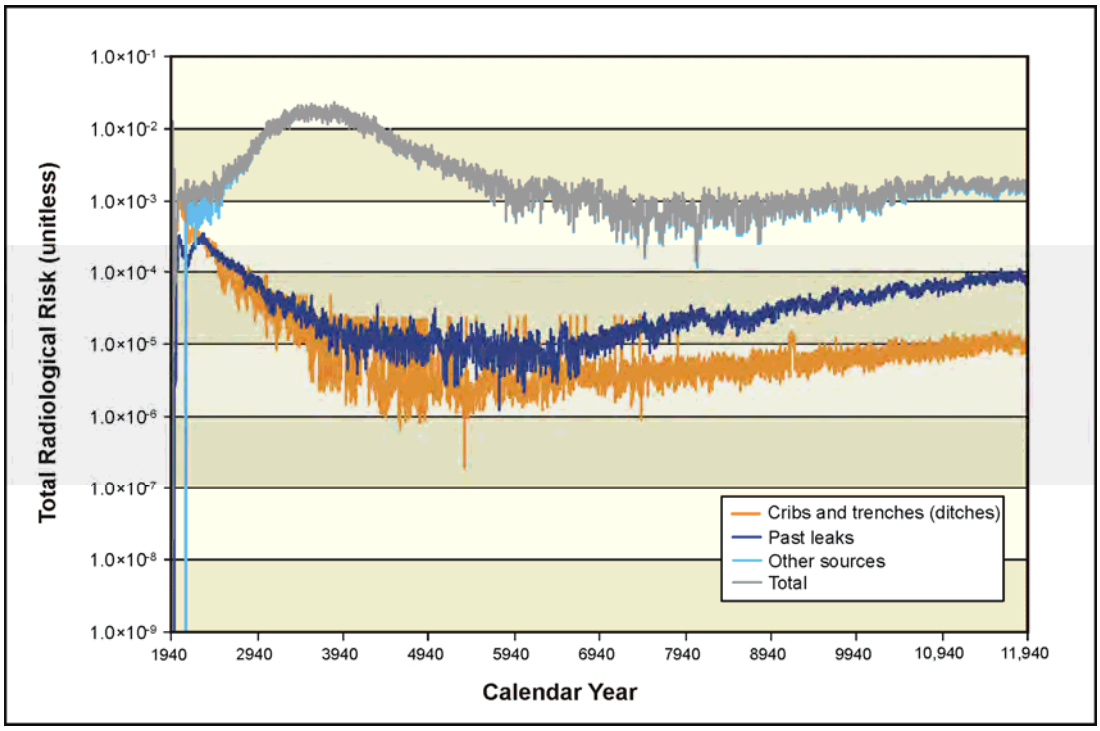


Figure 2–83. Tank Closure Alternative 1 – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.1.2.2 Tank Closure Alternative 2A

Under Tank Closure Alternative 2A, tank waste would be retrieved to a volume corresponding to 99 percent retrieval, but the residual material in the tanks would not be stabilized. After an institutional control period of 100 years, salt cake in the tanks was assumed to be available for dissolution in infiltrating water.

The dose standard would not be exceeded at the Core Zone Boundary for the drinking-water well user, and most of the dose would be due to the presence of tritium, technetium-99, and iodine-129 released from the cribs and trenches (ditches). The Hazard Index guideline would be exceeded for the drinking-water well user at the Core Zone Boundary primarily due to releases of chromium and nitrate from the cribs and trenches (ditches) and past leaks. The population dose was estimated to be 2.18×10^{-1} person-rem for the year of maximum impact, approximately 1×10^{-5} percent of the background dose.

Figure 2–84 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user due to releases from cribs and trenches (ditches), past leaks, and other sources, as well as the total risk from all three sources. The peak radiological risk from the cribs and trenches (ditches) under this alternative occurred around the year 1956 at the Core Zone Boundary and was dominated by tritium, technetium-99, and iodine-129. The peak radiological risk from past leaks for the period beginning in calendar year 1940 would occur around the year 2300 at the Core Zone Boundary and would be dominated by tritium, technetium-99, and iodine-129. For the period beginning in calendar year 2050, the peak radiological risk resulting from all three sources combined would occur around the year 2070 and would be dominated by tritium, technetium-99, iodine-129, and uranium-238.

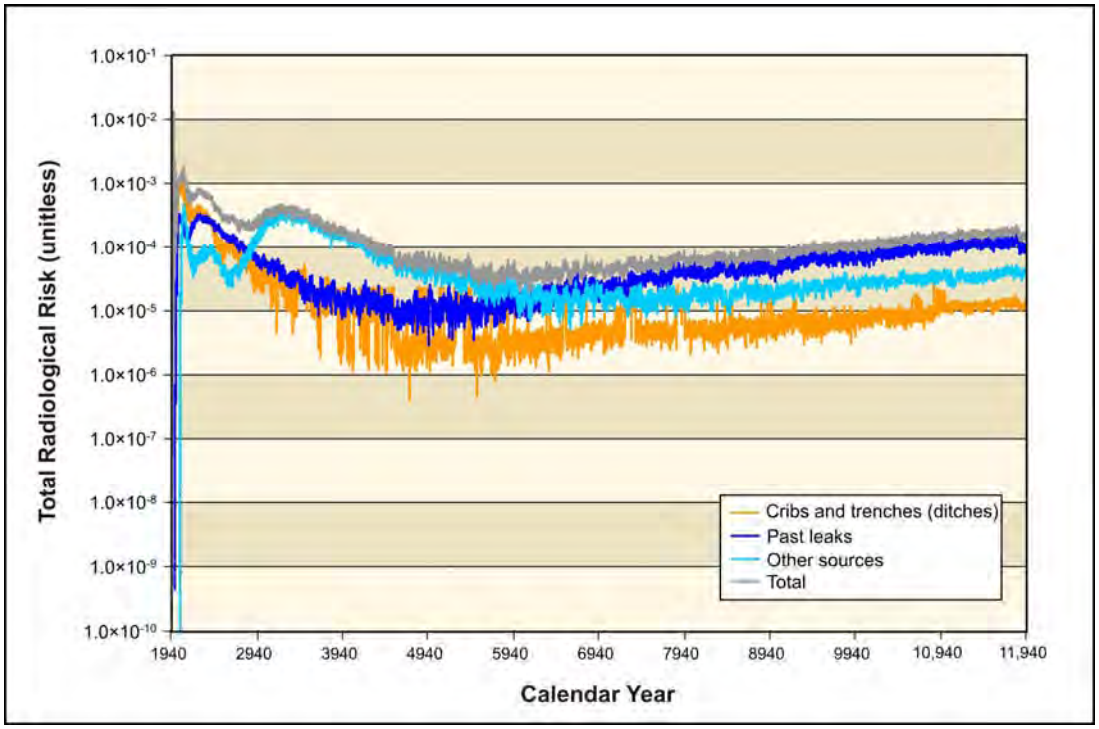


Figure 2–84. Tank Closure Alternative 2A – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.1.2.3 Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C

Activities under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would be similar to those under Tank Closure Alternative 2A, except that residual material in the tanks would be stabilized in place. Soil would be removed down to 4.6 meters (15 feet) at the BX and SX tank farms and replaced with clean soils from onsite sources. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier.

The risk and hazard drivers would be tritium, technetium-99, iodine-129, uranium-238, chromium, nitrate, and total uranium. The impacts would be slightly less than under Alternative 2A, but the Hazard Index guideline would be exceeded, similar to Alternative 2A. The population dose was estimated to be 1.95×10^{-1} person-rem for the year of maximum impact, approximately 1×10^{-5} percent of the background dose.

Figure 2–85 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user due to releases from cribs and trenches (ditches), past leaks, and other sources, as well as the total risk from all three sources. The peak radiological risk from the cribs and trenches (ditches) under these alternatives occurred around the year 1956 at the Core Zone Boundary and was dominated by tritium, technetium-99, and iodine-129. The peak radiological risk from past leaks for the time period beginning in calendar year 1940 would occur around the year 2030 at the Core Zone Boundary and would be dominated by tritium, technetium-99, and iodine-129. For time period beginning in calendar year 2050, the peak radiological risk from all three sources combined would occur around the year 2050 and would be dominated by tritium, technetium-99, and iodine-129.

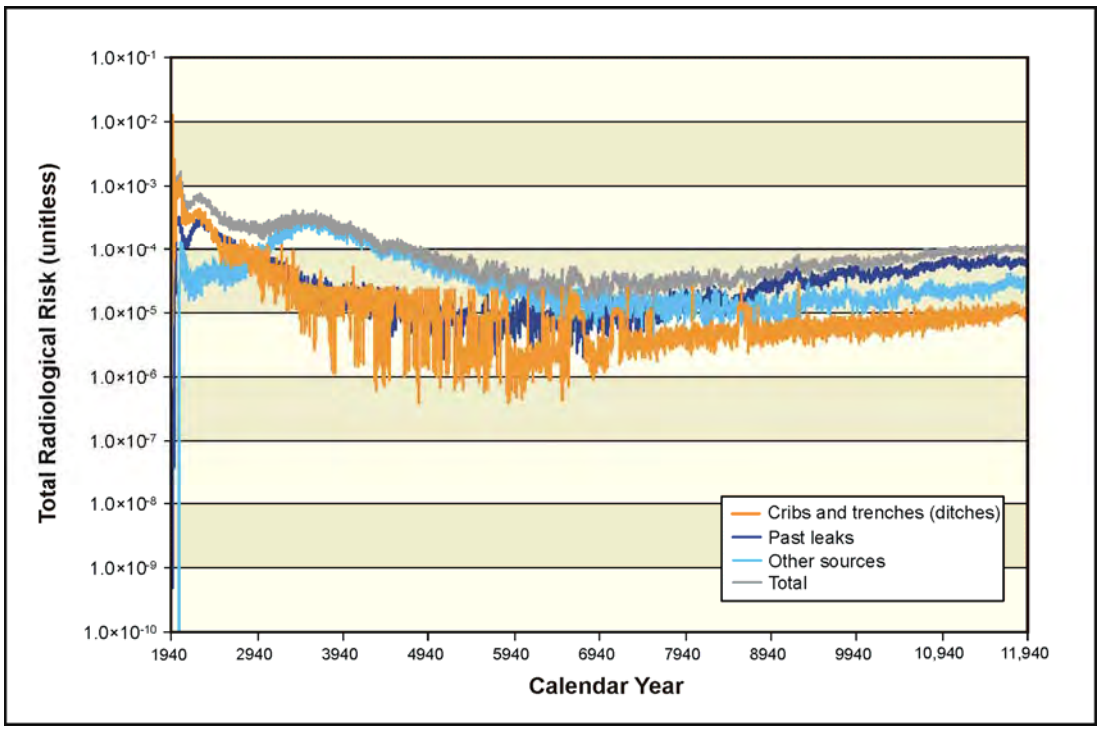


Figure 2–85. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.1.2.4 Tank Closure Alternative 4

Under Tank Closure Alternative 4, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval. Except for the BX and SX tank farms, residual material in the tanks would be stabilized in place and the tank farms and adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. The BX and SX tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would be conducted to remove contamination plumes within the soil column.

Similar to Alternatives 2A, 2B, 3A, 3B, 3C, and 6C, the risk and hazard drivers would be tritium, technetium-99, iodine-129, uranium-238, chromium, nitrate, and total uranium. The Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user for releases both from the cribs and trenches (ditches) and past leaks under Tank Closure Alternative 4. Impacts would be slightly less than under Alternatives 2B, 3A, 3B, 3C, and 6C for releases from past leaks as a result of clean closure of the two tank farms located within the B and S Barriers. Impacts at the Core Zone Boundary from cribs and trenches (ditches), past leaks, and other sources would also be slightly less than under Alternatives 2B, 3A, 3B, 3C, and 6C due to the combined releases. The population dose was estimated to be 1.93×10^{-1} person-rem for the year of maximum impact, approximately 1×10^{-5} percent of the background dose.

Figure 2–86 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user due to releases from cribs and trenches (ditches), past leaks, and other sources, as well as the total risk from all three sources. The peak radiological risk from the cribs and trenches (ditches) under this alternative occurred around the year 1956 at the Core Zone Boundary and was dominated by tritium, technetium-99, and iodine-129. The peak radiological risk from past leaks for the period beginning in 1940 would occur around the year 2030 at the Core Zone Boundary and would be dominated by tritium, technetium-99, and iodine-129. For the period beginning in calendar 2050, the peak radiological risk from all three sources combined would occur around the year 2050 and would be dominated by tritium, technetium-99, and iodine-129.

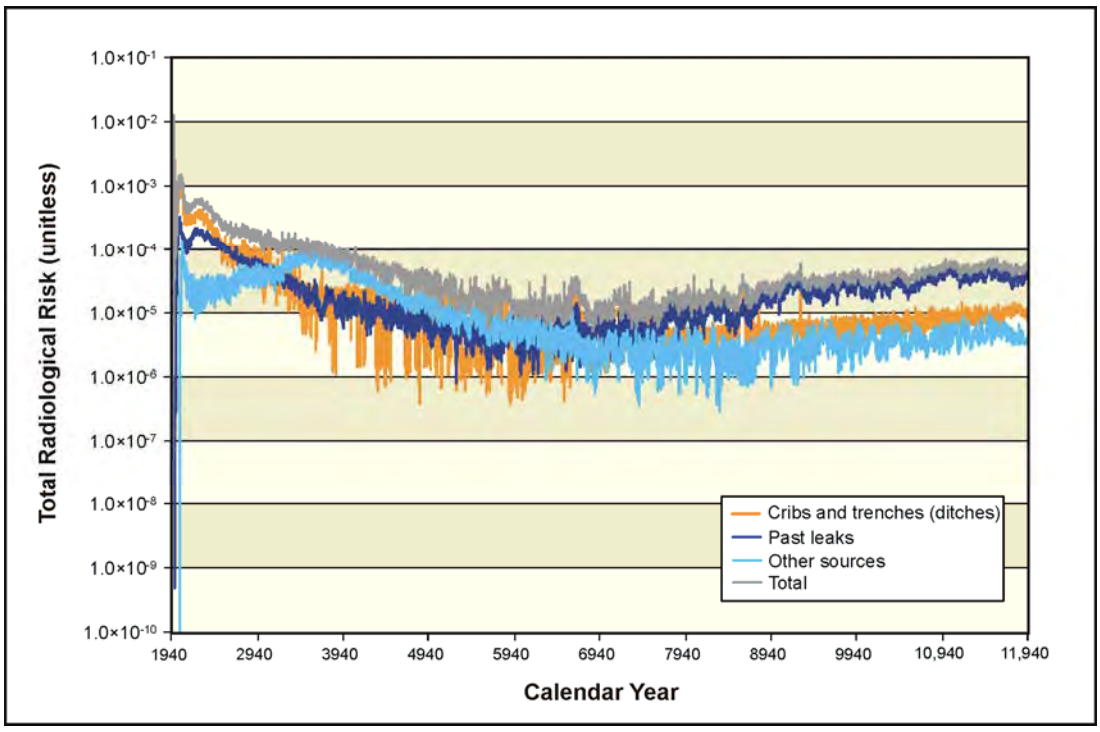


Figure 2–86. Tank Closure Alternative 4 – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.1.2.5 Tank Closure Alternative 5

Under Tank Closure Alternative 5, tank waste would be retrieved to a volume corresponding to 90 percent retrieval; residual material in tanks would be stabilized in place; and the tank farms and adjacent cribs and trenches (ditches) would be covered with a Hanford barrier.

The Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user both for releases from the cribs and trenches (ditches) and from past leaks. Impacts at the Core Zone Boundary due to the combined releases from cribs and trenches (ditches), past leaks, and other sources would occur at a later date than under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C. This may be due to the Hanford barrier. The population dose was estimated to be 3.39×10^{-1} person-rem for the year of maximum impact, which would represent approximately 2×10^{-5} percent of the background dose.

Figure 2–87 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user due to releases from cribs and trenches (ditches), past leaks, and other sources, as well as the total risk from all three sources. The peak radiological risk from the cribs and trenches (ditches) under this alternative occurred around the year 1956 at the Core Zone Boundary and was dominated by tritium, technetium-99, and iodine-129. The peak radiological risk from past leaks for the time period beginning in 1940 would occur around the year 2250 at the Core Zone Boundary and would be dominated by tritium, technetium-99, and iodine-129. For the time period beginning in calendar year 2050, the peak radiological risk from all three sources combined would occur around the year 4320 and would be dominated by technetium-99 and iodine-129.

2.9.1.2.6 Tank Closure Alternative 6A, Base and Option Cases

Under Tank Closure Alternative 6A, Base and Option Cases, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval, and all tank farms would be clean-closed by removing the tanks,

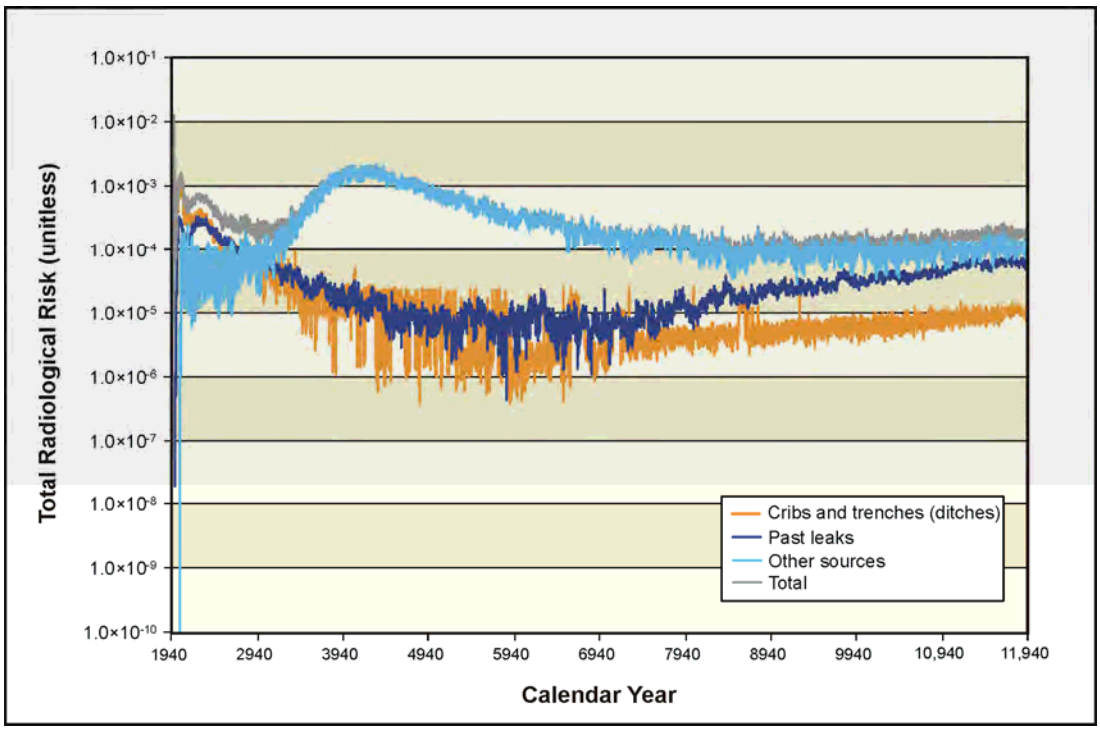


Figure 2–87. Tank Closure Alternative 5 – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. This would eliminate the "other sources" of releases that could impact groundwater. Under the Base Case, the adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier; under the Option Case, the adjacent cribs and trenches (ditches) would be clean-closed.

The Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user both for releases from the cribs and trenches (ditches) and from past leaks. Impacts at the Core Zone Boundary from the combined releases from cribs and trenches (ditches) and past leaks would be slightly greater than under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C. However, after the year 2940, the impacts would drop significantly as a result of tank farm removal and clean closure activities. The population doses for the year of maximum impact were estimated to be 2.07×10^{-1} person-rem for the Base Case and 2.05×10^{-1} person-rem for the Option Case, both of which would represent approximately 1×10^{-5} percent of the background dose.

Figures 2–88 and 2–89 depict time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user due to releases from cribs and trenches (ditches) and past leaks, as well as the total risk from both sources, for the Tank Closure Alternative 6A Base and Option Cases, respectively. The peak radiological risks from the cribs and trenches (ditches) under these cases occurred around the year 1956 at the Core Zone Boundary and were dominated by tritium, technetium-99, and iodine-129. The peak radiological risks from past leaks for the time period beginning in calendar year 1940 would occur around the year 2290 at the Core Zone Boundary and would be dominated by tritium, technetium-99, and iodine-129. For the time period beginning in calendar year 2050, the peak radiological risk from both sources combined would occur around the year 2050 under the Base Case and would be dominated by tritium, technetium-99, and iodine-129.

For the Option Case, the peak radiological risk resulting from both sources would occur around the year 2056 and would be dominated by technetium-99 and iodine-129.

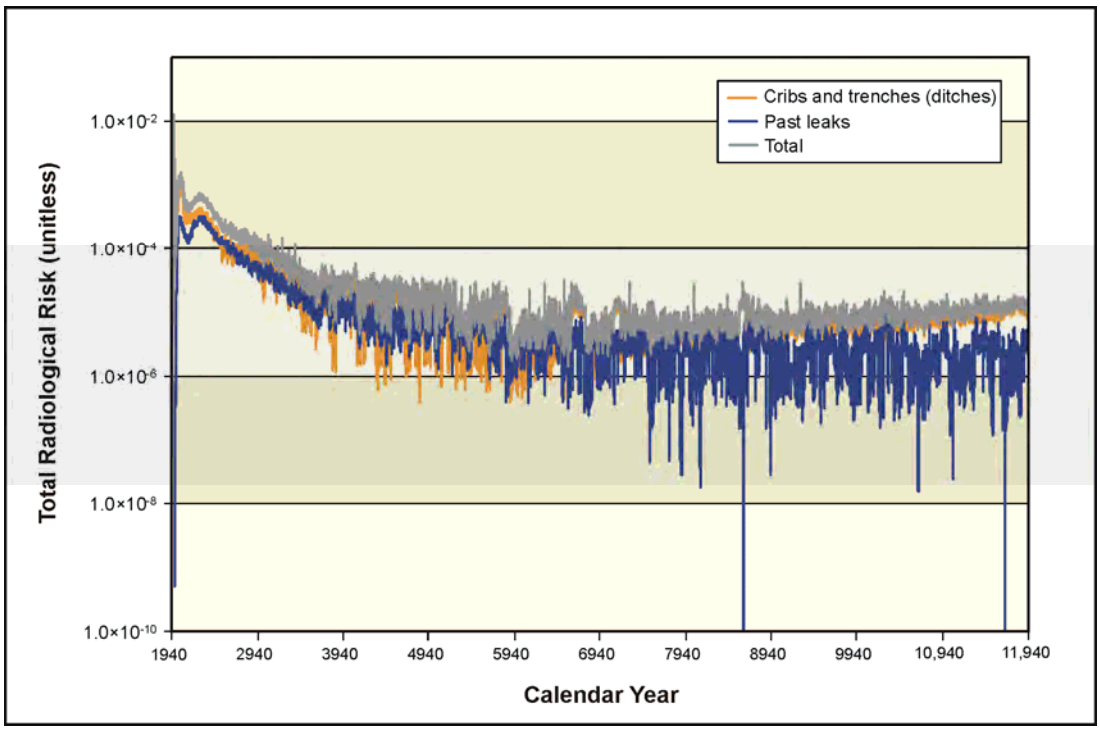


Figure 2–88. Tank Closure Alternative 6A, Base Case – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

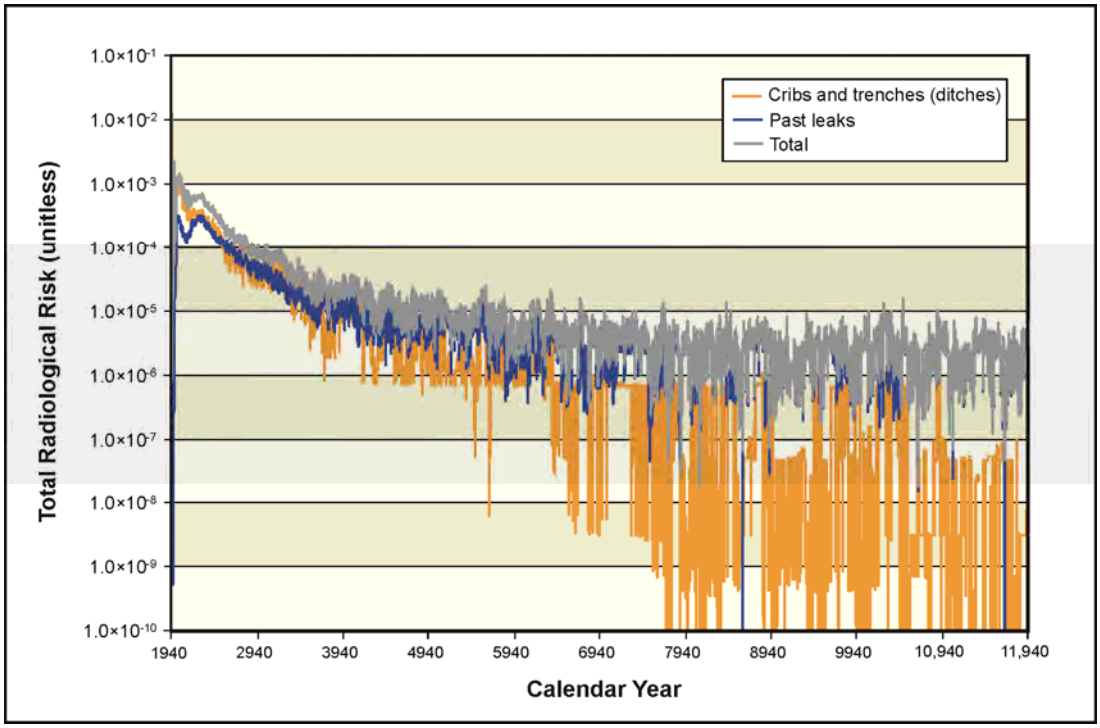


Figure 2–89. Tank Closure Alternative 6A, Option Case – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.1.2.7 Tank Closure Alternative 6B, Base and Option Cases

Tank Closure Alternative 6B, Base and Option Cases, resemble Tank Closure Alternative 6A, Base and Option Cases, except that waste retrieval and processing would proceed at a faster rate and closure would occur at an earlier date. All tank farms would be clean-closed and, for the Base Case, the adjacent crib and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier; for the Option Case, the adjacent cribs and trenches (ditches) would be clean-closed.

Impacts under Alternative 6B, Base and Option Cases, would be slightly less than those under Alternative 6A. The population dose for the year of maximum impact was estimated to be 2.05×10^{-1} person-rem for the Base Case and 2.00×10^{-1} person-rem for the Option Case, both of which would represent approximately 1×10^{-5} percent of the background dose.

Figures 2–90 and 2–91 depict a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user due to releases from cribs and trenches (ditches) and past leaks, as well as the total risk from both sources for the Tank Closure Alternative 6B Base and Option Cases, respectively. The peak radiological risks from the cribs and trenches (ditches) under these cases occurred around the year 1956 at the Core Zone Boundary and were dominated by tritium, technetium-99, and iodine-129. The peak radiological risks from past leaks for the time period beginning in calendar year 1940 would occur around the year 2034 at the Core Zone Boundary and would be dominated by tritium, technetium-99, and iodine-129. For the time period beginning in calendar year 2050, the peak radiological risk from both sources combined would occur around the year 2050 under the Base Case and would be dominated by technetium-99 and iodine-129.

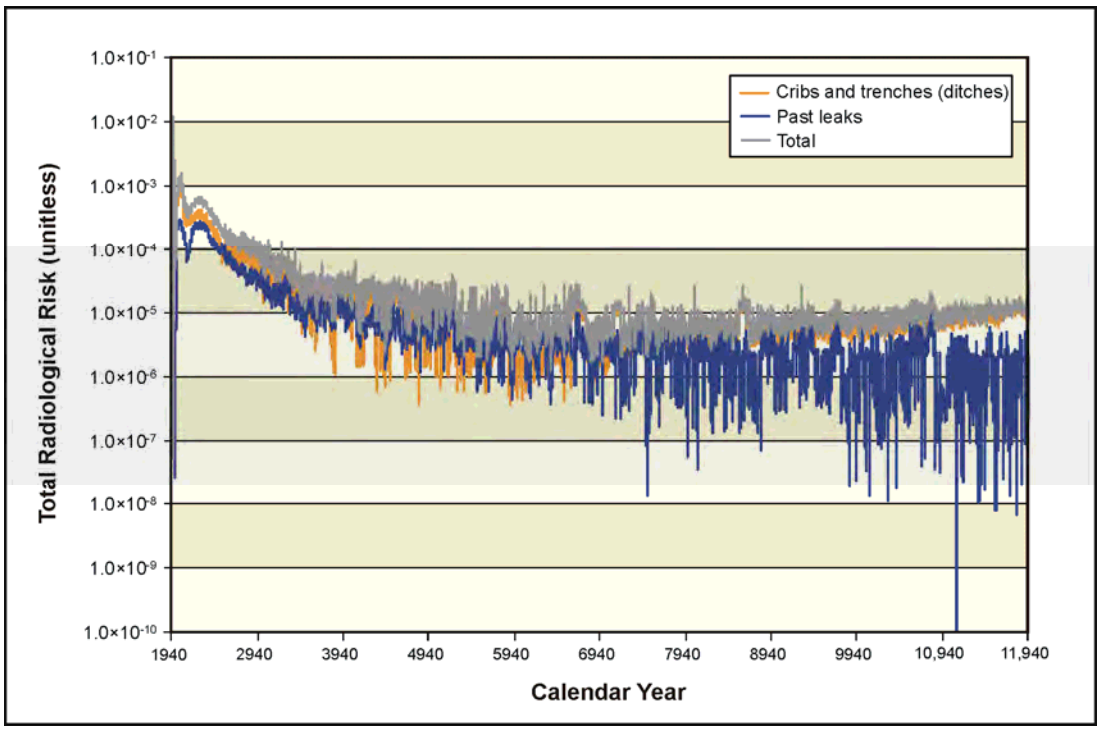


Figure 2–90. Tank Closure Alternative 6B, Base Case – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

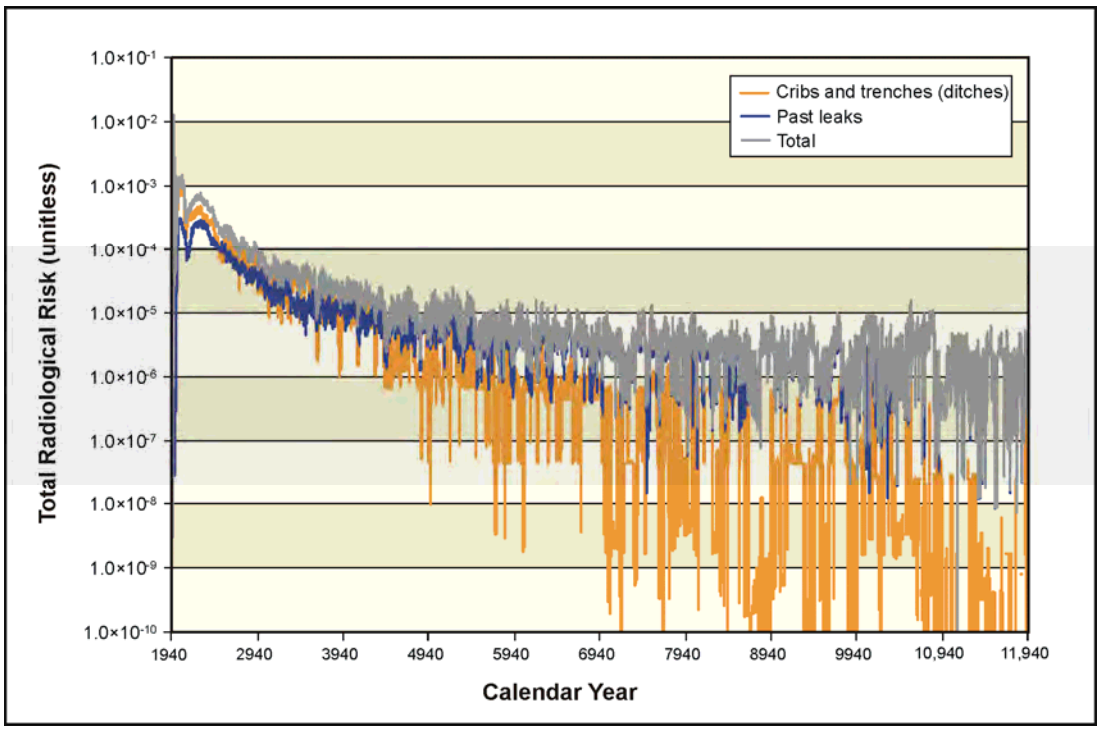


Figure 2–91. Tank Closure Alternative 6B, Option Case – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

For the Option Case, the peak radiological risk resulting from both sources combined would occur around the year 2058 and would be similarly dominated by technetium-99 and iodine-129.

2.9.1.3 Ecological Risk

Risk indices for ecological receptors exposed to COPCs as a result of air releases and groundwater discharges (see Appendix P) were used in this *TC & WM EIS* to compare Tank Closure alternatives. For ecological receptors, the risk indices are the Hazard Quotient for each chemical COPC and the Hazard Index, which is the sum of Hazard Quotients for all radiological COPCs. Risk indices less than one indicate little to no likelihood of adverse impact on the receptor. The uncertainties associated with risk indices and the meaning of Hazard Quotients and Hazard Indices for ecological receptors in this *TC & WM EIS* are discussed in Appendix P.

The potential long-term impacts on terrestrial receptors and on aquatic and riparian receptors, as quantified by risk indices for the highest-value COPC for each receptor are summarized in Tables 2–21 and 2–22, respectively. Long-term impacts would be greatest under Tank Closure Alternatives 3A and 3C for plants, invertebrates, lizards, and birds exposed to mercury at the onsite maximum-exposure location, which for this *TC & WM EIS* is the Core Zone Boundary (see Appendix P). Mercury Hazard Quotients range from 0 under the No Action Alternative (Tank Closure Alternative 1), where no mercury is expected to be released to air, to 3.92×10^2 for the side-blotched lizard under Tank Closure Alternatives 3A and 3C. For these receptors, risk indices for mercury ranged over several orders of magnitude, with the indices under Tank Closure Alternatives 3A and 3C two to three-and-one-half times larger than the other Tank Closure action alternatives. Long-term impacts would be greatest under Tank Closure Alternative 6A, Option Case, for mammals exposed to xylene and formaldehyde at the onsite maximum-exposure location. For example, xylene Hazard Quotients for mammals ranged from less than 1 under the No Action Alternative to 2.74×10^2 for the Great Basin pocket mouse under Tank Closure Alternative 6A.

Table 2–21. Tank Closure Alternatives – Long-Term Impacts of Contaminant Releases to Air on Terrestrial Receptors at the Onsite Maximum-Impact Location

Alternative	Hazard Quotient of Highest-Value COPC by Receptor								
	Plants	**Soil-Dwelling Invertebrate**	**Side-Blotched Lizard**	**Great Basin Pocket Mouse**	**Coyote**	**Mule Deer**	**Meadow Lark**	**Mourning Dove**	**Burrowing Owl**
	Mercury	**Mercury**	**Mercury**	**Xylene**	**Xylene**	**Formaldehyde**	**Mercury**	**Mercury**	**Mercury**
1	0			1.16	1.48×10^{-1}	1.63×10^{-1}	0		
2A	6.46	9.02×10^{-1}	1.52×10^{2}	1.21×10^{2}	1.54×10^{1}	1.29×10^{1}	9.12×10^{1}	7.53	6.35
2B	7.05	9.85×10^{-1}	1.66×10^{2}	9.79×10^{1}	1.24×10^{1}		9.95×10^{1}	8.22	6.92
3A	**1.67×10^{1}**	**2.33**	**3.92×10^{2}**	1.02×10^{2}	1.30×10^{1}	1.24×10^{1}	**2.35×10^{2}**	**1.94×10^{1}**	**1.64×10^{1}**
3B	4.80	6.70×10^{-1}	1.13×10^{2}	1.23×10^{2}	1.57×10^{1}	1.39×10^{1}	6.77×10^{1}	5.59	4.71
3C	**1.67×10^{1}**	**2.33**	**3.92×10^{2}**	1.07×10^{2}	1.35×10^{1}	1.26×10^{1}	**2.35×10^{2}**	**1.94×10^{1}**	**1.64×10^{1}**
4	6.67	9.31×10^{-1}	1.57×10^{2}	9.06×10^{1}	1.15×10^{1}	1.35×10^{1}	9.41×10^{1}	7.77	6.54
5	6.34	8.85×10^{-1}	1.49×10^{2}		1.90×10^{1}	1.79×10^{1}	8.94×10^{1}	7.38	6.22
6A, Base Case	6.56	9.16×10^{-1}	1.54×10^{2}	2.70×10^{2}	3.43×10^{1}	3.49×10^{1}	9.25×10^{1}	7.64	6.44
6A, Option Case	6.51	9.09×10^{-1}	1.53×10^{2}	**2.74×10^{2}**	**3.48×10^{1}**	**4.26×10^{1}**	9.18×10^{1}	7.58	6.39
6B, Base Case	7.33	1.02	1.72×10^{2}	1.51×10^{2}	1.92×10^{1}	2.32×10^{1}	1.03×10^{2}	8.54	7.20
6B, Option Case	7.30	1.02	1.71×10^{2}	1.56×10^{2}	1.98×10^{1}	3.09×10^{1}	1.03×10^{2}	8.50	7.16
6C	7.30	1.02	1.71×10^{2}	9.70×10^{1}	1.23×10^{1}	1.04×10^{1}	1.03×10^{2}	8.50	7.16

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.
Key: COPC=constituent of potential concern.

Table 2–22. Tank Closure Alternatives – Long-Term Impacts of Contaminant Releases to Air on Aquatic and Riparian Receptors at the Columbia River

Alternative	Hazard Quotient of Highest-Value COPC by Receptor					
	Benthic Invertebrate	Aquatic Biota/ Salmonids	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle
	Ammonia	Mercury				
1	3.5×10^{-2}	0				
2A	**6.8×10^{-2}**	1.3×10^{-2}	3.9×10^{-1}	3.3×10^{-2}	5.0×10^{-3}	8.0×10^{-3}
2B	1.7×10^{-2}	4.5×10^{-2}	4.25×10^{-1}	3.6×10^{-2}	1.6×10^{-2}	2.7×10^{-2}
3A	1.5×10^{-2}	5.4×10^{-2}	**5.08×10^{-1}**	**4.3×10^{-2}**	1.9×10^{-2}	3.2×10^{-2}
3B	1.7×10^{-2}	3.1×10^{-2}	2.89×10^{-1}	2.5×10^{-2}	1.1×10^{-2}	1.8×10^{-2}
3C	1.5×10^{-2}	5.4×10^{-2}	**5.08×10^{-1}**	**4.3×10^{-2}**	1.9×10^{-2}	3.2×10^{-2}
4	1.6×10^{-2}	3.4×10^{-2}	3.66×10^{-1}	3.1×10^{-2}	1.2×10^{-2}	2.0×10^{-2}
5	1.4×10^{-2}	5.1×10^{-2}	3.50×10^{-1}	3.0×10^{-2}	1.7×10^{-2}	3.0×10^{-2}
6A, Base Case	6.7×10^{-2}	7.0×10^{-3}	3.93×10^{-1}	3.3×10^{-2}	3.0×10^{-3}	5.0×10^{-3}
6A, Option Case	6.7×10^{-2}	7.0×10^{-3}	3.92×10^{-1}	3.3×10^{-2}	3.0×10^{-3}	5.0×10^{-3}
6B, Base Case	1.8×10^{-2}	**7.0×10^{-2}**	4.41×10^{-1}	3.7×10^{-2}	**2.4×10^{-2}**	**4.2×10^{-2}**
6B, Option Case	1.8×10^{-2}	**7.0×10^{-2}**	4.40×10^{-1}	3.7×10^{-2}	**2.4×10^{-2}**	**4.2×10^{-2}**
6C	1.7×10^{-2}	**7.0×10^{-2}**	4.40×10^{-1}	3.7×10^{-2}	**2.4×10^{-2}**	**4.2×10^{-2}**

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.
Key: COPC=constituent of potential concern.

For these receptors, risk indices for xylene ranged over several orders of magnitude, with the risk index under Tank Closure Alternative 6A, Base and Option Cases, two to three times larger than those under other alternatives with proposed actions. Long-term impacts of air releases on aquatic and riparian resources at the Columbia River would not be likely (see Table 2–22). Risk indices would be greatest under Tank Closure Alternative 2A for benthic invertebrates exposed to ammonia; Tank Closure Alternatives 3A and 3C for the spotted sandpiper and raccoon exposed to mercury; and Tank Closure Alternatives 6B (Base and Option Cases) and 6C for the least weasel, bald eagle, and aquatic biota, including salmonids (salmon and related fishes), exposed to mercury.

For groundwater discharging to the Columbia River (see Table 2–23), potential long-term impacts on aquatic and riparian receptors would be unlikely for all receptors and COPCs but chromium and aquatic biota, including salmonids. Risk indices for benthic invertebrates, mammals, and birds would be greatest under Tank Closure Alternative 1, by a factor of five or more (except the least weasel, for which all Hazard Quotients were similar); all Hazard Quotients were below the threshold value of 1, indicating no potential for adverse impacts. The uranium Hazard Quotient values for the raccoon exemplified this pattern. For the COPC with highest risk indices for aquatic biota (chromium), there would be little difference among the Tank Closure alternatives, and thus chromium risk indices for aquatic biota do not distinguish between alternatives.

Table 2–23. Tank Closure Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Ecological Resources

Alternative	Hazard Quotient or Hazard Index of Highest-Value Chemical or Radiological COPC by Receptor						
	Benthic Invertebrate	**Muskrat**	**Spotted Sandpiper**	**Raccoon**	**Least Weasel**	**Bald Eagle**	**Aquatic Biota/ Salmonids**
Tank Closure							
	Chromium			**Uranium[a]**	**Nitrate**	**Chromium**	
1	**1.20×10^{-1}**	**4.71×10^{-3}**	**8.16×10^{-1}**	**2.95×10^{-1}**	6.31×10^{-1}	**2.08×10^{-2}**	2.14×10^{1}
2A	2.35×10^{-2}	9.17×10^{-4}	1.59×10^{-1}	4.11×10^{-2}	6.25×10^{-1}	1.49×10^{-2}	2.20×10^{1}
2B, 3A, 3B, 3C, 6C	2.50×10^{-2}	9.79×10^{-4}	1.70×10^{-1}	2.88×10^{-2}	6.30×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
4	2.47×10^{-2}	9.67×10^{-4}	1.68×10^{-1}	2.32×10^{-2}	6.30×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
5	2.54×10^{-2}	9.93×10^{-4}	1.72×10^{-1}	4.12×10^{-2}	6.30×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
6A, Base Case	2.42×10^{-2}	9.46×10^{-4}	1.64×10^{-1}	2.72×10^{-3}	6.30×10^{-1}	1.50×10^{-2}	**2.22×10^{1}**
6A, Option Case	2.11×10^{-2}	8.24×10^{-4}	1.43×10^{-1}	1.01×10^{-4}	**6.36×10^{-1}**	1.44×10^{-2}	2.15×10^{1}
6B, Base Case	2.43×10^{-2}	9.52×10^{-4}	1.65×10^{-1}	2.72×10^{-3}	6.30×10^{-1}	1.50×10^{-2}	**2.22×10^{1}**
6B, Option Case	2.03×10^{-2}	7.95×10^{-4}	1.38×10^{-1}	7.41×10^{-5}	6.16×10^{-1}	1.47×10^{-2}	2.21×10^{1}

[a] Uranium as chemical.

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.

Key: COPC=constituent of potential concern.

Long-term modeling predicts peak air concentrations and cumulative soil concentrations of mercury and xylene that potentially would cause adverse impacts on some terrestrial ecological receptors at the onsite maximum-exposure location under all Tank Closure alternatives, except the No Action Alternative (Tank Closure Alternative 1). Likewise, maximum groundwater concentrations and nearshore surface-water concentrations of chromium resulting from all Tank Closure alternatives, including the No Action Alternative, could pose a toxicological risk to aquatic biota, including salmonids, exposed to surface water in the nearshore environment of the Columbia River. Potential long-term impacts of Tank Closure alternatives on ecological resources are discussed in greater detail in Chapter 5, Section 5.1.3, and the uncertainties associated with risk indices calculated using environmental concentrations predicted for air and groundwater releases under the Tank Closure alternatives are discussed in Appendix P.

Predicted maximum nearshore surface-water concentrations of nitrate from releases to groundwater discharging at the Columbia River under Tank Closure alternatives (1.5 milligrams per liter) exceeded the 2006 ambient concentrations, 1.0 milligrams per liter (Poston et al. 2007). With sufficient light and phosphorus, such increases in dissolved nitrogen could lead to eutrophication of nearshore aquatic habitats in the Columbia River.

2.9.1.4 Environmental Justice

The long-term human health analysis determined that the impacts of tank closure actions would be greatest under Tank Closure Alternative 1. This alternative could result in radiological doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the A, B, S, T, or U Barriers, the Core Zone Boundary, or the Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected within a reasonably foreseeable timeframe because the Core Zone is designated for Industrial-Exclusive land use, the Columbia River nearshore location is designated for Preservation (Hanford Reach National Monument), and the area between them is designated for Conservation (Mining) (DOE 1999). However, exposures to such individuals were evaluated using the exposure scenarios discussed in Section 2.9.1.2. The greatest risk would be to the American Indian resident farmer at the Core Zone Boundary. During the year of peak dose, this receptor would receive a radiological dose of 3.4 rem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent due primarily to their assumed lower consumption of locally grown food. No adverse impacts were identified for any receptors at offsite locations; therefore there would be no disproportionately high and adverse impacts on American Indian populations at offsite locations.

2.9.2 FFTF Decommissioning Alternatives: Long-Term Environmental Impacts

2.9.2.1 Water Quality

This section discusses the long-term impacts on groundwater quality from FFTF sources (i.e., any residual contaminants left within the FFTF barrier boundary under each FFTF Decommissioning alternative). Long-term impacts to groundwater quality from sources remaining within the tank farm barrier boundaries and from waste management sources are discussed in Sections 2.9.1.1 and 2.9.2.1, respectively. Three assessment boundaries were selected for the groundwater analysis based on a combination of regulatory, permit, and land-use requirements. For FFTF Decommissioning alternatives, the FFTF fence line and proposed engineered barrier were selected as the innermost (i.e., closest to the source) assessment boundary. Very little groundwater transport would occur between the time the

contaminants encounter the aquifer and the time they pass beneath the outer perimeter of the barrier; in general, this innermost assessment boundary shows the greatest water quality impacts.

The second area of groundwater analysis in this *TC & WM EIS* is established by the location of the Core Zone Boundary (see Figure 2–78). However, because FFTF is outside of and downgradient from the Core Zone Boundary, the FFTF Decommissioning alternatives would not have an effect on potential impacts at this assessment boundary.

The third area of analysis is the Columbia River nearshore. It approximates the location where contaminants in the groundwater system discharge into the surface-water system. Water quality impacts at the Columbia River reflect the superposition of releases from individual sources.

Groundwater impacts are described in terms of the concentrations of the COPC drivers at the assessment boundaries under the alternatives considered. The COPC drivers are tritium, iodine-129, technetium-99, uranium-238, chromium, nitrate, and total uranium. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is less than 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

Table 2–24 presents the maximum concentrations of the COPC drivers for each of the FFTF Decommissioning alternatives at the FFTF barrier; and Table 2–25, at the Columbia River nearshore.

Table 2–24. Maximum Concentrations in Groundwater at the Fast Flux Test Facility Barrier

Contaminant	FFTF Decommissioning Alternative			Benchmark Concentration
	1	2	3	
Radionuclide (picocuries per liter)				
Hydrogen-3 (tritium)	0.36 (2122)	0 N/A	N/A	20,000
Technetium-99	416 (2425)	407 (2819)	N/A	900
Iodine-129	0 N/A	0 N/A	N/A	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A	0 N/A	N/A	15
Chemical (micrograms per liter)				
Chromium	0.00009 (2465)	N/A	N/A	100
Nitrate	0 N/A	N/A	N/A	45,000
Total uranium	0.00033 (7484)	N/A	N/A	30

Note: Calendar year of peak impact shown in parentheses.
Key: FFTF=Fast Flux Test Facility; N/A=not applicable.

Table 2–25. Maximum Concentrations in Groundwater at the Columbia River Nearshore

Contaminant	FFTF Decommissioning Alternative			Benchmark Concentration
	1	2	3	
Radionuclide (picocuries per liter)				
Hydrogen-3 (tritium)	0.00024 (2243)	0 N/A	N/A	20,000
Technetium-99	12 (2702)	12 (2965)	N/A	900
Iodine-129	0 N/A	0 N/A	N/A	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A	0 N/A	N/A	15
Chemical (micrograms per liter)				
Chromium	0.0000026 (2810)	N/A	N/A	100
Nitrate	0 N/A	N/A	N/A	45,000
Total uranium	0.000011 (7088)	N/A	N/A	30

Note: Calendar year of peak impact shown in parentheses.
Key: FFTF=Fast Flux Test Facility; N/A=not applicable.

The location where the maximum concentrations would occur varies with time, contaminant, and alternative. The benchmark concentration for each contaminant is provided for comparison. The benchmark concentrations include EPA MCLs (i.e., primary drinking water standards), EPA interim drinking water standards, DOE-derived concentration guides, and other standards known or accepted to be associated with a specific level of effect. FFTF Decommissioning alternatives are not expected to result in exceedances of these benchmarks.

The magnitude of the impacts can be represented in terms of the total amounts of the COPC drivers released to the vadose zone from all sources related to a particular alternative. Releases of radionuclides are totaled in curies over the 10,000-year period of analysis.

The total amount of technetium-99 released to the vadose zone under the FFTF Decommissioning alternatives is presented in Figure 2–92 (no iodine-129 inventory is associated with the FFTF Decommissioning alternatives). The magnitude of the impact is governed by the amount of inventory removed, which ranges from essentially none (under FFTF Decommissioning Alternatives 1 and 2) to essentially 100 percent (under FFTF Decommissioning Alternative 3).

The peak impact can be represented in terms of the peak concentration of the COPC drivers at the FFTF barrier for each of the FFTF Decommissioning alternatives. The peak concentrations of technetium-99 at the FFTF barrier, presented in tabular form in Table 2–24, are presented in logarithmic format in Figure 2–93. For the FFTF Decommissioning alternatives, the peak impact is similarly governed by the amount of inventory removed.

2.9.2.2 Human Health

Implementation of activities defined for the FFTF Decommissioning alternatives could lead to releases of radiological and chemical constituents to the environment over long periods of time. In the case of FFTF Decommissioning Alternative 1, these releases would not be controlled by final decommissioning activities. In the case of FFTF Decommissioning Alternative 2, these releases would be controlled by

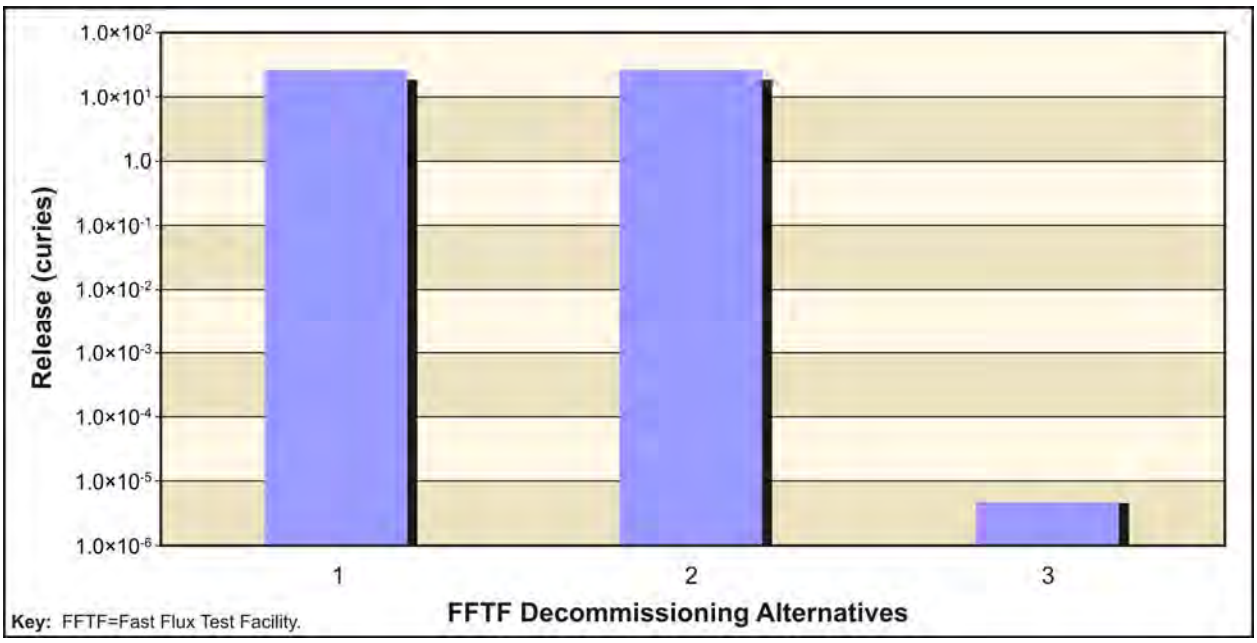


Figure 2–92. FFTF Decommissioning Alternatives – Total Technetium-99 Released to the Vadose Zone

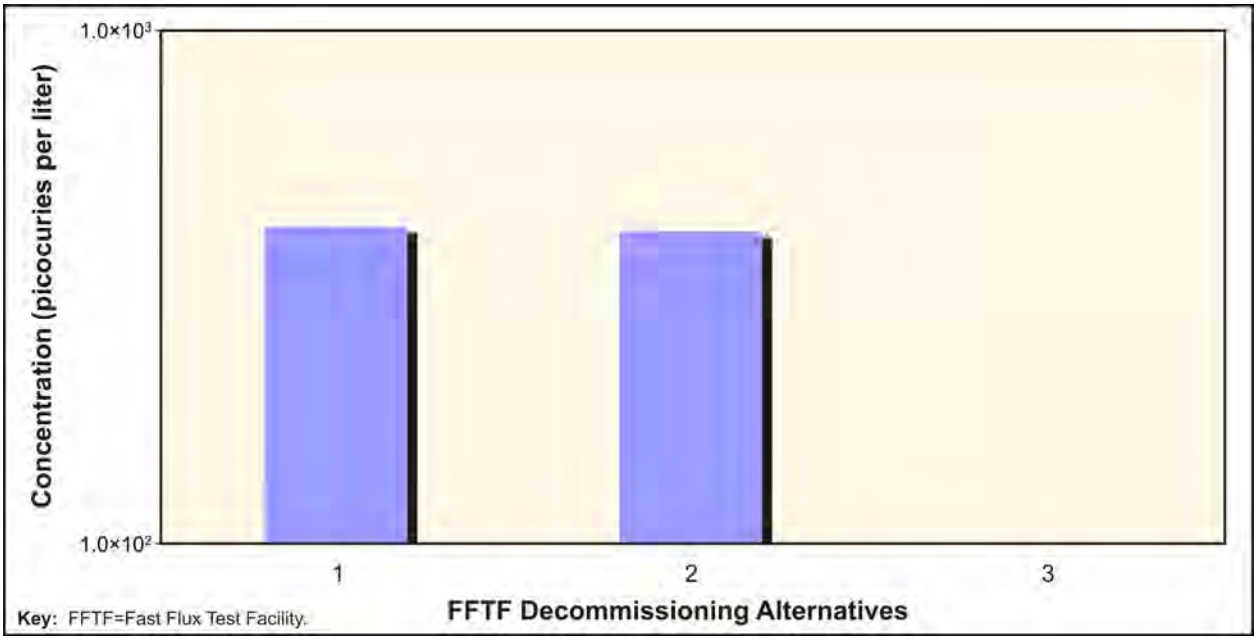


Figure 2–93. FFTF Decommissioning Alternatives – Peak Technetium-99 Concentrations at the FFTF Barrier

removal of all aboveground structures and minimal removal of below-grade structures, equipment, and materials. An RCRA-compliant barrier would be constructed over the RCB and any other remaining below-grade structures (including the reactor vessel). For FFTF Decommissioning Alternative 3, these releases would be further controlled by removal of all aboveground structures and contaminated below-grade structures (including the reactor vessel), equipment, and materials.

The four measures of human health impacts considered in this analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radionuclides, and the Hazard Index for

noncarcinogenic chemical constituents—were calculated for each year for 10,000 years for each receptor at three locations (the FFTF barrier, Columbia River nearshore, and surface water of the Columbia River). The large amount of information must be summarized to allow interpretation of results. The method chosen was to present the dose for the year of maximum dose, risks for the year of maximum risks, and the Hazard Index for the year of maximum Hazard Index. This choice was based on regulation of radiological impacts as dose and observations from the analysis results that the risk due to exposure to chemical constituents would be small relative to the risk due to exposure to radiological constituents and that peak noncarcinogenic impacts expressed as a Hazard Index may occur at times other than that of peak dose. The significance of dose impacts was evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 5400.5. Population doses were compared against the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The level of protection provided for the drinking water pathway was evaluated by comparison against the MCLs of 40 CFR 141 and other benchmarks presented in Appendix O.

The results of the analysis for the drinking-water well user at the FFTF Barrier for FFTF Decommissioning Alternatives 1, 2, and 3 are summarized in the sections below. Impacts on other types of receptors vary in proportion to the impacts on the drinking-water well user and do not provide additional information to discriminate among alternatives. Tables 2–26 and 2–27 provide the maximum dose and maximum Hazard Index, respectively, for the drinking-water well user by alternative according to the groundwater analysis results.

Table 2–26. FFTF Decommissioning Alternatives – Summary of Radiological Dose at Year of Peak Dose for the Drinking-Water Well User

Location	FFTF Decommissioning Alternative (millirem per year)		
	1	2	3
FFTF	7.29×10^{-1} (2425)	7.13×10^{-1} (2819)	N/A
Columbia River nearshore	2.16×10^{-2} (2702)	2.16×10^{-2} (2965)	N/A

Note: Calendar year of peak impact shown in parentheses.
Key: FFTF=Fast Flux Test Facility; N/A=not applicable (inventory completely removed under Alternative 3).

Table 2–27. FFTF Decommissioning Alternatives – Summary of Hazard Index at Year of Peak Hazard Index for the Drinking-Water Well User

Location	FFTF Decommissioning Alternative (unitless)		
	1	2	3
FFTF	3.19×10^{-6} (7484)	N/A	N/A
Columbia River nearshore	1.01×10^{-7} (7088)	N/A	N/A

Note: Calendar year of peak impact shown in parentheses.
Key: FFTF=Fast Flux Test Facility; N/A=not applicable (inventory completely removed under Alternative 3).

2.9.2.2.1 FFTF Decommissioning Alternative 1

Under FFTF Decommissioning Alternative 1, only those actions consistent with previous DOE NEPA actions would be completed. Final decommissioning of FFTF would not occur. For analysis purposes,

the remaining waste is assumed to become available for release to the environment after an institutional control period of 100 years. The key radiological constituent contributors to human health risk would be tritium and technetium-99. The chemical risk and hazard drivers would be essentially negligible. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose was estimated to be 9.8×10^{-3} person-rem for the year of maximum impact, approximately 5×10^{-7} percent of the background dose.

Figure 2–94 depicts a time series showing the lifetime radiological risk of incidence of cancer at the FFTF Barrier for the drinking-water well user. The peak radiological risk would occur around the year 2400 at the FFTF Barrier and would be dominated by technetium-99. Technetium-99 is a relatively mobile radionuclide that moves at the same velocity as groundwater.

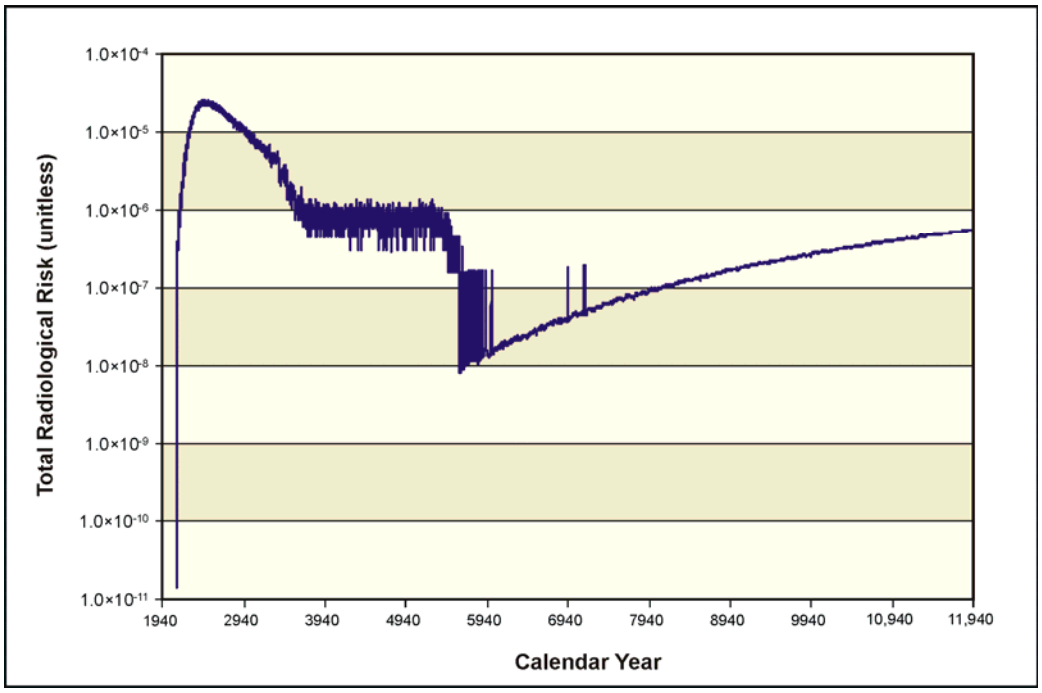


Figure 2–94. FFTF Decommissioning Alternative 1 – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the FFTF Boundary

2.9.2.2.2 FFTF Decommissioning Alternative 2

Under FFTF Decommissioning Alternative 2, all aboveground structures and minimal below-grade structures, equipment, and materials would be removed. An RCRA-compliant barrier would be constructed over the RCB and any other remaining below-grade structures (including the reactor vessel). The key radiological constituent contributor to human health risk would be technetium-99. The chemical risk and hazard drivers would be essentially negligible. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose was estimated to be 8.9×10^{-3} person-rem for the year of maximum impact, representing approximately 5×10^{-7} percent of the background dose.

Figure 2–95 depicts a time series showing the lifetime radiological risk of incidence of cancer at the FFTF Barrier for the drinking-water well user. The peak radiological risk would occur around the year 2800 for the FFTF Barrier and would be dominated by technetium-99. Technetium-99 is a relatively mobile radionuclide that moves at the same velocity as groundwater.

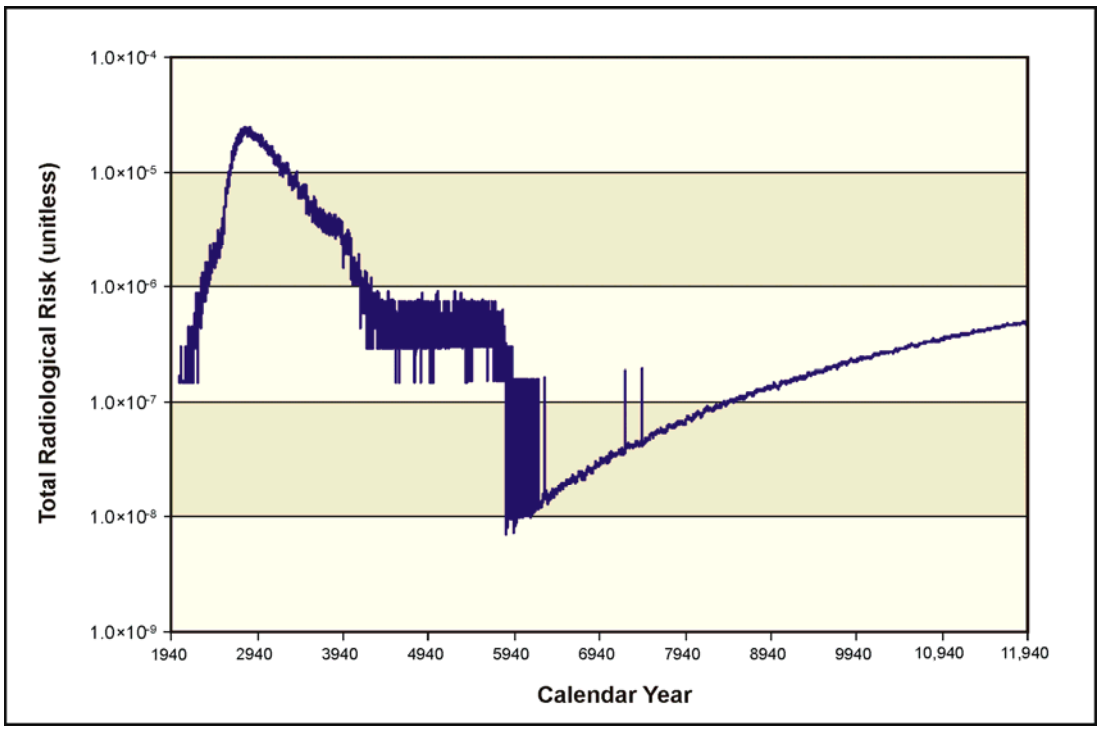


Figure 2–95. FFTF Decommissioning Alternative 2 – Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the FFTF Boundary

2.9.2.2.3 FFTF Decommissioning Alternative 3

Under FFTF Decommissioning Alternative 3, all aboveground structures, as well as contaminated below-grade structures, equipment, and materials would be removed. As a result of removal of all contaminated material, there would be no impacts to groundwater and no impacts to human health.

2.9.2.3 Ecological Risk

Risk indices for ecological receptors exposed to COPCs as a result of air releases and groundwater discharges (see Appendix P) are used in this *TC & WM EIS* to compare FFTF Decommissioning alternatives. Risk indices less than 1 indicate little to no likelihood of adverse impact on the receptor. The uncertainties associated with risk indices and the meaning of Hazard Quotients and Hazard Indices for ecological receptors in this *TC & WM EIS* are discussed in Appendix P.

The potential long-term impacts of air releases on terrestrial receptors and aquatic and riparian receptors, as quantified by risk indices for the highest-value COPC for each receptor, are shown in Table 2–28. Long-term impacts on all terrestrial, aquatic, and riparian receptors at all locations would be greatest under FFTF Decommissioning Alternative 1. For the COPC with the highest Hazard Quotients (xylene), the potential long-term impacts under the No Action Alternative are more than 250 times greater than the impacts if the Hanford options were selected for processing both RH-SCs and bulk sodium and more than 500 times greater than the Idaho options under FFTF Decommissioning Alternatives 2 and 3. The reduction in impacts would be intermediate between the two options if one of the waste types were processed at Hanford and the other at INL. The smallest difference between FFTF Decommissioning Alternative 1 and the other FFTF Decommissioning alternatives is the sevenfold larger value for aquatic biota, including salmonids, for benzene.

Table 2–28. FFTF Decommissioning Alternatives – Long-Term Impacts of Contaminant Releases to Air on Ecological Resources

FFTF Decommissioning Alternative	Hazard Quotient of Highest-Value COPC by Receptor[a]							
	Onsite Maximum-Exposure Location				Columbia River			
	Plants	Great Basin Pocket Mouse	Coyote	Mule Deer	Benthic Invertebrate	Aquatic Biota/ Salmonids	Raccoon	Least Weasel
	Toluene	Xylene		Formaldehyde	Xylene	Benzene	Xylene	
1	**4.68×10^{1}**	**2.12×10^{3}**	**2.69×10^{2}**	**4.79×10^{1}**	**5.0×10^{-3}**	**7.0×10^{-2}**	**3.6×10^{-5}**	**2.1×10^{-4}**
2 Hanford options	1.6×10^{-1}	7.60	9.6×10^{-1}	6.1×10^{-1}	5.0×10^{-4}	1.0×10^{-2}	3.1×10^{-6}	1.8×10^{-5}
2 Idaho options	8.0×10^{-2}	3.68	4.7×10^{-1}	4.2×10^{-1}	3.0×10^{-4}	9.0×10^{-3}	1.8×10^{-6}	1.0×10^{-5}
3 Hanford options	1.6×10^{-1}	7.65	9.7×10^{-1}	5.8×10^{-1}	5.0×10^{-4}	9.0×10^{-3}	3.1×10^{-6}	1.8×10^{-5}
3 Idaho options	8.0×10^{-2}	3.73	4.7×10^{-1}	3.9×10^{-1}	1.0×10^{-4}	5.0×10^{-3}	8.6×10^{-7}	5.0×10^{-6}

[a] The soil-dwelling invertebrate, side-blotched lizard, meadowlark, mourning dove, burrowing owl, spotted sandpiper, and bald eagle had no toxicity reference values or risk indices equal to zero for chemical COPCs and very small values for radiological COPCs in these analyses and thus are not shown.

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

For groundwater discharging to the Columbia River (see Table 2–29), risk indices were small under the FFTF Decommissioning alternatives. They would be greatest under FFTF Decommissioning Alternative 1 for all aquatic and riparian receptors. In all cases, the differences between alternatives were less than a factor of two. Long-term modeling predicts peak air concentrations and cumulative soil concentrations of benzene, toluene, xylene, and formaldehyde that would potentially cause adverse impacts on terrestrial ecological receptors at the onsite maximum-exposure location under FFTF Decommissioning Alternative 1: No Action. Maximum groundwater concentrations and nearshore surface-water and sediment concentrations resulting from all FFTF Decommissioning alternatives would not pose a toxicological risk to aquatic and riparian receptors exposed at the Columbia River. Potential long-term impacts under FFTF Decommissioning alternatives on ecological resources are discussed in greater detail in Chapter 5, Section 5.2.3, and the uncertainties associated with risk indices calculated using environmental concentrations predicted for air and groundwater releases under the FFTF Decommissioning alternatives are discussed in Appendix P.

Eutrophication of nearshore surface water as a result of groundwater releases under FFTF Decommissioning alternatives is not expected, because nitrate would not occur in groundwater discharging at the Columbia River under these alternatives.

Table 2–29. FFTF Decommissioning Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Ecological Resources

FFTF Decommissioning Alternative	Hazard Quotient or Hazard Index of Highest-Value COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/ Salmonids
	All Radiological COPCs						
1	**1.05×10^{-6}**	**9.76×10^{-6}**	**1.07×10^{-5}**	**1.01×10^{-5}**	**5.60×10^{-6}**	**1.98×10^{-6}**	**9.42×10^{-7}**
2	7.43×10^{-7}	6.69×10^{-6}	7.65×10^{-6}	7.06×10^{-6}	5.10×10^{-6}	1.80×10^{-6}	8.56×10^{-7}
3	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: The maximum Hazard Quotient for each receptor for each set of alternatives is indicated by **bold** text.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility; N/A=not applicable.

2.9.2.4 Environmental Justice

The long-term human health analysis determined that the impacts of FFTF decommissioning actions would be greatest under FFTF Decommissioning Alternative 1. Under this alternative, none of the hypothetical receptors at any of the assessment boundaries would receive a radiological dose in excess of regulatory limits or a chemical exposure with a Hazard Index greater than 1. The greatest risk would be to the American Indian resident farmer at the FFTF boundary. During the year of peak dose, this receptor would receive a radiological dose of 3.8 millirem compared with the regulatory limit of 100 millirem from all sources. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index less than 1. Therefore, none of the FFTF Decommissioning alternatives would pose a disproportionately high and adverse long-term human health risk to the American Indian population at offsite locations.

2.9.3 Waste Management Alternatives: Long-Term Environmental Impacts

2.9.3.1 Water Quality

This section discusses the long-term impacts on groundwater quality from waste management sources (i.e., contaminants from disposal at trenches 31 and 34, IDF-East, IDF-West, and the RPPDF). Long-term impacts on groundwater quality from sources remaining within the tank farm barrier boundaries and from sources within the FFTF barrier boundary are discussed in Sections 2.9.1.1 and 2.9.2.1, respectively. Three assessment boundaries were selected for the groundwater analysis based on a combination of regulatory, permit, and land-use requirements. For Waste Management alternatives, the innermost (i.e., closest to the source) area of analysis comprises the engineered barriers that would be installed above the IDF, RPPDF, and LLBG 218-W-5, trenches 31 and 34 (see Figure 2–78). Very little groundwater transport would occur between the time the contaminants encounter the aquifer and the time they pass beneath the outer perimeter of the barriers; in general, the greatest water quality impacts would occur at these innermost assessment boundaries.

The second area of analysis is established by the location of the Core Zone Boundary. The Core Zone Boundary is approximated by a rectangle encompassing the entire area that would be directly affected by candidate facilities. The Core Zone Boundary represents the “fence line” of the projected waste management operational facilities for each of the alternatives. The aquifer beneath the western portion of Core Zone Boundary has relatively low groundwater flux, which results in relatively high peak groundwater impacts. The eastern portion of the Core Zone Boundary is in an area of high groundwater flux, and peak groundwater impacts in the eastern part of the Core Zone Boundary would be correspondingly lower.

The third area of analysis is the Columbia River nearshore. It approximates the location where contaminants in the groundwater system discharge into the surface-water system. Water quality impacts at the Columbia River reflect the superposition of releases from individual sources.

Groundwater impacts are described in terms of the concentrations of the COPC drivers at the assessment boundaries under the alternative considered. The COPC drivers are tritium, iodine-129, technetium-99, uranium-238, chromium, nitrate, and total uranium. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is less than 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard

during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

The maximum concentrations of the COPC drivers are reported at the trenches 31 and 34 barrier under Waste Management Alternative 1 (see Table 2–30); at the IDF-East and RPPDF barriers under Waste Management Alternative 2 (see Tables 2–31 and 2–32); and at the IDF-East, IDF-West, and RPPDF barriers under Waste Management Alternative 3 (see Tables 2–33 through 2–35). Tables 2–36 and 2–37 show the maximum concentrations at the Core Zone Boundary under Waste Management Alternatives 2 and 3, respectively. Tables 2–38 and 2–39 show the maximum concentrations under Waste Management Alternatives 2 and 3 at the Columbia River nearshore. Waste Management Alternative 1 impacts at the Core Zone Boundary and the Columbia River nearshore are essentially negligible.

Table 2–30. Alternative 1 Maximum Concentrations in Groundwater at Trenches 31 and 34

Contaminant	Waste Management Alternative 1	Benchmark Concentration
Radionuclide (picocuries per liter)		
Hydrogen-3 (tritium)	0 N/A	20,000
Technetium-99	22 (3499)	900
Iodine-129	0.024 (3489)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0.0035 (11,939)	15
Chemical (micrograms per liter)		
Chromium	3 (3526)	100
Nitrate	47 (3534)	45,000
Total uranium	0.0000038 (11,848)	30

Note: Calendar year of peak impact shown in parentheses.

Key: N/A=not applicable.

Table 2–31. Alternative 2 Maximum Concentrations in Groundwater at the 200-East Area Integrated Disposal Facility

Contaminant	Waste Management Alternative 2												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	**2,041** (9004)	**2,878** (8486)	**5,659** (9048)	**30,126** (9032)	**6,494** (9035)	**3,513** (8276)	**2,185** (9004)	**2,824** (8580)	**2,894** (8580)		**3,039** (8646)		900
Iodine-129	**18.7** (8739)	**18.4** (8195)	**18.2** (8491)	**24.0** (8195)	**18.4** (8491)	**18.4** (8195)	**18.7** (8739)	**23.8** (9058)	**24.1** (9058)		**22.3** (8850)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	4 (8511)	2 (8278)	**437** (8940)	**436** (9071)	**224** (9069)	**335** (8735)	4 (8618)	3 (9308)	3 (8281)		3 (8561)		100
Nitrate	14,245 (8522)	14,384 (7821)	**50,237** (8665)	14,514 (7859)	28,997 (9330)	21,393 (8448)	14,245 (8522)	15,512 (8055)	16,645 (8162)		16,640 (7367)		45,000
Total uranium	0 N/A												30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: N/A=not applicable.

Table 2–32. Alternative 2 Maximum Concentrations in Groundwater at the River Protection Project Disposal Facility

Contaminant	Waste Management Alternative 2												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A					N/A	0 N/A	N/A	0 N/A				20,000
Technetium-99	33 (3825)				103 (3822)	N/A	33 (3825)	N/A	283 (3889)	340 (4213)	303 (3987)	386 (4013)	900
Iodine-129	0.1 (3772)				0.2 (3940)	N/A	0.1 (3772)	N/A	0.5 (4089)	0.6 (4176)	0.5 (4073)	0.6 (4172)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A					N/A	0 N/A	N/A	0 N/A				15
Chemical (micrograms per liter)													
Chromium	2 (3856)				6 (3804)	N/A	2 (3856)	N/A	6 (3868)	33 (4118)	6 (4109)	36 (3878)	100
Nitrate	149 (3811)				229 (4042)	N/A	149 (3811)	N/A	353 (3996)	9,073 (3962)	404 (4001)	10,251 (4544)	45,000
Total uranium	0.000001 (11,835)				0.000005 (11,837)	N/A	0.000001 (11,835)	N/A	0.000003 (11,890)	0.000001 (11,892)	0.000003 (11,927)	0.000001 (11,918)	30

Note: Calendar year of peak impact shown in parentheses.
Key: N/A=not applicable.

Table 2–33. Alternative 3 Maximum Concentrations in Groundwater at the 200-East Area Integrated Disposal Facility

Contaminant	Waste Management Alternative 3												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	3-A, Base Case	3-B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	471 (8991)	**1,604** (8486)	**5,022** (9048)	**29,171** (9032)	**5,638** (9826)	**2,388** (9701)	414 (10032)	334 (9823)	347 (10,643)		389 (9324)		900
Iodine-129	**1.4** (11243)	**1.7** (11284)	0.7 (10915)	**10.7** (8514)	**1.1** (11,228)	**1.2** (11,711)	**1.4** (11,243)	**1.7** (10,498)	**1.6** (11,363)		**1.6** (11,096)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	4 (8511)	2 (8278)	**436** (8940)	**436** (9071)	**223** (9069)	**335** (8735)	4 (8618)	3 (9308)	3 (8281)		3 (8037)		100
Nitrate	14,243 (8522)	14,381 (7821)	**50,234** (8665)	14,512 (7859)	28,995 (9330)	21,390 (8448)	14,243 (8522)	15,510 (7977)	16,643 (8162)		16,640 (7367)		45,000
Total uranium	0 N/A												30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–34. Alternative 3 Maximum Concentrations in Groundwater at the 200-West Area Integrated Disposal Facility

Contaminant	Waste Management Alternative 3												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	3-A, Base Case	3-B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	**20,209** (3713)												900
Iodine-129	**172.6** (3797)												1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0.09 (11,938)												15
Chemical (micrograms per liter)													
Chromium	2 (3696)												100
Nitrate	17 (3703)												45,000
Total uranium	0 N/A												30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–35. Alternative 3 Maximum Concentrations in Groundwater at the River Protection Project Disposal Facility

Contaminant	Waste Management Alternative 3												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	3-A, Base Case	3-B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A					N/A	0 N/A	N/A	0 N/A				20,000
Technetium-99	33 (3825)				103 (3822)	N/A	33 (3825)	N/A	283 (3889)	340 (4213)	303 (3987)	386 (4013)	900
Iodine-129	0.1 (3772)				0.2 (3940)	N/A	0.1 (3772)	N/A	0.5 (4089)	0.6 (4176)	0.5 (4073)	0.6 (4172)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A					N/A	0 N/A	N/A	0 N/A				15
Chemical (micrograms per liter)													
Chromium	2 (3856)				6 (3804)	N/A	2 (3856)	N/A	6 (3868)	33 (4118)	6 (4109)	36 (3878)	100
Nitrate	149 (3811)				229 (4042)	N/A	149 (3811)	N/A	353 (3996)	9,073 (3962)	404 (4001)	10,251 (4544)	45,000
Total uranium	0.000001 (11,835)				0.000005 (11,837)	N/A	0.000001 (11,835)	N/A	0.000003 (11,890)	0.000001 (11,892)	0.000003 (11,927)	0.000001 (11,918)	30

Note: Calendar year of peak impact shown in parentheses.
Key: N/A=not applicable.

Table 2–36. Alternative 2 Maximum Concentrations in Groundwater at the Core Zone Boundary

Contaminant	Waste Management Alternative 2												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	**1,178** (9155)	**1,253** (7998)	**8,156** (9163)	**24,782** (9067)	**3,094** (9499)	**1,497** (9155)	**1,152** (9155)	**1,145** (8365)	**1,138** (8365)	**1,351** (4466)	**1,180** (8173)		900
Iodine-129	**8.5** (8858)	**8.4** (8858)		**15.5** (8082)	**8.4** (8858)		**8.5** (8858)	**9.7** (9178)	**9.6** (9188)		**11.2** (11,300)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	2 (3889)		**265** (8760)	**174** (8397)	96 (8643)	**148** (8764)	2 (3889)	2 (8982)	11 (11,232)	97 (10,533)	11 (6384)	**125** (6610)	100
Nitrate	5,630 (9653)	5,859 (8905)	21,194 (8290)	4,971 (7269)	13,920 (8994)	7,417 (8887)	5,630 (9653)	5,695 (7905)	5,751 (8245)	28,374 (9305)	6,550 (6859)	30,238 (4627)	45,000
Total uranium	0.0000008 (11,828)				0.000004 (11,897)	0 N/A	0.0000008 (11,828)	0 N/A	0.000005 (11,903)	0.000002 (11,924)	0.000004 (11,938)	0.000001 (11,927)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–37. Alternative 3 Maximum Concentrations in Groundwater at the Core Zone Boundary

Contaminant	Waste Management Alternative 3												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	3-A, Base Case	3-B, Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	**7,555** (3690)		**7,838** (9163)	**24,626** (9067)	**7,596** (3690)	**7,537** (3690)	**7,555** (3690)	**7,537** (3690)	**7,747** (3690)	**7,586** (3690)	**7,765** (3690)	**7,935** (3690)	900
Iodine-129	**60.3** (3853)				**60.4** (3853)	**60.3** (3853)			**60.7** (3853)	**60.8** (3853)	**60.7** (3853)	**60.9** (3853)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0.022 (11,931)												15
Chemical (micrograms per liter)													
Chromium	3 (3628)		**265** (8760)	**174** (8397)	96 (8643)	**148** (8764)	3 (3628)	2 (8982)	12 (4042)	97 (10,533)	12 (4035)	**125** (6610)	100
Nitrate	5,630 (9653)	5,858 (8905)	21,193 (8290)	4,971 (7269)	13,919 (8994)	7,417 (8887)	5,630 (9653)	5,695 (7905)	5,751 (8245)	28,373 (9305)	6,550 (6859)	30,238 (4627)	45,000
Total uranium	0.0000008 (11,828)				0.000004 (11,897)	0 N/A	0.0000008 (11,828)	0 N/A	0.000005 (11,903)	0.000002 (11,924)	0.000004 (11,938)	0.000001 (11,927)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–38. Alternative 2 Maximum Concentrations in Groundwater at the Columbia River Nearshore

Contaminant	Waste Management Alternative 2												Benchmark Concentration
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	675 (9451)	815 (8273)	**1,686** (8927)	**7,608** (8274)	**2,030** (8117)	891 (8090)	674 (9451)	671 (8478)	703 (8477)	717 (8477)	848 (9284)	861 (9284)	900
Iodine-129	**7.0** (8700)			**8.2** (8699)	**7.0** (8699)			**5.6** (9652)		**5.7** (9652)	**5.6** (8985)	**5.7** (8985)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	1 (8898)	0.38 (4826)	**116** (9311)	**116** (9878)	64 (8079)	**110** (8819)	1 (8528)	1 (8354)	2 (5035)	17 (5522)	3 (4877)	20 (6701)	100
Nitrate	2,444 (8827)	3,681 (8144)	14,132 (9453)	3,318 (7744)	6,384 (8673)	4,560 (8787)	2,444 (8827)	4,068 (8056)	3,313 (7837)	5,696 (4618)	3,312 (7741)	5,616 (6522)	45,000
Total uranium	0.00000002 (11,918)				0.0000008 (11,920)	0 N/A	0.00000002 (11,918)	0 N/A	0.0000001 (11,598)	0.00000009 (11,906)	0.00000009 (11,892)	0.00000004 (11,864)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

Table 2–39. Alternative 3 Maximum Concentrations in Groundwater at the Columbia River Nearshore

Contaminant	Waste Management Alternative 3												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	**1,129** (4528)		**1,689** (8939)	**7,451** (9206)	**2,031** (8117)	**1,125** (4528)	**1,129** (4528)	**1,125** (4528)	**1,179** (3884)	**1,188** (4191)	**1,181** (4186)	**1,219** (4066)	900
Iodine-129	**8.3** (4729)				**8.3** (4728)	**8.3** (4729)			**8.4** (4392)			**8.4** (4728)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0.0002 (11,892)												15
Chemical (micrograms per liter)													
Chromium	1 (8879)	0.46 (4812)	**116** (9311)	**116** (9878)	64 (8079)	**110** (8819)	1 (8204)	1 (8353)	2 (4714)	17 (5522)	3 (4877)	20 (6701)	100
Nitrate	2,443 (8043)	3,680 (8144)	14,132 (9453)	3,318 (7528)	6,384 (8673)	4,559 (8787)	2,443 (8043)	4,067 (8056)	3,313 (7831)	5,697 (4618)	3,312 (7717)	5,616 (6522)	45,000
Total uranium	0.00000002 (11,918)				0.00000008 (11,920)	0 N/A	0.00000002 (11,918)	0 N/A	0.0000001 (11,598)	0.00000009 (11,906)	0.00000009 (11,892)	0.00000004 (11,864)	30

Note: Calendar year of peak impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: N/A=not applicable.

The location where the maximum concentrations would occur varies with time, contaminant, and alternative. The benchmark concentration for each contaminant is provided for comparison. The benchmark concentrations include EPA MCLs (i.e., primary drinking water standards), EPA interim drinking water standards, DOE-derived concentration guides, and other standards known or accepted to be associated with a specific level of effect. Core Zone Boundary, Columbia River nearshore, RPPDF, and IDF concentrations that would exceed the benchmark concentrations are indicated in bold text. As discussed in Section 2.9, three disposal groups were developed to facilitate analysis of the potential Hanford waste management construction, operations, and closure requirements.

Under Waste Management Alternative 1, there are no exceedances of benchmarks. Under Waste Management Alternatives 2 and 3, there are benchmark exceedances of iodine-129 and technetium-99 at the Core Zone under all disposal groups. These benchmark exceedances are driven by a combination of disposal of offsite-generated waste, tank farm supplemental treatment waste forms, and tank farm secondary waste (in declining order of impact).

The magnitude of the impacts can be represented in terms of the total amounts of the COPC drivers released to the vadose zone from all sources related to a particular alternative. Releases of radionuclides are totaled in curies over the 10,000-year period of analysis. The total amounts of iodine-129 and technetium-99 released to the vadose zone under the Waste Management alternatives are presented in Figures 2–96 and 2–97, respectively. The magnitude of the impact of Waste Management alternatives is governed by inventory and waste form performance. For iodine-129, the magnitude of Waste Management Alternative 2 and 3 impacts is nearly constant under all disposal groups and is driven by the inventory of iodine-129 in offsite-generated waste disposed of in an IDF. For technetium-99, the primary factor is the same as that for iodine-129, followed by differential retention in supplemental treatment and secondary waste forms.

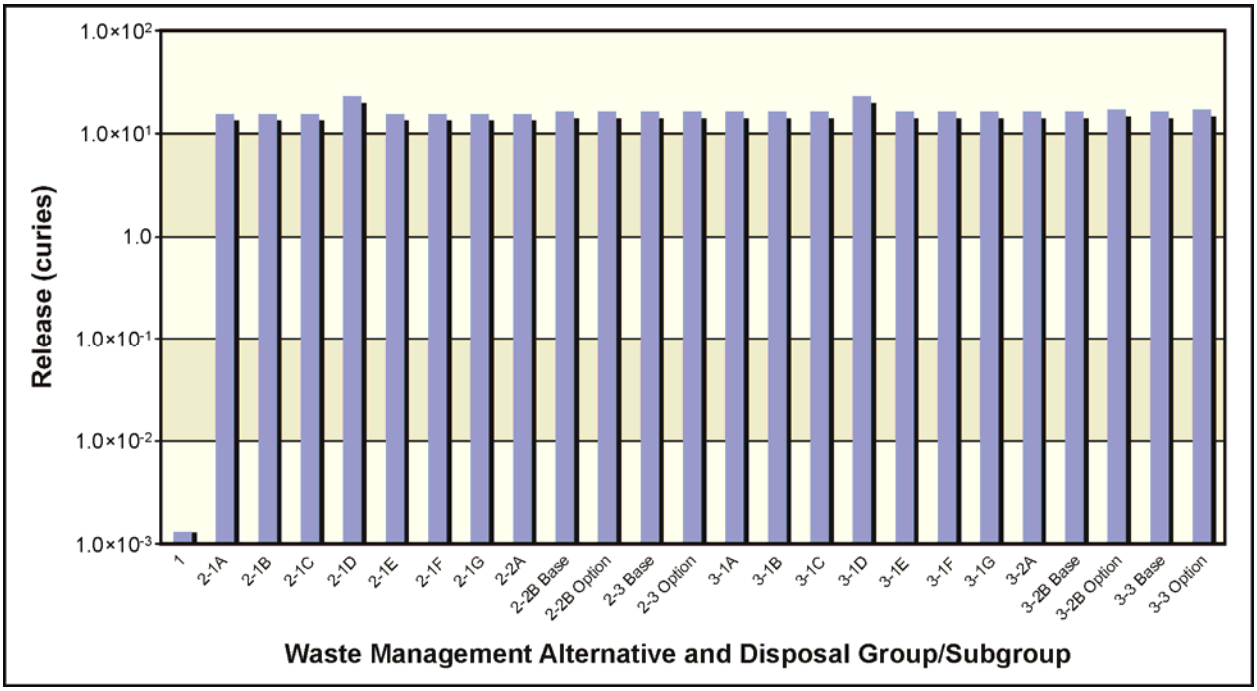


Figure 2–96. Waste Management Alternatives – Total Iodine-129 Released to the Vadose Zone

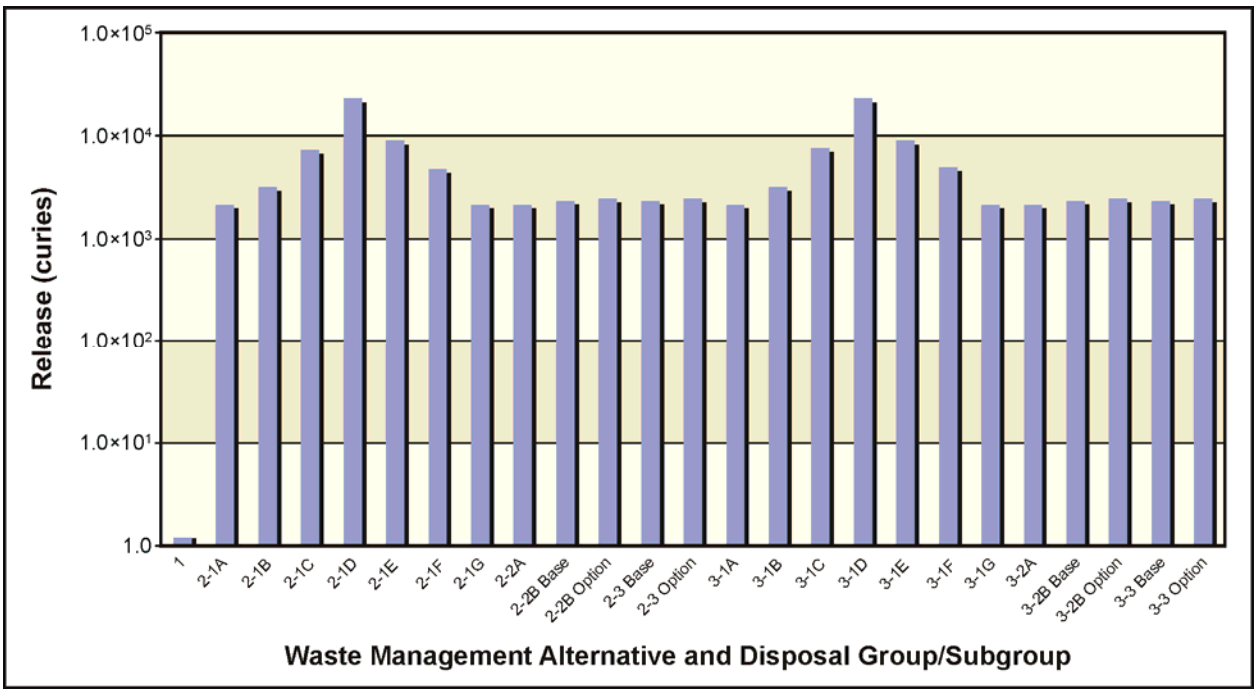


Figure 2–97. Waste Management Alternatives – Total Technetium-99 Released to the Vadose Zone

The peak impact can be represented in terms of the peak concentrations of the COPC drivers at the Core Zone for each of the Waste Management alternatives. The peak concentrations of iodine-129 and technetium-99 at the Core Zone Boundary presented in tabular form above (see Tables 2–36 and 2–37) are depicted in Figures 2–98 and 2–99, respectively. The peak impact of the Waste Management alternatives is governed by inventory (Waste Management Alternative 1 has the lowest inventory and the lowest peak intensity), by location (Waste Management Alternative 2 is located at IDF-East, with a lower infiltration rate and consequently lower rate of movement through the vadose zone than Waste Management Alternative 3, which has waste disposal in both IDF-East and IDF-West), and by rate of release from the waste form (which ranges from highest to lowest, starting with Disposal Group 1, Subgroup 1-D, which is dominated by steam reforming waste; then Subgroup 1-C, which is dominated by cast stone waste; then Subgroups 1-E and 1-F, which have a combination of case stone waste and bulk vitrification glass; then Subgroup 1-B, which is dominated by bulk vitrification glass; and finally Subgroup 1-A, which is dominated by ILAW glass).

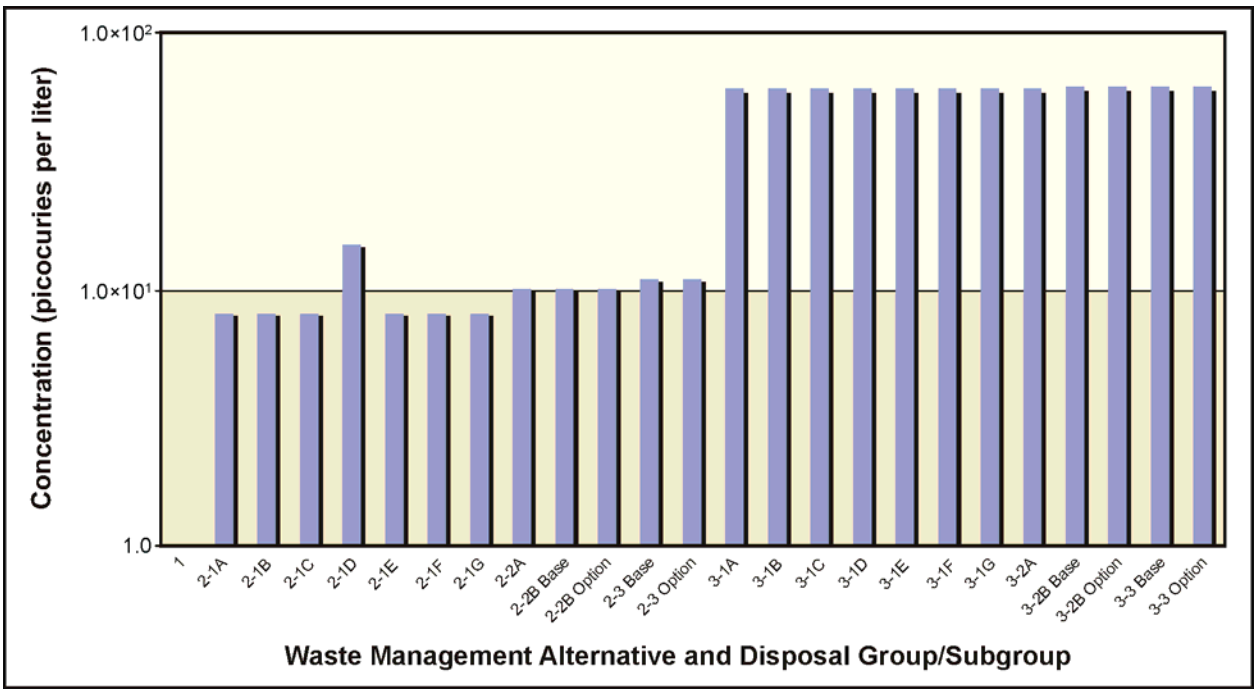


Figure 2–98. Waste Management Alternatives – Peak Iodine-129 Concentrations at the Core Zone Boundary

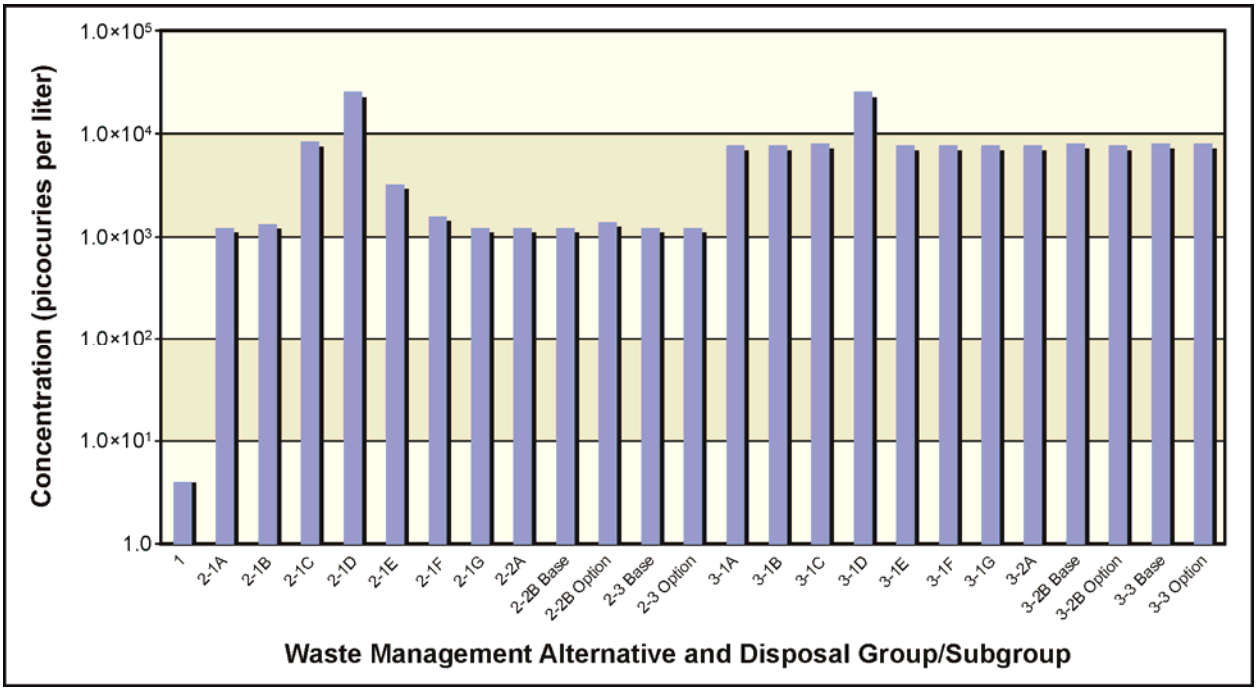


Figure 2–99. Waste Management Alternatives – Peak Technetium-99 Concentrations at the Core Zone Boundary

2.9.3.2 Human Health

Implementation of activities defined for the Waste Management alternatives could lead to releases of radioactive and chemical constituents to the environment over long periods of time. In the case of Waste Management Alternative 1, these releases would come from LLBG 218-W-5, trenches 31 and 34. In the case of Waste Management Alternative 2, these releases would come from IDF-East and the RPPDF. Under Waste Management Alternative 3, these releases would come from IDF-East, IDF-West, and the RPPDF.

The four measures of human health impacts considered in this analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radionuclides, and Hazard Index from chemical constituents—were calculated for each year for 10,000 years for each receptor at six locations (IDF-East, IDF-West, RPPDF, Core Zone Boundary, Columbia River nearshore, and surface water of the Columbia River). This large amount of information must be summarized to allow interpretation of results. The method chosen was to present the dose for the year of maximum dose, the risks for the year of maximum risks, and the Hazard Index for the year of maximum Hazard Index. This choice was based on regulation of radiological impacts as dose and observations from the analysis results that the risk due to exposure to chemical constituents would be small relative to the risk due to exposure to radiological constituents and that peak noncarcinogenic impacts expressed as a Hazard Index may occur at times other than that of peak dose. The significance of the dose impacts was evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 5400.5. Population doses were compared against the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The level of protection provided for the drinking water pathway was evaluated by comparison against the MCLs of 40 CFR 141, as presented in Appendix O. Only those radionuclides and chemical constituents that resulted in a lifetime risk greater than 1×10^{-10} are presented in the tables to reduce the size of the tables.

The results of the analysis for the drinking-water well user at the Core Zone Boundary are summarized below. Impacts on other types of receptors vary in proportion to the impacts on the drinking-water well user and do not provide additional information to discriminate among alternatives.

2.9.3.2.1 Waste Management Alternative 1

Under Waste Management Alternative 1, only those wastes currently generated on site at Hanford from non-CERCLA actions would continue to be disposed of in LLBG 218-W-5, trenches 31 and 34. Although the short-term impacts do not address the impacts associated with closure activities for this site, for purposes of analysis of the long-term impacts, it was assumed that these trenches would be closed using an RCRA-compliant barrier consistent with the closure plans for these burial grounds. As a result, the non-CERLCA waste to be disposed of in these trenches from 2008 to 2035 is assumed to become available for release to the environment. The maximum dose and maximum Hazard Index from the groundwater analysis of Waste Management Alternative 1 for the drinking-water well user are summarized in Tables 2–40 and 2–41. The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. These rather mobile radionuclides move at the same velocity as groundwater. The key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index would not be exceeded at any location. The population dose for the year of maximum impact was estimated to be 3.18×10^{-4} person-rem, approximately 2×10^{-8} percent of the background dose.

Table 2–40. Waste Management Alternative 1 Summary of Radiological Dose at Year of Peak Dose for the Drinking-Water Well User

Location	Alternative 1 (millirem per year)
LLBG 218-W-5, trenches 31 and 34	4.48×10^{-2} (3499)
Core Zone Boundary	7.96×10^{-3} (3471)
Columbia River nearshore	1.29×10^{-3} (3974)

Note: Calendar year of peak impact shown in parentheses.
Key: LLBG=low-level radioactive waste burial ground.

Table 2–41. Waste Management Alternative 1 Summary of Hazard Index at Year of Peak Hazard Index for the Drinking-Water Well User

Location	Alternative 1 (unitless)
LLBG 218-W-5, trenches 31 and 34	3.08×10^{-2} (3526)
Core Zone Boundary	5.92×10^{-3} (3615)
Columbia River nearshore	9.93×10^{-4} (4147)

Note: Calendar year of peak impact shown in parentheses.
Key: LLBG=low-level radioactive waste burial ground.

Figure 2–100 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3470 and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in LLBG 218-W-5, trenches 31 and 34.

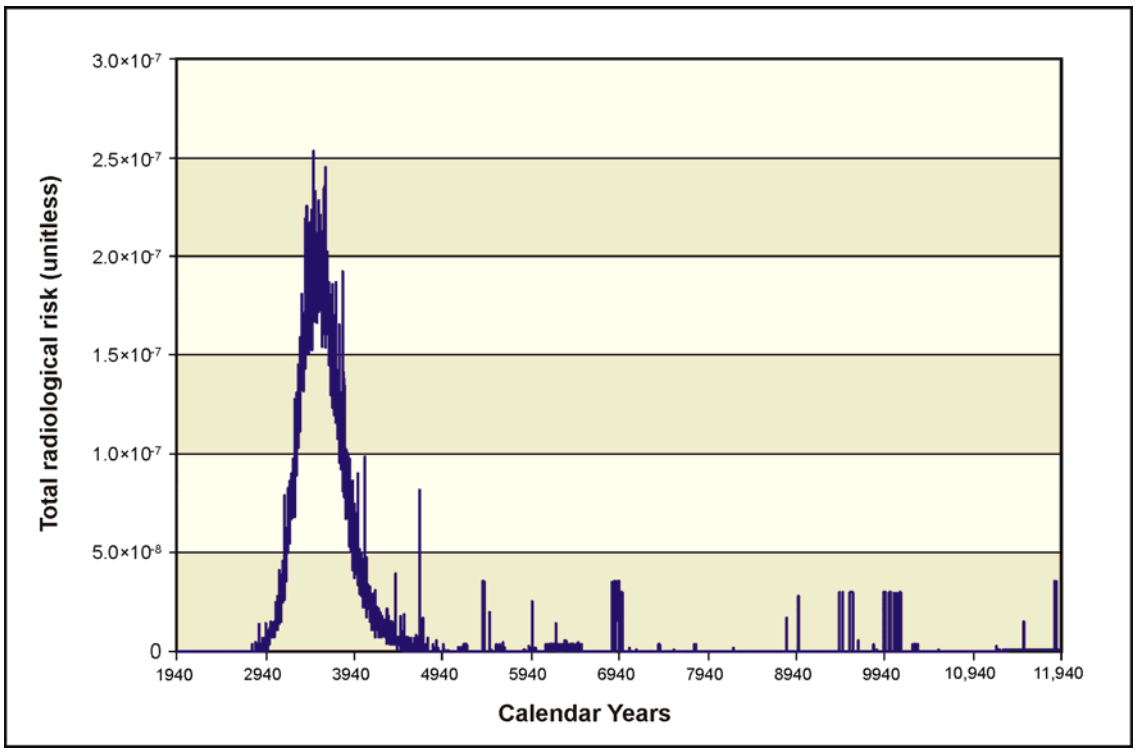


Figure 2–100. Waste Management Alternative 1 Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2 Waste Management Alternative 2, All Disposal Groups and Subgroups

Under Waste Management Alternative 2, waste from tank treatment operations, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-East. Waste from tank farm cleanup activities would be disposed of in the RPPDF. As a result, the waste disposed of in these two facilities is assumed to become available for release to the environment. Because different waste types would result from the Tank Closure action alternatives, three disposal groups were considered to account for the different IDF-East sizes and operational periods. In addition, within these three disposal groups, subgroups were identified to allow consideration of the different waste types resulting from the Tank Closure action alternatives (see Chapter 5, Section 5.3). Potential human health impacts of these subgroups under this alternative are discussed in the following sections. The maximum dose and maximum Hazard Index from the groundwater analysis of Waste Management Alternative 2 for the drinking-water well user are summarized in Tables 2–42 and 2–43.

Table 2–42. Waste Management Alternative 2, All Disposal Groups and Subgroups, Summary of Radiological Dose at Year of Peak Dose for the Drinking-Water Well User

	Waste Management Alternative 2 (millirem per year)											
	Disposal Group 1							Disposal Group 2			Disposal Group 3	
	Subgroup							Subgroup				
Location	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case
IDF-East	7.49 (8276)	8.81 (8739)	1.22×10^{1} (9509)	5.65×10^{1} (9032)	1.38×10^{1} (8944)	1.02×10^{1} (8276)	7.59 (8739)	1.12×10^{1} (8706)	1.14×10^{1} (8706)		1.08×10^{1} (8290)	
RPPDF	6.92×10^{-2} (3804)				2.15×10^{-1} (3822)	N/A	6.92×10^{-2} (3804)	N/A	5.92×10^{-1} (3889)	6.96×10^{-1} (4213)	6.35×10^{-1} (3987)	7.87×10^{-1} (4013)
Core Zone Boundary	3.13 (8438)	3.68 (8079)	1.59×10^{1} (9163)	4.42×10^{1} (9067)	5.91 (9576)	3.89 (8885)	3.07 (8858)	3.98 (9188)	3.96 (9188)		3.59 (8393)	4.10 (8393)
Columbia River nearshore	2.58 (8700)	2.77 (8700)	4.15 (8927)	1.48×10^{1} (9207)	4.36 (8117)	2.97 (8700)	2.61 (8700)	1.92 (9652)		1.94 (9652)	2.31 (9282)	2.34 (9284)

Note: Calendar year of peak impact shown in parentheses.

Key: IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Table 2–43. Waste Management Alternative 2, All Disposal Groups and Subgroups, Summary of Hazard Index at Year of Peak Hazard Index for the Drinking-Water Well User

	Waste Management Alternative 2 (unitless)											
	Disposal Group 1							Disposal Group 2			Disposal Group 3	
	Subgroup							Subgroup				
Location	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case
IDF-East	2.73×10^{-1} (8522)	2.66×10^{-1} (7821)	4.86 (8940)	4.30 (8442)	2.48 (9318)	3.51 (8735)	2.68×10^{-1} (8168)	2.98×10^{-1} (8216)	3.21×10^{-1} (8414)		3.07×10^{-1} (8236)	
RPPDF	2.19×10^{-2} (3856)				5.86×10^{-2} (3804)	N/A	2.19×10^{-2} (3856)	N/A	5.96×10^{-2} (3868)	3.91×10^{-1} (4260)	5.89×10^{-2} (4109)	4.29×10^{-1} (4387)
Core Zone Boundary	1.04×10^{-1} (9653)	1.06×10^{-1} (8905)	2.73 (8760)	1.69 (8397)	1.02 (9599)	1.47 (8764)	1.04×10^{-1} (9653)	1.05×10^{-1} (7905)	1.16×10^{-1} (3995)	1.38 (4564)	1.21×10^{-1} (9877)	1.35 (4628)
Columbia River nearshore	4.78×10^{-2} (8044)	6.74×10^{-2} (8144)	1.24 (9310)	1.12 (9878)	6.59×10^{-1} (8069)	1.09 (8819)	4.79×10^{-2} (8821)	7.46×10^{-2} (8055)	6.48×10^{-2} (7829)	2.29×10^{-1} (5180)	6.81×10^{-2} (7710)	2.29×10^{-1} (4954)

Note: Calendar year of peak impact shown in parentheses.

Key: IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

2.9.3.2.2.1 Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A

Disposal Group 1, Subgroup 1-A, addresses the waste resulting from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 2B.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be 3.1×10^{-1} person-rem, approximately 2×10^{-5} percent of the background dose.

Figure 2–101 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 8400 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms to be disposed of in IDF-East.

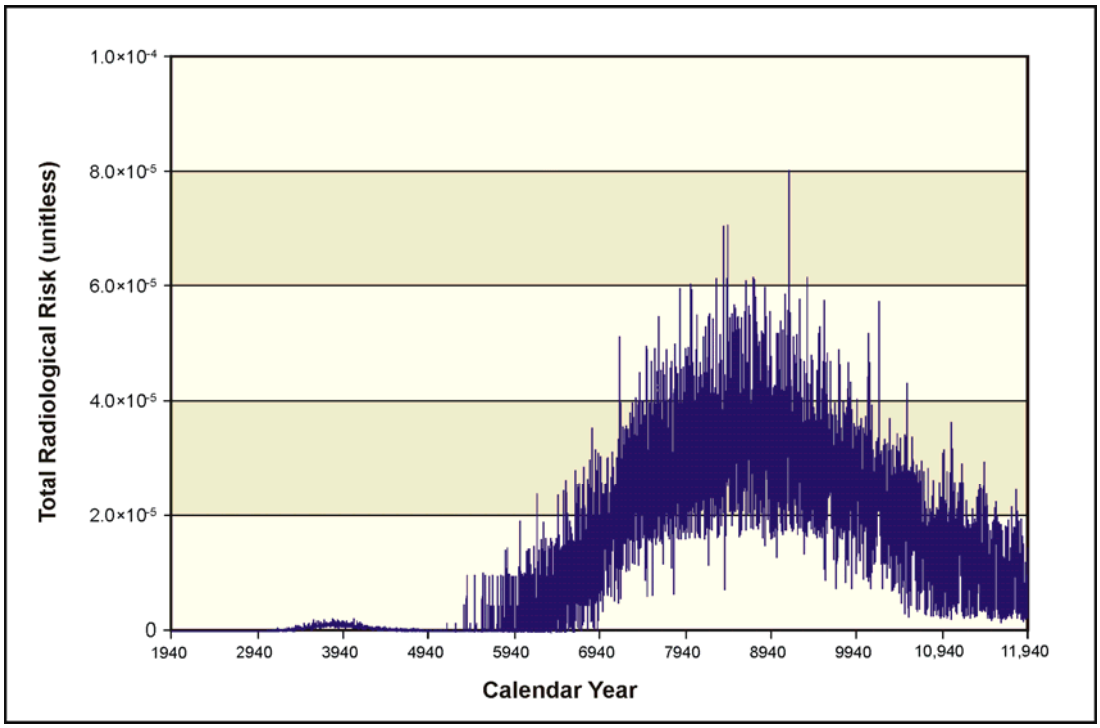


Figure 2–101. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Summary of Long-Term Human Health Impacts on the Drinking Water Well User at the Core Zone Boundary

2.9.3.2.2.2 Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B

Disposal Group 1, Subgroup 1-B, addresses the waste resulting from Tank Closure Alternative 3A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Bulk vitrification glass
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 3A.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; and the key chemical contributors would be boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be 3.88×10^{-1} person-rem, approximately 2×10^{-5} percent of the background dose.

Figure 2–102 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 8000 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

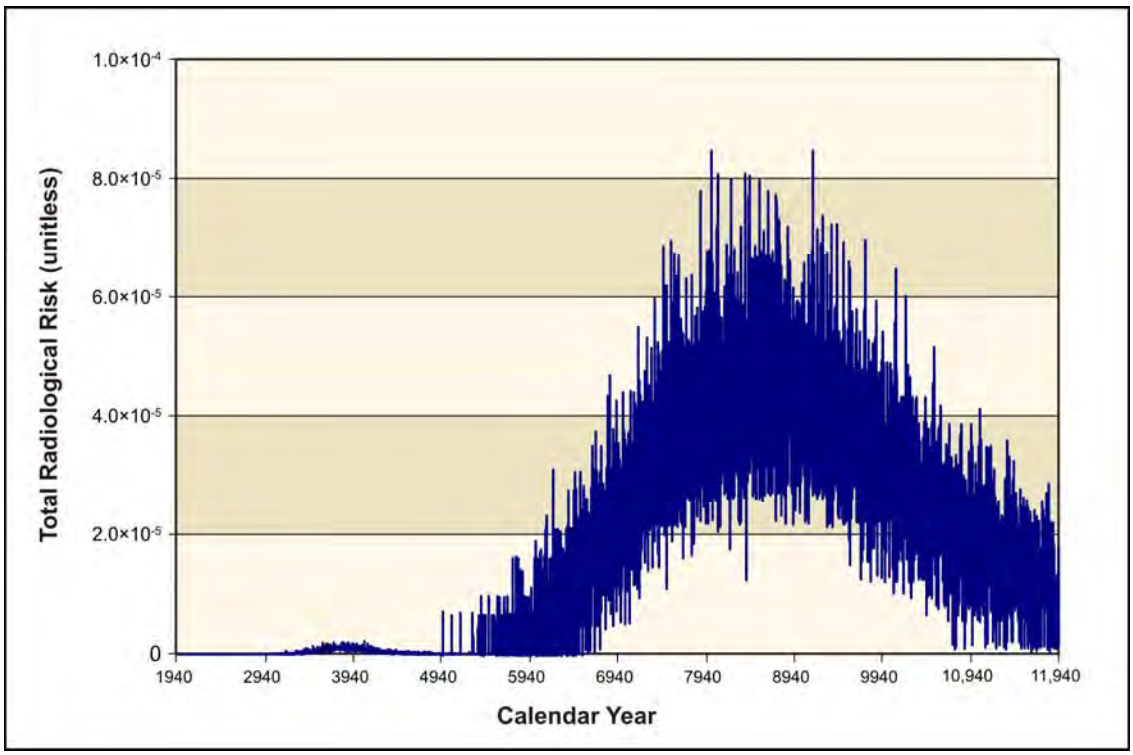


Figure 2–102. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.3 Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C

Disposal Group 1, Subgroup 1-C, addresses the waste resulting from Tank Closure Alternative 3B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Cast stone waste
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 3B.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user due primarily to the presence of chromium. The population dose for the year of maximum impact was estimated as 5.55×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–103 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 9100 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

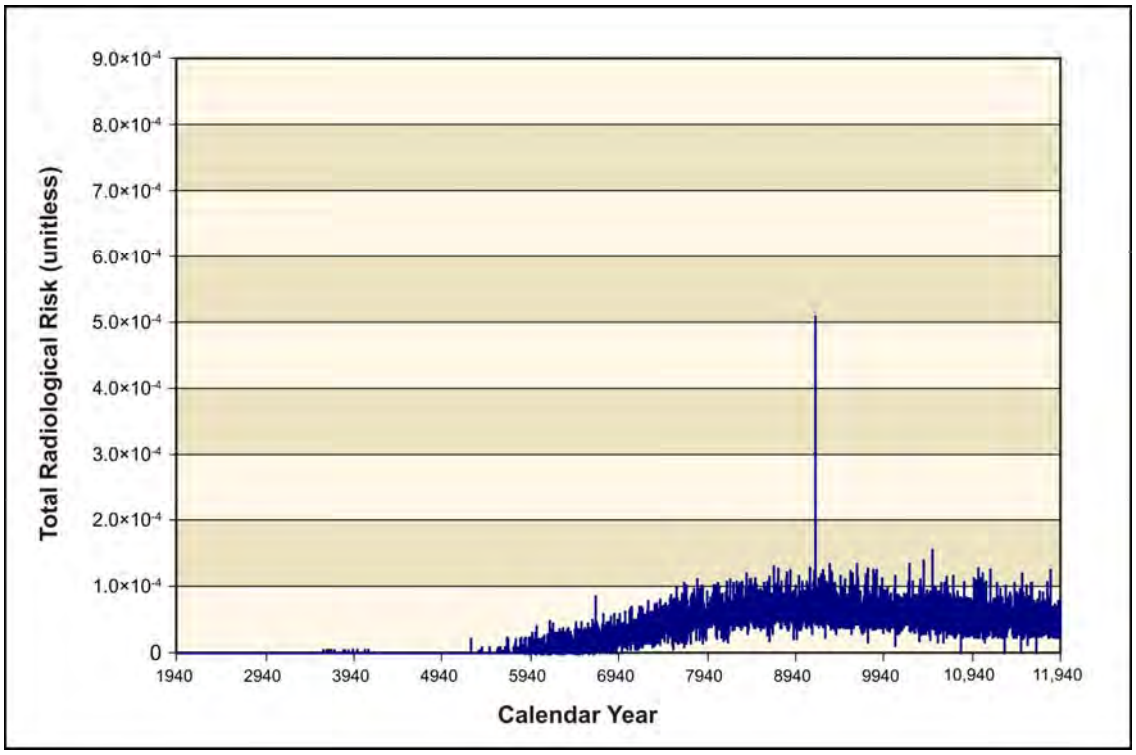


Figure 2–103. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.4 Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D

Disposal Group 1, Subgroup 1-D, addresses the waste resulting from Tank Closure Alternative 3C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Steam reforming waste
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 3C.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user due primarily to the presence of chromium. The population dose for the year of maximum impact was estimated to be 2.40 person-rem, approximately 1×10^{-4} percent of the background dose.

Figure 2–104 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 9000 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

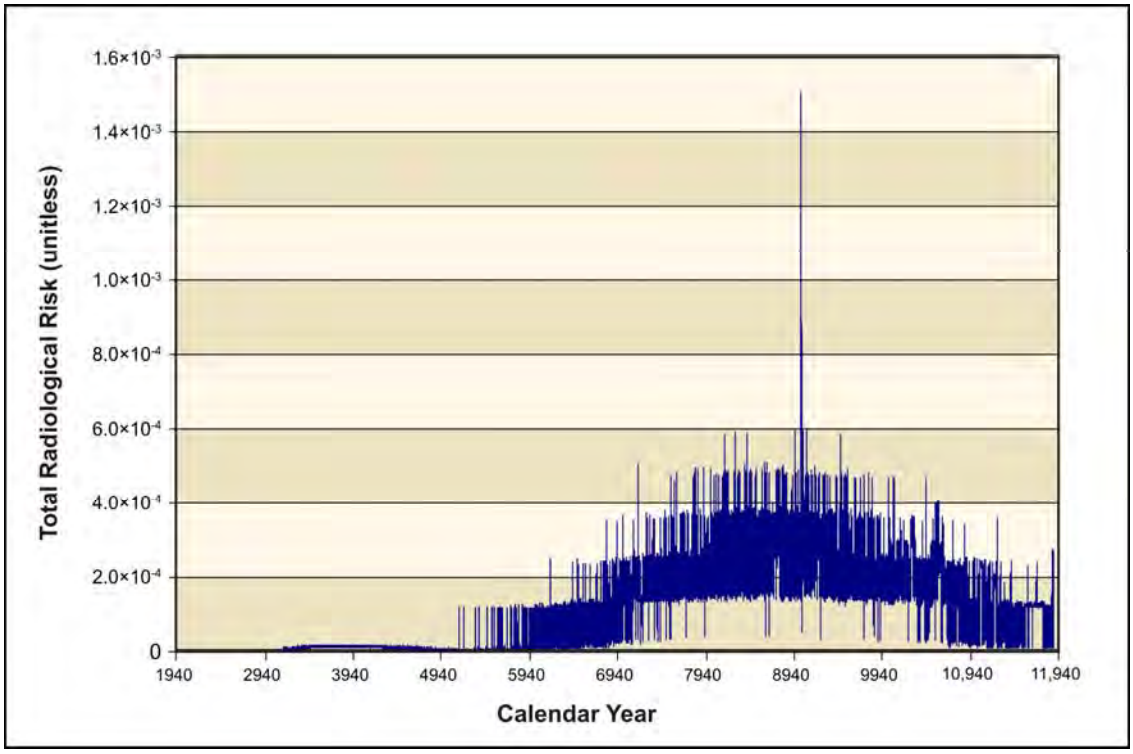


Figure 2–104. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.5 Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E

Disposal Group 1, Subgroup 1-E, addresses the waste resulting from Tank Closure Alternative 4, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Bulk vitrification glass
- Cast stone waste
- Tank closure secondary waste
- FFTF decommissioning secondary waste

- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms for the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 4.

The key constituent radiological contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user due primarily to the presence of chromium. The population dose for the year of maximum impact was estimated to be 6.25×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–105 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 9500 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

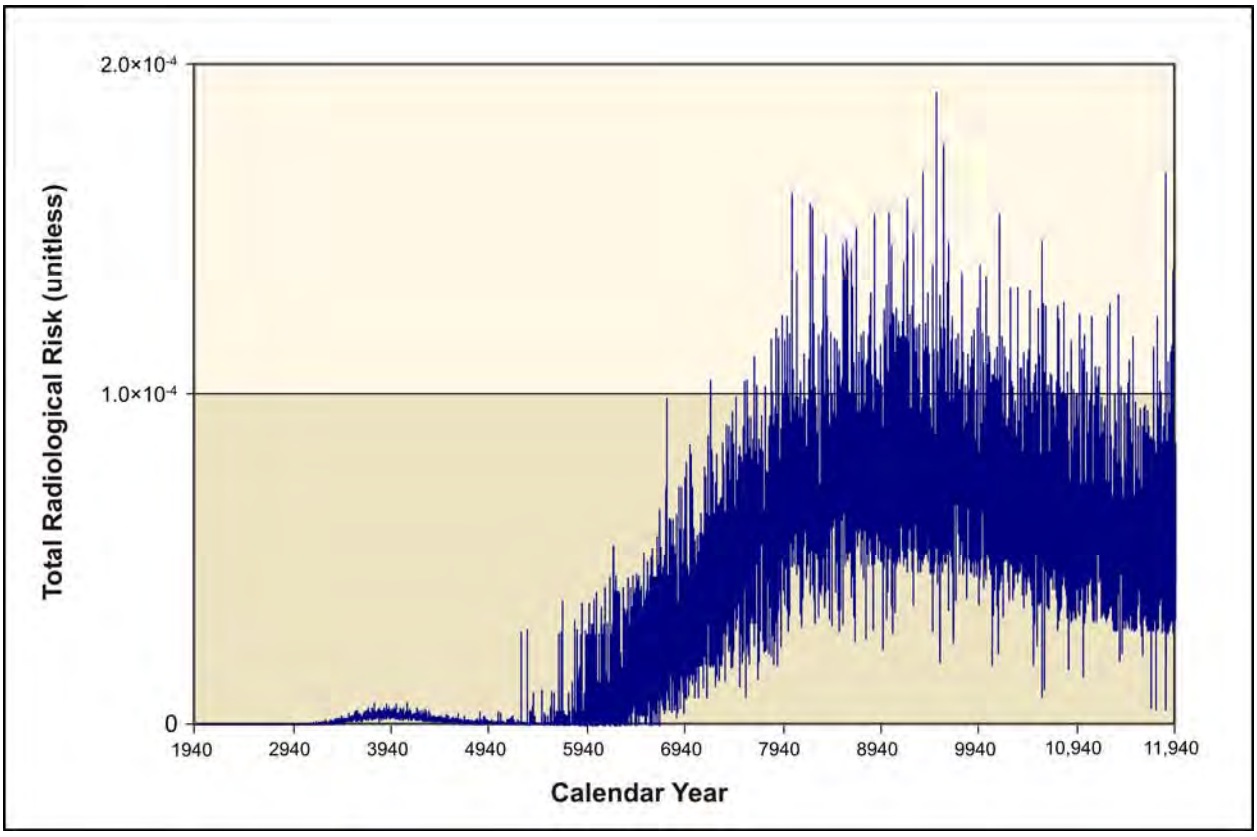


Figure 2–105. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.6 Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F

Disposal Group 1, Subgroup 1-F, addresses the waste resulting from Tank Closure Alternative 5, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Bulk vitrification glass
- Cast stone waste
- Sulfate grout
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

The RPPDF would not be constructed or operated under Tank Closure Alternative 5 because tank closure cleanup activities would not be conducted.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user due primarily to the presence of chromium. The population dose for the year of maximum impact was estimated to be 4.18×10^{-1} person-rem, approximately 2×10^{-5} percent of the background dose.

Figure 2–106 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 9000 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

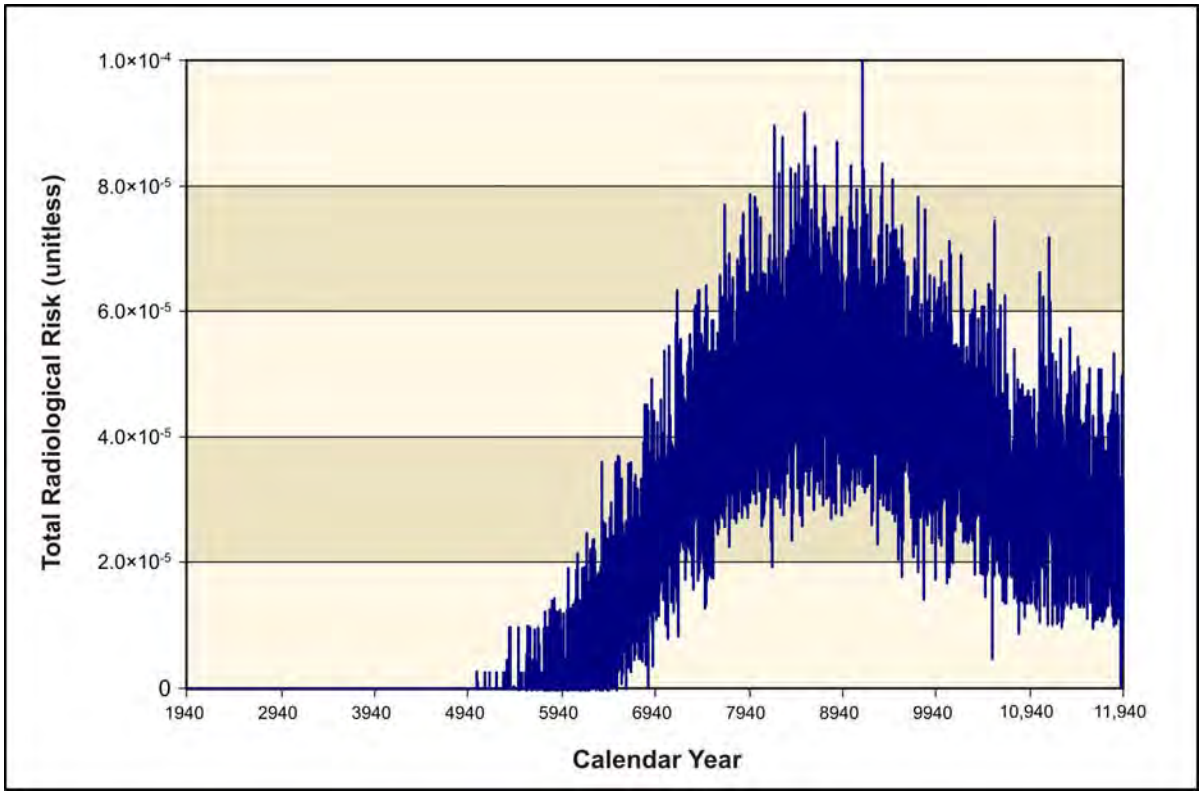


Figure 2–106. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.7 Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G

Disposal Group 1, Subgroup 1-G, addresses the waste resulting from Tank Closure Alternative 6C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 6C.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be 3.06×10^{-1} person-rem, approximately 2×10^{-5} percent of the background dose.

Figure 2–107 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 9100 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

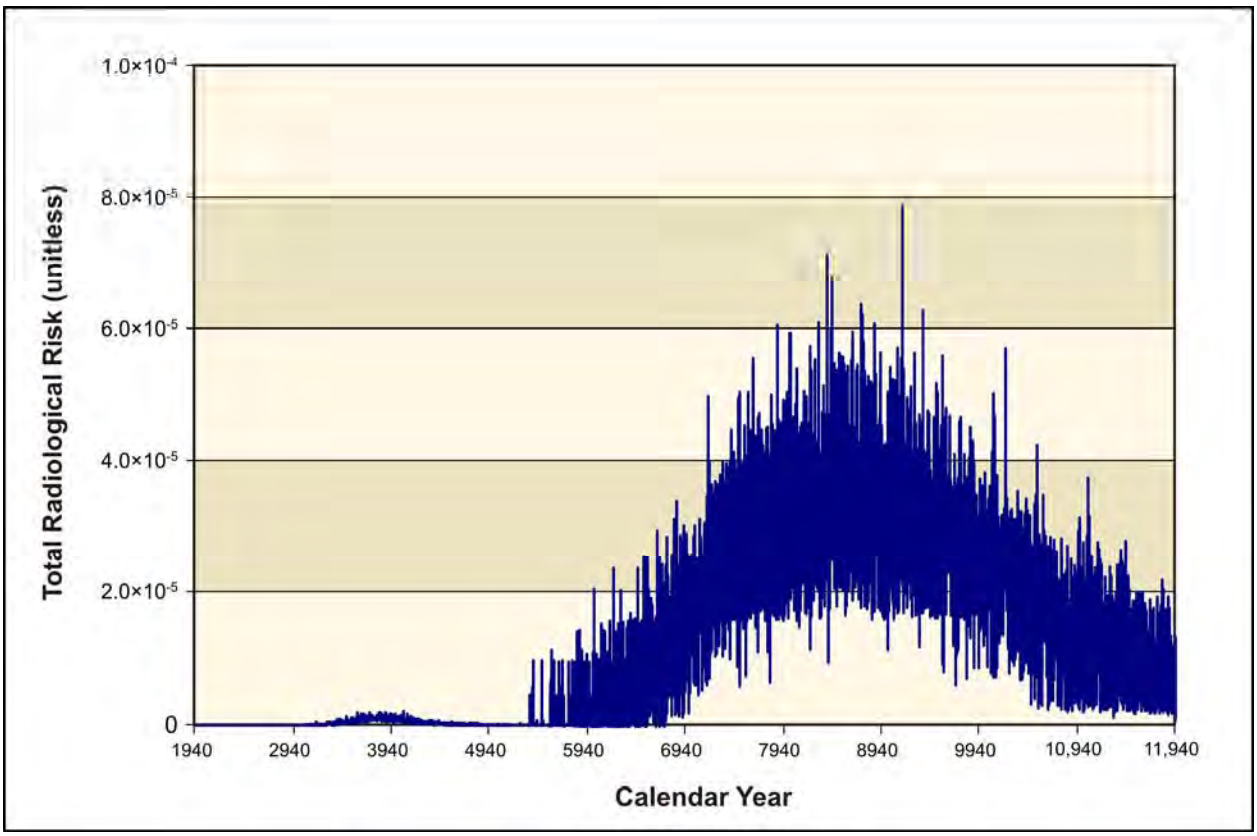


Figure 2–107. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.8 Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A

Disposal Group 2, Subgroup 2-A, addresses the waste resulting from Tank Closure Alternative 2A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

The RPPDF would not be constructed or operated under Tank Closure Alternative 2A because tank closure cleanup activities would not be conducted.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index would be exceeded. The population dose for the year of maximum impact was estimated to be 3.18×10^{-1} person-rem, approximately 2×10^{-5} percent of the background dose.

Figure 2–108 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 8500 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

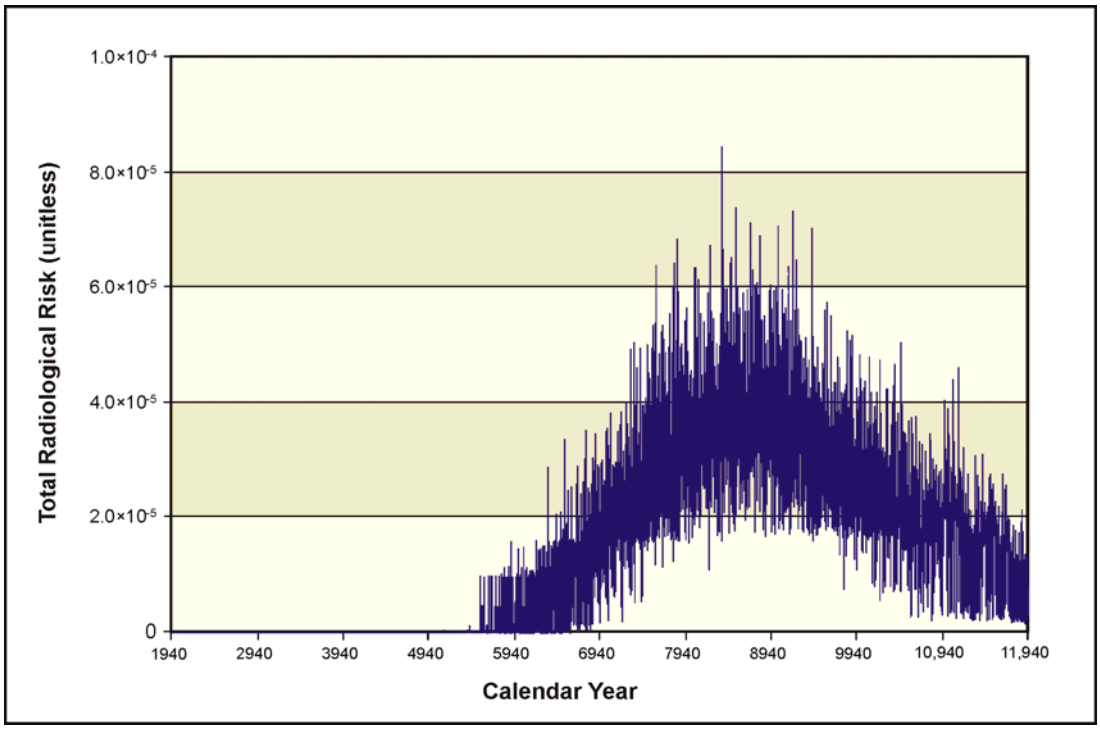


Figure 2–108. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.9 Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B

Disposal Group 2, Subgroup 2-B, addresses the waste resulting from Tank Closure Alternative 6B, Base and Option Cases; onsite non-CERCLA sources; FFTF decommissioning; waste management; and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- PPF glass
- PPF melters
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 6B, Base and Option Cases.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be

3.22×10^{-1} person-rem under Subgroup 2-B, Base Case, and 3.23×10^{-1} person-rem under Subgroup 2-B, Option Case. Each of these estimates of population dose is approximately 2×10^{-5} percent of the background dose.

Figures 2–109 and 2–110 depict a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user for the Base Case and Option Case, respectively. The early peak in Figures 2–109 and 2–110 is due to releases from the RPPDF, while the later peak is due to releases from IDF-East. Under Subgroup 2-B, Base Case, the peak radiological risk would occur around the year 8300 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East. Under Subgroup 2-B, Option Case, the peak radiological risk would occur around the year 4500 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in the RPPDF.

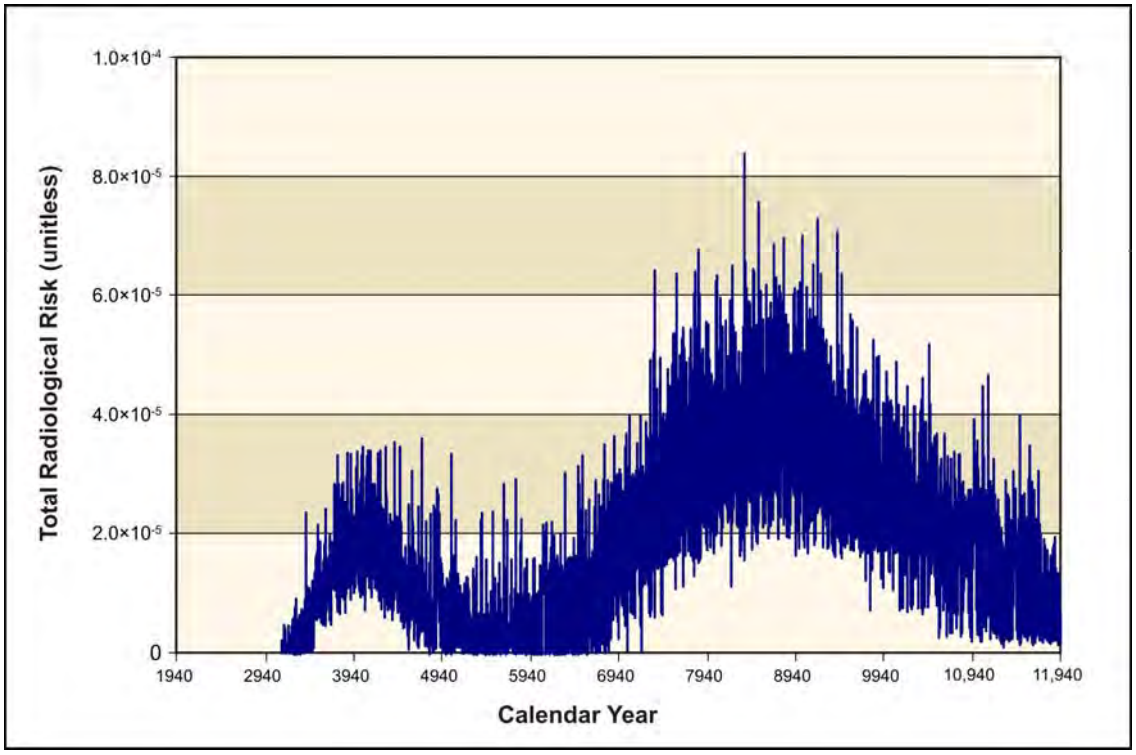


Figure 2–109. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

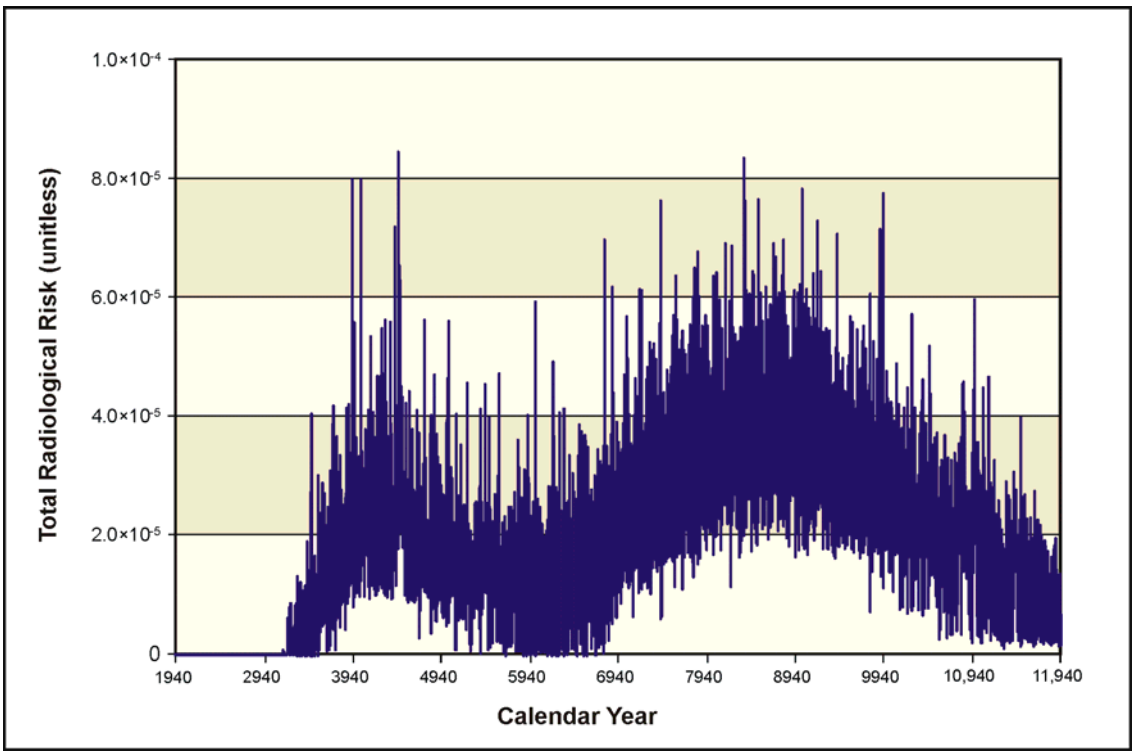


Figure 2–110. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.2.10 Waste Management Alternative 2, Disposal Group 3

Disposal Group 3 addresses the waste resulting from Tank Closure Alternative 6A, Base and Option Cases; onsite non-CERCLA sources; FFTF decommissioning; waste management; and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- PPF glass
- PPF melters
- Tank closure secondary waste
- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 6A, Base and Option Cases.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium. For radionuclides, the dose standard under both the Base and Option Cases would not be exceeded. In addition, under the Base Case, the Hazard Index guideline would not be exceeded. However, under the Option Case, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, due primarily to the presence of chromium. The population dose for the year of maximum impact was estimated to be 3.12×10^{-1} person-rem under Disposal Group 3, Base Case, and 3.13×10^{-1} person-rem under Disposal Group 3, Option Case. Each of these estimates of population dose is approximately 2×10^{-5} percent of background dose.

Figures 2–111 and 2–112 depict a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user for the Base Case and Option Case, respectively. The early peak in Figures 2–111 and 2–112 is due to releases from RPPDF, while the later peak is due to releases from IDF-East. Under the Base Case, the peak radiological risk would occur around the year 8200 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East. Under the Option Case, the peak radiological risk would occur around the year 8400 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

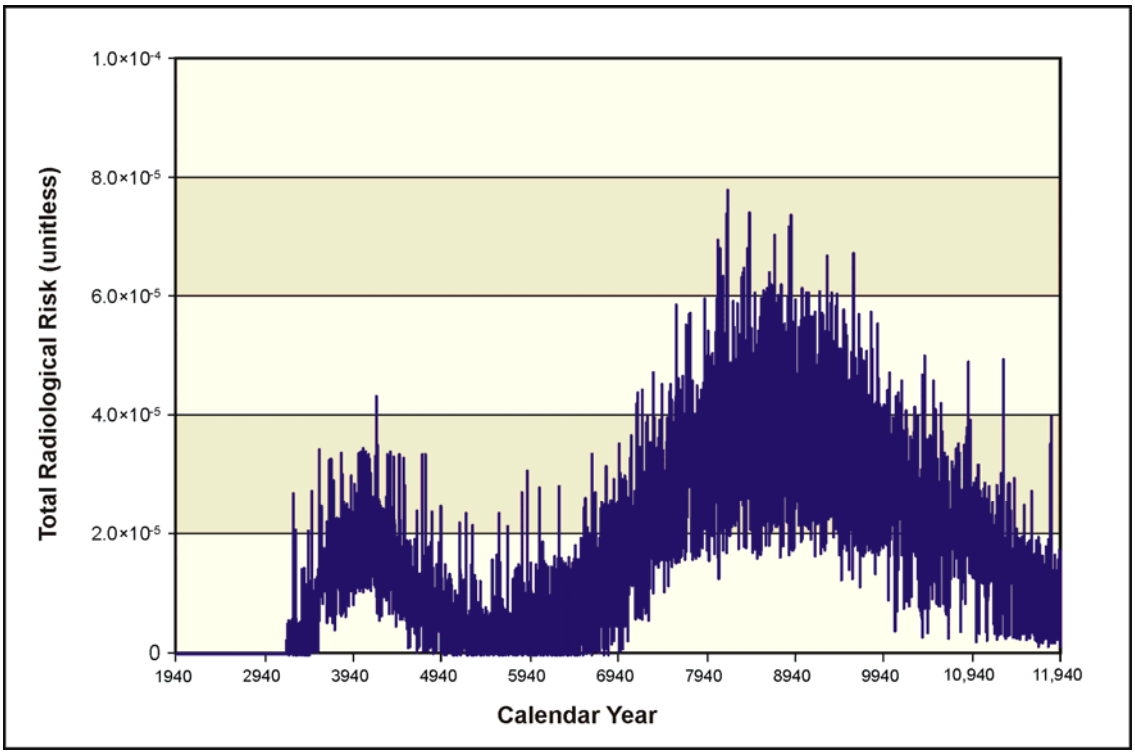


Figure 2–111. Waste Management Alternative 2, Disposal Group 3, Base Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

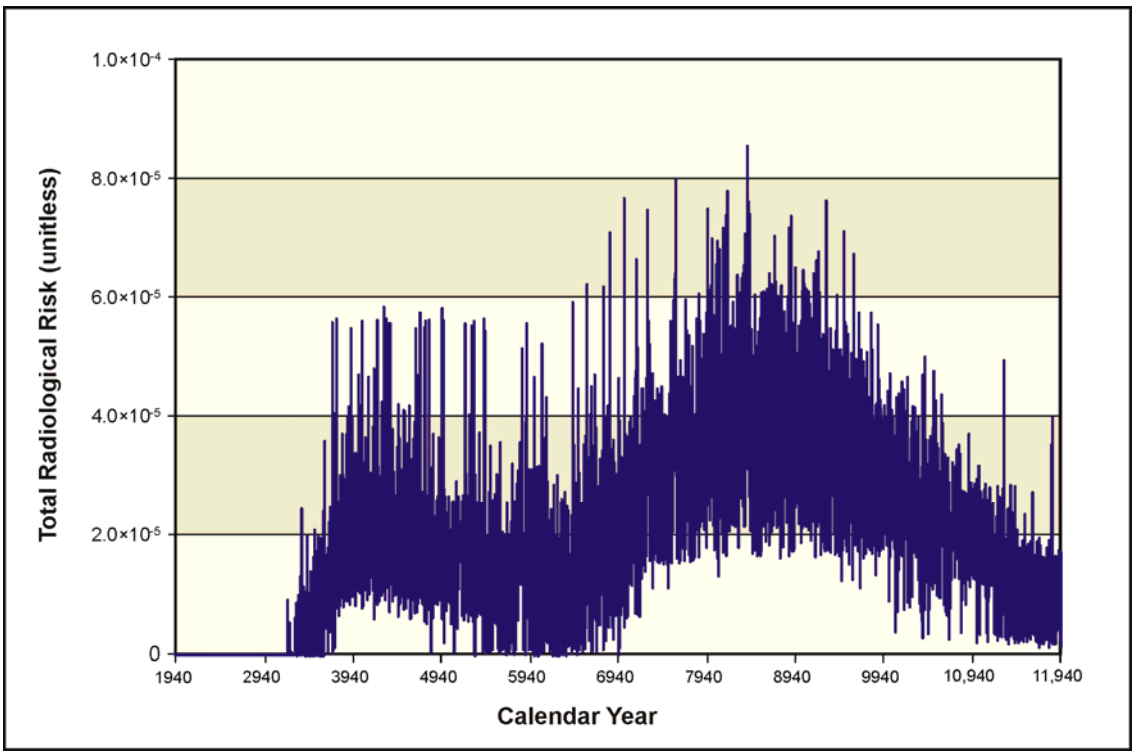


Figure 2–112. Waste Management Alternative 2, Disposal Group 3, Option Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.3 Waste Management Alternative 3, All Disposal Groups and Subgroups

Under Waste Management Alternative 3, the waste from tank treatment operations would be disposed of in IDF-East, and waste from onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-West. Waste from tank farm cleanup operations would be disposed of in the RPPDF. As a result, the waste disposed of in these three facilities is assumed to become available for release to the environment. Because of the different waste types that would result under the Tank Closure action alternatives, three disposal groups were considered to account for the different IDF-East sizes and operational periods. In addition, within these three disposal groups, subgroups were identified to allow consideration of the different waste types resulting from the Tank Closure alternatives. The potential human health impacts of these subgroups under this alternative are discussed in the following sections. The maximum dose and maximum Hazard Index from the groundwater analysis of Waste Management Alternative 3 for the drinking-water well user are summarized in Tables 2–44 and 2–45.

Table 2–44. Waste Management Alternative 3 Summary of Radiological Dose at Year of Peak Dose for the Drinking-Water Well User

Location	Waste Management Alternative 3											
	Disposal Group 1 (millirem per year)							Disposal Group 2 (millirem per year)			Disposal Group 3 (millirem per year)	
	Subgroup							Subgroup				
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	3-A, Base Case	3-B, Option Case
IDF-East	1.04 (11,257)	3.00 (8486)	8.88 (9048)	5.28×10^{1} (9032)	1.01×10^{1} (9826)	4.34 (9701)	9.07×10^{-1} (10,032)	8.64×10^{-1} (9988)	8.97×10^{-1} (11,141)		8.62×10^{-1} (11,896)	
IDF-West	8.08×10^{1} (3723)											
RPPDF	6.92×10^{-2} (3804)				2.15×10^{-1} (3822)	N/A	6.92×10^{-2} (3804)	N/A	5.92×10^{-1} (3889)	6.96×10^{-1} (4213)	6.35×10^{-1} (3987)	7.87×10^{-1} (4013)
Core Zone Boundary	2.73×10^{1} (3709)			4.39×10^{1} (9067)	2.73×10^{1} (3709)	2.72×10^{1} (3709)	2.73×10^{1} (3709)	2.72×10^{1} (3709)	2.76×10^{1} (3709)	2.77×10^{1} (3709)	2.75×10^{1} (3709)	2.76×10^{1} (3709)
Columbia River nearshore	3.37 (4388)		3.37 (8939)	1.40×10^{1} (7821)	3.98 (8117)	3.36 (4388)	3.37 (4388)	3.36 (4388)	3.53 (4389)	3.49 (4388)	3.45 (4389)	3.58 (4388)

Note: Calendar year of peak impact shown in parentheses.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

Table 2–45. Waste Management Alternative 3 Summary of Hazard Index at Year of Peak Hazard Index for the Drinking-Water Well User

Location	Waste Management Alternative 3											
	Disposal Group 1 (unitless)							Disposal Group 2 (unitless)			Disposal Group 3 (unitless)	
	Subgroup							Subgroup				
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	3-A, Base Case	3-B, Option Case
IDF-East	2.71×10^{-1} (8522)	2.64×10^{-1} (7821)	4.86 (8940)	4.30 (8442)	2.48 (9318)	3.51 (8735)	2.66×10^{-1} (8168)	2.96×10^{-1} (8216)	3.18×10^{-1} (8414)		3.06×10^{-1} (8236)	
IDF-West	1.95×10^{-2} (3756)											
RPPDF	2.19×10^{-2} (3856)				5.86×10^{-2} (3804)	N/A	2.19×10^{-2} (3856)	N/A	5.96×10^{-2} (3868)	3.91×10^{-1} (4260)	5.89×10^{-2} (4109)	4.29×10^{-1} (4387)
Core Zone Boundary	1.04×10^{-1} (9653)	1.06×10^{-1} (8905)	2.73 (8760)	1.69 (8397)	1.02 (9599)	1.47 (8764)	1.04×10^{-1} (9653)	1.05×10^{-1} (7905)	1.25×10^{-1} (4042)	1.38 (4564)	1.20×10^{-1} (9877)	1.36 (4628)
Columbia River nearshore	4.76×10^{-2} (8044)	6.71×10^{-2} (8144)	1.24 (9310)	1.12 (9878)	6.59×10^{-1} (8069)	1.09 (8819)	4.78×10^{-2} (8821)	7.45×10^{-2} (8055)	6.48×10^{-2} (7831)	2.30×10^{-1} (5180)	6.80×10^{-2} (7710)	2.30×10^{-1} (4954)

Note: Calendar year of peak impact shown in parentheses.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

2.9.3.2.3.1 Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A

Disposal Group 1, Subgroup 1-A, addresses the waste resulting from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Tank closure secondary waste

Waste forms to be disposed of in IDF-West include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 2B.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129; the key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be 5.75×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–113 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

2.9.3.2.3.2 Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B

Disposal Group 1, Subgroup 1-B, addresses the waste resulting from Tank Closure Alternative 3A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Bulk vitrification glass
- Tank closure secondary waste

Waste forms to be disposed of in IDF-West include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 3A.

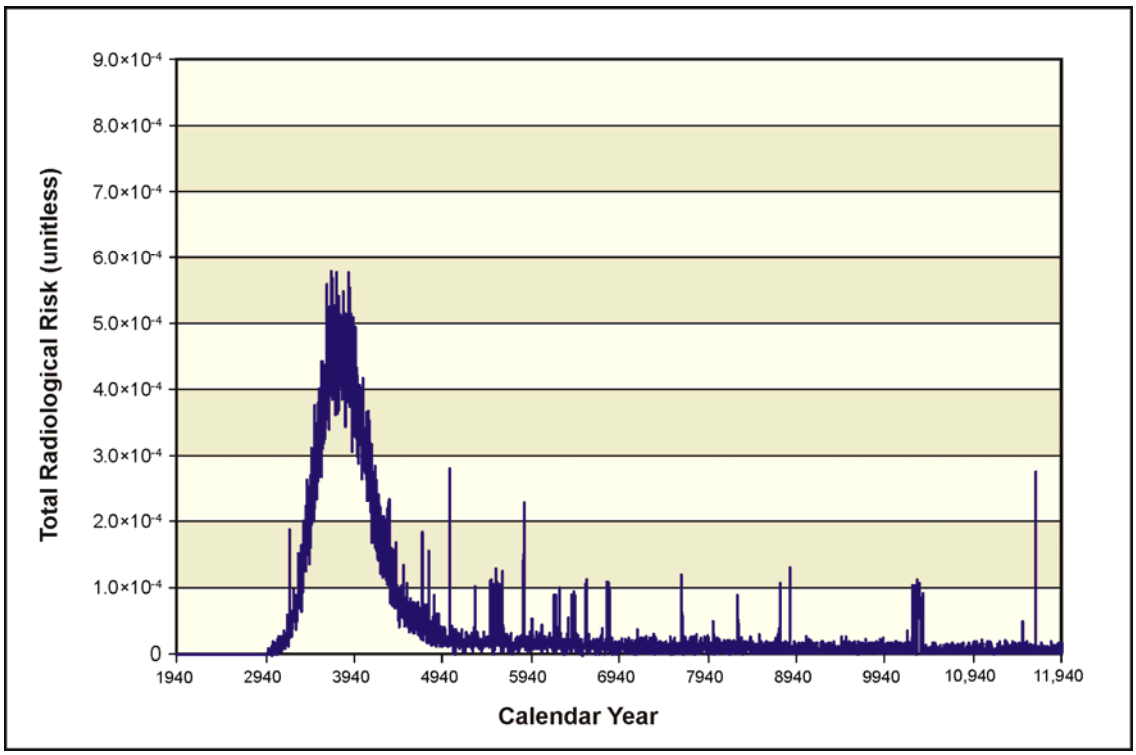


Figure 2–113. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be 5.75×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–114 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

2.9.3.2.3.3 Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C

Disposal Group 1, Subgroup 1-C, addresses the waste resulting from Tank Closure Alternative 3B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Cast stone waste
- Tank closure secondary waste

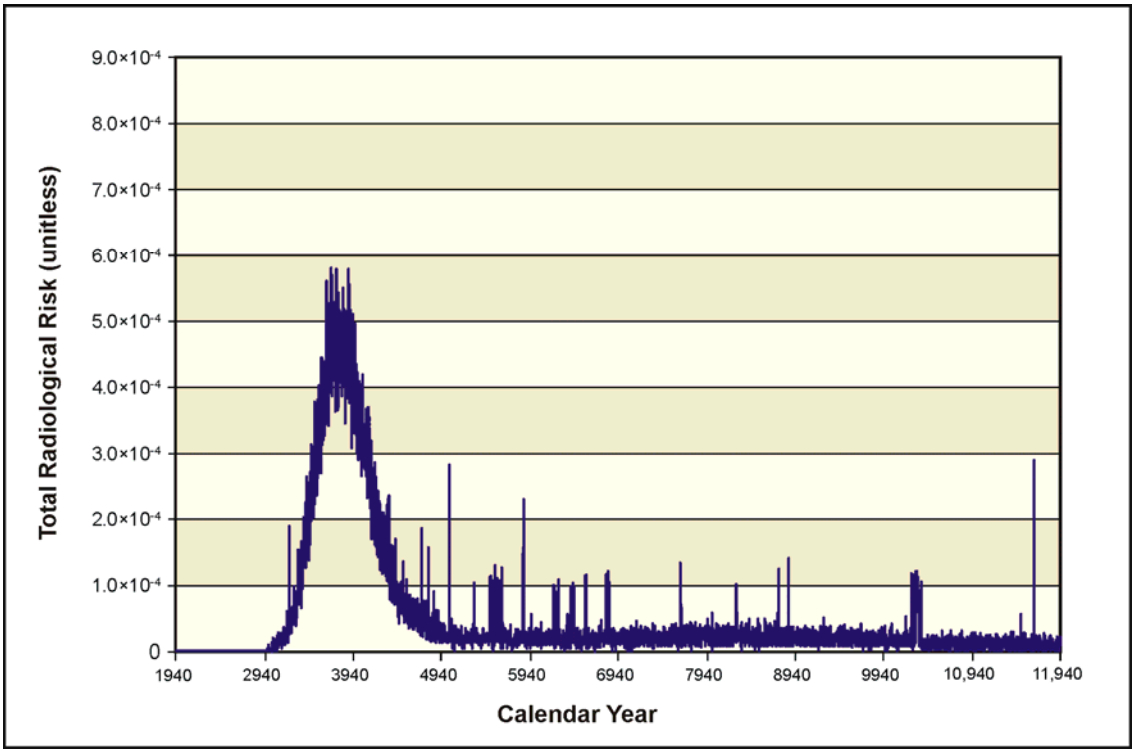


Figure 2–114. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

Waste forms to be disposed of in IDF-West would include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 3B.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, due primarily to the presence of chromium. The population dose was estimated to be 5.75×10^{-1} person-rem for the year of maximum impact, approximately 3×10^{-5} percent of the background dose.

Figure 2–115 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

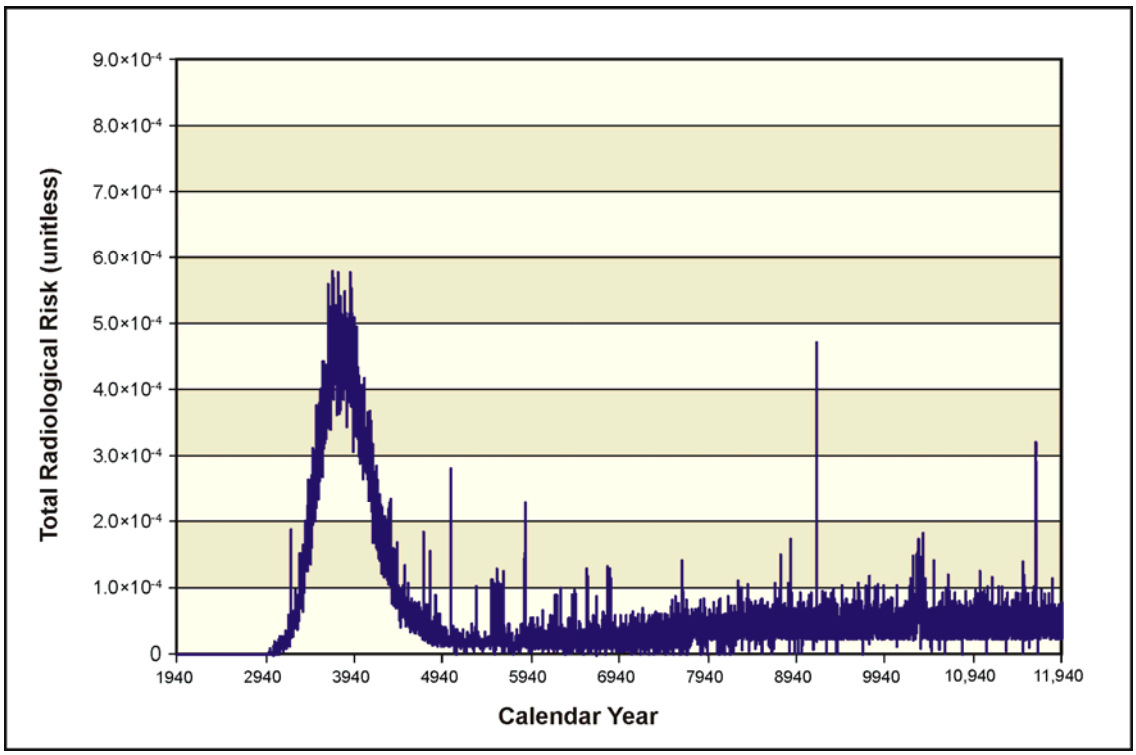


Figure 2–115. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.3.4 Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D

Disposal Group 1, Subgroup 1-D, addresses the waste resulting from Tank Closure Alternative 3C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Steam reforming waste
- Tank closure secondary waste

Waste forms to be disposed of in IDF-West include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 3C.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, due

primarily to the presence of chromium. The population dose for the year of maximum impact was estimated to be 2.24 person-rem, approximately 1×10^{-4} percent of the background dose.

Figure 2–116 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The early peak in Figure 2–116 is due to releases from IDF-West, while the later peak is due to releases from IDF-East. The peak radiological risk would occur around the year 9000 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-East.

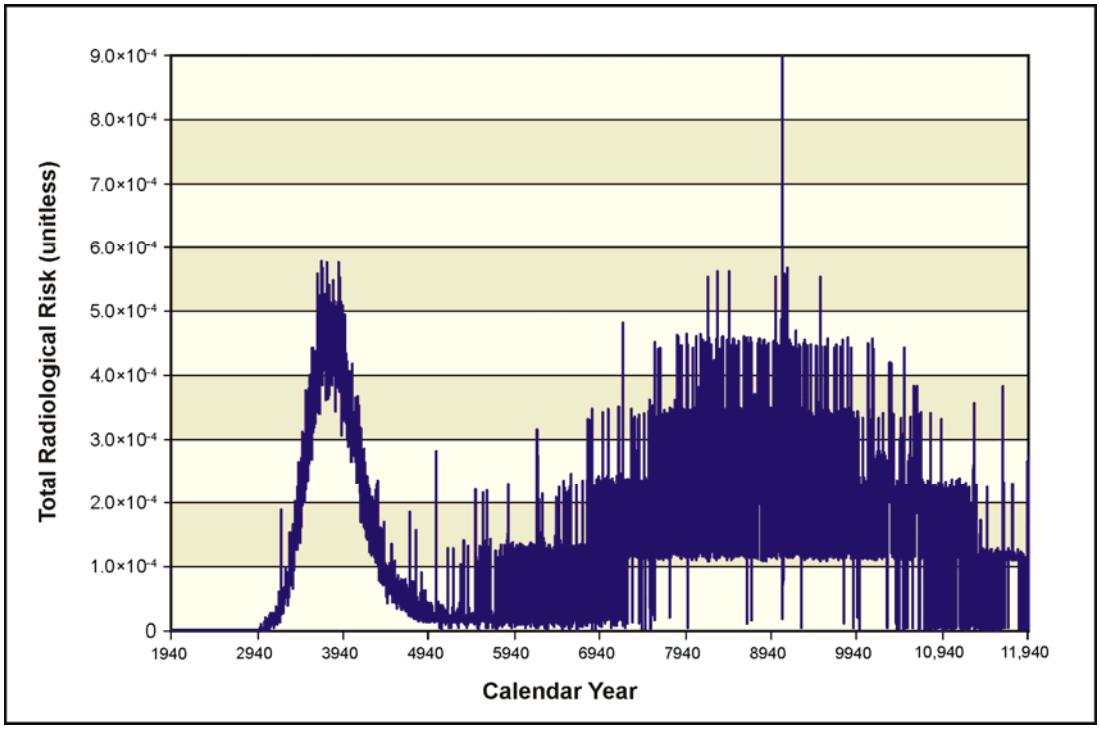


Figure 2–116. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.3.5 Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E

Disposal Group 1, Subgroup 1-E, addresses the waste resulting from Tank Closure Alternative 4, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Bulk vitrification glass
- Cast stone waste
- Sulfate grout
- Tank closure secondary waste

Waste forms to be disposed of in IDF-West include the following:

- FFTF decommissioning secondary waste

- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 4.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user due primarily to the presence of chromium. The population dose for the year of maximum impact was estimated to be 5.80×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–117 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

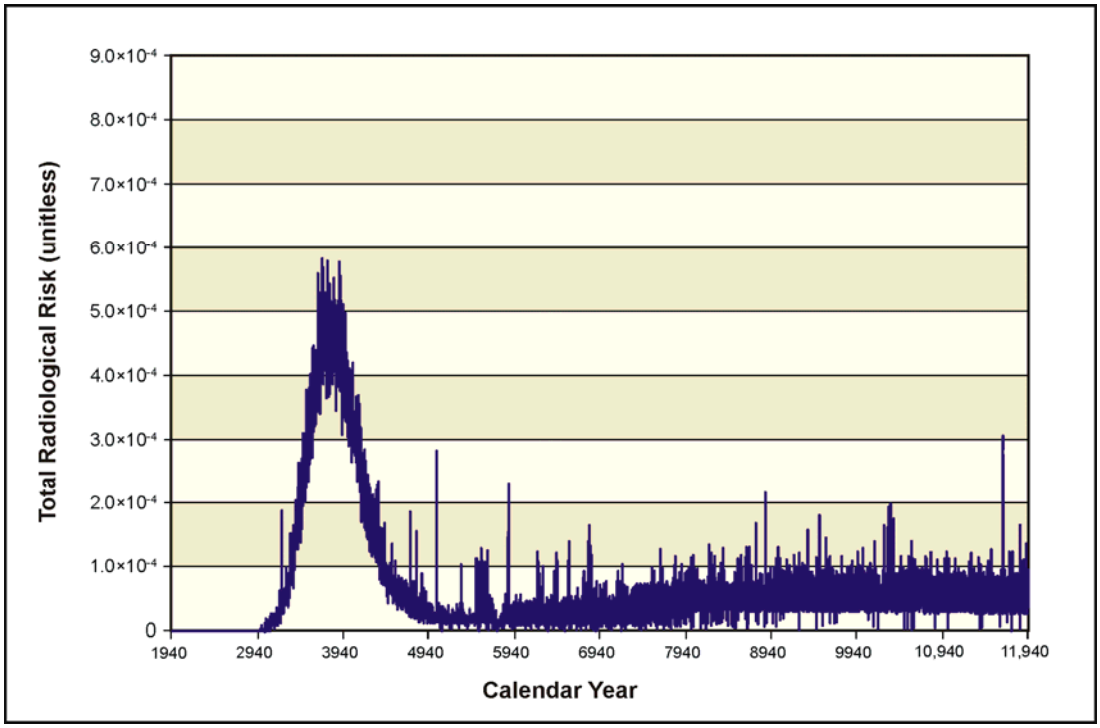


Figure 2–117. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.3.6 Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F

Disposal Group 1, Subgroup 1-F, addresses the waste resulting from Tank Closure Alternative 5, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Bulk vitrification glass
- Cast stone waste
- Sulfate grout
- Tank closure secondary waste

Waste forms to be disposed of in IDF-West would include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

The RPPDF would not be constructed or operated under Tank Closure Alternative 5 because tank closure cleanup activities would not be conducted.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. The radionuclides, the dose standard would not be exceeded. However, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, due primarily to the presence of chromium. The population dose for the year of maximum impact was estimated to be 5.75×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–118 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

2.9.3.2.3.7 Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G

Disposal Group 1, Subgroup 1-G, addresses the waste resulting from Tank Closure Alternative 6C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Tank closure secondary waste would be the single waste form disposed of in IDF-East.

Waste forms to be disposed of in IDF-West would include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 6C.

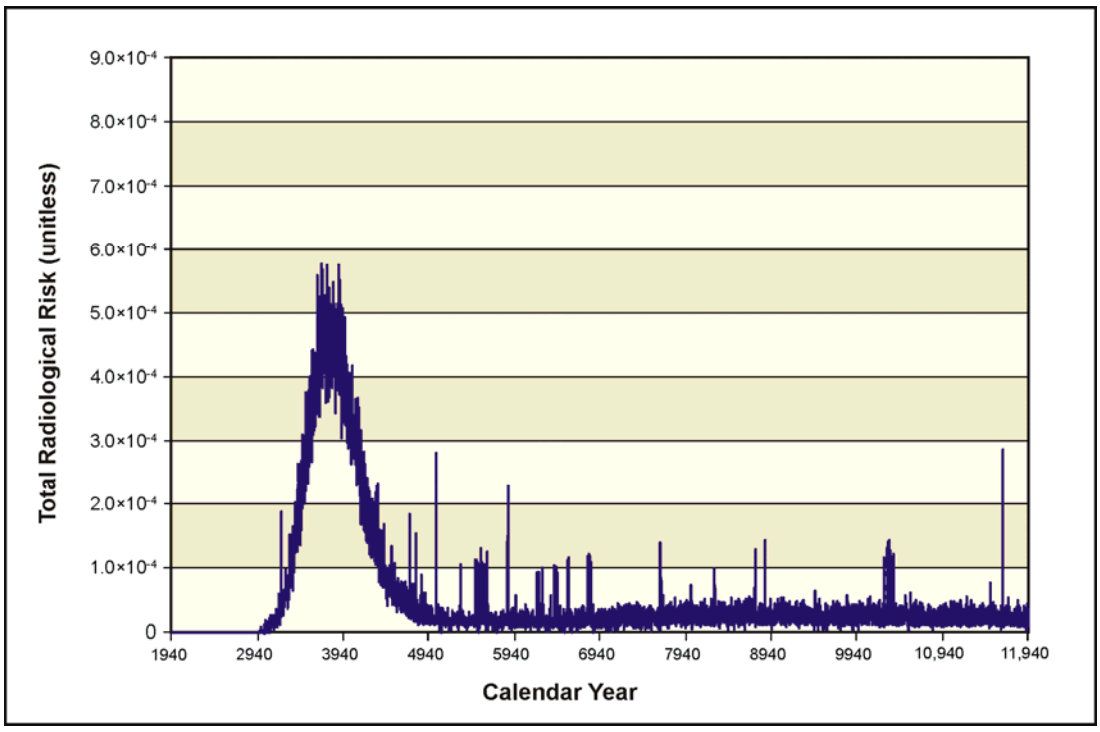


Figure 2–118. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be 5.75×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–119 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

2.9.3.2.3.8 Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A

Disposal Group 2, Subgroup 2-A, addresses the waste resulting from Tank Closure Alternative 2A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- ILAW glass
- LAW melters
- Tank closure secondary waste

Waste forms to be disposed of in IDF-West would include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste

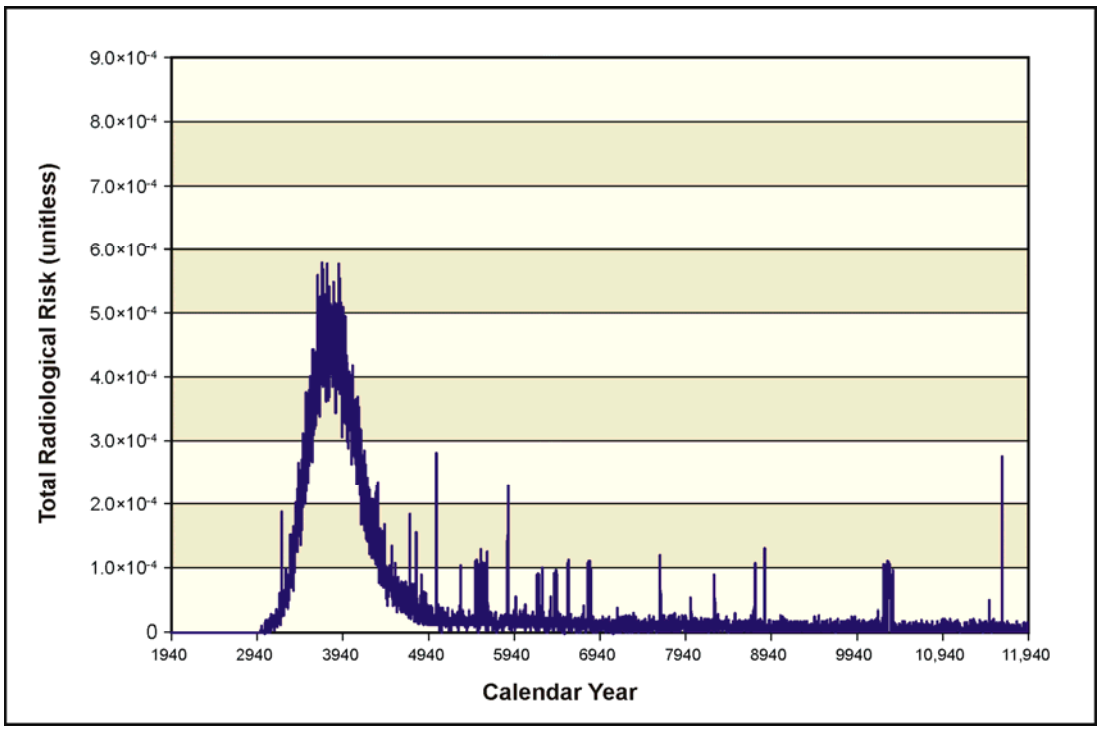


Figure 2–119. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

- Offsite waste
- Onsite non-CERCLA waste

The RPPDF would not be constructed or operated under Tank Closure Alternative 2A because tank closure cleanup activities would not be conducted.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be boron and boron compounds, chromium, fluoride, and nitrate. Neither the dose standard nor the Hazard Index guideline would be exceeded. The population dose for the year of maximum impact was estimated to be 5.75×10^{-1} person-rem, approximately 3×10^{-5} percent of the background dose.

Figure 2–120 depicts a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

2.9.3.2.3.9 Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B

Disposal Group 2, Subgroup 2-B, addresses the waste resulting from Tank Closure Alternative 6B, Base and Option Cases; onsite non-CERCLA sources; FFTF decommissioning; waste management; and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- PPF glass
- PPF melters
- Tank closure secondary waste

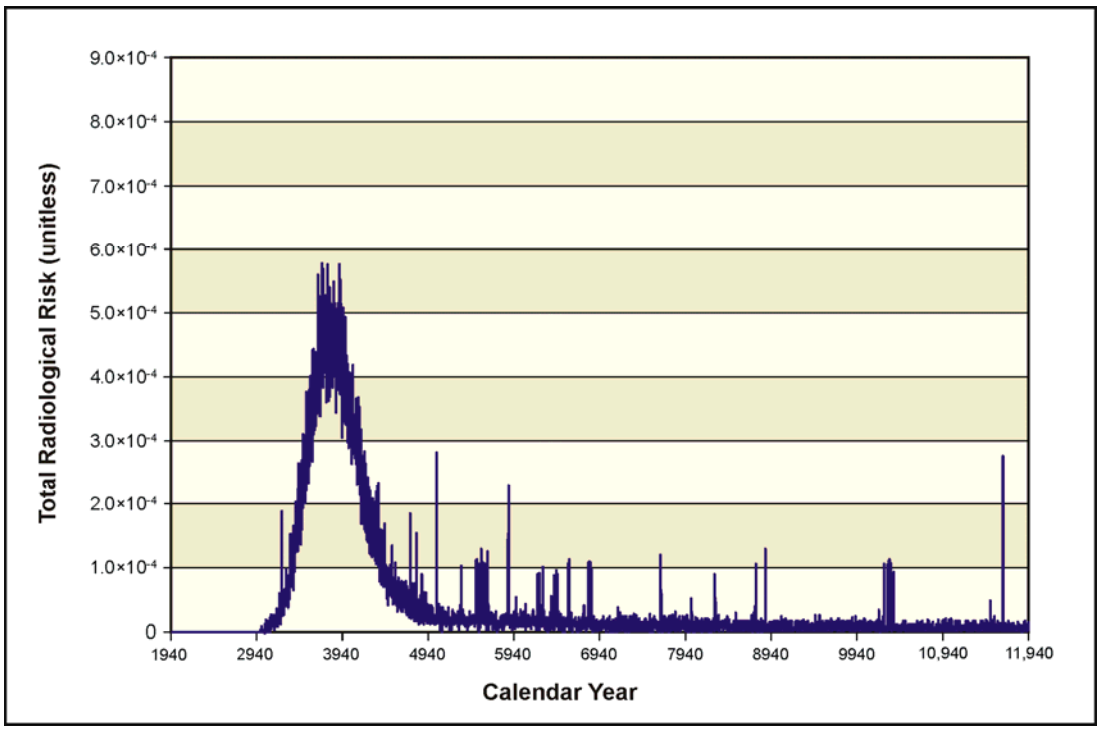


Figure 2–120. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

Waste forms to be disposed of in IDF-West would include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 6B, Base and Option Cases.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded for either the Base or Option Case. The Hazard Index guideline would not be exceeded under the Base Case, but would be exceeded under the Option Case, due primarily to the presence of chromium and nitrate. The population dose for the year of maximum impact was estimated to be 6.00×10^{-1} person-rem under the Base Case and 5.90×10^{-1} person-rem under the Option Case. Each of these estimates of population dose is approximately 3×10^{-5} percent of the background dose.

Figures 2–121 and 2–122 depict a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user for the Base Case and Option Case, respectively. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary under both the Base and Option Cases, and would be dominated by technetium-99 and iodine-129 from the naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

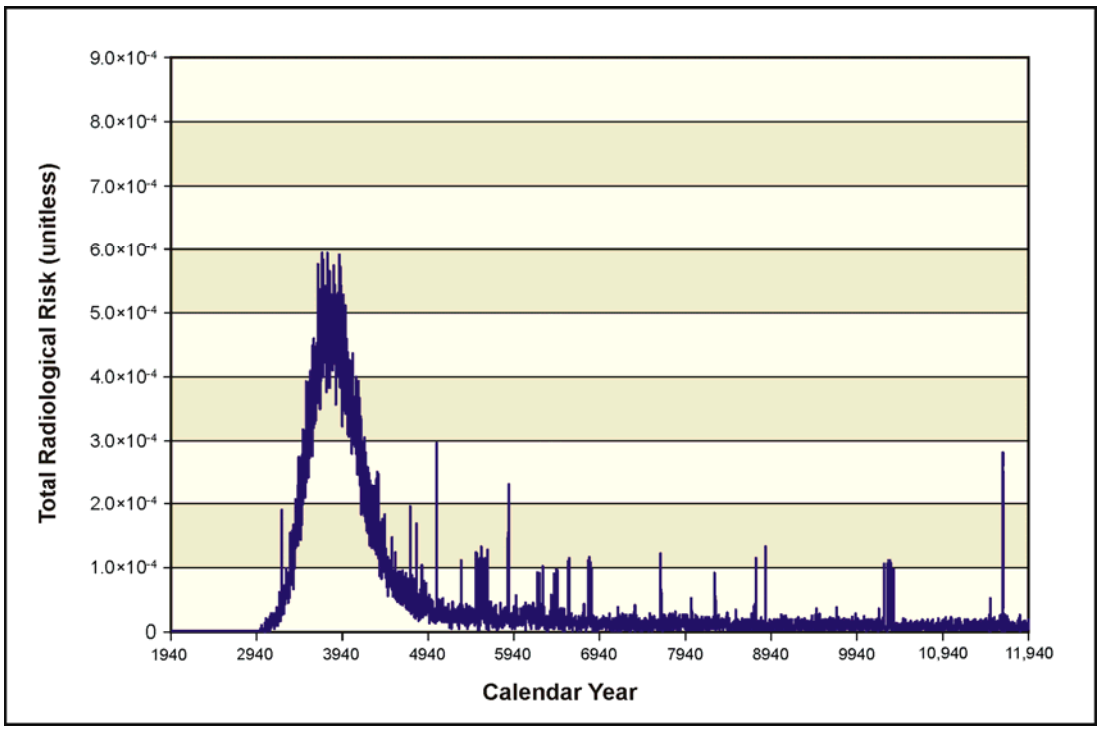


Figure 2–121. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

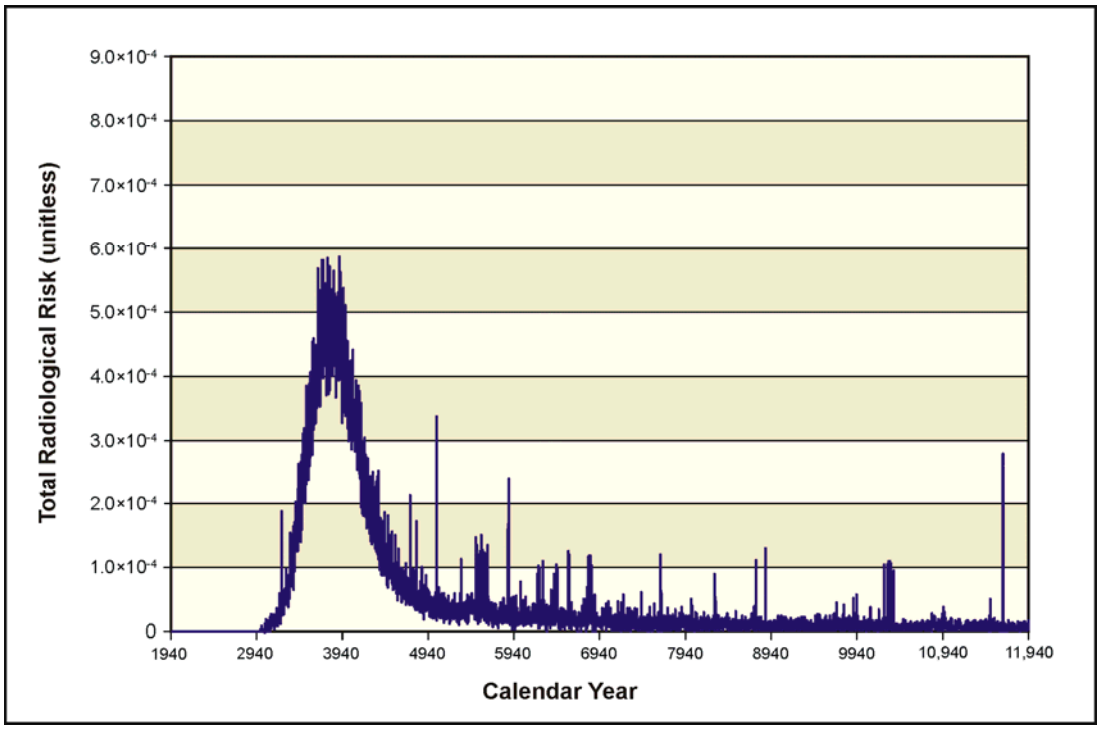


Figure 2–122. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.2.3.10 Waste Management Alternative 3, Disposal Group 3

Disposal Group 3 addresses the waste resulting from Tank Closure Alternative 6A, Base and Option Cases; onsite non-CERCLA sources; FFTF decommissioning; waste management; and other DOE sites. Waste forms to be disposed of in IDF-East would include the following:

- PPF glass
- PPF melters
- Tank closure secondary waste

Waste forms to be disposed of in IDF-West would include the following:

- FFTF decommissioning secondary waste
- Waste management secondary waste
- Offsite waste
- Onsite non-CERCLA waste

Waste forms to be disposed of in the RPPDF would include those resulting from tank closure cleanup activities under Tank Closure Alternative 6A, Base and Option Cases.

The key radiological constituent contributors to human health risk would be technetium-99 and iodine-129. The key chemical constituent contributors would be acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would not be exceeded for either the Base or Option Cases. The Hazard Index guideline would not be exceeded under the Base Case, but would be exceeded under the Option Case, due primarily to the presence of chromium and nitrate. The population dose for the year of maximum impact was estimated to be 5.95×10^{-1} person-rem under the Base Case and 5.95×10^{-1} person-rem under the Option Case. Each of these estimates of population dose is approximately 3×10^{-5} percent of the background dose.

Figures 2–123 and 2–124 depict a time series showing the lifetime radiological risk of incidence of cancer at the Core Zone Boundary for the drinking-water well user for the Base Case and Option Case, respectively. The peak radiological risk would occur around the year 3700 at the Core Zone Boundary under both the Base and Option Cases and would be dominated by technetium-99 and iodine-129 from naturally occurring release mechanisms and degradation of waste forms disposed of in IDF-West and the RPPDF.

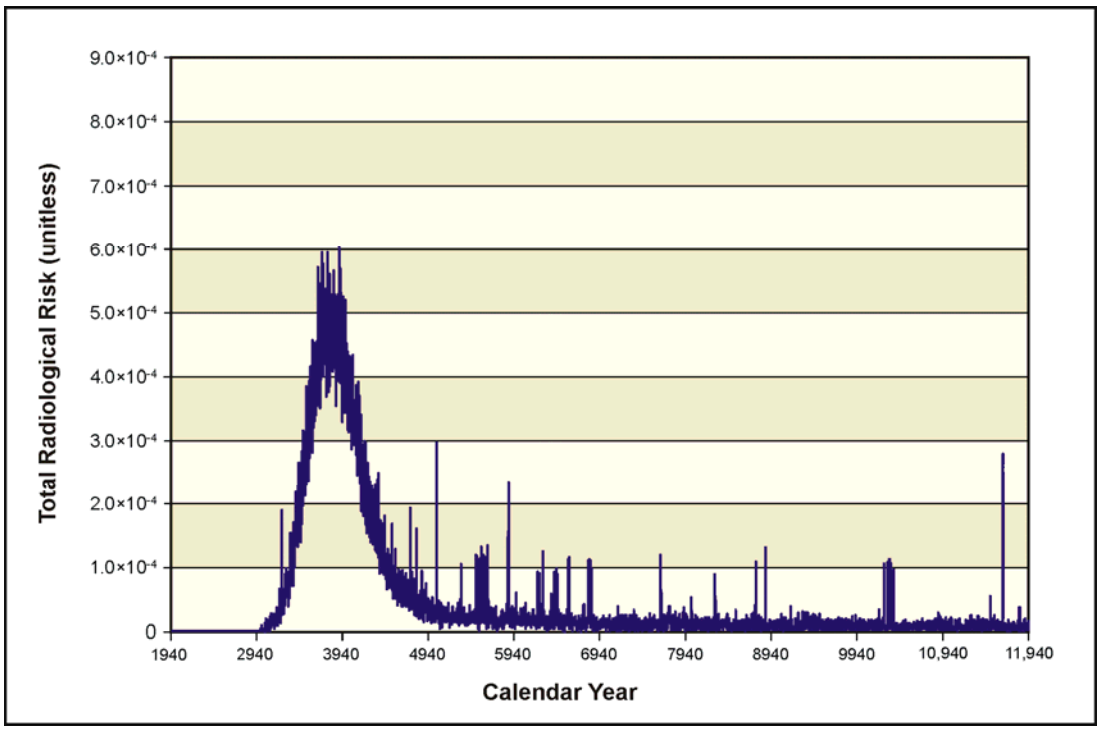


Figure 2–123. Waste Management Alternative 3, Disposal Group 3, Base Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

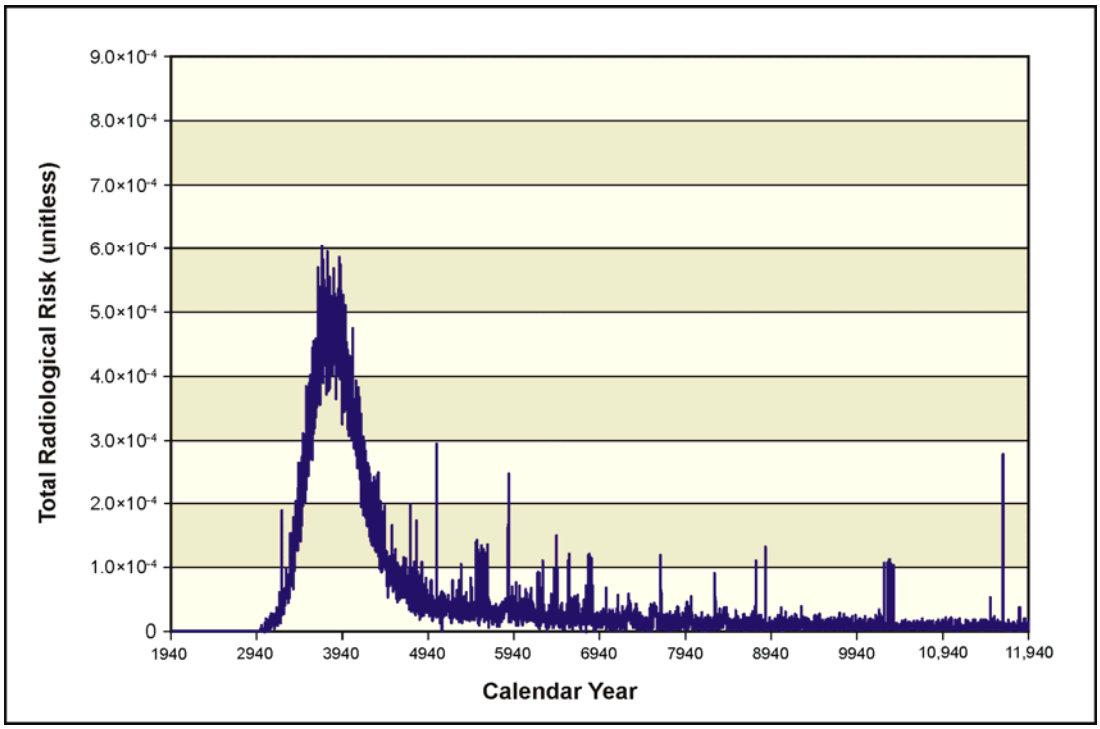


Figure 2–124. Waste Management Alternative 3, Disposal Group 3, Option Case, Summary of Long-Term Human Health Impacts on the Drinking-Water Well User at the Core Zone Boundary

2.9.3.3 Ecological Risk

Risk indices for ecological receptors exposed to COPCs as a result of air releases and groundwater discharge (see Appendix P) were used in this *TC & WM EIS* to compare Waste Management alternatives. Risk indices less than 1 indicate little to no likelihood of adverse impact on the receptor. The uncertainties associated with risk indices and the meaning of Hazard Quotients and Hazard Indices for ecological receptors in this *TC & WM EIS* are discussed in Appendix P.

The potential long-term impacts of air releases on terrestrial receptors and aquatic and riparian receptors, as quantified by risk indices for the highest-value COPC for each receptor are shown in Table 2–46. Long-term impacts on all terrestrial, aquatic, and riparian receptors, except the raccoon, would be greatest under Waste Management Alternatives 2 and 3, Disposal Group 3, for air releases at the onsite maximum-exposure location. For the raccoon, the greatest impacts of air releases would occur under Waste Management Alternative 3, Disposal Group 1. In general, for terrestrial receptors exposed to organic chemicals (toluene, xylene, and formaldehyde) and benthic invertebrates exposed to ammonia, risk indices under Waste Management Alternatives 2 and 3, Disposal Group 3 were approximately twice as large as those under Disposal Group 2, one order of magnitude larger than those under Disposal Group 1, and two orders of magnitude larger than those under Waste Management Alternative 1: No Action. The values for xylene in the Great Basin pocket mouse exemplified this pattern. The range of risk indices for aquatic biota, including salmonids, for the COPC with the highest Hazard Quotient (benzene) would not be as great between disposal groups; the Hazard Quotient under Waste Management Alternative 1: No Action, would be an order of magnitude lower. Impacts on the raccoon and least weasel under Waste Management Alternatives 2 and 3 were similar for all disposal groups and an order of magnitude greater than those under Waste Management Alternative 1.

Table 2–46. Waste Management Alternatives – Long-Term Impacts of Contaminant Releases to Air on Ecological Resources

Waste Management Alternative	Hazard Quotient of Highest-Value COPC by Receptor[a]							
	Onsite Maximum-Exposure Location				Columbia River			
	Plants	Great Basin Pocket Mouse	Coyote	Mule Deer	Benthic Invertebrate	Aquatic Biota/ Salmonids	Raccoon	Least Weasel
	Toluene	Xylene		Formaldehyde	Xylene	Benzene	Xylene	
1	6.9×10^{-2}	3.29	4.18×10^{-1}	4.75×10^{1}	3.8×10^{-5}	7.0×10^{-3}	2.7×10^{-7}	1.6×10^{-6}
2, DG 1	4.7×10^{-1}	2.59×10^{1}	3.29	1.04×10^{1}	1.0×10^{-3}	1.4×10^{-2}	4.0×10^{-6}	**2.3×10^{-5}**
2, DG 2	3.2	1.66×10^{2}	2.11×10^{1}	4.81×10^{1}	4.0×10^{-3}	5.6×10^{-2}	3.9×10^{-6}	**2.3×10^{-5}**
2, DG 3	**5.65**	**2.89×10^{2}**	**3.67×10^{1}**	8.07×10^{1}	**7.0×10^{-3}**	5.6×10^{-2}	3.9×10^{-6}	**2.3×10^{-5}**
3, DG 1	4.74×10^{-1}	2.63×10^{1}	3.34	1.12×10^{1}	1.0×10^{-3}	1.4×10^{-2}	**4.1×10^{-6}**	**2.3×10^{-5}**
3, DG 2	3.20	1.67×10^{2}	2.12×10^{1}	4.96×10^{1}	4.0×10^{-3}	**5.7×10^{-2}**	3.9×10^{-6}	**2.3×10^{-5}**
3, DG 3	5.58	**2.89×10^{2}**	**3.67×10^{1}**	**8.14×10^{-1}**	**7.0×10^{-3}**	**5.7×10^{-2}**	3.9×10^{-6}	**2.3×10^{-5}**

[a] The soil-dwelling invertebrate, side-blotched lizard, meadowlark, mourning dove, burrowing owl, spotted sandpiper, and bald eagle had no toxicity reference values or zeros for COPCs in these analyses and thus are not shown.

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.

Key: COPC=constituent of potential concern; DG=Disposal Group.

For groundwater discharging to the Columbia River (see Table 2–47), risk indices were small under the Waste Management alternatives. For all aquatic and riparian receptors, impacts of groundwater releases would be greatest under Waste Management Alternatives 2 and 3, Disposal Group 1, Subgroups 1-C and 1-D. This pattern was exemplified by the nitrate Hazard Quotients for the least weasel and the chromium Hazard Quotients for the bald eagle and aquatic biota, including salmonids. Impacts under the maximum reasonably foreseeable alternatives for all receptors were three and four orders of magnitude greater than those under the No Action Alternative.

Table 2–47. Waste Management Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Ecological Resources

Waste Management Alternative	Hazard Quotient or Hazard Index of Highest-Value COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/ Salmonids
	Chromium				Nitrate	Chromium	
1	7.15×10^{-5}	2.80×10^{-6}	4.85×10^{-4}	5.87×10^{-5}	9.10×10^{-6}	7.47×10^{-6}	4.72×10^{-3}
2, DG 1, SG 1-A	5.45×10^{-4}	2.13×10^{-5}	3.70×10^{-3}	4.48×10^{-4}	1.32×10^{-2}	5.15×10^{-5}	2.69×10^{-2}
2, DG 1, SG 1-B	2.75×10^{-4}	1.07×10^{-5}	1.86×10^{-3}	2.25×10^{-4}	1.30×10^{-2}	2.58×10^{-5}	1.33×10^{-2}
2, DG 1, SG 1-C	**8.51×10^{-2}**	**3.33×10^{-3}**	**5.77×10^{-1}**	**6.99×10^{-2}**	**5.72×10^{-2}**	7.72×10^{-3}	3.69
2, DG 1, SG 1-D	8.48×10^{-2}	3.32×10^{-3}	5.75×10^{-1}	6.97×10^{-2}	1.50×10^{-2}	**7.97×10^{-3}**	**4.12**
2, DG 1, SG 1-E	4.66×10^{-2}	1.82×10^{-3}	3.16×10^{-1}	3.83×10^{-2}	3.28×10^{-2}	4.40×10^{-3}	2.30
2, DG 1, SG 1-F	8.03×10^{-2}	3.14×10^{-3}	5.45×10^{-1}	6.60×10^{-2}	2.19×10^{-2}	7.01×10^{-3}	3.02
2, DG 1, SG 1-G	5.88×10^{-4}	2.30×10^{-5}	3.99×10^{-3}	4.83×10^{-4}	1.32×10^{-2}	5.34×10^{-5}	2.54×10^{-2}
2, DG 2, SG 2-A	5.51×10^{-4}	2.15×10^{-5}	3.74×10^{-3}	4.52×10^{-4}	1.39×10^{-2}	5.11×10^{-5}	2.57×10^{-2}
2, DG 2, SG 2-B, Base Case	1.69×10^{-3}	6.61×10^{-5}	1.15×10^{-2}	1.39×10^{-3}	1.43×10^{-2}	1.56×10^{-4}	7.74×10^{-2}
2, DG 2, SG 2-B, Option Case	1.24×10^{-2}	4.85×10^{-4}	8.41×10^{-2}	1.02×10^{-2}	1.66×10^{-2}	1.12×10^{-3}	5.25×10^{-1}
2, DG 3, Base Case	2.25×10^{-3}	8.79×10^{-5}	1.52×10^{-2}	1.85×10^{-3}	1.49×10^{-2}	1.92×10^{-4}	7.77×10^{-2}
2, DG 3, Option Case	1.50×10^{-2}	5.85×10^{-4}	1.02×10^{-1}	1.23×10^{-2}	1.73×10^{-2}	1.27×10^{-3}	4.99×10^{-1}
3, DG 1, SG 1-A	5.37×10^{-4}	2.10×10^{-5}	3.64×10^{-3}	4.41×10^{-4}	1.32×10^{-2}	4.96×10^{-5}	2.47×10^{-2}
3, DG 1, SG 1-B	3.36×10^{-4}	1.31×10^{-5}	2.28×10^{-3}	2.76×10^{-4}	1.30×10^{-2}	3.31×10^{-5}	1.89×10^{-2}
3, DG 1, SG 1-C	**8.51×10^{-2}**	**3.33×10^{-3}**	**5.77×10^{-1}**	**6.99×10^{-2}**	**5.72×10^{-2}**	7.72×10^{-3}	3.69
3, DG 1, SG 1-D	8.48×10^{-2}	3.32×10^{-3}	5.75×10^{-1}	6.96×10^{-2}	1.50×10^{-2}	7.96×10^{-3}	**4.12**
3, DG 1, SG 1-E	4.66×10^{-2}	1.82×10^{-3}	3.16×10^{-1}	3.83×10^{-2}	3.28×10^{-2}	4.40×10^{-3}	2.30
3, DG 1, SG 1-F	8.03×10^{-2}	3.14×10^{-3}	5.45×10^{-1}	6.59×10^{-2}	2.19×10^{-2}	7.01×10^{-3}	3.02
3, DG 1, SG 1-G	5.73×10^{-4}	2.24×10^{-5}	3.89×10^{-3}	4.71×10^{-4}	1.32×10^{-2}	5.11×10^{-5}	2.34×10^{-2}
3, DG 2, SG 2-A	5.24×10^{-4}	2.05×10^{-5}	3.55×10^{-3}	4.30×10^{-4}	1.39×10^{-2}	4.82×10^{-5}	2.38×10^{-2}
3, DG 2, SG 2-B, Base Case	1.75×10^{-3}	6.85×10^{-5}	1.19×10^{-2}	1.44×10^{-3}	1.43×10^{-2}	1.63×10^{-4}	8.18×10^{-2}
3, DG 2, SG 2-B, Option Case	1.25×10^{-2}	4.87×10^{-4}	8.45×10^{-2}	1.02×10^{-2}	1.66×10^{-2}	1.12×10^{-3}	5.26×10^{-1}
3, DG 3, Base Case	2.32×10^{-3}	9.07×10^{-5}	1.57×10^{-2}	1.91×10^{-3}	1.49×10^{-2}	1.98×10^{-4}	8.03×10^{-2}
3, DG 3, Option Case	1.50×10^{-2}	5.86×10^{-4}	1.02×10^{-1}	1.23×10^{-2}	1.73×10^{-2}	1.27×10^{-3}	5.00×10^{-1}

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.
Key: COPC=constituent of potential concern; DG=Disposal Group; SG=Subgroup.

Long-term modeling predicted peak air concentrations and cumulative soil concentrations of toluene, xylene, and formaldehyde that potentially would cause adverse impact on terrestrial mammals (mouse, coyote, and mule deer) at the onsite maximum-exposure location under Waste Management Alternatives 2 and 3. Maximum groundwater concentrations and resulting nearshore surface water and sediment concentrations under all Waste Management alternatives would be unlikely to pose a toxicological risk to aquatic and riparian receptors exposed at the Columbia River. Potential long-term impacts of Waste Management alternatives on ecological resources are discussed in greater detail in Chapter 5, Section 5.3.3, and the uncertainties associated with risk indices calculated using environmental concentrations predicted for air and groundwater releases under the Waste Management alternatives are discussed in Appendix P.

Eutrophication of nearshore surface water as a result of nitrate in groundwater discharging at the Columbia River under Waste Management alternatives would be unlikely. The predicted maximum nearshore surface water concentration of nitrate did not exceed 0.13 milligrams per liter, a small fraction of the 2006 ambient concentration, 1.0 milligram per liter (Poston et al. 2007).

2.9.3.4 Environmental Justice

The long-term human health analysis determined that the impacts of waste management actions would be greatest under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D. This alternative could result in radiological doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors on site at the IDF-East barrier, the Core Zone Boundary, or the Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected within a reasonably foreseeable timeframe because the Core Zone is designated for Industrial-Exclusive land use, the Columbia River nearshore location is designated for Preservation (Hanford Reach National Monument), and the area between them is designated for Conservation (Mining) (DOE 1999). However, exposures to such individuals were evaluated using the exposure scenarios discussed in Section 2.9.1.2. The greatest risk would be to the American Indian resident farmer at the IDF-East boundary. During the year of peak dose, this receptor would receive a radiological dose of 281 millirem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent due primarily to their assumed lower consumption of locally grown food. No adverse impacts were identified for any receptors at offsite locations; therefore there would be no disproportionately high and adverse impacts on American Indian populations at offsite locations.

2.10 KEY ENVIRONMENTAL FINDINGS

The following sections present an overview of the key findings associated with the Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Both short- and long-term impact analyses are included in this key findings discussion; however, the majority of the findings focus on long-term impacts.

2.10.1 Tank Closure Alternatives

The Tank Closure action alternatives described in this *TC & WM EIS* represent the range of reasonable approaches to storing Hanford tank waste; removing the waste from the tanks to the extent technically and economically feasible; treating the waste through vitrification in the existing WTP, in an expanded WTP, and/or in conjunction with one or more supplemental treatment technologies; packaging the waste for onsite storage or disposal or offsite shipment and disposal; and closing the SST system to permanently reduce the potential risk to human health and the environment. These alternatives were developed in part to allow comparisons of the short-term impacts of the construction, operation, and deactivation of the additional facilities proposed for storage, retrieval, treatment, and disposal of waste from the SST system, and for closure of the SST system. These action alternatives were also developed to allow similar comparisons of the long-term water quality, human health, and ecological risk impacts resulting from completion of these activities. The following is a brief discussion of the key findings for the Tank Closure alternatives.

Tank Farm Waste Retrieval. The Tank Closure alternatives allow the range of retrieval options to be evaluated. Under Tank Closure Alternative 1, the tank waste would not be retrieved. Under Tank Closure Alternative 5, retrieval of 90 percent of the waste would occur. Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, and 6C would achieve 99 percent retrieval. Tank Closure Alternatives 4, 6A, and 6B would retrieve 99.9 percent of the tank waste.

Continued storage of tank waste with no removal or treatment would have negligible additional short-term impacts but significant long-term impacts. Retrieving the tank waste rather than leaving it in place would reduce long-term impacts on groundwater and human health.

For potential short-term impacts, resource requirements and human health effects associated with tank waste retrieval are similar, and rather small compared with other construction, operations, and closure-related impacts under all Tank Closure alternatives.

The influence of degree of retrieval on the magnitude of long-term human health impacts is most clearly discernable through consideration of impacts due to tank farm sources other than past leaks. Potential long-term impacts due to sources in SST and DST farms include losses from residual waste remaining in tanks and ancillary equipment following retrieval, as well as retrieval leaks at SST farms. Estimates of lifetime radiological risk for a drinking water well user at the Core Zone Boundary for these sources at all tank farms are presented in Figure 2–125: Tank Closure Alternative 1 (no retrieval), Tank Closure Alternative 5 (90 percent retrieval), Tank Closure Alternatives 2B, 3A, 3B, 3C and 6C (99 percent retrieval), and Tank Closure Alternative 4 (99.9 percent retrieval). The results show that failure to retrieve waste under Tank Closure Alternative 1 would have the greatest potential impact on human health. For Tank Closure alternatives that include retrieval of waste, impacts due to tank farm residuals and ancillary equipment, and to a lesser degree, retrieval leaks, are the important contributors to estimates of impacts prior to calendar year 4000, and Tank Closure Alternative 4 has the lowest estimate of risk due to selective clean closure (complete removal of SST farms BX and SX). Estimates of impacts over longer periods are reduced in approximate proportion to the degree of retrieval.

Radiological Risk

In general, a measure of potential harm to populations or individuals due to the presence or occurrence of an environmental or manmade hazard. In terms of human health, risk comprises three components: a sequence of events leading to an adverse impact, the probability of occurrence of that sequence of events, and the severity of the impact. For the release of radionuclides affecting a population, the impact is the occurrence of a fatal cancer; risk is expressed as the expected number of latent cancer fatalities (i.e., the product of probability of occurrence and the magnitude of impact). For the release of radionuclides affecting individuals, the impact is the incidence of cancer; risk is expressed as the probability over a lifetime of developing cancer.

WTP Configuration. Use of the WTP would be required under each of the Tank Closure action alternatives, with the WTP configuration varying among these alternatives.

- Under Tank Closure Alternative 1, construction of the WTP would not be completed and no tank waste would be treated.
- Tank Closure Alternatives 2A, 3A, 3B, 3C, and 4 would use the existing WTP configuration.
- Tank Closure Alternatives 2B, 5, 6B, and 6C would use the existing WTP configuration supplemented with expanded ILAW treatment capacity.
- Tank Closure Alternative 6A would require modification of the WTP to provide IHLW vitrification capacity only—that is, no LAW vitrification capacity.

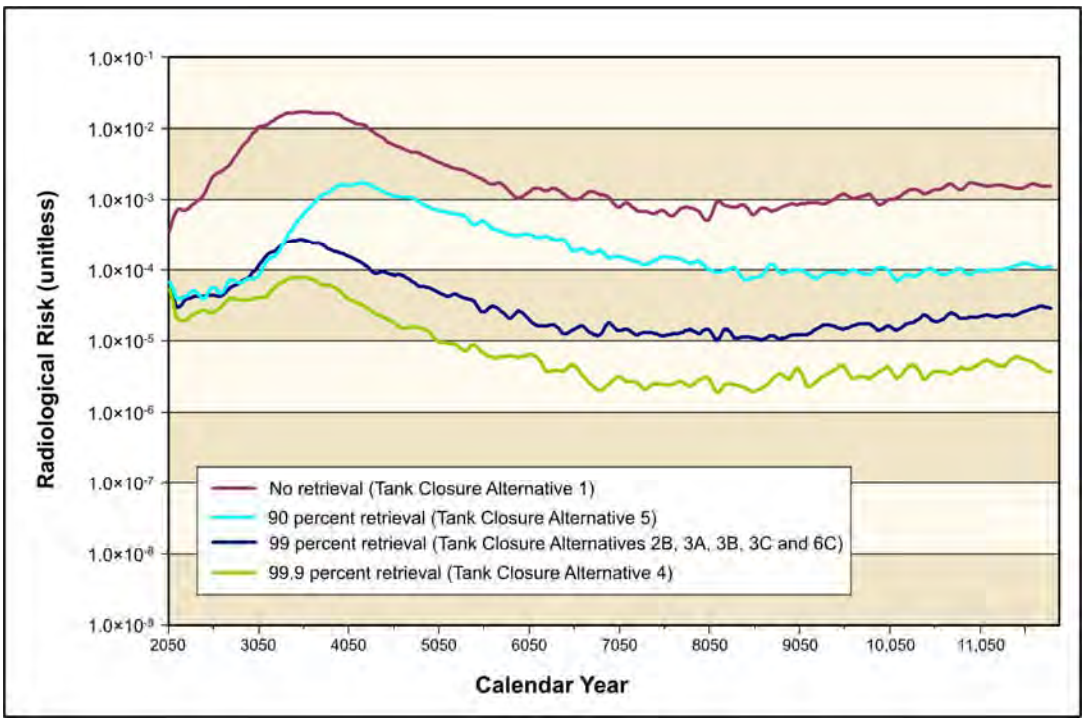


Figure 2–125. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Releases from Tank Farm Residuals and Ancillary Equipment and to Retrieval Leaks

Potential short-term impacts, including resource demands (e.g., land, utilities, geologic resources, workforce); air pollutant emissions; human health impacts; and waste generation, vary roughly in proportion to the magnitude of construction, with total operational impacts generally proportional to the duration of waste treatment. Using the existing WTP treatment configuration would extend treatment time and require replacement DSTs, which would increase short-term impacts. Using the existing WTP configuration supplemented by expanded ILAW treatment capacity would reduce the treatment time and result in minor impacts on most resources. Alternative 6A would have the highest demands for, and thus the greatest short-term impacts on, most resources. This is because this alternative would have the highest construction demands coupled with the longest period of WTP operations. It would be necessary to construct replacement WTP facilities twice as the predecessor facilities reached the end of their operational lifetimes. Varying the WTP configuration would not change the quantity and performance of waste forms and, therefore, would have minor influence on long-term impacts.

Primary, Supplemental, and Secondary Waste Forms. The Tank Closure alternatives also were developed to evaluate potential impacts of the primary waste form and a range of supplemental thermal and nonthermal waste forms. The primary waste form planned for disposal on site is ILAW glass; the thermal supplemental treatment waste forms are represented in this EIS by bulk vitrification glass and steam reforming waste; and the nonthermal supplemental treatment waste form is represented by cast stone waste. Waste processing using each of the primary or supplemental treatment technologies that generate these waste forms also produces secondary wastes, whose impacts are included as part of the evaluation. The Tank Closure alternatives that use these various supplemental treatment technology configurations are as follows:

- Tank Closure Alternative 2B – Thermal (ILAW glass) primary treatment in the 200-East Area
- Tank Closure Alternative 3A – Thermal (ILAW glass) primary treatment in the 200-East Area; thermal (bulk vitrification) supplemental treatment in both the 200-East and 200-West Areas

- Tank Closure Alternative 3B – Thermal (ILAW glass) primary treatment in the 200-East Area; nonthermal (cast stone) supplemental treatment in both the 200-East and 200-West Areas

- Tank Closure Alternative 3C – Thermal (ILAW glass) primary treatment in the 200-East Area; thermal (steam reforming) supplemental treatment in both the 200-East and 200-West Areas

Differences in potential short-term impacts of facility construction and supplemental treatment operations among the Tank Closure alternatives identified above are relatively small for most resource areas. Volumetrically, Tank Closure Alternative 2B produces no supplemental treatment waste for disposal, while Alternative 3C produces the highest amount (i.e., approximately 260,000 cubic meters [340,000 cubic yards]). While Tank Closure Alternative 3C would be similar to other supplemental treatment alternatives in its demands for, and thus total short-term construction and operational impacts on, most resources, it would have higher impacts in some resource areas, such as electric power consumption.

Estimates of potential long-term human health impacts due to disposal at the IDF barrier in the 200-East Area are presented in Figure 2–126 for the combined effect of primary, supplemental, and secondary wastes for the Waste Management alternatives and disposal groups that include the Tank Closure alternatives described above. The results show that segregation of the maximum amount of waste into the primary waste form (ILAW glass for Tank Closure Alternative 2B) produces the lowest estimate of risk. Because of the low rate of release from ILAW glass, the major impact of this treatment process is attributable to releases from secondary wastes, including the release of iodine-129 captured in the offgas of the melters that is solidified in the ETF secondary waste. A combination of the thermal treatment primary waste form (ILAW glass) with the thermal treatment bulk vitrification glass and secondary wastes (Tank Closure Alternative 3A) results in the next lowest estimate of impacts. The increase in Tank Closure Alternative 3A risk estimated for this treatment process relative to the Tank Closure Alternative 2B primary waste (ILAW glass) is due to the release from the inventory of technetium-99 deposited in the castable refractory block surrounding the bulk vitrification glass waste form. The treatment process resulting in the nonthermal cast stone waste form (Tank Closure Alternative 3B) produces higher estimates of impact due to the remaining inventory of technetium-99 not immobilized into IHLW glass and the relatively poor performance of the current Hanford site-specific grout formulation in retaining this radionuclide. The thermal treatment steam reforming waste form (Tank Closure Alternative 3C) provides the poorest performance of the supplemental waste forms based on assumed release mechanism data.

The analysis suggests that additional treatment or waste form development may be needed for secondary waste. DOE is currently evaluating potential secondary waste form research and development activities, which include ceramic and other waste forms. It is anticipated that research and development efforts will continue to address treatment of the liquid secondary waste, as this stream would not be generated until the WTP was operational. Measures could also be pursued involving the increased capture of iodine-129, technetium-99, or other target constituents in ILAW glass.

Tank-Derived TRU Waste. Under Tank Closure Alternatives 3A, 3B, 3C, 4, and 5, the waste in some selected tanks would be managed as mixed TRU waste and therefore, disposed of at WIPP. These alternatives were developed to determine the environmental impacts related to that approach.

Treating tank-derived TRU waste decreases the WTP and supplemental treatment process timeframes and reduces the volume of waste to be disposed of on site in an IDF and the associated long-term impacts. While treatment of some of the tank waste as TRU waste increases short-term impacts (e.g., air emissions, worker dose), the total incremental impact over the tank-derived TRU waste treatment period is negligible compared with other waste treatment impacts.

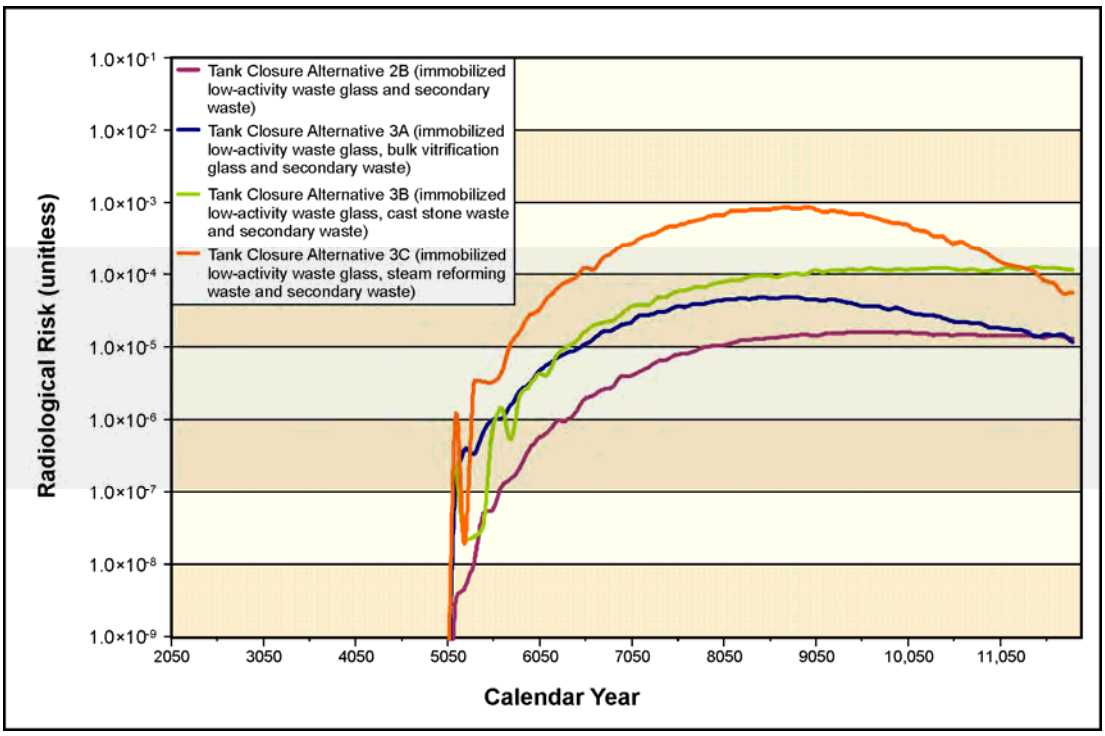


Figure 2–126. Lifetime Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier from Tank Closure Treatment Process–Generated Waste Forms

Technetium-99 Removal in WTP. The Tank Closure action alternatives were also developed to compare WTP pretreatment with or without technetium-99 removal. Tank Closure Alternatives 2B and 3B include technetium-99 removal within the WTP pretreatment process, while Tank Closure Alternatives 2A, 3A, 3C, 4, 5, and 6A through 6C do not.

Tank Closure Alternative 2B includes technetium-99 removal in the WTP, a pretreatment activity that separates technetium-99 and sends it for immobilization into IHLW glass. By contrast, Tank Closure Alterative 2A assumes no technetium-99 removal in the WTP; therefore, most of the technetium-99 is immobilized in ILAW glass and disposed of onsite in an IDF. The analysis indicates that ILAW glass with or without technetium-99 has similar potential short-term and long-term impacts. The analysis further indicates that removal of technetium-99 and disposal of it offsite as IHLW glass provides little reduction in the concentrations of technetium-99 at either the Core Zone Boundary or the Columbia River nearshore. This is because the rate of release of technetium-99 from ILAW glass is small when compared to the rate of release of technetium-99 from other sources such as ETF-generated secondary wastes and tank closure secondary wastes.

Sulfate Grout. Under Tank Closure Alternative 5, an additional sulfate removal technology is evaluated after WTP pretreatment to increase the waste loading in ILAW glass, thereby reducing the amount of ILAW glass produced in the WTP and allowing earlier completion of treatment. This alternative was developed to determine the environmental impact of a shorter treatment timeframe. Use of the sulfate removal technology results in a reduced treatment timeframe and reduced ILAW glass volume, with minimal potential short-term impacts and no long-term impacts. Tank Closure Alternative 5 short-term construction and operational impacts would be very similar to those of other Tank Closure alternatives, although impacts of the operation of the Sulfate Removal Facility would result in higher demands for some resources such as liquid fuels and water.

Closure of the Six Sets of Cribs and Trenches (Ditches). Although the scope of this *TC & WM EIS* does not include decisions to be made for six sets of cribs and trenches that are contiguous to the SST farms, they are included in the alternative analysis because of their close proximity to the SST farms and because it is difficult to distinguish sources of contamination in the vadose zone or groundwater. Tank Closure Alternatives 1 and 2A assume no closure of the SST system, including the cribs and trenches, while all the remaining Tank Closure alternatives assume landfill closure of the cribs and trenches except for Tank Closure Alternatives 6A, Option Case, and 6B, Option Case. These two alternatives analyze clean closure of the cribs and trenches.

Overall potential total short-term and peak short-term environmental impacts of closure activities would exceed total facility construction impacts under most alternatives, especially in terms of air emissions and resource demands. For closure of the cribs and trenches, there would be some impact tradeoffs between landfill closure of the cribs and trenches under the Base Cases and clean closure under the Option Cases. Landfill barrier construction would result in higher peak and total nonradiological air pollutant emissions than tank farm clean closure would. By contrast, clean closure of the cribs and trenches under the Alternatives 6A and 6B, Option Cases, would increase the total closure impacts, such as demands for utility resources and geologic materials, workforce requirements, and secondary waste generation, to levels measurably higher than those of the Base Cases.

Cribs and trenches are major contributors to potential long-term groundwater impacts for all Tank Closure alternatives due to their early discharges in the 1950s and 1960s. As shown in Figure 2–127, for Tank Closure Alternative 1 (no landfill closure of the cribs and trenches), Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C (landfill closure of the cribs and trenches), and Tank Closure 6B, Option Case (clean closure of the cribs and trenches), estimates of human health impacts (radiological risk to the drinking-water well user) correlate with the closure options. For example, Tank Closure Alternative 1 and Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C have similar radiological risk to the drinking-water well user at the Core Zone Boundary throughout the period of analysis, because the contaminants have already reached the vadose zone or groundwater and, therefore, there is minimal benefit to the addition of a landfill closure barrier. By contrast, results for Tank Closure Alternative 6B, Option Case, indicate that clean closure of the cribs and trenches significantly reduces radiological risk to the drinking-water well user at the Core Zone Boundary after calendar year 7000. The variability in lifetime radiological risk represented in Figure 2–127 is attributable primarily to the release of multiple constituents at differing times and rates from 35 sources comprising these sets of cribs and trenches and secondarily from variability in prediction of concentration inherent in the method applied (i.e., particle tracking) for simulation of transport of contaminants in the unconfined aquifer.

Closure of SST System Past Leaks. Currently, 67 of Hanford's 149 SSTs are listed as "known or suspected" leakers. The Tank Closure alternatives were developed to compare the long-term impacts on groundwater of closing the SST system, including the SST farm past leaks. Tank Closure Alternatives 1 and 2A assume no closure of the SST system, and past leaks would remain. Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C assume landfill closure of the entire SST system, and past leaks would remain. Tank Closure Alternative 4 assumes selective clean closure/landfill closure, which includes clean closure of the BX and SX SST farms and landfill closure of the remaining SST farms, and past leaks would be removed at the two clean-closed SST farms. Tank Closure Alternatives 6A, Base and Option Cases, and 6B, Base and Option Cases, assume clean closure of the SST farms and past leaks would be removed at all the SST farms.

Over the short-term, past leaks in and around the SST farms could affect clean closure activities. For example, construction dewatering would likely be necessary in some tank farm excavations to allow clean closure to proceed, and depending on the amount of pumping required and the levels of contamination found, may increase worker dose. Also, the water could require special handling and treatment at the ETF prior to release to the environment due to the expected high contamination levels.

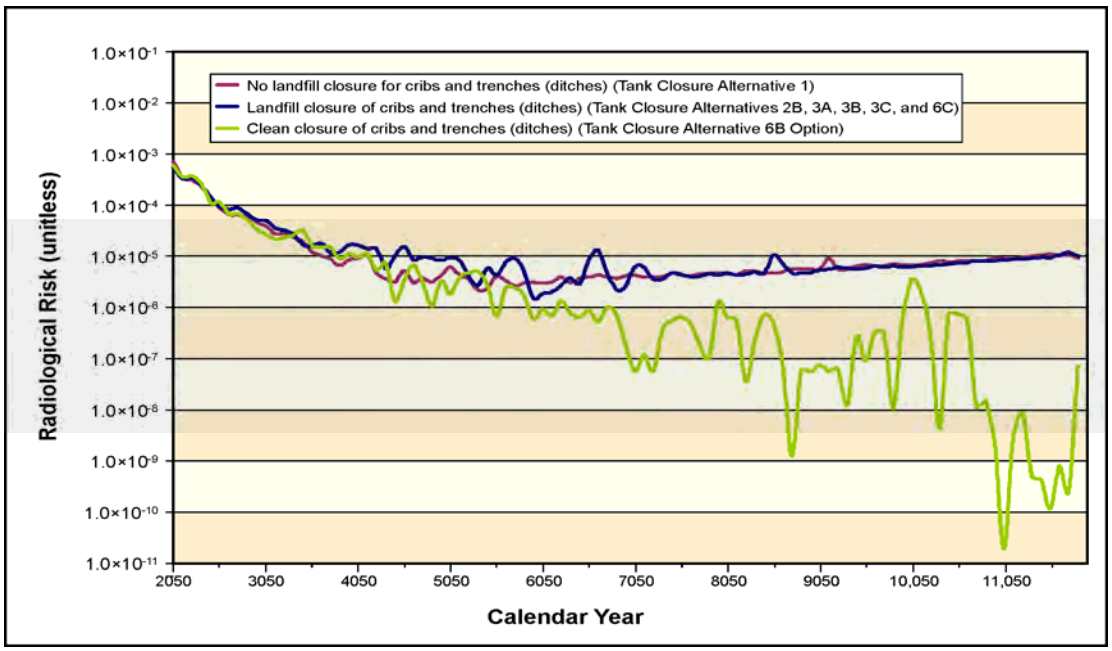


Figure 2–127. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Releases from the Six Sets of Cribs and Trenches (Ditches)

Past leaks are major contributors to potential long-term groundwater impacts. As shown in Figure 2–128, for Tank Closure Alternative 2A (no landfill closure), Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C (landfill closure), Tank Closure Alternative 4 (selective clean closure/landfill closure) and Tank Closure Alternative 6B, Base Case (clean closure of the SST system), estimates of human health impacts (radiological risk to the drinking-water well user) correlate with the closure options. For example, Tank Closure Alternative 2A has the highest radiological risk to the drinking-water well user at the Core Zone Boundary, while Tank Closure Alternative 6B, Base Case, has the lowest radiological risk to the drinking-water well user at the Core Zone Boundary. Impact estimates for Tank Closure Alternative 4 show a reduction in risk due to selective clean closure.

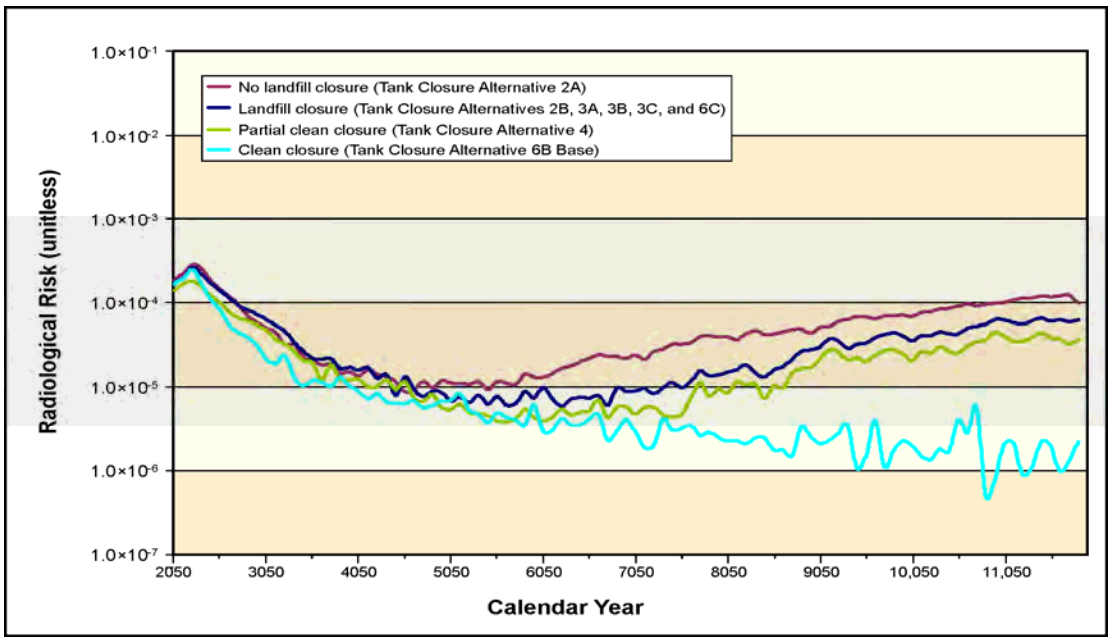


Figure 2–128. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Past Leaks at Single-Shell Tank Farms

Closure of SST System. The Tank Closure alternatives were also developed to compare the potential long-term impacts on groundwater of closing the SST system. Proposed closure options range from clean closure or selective clean closure/landfill closure to landfill closure with or without any contaminated soil removal. The closure assumptions of the Tank Closure alternatives are summarized below.

- Tank Closure Alternatives 1 and 2A assume no closure of the SST system.

- Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C assume landfill closure using an engineered modified RCRA Subtitle C barrier and removal of 4.6 meters (15 feet) of contaminated soils (which includes ancillary equipment) from two SST farms (BX and SX).

- Tank Closure Alternative 4 assumes selective clean closure of two SST farms (BX and SX) and landfill closure of the remaining SST farms using an engineered modified RCRA Subtitle C barrier.

- Tank Closure Alternative 5 assumes landfill closure of the SST farms using a Hanford barrier without removal of contaminated soils or ancillary equipment.

- Tank Closure Alternatives 6A and 6B assume clean closure of the SST system. The Base Cases would place an engineered modified RCRA Subtitle C barrier over the six sets of cribs and trenches (ditches) in the B and T tank farms, while the Option Cases would include deep soil removal and remediation of these six sets of cribs and trenches (ditches).

As previously mentioned, total short-term and peak short-term environmental impacts of SST farm closure activities would exceed total facility construction impacts for most alternatives, and would substantially add to short-term environmental impacts overall, especially in terms of emissions, worker doses, and resource demands. In terms of land resources, clean closure would allow future use of the tank farm areas, but, unlike all other Tank Closure alternatives, would require significant new, permanent land disturbance for new facilities to treat, store, and dispose of tank waste. In addition, geologic resource requirements (mainly for Borrow Area C material to backfill tank farm excavations) under Alternatives 6A and 6B would be higher than those under the landfill closure alternatives. The peak workforce would double to support clean closure, as compared to the landfill closure alternatives. Also worker population radiological dose increases by up to a factor of 10 in association with clean closure activities. Landfill closure using the Hanford barrier under Tank Closure Alternative 5 would result in higher peak and total nonradiological air pollutant emissions than landfill closure employing the modified RCRA Subtitle C barrier, as well as increased demands for utility resources and geologic materials.

Clean closure of the SST system when compared to landfill closure of the SST system would have the following potentially adverse short-term impacts:

- Total land commitments would increase by twofold
- Electricity use would increase by one order of magnitude
- Geologic resource requirements would increase fivefold
- Sagebrush habitat affected would increase by over two orders of magnitude
- Average radiation worker dose from normal operations would increase by over twofold
- LLW and MLLW generation volumes would increase by threefold
- Total recordable worker occurrences would increase by sixfold

One other significant uncertainty of clean closure in terms of technical feasibility and risk is the depth of excavation and soil exhumation that would be required. At a minimum, deep soil removal, including excavation to a depth of about 20 meters (65 feet) below land surface, would be required. This excavation depth should be sufficient to remove soils and sediments contaminated by retrieval-related

leaks, as well as contamination from historic waste releases that have accumulated horizontally on compacted strata beneath the waste tanks. For some SST sites, excavation to depths of up to 78 meters (255 feet) below the land surface may be required to remediate contaminant plumes from past-practice discharges that have migrated through the vadose zone soils and sediments and possibly to the water table. Since an effort of this scale in a radioactive environment has never been undertaken in the United States, it is unclear whether this operation could be conducted with adequate considerations for worker safety.

As shown by the radiological risk curves presented in Figure 2–129, the radiological risk peak occurs at approximately calendar year 4300 under Tank Closure Alternative 5 while at calendar year 3600 under Tank Closure Alternative 2B. The magnitude difference between the two curves is not a result of barrier performance, but of the volume of tank farm residuals (due to different retrieval assumptions). Thus, the Hanford barrier has negligible human health benefits (i.e., radiological risk to the drinking-water well user) at the Core Zone Boundary when measured against the modified RCRA Subtitle C barrier; it would delay release from landfills for only several hundred years.

Figure 2–129, which also includes retrieval leaks and releases from the SST residuals and ancillary equipment for Tank Closure Alternatives 2B (landfill closure) and 4 (selective clean closure/landfill closure), shows that the human health impacts (radiological risk to the drinking-water well user) at the Core Zone Boundary correlate to the closure actions. For example, Tank Closure Alternative 2B has a higher radiological risk than Tank Closure Alternative 4. Note: Tank Closure Alternative 6B is not included in Figure 2–129 because there are no long-term human health impacts; the three groundwater sources (tank retrieval leaks, releases from the tank residuals, and releases from ancillary equipment) are completely removed under this alternative.

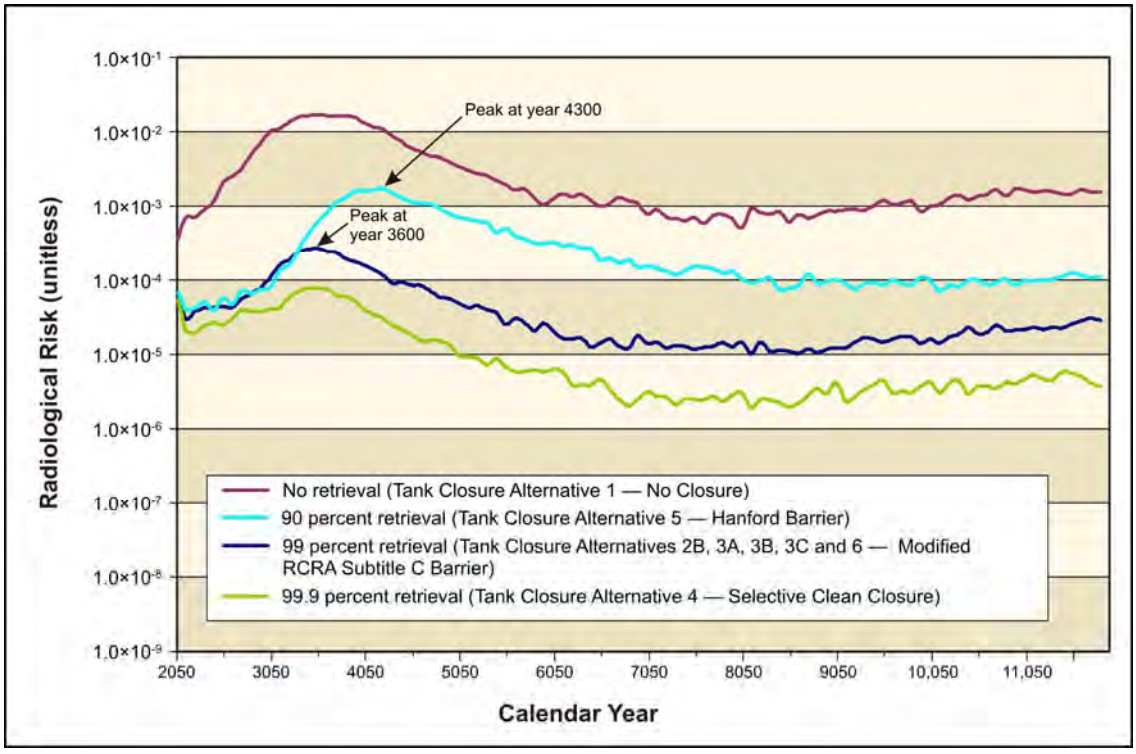


Figure 2–129. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Releases from Tank Farm Residuals and Ancillary Equipment and to Retrieval Leaks

Figures 2–127 and 2–128, which include the releases from the six sets of cribs and trenches (ditches) and the past leaks from the SSTs, respectively, also show that the clean closure of the SST farms (Tank Closure Alternatives 6B Base and Option Cases) provides some beneficial long-term impacts to the groundwater after calendar year 6000. However, clean closure would provide little, if any, reduction in long-term impacts to the groundwater before the calendar year 6000, due to the early releases from past leaks and cribs and trenches (ditches) contiguous to the SST farms.

The *TC & WM EIS* analysis further shows that the clean closure of the SST farms and contaminated soil would not reduce the concentrations of iodine-129 and technetium-99 below their respective benchmark concentrations for at least the first 2,000 years; concentrations will remain within an order of magnitude above the benchmark concentrations (i.e., 10 picocuries per liter and 9,000 picocuries per liter, respectively) through the duration of the period of analysis. Thus there would still be groundwater impacts under the clean closure alternatives due to the early releases from past leaks and intentional releases through the cribs and trenches (ditches).

As a result of the above conclusions and the excessive cost (see Table 2–52), DOE believes that clean closure may not be a viable alternative. Therefore, DOE prefers landfill closure. Hanford represents somewhat of a unique situation compared with other DOE sites such as West Valley, New York. Some of the tanks at Hanford have leaked and discharged contaminants to the soil column. In addition, there were intentional discharges to the soil column through the six sets of cribs and trenches (ditches) from the 1940s through the 1970s. Hanford also used many different separations processes, which produced a heterogeneous waste. In some cases, select radiological constituents at Hanford exist in amounts that are orders of magnitude higher than those at other DOE sites.

2.10.2 FFTF Decommissioning Alternatives

The FFTF Decommissioning alternatives were structured to encompass the range of facility disposition options. Under FFTF Decommissioning Alternative 1 (No Action), the facilities would be left in place and stabilized under a blanket of inert gas. By contrast, under FFTF Decommissioning Alternatives 2 (Entombment) and 3 (Removal), radioactive materials would be removed in varying degrees. FFTF Decommissioning Alternative 2 would remove and dispose of a minimal amount of radioactive materials and entomb the rest. All above-grade RCB and adjacent support facilities would be dismantled and either consolidated, entombed in below-grade spaces, or disposed of in an IDF. FFTF Decommissioning Alternative 3 would remove nearly all radioactive materials, including the reactor vessel, internal piping and equipment, and attached depleted-uranium shield, and dispose of these materials onsite in an IDF. Though the treatment of the RH-SCs and the disposition of bulk sodium are analyzed in FFTF Decommissioning Alternatives 2 and 3, they are nondiscriminating activities and, therefore, are not included in this discussion on key findings.

As shown in Table 2–10, potential short-term impacts on most resource areas would be similar under FFTF Decommissioning Alternatives 2 and 3, with a few notable exceptions. Emissions of nonradiological air pollutants, particularly particulate matter, associated with construction of facilities to support decommissioning activities and geologic resource requirements for backfill and site regrading following completion of removal activities would be higher under FFTF Decommissioning Alternative 3. Worker radiological doses and waste generation due to removal activities would also be higher under this alternative.

Because of the relatively small inventory of hazardous constituents at FFTF relative to that of facilities within the Core Zone Boundary, and the low rate of recharge to groundwater, potential long-term health impacts under all alternatives would be minimal and there would be little difference between the No Action and Entombment Alternatives, except that Entombment would delay any impacts for 500 years. From a facility disposition perspective, other than the need to treat the bulk sodium and

RH-SCs so the recovered sodium could be used in the WTP or for Hanford corrosion control, there would be little environmental impact on groundwater under any of the FFTF Decommissioning alternatives. The FFTF could remain in surveillance and maintenance status.

2.10.3 Waste Management Alternatives

The Waste Management alternatives described in this *TC & WM EIS* represent the range of reasonable approaches to storing and treating onsite-generated LLW, MLLW, and TRU waste; disposing of onsite- and offsite-generated LLW and MLLW (at Hanford) and onsite-generated TRU waste (at WIPP); and closing the disposal facilities to reduce water infiltration and the potential for intrusion. They were developed partly to compare the potential short-term impacts of the expansion of existing facilities and construction of new facilities, as well as the operation and deactivation of facilities used to store, treat, and dispose of waste. They were also developed to compare the potential long-term water quality, human health, and ecological risk impacts resulting from these activities.

Waste disposal would be required under all three Waste Management alternatives. The disposal options for waste and the amount of waste vary among the alternatives. Waste Management Alternative 1 would continue disposal of onsite-generated non-CERCLA, nontank LLW and MLLW in LLBG 218-W-5, trenches 31 and 34. For conservative analysis purposes, both Waste Management Alternatives 2 and 3 would provide for continued operation of these trenches through 2050, though the waste would be disposed of in an IDF. Waste Management Alternative 2 would provide for completion of IDF-East for the disposal of tank, onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW. Waste Management Alternative 3 would provide for the disposal of these waste types in two IDF facilities: IDF-East and IDF-West. Only waste from tank treatment operations would be disposed of in IDF-East. All other wastes would be disposed of in IDF-West. Both Waste Management Alternatives 2 and 3 would include construction and operation of the RPPDF for the disposal of lightly contaminated equipment and soils from closure activities.

For the disposal groupings under Waste Management Alternatives 2 and 3, potential demands for, and short-term impacts on, most resources would vary primarily in direct relation to the size (i.e., disposal capacity), and operational lifespan of the disposal facilities. Potential total short-term and peak short-term environmental impacts of disposal activities are projected to be very similar for Waste Management Alternatives 2 and 3. Thus, for short-term impacts, disposal facility configuration and location are not discriminators.

Low-Level Radioactive Waste Burial Ground 218-W-5, Trenches 31 and 34. Under Waste Management Alternative 1 (no action), the existing LLBG 218-W-5, trenches 31 and 34, would continue to accept onsite-generated non-CERCLA, nontank LLW and MLLW wastes. The analysis indicates that it would be safe to continue to dispose of LLW and MLLW in these trenches. Potential short-term impacts of ongoing disposal operations would be negligible.

Estimates of potential long-term impacts expressed as radiological risk to the drinking-water well user at the Core Zone Boundary due to the LLBG 218-W-5, trenches 31 and 34, are presented in Figure 2–130. The estimated radiological risk is well below 1×10^{-6}, especially as compared with the risks associated with the sources remaining at the SST farms under the Tank Closure alternatives (see Figure 2–125).

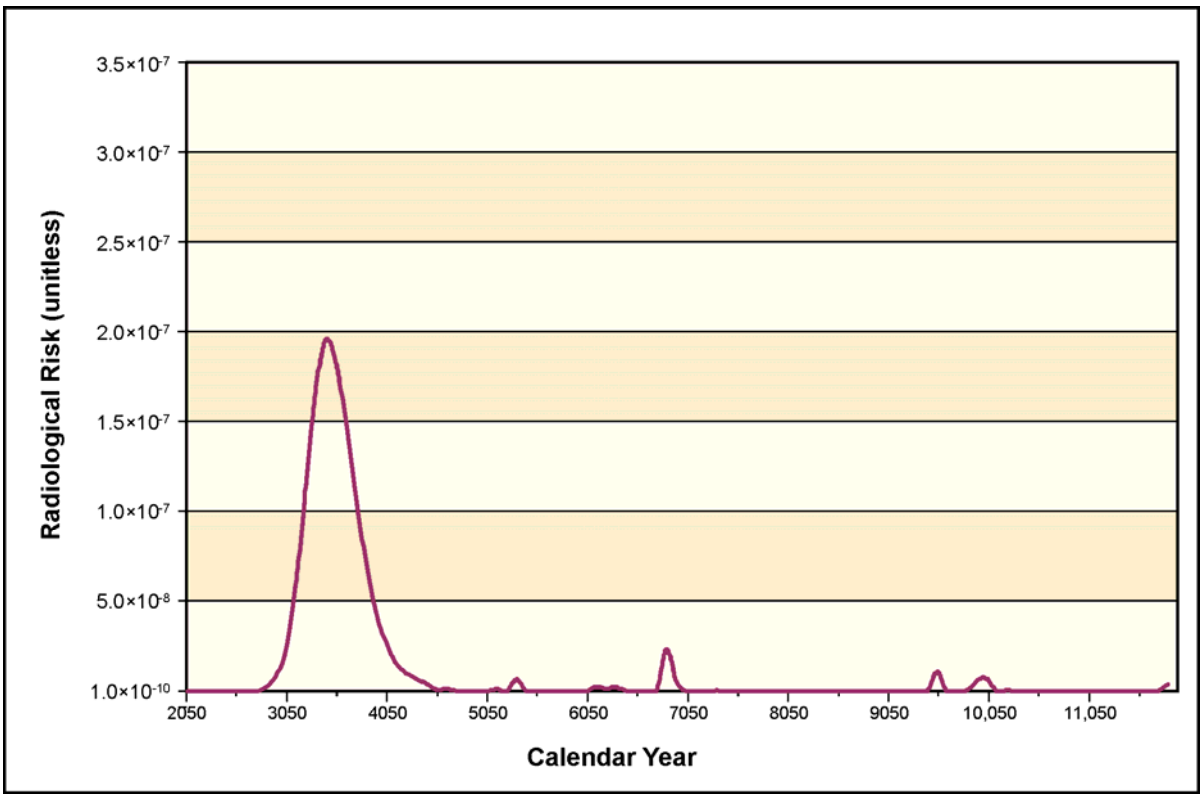


Figure 2–130. Waste Management Alternative 1 (No Action) Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Low-Level Radioactive Waste Burial Ground 218-W-5, Trenches 31 and 34

Disposal of Waste in IDF-East and IDF-West. Onsite-generated non-CERCLA, FFTF decommissioning, waste management, and offsite-generated LLW and MLLW would be disposed of in an IDF in the 200-East Area and the 200-West Area under Waste Management Alternatives 2 and 3, respectively.

Total short-term impacts of constructing and operating two IDFs under Waste Management Alternative 3 would be substantially the same as those under Waste Management Alternative 2 across nearly all resource areas. This is because no economy of scale is estimated to be achieved by having two IDFs, and short-term impacts are generally proportional to the total size (i.e., disposal capacity) and operational lifespan of disposal facilities rather than the number or location thereof.

Benchmark

Dose or concentration known or accepted to be associated with a specific level of effect. In some cases for groundwater, the benchmark is the maximum contaminant level (MCL). For example, the benchmark for iodine-129 is 1 picocurie per liter and for technetium-99 it is 900 picocuries per liter.

The long-term analysis indicates that an IDF in the 200-West Area does not perform as well as an IDF located in the 200-East Area because of the higher assumed infiltration rate for the 200-West Area location. As indicated in Figure 2–131, long-term human health impacts (radiological risk to the drinking-water well user) due to the waste streams listed above are higher at the IDF-West barrier boundary than at the IDF-East barrier boundary through calendar year 6550. In addition, Waste Management Alternative 3, which includes both IDF-West and IDF-East, shows greater exceedances of the benchmark concentrations at the Core Zone Boundary, than Waste Management Alternative 2, which only includes IDF-East. Table 2–48 provides the estimated concentration at the year of peak concentration for two of the predominant contaminants, technetium-99 and iodine-129, at the IDF-East and IDF-West barrier due to releases from all sources.

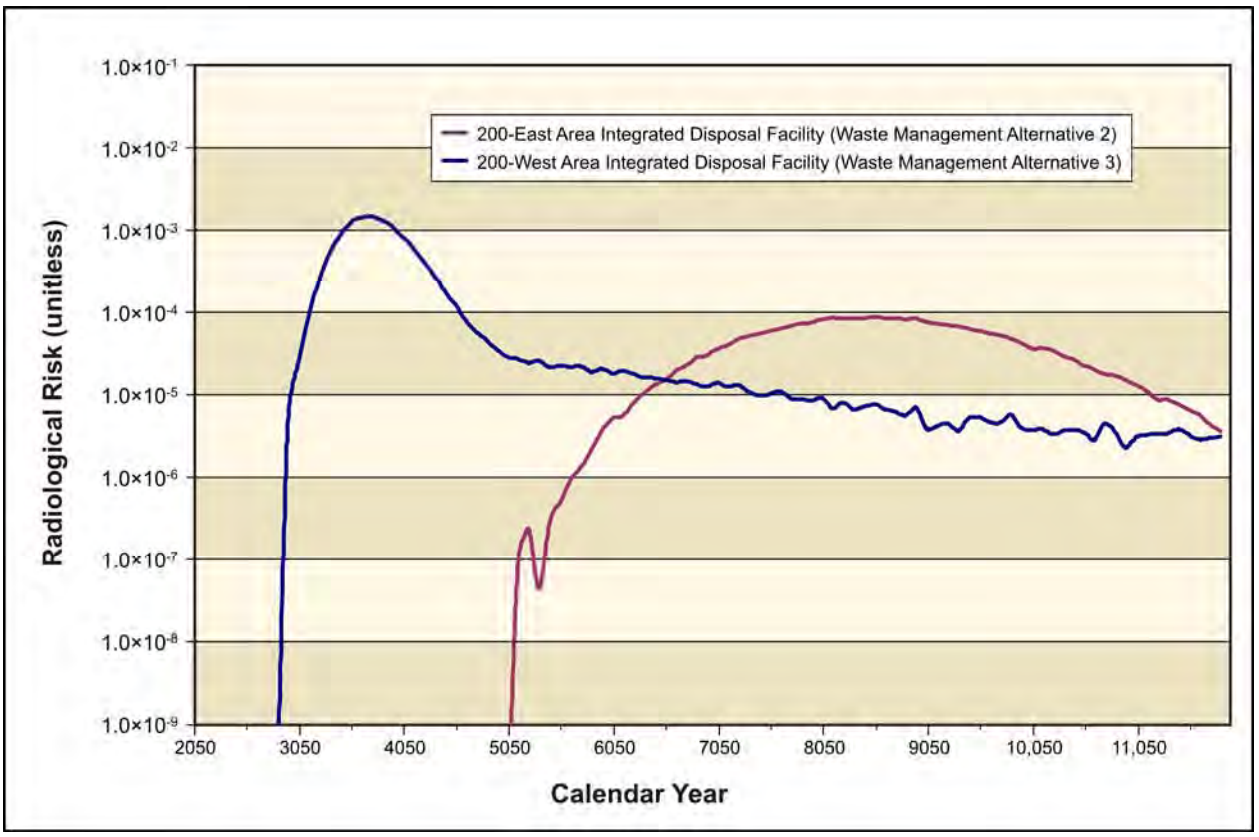


Figure 2–131. Lifetime Radiological Risk for the Drinking-Water Well User at the 200-East and 200-West Area Integrated Disposal Facility Barriers

Table 2–48. Maximum Concentrations of Technetium-99 and Iodine-129 in the Peak Year at the IDF-East and IDF-West Barriers

Contaminant	IDF-East (Waste Management Alternative 2)	IDF-West (West Management Alternative 3)	Benchmark Concentration
Radionuclide in picocuries per liter			
Technetium-99	1910	20,200	900
	(9005)	(3713)	
Iodine-129	18	173	1
	(8196)	(3797)	

Note: Corresponding calendar years are shown in parentheses.
Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility.

Disposal of Offsite Waste. Under Waste Management Alternatives 2 and 3, waste from other DOE facilities (i.e., offsite waste) is accepted and disposed of on site in an IDF. Under Waste Management Alternative 2, offsite waste is disposed of in IDF-East; under Waste Management Alternative 3, offsite waste is disposed of in IDF-West. The analysis shows that receipt of offsite waste streams that contain specified amounts of certain radionuclides, specifically iodine-129 and technetium-99, could have an adverse impact on the environment. Comparison of estimates of human health impacts at the IDF-East barrier under Waste Management Alternatives 2 and 3 for Tank Closure Alternative 2B, (see Figure 2–132) illustrates this finding. Estimates of radiological risk for Waste Management Alternative 2, which includes the disposal of offsite waste at IDF-East, are a factor of

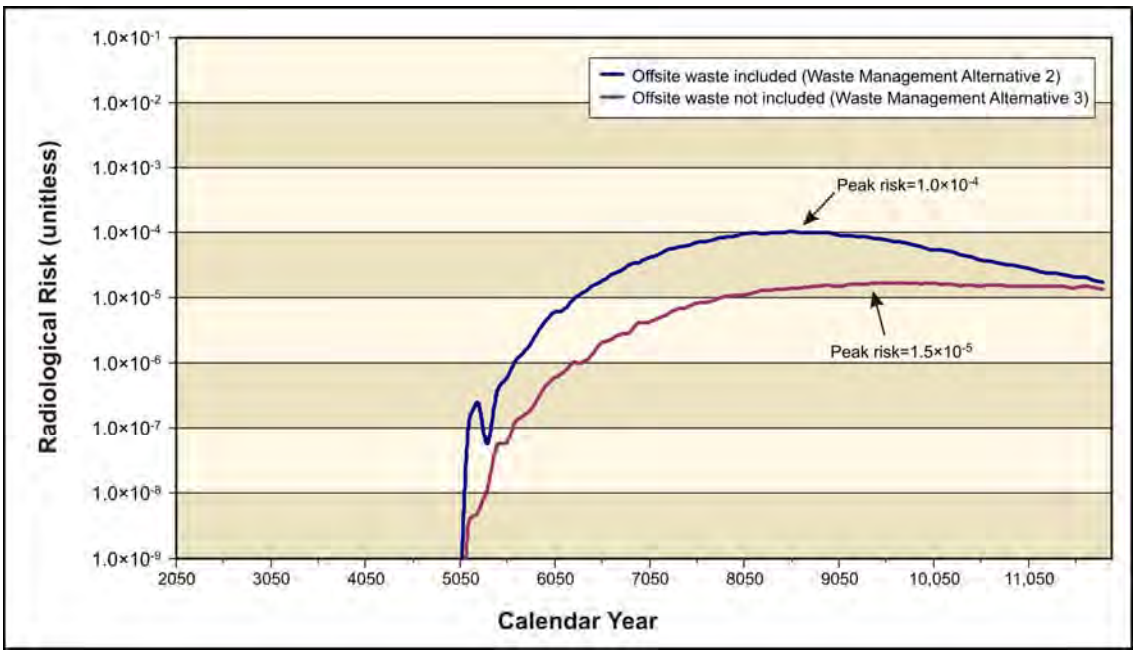


Figure 2–132. Tank Closure Alternative 2B Lifetime Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

approximately seven higher than those under Waste Management Alternative 3, which does not include disposal of offsite waste at IDF-East. Table 2–49 provides the estimated concentrations at the year of peak concentration for two of the predominant contaminants, technetium-99 and iodine-129, at the IDF-East barrier. Under both alternatives, as shown by the analysis, certain radionuclides, specifically technetium-99 and iodine-129 in offsite waste, are major contributors to groundwater impacts.

Table 2–49. Maximum Concentrations of Technetium-99 and Iodine-129 in the Peak Year at the IDF-East Barrier

Contaminant	Waste Management Alternative 2	Waste Management Alternative 3	Benchmark Concentration
Radionuclide in picocuries per liter			
Technetium-99	1910	471	900
	(9005)	(8991)	
Iodine-129	18	1.4	1
	(8196)	(11,243)	

Note: Corresponding calendar years are shown in parentheses.
Key: IDF-East=200-East Area Integrated Disposal Facility.

Disposal of Tank Closure Waste in the RPPDF. Waste Management Alternatives 2 and 3 would include construction and operation of the RPPDF for the disposal of lightly contaminated equipment and soils from closure activities. As shown in Figure 2–133, the RPPDF is a secondary contributor to human health impacts (radiological risk to the drinking-water well user) at the Core Zone Boundary throughout the period of analysis; the estimated radiological risks are less than 1×10^{-4}. The figure shows the higher lifetime radiological risk (approaching 1×10^{-4}) under Tank Closure Alternative 6B, Base Case, which is due to the disposal of large amounts of vadose zone sediments excavated from all SST farms, compared with the estimates under Tank Closure Alternative 4, which are due to disposal of vadose zone sediments from only two SST farms (BX and SX).

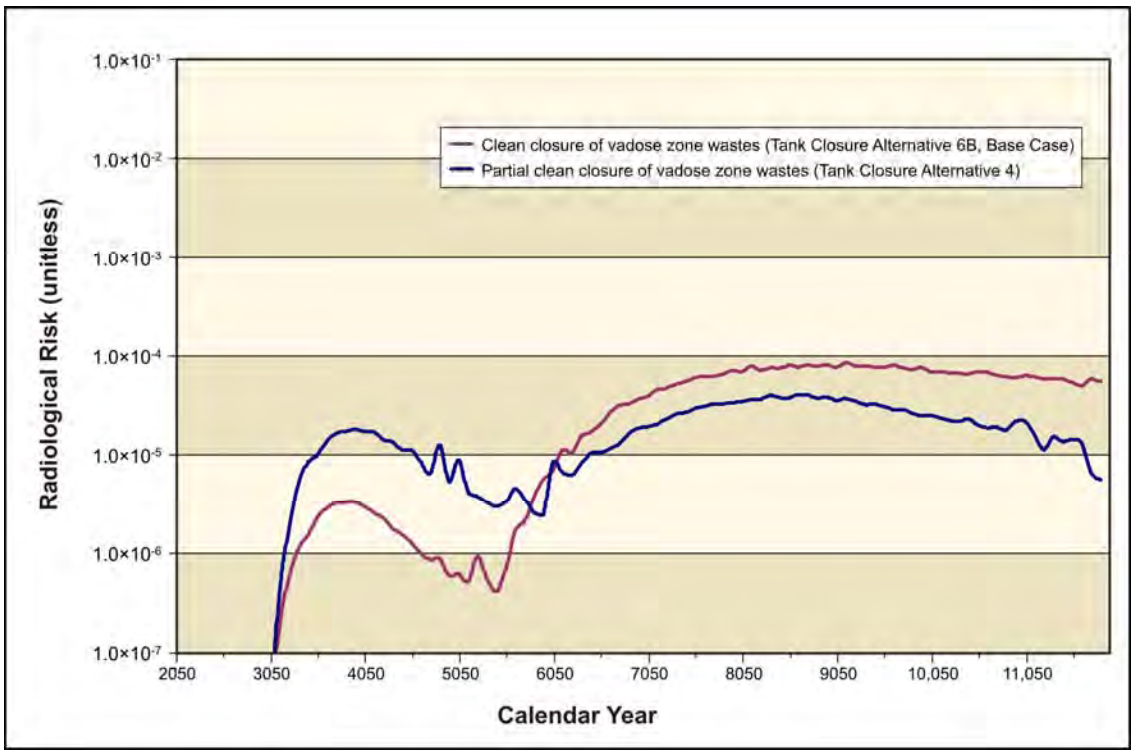


Figure 2–133. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary from River Protection Project Disposal Facility Releases

2.11 COST OF THE ALTERNATIVES

The *Cost Report for "Tank Closure and Waste Management Environmental Impact Statement" Alternatives* was prepared to estimate the consolidated costs for continued operation of existing facilities; construction, operations, and deactivation of new or modified facilities; and associated activities to support the proposed actions (e.g., waste form disposal costs) (DOE 2009).[15] The costs were calculated using constant 2008 dollars. Because the alternatives cover a broad range of remediation and closure pathways, the estimates developed for the various alternatives span a wide range of potential costs.[16]

Each of the *TC & WM EIS* Tank Closure, FFTF Decommissioning, and Waste Management alternatives is affected by uncertainties that influence confidence in the cost estimate. The following are among the uncertainties common to most of the alternatives (DOE 2009:3–23 to 3–27).

- **Conservative estimates.** NEPA analysis provides an understanding of the potential environmental impacts associated with the proposed actions and the alternatives. Conservative estimates of labor and material requirements, technology performance, and other aspects of the alternatives were adopted. To the extent that conservatism is inherent in the components of the alternatives, the cost estimate for the alternatives reflects higher costs than the point estimates developed for allocation of budgets and other planning exercises.

[15] In an EIS, the costs estimated and presented for each alternative are different in nature than the cost estimates used to support the annual DOE budget process (such as the budget estimates for RPP contracts). Budgets to support DOE contracts typically address a near-term timeframe (generally within 5 years) because more-specific information regarding discrete work activities is generally available with a higher degree of certainty.

[16] Because of the wide range of potential costs, the higher Tank Closure alternatives costs are presented in billions of 2008 dollars, whereas the lower FFTF Decommissioning and Waste Management alternatives costs are presented in millions of 2008 dollars.

- **Scope definition.** The level of definition associated with the alternatives and/or specific work elements contributes to uncertainty. Cost estimates based on limited definition (planning-level estimates or preconceptual data) are more uncertain than estimates based on detailed design information. Furthermore, there may be greater uncertainty regarding cost estimates for activities involving unspecified radiological and chemical inventories (e.g., resulting from soil remediation) because of the unknown impact the actual inventory may have on remediation costs.
- **Schedule and duration of activities.** With the exception of the No Action Alternatives, each alternative includes durations for completing the waste retrieval and TSD components of the RPP mission, as well as the deactivation and closure components, which vary among the alternatives. Cost estimates based on projecting current costs far into the future introduce other significant uncertainties. These uncertainties are driven by economic conditions and labor and material markets; changes in regulatory, technical, and safety requirements; political, scientific, and cultural conditions; and technological advances. All of the alternatives also assume a 100-year period of administrative controls/postclosure care following completion of D&D and/or closure activities. Cost estimates for activities extending into the next century are inherently uncertain and should be interpreted as only rough estimates used to describe the total cost of an alternative and the relative cost differences among the alternatives.
- **Development and use of technologies.** With the exception of the No Action Alternatives, each alternative involves development and use of unique, specialty technologies to address complex problems. These technologies are in varying stages of completion, ranging from conceptual design to pilot demonstration to full-scale construction. Consequently, in estimating costs, technology performance (e.g., facility throughputs, waste loading, separations efficiencies) was assumed based upon the design criteria. Should these key performance assumptions be found invalid, impacts on the alternative cost, schedule, and scope would occur.
- **Dependence upon external interfaces.** Many of the alternatives depend on the ability of WIPP and onsite disposal facilities to accept and dispose of waste forms (e.g., CH- and RH-mixed TRU waste). Impacts on various alternatives' cost, schedule, and scope would occur if the adopted assumptions for each of the alternatives proved invalid.
- **Embedded costs.** Efforts were made to remove embedded escalation costs, management reserves, contingency fees, and other fees (e.g., WTP estimate-at-completion values from the source data when the contribution of these overall cost additions were clearly identified in source documentation.)
- **Disposal costs.** Actual disposal costs are not currently available. Only estimated disposal costs based on the assumed waste types, quantities, and radiological content have been published. The estimated disposal costs will continue to vary as disposal facilities near completion, disposal quantities and types are modified, and cost bases are refined.

2.11.1 Tank Closure Alternatives

Cost estimates for each Tank Closure alternative are provided in Tables 2–50 through 2–52. Table 2–50 provides the estimated potential costs of construction, operations, and deactivation for each of the primary components of the proposed actions (storage, retrieval, treatment, disposal, and closure); costs for final waste form disposal on or off site are excluded. Table 2–51 provides the costs of final waste form disposal both on and off site by alternative. These costs represent the post-treatment disposal costs for ILAW, mixed TRU waste, MLLW, LLW, melters taken out of service, and HLW shielded boxes. Offsite disposal costs for IHLW are not included in the cost data. Alternatives that generate higher volumes of IHLW could ultimately have proportionally higher transportation and disposal costs. No credit was taken for cost-reducing actions such as waste volume reduction, alternative waste packaging, or use of alternative disposal sites.

Table 2–50. Tank Closure Alternatives – Summary Cost Estimates,[a] Excluding Waste Form Disposal Costs (billions of 2008 dollars)

Work Element	Storage	Retrieval	Treatment	Disposal[b]	Closure	Total[c]
Alternative 1: No Action						
Construction	0.02	--	1.9	--	--	2.0
Operations	0.6	--	--	--	--	0.6
Deactivation	0.4	--	--	--	--	0.4
Total[c]	**1.0**	**--**	**1.9**	**--**	**--**	**3.0**
Alternative 2A: Existing WTP Vitrification; No Closure						
Construction	3.5	2.8	14.7	1.2	--	22.1
Operations	16.0	2.1	24.5	1.0	0.7	44.3
Deactivation	0.4	0.1	0.9	<0.01	--	1.4
Total[c]	**19.8**	**5.1**	**40.2**	**2.2**	**0.7**	**67.9**
Alternative 2B: Expanded WTP Vitrification; Landfill Closure						
Construction	1.5	2.6	8.7	1.5	2.3	16.6
Operations	7.1	1.5	11.3	0.7	0.5	21.1
Deactivation	--	0.1	0.6	<0.01	1.8	2.5
Total[c]	**8.6**	**4.2**	**20.6**	**2.1**	**4.6**	**40.1**
Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure						
Construction	1.5	2.6	8.1	1.6	2.3	16.2
Operations	6.4	1.4	11.0	0.7	0.5	19.9
Deactivation	--	0.1	0.5	<0.01	1.8	2.4
Total[c]	**7.9**	**4.2**	**19.6**	**2.3**	**4.6**	**38.5**
Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure						
Construction	1.5	2.6	7.9	1.6	2.3	15.9
Operations	6.4	1.4	11.2	0.7	0.5	20.1
Deactivation	--	0.1	0.5	<0.01	1.8	2.4
Total[c]	**7.9**	**4.2**	**19.6**	**2.3**	**4.6**	**38.4**
Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure						
Construction	1.5	2.6	9.5	1.6	2.3	17.5
Operations	6.4	1.4	11.0	0.7	0.5	19.9
Deactivation	--	0.1	0.5	<0.01	1.8	2.4
Total[c]	**7.9**	**4.2**	**21.0**	**2.3**	**4.6**	**39.8**

Table 2–50. Tank Closure Alternatives – Summary Cost Estimates,[a] Excluding Waste Form Disposal Costs (billions of 2008 dollars) *(continued)*

Work Element	Storage	Retrieval	Treatment	Disposal[b]	Closure	Total[c]
Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure						
Construction	1.5	3.6	8.0	1.6	3.0	17.8
Operations	6.9	1.8	11.9	0.7	2.5	23.7
Deactivation	--	0.2	0.5	<0.01	1.4	2.1
Total[c]	**8.4**	**5.6**	**20.4**	**2.3**	**6.9**	**43.6**
Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure						
Construction	1.8	2.1	8.4	1.3	2.2	15.9
Operations	5.4	1.1	8.7	0.7	0.3	16.3
Deactivation	--	0.1	0.6	<0.01	0.8	1.5
Total[c]	**7.3**	**3.4**	**17.7**	**1.9**	**3.4**	**33.7**
Alternative 6A: All Vitrification/No Separations; Clean Closure						
Construction	8.1 *8.1*	5.1 *5.1*	21.8 *21.8*	69.9 *69.9*	2.6 *3.8*	107.5 *108.7*
Operations	28.7 *28.7*	3.4 *3.4*	48.6 *48.6*	36.2 *36.2*	10.9 *21.0*	127.8 *138.0*
Deactivation	--	0.3 *0.3*	1.4 *1.4*	<0.01 *<0.01*	3.2 *3.6*	4.9 *5.3*
Total[c]	**36.8** ***36.8***	**8.8** ***8.8***	**71.8** ***71.8***	**106.1** ***106.1***	**16.6** ***28.4***	**240.1** ***251.9***
Alternative 6B: All Vitrification with Separations; Clean Closure[d]						
Construction	1.5 *1.5*	3.6 *3.6*	8.8 *8.8*	3.2 *3.2*	2.6 *3.8*	19.7 *20.9*
Operations	7.1 *7.1*	1.8 *1.8*	12.3 *12.3*	0.7 *0.7*	9.3 *19.5*	31.1 *41.3*
Deactivation	--	0.2 *0.2*	0.6 *0.6*	<0.01 *<0.01*	3.2 *3.6*	4.0 *4.4*
Total[c]	**8.6** ***8.6***	**5.6** ***5.6***	**21.7** ***21.7***	**3.8** ***3.8***	**15.1** ***26.9***	**54.8** ***66.6***
Alternative 6C: All Vitrification with Separations; Landfill Closure						
Construction	1.5	2.6	8.7	2.3	2.3	17.3
Operations	7.1	1.5	11.2	0.7	0.5	20.9
Deactivation	--	0.1	0.6	<0.01	1.8	2.5
Total[c]	**8.6**	**4.2**	**20.4**	**2.9**	**4.6**	**40.7**

[a] Estimates are costs to the Hanford Site only.
[b] Includes post-treatment storage. Costs for disposal of the final waste forms (i.e., low-activity waste and transuranic waste) are presented separately in Table 2–51.
[c] Total may not equal the sum of the contributions due to rounding.
[d] Values presented are for Base Case. Values for the Option Case (additional clean closure of six adjacent cribs and trenches [ditches]) are presented in italics.

Note: Costs associated with the 100-year administrative and/or institutional control periods were assigned in the following manner: Alternatives 1 and 2A under "Storage" and all other alternatives under "Closure."
Key: WTP=Waste Treatment Plant.
Source: DOE 2009:Table 4–1.

Table 2–51. Tank Closure Alternatives – Costs for Final Waste Form Disposal (billions of 2008 dollars)

Tank Closure Alternative		Final Waste Form Disposal Costs
1	No Action	--
2A	Existing WTP Vitrification; No Closure	0.3
2B	Expanded WTP Vitrification; Landfill Closure	0.8
3A	Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	1.3
3B	Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	1.5
3C	Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	1.5
4	Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	2.0
5	Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	0.8
6A	All Vitrification/No Separations; Clean Closure[a]	2.8 *9.2*
6B	All Vitrification with Separations; Clean Closure[a]	2.8 *9.1*
6C	All Vitrification with Separations; Landfill Closure	0.6

[a] Values presented are for the Base Case. Values for the Option Case (additional clean closure of six adjacent cribs and trenches [ditches]) are presented in italics.

Key: WTP=Waste Treatment Plant.

Source: DOE 2009:Table 5–1.

The highest relative costs would apply to Tank Closure alternatives with more restrictive scopes (i.e., 99.9 percent retrieval of SST waste and/or clean closure components [Alternatives 4, 6A, and 6B]); extended schedules (Alternatives 2A and 6A); and high waste-form disposal costs (Alternatives 6A and 6B). These higher costs would be driven by required construction of treatment systems; longer relative operating schedules for waste treatment and tank farm facilities; and clean closure of the SST farms (Alternatives 6A and 6B).

DOE would proceed with onsite disposal of some of the final waste forms (e.g., ILAW) only if their disposal complies with applicable laws. Table 2–52 combines the cost data in Tables 2–50 and 2–51 to project a total cost for each Tank Closure alternative.

Table 2–52. Tank Closure Alternatives – Total Cost Projections, Including Waste Disposal Costs (billions of 2008 dollars)[a]

Tank Closure Alternative		Total Cost
1	No Action	3.0
2A	Existing WTP Vitrification; No Closure	68.2
2B	Expanded WTP Vitrification; Landfill Closure	40.9
3A	Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	39.8
3B	Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	39.9
3C	Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	41.3

Table 2–52. Tank Closure Alternatives – Total Cost Projections, Including Waste Disposal Costs (billions of 2008 dollars) *(continued)*

Tank Closure Alternative		Total Cost
4	Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	45.6
5	Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	34.5
6A	All Vitrification/No Separations; Clean Closure[b]	242.9 *261.1*
6B	All Vitrification with Separations; Clean Closure[b]	57.6 *75.7*
6C	All Vitrification with Separations; Landfill Closure	41.3

[a] Offsite disposal costs for immobilized high-level radioactive waste not included.

[b] Values presented are for the Base Case. Values for the Option Case (additional clean closure of six adjacent cribs and trenches [ditches]) are presented in italics.

Key: WTP=Waste Treatment Plant.

Source: Tables 2–50 and 2–51.

2.11.2 FFTF Decommissioning Alternatives

Table 2–53 provides summary cost estimates for each of the FFTF Decommissioning alternatives in terms of construction, operations, and deactivation. Table 2–54 presents the separate projected waste disposal costs for each alternative, as well as the projected waste volumes produced under each alternative, as the disposal costs shown depend on the type and quantities of waste produced. Table 2–55 combines the data in Tables 2–53 and 2–54 to provide the total estimated cost of each FFTF Decommissioning alternative.

Table 2–53. FFTF Decommissioning Alternatives – Summary Cost Estimates, Excluding Waste Form Disposal Costs (millions of 2008 dollars)

	FFTF Decommissioning Alternatives				
Work Element	**Alternative 1: No Action[a]**	**Alternative 2: Entombment**		**Alternative 3: Removal**	
Facility Disposition					
Construction	--	3.9		2.5	
Operations	--	99.1		109.2	
Deactivation	492.5	0.7		0.3	
Subtotal[b, c]	**492.5**	**103.7**		**112.1**	
Work Element		**Hanford Option[d]**	**Idaho Option[e]**	**Hanford Option[d]**	**Idaho Option[e]**
Disposition of Bulk Sodium	--	**64.3**	**33.9**	**64.3**	**33.9**
Disposition of RH-SCs[b]	--	**121.1**	**121.2**	**121.1**	**121.2**

[a] The No Action Alternative includes 100 years of surveillance and maintenance activities.

[b] Costs for disposal of the final waste forms are presented separately in Table 2–54.

[c] Subtotal may not equal the sum of the contributions due to rounding.

[d] Hanford Reuse Option for disposition of bulk sodium.

[e] Idaho Reuse Option for disposition of bulk sodium.

Key: FFTF=Fast Flux Test Facility; RH-SCs=remote-handled special components.

Source: DOE 2009:Table 4–3.

Table 2–54. FFTF Decommissioning Alternatives – Waste Form Disposal Cost Estimates

Waste Category (cubic meters disposed of)	Alternative 1: No Action[a]	Alternative 2: Entombment[b]	Alternative 3: Removal[b]
Low-level radioactive waste	1,700	140	750
Mixed low-level radioactive waste	60	670	280
Hazardous waste	400	--	60
Nonhazardous waste	--	460	460
Disposal Cost (millions of 2008 dollars)	**2.1**	**0.9**	**1.1**

[a] Waste volumes are secondary solid waste only.

[b] Waste volumes are a summation of primary and secondary solid waste and are not expected to differ between the Hanford or Idaho options for disposition of remote-handled special components and bulk sodium.

Note: To convert cubic meters to cubic feet, multiply by 35.315.

Key: FFTF=Fast Flux Test Facility.

Source: DOE 2009:Table 5-5.

Table 2–55. FFTF Decommissioning Alternatives – Total Cost Projections, Including Waste Disposal Costs (millions of 2008 dollars)

FFTF Decommissioning Alternatives		Total Cost
1	**No Action**	494.6
2	**Entombment**	
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Hanford Reuse Option	290.1
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Idaho Reuse Option	259.6
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Hanford Reuse Option	289.9
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Idaho Reuse Option	259.7
3	**Removal**	
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Hanford Reuse Option	298.7
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Idaho Reuse Option	268.1
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Hanford Reuse Option	298.5
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Idaho Reuse Option	268.3

Key: FFTF=Fast Flux Test Facility; RH-SCs=remote-handled special components.

Source: Tables 2–53 and 2–54.

2.11.3 Waste Management Alternatives

Table 2–56 provides the summary cost estimates for each of the Waste Management alternatives in terms of construction, operations, and deactivation of treatment and storage activities, as well as the construction, operations, closure, and transportation activities that would occur in association with each disposal group. Table 2–57 presents the separate costs for disposal of offsite-generated LLW and MLLW; onsite-generated non-CERCLA, nontank waste; and secondary waste from disposal operations.

These disposal costs do not differentiate between on- and offsite waste generators and are presented only for Waste Management Alternatives 2 and 3 (Waste Management Alternative 1: No Action, would not receive any waste for disposal). Table 2–58 combines the data in Tables 2–56 and 2–57 to provide the total estimated cost of each Waste Management alternative.

Table 2–56. Waste Management Alternatives – Summary Cost Estimates, Excluding Waste Form Disposal Costs (millions of 2008 dollars)

Work Element	Alternative 1: No Action	Alternative 2: Disposal in IDF, 200-East Area Only			Alternative 3: Disposal in IDF, 200-East and 200-West Areas		
Treatment and Storage							
Construction	--	337.9			337.9		
Operations	17.5	2,016.0			2,016.0		
Deactivation	451.3	30.7			30.7		
Subtotal	**468.8**	**2,384.5**			**2,384.5**		
Disposal		**Group 1**	**Group 2**	**Group 3**	**Group 1**	**Group 2**	**Group 3**
Construction	--	118.9	459.3	459.3	118.5	459.7	459.7
Operations	--	649.9	5,268.9	9,465.3	647.0	5,242.0	9,399.8
Closure	--	946.2	1,128.9	1,128.9	1,386.4	1,570.3	1,570.3
Transportation[a]	--	521.5	521.5	521.5	521.5	521.5	521.5
Subtotal	**--**	**2,236.5**	**7,378.5**	**11,575.0**	**2,673.4**	**7,793.6**	**11,951.3**
Total[b]	**468.8**	**4,621.1**	**9,763.1**	**13,959.5**	**5,057.9**	**10,178.1**	**14,335.9**

[a] Costs associated with transportation of offsite low-level radioactive waste and mixed low-level radioactive waste to Hanford for disposal. The waste quantity, generation location, and transportation distance are the same for each disposal group.

[b] Total may not equal the sum of the contributions due to rounding. Costs for disposal of the final waste forms are presented separately in Table 2–57.

Key: IDF=Integrated Disposal Facility.

Source: DOE 2009:Tables 4-2, 4-4, and 4-5.

Table 2–57. Waste Management Alternatives – Waste Form Disposal Costs

Waste Category (cubic meters disposed of)	Alternative 1: No Action[a]	Alternative 2: Disposal in IDF, 200-East Area Only	Alternative 3: Disposal in IDF, 200-East and 200-West Areas
Offsite-generated LLW and MLLW	--	82,000	82,000
Onsite-generated non-CERCLA, nontank waste	--	5,300	5,300
Secondary waste	--	3,000	3,000
Disposal Cost (millions of 2008 dollars)	**--**	**96.1**	**96.1**

[a] No waste would be received for disposal under this alternative.

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; IDF=Integrated Disposal Facility; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste.

Source: DOE 2009:Table 5-4.

Table 2–58. Waste Management Alternatives – Total Cost Projections, Including Waste Disposal Costs (millions of 2008 dollars)

Waste Management Alternatives		Total Cost
1	**No Action**	468.8
2	**Disposal in IDF, 200-East Area Only**	
	Disposal Group 1	4,717.2
	Disposal Group 2	9,859.2
	Disposal Group 3	14,055.6
3	**Disposal in IDF, 200-East and 200-West Areas**	
	Disposal Group 1	5,154.0
	Disposal Group 2	10,274.2
	Disposal Group 3	14,432.0

Key: IDF=Integrated Disposal Facility.
Source: Tables 2–56 and 2–57.

2.12 PREFERRED ALTERNATIVES

Council on Environmental Quality regulations require an agency to identify its preferred alternative(s), if one or more exists, in a draft EIS (40 CFR 1502.14e). The preferred alternative is the alternative that the agency believes would fulfill its statutory mission while giving consideration to environmental, economic, technical, and other factors.

This *TC & WM EIS* considers three sets of actions: tank closure, FFTF decommissioning, and waste management. The range of reasonable approaches to these three sets of actions is covered by a total of 17 alternatives.

Tank closure. Eleven alternatives for potential tank closure actions are evaluated in this draft EIS. These alternatives cover tank waste retrieval and treatment, as well as closure of the SSTs. DOE does not have specific preferred alternatives for retrieval or treatment of the tank waste, but has identified a range of preferred retrieval and treatment options. For retrieval, DOE prefers Tank Closure alternatives that would retrieve at least 99 percent of the tank waste. All Tank Closure alternatives would do this, with the exception of Alternative 1 (No Action) and Alternative 5. For treatment, DOE prefers Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5 because they would allow separation and segregation of the tank waste for management and disposition as LLW and HLW, according to the risks posed. In contrast, DOE does not prefer Tank Closure Alternatives 6A, 6B, or 6C because they would treat all tank waste as HLW. For closure of the SSTs, DOE prefers landfill closure, as provided under Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C, for the reasons described in Section 2.10.1. The Tank Closure alternatives that capture each of DOE's preferred retrieval, treatment, and closure options are Alternatives 2B, 3A, 3B, and 3C. For storage, DOE prefers Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5. These alternatives assume shipment of IHLW canisters for disposal off site.[17]

[17] As indicated in the Administration's fiscal year 2010 budget request, the Administration intends to terminate the Yucca Mountain program while developing nuclear waste disposal alternatives. Notwithstanding the decision to terminate the Yucca Mountain program, DOE remains committed to meeting its obligations to manage and ultimately dispose of HLW and SNF. The Administration intends to convene a blue ribbon commission to evaluate alternative approaches for meeting these obligations. The commission will provide the opportunity for a meaningful dialogue on how best to address this challenging issue and will provide recommendations that will form the basis for working with Congress to revise the statutory framework for managing and disposing of HLW and SNF.

Specific to this draft EIS, the inventory contained in the IHLW canisters is not included in the long-term groundwater analysis because it was assumed the canisters would be shipped off site. It was assumed in the EIS that the canisters would not be shipped immediately after the IHLW generation. Storage capacity was analyzed under the short-term impact analysis for on site IHLW interim storage. The number of storage facilities need to store the IHLW canisters on site is one more than the number of canister storage facilities analyzed under Tank Closure Alternative 2B. DOE expects the impacts to be similar.

FFTF decommissioning. There are three FFTF Decommissioning alternatives from which the Preferred Alternative was identified: (1) No Action, (2) Entombment, and (3) Removal. DOE's Preferred Alternative for FFTF decommissioning is Alternative 2: Entombment, which would remove all above-grade structures, including the reactor building. Below-grade structures, the reactor vessel, piping, and other components would remain in place and be filled with grout to immobilize the remaining and hazardous constituents. Waste generated from these activities would be disposed of in an IDF, and a modified RCRA Subtitle C barrier would be constructed over the filled area. The RH-SCs would be processed at INL, but bulk sodium inventories would be processed at Hanford.

Waste management. Three Waste Management alternatives were identified for the proposed actions: (1) Alternative 1: No Action, under which all onsite-generated LLW and MLLW would be treated and disposed of in the existing, lined 218-W-5 LLBG trenches and no offsite-generated waste would be accepted; (2) Alternative 2, which would continue treatment of onsite-generated LLW and MLLW in expanded, existing facilities and dispose of onsite-generated and previously treated offsite-generated LLW and MLLW in a single IDF (IDF-East); and (3) Alternative 3, which also would continue treatment of onsite-generated LLW and MLLW in expanded, existing facilities, but would dispose of onsite-generated and previously treated offsite-generated LLW and MLLW in two IDFs (IDF-East and IDF-West). DOE's Preferred Waste Management Alternative is Alternative 2, disposal of onsite-generated LLW and MLLW waste streams in a single IDF (IDF-East). Disposal of single shell tank closure waste, that is not highly contaminated, such as rubble, soils, and ancillary equipment in the RPPDF are also included under this alternative. After completion of disposal activities, IDF-East and the RPPDF would be landfill-closed under an engineered modified RCRA Subtitle C barrier. The preferred alternative also includes limitations and exemptions on off-site waste importation at Hanford until at least the Waste Treatment Plant is operational, as those limitations and exemptions are defined in DOE's January 6, 2006 Settlement Agreement with the State (as amended on June 5, 2008) regarding *Washington v. Bodman*, No. 2:03-cv-05018-AAM.

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DOE Order 430.1B, *Real Property Asset Management*, September 24, 2003.

DOE Order 435.1, *Radioactive Waste Management*, Change 1, August 28, 2001.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, Change 2, January 7, 1993.

DOE Standard 1098-99, *Radiological Control*, July 1999.

CHAPTER 3
AFFECTED ENVIRONMENT

In Chapter 3, the affected environment descriptions of the Hanford Site and Idaho National Laboratory are presented to provide the context for understanding the environmental consequences described in Chapter 4. As such, they serve as a baseline from which any environmental changes that may be brought about by implementing the proposed actions and alternatives can be identified and evaluated; the baseline conditions are the existing conditions. The affected environment is described for the following impact areas: land resources, infrastructure, noise and vibration, air quality, geology and soils, water resources, ecological resources, cultural and paleontological resources, socioeconomics, existing human health risk, environmental justice, waste management, and spent nuclear fuel.

3.1 APPROACH TO DEFINING THE AFFECTED ENVIRONMENT

This chapter describes the environment at both the Hanford Site (Hanford) and Idaho National Laboratory (INL) that could be affected through actions evaluated in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*. For each resource area, this environmental impact statement (EIS) describes first the existing environment of each site as a whole and then that of the areas of each site within which the proposed actions would take place.

The U.S. Department of Energy (DOE) evaluated the environmental impacts of the proposed actions within defined regions of influence (ROIs). These ROIs are specific to the resource area evaluated; encompass geographic areas within which any meaningful impact is expected to occur; and can include the areas within which the proposed actions would take place, the sites as a whole, or nearby or distant offsite areas. For example, impacts on historic resources were evaluated at specific facility locations within each site, whereas human health risks to the general public from exposure to airborne radiological contaminant emissions were assessed for an area within an 80-kilometer (50-mile) radius of the facility locations. Economic effects such as job and income changes were evaluated within a socioeconomic ROI that includes the counties in which each site is located and nearby counties in which a substantial portion of the site's workforce resides. Brief descriptions of the ROIs for each resource area are given in Table 3–1.

Baseline conditions for each environmental resource area were determined from information provided in previous EISs and environmental studies, other government reports and databases, and relevant laws and regulations. The *Hanford Site National Environmental Policy Act (NEPA) Characterization (Hanford NEPA Characterization Report)* (Duncan 2007); *Hanford Site Environmental Report for Calendar Year 2006 (Including Some Early 2007 Information) (Hanford Site Environmental Report)* (Poston et al. 2007); and *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DOE 2002a) were important sources of information on the affected environment at Hanford and INL.

3.2 HANFORD SITE

American Indians used the area along the Columbia River in eastern Washington, including the area occupied by Hanford, for thousands of years for fishing, hunting, and gathering. Following the expedition of Lewis and Clark, which reached the Hanford area in 1805, use of the land began to change as fur traders and settlers populated the area. By the beginning of the twentieth century, much of the area was used for farming and grazing (DOE 1999a:4-1, 4-3). The Hanford Engineer Works was established in 1943 as one of the three original Manhattan Project sites. Hanford occupies approximately 151,775 hectares (375,040 acres) in Washington State, just north of Richland (Duncan 2007:4.1).

Table 3–1. General Regions of Influence for the Affected Environment

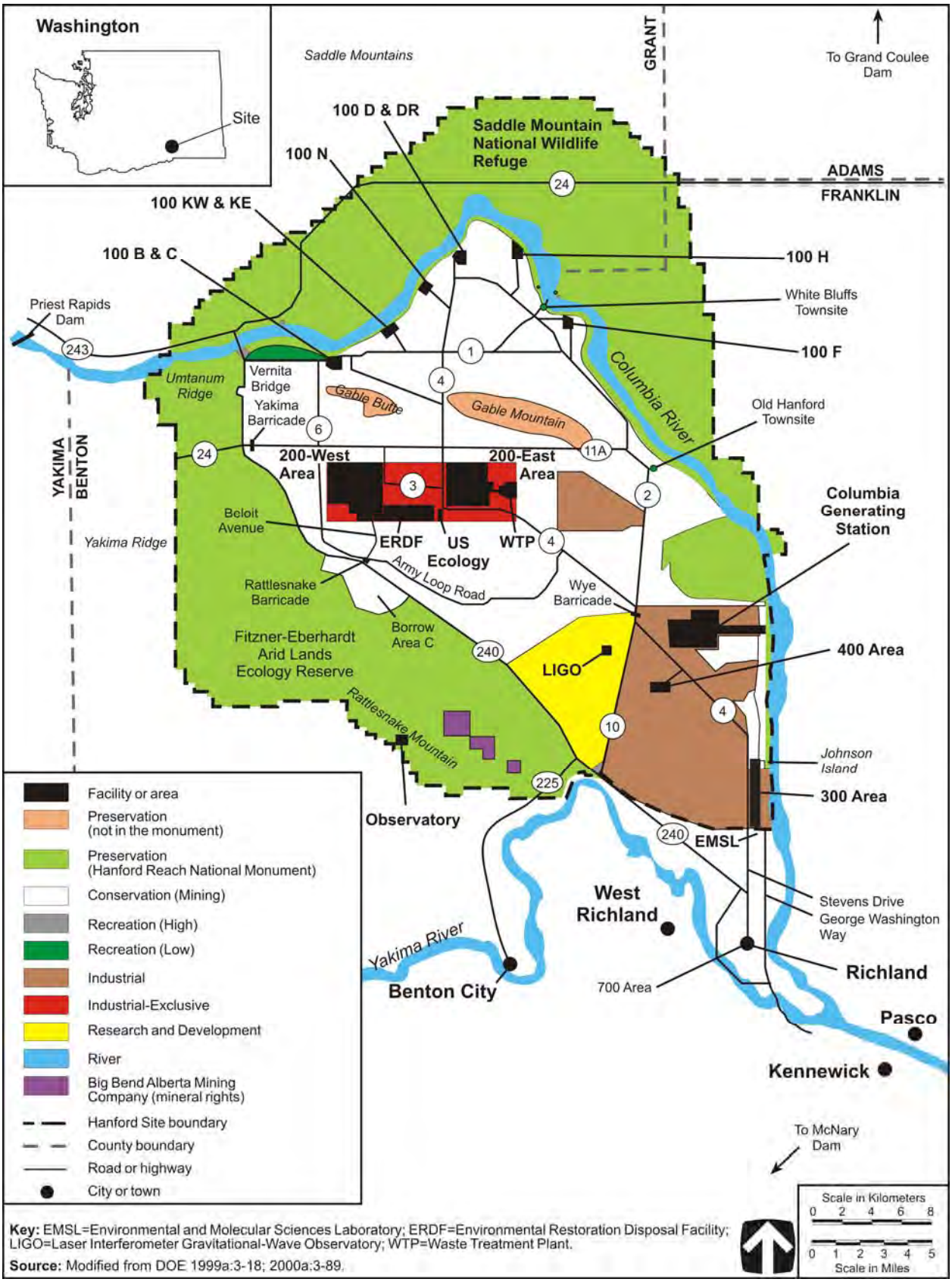
Environmental Resource Area	Region of Influence
Land resources	The proposed action areas,[a] the site, and areas immediately adjacent to the site
Infrastructure	The proposed action areas, the site, and local areas supporting the site
Noise and Vibration	The proposed action areas, the site, nearby offsite areas, and access routes to the site
Air quality	The proposed action areas, the site, and nearby offsite areas within local air quality control regions
Geology and soils	The proposed action areas, the site, and nearby offsite areas
Water resources	The proposed action areas, the site, and adjacent surface-water bodies and groundwater
Ecological resources	The proposed action areas, the site, and nearby offsite areas
Cultural and paleontological resources	The proposed action areas and the site
Socioeconomics	The counties where at least 90 percent of site employees reside
Existing human health risk	The proposed action areas, the site, offsite areas within 80 kilometers of the site, and the transportation corridors
Environmental justice	Offsite areas within 80 kilometers of the site and along the transportation corridors between the sites
Waste management	Site waste management facilities

[a] Proposed action areas are the 200 Areas, 400 Area, and Borrow Area C for the Hanford Site and the Fuel Manufacturing Facility for Idaho National Laboratory.

Note: To convert kilometers to miles, multiply by 0.6214.

The site extends over parts of Adams, Benton, Franklin, and Grant Counties (see Figure 3–1). In the past, Hanford was a U.S. Government defense materials production site that included nuclear reactor operation; uranium and plutonium processing; the storage and processing of spent nuclear fuel (SNF); and the management of radioactive, hazardous, and state dangerous wastes. The current mission at Hanford includes managing waste products, cleaning up the site, researching new ideas and technologies for waste disposal and cleanup, and reducing the size of the site (Poston et al. 2007:v, E.3). Present Hanford programs are diversified and include the management of radioactive waste; cleanup of waste sites, soil, and groundwater related to past releases; stabilization and storage of SNF; research into renewable energy and waste disposal technologies; cleanup of contamination; and stabilization and storage of plutonium.

Hanford is owned and used primarily by DOE, but portions of it are owned, leased, or administered by other Government agencies. Public access to the site is limited to travel on the Route 4 and Route 10 access roads as far as the Wye Barricade, State Routes 24 and 240, and the Columbia River. By restricting access, the public is shielded from portions of the site formerly used for the production of nuclear materials and currently used for waste storage and disposal. Only about 6 percent of the land area has been disturbed and is actively used, leaving mostly vacant land with widely scattered facilities (Neitzel 2005:4.144). Figure 3–1 shows the generalized land use at Hanford as developed in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)* (DOE 1999a) and modified by the designation of the Hanford Reach National Monument (65 FR 37253).



Key: EMSL=Environmental and Molecular Sciences Laboratory; ERDF=Environmental Restoration Disposal Facility; LIGO=Laser Interferometer Gravitational-Wave Observatory; WTP=Waste Treatment Plant.

Source: Modified from DOE 1999a:3-18; 2000a:3-89.

Figure 3–1. Generalized Land Use at the Hanford Site and Vicinity

Hanford includes extensive production, service, and research and development (R&D) areas. Onsite programmatic and general purpose facilities, many of which are inactive, occupy approximately 800,000 square meters (8.6 million square feet) of space. Fifty-one percent (409,000 square meters [4.4 million square feet]) is general purpose space, accommodating offices, laboratories, shops, warehouses, and other support facilities. The remaining 392,000 square meters (4.2 million square feet) of space are committed to programmatic facilities, including processing; evaporation; filtration; and waste recovery, treatment, and storage facilities, as well as R&D laboratories. While more than half of the general purpose and programmatic facilities are more than 30 years old, several new facilities, including the Waste Treatment Plant (WTP) and the privately owned Laser Interferometer Gravitational-Wave Observatory (LIGO), are being or have been constructed. Facilities designed to perform previous missions are being evaluated for reuse in the cleanup mission. The existing facilities are grouped into the numbered operational areas discussed in the following paragraphs (DOE 1996a:3-20, 3-21; Duncan 2007:4.1, 4.3).

The 100 Areas, which cover about 1,100 hectares (2,720 acres), are in the northern part of the site on the southern shore of the Columbia River. Within these areas are eight retired plutonium production reactors and the dual-purpose N Reactor, all of which have been permanently shut down since 1991. Waste sites throughout the 100 Areas are currently undergoing remediation, consisting of the excavation of contaminated soils and structural materials. Additionally, SNF currently stored in indoor basins in the 100 Areas is being moved to the 200 Areas. Contaminated groundwater in the 100 Areas is being treated via both ex situ and in situ methods.

The 200 Areas, which include the 200-East and 200-West Areas, are in the center of Hanford. Together, they cover about 5,100 hectares (12,602 acres) and are, respectively, about 11 and 8 kilometers (6.8 and 5 miles) south and 12 and 20 kilometers (7.5 and 12.4 miles) west of the Columbia River. Historically, these areas were devoted to nuclear fuel processing; plutonium processing, fabrication, and storage; and waste management and disposal. The WTP is currently under construction within the 200-East Area. This plant includes a number of facilities that will pretreat and separate waste recovered from the 200 Area tank farms into high-level radioactive waste (HLW) and low-activity waste (LAW) streams, vitrify the HLW stream, and vitrify or similarly immobilize the LAW stream. In addition to 18 underground tank farms, the 200 Areas contain a number of low-level radioactive waste burial grounds (LLBGs). DOE constructed the Environmental Restoration Disposal Facility (ERDF) in the southeast portion of the 200-West Area for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup waste. A commercial low-level radioactive waste (LLW) disposal facility occupies 40 hectares (100 acres) just southwest of the 200-East Area. This facility is leased by the State of Washington from the Federal Government and subleased to US Ecology, Inc. Facilities to be constructed under the Tank Closure alternatives analyzed in this *TC & WM EIS* are proposed to be located in the 200 Areas.

The 300 Area is in the southern part of the site, just north of the city of Richland, and covers 150 hectares (370 acres). From the early 1940s, most R&D activities were carried out in the 300 Area. It was also the location of nuclear fuel fabrication. A few of the facilities continue to support nuclear and nonnuclear R&D activities for the Pacific Northwest National Laboratory. Many of the facilities in the 300 Area are being deactivated. Waste sites in the 300 Area are currently undergoing remediation, consisting of the excavation of contaminated soils and structural materials. The 300 Area is undergoing accelerated remediation of waste sites and inactive buildings to support future non-DOE uses.

The 400 Area, located 8 kilometers (5 miles) northwest of the 300 Area, is the site of the Fast Flux Test Facility (FFTF) and the Fuels and Materials Examination Facility (FMEF). The latter facility, located to the west of FFTF, was constructed in the late 1970s and early 1980s to perform fuel fabrication and development and postirradiation examination of breeder reactor fuels. FMEF never operated and is currently in a layup condition suitable for a future mission. Designed and built as a liquid-sodium-cooled

reactor, FFTF was intended as the Nation's lead reactor for development and testing of materials and equipment for DOE's liquid metal fast breeder reactor programs. It operated for about 10 years (1982 to 1992) as a national research test facility, during which time it also produced a wide variety of medical isotopes and made hydrogen-3 (tritium) for the U.S. fusion research program. FFTF was ordered shut down in 1995, but the shutdown process was deferred in 1997 on receipt of DOE direction for the facility to come to a standby condition. Later, in the "Record of Decision for the *Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility*" (66 FR 7877), DOE announced that FFTF would be permanently deactivated. Completion of final decontamination and decommissioning of the facility is addressed in this *TC & WM EIS*.

The 600 Area is the designation for Hanford lands that are not part of any other designation. Thus, it includes all of Hanford not occupied by the 100, 200, 300 and 400 Areas (Duncan 2007:4.133).

Other areas at Hanford include the land occupied by the facilities of Energy Northwest (formerly known as the Washington Public Power Supply System) and an area currently leased by Washington State and used for disposal of hazardous substances. Energy Northwest operates the Columbia Generating Station on land leased from DOE that is located approximately 4 kilometers (2.5 miles) northeast of the 400 Area. The original lease called for the operation of three nuclear power plants; however, construction of two of the plants has been stopped and other industrial options are now being considered. Other facilities include the Hazardous Materials Management and Emergency Response Volpentest Training and Education Center, which is used to train hazardous materials response personnel. It is located in the southeastern portion of the site and covers about 32 hectares (80 acres). The Hanford Patrol Training Academy, a regional law enforcement training facility, provides classrooms, library resources, practice shoot houses, an exercise gym, and an obstacle course. LIGO, a national research facility built by the National Science Foundation for scientific research, is designed to detect cosmic gravitational waves. The facility consists of two optical tube arms, each 4 kilometers (2.5 miles) long and arrayed in an "L" shape, and is extremely sensitive to vibrations (DOE 1999a:4-8, 4-9). The 700 Area is the administrative center in downtown Richland and consists of Government-owned buildings (e.g., the Federal Building) (DOE 2000a:4-90).

In addition, there are DOE-leased facilities and DOE-contractor-owned or -leased facilities that support Hanford operations. These facilities are on private or Port of Benton land south of the 300 Area (DOE 1996a:3-21).

DOE has transferred the Richland North Area—formerly the 1100 Area, an area that served as a procurement, central warehousing, vehicle maintenance, transportation, and distribution center for Hanford—and the smaller 3000 Area to the Port of Benton for use in economic development and diversification (DOE 2000a:3-91).

3.2.1 Land Resources

Land resource areas include land use and visual resources. Land use is defined in terms of the kinds of anthropogenic activities (e.g., agriculture, residential, industrial) for which land is developed (EPA 2006). Natural resource and other environmental characteristic attributes make a site more suitable for some land uses than for others. Changes in land use may have beneficial or adverse effects on other resources—ecological, cultural, geologic, and atmospheric. Visual resources are natural and manmade features that give a particular landscape its character and aesthetic quality. Landscape character is determined by the visual elements of form, line, color, and texture. All four elements are present in every landscape.

3.2.1.1 Land Use

3.2.1.1.1 General Site Description

The Tri-Cities area southeast of Hanford includes residential, commercial, and industrial land uses. This area, which encompasses the cities of Richland, Kennewick, and Pasco, is the population center closest to Hanford. Additional cities near the southern boundary of Hanford include Benton City, Prosser, and West Richland. Agriculture is a major land use in the remaining areas surrounding Hanford. In 2002, wheat was the largest crop in terms of area planted in Adams, Benton, Franklin, and Grant Counties. Alfalfa, potatoes, corn, vegetables and fruit are some of the other crops grown in these counties (USDA 2007).

In 1977 DOE designated Hanford as a National Environmental Research Park, an outdoor laboratory for ecological research to study the environmental effects of energy development. The Hanford National Environmental Research Park is a shrub-steppe habitat that contains a wide range of semiarid land ecosystems and offers the opportunity to examine linkages between terrestrial, subsurface, and aquatic environments (DOE 2000a:3-91; Vaughan and Rickard 1977:1, 2). An integral part of the monument is the Fitzner-Eberhardt Arid Lands Ecology Reserve, which includes 31,080 hectares (76,800 acres) of primarily shrub-steppe vegetation to the west of State Route 240 (see Figure 3–1). This area was originally set aside in 1967 for ecological research and educational purposes (O'Connor and Rickard 2003:vi, 1).

Land use designations based on the Hanford Comprehensive Land Use Plan include Preservation, Conservation (Mining), Recreation, Industrial, Industrial-Exclusive, and Research and Development (see Figure 3–1). Approximately 6 percent of the site has been disturbed and is occupied by DOE facilities (Neitzel 2005:4.144). Hanford contains a variety of widely dispersed facilities, including retired reactors, R&D facilities, and various deactivated production and processing plants. Preservation and Conservation (Mining) are the predominant land uses at Hanford. Borrow Area C (also known as quarry No. 2) located south of State Route 240, falls within the Conservation (Mining) land use designation. The 200 Areas are classified as Industrial-Exclusive. Industrial areas include an area to the east of the 200 Areas and most of the southeast corner of the site, including the 400 Area.

Hanford Site Land Use Designations

Preservation – An area managed for the preservation of archaeological, cultural, ecological, and natural resources. No new consumptive uses are allowed within this area. Public access would be limited.

Conservation (Mining) – An area reserved for the management and protection of archaeological, cultural, ecological, and natural resources, but where limited and managed mining (e.g., quarrying for governmental purposes) could occur as a permitted special use. Public access is limited.

Recreation (High) – An area allocated for high-intensity, visitor-serving activities and facilities (commercial and governmental), such as golf courses, recreational-vehicle parks, boat-launching facilities, tribal fishing facilities, destination resorts, cultural centers, and museums.

Recreation (Low) – An area allocated for low-intensity, visitor-serving activities and facilities, such as improved recreational trails, primitive boat-launching facilities, and permitted campgrounds.

Industrial – An area suitable and desirable for activities such as reactor operations, rail and barge transport, mining, manufacturing, food processing, assembly, warehouse, and distribution operations.

Industrial-Exclusive – An area suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes.

Research and Development – An area designated for conducting (1) basic or applied research that requires the use of a large-scale or isolated facility, or (2) smaller-scale, time-limited research conducted in the field or within facilities that consume limited resources.

Source: DOE 1999a:3, 4.

Important areas within the Preservation land use designation include the Hanford Reach National Monument, which incorporates a portion of the Columbia River corridor, as well as the Fitzner-Eberhardt Arid Lands Ecology Reserve to the south and west and portions of Hanford north of the Columbia River (65 FR 37253). Other special status lands in the vicinity of Hanford include the McNary National Wildlife Refuge, which is administered by the U.S. Fish and Wildlife Service (USFWS), as well as the

Columbia River Islands Area of Critical Environmental Concern and McCoy Canyon, both of which are administered by the U.S. Bureau of Land Management (BLM) (DOE 2000a:3-91).

The Columbia River, which is adjacent to and runs through Hanford (see Figure 3–1), is used for numerous purposes, including public boating, waterskiing, fishing, hunting, transportation, irrigation, and municipal water supply. Public access is allowed to certain islands, while other areas are considered sensitive because they include unique habitats and cultural resources. The area known as the Hanford Reach includes the 0.4-kilometer (0.25-mile) strip of public land on either side of the last free-flowing, nontidal segment of the Columbia River in the United States. On June 9, 2000, under the authority of the American Antiquities Act of 1906 (16 U.S.C. 431 et seq.), the President issued a proclamation that established the Hanford Reach National Monument (65 FR 37253) on approximately 78,900 hectares (195,000 acres). This proclamation recognizes the unique character and biological diversity of the area, as well as its geologic, paleontological, historic, and archaeological significance. USFWS manages the monument under existing agreements with DOE. DOE manages land within the monument that is not subject to existing agreements; however, DOE consults with the Secretary of the Interior when developing any management plans affecting these lands. In the future, when appropriate cleanup has been completed, USFWS and DOE will extend management agreements to lands in the monument not currently managed by USFWS.

On June 27, 2000, a fire known as the 24 Command Fire was started by a fatal motor vehicle accident on State Route 24 about 3.2 kilometers (2 miles) west of the State Route 240 intersection. As a result of high winds, high temperatures, and low humidity, the fire spread rapidly and eventually consumed 66,322 hectares (163,884 acres) of Federal, state, and private lands. A total of 56,246 hectares (138,986 acres) within Hanford burned, including lands within the Hanford Reach National Monument, most of the Fitzner-Eberhardt Arid Lands Ecology Reserve, and areas near former production sites (see Figure 3–2). The fire was declared controlled on July 2, 2000. Fire suppression impacts included bulldozing 66 kilometers (41 miles) of fire lines, widening dirt roads, and cutting fences (DOI 2000:iii, iv). Vegetation loss due to the firefighting activities exposed the soil to erosion by subsequent wind and rain.

The most recent fire to burn across Hanford was the Wautoma Wildland Fire, which started on August 16, 2007 (see Figure 3–2). This fire burned approximately 27,114 hectares (67,000 acres) before it was contained on August 18, 2007. The fire started to the west of Hanford near the Benton-Yakima County line, grew rapidly to the north and east, and moved onto the Fitzner-Eberhardt Arid Lands Ecology Reserve of the Hanford Reach National Monument. It crossed State Route 240 and burned up to, and partially around, the 200-West Area. It also burned the northern slope of Rattlesnake Mountain (Burandt 2007).

DOE developed the *Hanford Comprehensive Land-Use Plan EIS* to provide the framework for future use of the site's lands and resources (DOE 1999a). Preparation of the plan was consistent with the National Defense Authorization Act (P.L. 104-201), which required the development of a future-use plan for at least the next 50 years. Preparation of the plan involved a number of cooperating agencies and consulting tribal governments, including BLM; the U.S. Bureau of Reclamation; USFWS; the City of Richland; Benton, Franklin, and Grant Counties; the Nez Perce Tribe; and the Confederated Tribes of the Umatilla Indian Reservation. The *Hanford Comprehensive Land-Use Plan EIS* consists of four basic elements: a map depicting land uses for the site; description of the purpose, intent, and principal uses of each land use designation; a set of policies governing land use actions; and implementing procedures. Figure 3–1 reflects land use designations developed in the plan. DOE recently issued the *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 2008a) to review information and update the status of activities since the original plan was issued in 1999. An amended Record of Decision (ROD) (73 FR 55824) was issued to clarify and confirm DOE's commitments to the Hanford Comprehensive Land-Use Plan process.

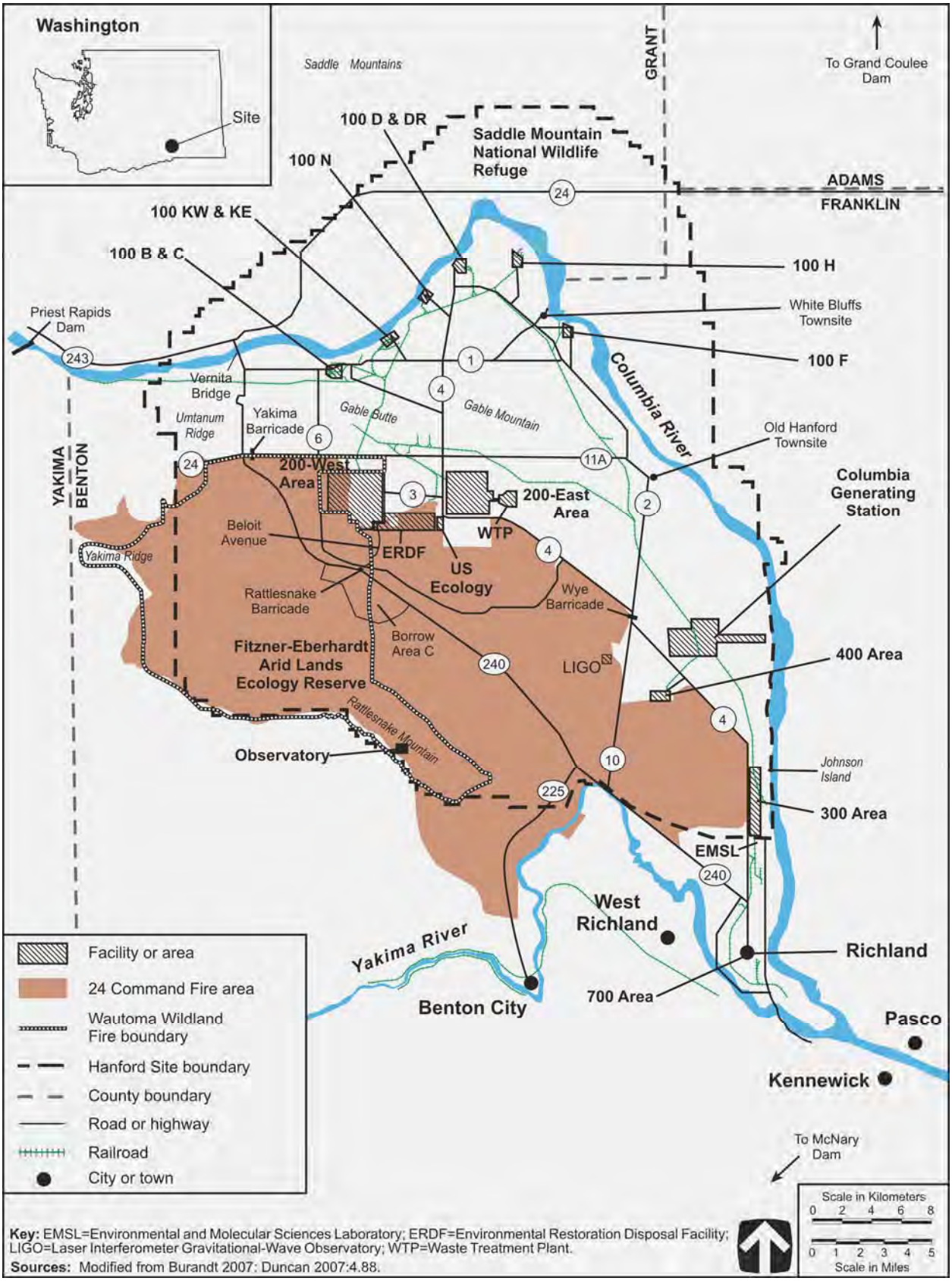


Figure 3–2. Extent of Area Burned During the 24 Command and Wautoma Wildland Fires

As noted earlier, Hanford lies within Adams, Benton, Franklin, and Grant Counties, each of which developed a comprehensive land use plan in response to Washington's Growth Management Act (RCW 36.70A). This act requires state and local governments to manage Washington's growth by identifying and protecting critical areas and natural resource lands, designating urban growth areas, preparing comprehensive plans, and implementing them through capital investments and development regulations (Washington State 2007). The counties have no jurisdiction over Federal lands.

The *Adams County Comprehensive Plan* (ACPC 2005) does not specifically mention Hanford; however, the small area of the site within the southwestern portion of the county is classified as General Agriculture. That portion of Hanford lying within Benton County is designated as the Hanford Region within its *County Comprehensive Land Use Plan*; however, a subarea plan has not been completed for this area (BCPC 2005). A recent update to the plan dealt primarily with changes in rural land designations and did not address Hanford (BCPC 2007). The *Franklin County Growth Management Comprehensive Plan* (Franklin County 2005) identifies Hanford as Federal land and labels it as the Hanford Reach National Monument on its Comprehensive Land Use Plan map. That portion of Hanford lying within Grant County is known as the Wahluke Slope. Within the *Grant County Comprehensive Plan/Environmental Impact Statement*, this area is identified as Hanford Federal Reserve (GCDCD 1999). A subarea plan has yet to be developed for this tract.

Under separate treaties signed in 1855 (see Section 8.1.7), much of the land in what is now referred to as eastern Washington, eastern Oregon, and Idaho was ceded to the United States by a number of regional American Indian tribes. The land area includes land occupied by Hanford. Under these treaties, the tribes retained the right to fish in usual and accustomed places. Tribal fishing rights are recognized on rivers within the ceded lands, including the Columbia River, which flows through Hanford.

In addition to fishing rights, the tribes retained under the treaties the privilege to hunt, gather roots and berries, and pasture horses and cattle on open and unclaimed lands. It is the position of DOE that Hanford, like other ceded lands that were settled or used for specific purposes, is not open and unclaimed land. While reserving all rights to assert their respective positions regarding treaty rights, the tribes are participants in DOE's land use planning process, and DOE considers tribal concerns in that process.

3.2.1.1.2 200 Areas Description

The *Hanford Comprehensive Land-Use Plan EIS* and subsequent supplement analysis (DOE 1999a:3-5, 3-18, 3-53, 2008a) and RODs (64 FR 61615, 73 FR 55824) designated a 5,064-hectare (12,513-acre) area within the Central Plateau of Hanford as Industrial-Exclusive (see Figure 3–1). This area, which includes the 200-East and 200-West Areas, encompasses the location of activities proposed under the various Tank Closure alternatives evaluated in this *TC & WM EIS*. The Industrial-Exclusive designation preserves DOE control of continuing remediation activities and use of the existing compatible infrastructure required to support activities such as dangerous radioactive and mixed waste treatment, storage, and disposal (TSD). Further, under this designation, DOE continues its Federal waste disposal mission, and the Northwest Low-Level Radioactive Waste Compact allows for continued use of the US Ecology, Inc., site for the disposal of commercial radioactive waste. The Industrial-Exclusive designation also allows for the expansion of existing facilities or the development of new compatible facilities in support of ongoing missions. Research supporting dangerous radioactive and mixed waste TSD facilities is also encouraged, and new uses of radioactive materials, such as food irradiation, could be developed within this land use designation.

3.2.1.1.3 400 Area Description

Under the *Hanford Comprehensive Land-Use Plan EIS* and subsequent supplement analysis (DOE 1999a:3-5, 3-18, 2008a) and RODs (64 FR 61615, 73 FR 55824), land in the 400 Area is

designated for industrial use, including reactor operations, manufacturing, warehousing, and related activities. The 400 Area occupies 61 hectares (150 acres) and is 7 kilometers (4.3 miles) to the west of the nearest site boundary. The Property Protected Area, within which FFTF and associated facilities are located, is 18 hectares (44.5 acres) in size.

3.2.1.1.4 Borrow Area C Description

Prior to April 1999, McGee Ranch (in the northwest corner of Hanford north of Route 24 and south of the Columbia River) was identified as the primary suitable source of silt, loam, and basalt rock borrow material. Based on public and tribal input received by DOE during the *Hanford Comprehensive Land-Use Plan EIS* process and as recorded in its RODs (64 FR 61615, 73 FR 55824), DOE decided to protect a wildlife corridor through the McGee Ranch and consolidate the many planned borrow areas at Hanford into one location, identified as Borrow Area C (see Figure 3–1), to keep a primary source of geological materials available for Hanford site remediation activities. Borrow Area C is a large polygonal area 926.3 hectares (2,289 acres) in size bordering State Route 240 on the south (see Figure 3–1). Although the area is contiguous with the Fitzner-Eberhardt Arid Lands Ecology Reserve, it is designated for Conservation (Mining) in the *Hanford Comprehensive Land-Use Plan EIS*. Such areas are typically reserved for management and protection of cultural, ecological, and natural resources; however, they may also be used in limited, managed mining activities (DOE 1999a:3-4, 3-18). Borrow Area C is largely undeveloped; consistent with its land use classification; however, a road was built in 2006 to access a portion of the site that will be used to generate borrow material for environmental remediation activities.

3.2.1.2 Visual Resources

3.2.1.2.1 General Site Description

Hanford lies in the Pasco Basin of the Columbia Plateau northwest of the city of Richland, where the Yakima and Columbia Rivers join. The land in the vicinity of Hanford ranges from generally flat to gently rolling. Rattlesnake Mountain, rising to 1,060 meters (3,480 feet) above mean sea level, forms the southwestern boundary of the site. Gable Mountain and Gable Butte are the highest landforms within the site, rising to a height of 329 meters (1,081 feet) and 238 meters (782 feet), respectively. The Columbia River flows through the northern part of the site, and turning south forms part of the eastern site boundary. White Bluffs, steep whitish-brown bluffs adjacent to the river, are a striking feature of the landscape (DOE 2000a:3-93).

Typical of the regional shrub-steppe desert, the site is dominated by widely spaced, low-brush grasslands. A large area of nonvegetated, stabilized sand dunes extends along the east boundary, and nonvegetated blowouts are scattered throughout the site. Hanford is characterized by mostly undeveloped land, with widely spaced clusters of industrial buildings along the southern and western banks of the Columbia River and at several interior locations (DOE 2000a:3-93).

Hanford facilities can be seen from elevated locations such as Gable Mountain, Gable Butte, Rattlesnake Mountain, and other parts of the Rattlesnake Hills along the western perimeter. Site facilities also are visible from State Routes 240 and 24 and the Columbia River. Because of terrain features, distances involved, the size of Hanford, and the size of individual structures, not all facilities are visible from the highways or the Columbia River (DOE and Ecology 1996:4-60).

DOE and its leaseholders operate and maintain buildings and equipment on Gable Mountain and Rattlesnake Mountain that also affect the view from these elevated natural features. The tallest structures, the six communication towers (height 30 meters [100 feet]) are located on Rattlesnake Mountain. Numerous other structures and related activities on these mountains (e.g., communication towers and equipment/structures, research and monitoring equipment/structures, an observatory, fire breaks, access roads) are currently visible from the surrounding area including State Route 240.

State Route 240 provides public access through the southwestern portion of Hanford. Views along this highway include the lands of the Fitzner-Eberhardt Arid Lands Ecology Reserve in the foreground to the west, with the prominent peak of Rattlesnake Mountain and the extended ridgelines of Rattlesnake Hills in the background. Views to the east feature rather flat terrain, with the structures of the 200-West Area visible in the central area and Gable Butte and Gable Mountain in the background. From the highway, the Saddle Mountains can be seen in the distance to the north, and steam plumes from the Energy Northwest reactor cooling towers are often visible in the distance to the east. The views along State Route 240 are expansive due to the flat terrain and the predominantly short, treeless vegetation cover.

The 24 Command Fire burned 66,322 hectares (163,884 acres) of Federal, state, and private lands, including 56,246 hectares (138,986 acres) within Hanford (see Figure 3–2), while firefighting activities resulted in the construction of 66 kilometers (41 miles) of bulldozed fire lines, widened dirt roads, and cut fences (DOI 2000:iii, iv). Thus, both the fire and the activities required to control it resulted in dramatic changes to the visual character of affected portions of the site. Visual resources were also affected by duststorms resulting from exposed soil. The most recent fire to burn across a large portion of Hanford was the Wautoma Wildland Fire (Burandt 2007). This fire left large areas blackened across the southwestern portion of the site, including the slope of Rattlesnake Mountain, which is visible from Richland and other areas in the region. Alterations to the visual character of Hanford resulting from these fires will change over time, however, the landscape will tend to recover as rains promote the growth of vegetation, fire lines are rehabilitated, and fences are repaired. Because of the slow regeneration of sagebrush, however, it will be years before the visual character of the area will mirror prefire conditions.

The landscape adjacent to Hanford consists primarily of rural rangeland and farms. The city of Richland, part of the Tri-Cities area, is the only adjoining urban area. Viewpoints affected by DOE facilities are primarily associated with the public access roadways, including State Routes 24 and 240, Horn Rapids Road, Route 4 South, and Stevens Drive; the Columbia River bluffs, and the northern edge of the city of Richland. The Energy Northwest nuclear reactors and DOE facilities are brightly lit at night and are highly visible from many areas. Developed areas are consistent with a BLM Visual Resource Management (VRM) Class IV rating, and for the remainder of Hanford VRM ratings range from Class II to Class III (BLM 1986:6, 7). Management activities within Class II and III areas may be seen but should not dominate the view; those in Class IV areas dominate the view and typically are the focus of viewer attention.

3.2.1.2.2 200 Areas Description

The tallest structure within the 200 Areas is the meteorological tower, with a height of 124 meters (408 feet) (Duncan 2007:4.8). Additionally, a number of stacks are around 61 meters (200 feet) in height. Travelers can see some site facilities in the 200-West Area on an 11-kilometer (7-mile) segment of State Route 240 south of the Yakima Barricade (near the junction of State Routes 240 and 24). At the closest approach, these structures are about 3.2 kilometers (2 miles) distant. However, not all facilities are visible, as many (e.g., storage tanks) are situated belowground, and undeveloped areas are present within and adjacent to the 200 Areas. It is within some of these undeveloped areas that a number of proposed project facilities would be located (see Chapter 4, Figures 4–1 and 4–2).

Aboveground structures throughout the 200 Areas are visible from elevated locations such as Gable Mountain, Gable Butte, and Rattlesnake Mountain. They are not visible from the Columbia River. Because the 200-East and 200-West Areas are highly developed industrial areas, they have a VRM Class IV rating. Natural features of visual interest within the vicinity of the 200 Areas include Gable Butte, 6.9 kilometers (4.3 miles) to the northwest; Gable Mountain, 8 kilometers (5 miles) to the northeast; Rattlesnake Mountain, 14 kilometers (8.7 miles) to the south; and the Columbia River, as close as 10 kilometers (6.2 miles) to the northwest.

3.2.1.2.3 400 Area Description

FMEF, the tallest building in the 400 Area, is 30 meters (100 feet) in height and can be seen from State Route 240; however, FFTF is also a prominent feature. Developed areas within the 400 Area are consistent with a VRM Class IV rating. Natural features of visual interest within a 40-kilometer (25-mile) radius include the Columbia River, 6.8 kilometers (4.2 miles) to the east; Rattlesnake Mountain, 18 kilometers (11 miles) to the west-southwest; Gable Mountain, 19 kilometers (12 miles) to the north-northwest; and Gable Butte, 27 kilometers (17 miles) to the northwest (DOE 2000a:3-94).

3.2.1.2.4 Borrow Area C Description

Borrow Area C, with the exception of a roadway completed in 2006, is an undeveloped area on the south side of State Route 240 (see Figure 3–1). It is generally indistinguishable from the Fitzner-Eberhardt Arid Lands Ecology Reserve, which surrounds it on three sides. Since the 24 Command Fire burned the area in 2000, the original vegetation of the area has changed substantially and it now appears as grassland with little shrub component. A large portion of Borrow Area C surface was burned by the recent 2007 Wautoma Wildland Fire. Due to the presence of the road across a portion of the site, Borrow Area C is consistent with a BLM VRM Class II rating. It is readily visible from State Route 240, located immediately adjacent to the area, and Rattlesnake Mountain, about 6.4 kilometers (4 miles) to the south. It is also visible in the distance from Gable Mountain, 12.9 kilometers (8 miles) to the northeast, and Gable Butte, 11.3 kilometers (7 miles) to the north.

3.2.2 Infrastructure

As used in this *TC & WM EIS*, infrastructure encompasses the condition, capacity, and usage of ground transportation and utilities (electricity, fuel, and water) at Hanford and in the site vicinity. In addition to the descriptions provided below, a summary of sitewide infrastructure characteristics is presented as Table 3–2. Further information on transportation infrastructure is presented in Section 3.2.9.4, and waste management infrastructure is addressed in Section 3.2.12.

Table 3–2. Hanford Sitewide Infrastructure Characteristics

Resource	Site Usage[a]	Site Capacity
Transportation		
Roads (kilometers)	607[b]	N/A
Railroads (kilometers)	184	N/A
Electricity		
Energy (megawatt-hours per year)	172,585	1,743,240
Peak load (megawatts)	24[c]	199[d]
Fuel		
Natural gas (cubic meters per year)	977,840	N/A
Fuel oil (liters per year)	2,954,100	(e)
Diesel fuel (liters per year)	1,191,900	(e)
Gasoline (liters per year)	150,330	(e)
Propane (liters per year)	551,410	(e)
Water (liters per year)	816,560,000	18,500,000,000(f)

[a] All values are for fiscal year 2006.

[b] Includes asphalt-paved roads only.

[c] Estimated from average sitewide electrical energy usage, assuming peak load is 120 percent of average demand.

[d] Reflects the capacity of the primary substations serving the 100, 200, 300, and 400 Areas but not necessarily the availability of electric power from the Bonneville Power Administration, which can vary (Uecker 2007).

[e] Limited only by the ability to ship resource to the site.

[f] Capacity of the Hanford Export Water System.

Note: To convert kilometers to miles, multiply by 0.6214; cubic meters to cubic feet, by 35.315; and liters to gallons, by 0.26417.

Key: N/A=not applicable.

Source: Duncan 2007:4.150, 4.152; Ferns 2003a, 2003b; Fluor Hanford 2006a:Attachments 1 and 2; Uecker 2007.

3.2.2.1 Ground Transportation

3.2.2.1.1 General Site Description

The DOE-maintained road network within Hanford consists of 607 kilometers (377 miles) of asphalt-paved road and provides access to the various work centers (see Figure 3–1). Primary access roads on the site are Routes 1, 2, 3, 4, 6, 10, and 11A, and Beloit Avenue. Public access to the 200 Areas and interior locations of Hanford is restricted by guarded gates at the Wye Barricade (at the intersection of Routes 10 and 4), the Yakima Barricade (at the intersection of State Route 240 and Route 11A), and the Rattlesnake Barricade (south of the 200-West Area) (Duncan 2007:4.152).

The Hanford rail system originally consisted of about 209 kilometers (130 miles) of track. It connected to the Union Pacific commercial track at the Richland Junction and to the now-abandoned commercial right-of-way (Chicago, Milwaukee, St. Paul, and Pacific Railroad) near Vernita Bridge in the northwest section of the site (see Figure 3–2). Prior to 1990, annual sitewide railcar movements numbered about 1,400, transporting materials such as coal, fuel, hazardous process chemicals, and radioactive materials and equipment. Coal deliveries ceased with the replacement of site coal-fired steam plants by oil and natural gas package boilers. In October 1998, 26 kilometers (16 miles) of track were transferred to the Port of Benton and are currently operated and maintained by the Tri-City and Olympia Railroad Company. Included were those track segments constituting the Hanford southern rail connection

(from Horn Rapids Road to Columbia Center), and those serving the Richland North Area (Duncan 2007:4.150).

3.2.2.1.2 200 Areas Description

The 200-East Area is accessed primarily by Route 4 South from the east, by Route 4 North off Route 11A from the north, and by Route 4 North off Route 11A for vehicles entering the site at the Yakima Barricade. The 200-West Area is accessed from State Route 240 by Beloit Avenue. A network of both improved and semi-improved roads provide access to individual facilities within the 200-East and 200-West Areas and to the WTP site. Inactive rail spurs traverse portions of both the 200-East and 200-West Areas (see Figure 3–2).

3.2.2.1.3 400 Area Description

The 400 Area access road can be reached directly via a roadway off Route 4. An inactive rail spur to the 400 Area originates northeast of the site from the vicinity of the Energy Northwest Columbia Generating Station.

3.2.2.1.4 Borrow Area C Description

Borrow Area C is accessible via a two-lane, 2.0-kilometer-long (1.25-mile-long) asphalt-paved roadway. Completed in 2006, the roadway extends southeast into the interior of Borrow Area C from the intersection of Beloit Avenue and State Route 240 and south of the Rattlesnake Barricade.

3.2.2.2 Electricity

3.2.2.2.1 General Site Description

Electrical power for Hanford is purchased wholesale from the Bonneville Power Administration, which provided nearly 90 percent of the electricity consumed on the site in 2006 (Duncan 2007:4.157). Hanford is a Priority Firm customer, and the Bonneville Power Administration is contractually obligated to provide as much power as Hanford requires. Being a Priority Firm customer ensures that, in the event of severe regional power shortages, Hanford (along with other Priority Firm customers) would be the last level of Bonneville Power Administration service to be shut off (Fluor Hanford 2005a:45, 46). Power for the 700 Area and the Richland North Area is provided by the City of Richland (DOE 1999a:4-112). The Richland Energy Services Department and the Benton and Franklin County public utility districts provide electricity to the Tri-Cities and surrounding areas and also purchase nearly all their electrical power from the Bonneville Power Administration (Duncan 2007:4.156). Because the transmission line capacity across the site was developed when the nine 100 Area reactors were operating, historically there has been surplus capacity on the Hanford electric transmission system (Ferns 2003a). In 2006, the sitewide average electric load demand was approximately 19.7 megawatts (172,585 megawatt-hours) for 8,760 hours (see Table 3–2).

Power to the electrical system that serves the 100 and 200 Areas is provided from two sources, the Bonneville Power Administration Midway substation at the northwestern site boundary and a transmission line from the Bonneville Power Administration Ashe substation near Energy Northwest's Columbia Generating Station. The 100/200 Area electrical system consists of about 80 kilometers (50 miles) of 230-kilovolt transmission lines, six primary substations, about 217 kilometers (135 miles) of 13.8-kilovolt distribution lines, and 124 secondary substations. The 100/200 Area transmission and distribution systems, like the Bonneville Power Administration source lines, have redundant routings to ensure electrical service to individual areas and designated facilities within those areas (DOE 1990:3-1–3-3, 1999b:3-47). The 100/200 Area system had been upgraded in the 1980s with an installed usable electric load capacity of 244 megavolt-amperes (about 195 megawatts) and had a peak

load demand of 54.7 megawatts at that time (DOE 1990:3-1–3-3; ICF KH Engineers Hanford 1995:4, 5). Presently, the 100 Areas are served by one primary substation (151-KW substation) that has a usable load capacity of 50 megavolt-amperes (about 40 megawatts) (Uecker 2007). Total electrical energy consumption in the 100 Areas was 23,440 megawatt-hours in fiscal year 2006, reflecting an average electric load demand of 2.7 megawatts (Fluor Hanford 2006a:Attachment 2).

3.2.2.2.2 200 Areas Description

The main 251-W substation that serves the 200 Areas has a current usable load capacity of 33 megavolt-amperes (about 26 megawatts) (Uecker 2007). The 251-W substation also serves as the electrical dispatch center for the 100, 200, and 300 Areas (DOE 1990:3-1–3-3; ICF KH Engineers Hanford 1995:4, 5).

In late 2001, DOE completed construction of a new 62.5-megavolt-ampere-capacity (about 50-megawatt) substation to support future WTP operations. The substation is supplied by 230-kilovolt transmission lines and can receive power directly from the Columbia Generating Station or the Priest Rapids Dam (DOE 2001a).

In fiscal year 2006, total electrical energy consumption was 53,915 megawatt-hours in the 200-East Area and 43,888 megawatt-hours in the 200-West Area, for a 200 Area total of 97,803 megawatt-hours (Fluor Hanford 2006a:Attachment 2). This consumption reflects an average electric load demand of about 11.2 megawatts for activities in the 200 Areas.

3.2.2.2.3 400 Area Description

For the 300 and 400 Areas, electric power is supplied via two separate 115-kilovolt Bonneville Power Administration transmission lines. The first originates from the Bonneville Power Administration Benton switch station south of the Columbia Generation Station; the second, from the Bonneville Power Administration White Bluffs substation in the southeast portion of Hanford (DOE 1990:3-6, 3-7). The primary 300 Area substation (351 substation) currently has a usable electric load capacity of 20 megavolt-amperes (about 16 megawatts) (Uecker 2007). Total electrical energy consumption in the 300 Area was 18,117 megawatt-hours in fiscal year 2006, reflecting an average electric load demand of 2.1 megawatts (Fluor Hanford 2006a:Attachment 2).

There is one 13.8-kilovolt tie line from the 300 Area to the 400 Area emergency power system that also provides alternate power for maintenance outages. Redundancy in the distribution lines to designated facilities ensures continuity of service and the rerouting of power for the maintenance of system components. There are two substations in the 400 Area: Building 451A (FFTF substation) which serves the FFTF reactor complex, and Building 451B (FMEF substation), serving FMEF and associated buildings (DOE 1990:3-8, 3-9, 1999b:3-47; Fluor Hanford 2005a:16). The FFTF substation has a usable load capacity of 50 megavolt-amperes (about 40 megawatts); the FMEF substation, a usable capacity of 33.3 megavolt-amperes (about 27 megawatts) (Uecker 2007).

Electrical energy usage for FFTF averaged approximately 55,000 megawatt-hours annually during standby, reflecting a peak load of about 6 megawatts (Fluor Hanford 2005a:46). The total electrical energy consumption for the 400 Area as a whole during fiscal year 2006 was 20,385 megawatt-hours, reflecting an average electric load demand of 2.3 megawatts (Fluor Hanford 2006a:Attachment 2).

3.2.2.2.4 Borrow Area C Description

No electric power distribution lines serve Borrow Area C at present. Overhead electric distribution lines could be extended to the site from the vicinity of Beloit Avenue and State Route 240 to support borrow area operations as needed.

3.2.2.3 Fuel

3.2.2.3.1 General Site Description

Both fuel oil and natural gas are used as energy sources at Hanford facilities. A commercial vendor supplies fuel oil to the site, including the 200 Areas. The primary fuel for the 300 Area is natural gas, which is supplied by the Cascade Natural Gas Corporation (Duncan 2007:4.157; Ferns 2003a).

Liquefied petroleum gas (propane) is the primary facility fuel source in the 100 Areas. In addition, diesel fuel, gasoline, and liquefied petroleum gas (propane) are consumed to operate vehicles and other equipment at Hanford (Fluor Hanford 2006a:Attachment 1:4, Attachment 2).

Individual package boilers supply heat and process steam to specific facilities in the 200-East, 200-West, and 300 Areas. Oil-fired package boilers produce steam in the 200 Areas, while natural gas-fired package boilers produce steam in the 300 Area. A new underground natural gas line was installed from south of Richland to the 300 Area to supply natural gas to the new package boilers (DOE 1999a:4-112).

Hanford sitewide fuel oil consumption, reflecting demands in the 200 Areas, was 2,954,100 liters (780,400 gallons) in fiscal year 2006. Total natural gas consumption by 300 Area facilities was about 977,840 cubic meters (34,530,000 cubic feet) during the same time period (see Table 3–2). Total diesel fuel consumption was 1,191,880 liters (314,860 gallons); total gasoline consumption, 150,330 liters (39,700 gallons); and total propane consumption, 551,410 liters (145,670 gallons). Fuel consumption by nonfleet vehicles and equipment was substantially lower in fiscal year 2006 than in previous years due to the slowdown in WTP construction (Fluor Hanford 2006a:Attachment 1:4, Attachment 2).

3.2.2.3.2 200 Areas Description

As indicated above, individual package boilers supply heat and process steam to facilities in the 200-East and 200-West Areas. When complete and operational, a dedicated fuel-oil-fired central utilities plant will supply heat and process steam to the WTP complex adjacent to the 200-East Area.

3.2.2.3.3 400 Area Description

At FFTF, fuel oil was required to operate the emergency fire pumps, emergency diesel generators, and the sodium preheaters in the main heat transport system dump heat exchanges. Fuel oil usage during operations averaged 76,000 liters (20,000 gallons) annually (Fluor Hanford 2005a:47). No fuel oil consumption was recorded for the 400 Area in fiscal year 2006 (Fluor Hanford 2006a:Attachment 2).

3.2.2.3.4 Borrow Area C Description

There is no liquid fuel storage or consumption in Borrow Area C.

3.2.2.4 Water

3.2.2.4.1 General Site Description

The Hanford water system includes numerous buildings, pumps, valve houses, reservoirs, and wells, as well as a distribution piping system that delivers water to all areas of the site. The Export Water System, the largest system at Hanford, delivers water from the Columbia River to the 100, 200, and parts of the 600 Areas (DOE 1999a:4-112). The Hanford water system is further divided into 9 DOE-owned, contractor-operated, regulated drinking water systems. These include two systems, the Wye and Yakima Barricade systems that were designated and formally registered in 2005 as Group B public water systems by the Washington State Department of Health. These systems serve fewer than 25 people for

60 or more days within a calendar year and physically consist of water holding tanks that were supplied with water trucked from the 200-West Area (283-W) Water Treatment Plant. Only 1 of the 9 systems (the 400 Area system) uses groundwater from the unconfined aquifer instead of water from the Columbia River. The 400 Area continues to use well 499-S1-8J (P-16) as its primary water supply well, with wells 499-S0-8 (P-14) and 499-S0-7 (P-15) serving as backup sources (Poston et al. 2007:10.55–10.57).

In the 300 Area, the water system distributes water supplied by the City of Richland. The Richland water supply system provides drinking water to the 300 Area, the Richland North Area, and the Hazardous Materials Management and Emergency Response Volpentest Training and Education Center (Poston et al. 2007:10.56). This system obtains about 82 percent of its water directly from the Columbia River, while the remainder is split between a well field in north Richland (recharged from the river) and groundwater wells. In 2006, the city of Richland's total water use was approximately 20.1 billion liters (5.3 billion gallons). The city of Pasco's water system draws from the Columbia River and used about 15.3 billion liters (4.0 billion gallons) in 2006. While the Kennewick water system partly depends on the Columbia River for its supply, two groundwater wells serve as the sole source of water between November and March. The total water usage by the city of Kennewick was 13.4 billion liters (3.5 billion gallons) in 2006. A significant number of Kennewick's residents (about 22,000 residential customers) also draw irrigation water from the Kennewick Irrigation District, which has the Yakima River as its source (Duncan 2007:4.155).

3.2.2.4.2 200 Areas Description

Water for the 200-East and 200-West Areas is filtered and chlorinated at the 283-W Water Treatment Plant (Ferns 2003b; Fluor Hanford 2006a:Attachment 1:8; Poston et al. 2007:10.55, 10.60). Construction of an additional 4.8 kilometers (3 miles) of pipeline was completed by DOE in late 2001 to deliver water to the WTP site for drinking, fire protection, and future WTP operations (DOE 2001a). The total raw water capacity of the Export Water System is currently rated at approximately 35,200 liters (9,300 gallons) per minute, or about 18.5 billion liters (4.89 billion gallons) per year. However, the potable water capacity of the treatment plant is about 5,680 liters (1,500 gallons) per minute, or about 2,980 million liters (788 million gallons) per year, which is limited by the plant's chlorination capacity (Ferns 2003b). The original Export Water System was designed to supply raw water to the 100-B, 100-D, 100-F, and 100-H Area reactor operations in addition to the 200 Areas. Since reactor shutdown, it has been reconfigured to mainly furnish water to the 200 Areas and has undergone further modification. Prior to 1990, the system had a daily average pumping demand of about 72 million liters (19 million gallons) per day, with the 200 Areas consuming over 22,700 million liters (6 billion gallons) annually (DOE 1990:5-3, 5-9). Hanford sitewide water production and usage totaled approximately 816.6 million liters (215.7 million gallons) in fiscal year 2006, including groundwater withdrawals in the 400 Area. Of this total, the amount of water produced and used in the 200 Areas was 303.1 million liters (80.1 million gallons) (Fluor Hanford 2006a:Attachment 1:8).

3.2.2.4.3 400 Area Description

In the 400 Area, the primary and two backup groundwater supply wells each have a production capacity of 833 liters (220 gallons) per minute (DOE 2000a:3-113). Groundwater is chlorinated at the well as it is pumped into one of three 1,100-cubic-meter (300,000-gallon) storage tanks. Approximately 4,500 liters (1,200 gallons) of sodium hypochlorite were consumed annually in water treatment (Fluor Hanford 2005a:46). Annual groundwater withdrawals during operations averaged about 197 million liters (52 million gallons) (DOE 2000a:3-113; Fluor Hanford 2005a:46). Groundwater production and usage in the 400 Area was measured at approximately 116 million liters (30.6 million gallons) in fiscal year 2006 (Fluor Hanford 2006a:Attachment 1:8).

3.2.2.4.4 Borrow Area C Description

No utility systems serve Borrow Area C at present. Development plans call for a new waterline to be extended down Beloit Avenue, from the 200-West Area distribution system to provide water in support of future borrow area operations.

3.2.3 Noise and Vibration

Noise is unwanted sound that interferes or interacts negatively with the human or natural environment. Noise may disrupt normal activities or diminish the quality of the environment. Noise sources, existing noise levels at Hanford, and noise standards are described in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a:3-29–3-31, F-31, F-32) and in the *Hanford NEPA Characterization Report* (Duncan 2007:4.161–4.165).

3.2.3.1 General Site Description

Background noise levels at Hanford were measured during two surveys in 1996 and 2007. Data from a survey of 15 sites at Hanford found that background noise levels (measured as the 24-hour equivalent sound level) ranged from 30 to 60.5 decibels A-weighted (dBA) (a unit of measurement that accounts for the frequency response of the human ear). A second survey of 5 isolated areas concluded that background sound levels in undeveloped areas could best be described as a mean 24-hour equivalent sound level of 24 to 36 dBA. Wind was identified as the primary contributor to background sound levels at Hanford (Duncan 2007: 4.162, 4.164).

Major noise sources within Hanford include various facilities, equipment, and machines (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems, construction and material handling equipment, vehicles). However, most Hanford industrial facilities are far enough from the site boundary that noise levels from these sources at the boundary are either unmeasurable or barely distinguishable from background noise levels. Hanford is currently in compliance with state noise regulations (DOE 1996a: 3-29, 3-31).

The primary source of noise at the site and nearby residences is traffic. The potential impact of traffic noise resulting from activities at Hanford was evaluated for a draft EIS addressing the siting of the proposed New Production Reactor (Duncan 2007:4.164). Estimates were made of baseline traffic noise along two major access routes: State Route 24, from Hanford west to Yakima, and State Route 240, south of the site and west of Richland, where it handles maximum traffic volume. About 9 percent of the employees at Hanford commute by vanpool or bus. Modeled traffic noise levels (equivalent sound level [1 hour]) at 15 meters (50 feet) from State Route 24 for both peak and offpeak periods were 62 dBA. Traffic noise levels from State Route 240 for both peak and offpeak periods were 70 dBA. These traffic noise levels were projections based on employment levels about 30 percent higher than actual levels at Hanford in 1997. Existing traffic noise levels may be different due to changes in site employment and ridesharing activities (DOE 1999b:3-8; Duncan 2007:4.161–4.165).

Washington State has established noise standards for different source and receiving areas. Hanford belongs to source area Class C (industrial). The maximum allowable noise level for residential, commercial, and industrial areas is 50 to 70 dBA (WAC 173-60). For industrial areas impacting a residential area, the limit is 60 dBA during daylight hours and 50 dBA at night. U.S. Environmental Protection Agency (EPA) guidelines for environmental noise protection include a day-night average sound level of no more than 55 dBA to protect the public from the effects of broadband environmental noise in typically quiet outdoor residential areas (EPA 1974:29). Land use compatibility guidelines adopted by the Federal Aviation Administration and the Federal Interagency Committee on Urban Noise

indicate that yearly day-night average sound levels less than 65 dBA are compatible with residential land uses (14 CFR 150). These guidelines further indicate that noise levels up to 75 dBA are compatible with residential uses if suitable noise reduction features are incorporated into structures. It is expected that, for most residences near Hanford, the day-night average sound level is less than 65 dBA and thus compatible with residential land use, although noise levels may be higher for some residences along major roadways. Truck traffic, especially on State Routes 240 and 10; excavation activity at various projects at Hanford, such as the WTP and the Hanford 200-East Area Integrated Disposal Facility (IDF-East); and roadwork on State Route 240 have resulted in ground vibration sufficient to interfere with operation of the LIGO (Raab 1996; SAIC 2006a).

3.2.3.2 200 Areas Description

No distinguishing noise characteristics in the 200 Areas have been identified. The 200 Areas are far enough away from the nearest site boundary (10 kilometers [6.2 miles]) that industrial noises emanating from those areas are either unmeasurable or barely distinguishable from background levels at the site boundary. The 200-West Area is about 2.3 kilometers (1.4 miles) from the closest part of the Hanford Reach National Monument.

3.2.3.3 400 Area Description

No distinguishing noise characteristics in the 400 Area have been identified. The 400 Area is far enough away from the site boundary (6.9 kilometers [4.3 miles]) that industrial-related noise levels at that boundary are unmeasurable or barely distinguishable from background levels. The 400 Area is also about 6.9 kilometers (4.3 miles) from the closest part of the Hanford Reach National Monument.

3.2.3.4 Borrow Area C Description

There are currently no quarry activities in Borrow Area C that would produce audible noise in the area of the Hanford Reach National Monument immediately adjacent to the quarry (SAIC 2006b). The major noise source in this area is traffic along State Route 240.

3.2.4 Air Quality

Air pollution refers to the direct or indirect introduction of any substance into the air that could endanger human health; harm living resources, ecosystems, or material property (e.g., buildings); or impair or interfere with the comfortable enjoyment of life or other legitimate uses of the environment. Air pollutants are transported, dispersed, and concentrated by meteorological and topographical conditions. Air quality is affected by air pollutant emission characteristics, meteorology, and topography. This section primarily discusses criteria and toxic air pollutants. Radiological air pollutants are discussed further in Section 3.2.10.

3.2.4.1 General Site Description

The climate at Hanford and the surrounding region is characterized as that of a semiarid steppe. The humidity is low, and winters are mild. According to data collected from 1946 through 2004, the average monthly temperatures at the Hanford Meteorological Station (located between the 200-East and 200-West Areas) range from a low of –0.7 degrees Celsius (°C) (31 degrees Fahrenheit [°F]) in January to a high of 24.7 °C (76 °F) in July. Annual average relative humidity is 55 percent. While the average annual precipitation is 17 centimeters (6.8 inches), most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November though February. The monthly average windspeeds are lower during the winter, averaging 2.7 to 3.1 meters per second (6 to 7 miles per hour); during the summer they average 3.6 to 4.0 meters per second (8 to 9 miles per hour). Prevailing winds are from the northwest (Duncan 2007:4.5–4.13).

Figures 3–3 and 3–4 show wind roses for the Hanford Meteorological Station at the 200 Area for the 9-meter (30-foot) and 61-meter (200-foot) elevations, respectively, for the period 1997 through 2006. Figures 3–5 and 3–6 show wind roses for the meteorological station at the 400 Area for the 9-meter (30-foot) and 61-meter 200-foot) elevations, respectively, for the period 1997 through 2006.

Tornadoes are infrequent and generally small in the northwestern portion of the United States. In the 10 counties closest to Hanford (Benton, Franklin, Grant, Adams, Yakima, Klickitat, Kittitas, and Walla Walla Counties in Washington, and Umatilla and Morrow Counties in Oregon), only 28 tornadoes have been recorded for the period from 1950 through December 2006. The average occurrence of thunderstorms in the vicinity of the Hanford Meteorological Station is 10 per year, with about 1.9 percent considered severe (Duncan 2007:4.13, 4:14).

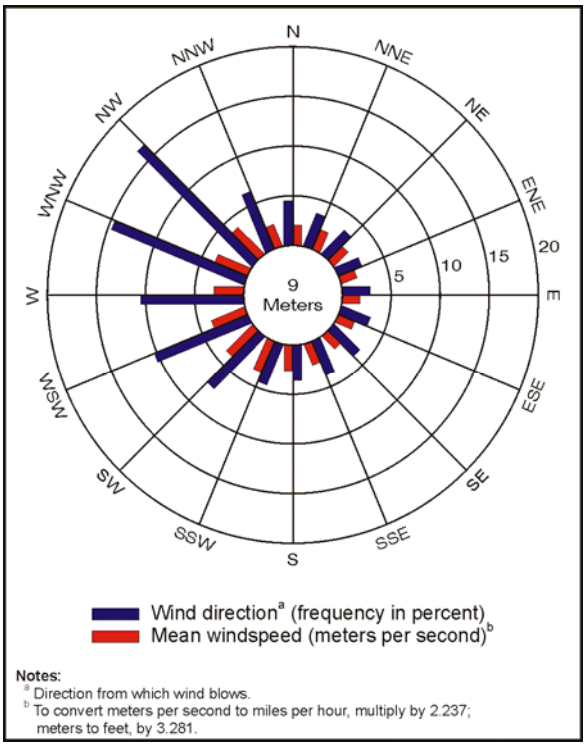


Figure 3–3. Wind Rose for the Hanford Meteorological Station at the 200 Area, 1997–2006 (9-Meter Elevation)

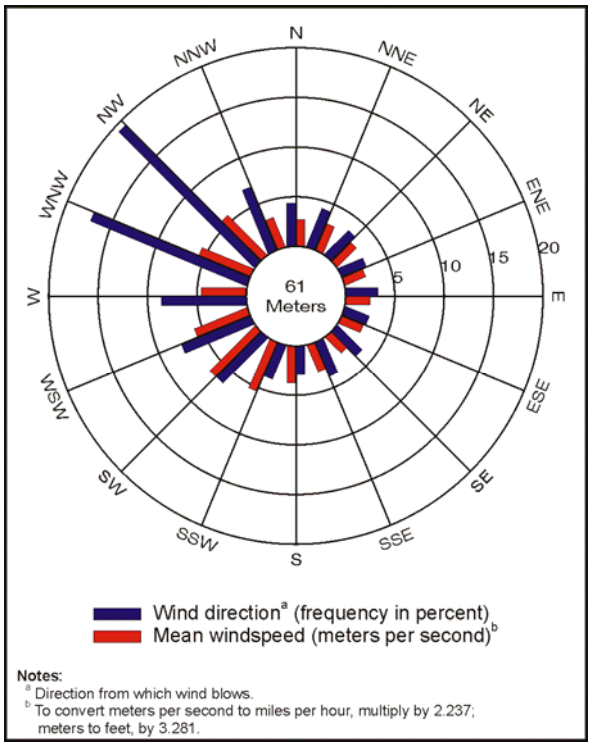


Figure 3–4. Wind Rose for the Hanford Meteorological Station at the 200 Area, 1997–2006 (61-Meter Elevation)

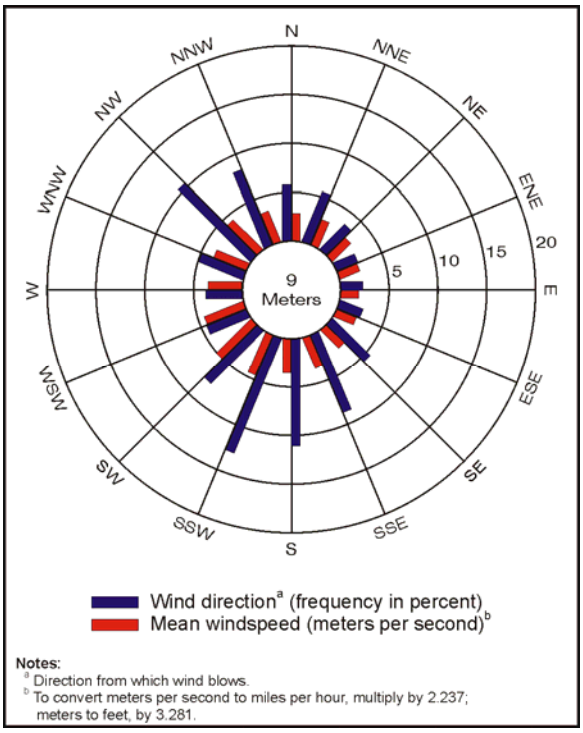


Figure 3–5. Wind Rose for the Fast Flux Test Facility Meteorological Station at the 400 Area, 1997–2006 (9-meter elevation)

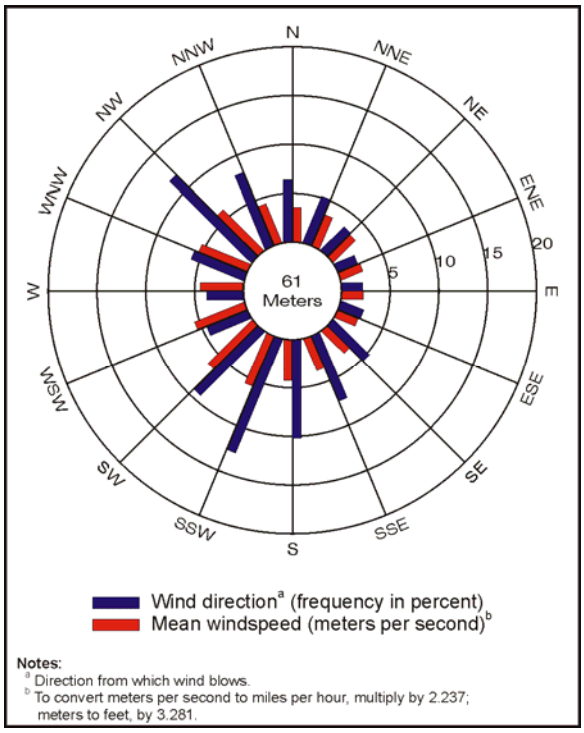


Figure 3–6. Wind Rose for the Fast Flux Test Facility Meteorological Station at the 400 Area, 1997–2006 (61-meter elevation)

Most of Hanford is within the South-Central Washington Intrastate Air Quality Control Region No. 230, but a small portion of the site is in the Eastern Washington-Northern Idaho Interstate Air Quality Control Region No. 62. None of the areas within Hanford and its surrounding counties are designated as nonattainment areas with respect to National Ambient Air Quality Standards (NAAQS) for criteria air pollutants (40 CFR 81.348). Particulate matter (PM) concentrations can reach relatively high levels in eastern Washington State because of extreme natural events such as duststorms and large brush fires. Duststorms are treated as uncontrollable natural events under EPA policy (Nichols 1996). Accordingly, the air quality impact of such storms can be disregarded in determining whether an area is in nonattainment for atmospheric particulates. However, states are required to develop and implement a natural-events action plan (Duncan 2007:4.19). Applicable NAAQS and Washington State ambient air quality standards are presented in Table 3–3.

Table 3–3. Modeled Nonradiological Ambient Air Pollutant Concentrations from Hanford Site Sources and Ambient Air Quality Standards

Pollutant	Averaging Period	Most Stringent Standard or Guideline[a]	Maximum Hanford Concentration[b]
		(micrograms per cubic meter)	
Criteria pollutants			
Carbon monoxide	8 hours	10,000[c]	39.5
	1 hour	40,000[c]	162
Nitrogen dioxide	Annual	100[c]	0.263
Ozone	8 hours 1 hour	147[d] 235[f]	(e) (e)
PM_{10}	Annual 24 hours	50[f, g] 150[c]	0.134 0.884
$PM_{2.5}$	Annual 24 hours	15[d] 35[d, g]	0.134[h] 0.884[h]
Sulfur dioxide	Annual	50[f]	0.00621
	24 hours	260[f]	0.52
	3 hours	1,300[c]	2.01
	1 hour	1,000[f]	4.56
	1 hour	660[e, i]	4.56
Other regulated pollutants			
Total suspended particulates	Annual	60[f]	0.134[h]
	24 hours	150[f]	0.884[h]
Ammonia	24 hours	100[j]	1.91

[a] The more stringent of the Federal and state standards is presented if both exist for the averaging period. The National Ambient Air Quality Standards (40 CFR 50), other than those for ozone, particulate matter, lead, and those standards based on annual averages, are not to be exceeded more than once per year. The annual arithmetic mean $PM_{2.5}$ standard is attained when the expected annual arithmetic mean concentration (3-year average) is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 98th percentile over 3 years of 24-hour average concentrations is less than or equal to the standard value. The 24-hour PM_{10} standard is met when the 99th percentile over 3 years of 24-hour concentrations is less than or equal to the standard value.

[b] Site contributions based on a 2005 emissions inventory, including emissions from the 200 Areas.

[c] Federal and state standard.

[d] Federal standard.

[e] Not directly emitted or monitored by the site.

[f] State standard.

[g] The U.S. Environmental Protection Agency recently revoked the annual PM_{10} standard and changed the 24-hour $PM_{2.5}$ standard from 65 to 35 micrograms per cubic meter.

[h] Assumed to be the same as the concentration of PM_{10} because there are no specific data for total suspended particulates or $PM_{2.5}$.

[i] Not to be exceeded more than twice in any 7 consecutive days.

[j] State acceptable source impact level.

Note: The National Ambient Air Quality Standards include standards for lead. Lead emissions identified at the site are small (less than 1 kilogram [2.2 pounds] per year) and were not modeled. The State of Washington also has ambient standards for fluorides. No emissions of fluorides have been reported at Hanford. To convert cubic meters to cubic feet, multiply by 35.315.

Key: PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: 40 CFR 50; 71 FR 61144; Johnson 2006; Poston et al. 2006:10.12; WAC 173-460, 173-470, 173-474, 173-475, 173-481, 173-490.

The primary sources of criteria and toxic air pollutants at Hanford include emissions from power generation and chemical processing (Duncan 2007:4.19). Other sources include vehicular emissions and construction, environmental remediation, and waste management activities (Wisness 2000). The tank farms in the 200 Areas produced reportable quantities of ammonia emissions in 2006 (Poston et al. 2007:10.10). The ambient air pollutant concentrations at the site boundary attributable to existing sources at Hanford are presented in Table 3–3.

These ambient air pollution concentrations are based on dispersion modeling using year 2005 emissions for Hanford, which are presented in Table 3–4. Only those pollutants that would be emitted under any of the alternatives evaluated in this *TC & WM EIS* are presented. Emissions from carbon tetrachloride vapor extraction work in the 200-West Area are included among the toxic pollutant emissions shown. Emissions from tank vents other than ammonia and criteria pollutants are included among the composite toxic air pollutants. These emissions include 1,3-butadiene, 2-hexanone, 2-pentanone, acetone, acetonitrile, benzene, heptane, hexane, methyl amyl ketone, nonane, octane, phosphoric acid tributyl ester, and toluene (DOE and Ecology 1996:G-36–G-38). The concentrations at the site were calculated from 2000–2004 meteorological data using the American Meteorological Society/EPA Regulatory Model (AERMOD) dispersion model.

Table 3–4. Nonradioactive Constituents Emitted to the Atmosphere at the Hanford Site, 2005

Constituent	Emissions (kilograms)
Carbon monoxide	14,000
Nitrogen oxides	12,000
Particulate matter PM_{10} $PM_{2.5}$	6,500 2,800 1,000
Sulfur oxides	3,000
Lead	0.47
Volatile organic compounds[a]	14,000[b]
Ammonia[c]	12,000[c]
Other toxic air pollutants[d]	6,600[d]

[a] Produced from burning fossil fuels for steam generation and electrical generators and calculated from estimates of emissions from the 200-East and 200-West Area tank farms; evaporation losses from fuel dispensing; and operation of the 242-A Evaporator and the 200 Area Effluent Treatment Facility, Central Waste Complex, T Plant complex, and Waste Receiving and Processing Facility.

[b] Estimate does not include emissions from certain laboratory operations and mobile sources.

[c] Calculated estimates of releases from the 200-East and 200-West Area tank farms, operation of the 242-A Evaporator, and the 200 Area Effluent Treatment Facility.

[d] A composite of calculated estimates of toxic air pollutants, excluding ammonia.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: Poston et al. 2006:10.12**.**

Background concentrations of criteria pollutants are well below ambient standards. As shown in Table 3–3, these modeled concentrations from Hanford sources represent a small percentage of the ambient air quality standards. Hanford emissions should not result in air pollutant concentrations that violate the ambient air quality standards for criteria pollutants. Detailed information on emissions of other pollutants at Hanford is discussed in the *Hanford Site Environmental Report* (Poston et al. 2007:10.10–10.12).

The principal sources of radioactive emissions at Hanford are facilities in the 100, 200, 300, 400, and 600 Areas. Source emissions in the 600 Area are reported with those from the 200-West Area due to their proximity. Emission sources are discussed in the *Hanford Site Environmental Report* (Poston et al. 2007:10.10). Radioactive airborne emissions in 2006 are summarized in Table 3–5. Emissions data are provided as a baseline and are the basis for the human health baseline information discussed in Section 3.3.10, but are not used in the modeling for this *TC & WM EIS*.

Table 3–5. Radionuclides Discharged to the Atmosphere at the Hanford Site, 2006 (curies)

Radionuclide	Release Point				
	100 Areas	**200-East Area**	**200-West Area**	**300 Area**	**400 Area**
Hydrogen-3 (tritium) (as elemental tritium)	NM	NM	NM	7.0×10^{1}	NM
Hydrogen-3 (tritium) (as tritiated water vapor)	NM	NM	NM	2.6×10^{2}	3.7×10^{-1}
Strontium-90	2.3×10^{-5}[a]	4.3×10^{-5}[a]	3.2×10^{-5}[a]	1.2×10^{-6}[a]	NM
Iodine-129	NM	1.5×10^{-3}	NM	NM	NM
Xenon-131m	NM	NM	NM	3.1×10^{-8}	NM
Xenon-135	NM	NM	NM	1.0×10^{-8}	NM
Cesium-137	NM	1.3×10^{-5}	1.2×10^{-7}	6.0×10^{-6}[b]	7.2×10^{-6}[b]
Radon-220	NM	NM	NM	30	NM
Radon-222	NM	NM	NM	0.91	NM
Plutonium-238	2.2×10^{-6}	2.1×10^{-11}	6.0×10^{-7}	ND	NM
Plutonium-239 and -240	1.5×10^{-5}[c]	1.3×10^{-6}[c]	3.2×10^{-5}[c]	1.1×10^{-7}[c]	1.2×10^{-6}[c]
Plutonium-241	8.3×10^{-5}	ND	2.5×10^{-5}	7.4×10^{-10}	NM
Americium-241	1.3×10^{-5}	1.8×10^{-7}	6.6×10^{-6}	4.7×10^{-7}[d]	NM
Americium-243	NM	NM	NM	3.0×10^{-9}	NM
Curium-243 and -244	NM	NM	NM	ND	NM

[a] This value includes gross beta release data, treated as strontium-90 in dose calculations.

[b] This value includes gross beta release data, treated and censium-137 in dose calculations.

[c] This value includes gross alpha release data, treated as plutonium-239 and -240 in dose calculations.

[d] This value includes gross alpha release data, treated as americium-241 in dose calculations.

Key: ND=not detected; NM=not measured.

Source: Poston et al. 2007:7:10.11.

The nearest Prevention of Significant Deterioration (PSD) Class I areas to Hanford are Mount Rainier National Park, 160 kilometers (100 miles) to the west; Goat Rocks Wilderness Area, about 145 kilometers (90 miles) to the west; Mount Adams Wilderness Area, about 153 kilometers (95 miles) to the southwest; and Alpine Lakes Wilderness Area, about 177 kilometers (110 miles) to the northwest (40 CFR 81.434; Ecology 2005; Duncan 2007:4.19). A Class I area is one in which very little increase in pollution is allowed owing to the pristine nature of the area. Hanford and its vicinity are classified as a Class II area, in which more moderate increases in pollution are allowed. The Plutonium-Uranium Extraction (PUREX) and Uranium Trioxide Plants were issued a PSD permit for nitrogen oxide emissions in 1980. These facilities were permanently shut down in the late 1980s and deactivated in the 1990s. None of the currently operating Hanford facilities have nonradiological emissions of sufficient magnitude to warrant consideration under PSD regulations (Duncan 2007:4.17). DOE has applied for and received a PSD permit for the WTP, which includes the Pretreatment Facility, HLW and LAW Facilities, six steam-generating boilers, two diesel fire pumps, and three emergency diesel generators (Ecology 2001, 2005; Hibbard 2003). New emission sources may require a PSD increment consumption analysis if they have significant emissions and air quality impacts. The PSD increments are shown in Table 3–6.

Table 3–6. Prevention of Significant Deterioration Increments for the Hanford Site

Emission	Class I Areas	Class II Areas
	(micrograms per cubic meter)	
Sulfur dioxide		
Annual	2	20
24-hour	5	91
3-hour	25	512
PM_{10}		
Annual	4	17
24-hour	8	30
Nitrogen dioxide		
Annual	2.5	25

Note: To convert cubic meters to cubic feet multiply by 35.315.
Key: PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers.
Source: 40 CFR 52.21.

A sitewide air operating permit for Hanford (permit No. 00-05-006) became effective in July 2001 and was renewed in December 2006 (Duncan 2007:6.23) in accordance with Title V of the Clean Air Act and Amendments of 1990, the Federal and state programs under "State Operating Permit Programs" (40 CFR 70), and the *Washington Administrative Code* (*WAC*) (WAC 173-401). The Hanford Site Air Operating Permit (Ecology 2001, 2006) includes a compilation of requirements for both radioactive emissions covered by the existing state license and nonradioactive emissions. It entails emission and reporting requirements for various sources in the 200 Areas, including oil-fired boilers, large internal-combustion engines, tank exhausters, waste retrieval systems, rotary-mode core sampling systems, tank sluicing, emergency fire pump generators, the 200 Area Effluent Treatment Facility (ETF), tank waste retrieval, tank farm ventilation system, storage of vented waste containers at the Central Waste Complex (CWC), the Waste Receiving and Processing Facility (WRAP), IDF-East, the Bulk Vitrification Facilities, the WTP, the WTP's Concrete Batch Plant, the T Plant complex, and the Plutonium Finishing Plant. The requirements include a limitation of 0.05 percent sulfur distillate fuel oil for larger boilers in the 200 Areas. The primary effects of the permit are to consolidate approval orders and applicable requirements into one permit; require the permitted party to conduct periodic monitoring to show continuous compliance with permit conditions and applicable requirements; and require biannual reporting and annual certification of continuous compliance. A final PSD permit for the WTP was issued by the Washington State Department of Ecology (Ecology) in November 2003. That permit applies to two HLW melters, two LAW melters, and six boilers and requires the use of ultralow-sulfur (maximum 0.003 percent sulfur) fuel in the boilers, diesel fire pump, and diesel generators (Ecology 2005, 2006; Hibbard 2003). The revised application for this permit indicates that concentrations of the pollutants for which the PSD analysis was required (nitrogen dioxide and PM) would be below significance levels for Class II areas and nearby Class I areas when the required best-available control technology was applied. The maximum contributions to ambient air concentrations from these sources are shown in Table 3–7 (Ecology 2005; Su-Coker and Curn 2003).

Table 3–7. Maximum Waste Treatment Plant Contributions to Ambient Air Concentrations as Analyzed for the Revised Prevention of Significant Deterioration Permit Application

Emission	Class I Areas	Class II Areas
	(micrograms per cubic meter)	
PM_{10}		
Annual	0.0008	0.11
24-hour	0.058	1.93
Nitrogen dioxide		
Annual	0.00505	0.61

Note: To convert cubic meters to cubic feet, multiply by 35.315.
Key: PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers.
Source: Ecology 2005; Su-Coker and Curn 2003.

As determined in 2004 monitoring conducted off site by the Benton County Clean Air Authority, the maximum and annual average $PM_{2.5}$ and PM_{10} concentrations were below EPA and Washington State standards (Duncan 2007:4.19). Ambient air quality at Hanford is discussed in more detail in the *Hanford Site Environmental Report* (Poston et al. 2007:10.13–10.26). The air operating permit indicates that toxic air pollutants from tank farm activities in the 200 Areas have been demonstrated to be below the acceptable source impact levels and are required to remain below these levels (Ecology 2001, 2006).

Routine monitoring of most nonradiological pollutants is not conducted at the site. Monitoring of nitrogen oxides and total suspended particulates at Hanford has been discontinued as a result of the phasing out of those programs that required the monitoring. Carbon monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of Hanford (Duncan 2007:4.19). In 1995, moreover, air samples of semivolatile organic compounds were collected on the site and at an offsite location, and results are discussed in the site's annual environmental report. All concentrations of these compounds were below the applicable risk-based concentrations (Dirkes and Hanf 1996:95–108). Continuous monitoring of PM_{10} and $PM_{2.5}$ was initiated at the Hanford Meteorological Station and the 300 Area in 2001. Values reported for PM_{10} exceeded the 24-hour standard value only once during 2005 on a windy day. The PM monitors involved in this effort are not used to determine compliance with ambient standards (Poston et al. 2006:10.26, 10.27). Ambient monitoring of ammonia and other toxic pollutants is not routinely conducted at Hanford.

Continuous monitoring is performed for radioactive airborne emissions from Hanford activities that have the potential to exceed 1 percent of the 10-millirem per-year standard for offsite doses specified in the "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 CFR 61.90–61.97, Subpart H) and in the state "Ambient Air Quality Standards and Emission Limits for Radionuclides," subsection "Ambient Standard" (WAC 173-480-040). These emissions are primarily from ventilation stacks in the 100, 200, 300, 400, and 600 Areas. Radioactivity in the ambient air is routinely monitored in the area near Hanford. The radiological monitoring network includes downwind air samplers near the sites and facilities and in distant offsite communities. Monitoring in 2006 consistently detected concentrations of uranium-234 and -238 at most of the 100 Areas, in the 200-East Area, near the 200-West Area, and within the 300 Area. Occasional detection of other radionuclides varied by area: americium-241, plutonium-239 and -240, strontium-90, and uranium-235 at the 100 Areas; cesium-137 and plutonium-239 and -240, at the 200-East Area; and plutonium-239 and -240 and uranium-235 near the 200-West Area. Average concentrations in near-facility air samples are compared to those in distant communities in the *Hanford Site Environmental Report* (Poston et al. 2007:10.9, 10.10, 10.15–10.17).

Radionuclides are also regulated under the Washington State "Radiation Protection Standards" (WAC 246-221), which limit the maximum total effective dose equivalent for any member of the public to 100 millirem per year.

3.2.4.2 200 Areas Description

Prevailing winds in the 200 Areas are from the west-northwest to northwest (Duncan 2007:4.8, 4.9). The 200 Areas emit various nonradiological air pollutants. The sources of criteria and toxic air pollutant emissions in the 200 Areas include generators; tank farm exhausters; evaporators; boilers; vehicles; and construction, environmental remediation, and waste management activities (Hebdon 2003; Johnson 2006; Wisness 2000). The tank farms in the 200 Areas produced reportable ammonia emissions in 2006 (Poston et al. 2007:10.10). Year 2005 emissions for the 200 Areas are included in the sitewide emissions presented in Table 3–4. Emissions from carbon tetrachloride vapor extraction work in the 200-West Area are included in the toxic pollutant emissions shown. Emissions from tank vents other than ammonia and criteria pollutants are included in the composite toxic air pollutants. These emissions include 1,3-butadiene, 2-hexanone, 2-pentanone, acetone, acetonitrile, benzene, heptane, hexane, methyl amyl ketone, nonane, octane, phosphoric acid tributyl ester, and toluene (DOE and Ecology 1996:G-36–G-38).

The primary sources of radioactive emissions to the air from the 200 Areas are the storage and treatment of radioactive waste. In 2006, emissions from the 200 Areas originated from the PUREX Plant, Waste Encapsulation and Storage Facility, Plutonium Finishing Plant, T Plant, underground storage tanks, and waste evaporators (Poston et al. 2007:10.10). Radioactive airborne emissions from the 200 Areas in 2006 are summarized in Table 3–5.

The Hanford Site Air Operating Permit (Ecology 2006) includes emission and reporting requirements for various sources in the 200 Areas, including oil-fired boilers, large internal-combustion engines, tank exhausters, waste retrieval systems, rotary-mode core sampling systems, tank sluicing, emergency fire pump generators, the 200 Area ETF, tank waste retrieval, tank farm ventilation systems, storage of vented waste containers at the CWC, and WRAP.

3.2.4.3 400 Area Description

Prevailing winds in the 400 Area are from the south-southwest, with a secondary maximum from the northwest (Duncan 2007:4.9). The 400 Area emits no nonradiological air pollutants of regulatory concern (see Section 3.2.4.1) (Poston et al. 2007:10.11). Operations and support activities at FFTF and the Maintenance and Storage Facility release small quantities of radioactive material to the environment (Poston et al. 2007:10.10, 10.11).

3.2.4.4 Borrow Area C Description

Prevailing winds in the area around Borrow Area C are likely from the west-northwest to northwest, although farther to the west, under the influence of Yakima Ridge, they are from the west-southwest (Duncan 2007:4.9). There are currently no quarry activities in Borrow Area C that would produce emissions of air pollutants.

3.2.5 Geology and Soils

The geologic and soil resources of Hanford and the vicinity are described below with respect to regional physiography and geologic structure; site stratigraphy; rock and mineral resources; geologic hazards, including regional seismicity; and soil attributes. The geologic and soil characteristics of the 200 Areas, 400 Area, and Borrow Area C are specifically described.

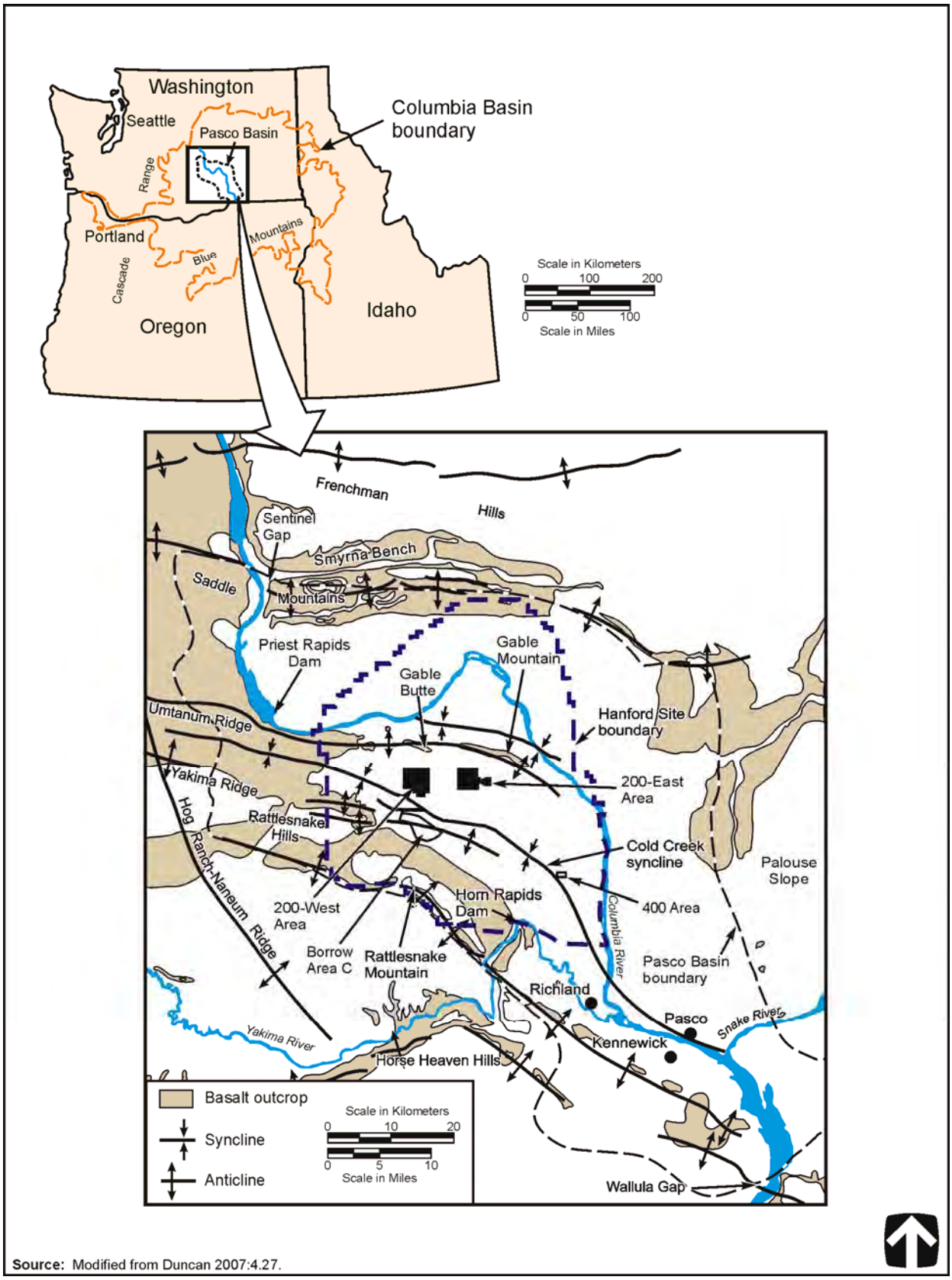
3.2.5.1 General Site Description

3.2.5.1.1 Physiography and Structural Geology

Hanford lies within the Columbia Basin, which comprises the northern part of the Columbia Plateau physiographic province and the Columbia River flood-basalt geologic province (Duncan 2007:4.25; Reidel et al. 1994:159). Thus, the extent of the Columbia Basin is generally defined as that area underlain by the Columbia River Basalt Group. Within this region, Hanford lies within the Pasco Basin, a structural and topographic depression of generally lower-relief plains and anticlinal ridges (Duncan 2007:4.25, 4.26). Elevations across the central portion of the basin and Hanford range from about 119 meters (390 feet) above mean sea level at the Columbia River to 229 meters (750 feet) above mean sea level across the 200 Areas. The Pasco Basin is bounded on the north by the Saddle Mountains; on the west by Hog Ranch–Naneum Ridge and the eastern extension of Umtanum and Yakima Ridges; on the south by Rattlesnake Mountain and the Rattlesnake Hills; and on the east by the Palouse Slope. Two east-west trending ridges, Gable Butte and Gable Mountain, lie in the central portion of Hanford between the 100 and 200 Areas. These features reflect the eastern extension of Umtanum Ridge into Hanford. Rattlesnake Mountain, the highest of the Rattlesnake Hills, reaches an elevation of 1,060 meters (3,480 feet) above mean sea level, the highest elevation in the area. A geological fault is typically present on the north side of the folded ridges where the strata fractured as the ridges were folded (see Figures 3–7 and 3–8) (DOE 1999a:4.12, 4.13; Duncan 2007:4.25, 4.26, 4.29, 4.159).

Several geologic processes, acting over millions of years, have shaped the surface topography of the Columbia Basin and specifically formed the rocks, sediments, and soils found across Hanford. The area was covered with numerous basaltic lava flows (now represented by the Columbia River Basalt Group) between 6 million and 17 million years ago. This was followed by tectonic forces that folded the basalt. In this landscape, the ancestral Columbia River meandered across the area, leaving behind layers of sediment called the Ringold Formation (Duncan 2007:4.25, 4.29, 4.30, 4.35). Beginning as early as 1.8 million years ago and extending through much of the Pleistocene epoch (i.e., until 15,000 years ago), the region was inundated by a series of ice-age floods that deposited sediments that are informally referred to as the "Hanford formation." During the freezes and thaws that occurred in the Ice Age, an ice dam across the Clark Fork River and glacial Lake Missoula in Montana formed and failed many times, each time releasing a wall of water that surged southwest through the Columbia Basin, inundating the area that is now Hanford. The most recent major glacial flood cycle is thought to have occurred between 15,000 and 30,000 years ago. Fine-grained deposits associated with the last floods commonly contain Mount St. Helens volcanic ash, dated approximately 15,000 years ago.

Current interpretations suggest that as many as 40 individual flooding events occurred during the most recent glacial cycle, as ice-dams holding back glacial Lake Missoula repeatedly formed and burst. In addition to flood episodes from Lake Missoula, there was also at least one flood from glacial Lake Bonneville in Utah, and possibly floods from other ice-dammed, lakes in northern Washington and Idaho. Temporary lakes were created when flood waters were hydraulically dammed, resulting in the formation of the short-lived glacial Lake Lewis behind Wallula Gap. Evidence for these temporary lakes includes high-water marks inferred from ice-rafted boulders and sediments along the basin margins at elevations between 370 and 385 meters (1,214 to 1,261 feet) above sea level, far above the present Pasco Basin bottom. As the water moved across eastern Washington, it eroded the basalt, forming channels of barren rocky land referred to as the "scablands." At other localities, away from the main flood channels, the water deposited bars of gravel and sand. Branching flood channels, giant current ripples, ice rafted erratics, and giant flood bars are among the landforms created by the floods and readily seen at Hanford (Duncan 2007:4.33; USGS 2002).



Source: Modified from Duncan 2007:4.27.

Figure 3–7. Physiographic Setting and General Structural Geology of the Pasco Basin and Hanford Site

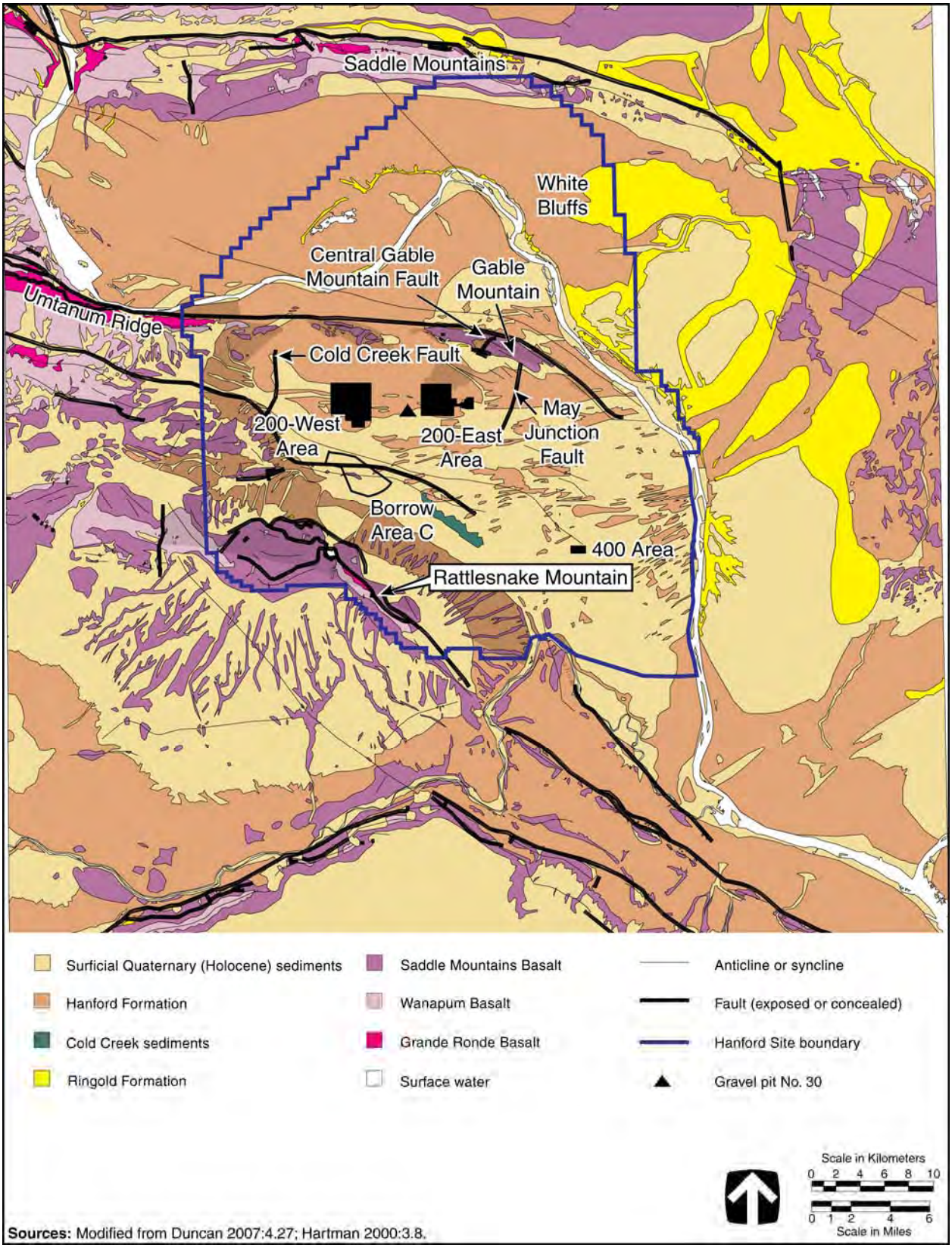


Figure 3–8. Surface Geology and Structural Features of the Pasco Basin and Hanford Site

Since the end of the Pleistocene epoch, winds have locally reworked the flood sediments, depositing dune sands in the lower elevations and loess (windblown fine sand and silt) around the margins of the Pasco Basin. Anchoring vegetation has stabilized many sand dunes. Active dunes exist north of the 300 Area in the Hanford Reach National Monument. Some dunes were temporarily reactivated by the removal of vegetation resulting from the 24 Command Fire of June–July 2000 (Duncan 2007:4.25, 4.34).

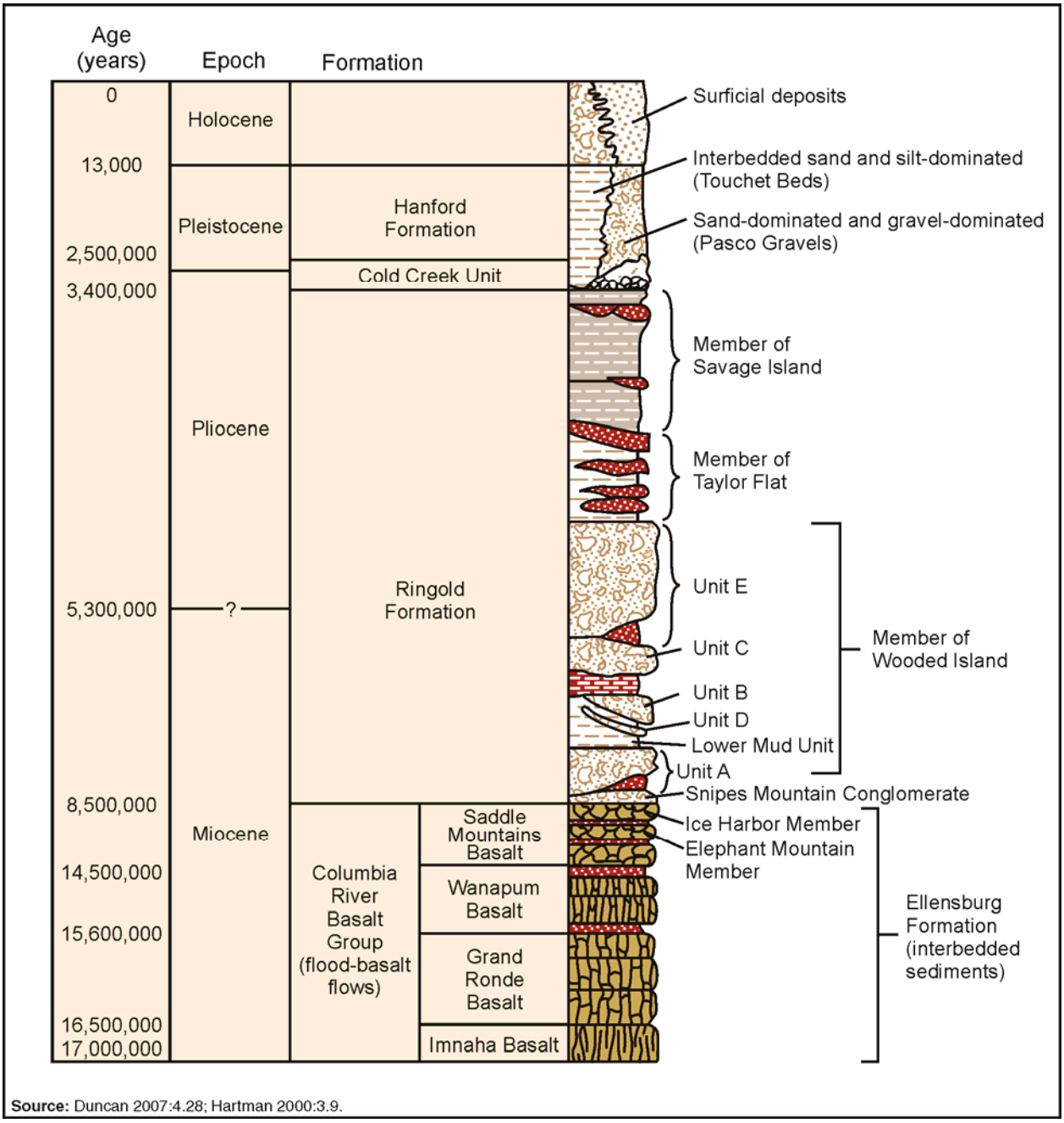
Structurally, Hanford is near the junction of the Yakima Fold Belt and the Palouse Slope. The underlying basalt of the Palouse Slope dips gently toward the central Columbia Basin and exhibits mild structural deformation. A wedge of Columbia River basalt underlies the Palouse Slope (see Figure 3–7) and thins gradually toward the east and north. The Yakima Fold Belt consists of all the generally east-west-trending, long, narrow ridges (anticlines) and intervening valleys (synclines) that arose as tectonic forces buckled and folded the basalt and associated sediments in the western Columbia Basin. The fold belt was growing during the eruption of the Columbia River basalts and continued to grow into the Pleistocene epoch and probably into the present from north-south compression. A fault is typically present on the north side of the ridges where the rock broke as it was folded (Duncan 2007:4.25-4.27, 4.30, 4.35, 4.36).

Mapped faults in the Hanford area include reverse or thrust faults on the north side of the Saddle Mountains on the northern Hanford boundary and in association with Rattlesnake Mountain and the Rattlesnake Hills in the southwestern portion of the site (part of the Rattlesnake-Wallula alignment, which passes along the southwest boundary of Hanford) (see Figure 3–8) (Duncan 2007:4.35, 4.37). Other faults include the Cold Creek Fault, on the west end of the Cold Creek syncline, and the May Junction Fault, located nearly 4.5 kilometers (3 miles) east of the 200-East Area. Moreover, a potential for Quaternary-age (Holocene) faulting has been identified on the Gable Butte–Gable Mountain Segment of the Umtanum Ridge–Gable Mountain anticline—specifically, on Gable Mountain where the Central Gable Mountain Fault has offset sediments 13,000 years old (Reidel et al. 1994:170–172).

3.2.5.1.2 Stratigraphy

The unconsolidated sediments and rocks beneath Hanford consist of Miocene-age (5 million to 24 million years old) and younger strata that overlie older Cenozoic sedimentary and volcanic basement rocks (DOE 1999a:4-12, 4-16; Duncan 2007:4.26, 4:28). The major geologic units immediately underlying Hanford are, in ascending order (1) the Columbia River Basalt Group and interbedded Ellensburg Formation and (2) the Ringold Formation, Cold Creek Unit, and Hanford formation, collectively known as the suprabasalt sediments. The surficial occurrence and distribution of these units is shown in Figure 3–8. Figure 3–9 presents a stratigraphic profile of Hanford.

The Columbia River Basalt Group consists of sequences of Miocene-age continental flood basalts that cover an extensive area across Washington, Oregon, and Idaho. These basalts erupted over a period ranging from approximately 6 million to 17 million years ago. Columbia River basalt flows erupted from north-northwest trending fissures or linear vent systems mostly in north-central and northeastern Oregon, eastern Washington, and western Idaho. Beneath Hanford is a minimum of 50 basalt flows with a combined thickness greater than 3,000 meters (9,800 feet). Basalt outcrops are exposed on ridges at Gable Mountain, Gable Butte, and the Saddle Mountains in the northern part of Hanford, and on Rattlesnake Hills and Yakima Ridge on the western and southwestern edges of the site (see Figure 3–7). Basalt flows at Hanford have eroded to various degrees in localized areas. Interbedded with, and in some places overlying the Columbia River Basalt Group, are the volcaniclastic (volcanic-sedimentary) and fluvial (stream-deposited) sedimentary materials of the Ellensburg Formation. In the western Columbia Basin, the Ellensburg Formation is mostly volcaniclastic sediment; in the central and eastern basin, fluvial mainstream and overbank sediments of the ancestral Clearwater-Salmon and Columbia Rivers form the dominant lithologies (Duncan 2007:4.29; Reidel et al. 1994:160).



Source: Duncan 2007:4.28; Hartman 2000:3.9.

Figure 3–9. Stratigraphic Column of the Hanford Site

The Ringold Formation consists of a mix of variably cemented gravel, sand, silt, and clay deposited by the ancestral Columbia River system (Duncan 2007:4.31; Hartman 2000:32). Ringold Formation deposits represent an eastward shift of the Columbia River across Hanford. The Columbia River first flowed across the west side of Hanford (where Dry Creek is now), crossing through Rattlesnake Hills. The river eventually shifted to a course that took it through Gable Mountain–Gable Butte Gap (Gable Gap) and south across the present 200-East Area (Hartman 2000:3.2). In summary, about 8.5 million years ago, the river meandered across a gravelly braided plain, depositing the extensive gravel and interbedded sand of the oldest Ringold sediments, Unit A, Member of Wooded Island (see Figure 3–9). Between 5 and 7 million years ago, the Columbia River abandoned the Yakima River water gap (near present-day Benton City) and began to exit the Pasco Basin through Wallula Gap. Around 6.7 million years ago, the

Columbia River became a sandy alluvial system, depositing extensive lake and stream overbank sediments known as the Ringold Formation Lower Mud Unit. The Lower Mud Unit was covered by another extensive sequence of mainstream gravels and sands in the central Pasco Basin and fine-grained overbank deposits near the 100 Areas. The most extensive of the coarse sediments, Unit E, Member of Wooded Island, underlies much of the 200 Areas. The Columbia River sediments became more sand-dominated about 5 million years ago when over 90 meters (295 feet) of interbedded fluvial sand and overbank deposits accumulated at Hanford. These deposits are collectively called the Member of Taylor Flat. The fluvial sands of the Member of Taylor Flat dominate the lower cliffs of the White Bluffs but have been subsequently eroded from most of Hanford. The last Ringold unit (Member of Savage Island) was deposited between 3.4 and 4.8 million years ago in the form of lake deposits. A series of three successive lakes are recognized along the White Bluffs and elsewhere along the margin of the Pasco Basin. Then, regional uplift associated with the Cascade Mountains marked a change from sedimental disposition to removal and caused the river to cut through its own earlier deposits (the Ringold Formation), exposing the White Bluffs (Duncan 2007:4.31). The Ringold Formation at Hanford is as much as 185 meters (600 feet) thick and attains a thickness of about 285 meters (935 feet) along White Bluffs (see Figure 3–8) (Neitzel 2005:4.32; Reidel et al. 1994:162).

The Cold Creek Unit includes all alluvial and eolian (wind-deposited) sediments, as well as a series of extensively weathered, carbonate-rich, buried soil profiles called Paleosols. These sediments and paleosols overlie the Ringold Formation and underlie the Hanford formation in the vicinity of the 200-West Area, and may extend over most of the central Pasco Basin. This unit is also locally prevalent in the Cold Creek syncline in the subsurface. It includes deposits referred to as the "Plio-Pleistocene Unit" and "pre-Missoula gravels," as well as the 200-West Area's "early Palouse soils" and "caliche layer" (DOE 2002b:3-1, 3-2). Because it was formed when the Ringold Formation was eroding and relatively little was being deposited, the distribution of the unit depends in part on erosion and weathering of the underlying Ringold Formation and postdepositional erosion by the ice-age floods. As such, the unit is discontinuous, with a thickness ranging from 0 to 20 meters (0 to 66 feet) (Neitzel 2005:4.32). Cold Creek Unit paleosols and small-stream drainages were developing in the 200-West Area while the Columbia River was still eroding the 200-East Area. The paleosols and side-stream sediments, which are referred to as the "Lower Cold Creek Unit," are consequently more numerous and heavily cemented, forming layers known as caliches or hardpans in the 200-West Area. Eolian and minor fine-grained stream sediments were deposited on the Lower Cold Creek Unit, resulting in a wide variety of sediments that are called the Upper Cold Creek Unit. The thickness and type of sediment is highly variable due to several localized environments. Because of their fine-grained or cemented nature, the Upper and Lower Cold Creek Units play important roles in the movement of water and contaminants through the vadose zone. Gravels of mixed lithologies in a sand matrix reflect deposition by the Columbia River as it flowed through Gable Gap. These mainstream gravel deposits, which are informally called the pre-Missoula gravels, immediately overlie the Ringold Formation. They are often difficult to differentiate from similar gravel deposits in the Ringold Formation and Hanford formation (Duncan 2007:4.32, 4.33; Hartman 2000:3.3).

The gravel, sand, and silt deposits composing the strata informally called the Hanford formation are products of Ice-Age floods that inundated the Pasco Basin and Hanford during the Pleistocene epoch as previously described in Section 3.2.5.1. The Hanford formation sediments were left after the floodwater receded and now blanket low-lying areas over most of Hanford. Associated deposits occur in three distinct assemblages, dominated by coarse sand and gravel, sand, and interbedded sand and silt (Duncan 2007:4.33). The sediments range up to boulder size, with the lithofacies (sediment types) grading or interfingering with one another in both the horizontal and vertical direction (DOE 2002b:3-9). The gravel-dominated flood deposits are generally confined to tracts within or adjacent to flood channels and reflect higher-energy depositional environments. A major depositional feature called the Cold Creek bar underlies the 200 Areas at Hanford and was deposited just south of one such channel. Gravel-dominated flood sediments deposited on the north side of the bar grade into sand-dominated

sediments on the south side. Gravel- and sand-dominated sediments compose most of the vadose zone beneath Hanford. Coarse- to fine-sand deposits represent a transitional depositional environment between the fluvial gravel-dominated deposits and the interbedded sands and silts. The interbedded sand- and silt-dominated sediments were deposited in low-energy slackwater areas around the margins of the Pasco Basin, and they are rarely encountered during Hanford operations. They specifically consist of rhythmically bedded silt and sand (referred to as rhythmite deposits) and have been named the "Touchet Beds" at Hanford (see Figure 3–9) (Duncan 2007:4.33; Hartman 2000:3.3).

Clastic dikes are vertical to subvertical tabular structures that crosscut normal sedimentary layers and are usually filled with multiple layers of unconsolidated sediments. They are common in Hanford vadose zone sediments (Duncan 2007:4.34) (see Appendix N, Section N.3.5) for additional information on clastic dikes).

Surficial Quaternary-age (Holocene) deposits (gravel, sand, and silt) with a total thickness of generally less than 5 meters (16 feet), span much of Hanford. Eolian deposits of fine-grained sand and silt also occur, particularly in the southern part of the 200-East Area and in the 200-West Area (Hartman 2000:3.4). An extensive, stabilized field of sand dunes extends from the southern boundary of the 200-East Area to the south across the 300 Area and east to the Columbia River. An active dune field is located just north of Energy Northwest in Hanford Reach National Monument (DOE 1999a:4-22; Duncan 2007:4.33).

3.2.5.1.3 Rock and Mineral Resources

Geologic resources, including relatively large volumes of gravel, sand, and silt, are available from the suprabasalt sediments and associated soils on Hanford. Basalt is also plentiful. As discussed in the *Environmental Assessment, Use of Existing Borrow Areas, Hanford Site, Richland, Washington* (DOE 2001b), a number of active gravel and sand pits and two rock quarries at Hanford have been identified for use as a continuing source of borrow materials for new facility construction and the maintenance of existing facilities and transportation corridors, as well as fill and capping material for remediation and other sites. Specifically addressed in the environmental assessment was the provision of an additional 7.6 million cubic meters (10 million cubic yards) of materials over a 10-year period (beginning in fiscal year 2001), including 692,000 cubic meters (905,000 cubic yards) to support WTP project activities.

Of the two designated quarries on the site, quarry No. 2 (referred to as Borrow Area C in this *TC & WM EIS*), located due south of the 200-West Area and just south of State Route 240, is described as having large volumes of basalt and sand (DOE 1999a:D–7, 2001b:2-2, 3-1–3-4). Borrow Area C is a 926.3-hectare (2,289-acre) area that would be operated to provide necessary rock riprap (basalt), aggregate (gravel and sand), and soil (silt and loam) to support facility construction and tank closure activities as described in this *TC & WM EIS* (DOE 2003a:5-3, 6-15, 6-21, 6-46, 6-73). This borrow site would be developed using modern open-pit excavation techniques, with excavations averaging 4.6 meters (15 feet) in depth and provision for cut-slope maintenance, haul roads, and stockpile and buffer areas. It is estimated that Borrow Area C could yield 42.6 million cubic meters (55.7 million cubic yards) of borrow material (SAIC 2006b). The other quarry, gravel pit No. 30, located between the 200-East and 200-West Areas, is an approximately 54-hectare (134-acre) borrow site containing a large quantity of aggregate suitable for multiple uses (DOE 2001b:3-4, A-3). Aggregate reserves at pit No. 30 are estimated at 15.3 million cubic meters (20 million cubic yards) of material (DOE 1999a:D-4). This pit continues to provide aggregate (sand and gravel) for onsite concrete batch plants in support of the construction of new facilities, including those at the WTP adjacent to the 200-East Area.

As for other geologic resources on the site, placer gold was historically extracted along the Columbia River on and near Hanford, and small volumes of natural gas were produced from wells developed on Rattlesnake Mountain from about 1929 to 1941 (DOE 1999a:4-18).

3.2.5.1.4 Seismicity and Geologic Hazards

The seismicity of the Columbia Plateau, as determined by the rate of earthquakes per area and the magnitude of these events, is lower than that of other regions in the Pacific Northwest. Nevertheless, Hanford has been affected by earthquakes within and beyond the Columbia Plateau. The largest known earthquake in the Columbia Plateau occurred in 1936 near Milton Freewater, Oregon. This moderate earthquake had a magnitude of 5.75 and a maximum Modified Mercalli Intensity (MMI) of VII, and it featured a number of aftershocks (Duncan 2007:4.43). Appendix F, Table F–7, summarizes and compares the parameters cited in this *TC & WM EIS* to describe earthquakes and their effects. Other moderate-to-major earthquakes with magnitudes greater than 5 or MMIs of VI have occurred along the boundaries of the Columbia Plateau northwest of Hanford and extending into the northern Cascade Range. A strong-to-major earthquake of uncertain location occurred in north-central Washington in 1872. This event had an estimated magnitude of 7.4 and an estimated maximum MMI ranging from VIII to IX (Duncan 2007:4.43; USGS 2003). Evidence of landslides near Lake Chelan, Washington, suggests a location near there. A more recent study of this event indicates a magnitude of 6.8, a maximum MMI of VIII, and a location at the south end of Lake Chelan (Duncan 2007:4.43). Nevertheless, it was reportedly felt over a wide area from British Columbia, Canada, to Oregon and from the Pacific Ocean to Montana. Near Lake Chelan, huge landslides, massive fissures in the ground, and a 9-meter-high (29-foot-high) geyser were reported. Shaking-intensity maps produced for the event indicate that MMI VI shaking extended southeast across the Columbia Plateau and beyond Hanford (USGS 2003).

Major earthquakes have also occurred east of the Columbia Plateau in the Rocky Mountains. These include the 1959 Hebgen Lake earthquake in western Montana, which had a magnitude of 7.5 and an MMI of X, and the 1983 Borah Peak earthquake in eastern Idaho, which had a magnitude of 7.3 and an MMI of IX. A number of strong-to-major earthquakes (magnitude 6 to greater than 7) have occurred in western Washington in and around the Puget Sound area in association with the subducting Juan de Fuca tectonic plate. Most recently, a magnitude-6.8 earthquake (termed the "Nisqually earthquake") occurred on February 28, 2001, near Olympia, Washington. It produced ground shaking that reached an MMI of VIII. This event was similar to other events recorded in 1949 and 1965 (Duncan 2007:4.42, 4.43).

The two largest earthquakes near Hanford occurred in 1918 and 1973; each had an approximate magnitude of 4.4 and an MMI of V. They occurred in the central portion of the Columbia Plateau north of Hanford near Othello, Washington (Duncan 2007:4.43). The epicenter of the December 20, 1973, event was instrumentally located approximately 49 kilometers (30 miles) northeast of the 200 Areas. This earthquake occurred at a rather shallow depth of about 1 kilometer (0.6 miles) (USGS 2007a). Earthquakes in eastern Washington generally originate at shallow depths, most at depths of less than 6 kilometers (3.7 miles). The Saddle Mountains region in which the December 20, 1973, earthquake occurred is one of the most active earthquake areas in eastern Washington; earthquakes there tend to occur in clusters or "swarms" (i.e., the earthquakes are concentrated in an area and occur in a series over a short period of time) (Noson, Qamar, and Thorsen 1988). Earthquake swarms have also occurred in several locations within Hanford. Deeper earthquakes in the central Columbia Plateau occur up to depths of about 30 kilometers (18.6 miles). These deeper earthquakes are less clustered and generally occur as isolated events. Survey data indicate that the shallow earthquake swarms are occurring in the Columbia River Basalts and the deeper earthquakes in deeper, crustal layers (Duncan 2007:4.43, 4.45). Eighty small earthquakes (ranging in magnitude from 2.5 to 4.3) have been recorded within a radius of 90 kilometers (56 miles) of the Central Plateau of Hanford (200 Areas) since the December 1973 earthquake. The closest of these was a magnitude-3.3 event on November 13, 1994; it had an epicenter about 8 kilometers (5 miles) north of the 200 Areas (USGS 2007a).

As part of the operating license review for Energy Northwest, the U.S. Nuclear Regulatory Commission (NRC) concluded that four Hanford earthquake sources should be considered for seismic design: the Rattlesnake-Wallula alignment, Gable Mountain, a "floating" earthquake in the tectonic province, and a swarm area. The Commission estimated a maximum earthquake magnitude of 6.5 for the Rattlesnake-Wallula alignment and 5.0 for Gable Mountain. The floating-earthquake design criterion was developed from the largest event located in the Columbia Plateau, the magnitude-5.75 Milton-Freewater earthquake. The maximum-swarm earthquake for the purposes of seismic design was a magnitude-4.0 event based on the December 1973 earthquake (Duncan 2007:4.45, 4.46).

Earthquake-produced ground motion is expressed in units of percent *g* (force of acceleration relative to that of the Earth's gravity). Two differing measures of this motion are peak horizontal (ground) acceleration and response spectral acceleration. New seismic hazard metrics and maps developed by the U.S. Geological Survey (USGS) and adapted for use in the *International Building Code* depict maximum considered earthquake ground motions of 0.2- and 1.0-second spectral accelerations based on a 2 percent probability of exceedance in 50 years (USGS 2007a). This corresponds to an annual probability (chance) of occurrence of about 1 in 2,500. Appendix F, Section F.5.2, of this *TC & WM EIS* provides a more-detailed explanation of these map parameters and their use. For the 200 Areas, the calculated maximum considered earthquake ground motion is approximately 0.46 *g* for a 0.2-second spectral acceleration and 0.15 *g* for a 1.0-second spectral acceleration. The calculated peak ground acceleration for the given probability of exceedance at the site is approximately 0.20 *g* (USGS 2007b). For comparison, the aforementioned 2001 Nisqually earthquake produced peak horizontal (ground) accelerations ranging from 0.0016 to 0.0055 *g*, as measured across Hanford (Duncan 2007:4.43). The *International Building Code* maximum considered earthquake values are cited to provide the reader with a general understanding of seismic hazard. However, for the design of moderate- or high-hazard nuclear facilities, DOE prescribes seismic criteria that are more rigorous and thus provide a greater margin of safety than the *International Building Code* values cited here (see Appendix F, Section F.5.2).

Probabilistic seismic hazard analyses are used to determine ground motions expected from multiple earthquake sources, which are then used to design or evaluate facilities at Hanford. On the basis of the most recent site-specific seismic analyses, it is estimated that an earthquake producing a horizontal (ground) acceleration of 0.10 *g* at Hanford would be experienced on average every 500 years (annual probability of occurrence of 1 in 500). An earthquake producing a peak horizontal (ground) acceleration of 0.2 *g* is calculated to have an annual probability of occurrence of 1 in 2,500, which is in approximate agreement with the national seismic hazard maps produced by the USGS (Duncan 2007:4.46). As stated in DOE Order 420.1B, DOE requires nuclear and nonnuclear facilities to be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. A site-specific ground response model developed for the WTP being constructed at Hanford stipulated increased ground motions for the design basis of this facility by up to 40 percent to be more conservative (Duncan 2007:4.46).

Several major volcanoes are in the Cascade Range west of Hanford, including Mount Adams and Mount St. Helens, 165 kilometers (102 miles) and 220 kilometers (137 miles), respectively, from the site. Ashfalls from at least three Cascade volcanoes have blanketed the central Columbia Plateau since the late Pleistocene epoch. Generally, ashfall layers have not exceeded more than a few centimeters (less than 1.5 inches) in thickness, with the exception of the Mount Mazama (Crater Lake, Oregon) eruption, when as much as 10 centimeters (3.9 inches) of ash fell over eastern Washington (Barghusen and Feit 1995:2.2–2.14).

Slope failure is also a potential concern at Hanford, although only the slopes of Gable Mountain and White Bluffs are steep enough to warrant landslide concern. White Bluffs, east of the Columbia River, poses the greatest concern. This risk is in part attributable to the largely unconsolidated and uncemented nature of the Ringold sediments composing much of the bluffs, the discharge of irrigation water atop the

bluffs and subsequent percolation thereof through the sediments, and the general dip of the sediments toward the Columbia River (DOE 1999a:4-18, 4-21; Duncan 2007:4.39, 4.40).

3.2.5.1.5 Soils

Fifteen different soil types occur at Hanford. These soils vary from sand to silty and sandy loam. The dominant soil types are Quincy (Rupert) sand, Burbank loamy sand, Ephrata sandy loam, and Warden silt loam (Duncan 2007:4.39, 4.40). No soils at Hanford are currently classified as prime farmland soils because there are no current soil surveys, and the only prime farmland soils in the region are irrigated (DOE 1999a:4-23, 4-24). The parent material for the predominant soil types at Hanford includes Hanford formation and Holocene-age surficial deposits, as discussed in Section 3.2.5.1. Quincy (Rupert) sand is the most widespread soil type at Hanford and makes up much of the southeast and east-central portions of the site. However, it is also found across portions of the 200-East Area and the majority of the western portion of the 200-West Area. It developed from sandy alluvial deposits mantled by windblown sand. The soils are deep to moderately deep—51 to 76 centimeters (20 to 30 inches). Burbank loamy sand occurs mainly north of the 200 Areas and south of the Columbia River, along with Ephrata sandy loam. The Burbank soil is moderately deep overall, but grades to a gravelly subsoil. The surface soil may be up to 76 centimeters (30 inches) thick, with the subsoil containing up to 80 percent gravel. While this soil intermingles with Quincy (Rupert) sand and Ephrata sandy loam in the 200-East Area, it composes the balance (eastern portion) of the 200-West Area. Warden silt loam occurs in a broad band in the south and southwestern portions of the site, running from the south boundary of the site and downslope of Rattlesnake Mountain (DOE 1999a:4-23–4-27; Duncan 2007:4.40–4.42).

3.2.5.2 200 Areas Description

The Central Gable Mountain Fault is the nearest potentially active fault to the 200 Areas; it is 4 kilometers (2.5 miles) northeast of the 200-East Area (see Figure 3–8). The geology of the 200-West Area is notably different from that of the 200-East Area, despite the fact that they are separated by a distance of only 6.4 kilometers (4 miles). The 200-West Area has one of the most complete suprabasalt stratigraphic sections on Hanford, including the Cold Creek Unit, with a stratigraphic thickness of up to 168 meters (550 feet) (Hartman 2000:3.11).

The Hanford formation is the main geologic unit at the surface for both the 200 Areas. The Hanford formation is thickest in the vicinity of the 200-East Area, where it is over 100 meters (330 feet) thick. Gravel-dominated sediments make up most of the Hanford formation in the northern part of the 200-East Area and across the 200-West Area. Also in the northern part of the 200-East Area, the Hanford formation generally rests directly on basalt, and an erosional window through the Elephant Mountain Member is suspected near the northeast corner of the 200-East Area. Regardless, gravel-dominated Hanford sediments were deposited by high-energy water in or immediately adjacent to the main cataclysmic flood channels. The sand-dominated sediments are most common in the central to southern parts of the 200 Areas and were deposited adjacent to the main flood channels during the waning stages of flooding. Finer rhythmite deposits (also called Touchet Beds) are primarily found south and west of the 200 Areas (Duncan 2007:4.38, 4.39).

The Cold Creek Unit in the 200-East Area may be represented by the mainstream pre-Missoula gravels. Beneath some of the 200-East Area tank farms, two suspected Cold Creek Unit sediment types have been encountered between the Hanford formation and underlying Columbia River Basalt that include fine-grained silt up to 10 meters (33 feet) thick and sandy gravel to gravelly sand. Beneath the 200-West Area, the Cold Creek Unit overlies the tilted and eroded Ringold Formation where both the lower and upper portions of the unit have been identified. The Lower Cold Creek Unit mainly consists of basaltic to quartzitic gravels, sands, silt, and clay that are cemented with one or more layers of calcium carbonate and other assemblages. The Upper Cold Creek Unit primarily consists of a distinctive silt-rich

interval representing eolian deposits in the 200-West Area. Locally, interbedded layers of fine sand and silt, more characteristic of stream deposits, are found with the eolian deposits. The silt-dominated deposits can be correlated across most of the 200-West Area (Duncan 2007:4.38, 4.39).

Sediments of the Ringold Formation are generally not present across much of the northern part of the 200-East Area, while some units are present in the southern part. The Lower Mud Unit is present under much of Hanford and is a nearly continuous feature beneath the 200-West Area and the southern half of the 200-East Area. The Lower Mud Unit consists primarily of lake bed silt and clay deposits, with at least one well-developed paleosol at the top of the sequence in the 200-West Area. Where present, the Lower Mud Unit forms the base of the unconfined aquifer at Hanford and acts as an aquitard, separating groundwater in the underlying Ringold Unit A from the unconfined aquifer (Duncan 2007:4.31, 4.38).

Unit E of the Member of Wooded Island is by far the thickest of the Ringold Formation units present beneath the 200 Areas and consists of well-rounded gravel in a sand and silt matrix. Erosion by the Columbia River during Cold Creek Unit deposition and flooding during Hanford formation deposition have removed Unit E from most of the northeastern part of the 200-East Area. The Ringold Formation Member of Taylor Flat consists of a sequence of fluvial sands and overbank deposits. Erosional remnants of the Member of Taylor Flat are found beneath parts of the 200-West Area, but it has been eroded from beneath all of the 200-East Area (Duncan 2007:4.38). As described in Section 3.2.5.1.5, the predominant soil types across the 200 Areas developed from the surficial sediments are Quincy (Rupert) sand and Burbank loamy sand.

3.2.5.3 400 Area Description

The nearest potentially active fault to the 400 Area (Central Gable Mountain Fault) is 19 kilometers (12 miles) away (see Figure 3–8). Surficial stratigraphy in the 400 Area consists of sand-dominated sediments of the Hanford formation, which attain a thickness of about 37 to 55 meters (120 to 180 feet) beneath the area. These glaciofluvial sediments are specifically composed of poorly graded, fine-to-medium, dense sands that are locally silty and gravelly. The sands grade downward to dense gravelly sands. Reworked gravelly sands and the sandy gravel of the Ringold Formation immediately underlie the Hanford formation sediments, which transition into silty sand, silts, and clays. Ringold Formation sediments extend to a depth of 181 meters (594 feet) beneath the 400 Area, where they contact the Elephant Mountain Member of the Saddle Mountain Basalt Formation. Eolian deposits overlie the Hanford formation sediments across the 400 Area. These deposits consist of 1.5 to 4.6 meters (5 to 15 feet) of fine-to-medium sand dunes that have been stabilized by sagebrush and grasses (WHC 1992:30–33). The predominant soil type in the 400 Area is Quincy (Rupert) sand (DOE 1999a:4.25; Duncan 2007:4.40).

3.2.5.4 Borrow Area C Description

The surficial geology of Borrow Area C is mainly dominated by the gravelly, sandy, and silty Quaternary-age sediments that cover much of the southern half of Hanford. The deposits also include even younger alluvium deposited by the Cold Creek drainage that traverses Borrow Area C. Pockets of older Hanford formation sediments and of Saddle Mountain Basalt also occur at the surface, and at depth, across the area (see Figure 3–8). This assemblage of fine- to coarse-grained sediments and basalt provides a wide range of borrow materials for multiple uses as described in Section 3.2.5.1.3. Mapped soils across Borrow Area C mainly include the Hezel sand interlaced with Esquatzel silt loam. Hezel sand is similar to Quincy (Rupert) sand. Hezel sand soils developed in wind-blown sands that mantled lake-laid sediment. Esquatzel silt loam is a deep soil that formed in recent alluvium derived from loess and lake sediment (Duncan 2007:4.40–4.42).

3.2.6 Water Resources

Water resources include all forms of surface water and groundwater, as well as the content of the so-called vadose zone. Surface water is defined as all water bodies that occur above the ground surface, including rivers, streams, lakes, and ponds, and other features. The vadose zone is the unsaturated or partially saturated region between the ground surface and the groundwater-saturated zone (the top of the water table). Groundwater refers to water within the saturated zone—i.e., water that, as at Hanford, typically originates as natural recharge from rain and snowmelt or artificially as recharge from activities such as irrigation, industrial processing, and wastewater disposal, and water destined to return to the surface through discharge to springs and seepage into rivers and streams, evaporation from shallow water table areas, or human activity involving wells or excavations.

3.2.6.1 Surface Water

3.2.6.1.1 General Site Description

Major surface-water features at Hanford include the Columbia River; Columbia riverbank seepage; springs; and ponds, including those constructed for effluent management (see Figure 3–10). In addition, the Yakima River flows along a short section of the southern boundary of the site. The Columbia River is the second-largest river in the contiguous United States in terms of total flow and the dominant surface-water feature on the site. Flow of the Columbia River is regulated by several dams, seven upstream and four downstream from the site. The nearest dam upstream from Hanford is the Priest Rapids Dam, and the nearest one downstream is the McNary Dam (Duncan 2007:4.49).

The 82-kilometer (51-mile) Hanford Reach, which is the last free-flowing, nontidal section of the river in the United States, extends from the Priest Rapids Dam to the upstream edge of Lake Wallula behind the McNary Dam. Because the flows are regulated, flow rates in the Hanford Reach can vary considerably. Columbia River flow rates near the Priest Rapids Dam during the 90-year period from 1917 to 2007 averaged nearly 3,330 cubic meters (117,600 cubic feet) per second; however, daily average flows during this period ranged from 570 to 19,500 cubic meters (20,100 to 689,000 cubic feet) per second (Duncan 2007:4.49, 4.51). In 2006, the Columbia River had normal flows; the average daily flow rate downstream of Priest Rapids Dam was 3,350 cubic meters (118,300 cubic feet) (Poston et al. 2007:10.29). Columbia River flows typically peak from April through June during spring runoff from snowmelt and are lowest from September through October. As a result of daily fluctuations in discharges from the Priest Rapids Dam, the depth of the river varies widely over a short time period, with stage changes of up to 3 meters (10 feet) during a 24-hour period along the Hanford Reach. The width of the river varies from approximately 300 to 1,000 meters (1,000 to 3,300 feet) along the Hanford Reach. This variation also occurs with changes in flow rate, which cause repeated wetting and drying of an area along the shoreline (Duncan 2007:4.51; Poston et al. 2007:10.29, 10.31).

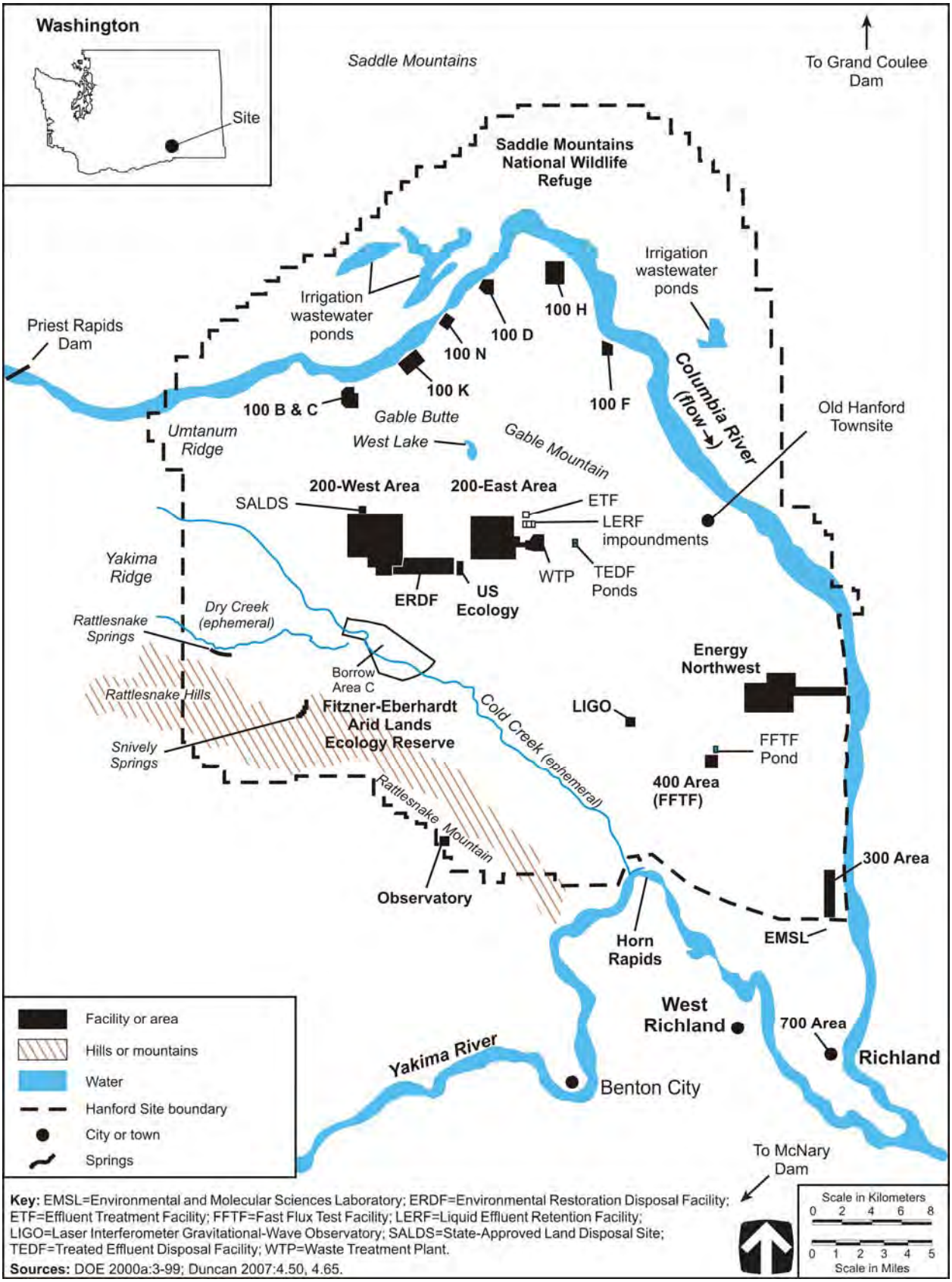


Figure 3–10. Major Surface-Water Features on the Hanford Site

Primary uses of the Columbia River include hydroelectric power generation, irrigation of crops in the Columbia Basin, and materials transport by barge. The Hanford Reach is the upstream navigable limit of barge traffic. Barges are used to transport reactor vessels from decommissioned nuclear vessels to Hanford for disposal. The Columbia River is also used extensively for recreation, including fishing, hunting, boating, sailboarding, water skiing, diving, and swimming. In addition to its use as a water supply source for Hanford, the river is a source of drinking water for several communities (Duncan 2007:4.52).

Ecology has designated that segment of the Columbia River extending from the Grand Coulee Dam to the Washington-Oregon border, and encompassing the Hanford Reach, for the following uses: salmon and trout spawning, rearing; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting, commerce and navigation; boating; and aesthetic values (WAC 173-201A).

No federally designated Wild and Scenic Rivers exist in the Hanford vicinity. In 1996, the National Park Service proposed designation of the Hanford Reach as a "recreational river" under the National Wild and Scenic Rivers System as part of broader resource conservation initiatives (DOE 1999a:4-5). The Hanford Reach was proclaimed a National Monument in 2000 (see Section 3.2.1.1.1). Creation of the National Monument did not convey with it full protection of the river's eligibility as a Wild and Scenic River. Section 404 of the Omnibus Parks and Public Lands Management Act of 1996 (P.L. 104-333) amended the original study legislation (P.L. 100-605) to mandate that no federal agency may construct any dam, channel, or navigation project. Under the Wild and Scenic Rivers Act and U.S. Department of the Interior practices, the USFWS manages the river as if it were a Wild and Scenic River and will take no actions that would change its status. This protection only partially extends to other federal agencies. Those agencies are obliged to take all reasonable care to protect the river's free flow and "outstandingly remarkable resources" as defined by the Wild and Scenic Rivers Act, but they are not obliged to forego projects if no reasonable alternative exists (USFWS 2008:3-2012).

DOE continues to assert a federally reserved water withdrawal right for the Columbia River (DOE 1999a:4-49, 4-50). In fiscal year 2006, total sitewide water consumption was about 817 million liters (215.7 million gallons). Ten of the 11 DOE-owned, contractor-operated water treatment and distribution systems, as well as the City of Richland system that serves the 300 Area, use water pumped from the Columbia River. The 400 Area continued to use a groundwater supply well in 2005 (see Section 3.2.2.4).

About one-third of Hanford surface water drains into the Yakima River. The average flow rate of the river, based on nearly 72 years of daily flow records, is about 100 cubic meters (3,530 cubic feet) per second. The average monthly maximum flow rate is 497 cubic meters (17,600 cubic feet) per second, and the minimum is 4.6 cubic meters (165 cubic feet) per second. In 2006, the average daily flow rate was 100 cubic meters (3,530 cubic feet) per second (Duncan 2007:4.55).

Rattlesnake Springs and Snively Springs are in the western portion of the site and flow into intermittent streams that infiltrate rapidly into the surface sediments (see Figure 3–10). Water discharged from Rattlesnake Springs flows down Dry Creek, a tributary to Cold Creek, for about 3 kilometers (1.9 miles) before infiltrating into the ground. An alkaline spring has been documented at the east end of Umtanum Ridge. Several springs are also found on the slopes of Rattlesnake Mountain along the western and southwestern edges of the site. The seepage of groundwater into the Columbia River was documented along the Hanford Reach long before Hanford operations began. This seepage occurs both below the river surface and on the exposed riverbank. Seepage flows are rather small and intermittent, influenced primarily by changes in the river level. Contaminants originating at Hanford have been documented in some of these discharges along the Hanford Reach (DOE 1999a:4-29–4-32; Duncan 2007:4.55, 4:56).

Other naturally occurring surface-water features at Hanford include West Lake and, in three clusters, approximately 20 vernal ponds or pools. The clusters are located on the eastern end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain. The ponds appear to form during the wetter winter periods in shallow depressions underlain by a layer of basalt (DOE 1999a:4-31, 4-32; Duncan 2007:4.64).

West Lake is a natural pond located north of the 200 Areas that is sustained by limited groundwater discharge in a topographic depression. Historically the lake benefited from an artificially elevated water table beneath much of Hanford attributable to waste management activities in the 200 Areas. With the cessation of production activities at Hanford, the amount of water discharged to the ground in the 200 Area plateau has substantially decreased. Accordingly, over the past 10 years West Lake has decreased in size to the point that it currently consists of a group of small isolated pools and mudflats. Artificial ponds primarily associated with waste management activities also exist on the site. These include two Treated Effluent Disposal Facility (TEDF) disposal ponds, three Liquid Effluent Retention Facility (LERF) impoundments adjacent to the 200-East Area, and the FFTF Ponds in the 400 Area that is used by FFTF and other facilities (see Figure 3–10) (Duncan 2007:4.50, 4.64; Poston et al. 2007:6.22, 6.24, 6.25, 10.30, 10.31, 10.42). In addition, there are irrigation ponds and wetlands in the northwest portion of the site and north of the Columbia River (Duncan 2007:4.50, 4.73).

Hanford has one EPA-issued National Pollutant Discharge Elimination System (NPDES) Permit—No. WA-002591-7. This permit covered three active outfalls: outfall 001 for the 300 Area TEDF and outfalls 003 and 004 in the 100-K Area (Poston et al. 2007:5.11). The permit was issued to Fluor Daniel Hanford, Inc., DOE's contractor in 1999, and expired May 5, 2004 (EPA 1999). On January 22, 2004, EPA issued a letter administratively extending the terms and conditions of the current NPDES Permit in accordance with 40 CFR 122.6 until a new permit is issued (Lidgard 2004). The site was also covered by one stormwater permit in 2006. The EPA NPDES Storm Water Multi-Sector General Permit No. WAR05A57F establishes the terms and conditions under which stormwater discharges associated with industrial activity are authorized. This permit was issued in 2000 and expired October 30, 2005. A new permit to replace it has not been issued, but facilities covered by the permit are automatically granted an administrative continuance of coverage. Discharges from the 200 Area TEDF Ponds, ETF, and LERF in the 200-East Area, the FFTF Ponds, the 100-N Area sewage lagoon, and consolidated industrial activities are covered by state waste discharge permits issued by Ecology. Ecology-issued NPDES general permits for mining activities are also in place, including a General Sand and Gravel permit for operation of the Concrete Batch Plant and for gravel pit No. 30 located between the 200-East and 200-West Areas. There were no permit violations during 2006. Numerous sanitary waste discharges to the ground from sanitary systems serving facility personnel in the 100 and 200 Areas are permitted by the Washington State Department of Health. Sanitary waste discharges from the 400 Area are conveyed to Energy Northwest's treatment facility. Sanitary waste from the 300 Area and other facilities in and north of Richland discharge to the City of Richland wastewater treatment facility. Wastewater from the William R. Wiley Environmental Molecular Sciences Laboratory, located in the Richland North Area also discharge to the city's wastewater treatment facility under pretreatment permit No. CR-IU005. This permit was most recently reissued in 2001 (Poston et al. 2007:5.11, D.2).

During 2006, Columbia River samples were collected and analyzed to compile data on radiological, chemical, and physical water quality parameters. Water samples were collected from fixed monitoring stations at the Priest Rapids Dam and Richland, Washington, and from cross-river transects and nearshore locations. Samples were also collected upstream from Hanford facilities at the Priest Rapids Dam and the Vernita Bridge to provide background data from locations unaffected by site operations, as well as from other locations, to identify any increase in contaminant concentrations attributable to such operations. During the 2006 study, tritium, strontium-90, uranium-234 and -238, plutonium-239 and -240, and naturally occurring beryllium-7 and potassium-40 were consistently measured in river water at levels greater than their reported minimum detectable concentrations. Concentrations of all other radionuclides

were typically below the minimum detectable concentrations. Most of these radionuclides derive from worldwide fallout from historical nuclear weapons testing and effluent from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford effluent (Poston et al. 2007:10.33–10.40, C.7–C.10). Nevertheless, all radiological contaminant concentrations measured in the Columbia River in 2006 were lower than applicable DOE derived concentration guides for ingested water (DOE Order 5400.5) and Washington State ambient surface-water-quality criteria.

DOE also conducts sampling of groundwater seeps (also referred to as "riverbank springs") along the Columbia River nearshore during periods of low flow. Water samples were collected from eight shoreline spring areas in 2005. The majority of samples were analyzed for gamma-emitting radionuclides, gross alpha and gross beta concentrations, and tritium. Samples from selected springs were analyzed for strontium-90; technetium-99; and uranium-234, -235, and -238. Analysis for iodine-129 was not performed in 2006. Most samples were also analyzed for metals and anions, and selected samples for volatile organic compounds as well. Contaminants of Hanford origin continued to be detected in water from shoreline springs entering the Columbia River in 2006; included were tritium; strontium-90; technetium-99; and uranium-234; -235, and -238. Concentrations of radionuclides in shoreline springwater have varied over the years with changes in the degree of river water and groundwater mixing (i.e., the bank storage effect). All radiological contaminant concentrations measured in riverbank springs in 2006 were lower than the applicable DOE-derived concentration guides, although other exceedances were observed. Gross alpha activity exceeded the ambient surface-water quality and EPA maximum contaminant level (MCL) of 15 picocuries per liter in riverbank springwater at the 300 Area, with a maximum value of 97 ± 20 picocuries per liter. Total uranium levels exceeded the EPA primary drinking water standard of 30 micrograms per liter (equivalent to 27 picocuries per liter) in 300 Area springwater, with a maximum total uranium concentration of 130 ± 14 micrograms per liter (120 ± 13 picocuries per liter). This chemical toxicity standard, which became effective December 8, 2003, is deemed more protective of human health than the radiological dose standard (65 FR 76708). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area as a result of past Hanford operations. The gross alpha and gross beta concentrations observed in 300 Area riverbank springwater parallel those of uranium and are likely associated with its presence. In 2006, the maximum observed tritium concentration was 19,000 ± 1,300 picocuries per liter at the Old Hanford Townsite riverbank spring. This value is just below the ambient surface-water-quality criterion of 20,000 picocuries per liter (Poston et al. 2007:10.48–10.51, C.16, C.17, D.5).

Concentrations of almost all nonradiological contaminants measured in riverbank springs on the Hanford shoreline from 2001 through 2006 were below the applicable Washington State ambient surface-water-quality criteria. The only exception was chromium, whose concentrations in springwater in the 100-B, -K, -N, -D, -H, and -F Areas were above state ambient surface-water acute-toxicity levels. Volatile organic compounds were near or below detection limits for most samples (Poston et al. 2007:10.52).

West Lake and the FFTF Ponds were sampled periodically during 2006 for water quality. The ponds remained inaccessible to the public and, therefore, did not constitute a direct offsite environmental impact during 2006. However, they were accessible to migratory waterfowl and deer, creating a potential biological pathway for the dispersion of contaminants, and they are near facilities undergoing remediation. Grab samples were collected quarterly from the FFTF Ponds (water) and from West Lake (water and sediment). All water samples were analyzed for tritium. Water samples from the FFTF Ponds were also analyzed for gross alpha and gross beta concentrations, as well as gamma-emitting radionuclides. All radionuclide concentrations in onsite pond water samples were lower than applicable values in the DOE-derived concentration guides (DOE Order 5400.5) and the Washington State ambient surface-water-quality criteria. The median tritium concentration in FFTF Pond water during 2006 was 13 percent of the Washington State ambient surface-water-quality criterion of 20,000 picocuries per liter. The sources of contaminants in the pond water are groundwater contaminant plumes from the 200 Areas

that have migrated to water supply wells near the 400 Area. Tritium concentrations in West Lake water during 2006 were similar to those observed in the past. The median concentration of tritium in West Lake water in 2005 was 1.5 percent of the Washington State ambient surface-water-quality criterion, and that figure reflected groundwater concentrations in the area (Poston et al. 2007:10.42, 10.44).

Flooding of the site has occurred along the Columbia River, but the likelihood of a recurrence of large-scale flooding has been greatly reduced by the upstream construction of several flood control/water storage dams. Major floods are typically due to melting of the winter snowpack combined with above-normal precipitation. No maps of flood-prone areas have been produced by the Federal Emergency Management Agency, as these maps are produced only for areas that could be developed and are not under Federal control. However, analyses have been completed to determine the potential for the probable maximum flood. This is determined through hydrologic factors such as precipitation within the drainage basin, snowmelt, and tributary conditions. The probable maximum flood for the Columbia River below the Priest Rapids Dam has been calculated at 40,000 cubic meters (1.4 million cubic feet) per second, which is greater than the 500-year flood (DOE 1999a:4-34; Duncan 2007:4.58). The extents of the 1894 and 1948 floods and of the probable maximum flood are shown in Figure 3–11.

3.2.6.1.2 200 Areas Description

The 200 Areas are located in the Central Plateau of Hanford approximately 10 kilometers (6.2 miles) southeast of the Columbia River. Neither the 200-East nor 200-West Area lies within the probable maximum flood area of the Columbia or Yakima River (see Figure 3–11). However, the southwest corner of the 200-West Area is within the probable maximum flood area of Cold Creek. This portion of the 200-West Area is largely undeveloped, and the 200-West Area tank farms are east of the delineated probable maximum flood area boundary.

West Lake located north of the 200-East Area, is a natural feature recharged from groundwater. The lake has not received direct effluent discharges from Hanford facilities; rather, its existence is attributable to intersection of the elevated water table with the land surface in the topographically low area. West Lake water levels fluctuate with water table elevation, which is influenced by wastewater discharge in the 200 Areas. The water level and size of the lake have been decreasing over the past several years because of reduced wastewater discharge (Duncan 2007:4.64). The 200 Area TEDF consists of two disposal ponds from which wastewater percolates into the subsurface. These ponds, each 2 hectares (5 acres) in size, receive industrial wastewater under Ecology-issued State Waste Discharge Permit No. ST-4502, issued in accordance with WAC 173-216. The 200 Area TEDF received 765.3 million liters (202.2 million gallons) of unregulated effluent for disposal in 2006. The major source of this effluent was uncontaminated cooling water and steam condensate from the 242-A Evaporator with a variety of other recent uncontaminated waste streams from other Hanford facilities. Sanitary wastewater in the 200 Areas is primarily treated in a series of onsite sewage systems (Poston et al. 2007:6.25, D.2).

Water for the 200 Areas is provided by the 283-W Water Treatment Plant. The water source for this filtration and chlorination plant is the Columbia River (see Section 3.2.2.4.2).

3.2.6.1.3 400 Area Description

The 400 Area is 6.3 kilometers (3.9 miles) from the west bank of the Columbia River. No specific flooding analyses have been completed for the 400 Area, but analyses have been completed for the site as a whole. According to the sitewide data, the elevation of the ground surface in the 400 Area is higher than that of the probable maximum flood of the Columbia River. It is also higher than the elevations of the maximum historical floods of 1894 and 1948 (see Figure 3–11) (DOE 2000a:3-105).

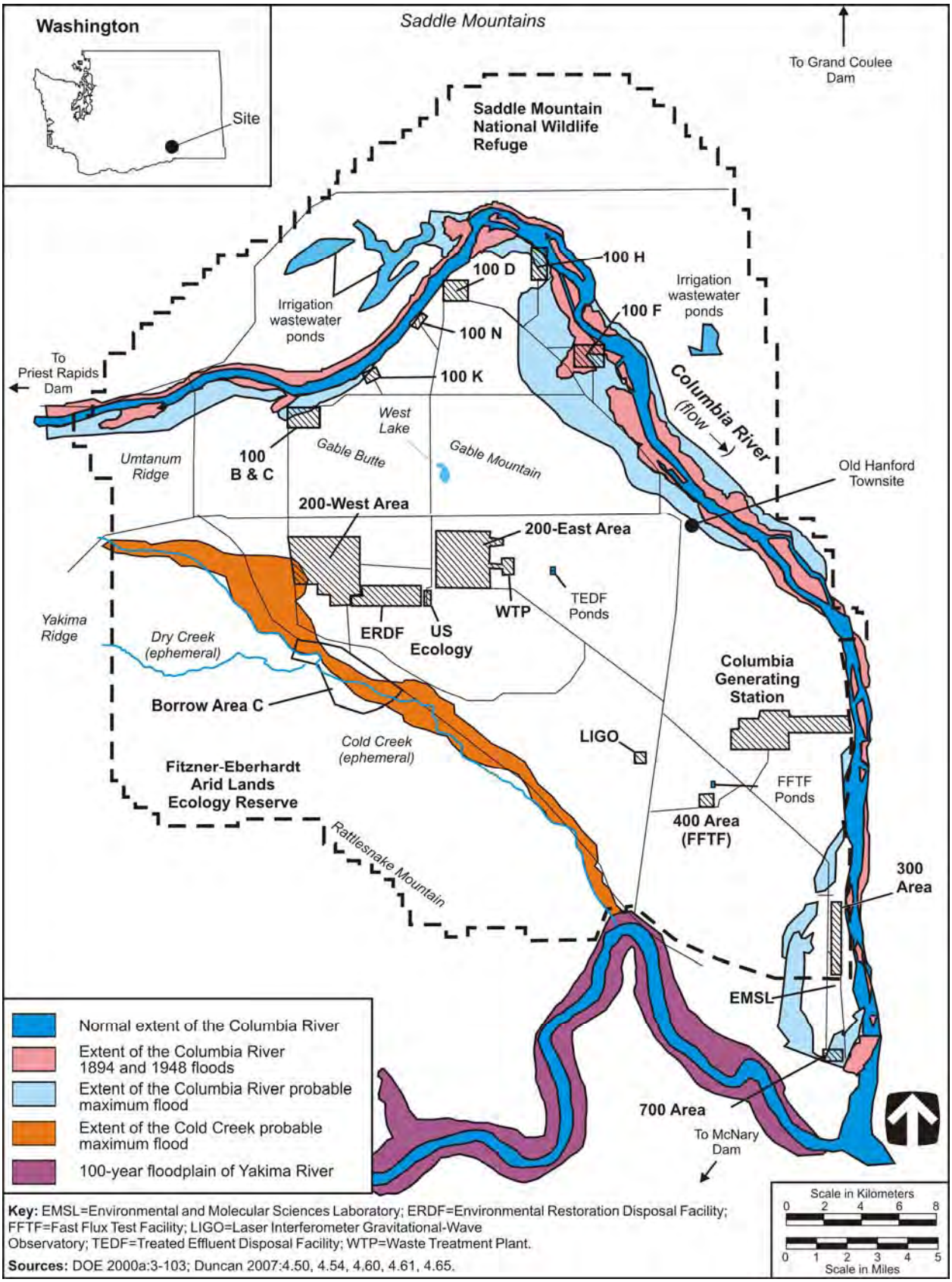


Figure 3–11. Floodplains on the Hanford Site

The only surface-water bodies in the vicinity of the 400 Area are the FFTF Ponds (i.e., the 4608 B/C ponds) located just north of the 400 Area (DOE 1999a:4-31; Duncan 2007:4.50; Poston et al. 2007:10.30). The ponds receive nonradioactive industrial process wastewater discharge collected by the process sewer system from four 400 Area facilities, including FFTF, FMEF, the Maintenance and Storage Facility, and the water pumphouse. The pond system consists of two cells that measure 15 by 30 meters (50 by 100 feet) and have 1.2-meter (4-foot) walls. Most of the wastewater discharged to the pond system was cooling-tower blowdown from eight FFTF auxiliary cooling towers and three FMEF cooling towers. Individual effluent streams were collected at a central drain line that runs to the pond and the effluent is monitored before discharge. Approximately 76 million liters (20 million gallons) per year of process wastewater were historically discharged to the FFTF Ponds. Discharged wastewater rapidly percolates into the ground, leaving the ponds dry under normal conditions (DOE 2000a:3–105, 3–106). Discharges to the ponds continue to be regulated under State Waste Discharge Permit No. ST-4501, and the effluent is periodically sampled and analyzed for permit compliance. During 2006, grab samples for selected radionuclides were collected and analyzed quarterly from the FFTF Ponds. Average levels of gross beta and tritium have remained stable over recent years. The average tritium concentration in the FFTF Ponds water during 2006 was 13 percent of the Washington State ambient surface-water-quality criterion of 20,000 picocuries per liter. The sources of contaminants in the pond water are groundwater contaminant plumes from the 200 Areas that have migrated to wells within the 400 Area that supply water to facility operations (Poston et al.: 2007:10.43, 10.44, D.2).

About 3.8 million liters (1 million gallons) of sanitary wastewater also were discharged annually from 400 Area facilities to the Energy Northwest system for treatment. Moreover, liquid LLW from equipment washing was generated during standby operations at a maximum rate of about 3,785 liters (1,000 gallons) per year. It was collected in tanks and transported to the 200 Area ETF for treatment and disposal (DOE 2000a:3–106).

Waste management activities and facilities are discussed in greater detail in Section 3.2.12.

3.2.6.1.4 Borrow Area C Description

No perennial surface-water features, including streams and ponds, have been documented within the boundaries of Borrow Area C. However, portions of the area lie within the probable maximum flood zone associated with Cold Creek (see Figure 3–11). This ephemeral stream may only contain water after large precipitation or snowmelt events before the water rapidly infiltrates into the subsurface (Duncan 2007:4.49).

3.2.6.2 Vadose Zone

3.2.6.2.1 General Site Description

Unconsolidated sands and gravels of the Hanford formation make up most of the vadose zone. In some areas, however, such as most of the 200-West Area and in some of the 100 Areas, the sediments of the Ringold Formation make up the lower part of the vadose zone. The Cold Creek Unit also composes part of the vadose zone in the western portion of the site. Where sediments are present, the thickness of the vadose zone ranges from less than 1 meter (3.3 feet) at the Columbia River to more than 100 meters (328 feet) near the center of Hanford (Duncan 2007:4.66).

Moisture movement through the vadose zone is important at Hanford because it is the driving force for migration of most contaminants to the groundwater. Radioactive and hazardous wastes in the soil column from past intentional liquid waste disposals, unplanned leaks, solid waste burial grounds, and underground tanks are potential sources of continuing and future vadose zone and groundwater contamination. Contaminants may continue to move downward for long periods (tens to hundreds of years, depending on recharge rates) after termination of liquid waste disposal. Except for the

State-Approved Land Disposal Site (SALDS), the 200 Area TEDF, and septic drain fields, substantial artificial recharge to the vadose zone ended in the mid-1990s. Currently, the major source of recharge is natural precipitation. Natural infiltration in the vadose zone causes preexisting water to be displaced downward by newly infiltrated water. The amount of recharge at any particular site highly depends on the soil type and the presence of vegetation. Usually vegetation reduces the amount of infiltration through the biological process of transpiration (Duncan 2007:4.66).

The stratigraphy of the vadose zone influences the movement of liquid through the soil column. Where conditions are favorable, liquid effluent may be spread laterally or local perched water zones may develop. Perched water zones form where downward-moving moisture accumulates on top of low-permeability soil lenses or highly cemented horizons. Preferential flow may also occur along discontinuities such as clastic dikes and fractures. Clastic dikes are a common geologic feature in the suprabasalt sediments at Hanford (see Section 3.2.5.1.2). Their most important feature is their potential to either enhance or inhibit vertical and lateral movement of contaminants in the subsurface, depending on the textural relationships of the strata involved (Duncan 2007:4.66).

Hanford has more than 800 past-practice liquid disposal facilities. Radiochemical and hazardous-chemical-bearing liquid wastes were discharged to the vadose zone through reverse (injection) wells, French drains, ponds, cribs, and trenches (ditches). From 1944 through the late 1980s, 1.5 billion to 1.7 billion cubic meters (396 billion to 449 billion gallons) of effluent were disposed of in the soils. Most effluent was released in the 200 Areas. The major groundwater contaminant plumes emanating from the 200 Areas are tritium and nitrate. The major sources for both were discharges resulting from the chemical processing of irradiated nuclear fuel rods. Also of concern are technetium-99 and iodine-129, which, like tritium and nitrate, are mobile in the vadose zone and groundwater. The major sources of technetium-99 and iodine-129 were discharges to liquid disposal facilities. Vadose zone sources for these contaminants remain beneath many past-practice disposal facilities. However, other than physical sampling and laboratory analysis, there are no currently available monitoring techniques for tritium, nitrate, technetium-99, and iodine-129 in the vadose zone (Duncan 2007:4.67).

Approximately 280 unplanned releases in the 200 Areas also contributed contaminants to the vadose zone. Many of these were from underground tanks. In addition, approximately 50 active and inactive septic tanks and drain fields and numerous radioactive and nonradioactive landfills and dumps have impacted the vadose zone (Duncan 2007:4.67).

In the 200 Areas, 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs) have been used to store HLW and mixed waste. The waste resulted from uranium and plutonium recovery processes and, to a lesser extent, from strontium and cesium recovery processes (Duncan 2007:4.67). Sixty-seven of the SSTs are known or suspected to have leaked liquid waste to the vadose zone between the 1950s and the present, although it is likely that some of the tanks have not actually leaked. Nevertheless, estimates of the total leak loss range from less than 2,840 million liters (750,000 gallons) to as much as 3,970 million liters (1,050 million gallons). The three largest tank leaks were 435,000 liters (115,000 gallons), 37,900 to 1,049,000 liters (10,000 to 277,000 gallons), and 265,000 liters (70,000 gallons) (Hanlon 2003:B-13–B-16). The average tank leak was between 41,600 and 60,565 liters (11,000 and 16,000 gallons) (Duncan 2007:4.67). However, these estimates were compiled in the late 1980s and early 1990s from information sources of varying quality. While leak volumes for some tanks are well documented, including tank 241-T-106, which from liquid-level measurements is known to have leaked 435,000 liters (115,000 gallons) of waste, documentation of past leaks for 19 of the 67 tanks that are known or suspected "leakers" is less certain (Hanlon 2003:B-13–B-16). Much effort has been expended to improve SST leak volume estimates using information gathered from extensive tank farm vadose zone investigations. This effort included an extensive program of field drilling, sampling, and soil analysis in multiple SST farms, as well as directed fundamental research and extensive review of historical process records and gamma logging data (DOE 2003b:6-19–6-22).

In addition to removing pumpable liquids from the SSTs, interim measures have been taken to reduce the movement of tank farm contaminants in the vadose zone. Infiltration of water has been identified as the primary means by which contaminants are displaced beneath the farms. Surface-water controls have been constructed to reduce surface-water run-on from major meteorological events and from breaks in waterlines. Also, waterlines that were determined to be unnecessary have been isolated, cut, and capped. Waterlines that were found to be necessary for continued operations are being leak tested, and any lines found to be leaking will be replaced (Duncan 2007:4.67, 4.68).

Other sources of vadose zone contamination include reactor cooling-water releases from cracked retention basins and direct discharges of cooling water to trenches (ditches) from the 100-KE, -KW, and -N Reactors. The released cooling waters contained fission and neutron activation products and some chemicals and actinides. Of greatest concern are the impacts of tritium, strontium-90, nitrate, and chromium migrating through the vadose zone to groundwater and, ultimately, to the Columbia River. Leakage from fuel storage basins in the 100-K Area also contributed potentially large inventories of fission products, transuranics (TRUs), and carbon-14 to the soil column. Thus, both past-practice sites and fuel storage basin leakage are potential sources of vadose zone contaminants in the 100 Areas (Duncan 2007:4.68). DOE established the Groundwater/Vadose Zone Integration Project in 1997. On July 1, 2002, the project was transferred from the environmental restoration contractor, Bechtel Hanford, Inc., to Fluor Hanford, Inc., and designated as the Groundwater Remediation Project (now known as the Soil and Groundwater Remediation Project). The purpose of this project is to coordinate all projects at Hanford involved in characterization, monitoring, and remediation of groundwater and vadose zone contamination, with the overall objective of protecting the Columbia River. Treatment systems are being employed in a number of locations across Hanford to remediate underlying sources of contaminants from past-practice releases. Information on these remediation efforts is detailed in the annual site environmental report for Hanford (Poston et al. 2007:10.61).

Several compilations of vadose zone contamination have been formulated through the years. A series of reports have been issued in recent years by the Hanford Tank Farm Vadose Zone Project that estimate the curies of gamma-emitting radionuclides and the volumes of contaminated soil associated within each SST farm. The results were compiled from the baseline spectral gamma logging project and are summarized in 12 spectral gamma logging tank farm reports issued by MACTEC-Environmental Remediation Services between 1996 and 2000 (DOE 2003b:6-20, 6-21; Duncan 2007:4.68).

3.2.6.2.2 200 Areas Description

The thickness of the vadose zone across the 200 Areas ranges from approximately 50 meters (164 feet) in the 200-West Area to approximately 100 meters (328 feet) beneath portions of the 200-East Area (Hartman 2000:4.9, 4.16), as illustrated in Figure 3–12. The geologic and groundwater environments of the 200 Areas are further described in Sections 3.2.5.2 and 3.2.6.3.2, respectively.

3.2.6.2.3 400 Area Description

The thickness of the vadose zone in the 400 Area is approximately 50 meters (164 feet). The geologic and groundwater environments of the 400 Area are further described in Sections 3.2.5.3 and 3.2.6.3.3, respectively.

3.2.6.2.4 Borrow Area C Description

The thickness of the vadose zone across Borrow Area C, estimated to average approximately 50 meters (164 feet), similar to that of the 200-West Area, particularly in areas where basalt does not occur at or near the surface. Accordingly, thinning of the vadose zone is expected to the west and south across the area.

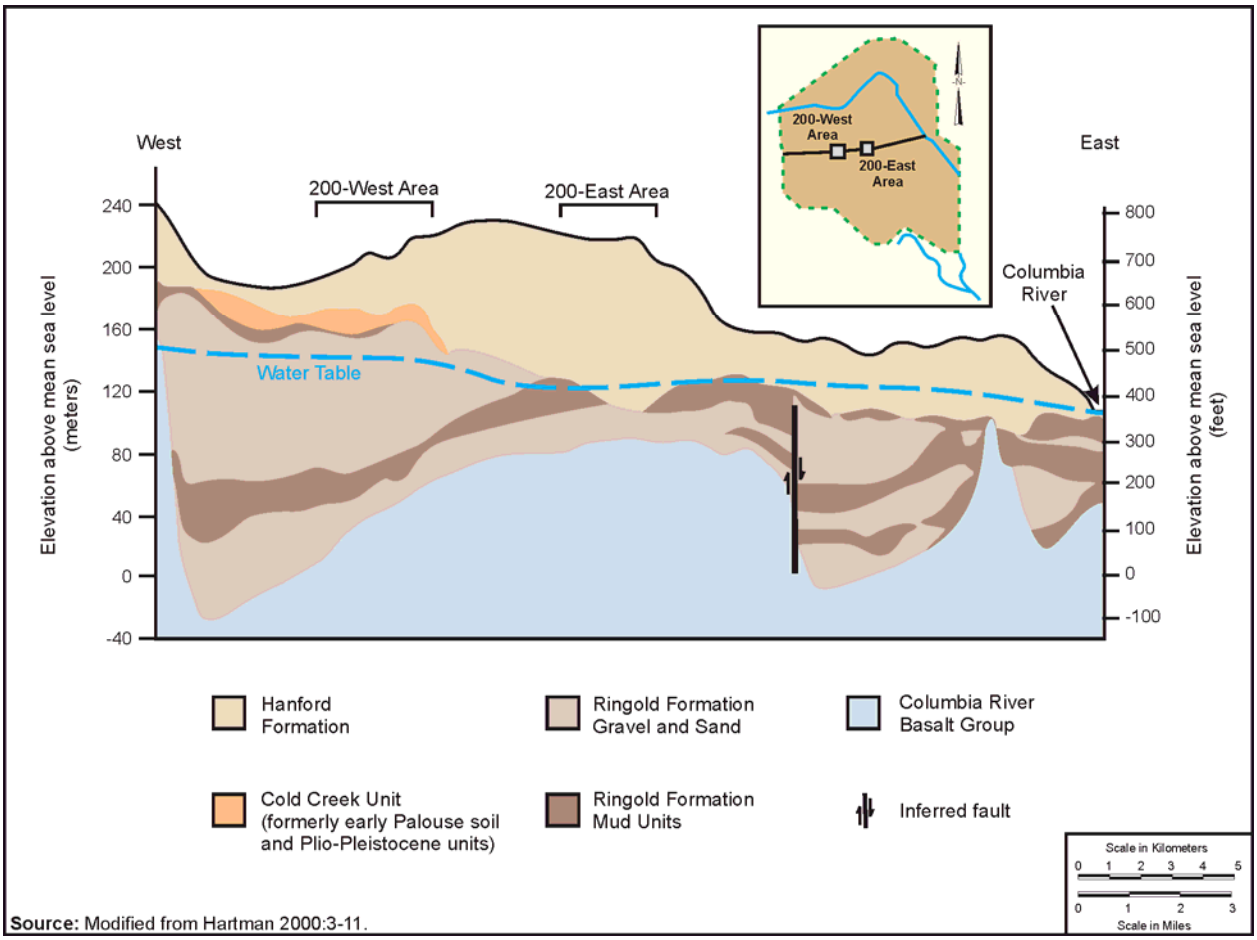


Figure 3–12. Hydrogeologic Cross Section Through the 200 Areas

3.2.6.3 Groundwater

3.2.6.3.1 General Site Description

Groundwater under Hanford occurs in confined and unconfined aquifer systems. The hydrostratigraphic (water-bearing) units composing these systems are illustrated in the cross section shown as Figure 3–12.

The unconfined aquifer system, also referred to as the "suprabasalt aquifer system" or Hanford/Ringold aquifer system, lies within the sands and gravels of the Hanford formation and, to a greater degree, the sediments of the Ringold Formation. Portions of the suprabasalt aquifer system are locally confined because major sand and gravel units of the Ringold Formation (e.g., Units A, B, C, D, and E) (see Figure 3–9) are separated by fine-grained (e.g., silt- and clay-dominated) units. In some places, the fine-grained units act as aquitards that locally confine groundwater in deeper permeable sediments. Nevertheless, groundwater generally flows eastward across the site from recharge areas in the higher elevations on the western site boundary and discharges primarily to the Columbia River (see Figure 3–13). The Yakima River is also considered a source of recharge. Since the beginning of Hanford operations in 1943, the water table has risen about 9.1 meters (30 feet) under disposal ponds near the 200-East Area and as much as 27 meters (89 feet) in the 200-West Area. This has caused groundwater mounding with radial and northward flow components in the 200 Areas, although groundwater elevations have declined since 1984 with decreased wastewater disposal.

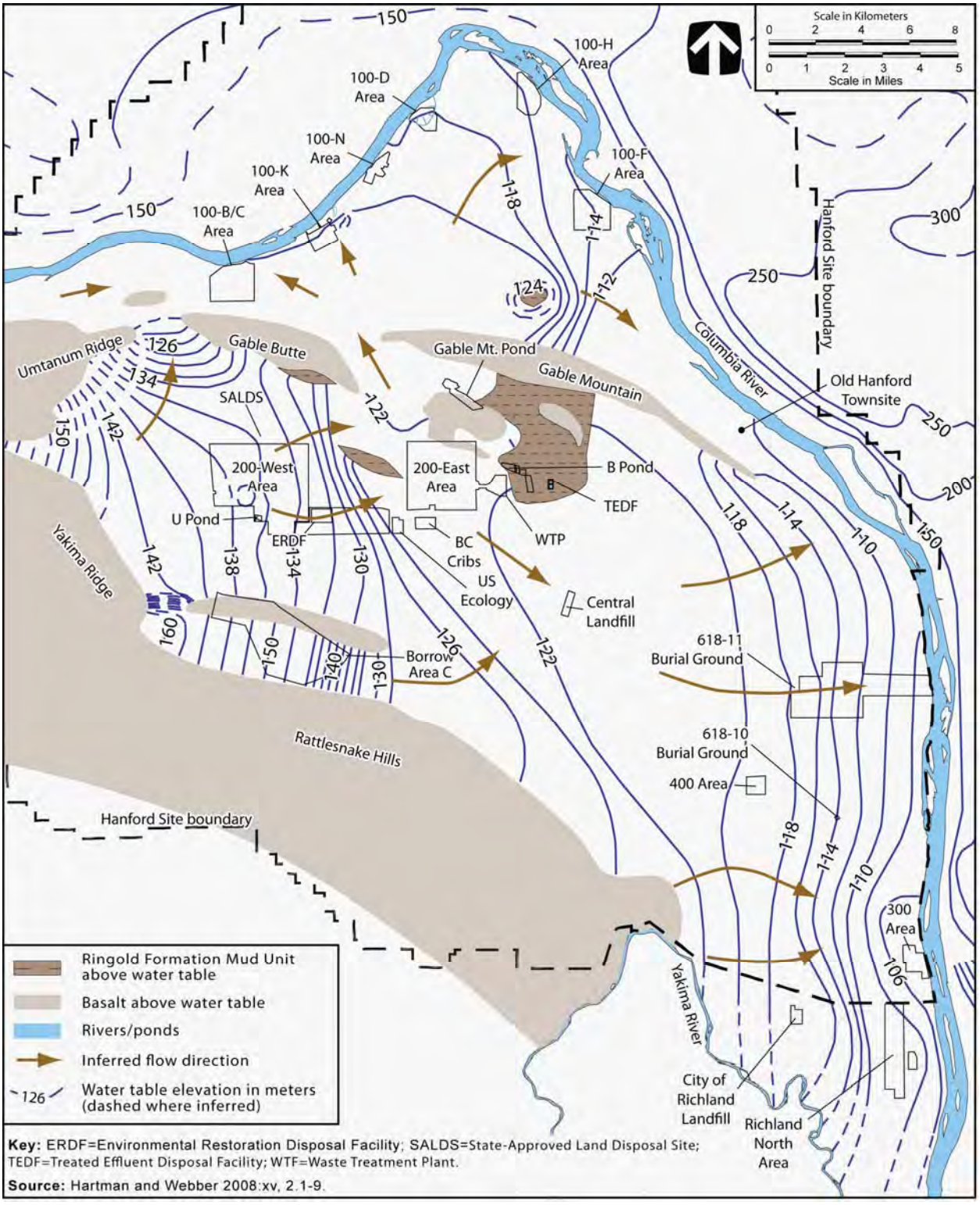


Figure 3–13. Water Table Elevations and Inferred Groundwater Flow for the Unconfined Aquifer System

However, a groundwater mound beneath the 200-West Area still exists, as do small groundwater mounds near the 200 Area TEDF and the SALDS (Duncan 2007:4.68–4.71; Hartman 2000:3.4, 3.5). The 200 Area TEDF is a collection and disposal system for pretreated non–Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901 et seq.)-permitted waste streams that began operations in April 1995. Effluent is conveyed to the facility through 18 kilometers (11 miles) of buried pipelines connecting three pumping stations, one disposal sample station (Building 6653), and two 2-hectare (5-acre) disposal ponds east of the 200-East Area.

Discharges are regulated by State Waste Discharge Permit No. ST-4502 (see Section 3.2.6.1.2). The TEDF has a capacity of 12,900 liters (3,400 gallons) per minute. In 2006, the 200 Area TEDF disposed of 765.3 million liters (202.2 million gallons) of wastewater to the subsurface. The major sources of this effluent were uncontaminated cooling water and steam condensate from the 242-A Evaporator, as well as a variety of other uncontaminated waste streams received from other Hanford facilities. The SALDS (also known as the 616-A crib), located north of the 200-West Area, is the ultimate discharge point for liquid waste treated in the 200-East Area ETF, which first passes through the LERF impoundments. The 200-East Area ETF treats liquid effluent to remove toxic metals, radionuclides, and ammonia, and to destroy organic compounds. It began operations in December 1995. The treated effluent is stored in tanks, sampled, and analyzed prior to being discharged to the SALDS. The disposal site is located just north of the 200-West Area and is an underground drain field. The treatment process constitutes the best available technology; it includes pH adjustment, filtration, ultraviolet light and peroxide destruction of organic compounds, reverse osmosis to remove dissolved solids, and ion exchange to remove the last traces of contaminants. Discharges are regulated by State Waste Discharge Permit No. ST-4500. The ETF has a maximum treatment capacity of 570 liters (150 gallons) per minute of effluent. In 2006, the volume of wastewater treated and disposed of was approximately 15.6 million liters (4.13 million gallons). This was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 Operable Unit in the 200-West Area and ERDF leachate) (Poston et al. 2007:6.25, D.2).

The generally more consolidated and partially cemented sands and gravels within the Ringold Formation are 10 to 100 times less permeable than the sediments of the overlying Hanford formation, which results in significantly lower hydraulic conductivities. Before wastewater disposal operations at Hanford, the uppermost aquifer was mainly within the Ringold Formation, and the water table extended into the Hanford formation at only a few locations. However, wastewater discharges raised the water table elevation across the site. The general increase in groundwater elevation caused the unconfined aquifer to extend upward into the Hanford formation over a larger area, particularly near the 200-East Area. This increased the groundwater velocity because of both the greater volume of groundwater and the higher permeability of the newly saturated Hanford sediments (Duncan 2007:4.71, 4.72).

The saturated thickness of the unconfined aquifer system is greater than 180 meters (590 feet) in areas near the Central Landfill, in areas west of the 200-West Area and north of Gable Butte near the 100-B, -C, and -K Areas, but the aquifer pinches out along the flanks of the basalt ridges. Perched water table conditions have been encountered in sediment above the unconfined aquifer system in the 200-West Area. Depth to the water table across the site ranges from less than 1 meter (3.3 feet) along the Columbia River to more than 100 meters (328 feet) near the center of the site (see Figure 3–12). Daily river-level fluctuations may result in changes in the water table of up to 3 meters (10 feet) near the Columbia River during periods of high-river stage. As the river stage rises, a pressure wave is transmitted inland through the groundwater. The longer the duration of the higher-river stage, the farther inland the effect is propagated. The pressure wave is observed farther inland than the water actually moves. For the river water to flow inland, the river level must be higher than the groundwater surface and must remain high long enough for the water to flow through the sediments. Typically, this inland flow of river water is restricted to within several hundred meters of the shoreline (Duncan 2007:4.69).

The confined aquifer system at Hanford consists of a sequence of basalt-confined aquifers within the Columbia River Basalt Group. Individual aquifers consist of the relatively permeable sedimentary interbeds and the more porous tops and bottoms of basalt flows that compose the group (see Figure 3–9). Saturated but fairly impermeable, dense interior sections of the basalt flows have horizontal hydraulic conductivities that are about five orders of magnitude lower than some of the confined aquifers that lie between these basalt flows. The upper basalt-confined aquifer is believed to be recharged from upland areas along the margins of the Pasco Basin as a result of the infiltration of precipitation and surface water where the basalt and interbeds are exposed at or near the ground surface. Hydraulic head information indicates that groundwater in the basalt-confined aquifers generally flows toward the Columbia River and, in some places, toward areas of enhanced vertical interflow with the unconfined aquifer system. Limited water chemistry data indicate that interaquifer flow has taken place in an area near the Gable Mountain anticlinal structure north of the 200-East Area (Duncan 2007:4.69; Hartman 2000:3.4, 3.5). Recharge may also occur through the Hanford/Ringold aquifer system in areas where the hydraulic gradient is downward and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge. The Columbia River is a discharge area for this aquifer system in the southern portion of the site, but not the northern portion. Discharge also occurs to the overlying Hanford/Ringold aquifer system in areas where the hydraulic gradient is upward. Discharge to overlying or underlying aquifers in the vicinity of the Gable Butte/Gable Mountain structural area may occur through erosional windows in the basalt (Hartman and Webber 2008:2.14−3).

Tritium and carbon-14 measurements indicate that groundwater residence or recharge time (the length of time that groundwater has been in the subsurface) is up to thousands of years for the unconfined aquifer and more than 10,000 years for groundwater in the shallow confined aquifer. Chlorine-36 and noble gas isotope data suggest groundwater ages greater than 100,000 years in the deeper confined systems. These rather long residence times are consistent with semiarid-site recharge conditions. However, groundwater travel time from the 200-East Area to the Columbia River has been shown to be much faster, in the range of 10 to 30 years. This is because of the large volumes of recharge from wastewater disposed of in the 200 Areas between 1944 and the mid-1990s and the rather high permeability of Hanford formation sediments, which are below the water table between the 200 Areas and the Columbia River. Residence times in this portion of the aquifer are expected to increase because of the reduction in wastewater recharge in the 200 Areas. Travel time from the 200-West Area is greater because of the lower permeability of Ringold Formation sediments. Plume monitoring indicates that groundwater from the 200-West Area has moved about 6 kilometers (3.7 miles) during the past 50 years (Duncan 2007:4.72).

Water use in the Pasco Basin, which includes Hanford, is primarily via surface-water diversion; groundwater accounts for less than 10 percent of water use (DOE 1999a:4-49). While most of the water used by Hanford is surface water withdrawn from the Columbia River, some groundwater is used. One of the principal users of groundwater was FFTF in the 400 Area, which used about 697,000 liters (184,000 gallons) per day when it operated (DOE 2000a:3-109). The 400 Area continued to use a groundwater supply well for drinking water in 2006 (see Section 3.2.2.4.1).

Groundwater quality beneath large portions of Hanford has been affected by past liquid waste discharges, primarily to ponds, cribs, and trenches (ditches) and from spills, injection wells, and leaks from waste storage tanks. Additional contaminants from spills, leaking waste tanks, and burial grounds (landfills) have also impacted groundwater in some areas. Contaminant concentrations in the existing groundwater plumes are expected to decline through radioactive decay, chemical degradation, and dispersion. However, contaminants also exist within the vadose zone beneath waste sites (see Section 3.2.6.2), as well as in waste storage and disposal facilities. These contaminants could continue to move downward into the unconfined aquifer system. Some contaminants, such as tritium, move with the groundwater, while movement of other contaminants (e.g., strontium, cesium, and plutonium) is slower because they react with or are sorbed on the surface of minerals within the aquifer or the vadose zone (Duncan 2007:4.73, 4.74). Groundwater contamination is monitored and is being actively remediated in

several areas through pump-and-treat operations. The unconfined aquifer system contains radiological and nonradiological contaminants at levels that exceed water quality criteria and standards. During fiscal year 2007, 681 wells and 202 aquifer tubes were sampled for radiological and/or chemical constituents. Overall, tritium, nitrate, and iodine-129 continue to be the most widespread groundwater contaminants associated with past Hanford operations (Hartman and Webber 2008:1.0-2).

Figures 3–14 and 3–15, respectively, show the distribution of major radionuclides and hazardous chemicals in the unconfined aquifer system, including those concentrations above applicable MCL or drinking water standards, during fiscal year 2007. The figures depict groundwater quality on a regional scale. Discussion of additional, smaller scale, contaminant plumes can be found in Appendices L, N, and O. The figures also depict the locations of former waste management sites (e.g., Gable Mountain Pond, U Pond, B Pond, effluent disposal cribs) and burial grounds. Also shown are locations of active waste management and treatment facilities such as the SALDS, the 200 Area TEDF, and the ERDF.

The areas of the tritium and iodine-129 plumes are the largest areas in which contaminant concentrations exceed drinking water standards. These dominant plumes have sources in the 200-East Area and extend toward the east and southeast. Less extensive tritium and iodine-129 plumes are also present in the 200-West Area. Technetium-99 exceeds standards in plumes within both the 200-East and 200-West Areas. One technetium-99 plume has moved northward from the 200-East Area. Uranium is less mobile than tritium, iodine-129, or technetium-99; isolated plumes are found in the 200-East, 200-West, and 300 Areas. Strontium-90 is not very mobile in groundwater, but it exceeds standards in the 100 Areas, the 200-East Area, and beneath the former Gable Mountain Pond. Other radionuclides, including cesium-137, cobalt-60, and plutonium, are even less mobile in the subsurface and exceed drinking water standards in only a few wells in the 200-East Area (Hartman and Webber 2008:xvi, xvii).

Nitrate is a widespread nonradiological contaminant in Hanford groundwater, with plumes originating from the 100 and 200 Areas and from offsite industry and agriculture. Carbon tetrachloride, the most widespread organic contaminant on Hanford, forms a large plume beneath the 200-West Area. Other organic contaminants include chloroform, found in the 200-West Area, and trichloroethene. Trichloroethene plumes that approach or exceed the drinking water standard are found in the 100-K, 100-F, and 200-West Areas, as well as in wells in the 300 Area. Chromium contamination underlies portions of the 100-K, -D, and -H Areas. Local plumes of chromium contamination also are present in the 200 Areas, particularly the north part of the 200-West Area (Hartman and Webber 2008:xvi-xix). Information on groundwater monitoring and chemical analysis is further summarized in the annual site environmental report, and detailed results are provided in the Hanford annual groundwater monitoring report (Hartman and Webber 2008; Poston et al. 2007). Vertical gradients between the basalt-confined aquifer and the unconfined aquifer systems are upward on most of Hanford. Downward gradients are measured in the west portion of Hanford, near B Pond, and north and east of the Columbia River (Hartman and Webber 2008:xxxiv). No aquifers have been designated sole-source aquifers in the Columbia Plateau (EPA 2009).

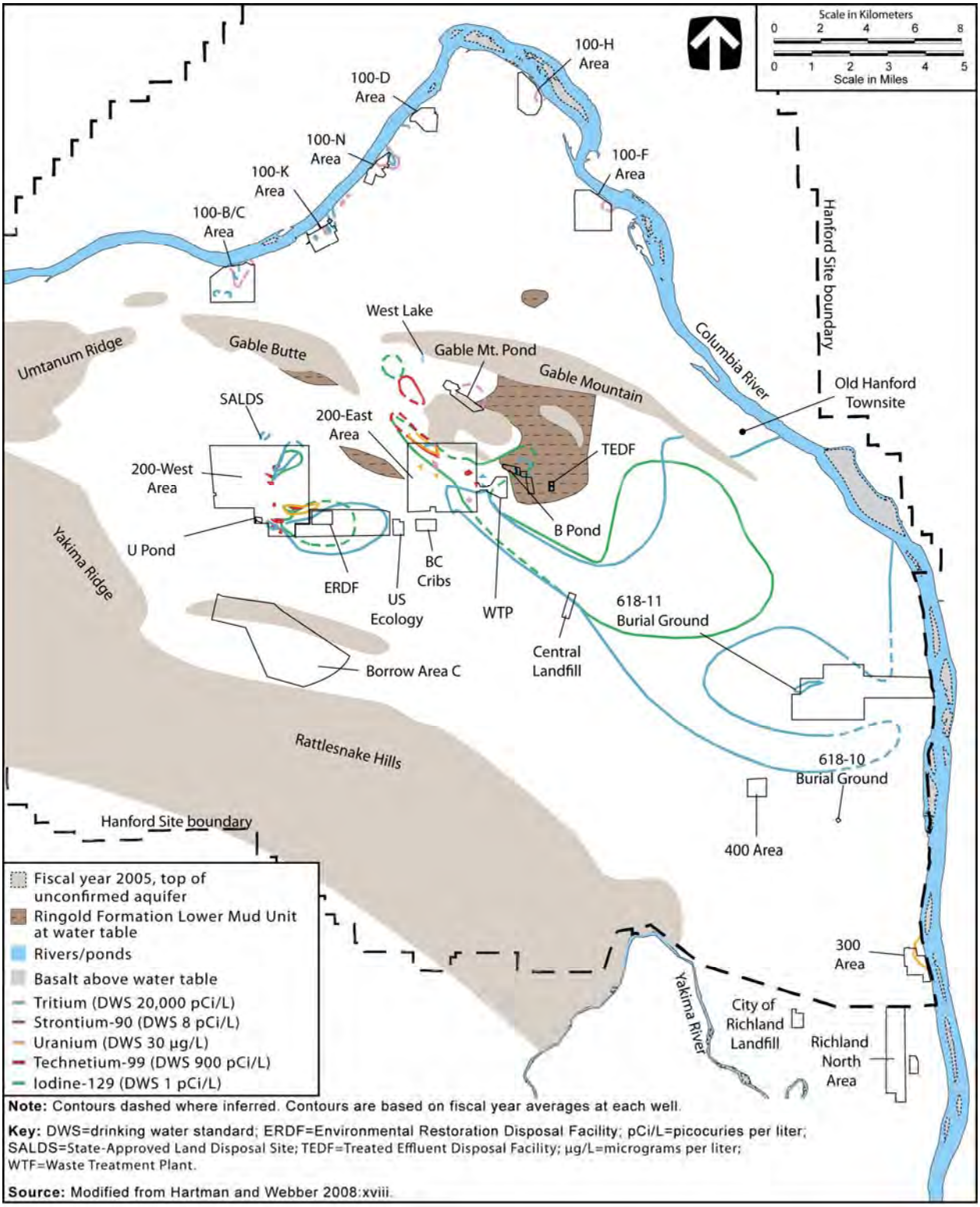


Figure 3–14. Distribution of Major Radionuclides in the Unconfined Aquifer System During Fiscal Year 2007

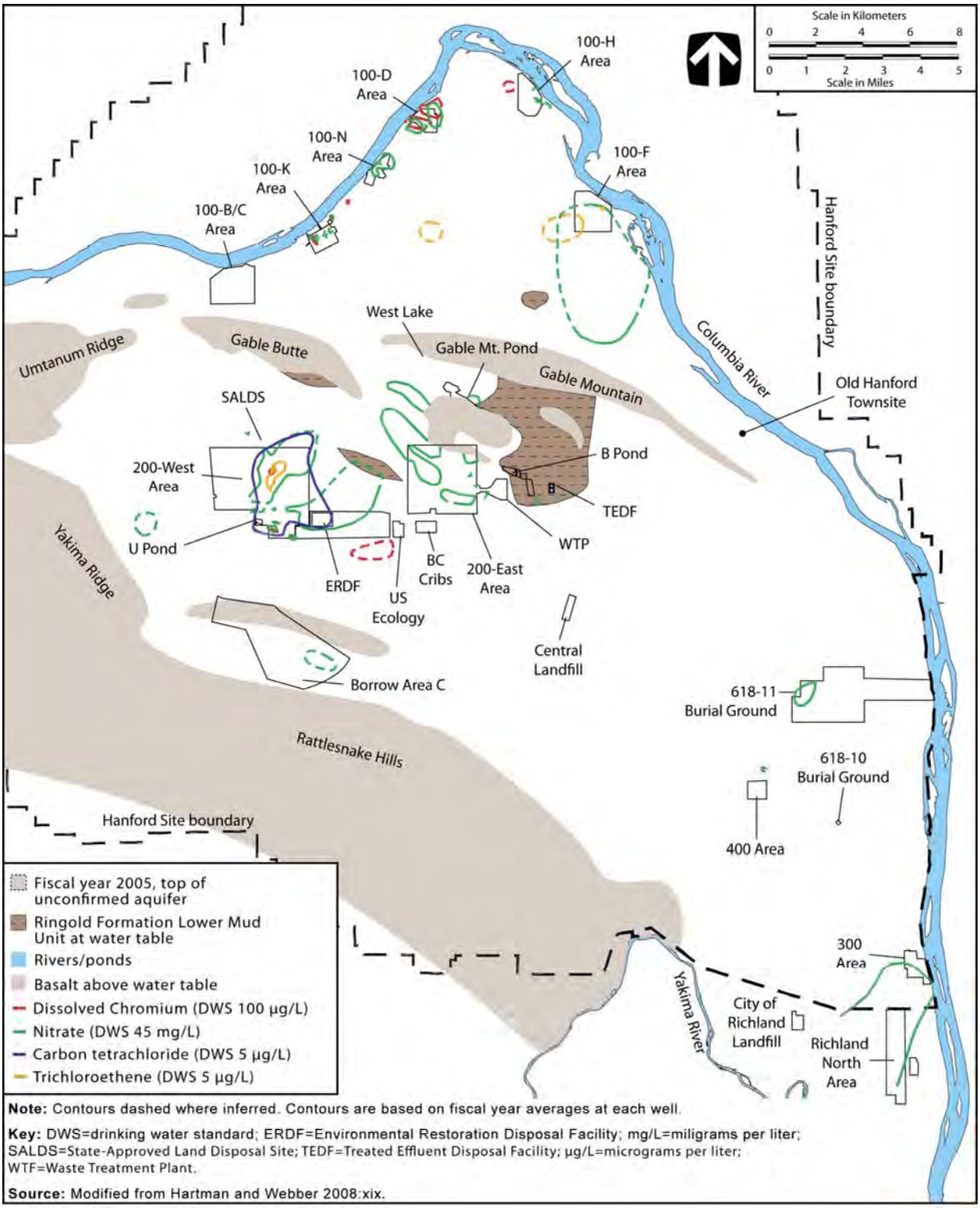


Figure 3–15. Distribution of Major Hazardous Chemicals in the Unconfined Aquifer System During Fiscal Year 2007

3.2.6.3.2 200 Areas Description

Along the southern edge of the 200-East Area and in the 200-West Area, the water table occurs almost entirely in the upper gravel layers (unit E) of the Ringold Formation, while in most of the 200-East Area, it occurs primarily in the Hanford formation and in the lower gravel layers (unit A) of the Ringold Formation. The upper Ringold strata across most of the 200-East Area were eroded by the ancestral Columbia River and, in some places, by the Missoula floods that subsequently deposited Hanford gravels and sand on what was left of the Ringold Formation. Because the Hanford formation and Cold Creek Unit sand and gravel deposits are much more permeable than the Ringold gravels, the water table is rather flat in the 200-East Area, but groundwater flow velocities are higher. On the north side of the 200-East Area, there is evidence of erosion channels that may allow interaquifer flow between the unconfined and uppermost basalt-confined aquifer systems (Duncan 2007:4.75).

The subsurface hydrology of the 200 Areas has been strongly influenced by the discharge of large quantities of wastewater to the ground for more than 50 years. Those discharges have caused elevated water levels across much of Hanford, resulting in a groundwater mound beneath the former B Pond east of the 200-East Area and a larger groundwater mound beneath the former U Pond in the 200-West Area. Water table changes beneath the 200-West Area have been greatest because of the lower transmissivity of the aquifer in this area. In recent years, discharges of water to the ground have been greatly reduced, and corresponding decreases in the water table elevation have been measured. The decline in part of the 200-West Area has been more than 8 meters (26 feet). Water levels are expected to continue to decrease as the unconfined groundwater system reaches equilibrium with the new level of artificial recharge (Duncan 2007:4.75, 4.81). Currently, the water table elevation is about 11 meters (36 feet) above the estimated water table elevation prior to the start of Hanford operations. Computer simulations show that when equilibrium conditions are established in the aquifer after site closure, the water table may still be 5 to 7 meters (16 to 23 feet) higher than the pre-Hanford water table because of modeling uncertainties, artificial recharge from offsite irrigation, or differences in current Columbia River conditions as compared to pre-Hanford times, such as dam construction (Hartman and Webber 2008:2.1-2).

Across the 200-East Area, the depth to the water table varies from approximately 65 meters (164 feet) to 100 meters (328 feet), and the thickness of the saturated zone above the top of the basalt varies from 0 meters in the north to about 80 meters (262 feet) in the south. The depth to the water table in the 200-West Area varies from about 50 meters (164 feet) to greater than 100 meters (328 feet). Beneath the 200-West Area, the saturated thickness of the unconfined aquifer varies from about 65 meters (213 feet) to greater than 150 meters (492 feet) (Hartman 2000:4.9, 4.16).

Groundwater beneath the 200-West Area generally flows from west to east across most of the area, but trends toward the northeast in the northern part of the area; flow is locally altered by pumping, injection, and waste discharge. The decline in liquid effluent discharges to the soil in the 200-West Area and the resulting decline in the water table have changed the flow direction in the northern part of the area about 35 degrees over the past decade from a north-northeast to a more eastward direction. Flow in the central part of the 200-West Area (the south part of the 200-ZP-1 Operable Unit) is heavily influenced by the operation of the 200-ZP-1 groundwater pump-and-treat remediation system. This system extracts water from the vicinity of the 216-Z cribs and trenches (ditches), treats it to remove carbon tetrachloride and other volatile organic compounds, then reinjects the water into the aquifer west of the area (Hartman and Webber 2008:2.8-1, 2.8-2).

Groundwater flow in the central portion of Hanford, which encompasses the 200-East Area, is significantly affected by the presence of a buried flood channel that lies in a northwest-to-southeast orientation. The water table in this area is very flat due to the high permeability of the Hanford formation. Groundwater flow in this region is significantly affected by the presence of the low-permeability sediment of the Ringold Formation (i.e., the Lower Mud Unit) at the water table east

and northeast of the 200-East Area, as well as basalt above the water table (see Figure 3–13) while the precise location of the flow divide has not been established, it has been established through water-level data. These features constitute barriers to groundwater flow. The extent of the basalt units above the water table continues to increase slowly due to the declining water table, resulting in an even greater effect on groundwater flow in this area. Because of the very low hydraulic gradient in the 200-East Area and vicinity, as well as uncertainty in the water-level elevation data, determining precisely the direction of groundwater flow is problematic. What is observable is that water enters the 200-East Area and vicinity from the west and southwest, as well as from beneath the mud units to the east and from the underlying aquifers (i.e., the upper basalt-confined aquifer system), where the confining units have been removed or thinned by erosion. The flow of water divides into two flow paths, one moving to the north through Gable Gap and the other southeast toward the central part of the site (see Figure 3–13). While the precise location of the flow divide has not been established, it has been determined through water-level data that groundwater flows north through Gable Gap and southeast between the 200-East Area and the Central Landfill (Hartman and Webber 2008:2.1-2, 2.1-3).

3.2.6.3.3 400 Area Description

Groundwater flow within the unconfined aquifer across the 400 Area is generally to the east-southeast. The Hanford formation immediately underlying the area consists mainly of sand-dominated sediments. Depth to the water table, located near the contact between the Hanford and Ringold Formations, is estimated at 49 meters (161 feet). Sediments of the Hanford formation dominate groundwater flow in the 400 Area because of their higher permeability than those of the Ringold Formation. The Ringold Formation consists of gravelly sands, sandy gravel, silty sands, fluvial gravels, and overbank and lacustrine silt and clay. The saturated thickness of this aquifer system is about 140 meters (460 feet) (Hartman 2000:4.25; Hartman and Webber 2008:2.11−23).

Nitrate has historically been the only significant contaminant attributable to 400 Area operations. Elevated nitrate has been attributed to a former sanitary sewage lagoon located west and upgradient of the FFTF Ponds (Hartman 2000:4.25; WHC 1992:44). However, in fiscal year 2007, nitrate concentrations were below the drinking water standard of 45 milligrams per liter in all 400 Area water supply wells (Hartman and Webber 2008:2.11−5, 2.11−24).

The 400 Area's three water supply wells are completed in the unconfined (Hanford/Ringold) aquifer system (see Section 3.2.2.4.3). The primary production well (499-S1-8J) was installed in 1985 in the lower unconfined aquifer system after tritium contamination was detected in the original two wells (499-S0-7 and 499-S0-8) near the top of the aquifer (Hartman 2000:4.25). These elevated tritium levels were associated with the groundwater plume from the vicinity of the PUREX Plant in the 200-East Area. Well 499-S1-8J now serves as the main water supply well for the 400 Area, while 499-S0-7 and 499-S0-8 are backup supply wells. During fiscal year 2007, tritium levels were below the drinking water standard (20,000 picocuries per liter); the highest tritium concentration during fiscal year 2007 was measured in well 499-S0-7 at 11,000 picocuries per liter. Fiscal year 2007 and earlier data from 400 Area and surrounding wells indicated no other constituents were present at levels above the drinking water standards (Hartman and Webber 2008:2.11-2–2.11-5, 2.11-23, 2.11-24.

3.2.6.3.4 Borrow Area C Description

Groundwater flow across Borrow Area C is inferred as to be generally to the east and northeast. Depth to the water table is estimated to average approximately 52 meters (170 feet). No groundwater wells have been developed in Borrow Area C.

3.2.7 Ecological Resources

Ecological resources include terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Terrestrial resources are the plant and animal communities most closely associated with the land; for aquatic resources, a water environment. Wetlands are "those areas that are inundated or saturated by groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR 328.3). Endangered species are those plants and animals in danger of extinction throughout all or a large portion of their range; threatened species, those species likely to become endangered within the foreseeable future. Other organisms may be designated by USFWS and the state as special status species, such as candidate, species of concern, sensitive, and watch.

3.2.7.1 Terrestrial Resources

3.2.7.1.1 General Site Description

Hanford is within the Columbia Basin Ecoregion, an area that historically included over 6 million hectares (14.8 million acres) of steppe and shrub-steppe vegetation. In the early 1800s, the dominant plant in the Hanford area was big sagebrush underlain by perennial Sandberg's bluegrass and bluebunch wheatgrass. With the advent of settlement, livestock grazing and agricultural production contributed to colonization by nonnative plant species. Although agriculture and livestock production were the primary activities within the region and on Hanford at the beginning of the twentieth century, these activities ceased at the site when the Government acquired it in 1943. Remnants of past agricultural practices are still evident. Now the site encompasses undeveloped land interspersed with the industrial development; only about 6 percent of the site has been developed (Duncan 2007:4.84; Neitzel 2005:4.144).

A variety of both native and nonnative plant species are found across the site. A total of 727 species of vascular plants has been recorded on the site, of which 179 are nonnative species. In addition, 29 soil lichens and 6 moss species have been identified. Prior to the 24 Command Fire in July 2000, studies identified as many as 48 vegetation communities and land use areas on Hanford (see Figure 3–16). However, these may be roughly grouped into shrublands, grasslands, areas containing trees, and riparian areas and wetlands (Duncan 2007:4.85–4.87).

Shrublands occupy the most extensive area on Hanford. Of the numerous types present, sagebrush-dominated communities predominate; other shrub communities vary with changes in soils and elevation. Typical vegetation in shrub land habitat includes big sagebrush, threetip sagebrush, bitterbrush, gray rabbitbrush, winterfat, snow buckwheat, and spiny hopsage. In the recent past, big sagebrush plant communities covered about 80 percent of the mapped land on the site; however, much of this area (28,750 hectares [71,040 acres]) was burned by the 24 Command Fire in 2000 and again by the Wautoma Wildland Fire in 2007 (Burandt 2007; Duncan 2007:4.89).

Washington State considers pristine shrub-steppe habitat as a priority habitat because of its relative scarcity in the state and its importance to several state-listed wildlife species (WDFW 2007). Designation and characterization of priority habitat provide a basis for sound, defensible land management planning and assist in the management of regulated species. Sagebrush communities are also considered a Level III resource under the *Hanford Site Biological Resources Management Plan*. Biological resources are ranked from Level I to Level IV with Level IV being the most significant in terms of the presence of threatened or endangered species, as well as rare, unique, or vanishing habitat. Impacts on Level III resources should be avoided or minimized; however, when avoidance and minimization are not possible, rectification or mitigation is recommended (DOE 2001c:4.7).

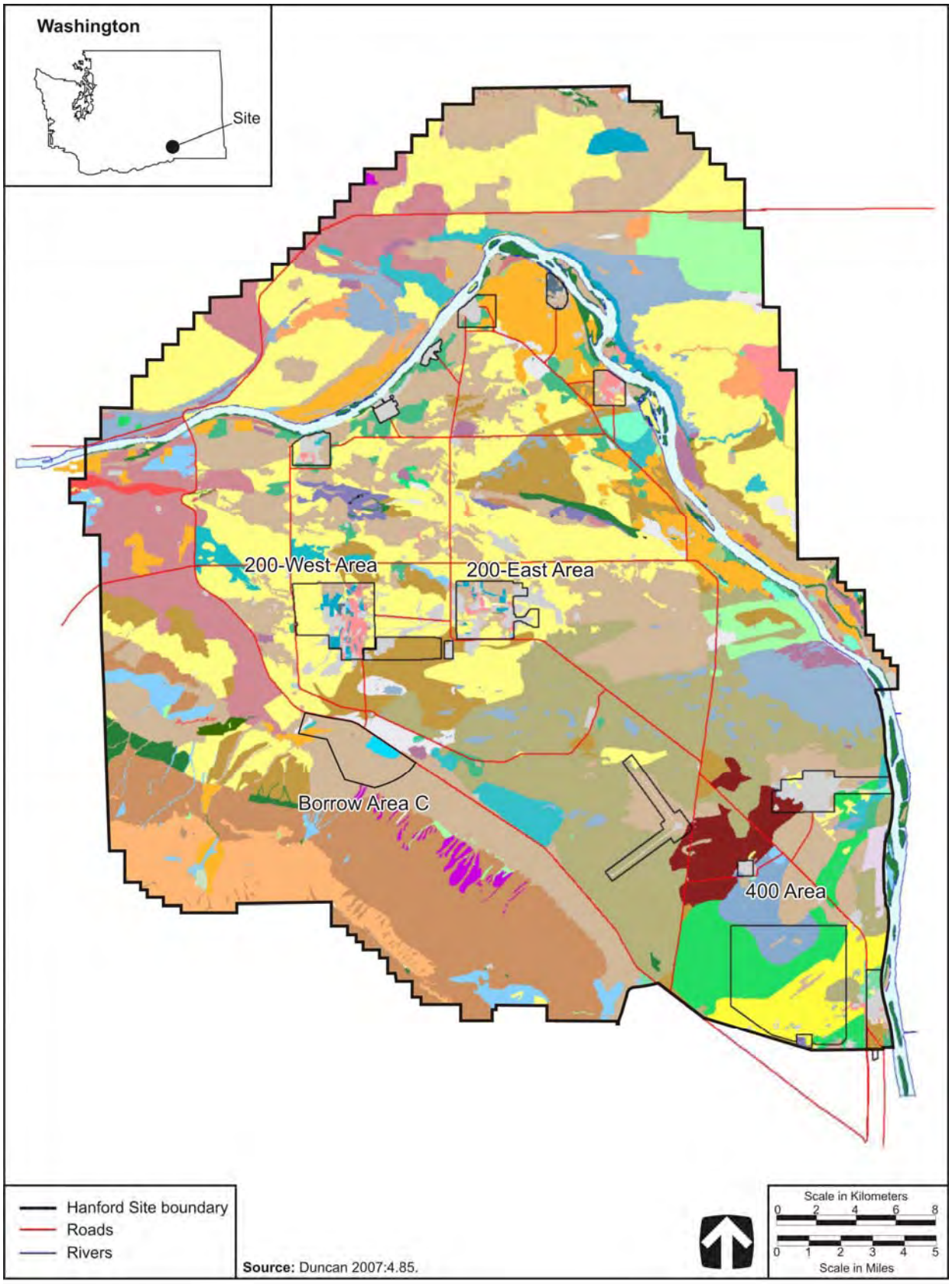


Figure 3–16. Vegetation Communities on the Hanford Site



Figure 3–16. Vegetation Communities on the Hanford Site *(continued)*

While most grasses occur as understory in shrub-dominated plant communities, there are a number of grassland communities on the site. Common species include Sandberg's bluegrass, needle-and-thread grass, Indian ricegrass, and thickspike wheatgrass. Cheatgrass has replaced many native perennial grass species and is well established in many low-elevation (less than 244 meters [800 feet]) and/or disturbed areas (Duncan 2007:4.90).

Before settlement, Hanford's landscape lacked trees, although the Columbia River nearshore supported a few scattered cottonwoods or willows. Homesteaders planted trees in association with agricultural areas. Shade and ornamental trees were planted around former military installations and industrial areas on the site. Currently, 23 species of trees occur on Hanford. The most common species are black locust, Russian olive, cottonwood, mulberry, sycamore, and poplar. These trees provide nesting habitat and cover for many birds and mammals (Duncan 2007:4.90).

Riparian habitat includes riffles, gravel bars, backwater sloughs, shorelines, islands, and palustrine areas associated with the Columbia River floodplain, as well as site springs. Vegetation occurring along the river shoreline includes water smartweed, pondweed, sedges, reed canary grass, and bulbous bluegrass. Trees include willow, mulberry, and Siberian elm. Other riparian vegetation associated with perennial springs and seeps includes bulrush, spike rush, and cattail. North of the Columbia River, several irrigation return ponds support riparian vegetation. The riparian areas associated with Snively and Rattlesnake Springs were greatly impacted by the 24 Command Fire (Duncan 2007:4.92, 4.93).

Within the Columbia Basin, microbiotic crusts commonly occur in the top 1 to 4 millimeters (0.04 to 0.16 inches) of soil and are composed primarily of algae, lichen, and mosses. Living organisms (primarily green algae) and their byproducts bind individual soil particles together to form these crusts. The functions of microbiotic crusts include soil stability and protection from erosion; fixation of atmospheric nitrogen; nutrient contribution to plants, thereby influencing soil-plant water relations; and increased water infiltration, seedling germination, and plant growth. The ecological roles of microbiotic crusts depend on the cover of various crustal components. Carbon inputs are higher when mosses and lichens are present than when the crust is dominated by cyanobacteria. Nitrogen inputs are higher with greater water infiltration. Soil surface stability is related to cyanobacterial biomass, as well as total moss and lichen cover (Duncan 2007:4.87, 4.88).

Several unique habitats and populations of rare plants on Hanford contribute to its biodiversity. Unique habitats include basalt outcrops, river bluffs, dunes, and islands. The tops of Rattlesnake Mountain, Umtanum Ridge, Gable Butte, and Gable Mountain have rock outcrops and thin rocky soils. Plant communities dominated by thymeleaf buckwheat and Sandberg's bluegrass most often occupy these basalt outcrops. The White Bluffs border the Columbia River along the northern shoreline, presenting a steep environment with sparse and patchy vegetation. Vegetation includes black greasewood, spiny hopsage, Indian ricegrass, and a number of sensitive species. Dune areas, such as those occurring on the eastern part of the site near the Energy Northwest complex, support bitterbrush, scrufpea, and thickspike wheatgrass. Island habitat accounts for about 466 hectares (1,152 acres) on Hanford. Vegetation characterizing the islands includes willow, poplar, Russian olive, mulberry, snow buckwheat, lupine, mugwort, and yarrow. The Nature Conservancy of Washington has conducted a number of surveys of the site and has identified a total of 127 populations of 30 rare plants (Duncan 2007:4.89, 4.95, 4.96).

Approximately 300 species of terrestrial vertebrates have been observed on Hanford, including 46 of mammals, 258 of birds, 10 of reptiles, and 5 of amphibians. The shrub and grassland habitats of Hanford support many groups of terrestrial wildlife. Mammals include large game animals such as the Rocky Mountain elk and mule deer; predators such as coyote, bobcat, and badger; and herbivores such as deer, harvest mice, ground squirrels, voles, and black-tailed jackrabbits. Forty-one bird species are common to shrub and grassland habitats, including the western meadowlark, horned lark, long-billed curlew, vesper and sage sparrows, loggerhead shrike, northern harrier, and golden eagle.

The side-blotched lizard is the most abundant species of lizard on Hanford, while the Great Basin gopher snake, western yellow-bellied racer, and western rattlesnake are the most common snakes. The Great Basin spadefoot toad, Woodhouse's toad, Pacific tree frog, tiger salamander, and bullfrog are the only amphibians found on the site (Duncan 2007:4.83, 4.84, 4.90-4.92).

Many species of insects occur throughout all of the habitats found at Hanford. Butterflies, grasshoppers, and darkling beetles are among the most conspicuous of the approximately 1,500 species of insects identified from specimens collected on the site. The actual number of insect species occurring on Hanford may reach as high as 15,500. Recent site surveys performed by The Nature Conservancy identified 43 new taxa and 142 new findings for the State of Washington. The high diversity of insect species on Hanford is believed to reflect the size, complexity, and quality of the shrub-steppe habitat (Duncan 2007:4.92)

Riparian areas provide nesting and foraging habitat and escape cover for many species of birds and mammals. Mammals occurring primarily in riparian areas include rodents, bats, mink, porcupine, raccoon, and mule deer. Birds common to these areas include the American robin, black-billed magpie, song sparrow, and dark-eyed junco. Great blue herons and black-crowned night herons are associated with trees in riparian habitat, and bald eagles have wintered on Hanford since 1960. Hanford is located in the Pacific Flyway and serves as a resting area for neotropical migrant birds, migratory waterfowl, and shorebirds (Duncan 2007:4.93, 4.94).

A number of species are associated with unique habitats found on Hanford. White Bluffs and Umtanum Ridge provide nesting for birds, including the red-tailed hawk, cliff swallow, and rough-winged swallow. Bluff areas also provide habitat for sensitive species (e.g., the peregrine falcon) that otherwise might be subject to impacts of repeated disturbance. Trees that do not normally occur in arid steppe habitat supply nesting, perching, and roosting sites for many birds such as the ferruginous and Swainson's hawks. Dunes are unique in their association with the surrounding shrub-steppe vegetation and afford habitat for mule deer, burrowing owls, and coyotes. The islands of the Columbia River also afford a unique habitat at Hanford for waterfowl and shorebirds, including the Canada goose, California and ring-billed gulls, and Foster's tern. Some islands accommodate colonial nesting species that may range in population size upward of 2,000 individuals (Duncan 2007:4.95, 4.96).

In response to the 24 Command Fire of 2000, which burned 56,246 hectares (138,986 acres) within Hanford, USFWS prepared the *24 Command Fire, Benton County, Washington, June–July 2000, Burned Area Emergency Rehabilitation (BAER) Plan* (DOI 2000) that assessed resource issues and impacts and provided recommendations. While vegetation resources were substantially reduced on about 85 percent of the fire area, due to the rather fast passage of the fire over any one area, most soils showed little damage and seed bank sources in the soil were not adversely impacted. Although this will aid natural revegetation, recovery of some plant associations (e.g., sagebrush) may require planting and could take years. Potential long-term impacts of the fire include the establishment of noxious weeds and changes in natural plant communities. The 24 Command Fire had immediate direct impacts on wildlife, including loss of individual animals, especially smaller, less-mobile species and the young of the year, and displacement of more-mobile animals to unaffected areas. However, displacement itself can lead to increased mortality due to road kills; in the case of Rocky Mountain elk, this has already occurred. Long-term impacts on wildlife due to loss of food, cover, and breeding habitat are expected as a result of the fire (DOI 2000:94, 95, 99, 100, 119). The Wautoma Wildland Fire of 2007 burned a large portion of the same area as the 24 Command Fire (see Figure 3–2); however, an assessment of impacts on vegetation and wildlife has not yet been made. It is likely that the fire will have many of the same impacts on vegetation and wildlife as the 24 Command Fire.

3.2.7.1.2 200 Areas Description

Figures 3–17 and 3–18 illustrate vegetation and land cover in and around the 200-East and 200-West Areas following the 24 Command and Wautoma Wildland Fires. Most of the 200 Areas were not directly impacted by either fire (see Figure 3–2). Undisturbed portions of the 200 Areas are characterized by the following communities: big sagebrush/bunchgrass-cheatgrass, cheatgrass-bluegrass, crested wheatgrass-bunchgrass-cheatgrass, and gray rabbitbrush/cheatgrass-bluegrass. The former two communities are prominent in the 200-East Area, while the latter two are more common in the 200-West Area. Most of the waste disposal and storage sites are covered by nonnative vegetation or are kept in a vegetation-free condition by the controlled application of approved herbicides because plants could potentially accumulate waste constituents. Where vegetation is present, it aids in stabilizing surface soil, controlling soil moisture, or displacing more-invasive, deep-rooted species like Russian thistle (Duncan 2007:4.98). Due to the disturbed nature of most of the 200 Areas, wildlife use is limited; however, surveys have recorded the badger, coyote, Great Basin pocket mouse, mule deer, long-billed curlew, killdeer, horned lark, Say's phoebe, American robin, American kestrel, western meadowlark, and common raven (Sackschewsky 2003a:3, 2003b:9, 10; Sackschewsky and Downs 2007).

Surveys of areas potentially affected by the proposed Tank Closure alternatives have been completed (Sackschewsky 2003c, 2003d; Sackschewsky and Downs 2007). While large portions of the 200 Areas have been disturbed, sagebrush habitat, considered a priority habitat by the State of Washington and a Level III resource by the *Hanford Site Biological Resources Management Plan* (DOE 2001c), does occur in a number of locations (see Figures 3–17 and 3–18). It is found within the south-central portion of the 200-East Area and much of the area surrounding the WTP. The former area includes the site of IDF-East, while the latter includes the location within which the DSTs could be built, the location of the Supplemental Treatment Technology Site in the 200-East Area (STTS-East), and the area designated for interim canister storage (see Chapter 4, Figure 4–1). Sagebrush habitat is also found within the southeast corner of the 200-West Area, the location of the STTS-West (see Chapter 4, Figure 4–2).

3.2.7.1.3 400 Area Description

The 400 Area, which is classified as "Disturbed/nonvegetated" (see Figure 3–16), is located within postfire shrub-steppe habitat dominated by cheatgrass and small shrubs, including gray and green rabbitbrush. Owing to past disturbances and human occupancy of the 400 Area, wildlife is not as abundant as in undisturbed areas. However, a number of species are expected to occur. For example, surveys have identified 50 different bird species in habitats surrounding the building complexes, and 19 species actively nest on or near existing buildings. Species likely present include the American robin, barn swallow, European starling, and pigeon (PNNL 2008).

3.2.7.1.4 Borrow Area C Description

Most of the original vegetation in Borrow Area C was burned in the 24 Command Fire of June 2000. The largest prefire plant community was dominated by Sandberg's bluegrass and cheatgrass, but communities containing other grasses and big sagebrush were also present. Few shrubs remained after the fire, and Sandberg's bluegrass-cheatgrass became the dominant plant community. There is also a rather large, high-quality needle-and-thread grass-Indian ricegrass community, an unusual and relatively pristine community type, in the eastern and western portions of the site (see Figure 3–19). Wildlife inhabiting Borrow Area C include mammals such as the badger, coyote, Rocky Mountain elk, mule deer, and northern pocket gopher; birds such as the horned lark, lark sparrow, rock wren, short-eared owl, and western meadowlark; and reptiles such as the side-blotched lizard (Sackschewsky 2003b:4-7; Sackschewsky and Downs 2007:7-8). A large part of Borrow Area C was burned during the 2007 Wautoma Wildland Fire (see Figure 3–2). A biological assessment of the fire has not yet been made; however, one effect was to maintain the area as grassland.

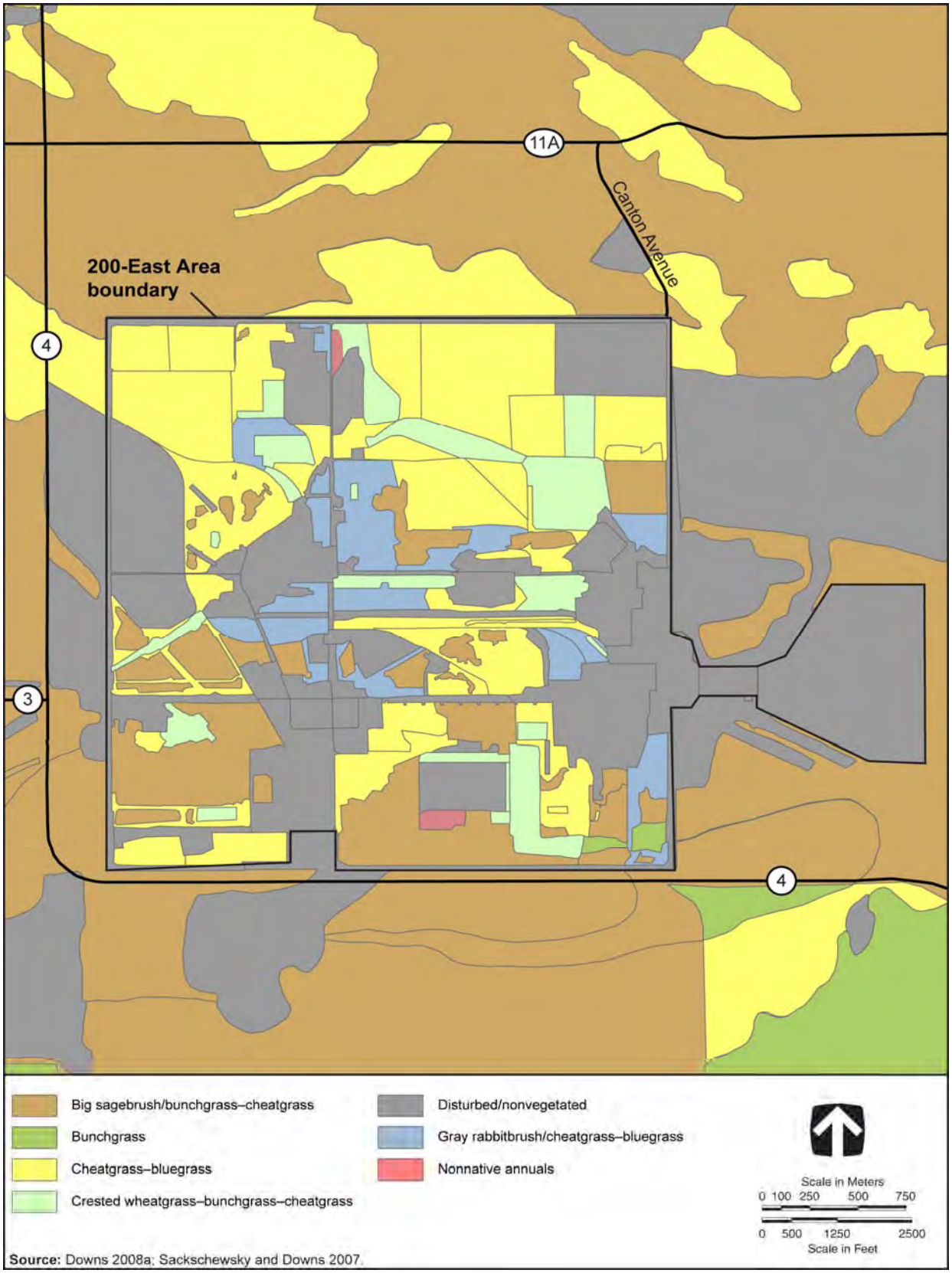


Figure 3–17. Vegetation Communities in and Near the 200-East Area

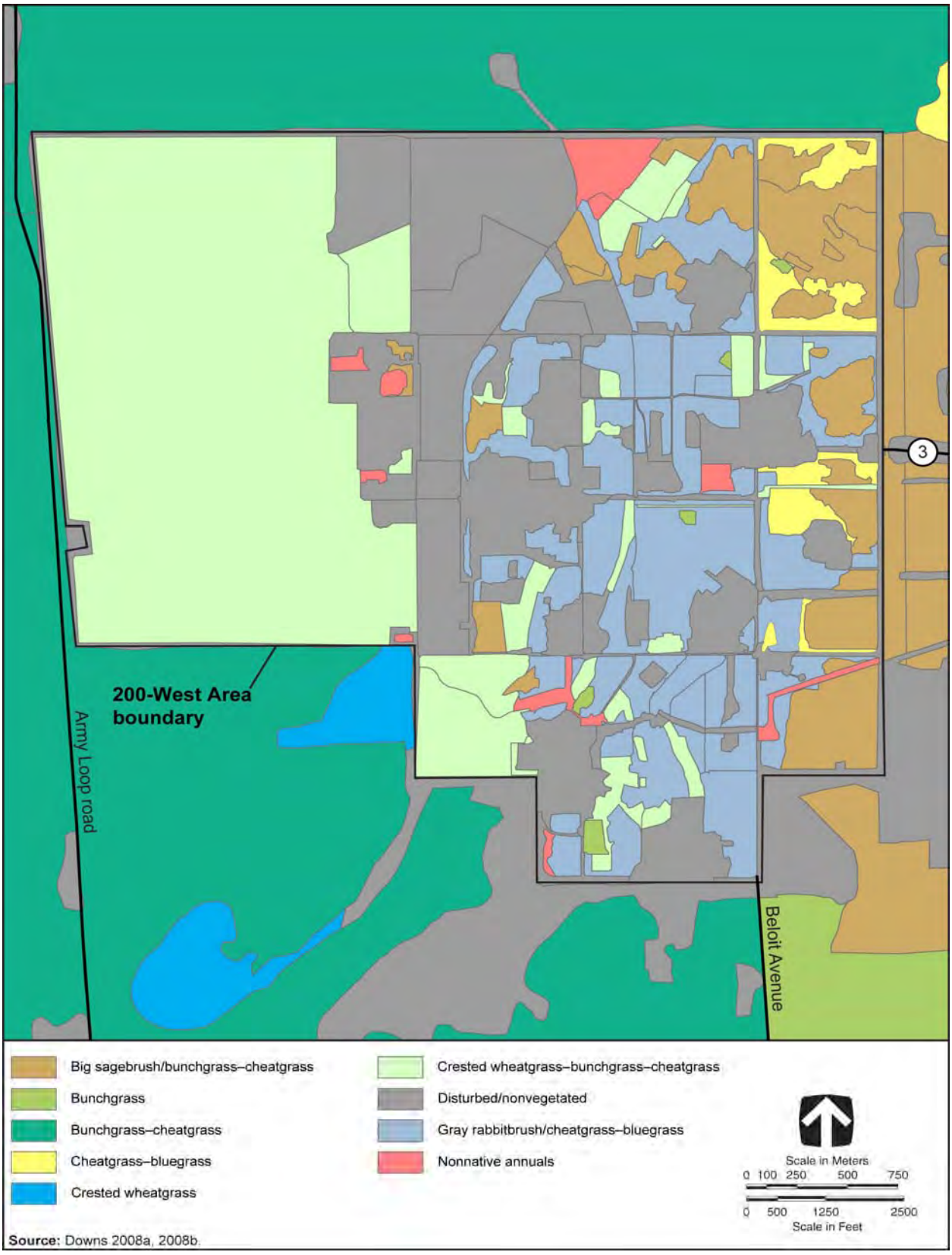


Figure 3–18. Vegetation Communities in and Near the 200-West Area

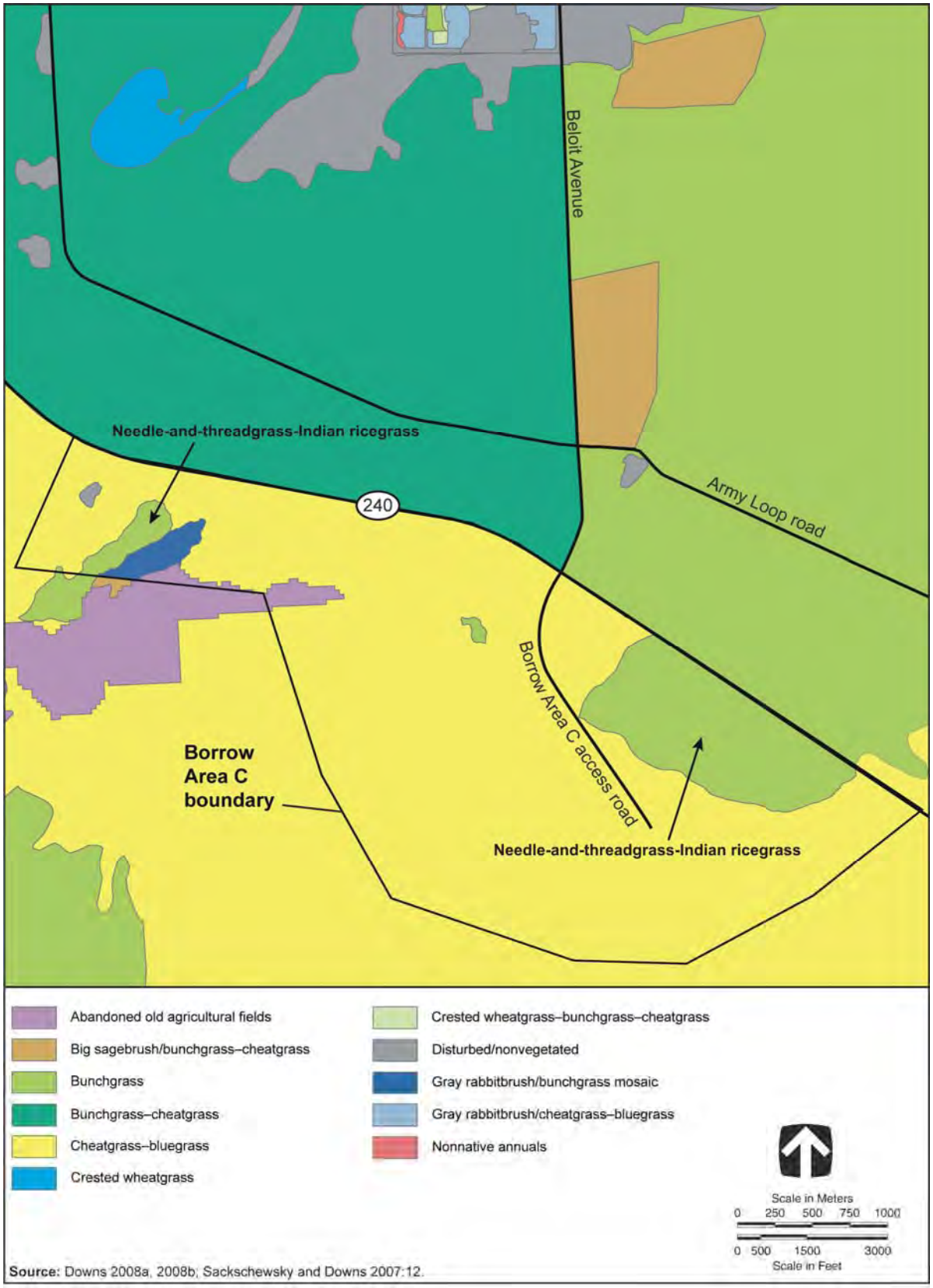


Figure 3–19. Distribution of Vegetation Communities in and Near Borrow Area C

3.2.7.2 Wetlands

3.2.7.2.1 General Site Description

Riparian habitat occurring in association with the Columbia River includes riffles, gravel bars, backwater sloughs, and coble shorelines. These habitats occur infrequently along the Hanford Reach and have acquired greater significance because of the loss of wetland habitat elsewhere within the region. Vegetation that occurs along the river shoreline includes willow, mulberry, Siberian elm, water smartweed, reed canary grass, sedges, and rushes (Duncan 2007:4.29, 4.93).

Other large wetland areas at Hanford can be found north of the Columbia River within the Saddle Mountain National Wildlife Refuge and the Wahluke Unit. These two areas encompass all the lands extending from the north bank of the Columbia River northward to the site boundary and east of the Columbia River down to Ringold Springs. Wetland habitat in these areas consists of fairly large ponds resulting from irrigation runoff. These ponds have extensive stands of cattails and other emergent aquatic vegetation surrounding the open-water regions. They are extensively used as nesting sites by waterfowl (Duncan 2007:4.93).

Some wetland habitat exists in the riparian zones of some of the larger spring-fed streams on the Fitzner-Eberhardt Arid Lands Ecology Reserve. These zones are not extensive and usually amount to less than 1 hectare (2.5 acres) in size. On the western side of Hanford, Rattlesnake Springs supports a riparian zone of 2.0 kilometers (1.2 miles) in length, which features cattail, peachleaf willow, and other exotic plants. Snively Springs also contains a diverse biotic community similar to that of Rattlesnake Springs (Duncan 2007:4.23). The 24 Command Fire affected approximately 17.8 hectares (44 acres) of willow riparian habitat, including areas around Rattlesnake Springs, Snively Canyon, Benson Springs, and the Yakima River (DOI 2000:108).

3.2.7.2.2 200 Areas Description

The only wetland area in the vicinity of the 200 Areas is West Lake. With the cessation of nuclear materials production activities at Hanford, the amount of water discharged to the ground in the 200 Areas substantially decreased. Thus, over the past 10 years, the lake has decreased in size and currently consists of a group of small isolated pools and mudflats. Predominant plants at West Lake include alkali salt grass, plantain, and salt rattlepod. Bulrush grows along the shoreline; however, the water is too saline to support aquatic macrophytes (i.e., large aquatic plants) (Duncan 2007:4.98, 4.99).

3.2.7.2.3 400 Area Description

There are no natural wetlands in the 400 Area, although the FFTF Ponds (i.e., 4608 B/C Ponds) are present. Wildlife species observed using the cooling and wastewater ponds include a variety of mammals and waterfowl (DOE 1999b:3-36).

3.2.7.2.4 Borrow Area C Description

There are no wetlands located within Borrow Area C.

3.2.7.3 Aquatic Resources

3.2.7.3.1 General Site Description

The Hanford Reach of the Columbia River flows through the northern portion of the site and forms the eastern site boundary. It is the last free-flowing, nontidal segment of the Columbia River in the United States (Duncan 2007:4.99).

Macrophytes are generally sparse in the Columbia River; however, rushes and sedges occur along the shorelines of the slack-water areas. Where they exist, they provide food and shelter for juvenile fish and spawning areas for some species of warm-water game fish. Phytoplankton (free-floating algae) and periphyton (attached algae) are abundant in the Columbia River and provide food for herbivores such as immature insects, which in turn are consumed by predators. Both zooplankton (small, free-floating aquatic animals) and macrophytes are generally sparse in the river because of the strong currents, rocky bottom, and frequently fluctuating water levels. Benthos, or bottom-dwelling organisms, including insect larvae, clams, snails, and crayfish, are found in the river. These organisms are an important food source for juvenile and adult fish (Duncan 2007:4.100).

The Hanford Reach supports 45 anadromous and resident species of fish. Of these species, spring-run Chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Additionally, fall-run Chinook salmon and steelhead trout spawn in the Hanford Reach. Inundation of other mainstream Columbia spawning grounds by dams has increased the importance of the Hanford Reach to fall-run Chinook salmon production in the Columbia and Snake Rivers. American shad is another anadromous species that may spawn in the Hanford Reach (Duncan 2007:4.100, 4.101).

Other fish of importance to sport fishermen are mountain whitefish, white sturgeon, smallmouth bass, crappie, channel catfish, walleye, and yellow perch. Large populations of rough fish are also present, including common carp, redside shiner, suckers, and northern pikeminnow (Duncan 2007:4.101).

The Yakima River borders the southern portion of Hanford. Fish found in the river in the site vicinity include smallmouth bass, salmon, steelhead trout, and channel catfish. Cold Creek and its tributary, Dry Creek, both ephemeral streams within the Yakima River drainage system, do not support any fish populations (DOE 2000a:3-121; YBFWRB 2008).

There are several springs at Hanford. Rattlesnake Springs, Bobcat Springs, and Snively Springs, located on the Fitzner-Eberhardt Arid Lands Ecology Reserve form short streams that seep into the ground. None of the springs support any fish populations; however, dense blooms of watercress occur, and aquatic insect populations are higher than they are in mountain streams. Site springs are an important source of water for terrestrial animals (DOE 2000a:3-120; Duncan 2007:4.103).

Three clusters of approximately 20 vernal pools are distributed on the eastern end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain (DOE 1999a:4-31). Vernal pools are seasonally flooded depressions that retain water much longer than the surrounding uplands; nonetheless, the pools are shallow enough to dry up each season. Only plants and animals that are adapted to this cycle of wetting and drying can survive in vernal pools over time. These pools can host freshwater crustaceans and other invertebrates and are of value to terrestrial species.

3.2.7.3.2 200 Areas Description

The LERF and TEDF, located in and adjacent to the 200-East Area, contain five ponds. There are three evaporation ponds associated with the LERF, each of which is about 0.8 hectares (2 acres) in size. The two disposal ponds associated with the TEDF are each about 2 hectares (5 acres) in size. While these ponds do not support fish populations, they are accessible to wildlife. West Lake, which has decreased in size in recent years (see Section 3.2.6.1.2), is the only other water body near the 200 Areas; however, the lake is too saline to support aquatic macrophytes (Duncan 2007:4.98, 4.99).

3.2.7.3.3 400 Area Description

Although no natural aquatic habitat occurs in the 400 Area, the FFTF Ponds (i.e., 4608 B/C Ponds) are present (DOE 1999b:3-36). The 400 Area is 6.8 kilometers (4.2 miles) west of the Columbia River.

3.2.7.3.4 Borrow Area C Description

There are no aquatic resources within Borrow Area C.

3.2.7.4 Threatened and Endangered Species

Endangered species are those plants and animals that are in danger of extinction throughout all or a large portion of their range. Threatened species are those species that are likely to become endangered within the foreseeable future. In addition to threatened and endangered species, USFWS, National Marine Fisheries Services, and the state designate other organisms as candidate, species of concern, sensitive, watch, and review (see Table 3–8). This section addresses special status species for Hanford as a whole, as well as for the proposed facility locations. Informal consultation has been conducted with USFWS, National Oceanic and Atmospheric Administration Fisheries, the Washington State Department of Fish and Wildlife, and the Washington Natural Heritage Program concerning listed species that are potentially present on Hanford (see Appendix C).

Table 3–8. Hanford Site Threatened, Endangered, and Other Special Status Species

Common Name	Scientific Name	Status	
		Federal	State
Plants			
Annual paintbrush	*Castilleja exilis*		Watch
Annual sandwort	*Minuartia pusilla* var. *pusilla*		Review Group 1
Awned halfchaff sedge	*Lipocarpha (=Hemicarpha) aristulata*		Threatened
Basalt milkvetch	*Astragalus conjunctus* var. *rickardii*		Watch
Beaked spike-rush	*Eleocharis rostellata*		Sensitive
Bristly combseed	*Pectocarya setosa*		Watch
Brittle Prickly Pear	*Opuntia fragilis*		Review Group 1
Canadian St. John's wort	*Hypericum majus*		Sensitive
Chaffweed	*Centunculus minimus*		Review Group 1
Columbia milkvetch	*Astragalus columbianus*	Species of concern	Sensitive
Columbia River mugwort	*Artemisia lindleyana*		Watch
Coyote tobacco	*Nicotiana attenuata*		Sensitive
Crouching milkvetch	*Astragalus succumbens*		Watch
Desert dodder	*Cuscuta denticulate*		Threatened
Desert evening primrose	*Oenothera caespitosa* ssp. *caespitosa*		Sensitive
Dwarf evening primrose	*Camissonia (=Oenothera) pygmaea*		Sensitive
False pimpernel	*Lindernia dubia* var. *anagallidea*		Watch
Fuzzytongue penstemon	*Penstemon eriantherus whitedii*		Sensitive
Geyer's milkvetch	*Astragalus geyeri*		Threatened
Giant helleborine	*Epipactis gigantea*		Watch
Grand redstem	*Ammannia robusta*		Threatened
Gray cryptantha	*Cryptantha leucophaea*	Species of concern	Sensitive

Table 3–8. Hanford Site Threatened, Endangered, and Other Special Status Species *(continued)*

Common Name	Scientific Name	Status	
		Federal	State
Plants *(continued)*			
Great Basin gilia	*Gilia leptomeria*		Threatened
Hedgehog cactus	*Pediocactus simpsonii* var. *robustior*		Review Group 1
Hoover's desert parsley	*Lomatium tuberosum*	Species of concern	Sensitive
Kittitas larkspur	*Delphinium multiplex*		Watch
Loeflingia	*Loeflingia squarrosa* var. *squarrosa*		Threatened
Lowland toothcup	*Rotala ramosior*		Threatened
Medic milkvetch	*Astragalus speirocarpus*		Watch
Medick milkvetch	*Astragalus speirocarpus*		Watch
Miner's candle	*Cryptantha scoparia*		Sensitive
Mousetail	*Myosurus clavicaulis*		Sensitive
Persistent sepal yellowcress	*Rorippa columbiae*	Species of concern	Endangered
Piper's daisy	*Erigeron piperianus*		Sensitive
Porcupine sedge	*Carex hystericina*		Watch
Robinson's onion	*Allium robinsonii*		Watch
Rosy balsamroot	*Balsamorhiza rosea*		Watch
Rosy pussypaws	*Calyptridium roseum*		Threatened
Scilla onion	*Allium scilloides*		Watch
Small-flowered evening primrose	*Camissonia* (=*Oenothera*) *minor*		Sensitive
Small-flowered nama	*Nama densum* var. *parviflorum*		Watch
Smooth cliffbrake	*Pellaea glabella var. simplex*		Watch
Snake River cryptantha	*Cryptantha spiculifera (= C. interrupta)*		Sensitive
Stalked-pod milkvetch	*Astragalus sclerocarpus*		Watch
Suksdorf's monkey flower	*Mimulus suksdorfii*		Sensitive
Thompson's sandwort	*Arenaria franklinii* var. *thompsonii*		Review Group 1
Umtanum desert buckwheat	*Eriogonum codium*	Candidate	Endangered
White Bluffs bladderpod	*Lesquerella tuplashensis*	Candidate	Threatened
White eatonella	*Eatonella nivea*		Threatened
Winged combseed	*Pectocarya penicillata*		Watch
Insects			
Columbia River tiger beetle[a]	*Cicindela columbica*		Candidate
Mollusks			
California floater	*Anodonta californiensis*	Species of concern	Candidate
Giant Columbia River limpet	*Fisherola (=Lanz) nuttalli*		Candidate
Giant Columbia River spire snail	*Fluminicola (=Lithoglyphus) columbiana*	Species of concern	Candidate

Table 3–8. Hanford Site Threatened, Endangered, and Other Special Status Species *(continued)*

Common Name	Scientific Name	Status	
		Federal	State
Fish			
Bull trout[b]	*Salvelinus confluentus*	Threatened	Candidate
Leopard dace[b]	*Rhinichthys flacatus*		Candidate
Mountain sucker[b]	*Catastomus platyrhynchus*		Candidate
River lamprey[b]	*Lampetra ayresi*	Species of concern	Candidate
Spring-run Chinook salmon	*Oncorhynchus tshawytscha*	Endangered[c]	Candidate
Steelhead	*Oncorhynchus mykiss*	Endangered[c] Threatened[d]	Candidate
Reptiles			
Northern sagebrush lizard	*Sceloporous graciosus*	Species of concern	Candidate
Striped whipsnake	*Masticophis taeniatus*		Candidate
Birds			
American white pelican	*Pelecanus erythrorhynchos*		Endangered
Bald eagle[e]	*Haliaeetus leucocephalus*	Species of concern	Sensitive
Burrowing owl	*Athene cunicularia*	Species of concern	Candidate
Common loon	*Gavia immer*		Sensitive
Ferruginous hawk	*Buteo regalis*	Species of concern	Threatened
Flammulated owl[b]	*Otus flammeolus*		Candidate
Golden eagle	*Aquila chrysaetos*		Candidate
Lewis's woodpecker[b]	*Melanerpes lewis*		Candidate
Loggerhead shrike	*Lanius ludovicianus*	Species of concern	Candidate
Merlin	*Falco columbarius*		Candidate
Northern goshawk[b]	*Accipter gentilis*	Species of concern	Candidate
Peregrine falcon	*Falco peregrinus*	Species of concern	Sensitive
Sage sparrow	*Amphispiza belli*		Candidate
Sage thrasher	*Oreoscoptes montanus*		Candidate
Sandhill crane	*Grus canadensis*		Endangered
Western grebe	*Aechmophorus occidentalis*		Candidate
Western sage grouse	*Centrocercus urophasianus phaios*	Candidate	Threatened
Mammals			
Black-tailed jackrabbit	*Lepus californicus*		Candidate
Merriam's shrew	*Sorex merriami*		Candidate
Townsend's ground squirrel	*Spermophilus townsendii*		Candidate
Washington ground squirrel[b]	*Spermophilus washingtoni*	Candidate	Candidate
White-tailed jackrabbit	*Lepus townsendii*		Candidate

[a] Probable but not observed on the Hanford Site.
[b] Reported but seldom seen on the Hanford Site.
[c] Protected as an Evolutionarily Significant Unit for the upper Columbia River.
[d] Protected as an Evolutionarily Significant Unit for the middle Columbia River.
[e] Removed from the list of threatened wildlife in the lower 48 states effective August 8, 2007 (72 FR 37346).

Table 3–8. Hanford Site Threatened, Endangered, and Other Special Status Species *(continued)*

Federal:

Candidate: Current information indicates the probable appropriateness of listing as endangered or threatened.

Endangered: In danger of extinction throughout all or a significant portion of its range.

Species of Concern: Conservation standing is of concern, but status information is still needed (not published in the *Federal Register*).

Threatened: Likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

State:

Candidate: Current information indicates the probable appropriateness of listing as endangered or threatened.

Endangered: In danger of becoming extinct or extirpated from Washington State within the foreseeable future if factors contributing to its decline continue.

Review Group 1: Of potential concern; additional fieldwork is needed before a status can be assigned.

Review Group 2: Of potential concern; unresolved taxonomic questions.

Sensitive: Vulnerable or declining and could become endangered or threatened in Washington State without active management or removal of threats.

Threatened: Likely to become endangered in Washington State within the foreseeable future if factors contributing to its decline or habitat degradation or loss continue.

Watch: More abundant and/or less threatened than previously assumed, but still of interest to the state.

Source: Duncan 2007:4.106, 4.107, 4.109–4.113; USFWS 2007:2-35–2-37; WDFW 2008; WNHP 2005, 2008.

3.2.7.4.1 General Site Description

Threatened, endangered, and other federally and state-listed special status species that occur on Hanford are presented in Table 3–8. Two federally endangered species and 2 federally threatened species are found on the site. Two species of plants, 1 species of bird, and 1 species of mammal are listed as Federal candidates, and 4 plants, 2 mollusks, 1 fish, 1 reptile, and 6 birds are designated as Federal species of concern. Neither the candidates nor the species of concern receive legal protection; however, they should be considered during project planning. At the state level, 2 species of plants and 2 species of birds are listed as endangered, and 10 plants and 2 birds are listed as threatened. Numerous additional plants and animals have other state special status designations.

Of the three fish species listed as threatened and endangered, only the upper Columbia River steelhead spawns in the Hanford Reach, although the extent of spawning is not known. The Upper Columbia River spring-run Chinook salmon do not spawn in the Hanford Reach, but adults pass through the Reach while migrating to spawning grounds, and the juveniles use it as a nursery area until they migrate toward the ocean. The bull trout primarily inhabits smaller streams, usually at higher elevations. The bald eagle is a relatively common winter resident along the Hanford Reach. Although it has occasionally attempted to nest on Hanford, it has not been successful (Duncan 2007:4.105, 4.108). Although not listed in Table 3−8 as a special status species, the long-billed curlew is a state monitor species, indicating that it is monitored for status and distribution.

Twelve species of plants that occur on Hanford are listed as threatened or endangered in Washington (see Table 3–8). Four of these, the awned halfchaff sedge, grand redstem, lowland toothcup, and persistent sepal yellowcress, are found in areas along the Columbia River. Desert dodder has been found along a dry drainage in Cold Creek Valley and on White Bluffs. Other species associated with White Bluffs include Geyer's milkvetch and White Bluffs bladderpod. White Bluffs bladderpod has been reported nowhere else in the world. Great Basin gilia has been reported near Gable Mountain and at various locations on the Wahluke Slope. Loeflingia and rosy pussypaws have been found in the sandy areas north of Gable Mountain. Umtanum desert buckwheat has been reported growing in thin rocky soils along the crest of Umtanum Ridge and nowhere else in the world. White eatonella has been found locally on steep, sandy slopes near Vernita Bridge (Sackschewsky and Downs 2001:3.15, 3.34, 3.40, 3.45, 3.49, 3.54, 3.72, 3.92, 3.94, 3.101).

Four state-listed threatened or endangered animals have been recorded at Hanford. The American white pelican is fairly common along the Hanford Reach, but does not appear to nest or reproduce there. The ferruginous hawk has nested in several areas, including numerous locations in the eastern portion of the site. The western sage grouse was sighted on the Fitzner-Eberhardt Arid Lands Ecology Reserve in the late 1900s and, in 2003, a dead individual was found near the 100-F Area. Sandhill cranes have been occasionally observed on the Hanford Reach during their spring migration (DOE 1999a:4-59; Duncan 2007:4.105).

Although no critical habitat for threatened and endangered species, as defined in the Endangered Species Act, exists on Hanford, Washington State considers pristine shrub-steppe habitat to be a priority habitat. It is so designated because of its relative scarcity in the state and its requirement as nesting/breeding habitat by several federally and state-listed species (WDFW 2007). Designation and characterization of priority habitat provide a basis for sound and defensible land management planning and assist DOE in integrating stewardship activities into site management to protect regulated species.

Up to 9 plant and 10 animal special status species could have been found in the 56,246-hectare (138,986-acre) area that was burned by the 24 Command Fire at Hanford (DOI 2000:v, 121). Direct effects of the fire on protected vegetation included loss of plants and seed stock. Indirect effects included increased competition from invasive plant species, potential loss of soil productivity due to wind erosion, and loss of seed viability; however, indirect effects could also include such benefits as the release of nutrients back into the soil and reduced competition for soil nutrients, soil moisture, and sun. As for wildlife, the 24 Command Fire was determined to have had no effect on any federally listed threatened or endangered species. Potential impacts on state-listed species included direct loss of adults and young, while indirect effects included loss of habitat used as cover and for feeding and raising young. An assessment of the impacts of the 2007 Wautoma Wildland Fire on threatened and endangered species has yet to be made.

3.2.7.4.2 200 Areas Description

No federally or state-listed threatened or endangered species have been observed within, or in the immediate vicinity of, the 200 Areas; however, a number of other special status species have been found within areas potentially affected by Tank Closure alternatives (Sackschewsky 2003c, 2003d; Sackschewsky and Downs 2007). Piper's daisy has been observed in the vicinity of the WTP, along the route of the 200-East Area underground transfer line, between the 200-East and 200-West Areas, and within the STTS-West. Stalked-pod milkvetch has been found in the vicinity of the WTP and within both the STTS-East and -West. Another milkvetch species, crouching milkvetch, was observed within the vicinity of the WTP, within the STTS-East, and between the 200-East and 200-West Areas.

Special status animal species that have been observed within areas potentially impacted by Tank Closure alternatives include the sage sparrow, black-tailed jackrabbit, and loggerhead shrike. The sage sparrow has been found within the vicinity of the WTP, within the STTS-West, and between the 200-East and 200-West Areas. The black-tailed jackrabbit has been seen along the route of the 200-East Area underground transfer line and between the 200-East and 200-West Areas. The loggerhead shrike was observed within the STTS-West and between the 200-East and 200-West Areas. The loggerhead shrike was observed within the STTS-West and between the 200-East and 200-West Areas. Finally, the long-billed curlew, a state monitor species, was observed along the route of the 200-East Area underground transfer line. Because of the importance of sagebrush habitat, many of these species could be present anywhere such habitat exists (Sackschewsky 2003c, 2003d; Sackschewsky and Downs 2007). In addition to those animals observed within the 200 Areas, the ferruginous hawk, loggerhead shrike, and burrowing owl have been observed nesting in the vicinity, and the block of habitat to the south provides some of Hanford's best sage sparrow habitat (DOE 1999a:4-57, 4-59).

3.2.7.4.3 400 Area Description

No federally or state-listed threatened or endangered plants or animals have been found in the vicinity of the 400 Area (Duncan 2007:106, 107), although a potential exists for the incidental occurrence of some migratory species such as the peregrine falcon. State-listed sensitive plant species have not been found in the 400 Area; however, Piper's daisy does occur in the vicinity. A fire burned the area in the mid-1980s, leaving it dominated by cheatgrass and some small shrubs (DOE 2000a:3–122).

3.2.7.4.4 Borrow C Area Description

Although no federally or state-listed threatened or endangered species occur within Borrow Area C the area provides extensive habitat for ground-nesting birds, including the long-billed curlew. Two special status plant species have been observed there. Piper's daisy is known to occur in rather high numbers south of the area, and at least one individual has been found along the new access road. Crouching milkvetch and stalked-pod milkvetch has also been observed in Borrow Area C (Sackschewsky 2003b:7; Sackschewsky and Downs 2007:8).

3.2.8 Cultural and Paleontological Resources

Cultural resources are of two primary categories: prehistoric resources, or physical properties reflecting human activities that predate written records; and historic resources, or physical properties that postdate the advent of written records—in the United States, generally considered to be those documented no earlier than 1492. These resources are of special interest and importance to American Indians and include all areas, sites, and materials deemed important for religious or heritage-related reasons, as well as certain natural resources such as plants, which have many uses within various American Indian groups. Paleontological resources are the physical remains, impressions, or traces of plants or animals from a former geologic age that may be sources of information on paleoenvironments and the evolutionary development of plants and animals.

Historic and prehistoric human imprints on the Hanford landscape are well documented, as are local traces of plants and animals from earlier geologic ages, and these cultural and paleontological resources are defined and protected by a series of Federal laws, regulations, and guidelines. The *Hanford Cultural Resources Management Plan* (DOE 2003c) established guidance for identifying, evaluating, recording, curating, and managing such resources. Moreover, cultural resource reviews are typically conducted whenever projects are proposed in previously unsurveyed areas (Neitzel 2005:4.99). Such a review has been conducted in those areas of Hanford that could be developed in connection with the proposed actions analyzed in this *TC & WM EIS* (Prendergast-Kennedy 2003). Archaeological reconnaissance projects dated from 1926 to 1968 and more-recent National Historic Preservation Act Section 106 and Section 110 surveys conducted between 1987 and 2007 have resulted in formal recording of these resources on archaeological forms and Washington State Historic Property Inventory Forms. DOE archives these records (Duncan 2007:4.6). Additionally, consultation with the Washington State Historic Preservation Office and interested American Indian tribes has been initiated for this EIS (see Appendix C).

During 1990, the National Park Service formalized the concept of the traditional cultural property (TCP) as a means to identify and protect cultural landscapes, places, and objects that have special cultural significance to American Indians and other ethnic groups. A TCP that is eligible for the National Register of Historic Places (National Register) is associated with the cultural practices or beliefs of a living community that are rooted in that community's history and are important in maintaining the continuing cultural identity of the community.

The Hanford Reach and the greater Hanford Site are central to the practice of the American Indian religion of the region. Native plants and animals are used in ceremonial foods. Prominent landforms

such as Rattlesnake Mountain, Gable Mountain, and Gable Butte as well as various sites along and including the Columbia River, remain sacred.

American Indian TCPs within Hanford include, but are not limited to, a wide variety of landscapes such as archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant-gathering areas, holy lands, landmarks, and important places of American Indian history and culture (Duncan 2007:4.120).

3.2.8.1 Prehistoric Resources

3.2.8.1.1 General Site Description

More than 8,000 years of prehistoric human activity in the largely arid environment of the middle Columbia River region have left extensive archaeological deposits along the river shores. Well-watered areas inland from the river also show evidence of concentrated human activity, and recent surveys have indicated transient use of arid lowlands for hunting. These cultural sites were occupied continuously or intermittently over substantial timespans. For this reason, a single location may contain evidence of use during both the prehistoric and historic periods, and thus the number of "occupations" could prove substantially greater than the number of identified sites (Neitzel 2005:4.103).

To date, approximately 32,630 hectares (80,640 acres) of Hanford and adjacent areas have been surveyed for archaeological resources. Approximately 1,550 cultural resource sites and isolated finds and 531 buildings and structures have been documented. Forty-nine cultural resource sites are listed in the National Register. Most of these sites are associated with the American Indian landscape and are part of six archaeological districts situated on the shores and islands of the Columbia River. To protect resources, the National Historic Preservation Act (16 U.S.C. 470 et seq.), Section 304, and the Archaeological Resources Protection Act (16 U.S.C. 470aa et seq.), Section 9, require agencies to withhold from public disclosure information on the location and character of cultural resources (Duncan 2007:4.115).

Prehistoric period sites common to Hanford include remains of numerous pithouse villages, various types of open campsites, spirit quest monuments (rock cairns), hunting camps, game drive complexes, quarries in mountains and rocky bluffs, hunting and kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water away from the river (Duncan 2007:4.120).

Although development and amateur artifact collectors have disturbed many prehistoric resources throughout the region, restricted public access imposed at Hanford has resulted in less destruction than in many other areas (Duncan 2007:4.120). Destruction from other causes is also slight. A preliminary assessment of possible effects of the 24 Command Fire, for example, determined that a minimum of 190 previously recorded prehistoric and historic archaeological sites could have been affected (DOI 2000:80). These sites range from lithic to can scatters, Indian hunting sites to ranch buildings, and spirit quest monuments to gas production wells. The assessment found that wooden structures (e.g., a corral) were destroyed, but that other surface and subsurface artifacts such as glass and lithic debris were not severely altered by the fire. Postfire surface visibility, in fact, has been greatly enhanced, presenting opportunities for archaeologists and historians to refine the boundaries of known sites and to locate new sites, though it also increases the potential for looting and vandalism.

3.2.8.1.2 200 Areas Description

A number of cultural resource surveys have been conducted within the 200 Areas (Chatters and Cadoret 1990; Prendergast-Kennedy 2003). The most important archaeological resource discovered in the 200 Areas is White Bluffs Road, an extensive linear feature that passes diagonally northeast to southwest through the 200-West Area. In the prehistoric period, the road was used as an American Indian

trail. White Bluffs Road, which was mapped prior to 1881, originally ran from Fort Colville to White Bluffs Landing on the Columbia River, then southwest to the Yakima River at a point near Sunnyside, Washington, where it connected with routes to The Dalles, Oregon (Chatters and Cadoret 1990:11). White Bluffs Road in its entirety has been determined to be eligible for listing in the National Register. Two intact segments of the road within the 200-West Area are considered contributing elements. These occur in the southwest and northeast parts of the 200-West Area. A 100-meter (328-foot) easement was created to protect these segments of the road from uncontrolled disturbance. The remaining central portion of the road within the 200-West Area has been determined to be noncontributing. The noncontributing segments of White Bluffs Road are those that do not add to the historic significance of the road, but retain evidence (i.e., contiguous traces) of its bearing (Chatters and Cadoret 1990:11, 21; Duncan 2007:4.130).

Additional finds within and adjacent to the 200 Areas that are associated with the prehistoric period include two cryptocrystalline flakes (i.e., fragments chipped from a rock core during tool making) and a cryptocrystalline silica base of a projectile point. The former was found within the northwestern portion of the 200-West Area 300 meters (984 feet) northwest of White Bluffs Road and may have been associated with its use (Chatters and Cadoret 1990:15, 16). The latter was discovered immediately to the east of the 200-East Area (Prendergast-Kennedy 2003:2). These artifacts have become part of the curated Hanford collection.

3.2.8.1.3 400 Area Description

In 1978, an archaeological reconnaissance survey of the 400 Area was conducted. At that time, the survey indicated that most of the 400 Area, with the exception of 12.1 hectares (30 acres), had already been disturbed by the construction of FFTF. The survey did not disclose any archaeological resources, and other surveys conducted near the project area disclosed no cultural resources. The 400 Area is considered a low-archaeological-sensitivity area (Duncan 2007:4.133; Prendergast 2002).

3.2.8.1.4 Borrow Area C Description

Survey results and geological data on Borrow Area C indicate no-to-low potential of the presence of prehistoric subsurface cultural deposits (PNNL 2007). Both the 2000 24 Command Fire and 2007 Wautoma Wildland Fire burned over all or a large portion of Borrow Area C (see Figure 3–2).

3.2.8.2 Historic Resources

3.2.8.2.1 General Site Description

Lewis and Clark were some of the first European Americans to visit the Hanford region during their 1804–1806 expedition. They were followed by fur trappers, military units, and miners. It was not until the 1860s that merchants set up stores, a freight depot, and the White Bluffs Ferry on the Hanford Reach, and gold miners began to work the gravel bars. Cattle ranches opened in the 1880s, and farmers soon followed. Several small thriving towns, including Hanford, White Bluffs, and Ringold, grew up along the riverbanks in the early twentieth century. Other ferries were established at Wahluke and Richland. These towns, and nearly all other structures, were razed after the U.S. Government acquired the land for the original Hanford Engineer Works (part of the Manhattan Project) in the early 1940s (Neitzel 2005:1.104). Today, the remnants of homesteads, farm fields, ranches, and abandoned military installations can be found throughout Hanford. There are nearly 5,260 hectares (13,000 acres) of abandoned agricultural lands on the site (DOE and Ecology 1996:4-37).

During the years of the Manhattan Project and the Cold War, numerous nuclear reactors and associated processing facilities were constructed at Hanford. The reactor sites cover over 930 hectares (2,300 acres) of land. All of the reactor buildings and major processing facilities still stand, although many ancillary

support structures have been removed. Plutonium produced at Hanford was used in the bomb that destroyed Nagasaki, Japan, to help end World War II. The Hanford 105-B Reactor, the world's first full-scale plutonium production reactor, is listed in the National Register and is designated a National Mechanical Engineering Landmark, a National Historic Civil Engineering Landmark, and a National Nuclear Engineering Landmark (DOE and Ecology 1996:4-37; Neitzel 2005:4.109). On August 19, 2008, the B Reactor was designated as a National Historic Landmark (DOE and DOI 2008).

Approximately 650 historic archaeological sites associated with the early-settler cultural landscape have been recorded since 1987. Archaeological resources from this period are scattered over Hanford and include numerous areas with gold-mining features along the Columbia riverbanks, as well as the remains of homesteads, building foundations, agricultural equipment and fields, ranches, and irrigation features. Properties from this period include the Hanford Irrigation Ditch; Old Hanford Townsite; Wahluke Ferry; White Bluffs Townsite; Richmond Ferry; Arrowsmith Townsite; White Bluffs Road; and Chicago, Milwaukee, St. Paul, and Pacific Railroad (Neitzel 2005:4.106).

The Manhattan Project and Cold War era landscape includes cultural resources associated with plutonium production, military operations, R&D, waste management, and environmental monitoring activities. Such activities began with the establishment of Hanford (the Hanford Engineer Works) in 1943 and continued until the end of the Cold War in 1990. DOE identified a National Register–eligible Hanford Site Manhattan Project and Cold War Era Historic District. Approximately 900 buildings and structures were identified as either contributing properties with no individual documentation requirement (not selected for mitigation) or as noncontributing/exempt properties (Duncan 2007:4.119). There are 528 Manhattan Project and Cold War era buildings/structures and complexes eligible for National Register listing as contributing properties within the Historic District. Of that number, 190 have been recommended for individual documentation (Duncan 2007:4.119, 4.124).

3.2.8.2.2 200 Areas Description

Much of the 200 Areas has been altered by Hanford operations. The Hanford Cultural Resources Program conducted a comprehensive archaeological resources survey of the fenced portions of the 200 Areas during 1987 and 1988 (Chatters and Cadoret 1990). The results indicate minimal evidence of American Indian cultural landscape resources and early settler/farming landscape resources. Archaeological surveys conducted since that time have revealed the same pattern (Duncan 2007:4.6.4.2).

As stated previously (see Section 3.2.8.1.2), the White Bluffs Road traverses the 200-West Area. It was originally used as an American Indian trail connecting an important water source, Rattlesnake Springs, with a favorite river crossing on the Columbia River at White Bluffs. White Bluffs Road was an important transportation route during mining, cattle ranching, and settlement eras in the Washington Territory. It played a role in European-American immigration, development, agriculture, and Hanford operations, and thus is of historic importance (Chatters and Cadoret 1990:17; Neitzel 2005:4.113). The survey conducted during 2000 on White Bluffs Road recorded an additional 54 historic isolated finds and two precontact isolated finds, as well as six dump features (Duncan 2007:4.130).

The only historic artifacts more than 50 years old that were found in the 200-East Area are a hole-in-top can and a flat-topped crimped can. These artifacts were found in the south-central part of the area (Chatters and Cadoret 1990:11, 13, 15, 16; Prendergast-Kennedy 2003:2). An additional site containing cans is located south of the WTP and slightly north of Route 4 South. This site consists of a small military refuse pile of cans and Coke bottles and is likely associated with the National Register–eligible anti-aircraft artillery site located about 400 meters (1,312 feet) south of Route 4 South. This site is considered a noncontributing feature associated with the anti-aircraft artillery site and thus not eligible for listing in the National Register (Prendergast-Kennedy 2003:2).

A historic property inventory has been completed for 72 buildings and structures in the 200 Areas. Of that number, 58 have been deemed eligible for National Register listing as contributing properties within the historic district and thus recommended for mitigation. Included are the 234-5Z Plutonium Finishing Plant, 236-Z Plutonium Reclamation Facility, 242-Z Water Treatment Facility, 231-Z Plutonium Metallurgical Laboratory, 225-B Encapsulation Building, 221-T Canyon (T Plant) Building, 202-A PUREX Building, 202-S REDOX (Reduction-Oxidation) Plant, 212-N Lag Storage Facility, 282-E Pumphouse and Reservoir Building, 283-E Water Filtration Plant, and 284-W Power House and Steam Plant. The 232-Z Waste Incinerator Facility and the 233-S Plutonium Concentration Building are also eligible for the National Register and, along with the 221-T Plant, have been documented to Historic American Engineering Record Standards. The 233-S building was recently demolished. As required by a programmatic agreement with the Advisory Council on Historic Preservation and the Washington State Historic Preservation Office, DOE assessed the contents of the historic buildings and structures within the 200 Areas, and identified and tagged artifacts with interpretive and/or educational value as exhibits within local, state, or national museums (DOE 1996b:8).

An additional feature of historic importance located to the west of the 200-East Area is a small portion of one of the Hanford Atmospheric Dispersion Test Facility arc roads. This portion of the road was determined to be a contributing property within the Manhattan Project and Cold War Era Historic District and was recommended for individual documentation. A Historic Property Inventory Form was completed, and numerous artifacts were identified as having interpretive or educational value in potential exhibits. A selected, representative number of these artifacts were removed and added to the curated Hanford collection (Prendergast-Kennedy 2003:2).

3.2.8.2.3 400 Area Description

Most of the 400 Area has been so altered by construction activities that archaeologists surveying the site during 1978 were able to find only 122 hectares (300 acres) that were undisturbed (Duncan 2007:4.133). In 2002 the Hanford Cultural Resources Laboratory of Pacific Northwest National Laboratory conducted a cultural resource review for deactivation and decommissioning of FFTF within the 400 Area at Hanford (Prendergast 2002). A historic properties survey conducted as part of the review included a literature and records search for the Area of Potential Effect. Six facilities within FFTF were determined to be eligible for National Register listing under criterion A—i.e., they are contributing properties recommended for mitigation within the Hanford Site Manhattan Project and Cold War Era Historic District. The six facilities include the 405 FFTF Reactor Containment Building, the 436 Training Facility, the 4621-W Auxiliary Equipment Facility, the 4703 FFTF Control Building, the 4710 Operation Support Building and, the 4790 Patrol Headquarters. Selection of these six properties followed from a programmatic agreement between DOE, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office (DOE 1996b). Both Historic Property Inventory Forms and Expanded Historic Property Inventory Forms were completed for these facilities (Duncan 2007:4.133).

In addition to these 6 facilities, 11 additional facilities within FFTF are eligible for inclusion in the National Register as contributing properties within the Hanford Site Manhattan Project and Cold War Era Historic District, and for these no individual documentation is required. These 11 facilities include the 403 Fuel Storage Facility, 408 A/B/C Dump Heat Exchangers, 409 A/B Closed Loop Dump Heat Exchangers, 437 Maintenance and Storage Facility, 451-A Substation, 481 Pump House, 481-A Pump House, 491 E/S/W Heat Transport Buildings, 4621-E Auxiliary Equipment Building East, 4701-Guard House, and 4717 Reactor Service Building (Prendergast 2002).

An additional 16 facilities within FFTF are noncontributing properties and thus not eligible for the National Register. They are the 480-A Well Pump House, 480-B Well Pump House, 480-D Well Pump House, 440 90-Day Pad, 432-A Rigging Shed, 482-A Water Storage Tank T-58, 482-B Water Storage

Tank T-87, 482-C Water Storage Tank T-330, 484 Incontainment Chilled Water Building, 4713-A Carpenter Shop, 4713-B Maintenance Shop, 4713-C Warehouse, 4713-D Manipulator Repair Shop, 4716 Rigging Loft, 4721 Turbine Generator, and 4608-B Process Sewer Building (Prendergast 2002).

In December 2002 the Hanford Cultural Resources Laboratory was contracted by the DOE Richland Operations Office (DOE-RL), under a Request for Cultural Resources Review, to prepare a curation management plan for the deactivation and decommissioning of FFTF. The purpose of the plan was to ensure the project is in compliance with the requirements of the National Historic Preservation Act of 1966 (as amended) and the programmatic agreement regarding the maintenance, deactivation, alteration, and demolition of the built environment at Hanford (Harvey 2002).

The Hanford Cultural Resources Laboratory conducted walkthroughs and prepared written and photographic documentation of the five buildings (405, 436, 4621-W, 4703, and 4710) inside the 400 Area Property Protected Area that were identified as eligible for inclusion in the National Register under criterion A using either a Historic Property Inventory Form or an Expanded Historic Property Inventory Form. Given the possible occurrence of significant artifacts, the Hanford Cultural Resources Laboratory also conducted walkthroughs of the 16 contributing properties for which no individual documentation was required. In total, 30 artifacts were identified and tagged in 8 of the 21 historic buildings (405, 4703, 436, 403, 4621-E, 4621-W, 4710, and 4701-A) and 1 of the nonhistoric buildings (4732-C). Included were industrial equipment and machinery, photographs and graphs, publications, control room panels, and models. Dimensions of the artifacts were taken with a view to assessing storage and curation needs. Issues concerning the eventual storage and curation of these artifacts are not yet resolved (Harvey 2002).

A curation management plan was submitted to the State of Washington's Office of Archaeology and Historic Preservation for review and concurrence. In a response dated February 26, 2003, the Deputy State Historic Preservation Officer reported concurrence with the plan's findings and conclusions and support of its recommendations as to interpretation, storage, and curation of the artifacts at FFTF. The Deputy State Historic Preservation Officer did express concern, however, over the levels of contamination at FFTF and in that connection raised the possibility that none of the historic artifacts would be preserved in light of contamination found at FFTF (Griffith 2003).

3.2.8.2.4 Borrow Area C Description

Survey results and geological data on Borrow Area C indicate no-to-low potential of the presence of historic subsurface cultural deposits (PNNL 2007).

3.2.8.3 American Indian Interests

3.2.8.3.1 General Site Description

In prehistoric and early historic times, American Indians of various tribal affiliations heavily populated the Hanford Reach, and some of their descendants still live in the region. Present-day tribal members retain traditional secular and religious ties to the region, and many have knowledge of the ceremonies and lifeways of their culture. The Washani, or Seven Drums religion, which has ancient roots, is still practiced by many American Indians. Native plant and animal foods, some of which can be found at Hanford, are used in ceremonies performed by tribal members (DOE 2000a:3-125).

Under separate treaties signed in 1855, a number of regional American Indian tribes ceded lands that included the present area of Hanford to the United States. Under the treaties, the tribes reserved the right to fish at usual and accustomed places in common with the citizens of the territory. They also retained the privilege of hunting, gathering roots and berries, and pasturing horses and cattle upon open and unclaimed

land. However, it is the position of DOE that Hanford, like other ceded lands that were settled or used for specific purposes, is not open and unoccupied land. All of these tribes are active participants in decisions regarding Hanford and have expressed concerns about hunting, fishing, pasture rights, and access to plant and animal communities and important sites. American Indian TCPs within Hanford include, but are not limited to, various archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant-gathering areas, holy lands, landmarks, places important in Indian history, places of persistence and resistance, and "landscapes of the heart" (Duncan 2007:4.120). Culturally important geographic features include Rattlesnake Mountain, Gable Mountain, Gable Butte, Coyote Rapids, and the White Bluffs portion of the Columbia River.

3.2.8.3.2 200 Areas Description

As noted above (see Section 3.2.8.1.2), White Bluffs Road, which was originally used as an American Indian trail, traverses the 200-West Area. In addition, two cryptocrystalline flakes and a cryptocrystalline silica base of a projectile point were found in or near the 200 Areas (Prendergast-Kennedy 2003:2). Many sites used for hunting and religious activities lie just to the north of the 200 Areas on Gable Mountain and Gable Butte. These sites are associated with the Gable Mountain/Gable Butte Cultural District (Duncan 2007:4.130).

3.2.8.3.3 400 Area Description

The 400 Area is not known to contain any American Indian areas of interest (PNNL 2007). The area is visible from State Route 240 and from three promontories of cultural and religious significance to area tribes: Rattlesnake Mountain to the southwest, Gable Mountain to the north, and Gable Butte to the northwest.

3.2.8.3.4 Borrow Area C Description

Borrow Area C is designated Conservation (Mining) under the *Hanford Comprehensive Land-Use Plan EIS* and subsequent supplement analysis (DOE 1999a:3-4, 3-18, 2008a) and RODs (64 FR 61615, 73 FR 55824). Although limited, managed mining can occur within such areas, they are reserved for the management and protection of archaeological, cultural, ecological, and natural resources.

3.2.8.4 Paleontological Resources

3.2.8.4.1 General Site Description

Remains from the Pliocene and Pleistocene ages have been identified at Hanford. The Upper Ringold Formation dates to the late Pliocene age and contains fish, reptile, amphibian, and mammal fossil remains. Late Pleistocene Touchet Beds have yielded mammoth bones. These beds are composed of fluvial sediments deposited along the ridge slopes that surround Hanford (DOE 2000a:3-126).

3.2.8.4.2 200 Areas Description

No paleontological resources have been identified in the 200 Areas (Schinner 2003).

3.2.8.4.3 400 Area Description

No paleontological resources have been reported in the 400 Area. Late Pleistocene Touchet beds, which have yielded mammoth bones, are found at distances greater than 5 kilometers (3.1 miles) from the 400 Area (DOE 2000a:3-127).

3.2.8.4.4 Borrow Area C Description

No paleontological resources have been reported in Borrow Area C (PNNL 2007).

3.2.9 Socioeconomics

This section describes socioeconomic variables associated with community growth and development within the Hanford ROI that could potentially be affected, directly or indirectly, by changes at Hanford. Included are economic characteristics, the region's demography, housing and community services, and local transportation.

Hanford and the communities that support it can be described as a dynamic socioeconomic system. The communities provide the people, goods, and services required by Hanford operations. Hanford, in turn, creates the demand for people, goods, and services and pays for them in the form of wages, salaries, benefits, and payments for goods and services. Effective community support of Hanford's demands depends on the communities' ability to respond to changing environmental, social, economic, and demographic conditions.

The areas in which Hanford employees and their families reside, spend their incomes, and use their benefits, thereby affecting the economic conditions of the region, define the Hanford socioeconomic ROI. This ROI encompasses Benton and Franklin Counties, Washington, which coincides with the statistical boundaries of the Tri-Cities (Richland, Pasco, and Kennewick) Metropolitan Statistical Area. According to employee residence records from April 2007, over 90 percent of DOE contract employees of Hanford live in Benton and Franklin Counties. Approximately 73 percent reside in Richland, Pasco, or Kennewick—more than 36 percent in Richland, 11 percent in Pasco, and 25 percent in Kennewick. Residents of other areas of Benton and Franklin Counties, including West Richland, Benton City, and Prosser, account for about 17 percent of total DOE contractor employment (Duncan 2007).

3.2.9.1 Regional Economic Characteristics

In fiscal year 2006 Hanford employed an average of 9,759 persons, approximately 11 percent of the civilian labor force in the ROI (Duncan 2007). For each full-time person employed at Hanford, approximately 0.75 full-time job was added to the local economy (Perteet, Thomas/Lane, and SCM 2001), resulting in creation of an estimated 7,300 additional full-time jobs. This total employment of 17,000 persons (Hanford employment plus indirect employment) was equal to approximately 15 percent of the civilian labor force in the ROI.

In 2006, the civilian labor force in the ROI reached 111,880. The annual unemployment average in the regional economic area at that time was 6.1 percent, higher than the annual average of 5.0 percent in Washington State (WSESD 2007).

In general, three major sectors of employment have been the principal driving forces of the economy since the early 1970s: DOE and its contractors operating Hanford, Energy Northwest (formerly the Washington Public Power Supply System), and the agricultural community. Three other components can also be readily identified as contributors to the economic base of the Tri-Cities area. The first, loosely termed "other major employers," includes the five major non-Hanford employers in the region; the second is the tourism industry; and the third, the local purchasing power of retired former employees (Duncan 2007).

3.2.9.2 Demographic Characteristics

The demographic profile of the population from the year 2000 U.S. census is presented in Table 3–9. In that year the population of the ROI was 191,822. This figure represented an increase over

the preceding group of 27.9 percent, as opposed to a 21.1 percent increase for the state of Washington (Census 2007a). Self-designated minority individuals constituted 27.1 percent of the total population. The largest group of this minority population was Hispanic or Latino.

Table 3–9. Demographic Profile of Populations in the Hanford Site Socioeconomic Region of Influence, 2000

Population Group	Benton County		Franklin County		Region of Influence	
	Population	Percentage of Total	Population	Percentage of Total	Population	Percentage of Total
Nonminority						
White alone	116,457	81.7	23,470	47.6	139,927	72.9
Minority						
Black or African American[a]	1,319	0.9	1,230	2.5	2,549	1.3
American Indian and Alaska Native[a]	1,165	0.8	362	0.7	1,527	0.8
Asian[a]	3,134	2.2	800	1.6	3,934	2.1
Native Hawaiian and other Pacific Islander[a]	163	0.1	57	0.1	220	0.1
Some other race[a]	9,986	7.0	14,300	29.0	24,286	12.7
Two or more races[a]	3,829	2.7	2,045	4.1	5,874	3.1
White Hispanic	6,422	4.5	7,083	14.4	13,505	7.0
Total minority	**26,018**	**18.3**	**25,877**	**52.4**	**51,895**	**27.1**
Total	**142,475**		**49,347**		**191,822**	

[a] Includes individuals who identified themselves as Hispanic or Latino.

Source: Census 2007a.

According to income information from the 2000 census (see Table 3–10), the median annual household income for 1999 in Benton County was slightly higher than that for the state of Washington, while Franklin County's was approximately $7,000 lower than that for the state. Also, in 1999, only 10.3 percent of the population in Benton County were below the official poverty level, while 19.2 percent of the population of Franklin County were below that level (Census 2007b).

Table 3–10. Income Information for the Hanford Site Region of Influence

Year 1999	Benton County	Franklin County	Washington State
Median household income	$47,044	$38,991	$45,776
Percent of persons below the poverty level	10.3	19.2	10.6

Source: Census 2007b.

3.2.9.3 Housing and Community Services

Table 3–11 presents information on housing availability, public education, and community health-care services in the ROI. In 2000 there were 72,047 housing units in the two-county area, of which 67,706 were occupied. The median value of owner-occupied units was $111,200 in Benton County, which was higher than in Franklin County. The vacancy rate was lowest in Benton County (5.5 percent) and highest in Franklin County (7.7 percent). In 2000 there were an estimated 10,226 apartments in the Tri-Cities, with a vacancy rate of 4.3 percent and approximately 440 available units. This vacancy rate rose to a state high of 9.8 percent in the fall of 2006 (WCRER 2006).

Table 3–11. Housing and Community Services in the Hanford Site Region of Influence

Assessment	County		Region of Influence
	Benton	Franklin	
Housing, 2000[a]			
Total units	55,963	16,084	72,047
Occupied housing units	52,866	14,840	67,706
Vacant units	3,097	1,244	4,341
Vacancy rate (percent)	5.5	7.7	6.0
Median value[b]	$111,200	$95,200	N/A
Public Education, 2005[c]			
Total enrollment	30,006	13,163	43,169
Student-to-teacher ratio	19.7	18.4	19.3
Community Health Care, 2005[d]			
Hospitals	4	1	5
Hospital beds per 1,000 persons	2.1	1.5	1.9
Physicians per 1,000 persons[e]	2.4	1.0	2.0

[a] Census 2007a, 2007b.
[b] Represents median value of all owner-occupied housing units.
[c] USDE 2007.
[d] WSHA 2007.
[e] AMA 2005.
Key: N/A=not applicable.

Community services include public education and health care (hospitals, hospital beds, and doctors). In the 2004–2005 school year, 10 school districts provided public education in the ROI, with a total enrollment of 43,169 students. During that time, the average Hanford region public school student-to-teacher ratio was 19.3 to 1, while the state public school student-to-teacher ratio was 19.2 to 1 (USDE 2007).

There are five hospitals within the ROI, including Kadlec Medical Center, Kennewick General Hospital, Lourdes Counseling Center–Richland, Prosser Memorial Hospital in Benton County, and Lourdes Medical Center in Franklin County. The bed-to-person ratio in Benton and Franklin County hospitals (using the 2005 population) averaged 1.9 beds to 1,000 people (WSHA 2007).

A total of 448 physicians serve the ROI. The average physician-to-population ratio (using the 2005 population) is 2.0 physicians to 1,000 people (AMA 2005). Benton and Franklin Counties are designated by the Federal Government as health professional shortage areas. This designation can be used to access Federal dollars for improved access to health care in underserved areas of Washington State. Franklin County has already been designated as a medically underserved area (WSDOH 2007).

3.2.9.4 Local Transportation

The transportation network in the vicinity of Hanford includes two interstate highways: Interstates 82 and 182. Interstate 82 is 8 kilometers (5 miles) south-southwest of Hanford. Interstate 182, a 24-kilometer-long (15-mile-long) urban connector route 8 kilometers (5 miles) south-southeast of the site, provides an east-west corridor linking Interstate 82 to the Tri-Cities area. Interstate 82 also serves as a primary link between Hanford and Interstates 90 and 84. Interstate 90, north of the site, is the major link to Seattle and Spokane and extends to the east coast. Interstate 84, south of Hanford in Oregon, is a major corridor leading to Portland, Oregon. State Route 224 (Van Giesen Street), also south of the site, serves as a 16-kilometer (10-mile) link between Interstate 82 and State Route 240. State Route 24 enters the site

from the west, continues eastward across the northernmost portion of the site, and intersects State Route 17 approximately 24 kilometers (15 miles) east of the site boundary. State Route 17 is a north-south route that links Interstate 90 to the Tri-Cities and joins U.S. Route 395 before continuing south through the Tri-Cities. U.S. Route 395 North also provides direct access to Interstate 90. State Routes 240 and 24 traverse Hanford and are maintained by Washington State (Duncan 2007:4.151).

Access to Hanford is via three main routes: Hanford Route 4 South from Stevens Drive or George Washington Way in the city of Richland, Route 10 from State Route 240 near its intersection with State Route 225, or Route 11A from State Route 240 near its intersection with State Route 24 (see Figure 3–20). The primary commute to Hanford requires most employees to travel through the city of Richland by way of State Route 240 (Bypass Highway) or George Washington Way. These two roadways have an average daily traffic volume of between 30,000 and 40,000 vehicles. To help accommodate the high volume of traffic, the Washington State Department of Transportation (WSDOT) completed the expansion of the Bypass Highway from four to six lanes in 2002. Similarly, the City of Richland made major capacity improvements on Stevens Drive north of State Route 240. The average daily traffic volume across State Route 240 Yakima River Causeway was 55,000 in 2005, up from 47,000 in 1994 (BFCOG 2006:2-2–2-4; Duncan 2007:4.152). In 2007, WSDOT completed the expansion of State Route 240 from Interstate 182 south to the Columbia Center Interchange from four to eight lanes, as well as the expansion of the Interstate 182 overcrossing extending from George Washington Way to southbound State Route 240 from one to two lanes. These much-needed capacity improvements should substantially alleviate congestion during the daily commute (Duncan 2007:4.152). Hanford's onsite road network is further described in Section 3.2.2.1.

Private vehicles account for 91 percent of the person-trips to Hanford based on a survey of commuters using either the State Route 240 Bypass Highway or George Washington Way. The remaining person-trips are by forms of high-occupancy vehicles (mostly vanpools). Of the 91 percent of person-trips to Hanford by private vehicles, only 3 percent involve carpools; the remaining 88 percent involve single-occupancy vehicles (BFCOG 2006:2-4; Duncan 2007:4.152). As the *Regional Transportation Plan for the Tri-Cities Metropolitan Area and the Benton-Franklin-Walla Walla RTPO* (BFCOG 2006:E−2) assumed 13,531 employees working at Hanford in 2005, it may be concluded that 11,907 single-occupancy vehicle trips were made daily.

A Washington State law of March 2006 requires urban growth areas containing a state highway segment exceeding a threshold of 100 person-hours of daily delay per mile during the peak period from 6:00 A.M. to 9:00 A.M. on weekdays to implement commute trip reduction programs. The intent is to reduce the time of commutes by workers from their homes to major worksites during that peak period. State highway segments exceeding the daily delay threshold in the Tri-Cities include (1) the State Route 240 northbound single-lane flyover ramp from the Yakima River Bridge to Interstate 182 westbound; (2) the U.S. Route 395 northbound off-ramp loop to State Route 240 westbound (interchange south of Blue Bridge); and (3) the Columbia Drive westbound off-ramp loop to U.S. Route 395 southbound (interchange south of Blue Bridge).

The WSDOT was required to establish rules for commute trip reduction plans and implementation procedures by March 1, 2007. Benton and Franklin Counties and the cities of Kennewick, Pasco, Richland, and West Richland must adopt commute trip reduction plans and related ordinances for major employers. The Benton County plan and ordinance must include the DOE Hanford Reservation. Construction worksites are excluded under the law, provided the construction duration is less than 2 years. The ongoing construction of the WTP would not likely be exempt (BFCOG 2006:2–5, 2–6).

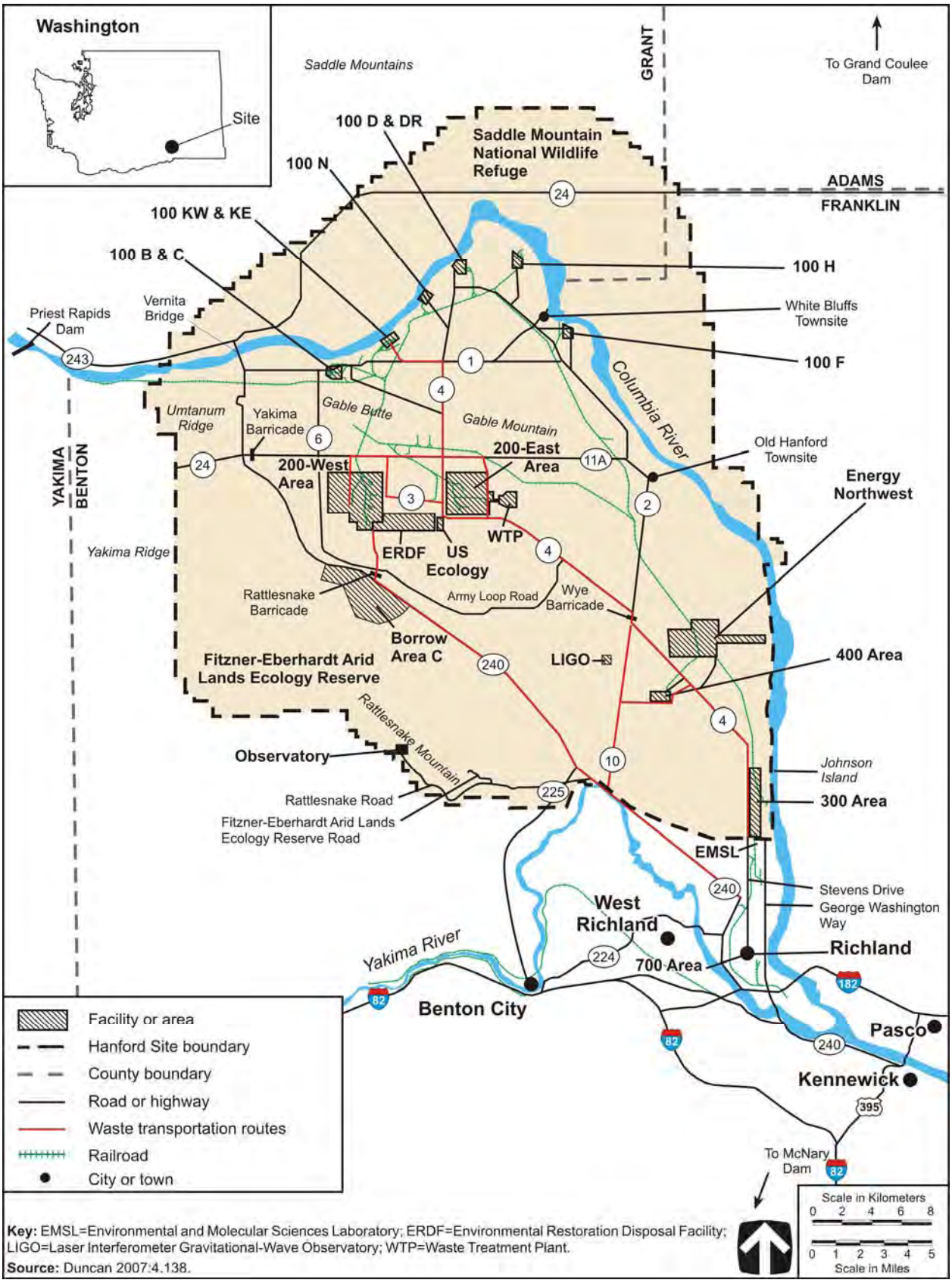


Figure 3–20. Transportation Routes on and Near the Hanford Site

The local intercity transit system, Ben Franklin Transit, provides public transit service throughout the Tri-Cities. The company's rideshare/vanpool program includes a fleet of 200 vans that operate in 14 cities, six counties, and two states, and services major worksites where riders share the cost of operating the vans. Its services also include ride-matching for individuals seeking private vanpools or carpools (BFCOG 2006:2-5, 2-7, 4-26–4-28). Ben Franklin Transit currently has 24 fixed routes, including one between Richland and the Hanford 300 Area. Its vanpools serve eight locations across Hanford and Energy Northwest. Early in 2005, 95 vans were commuting to the WTP; subsequent construction layoffs, however, have reduced that fleet to about 70 vans. Transit service availability notwithstanding, ridesharing remains an underutilized resource for reducing congestion, particularly along the routes of the Hanford commute in the Tri-Cities area.

As stated in Section 3.2.2.1.1, the Hanford rail system originally consisted of approximately 209 kilometers (130 miles) of track connecting to the Union Pacific commercial track at the Richland Junction and to a now-abandoned Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way near Vernita Bridge. In October 1998, 26 kilometers (16 miles) of track from Columbia Center to Horn Rapids Road were transferred to the Port of Benton and are currently operated by the Tri-City and Olympia Railroad for the Port of Benton (Duncan 2007:4.150). Along with the rail line, the port received from DOE about 304 hectares (750 acres) of land and numerous buildings encompassing the Richland North Area for economic development purposes. The area is now called the Port of Benton Manufacturing Mall. The Tri-City and Olympia Railroad operates from Kennewick through Richland to the manufacturing mall and also services the city of Richland's Horn Rapids Industrial Site via a spur line built in 1999 (BFCOG 2006:4-34).

The Tri-Cities serve as a regional transportation and distribution center with major land, river, and air connections. The Burlington Northern Santa Fe Railroad main line from Vancouver to Spokane via Pasco is traversed by 45 to 55 through-freight movements daily. The total tonnage reflects the large number of export grain trains that operate via this route to water terminals at Portland, Kalama, and Longview. This line operates at or near its maximum practical capacity. Burlington Northern Santa Fe also operates tracks from the Tri-Cities to Auburn via Yakima, Ellensburg, and Stampede Pass. This line has 6 to 10 freight movements daily. The Union Pacific Railroad also operates a line from Portland to Spokane that enters Walla Walla County south of Wallula Junction, then passes along the east side of the Columbia and Snake Rivers, exiting the county at Lyons Ferry (BFCOG 2006:4-33, 4-34).

Passenger rail service is provided by Amtrak from the Pasco Intermodal Depot. Amtrak operates daily on the Burlington Northern Santa Fe tracks from Vancouver through Pasco to Spokane. Similar service is provided between Seattle and Spokane, where the two trains link to continue toward Chicago (BFCOG 2006:4-34).

The Columbia-Snake River system, with its government locks at each of eight dams, affords 748 kilometers (465 miles) of water transportation from Astoria, Oregon, to Lewiston, Idaho. The system allows the three barge lines serving the region to transport commodities to and from locations throughout the world via the ports of Kalama, Longview, Vancouver, and Portland (the Nation's largest wheat export portal). Over 9 million metric tons of cargo move on this water highway every year. Docking facilities at the Ports of Benton, Kennewick, and Pasco play important roles in this regional system. Closer to Hanford, the Port of Benton has over 1,830 meters (6,000 feet) of Columbia River frontage zoned for heavy industrial use at the Richland Technology and Business Campus on the west bank of the Columbia River in North Richland. The dock facilities near the north end of the site are used to unload construction materials and heavy equipment, much of it destined for Hanford, as well as other cargoes bound for North Richland (BFCOG 2006:4-35, 4-37).

Daily air passenger and freight services connect the area with most major cities through the Tri-Cities Airport in Pasco. This modern commercial airport links the Tri-Cities to major hubs. Scheduled air

service includes Delta Connection service to Salt Lake City, Horizon Air service to Seattle and Portland, United Express service to Denver, and Allegiant Air service to Las Vegas (BFCOG 2006:4-31). Either of two runways—a main runway and a minor runway—is available for use as dictated by crosswinds. The main runway is equipped for precision instrumentation landings and takeoffs. Each runway can accommodate landings and takeoffs by medium-range commercial aircraft (Duncan 2007:4.150, 4.151). The immediate area is also served by Richland Airport, which lies northwest of the Richland central business district and adjacent to the Richland Bypass (State Route 40). Owned by the Port of Benton, this general aviation airport has two paved runways and a localizer instrument system (BFCOG 2006:4-31).

3.2.10 Existing Human Health Risk

Environmental health risks of the activities at Hanford include the effects of acute and chronic exposures to ionizing radiation and hazardous chemicals. Ongoing programs to monitor releases and evaluate their potential health impacts are conducted at Hanford. Additionally, studies have been conducted of the pathways and potential risks of radionuclide and toxic chemical releases during past operations at Hanford. These studies focused on the impacts of the releases in terms of risks of cancer incidence and mortality to site workers, the general public, and the maximally exposed individual (MEI). Results of the current assessments and historic studies indicate little risk of enhanced carcinogenesis; exposures to site radionuclide releases tend to be far lower than those to natural background radiation, and chemical exposures are well within stipulated guidelines. Yet in keeping with the goal of optimum protection of vulnerable populations, DOE maintains a comprehensive emergency management program that features exemplary hazard-specific plans, procedures, and controls (DOE Order 151.1C).

3.2.10.1 Radiation Exposure and Risk

3.2.10.1.1 General Site Description

Major sources and average levels of background radiation exposure to individuals in the Hanford vicinity are shown in Table 3–12. Average annual background radiation doses to individuals are expected to remain fairly constant over the time period of the proposed actions. The total dose to the population, in terms of person-rem,[1] changes with the population size. Background radiation doses, as identified in Table 3–12, are unrelated to Hanford operations.

[1] The unit of collective radiation dose to a given population; it is derived from the sum of the doses estimated to be received by members of the population.

Table 3–12. Sources of Radiation Exposure of Individuals in the Hanford Site Vicinity Unrelated to Hanford Site Operations

Source	Effective Dose Equivalent (millirem per year)[a]
Natural Background Radiation	
Cosmic radiation	30
External terrestrial radiation	30
Internal radiation	40
Radon in homes (inhaled)	200
Other Background Radiation	
Diagnostic x-rays and nuclear medicine	53
Consumer and industrial products	10
Other (e.g., air travel, weapons test fallout)	Less than or equal to 2
Total	**365**

[a] Averages for the United States.

Source: Poston et al. 2007:10.146.

Releases of radionuclides to the environment from Hanford operations provide another source of radiation exposure to individuals in the vicinity of Hanford. Types and quantities of radionuclides released from Hanford operations in 2006 are listed in the *Hanford Site Environmental Report* (Poston et al. 2007:10.11, 10.27). Doses to the public resulting from these releases are presented in Table 3–13. These doses fall within the limits established in DOE Order 5400.5 and are much lower than those due to background radiation.

Table 3–13. Radiation Doses to the Public from Hanford Site Normal Operations in 2005 (Total Effective Dose Equivalent)

Members of the Public	Atmospheric Releases[a]		Liquid Releases		Total	
	Standard[b]	Estimated	Standard[b]	Estimated[c]	Standard[b]	Estimated[d]
Maximally exposed individual (millirem)	10	0.063	4	0.0047	100	0.068
Population within 80 kilometers (person-rem)[e]	None	0.51	None	0.13	None	0.65
Average individual within 80 kilometers (millirem)[f]	None	0.001	None	0.0003	None	0.0013

[a] Includes direct radiation dose from radioactive material released to the atmosphere and subsequently deposited on surfaces.

[b] The standards for individuals are given in DOE Order 5400.5. As discussed in that order, the 10-millirem-per-year limit for airborne emissions is established by the Clean Air Act; the 4-millirem-per-year limit established by the Safe Drinking Water Act applies to only the drinking water pathway.

[c] Includes the drinking water dose.

[d] Total may not equal the sum of the contributions due to rounding.

[e] The projected population of about 486,000 is based on the 2000 census.

[f] Values were obtained by dividing the population dose by the number of people living within 80 kilometers of the site.

Note: To convert kilometers to miles, multiply by 0.6214.

Source: Poston et al. 2007:10.144, 10.145.

From a risk coefficient of 600 cancer deaths per 1 million person-rem (0.0006 latent cancer fatalities [LCFs] per person-rem) to the public (see Appendix K**,** Section K.1.1.3), the risk of an LCF to the MEI due to radiological releases from Hanford operations in 2006 was estimated to be 4.1×10^{-8}. That is, the estimated probability of this person dying of cancer at some time in the future as a result of a radiation

dose associated with emissions from 1 year of Hanford operations is about 1 in 25 million. Depending on the type of cancer, it takes a few years to several decades from the time of exposure for a radiation-induced cancer to manifest itself. The hypothetical MEI is a person whose place of residence and lifestyle make it unlikely that any other member of the public would receive a higher radiological dose from Hanford releases. This person is assumed to be exposed to radionuclides in the air and on the ground from Hanford emissions, ingest locally grown food irrigated with water from the Columbia River downstream from Hanford, ingest fish from the Columbia River, and use the river for recreation.

Using the same risk coefficient, the calculated risk value of 3.9×10^{-4} implies no excess LCFs are expected in the population of 486,000 living within 80 kilometers (50 miles) of Hanford from normal operations in 2006. To place this number in perspective, it may be compared with the number of cancer fatalities expected in the same population from all causes. The mortality rate from cancer for the entire U.S. population in 2000 was about 200 deaths per 100,000 people, or 0.2 percent per year (Weir et al. 2003:Figure 1). At that rate, expected fatalities from all cancers in the population living within 80 kilometers (50 miles) of Hanford during 2006 would be 972. This figure is much higher than the 3.9×10^{-4} LCFs calculated to result from Hanford operations in 2006.

Hanford workers receive the same dose as the general public from background radiation, but they receive an additional dose from working in and near facilities with radioactive materials. The average dose to the individual worker and the cumulative dose to all workers at Hanford from operations in 2006 are presented in Table 3–14. Using a risk coefficient of 0.0006 LCFs per person-rem among workers (see Appendix K, Section K.1.1.3), the projected number of LCFs among Hanford workers from normal operations in 2006 was 0.08.

Table 3–14. Radiation Doses to Workers from Hanford Site Normal Operations in 2006 (Total Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard[a]	Actual
Average radiation worker (millirem)	5,000	70
Total of all radiation workers (person-rem)[b]	None	132.9

[a] No standard is specified for an "average radiation worker"; however, the maximum dose to a worker is limited as follows: The dose limit for an individual worker is 5,000 millirem per year (10 CFR 835). However, the U.S. Department of Energy's (DOE's) goal is to maintain radiological exposure as low as is reasonably achievable. DOE has therefore established the Administrative Control Level of 2,000 millirem per year; the site contractor sets facility administrative control levels below the DOE level, with 500 millirem per year considered a reasonable goal for trained radiological workers and 100 millirem per year for nonradiological workers.

[b] There were 1,911 workers with measurable doses in 2006.

Note: Total radiation worker dose presented in the table differs from that calculated from data shown due to rounding.

Source: 10 CFR 835.202; DOE Standard 1098–99; DOE 2007a:3-10; Fluor Hanford 2006b:2.

A number of people work inside the Hanford boundary yet outside access-controlled areas. Considered members of the public, these people are associated with the Columbia Generating Station, operated by Energy Northwest, and with LIGO, operated by the University of California. The calculated radiological dose to the MEI at LIGO in 2006 was 0.0028 millirem. This dose, attributed to Hanford stack emissions and assuming full-time occupancy of the facility; is well below the 10-millirem-per-year limit for air emissions established by the Clean Air Act (Poston et al. 2007:10-147).

Members of the public may also be exposed to radioactivity through the consumption of wildlife that has access to Hanford. The only Hanford-generated radionuclides detected in routinely collected wildlife samples were in suckers sampled in 2006 from the Columbia River near the 300-Area. According to an estimation based on these samples, a member of the public would receive a radiological dose of about 0.0002 millirem for every 1 kilogram (2.2 pounds) of suckers consumed (Poston et al. 2007:10-148).

There are several non-DOE-related sources of radiation exposure at or near Hanford. These sources include the LLW disposal facility operated by US Ecology, Inc.; the Columbia Generating Station, a nuclear fuel production plant operated by AREVA NP, a commercial LLW treatment facility operated near the site by Pacific EcoSolutions (now Perma-Fix Northwest, Inc.), and a commercial decontamination facility operated near the site by PN Services. The radiation dose to a member of the public from these sources in 2006 was conservatively estimated at approximately 0.02 millirem. Therefore, the combined annual dose to a member of the public in 2006 from Hanford area DOE and non-DOE sources was well below any regulatory dose limit (Poston et al. 2007:10-149).

A more-detailed presentation of the radiation environment, including background exposures and radiological releases and doses, is presented in the *Hanford Site Environmental Report* (Poston et al. 2007). The concentrations of radioactivity in various environmental media (including air, water, and soil) in the site region (on and off site) are also presented in that report.

3.2.10.1.2 200 Areas Description

External radiation doses on and near Hanford are measured and reported by the site environmental surveillance program. In 2006 the mean annual external dose in the 200 Areas was about 110 millirem—about 40 millirem higher than the historic average of the doses measured at offsite (distant) control locations (Poston et al. 2006:10.166; 2007:10.136). This onsite external dose, which affects workers only, is well below the administrative limit identified in Table 3–14, footnote "a." Columbia River water is used as a source of drinking water by workers in the 200 Areas. Annual average radionuclide concentrations measured in the drinking water during 2006 were below applicable standards (40 CFR 141; Poston et al. 2007:10-179).

3.2.10.1.3 400 Area Description

In 2006 the mean annual external dose in the 400 Area was about 81 millirem, about 10 millirem higher than the average of doses measured at offsite (distant) control locations (Poston et al. 2006:10.166; 2007:10.136). This onsite external dose, which affects workers only, is well below the administrative limit identified in Table 3–14, footnote "a."

Drinking water is obtained from groundwater wells in the 400 Area and is consumed by FFTF workers. Tritium was detected in these groundwater wells at levels higher than typical background values. The measured concentrations in 2006 suggest a potential annual dose to FFTF workers of approximately 0.4 millirem, well below the EPA limit of 4 millirem per year for public drinking water supplies (Poston et al. 2007:10.148).

3.2.10.2 Chemical Environment

The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media, through which people may come in contact with hazardous chemicals (e.g., surface water during swimming, soil through direct contact, food). Hazardous chemicals can cause cancer- and non-cancer-related health effects.

3.2.10.2.1 Carcinogenic Effects

Estimation of carcinogenic health effects focuses on the probability of an individual's developing cancer over a lifetime as a result of exposure to a potential carcinogen. This probability can be expressed as an incremental or excess individual lifetime cancer risk. The risks from exposure to carcinogenic chemicals are evaluated using chemical-specific unit risk factors published by the EPA. The unit risk factor represents the estimated lifetime probability that an individual will develop cancer as a result of exposure

to a given concentration of a chemical in air. Assessment of cancer risk from chemical exposures is described in Appendix K, Section K.1.1.9.

3.2.10.2.2 Noncarcinogenic Effects

Noncarcinogenic health effects are expressed in terms of the Hazard Quotient and Hazard Index. The Hazard Quotient is the ratio between the estimated exposure to a toxic chemical and the level of exposure at which adverse health effects can be expected. Hazard Quotients for noncarcinogens are summed to obtain the Hazard Index. If the Hazard Index is less than 1, no adverse health effects are to be expected.

Adverse public health impacts may result from the inhalation of hazardous chemicals released to the atmosphere during normal Hanford operations. Risks to public health from other possible pathways, such as the ingestion of contaminated drinking water or direct contact with hazardous chemicals, are lower than those from inhalation. Administrative and design controls have been instituted to reduce hazardous chemical releases to the environment and help achieve compliance with permit requirements (e.g., air emission permits, NPDES permits). Moreover, baseline studies have been performed to estimate the highest existing offsite concentrations and the highest concentrations to which members of the public could be exposed, and these studies have been used to develop baseline air emission and other applicable standards for hazardous chemicals (see Section 3.2.4). Hazardous chemical concentrations remain in compliance with applicable guidelines and regulations. Nevertheless, the effectiveness of all controls and mitigation measures is constantly verified through routine monitoring and inspection.

Exposure pathways to Hanford workers during normal operations include the inhalation of contaminants in the workplace atmosphere and direct contact with hazardous materials. The potential for health impacts varies among facilities and workers. DOE policy requires that the workplace be as free as possible from recognized hazards—i.e., conditions likely to cause illness or physical harm. In general, workers are protected from such hazards through adherence to Occupational Safety and Health Administration and EPA limits on atmospheric and drinking water concentrations of potentially hazardous chemicals. Exposure to hazardous chemicals is also minimized by appropriate training, use of personal protective equipment, monitoring of the workplace environment, limits on the duration of exposure, and engineered and administrative controls. Monitoring and controlling hazardous chemical usage in operational processes help ensure that workplace standards are not exceeded and worker risk is minimized.

3.2.10.3 Health Effects Studies

The question of whether the population around Hanford is subject to elevated cancer incidence or cancer mortality is unresolved. Recent studies of the health effects of Hanford activities, including studies reported in prior EISs, are summarized below. Included is a summary of the results of the Hanford Environmental Dose Reconstruction (HEDR) Project, even though studies encompassed by that project do not directly address health effects. Existing studies and data suggest that cancer mortality in populations residing near Hanford is not elevated. A survey sponsored by the National Cancer Institute and published in the *Journal of the American Medical Association* (Jablon, Hrubec, and Boice 1991) detected no general increase in the risk of cancer death for people living in 107 counties close to or containing 62 nuclear facilities, including Hanford. Cancer mortality data from Benton, Franklin, and Grant Counties were used in the survey. The survey did not provide an estimate of actual exposures to ionizing radiation or hazardous chemicals, nor did it allow for identification of areas within a given county that might have increased or decreased cancer rates relative to the country as a whole. The authors of the study concluded that, if any excess cancer mortality risk were present in U.S. counties with nuclear facilities, it was too small to be detected using the methods employed.

Sixteen counties are within 80 kilometers (50 miles) of the Hanford boundary—13 counties in Washington and 3 in Oregon. Although the prevailing winds on the 200 Area plateau are from the northwest, in the direction of Franklin County, the prevailing winds at Hanford as a whole are from the south and south-southwest, toward Grant County, Washington. Therefore, Grant County and Franklin County are expected to bear the major burden of wind-borne contamination from Hanford. Cancer mortality data published by the National Cancer Institute for both white female and white male residents of all U.S. counties from 1970 to 1994 show no elevated cancer rates for white residents of Franklin or Grant County. Cancer mortality rates among white females in the 16 counties ranged from a low of 80.1 per 100,000 person-years[2] in Gilliam County, Oregon, to a high of 149.5 per 100,000 person-years in Lincoln County, Washington. Only Adams, Klickitat, and Lincoln Counties had rates higher than the national rate of 135.9 per 100,000 person-years. Cancer mortality rates among white males in the 16 counties ranged from a low of 161.9 per 100,000 person-years in Gilliam County, Oregon, to a high of 211.8 per 100,000 person-years in Morrow County, Oregon. Morrow County was in fact the only county of the 16 to have a rate higher than the national rate of 209.5 per 100,000 person-years. The data do not include estimates of human exposure to ionizing radiation or hazardous chemicals (Jablon, Hrubec, and Boice 1991).

Two studies of birth defects in Benton and Franklin Counties were published in 1988 (Sever et al. 1988a, 1988b). The studies focused on congenital malformations among infants born from 1968 to 1980. Results showed a statistically significant association between preconception exposure of the parents to ionizing radiation and neural tube defects in their infants. However, no such association could be observed in regard to other defects in the infants.

The HEDR Project, conducted in the 1980s and 1990s, focused on dose estimation rather than health effects. It featured investigation of the amounts and types of radioactive materials Hanford released from 1944 through 1972, movement of materials through the environment, and exposure of and doses to people. Of primary concern were radioactive releases to the air and to the Columbia River. As for airborne releases, the HEDR Project studies showed that more than 98 percent of the radiation doses that most people outside of Hanford's boundaries received came from iodine-131 released from December 1944 through 1957. Consumption of milk from cows and goats that grazed on pastures downwind of Hanford was the most important iodine-131 exposure pathway. The highest radiation doses, ranging from 24 to 350 rad, were to children who lived closest to Hanford from 1944 through 1951. Project studies also revealed that the largest releases of radioactive material to the Columbia River occurred from 1950 through 1971, the five most prominent contributors to dose being sodium-24, phosphorus-32, zinc-65, arsenic-76, and neptunium-239. Consumption of nonmigratory fish species was the most important exposure pathway. The maximum individual dose during this time period was estimated to be 1.4 rem (TSP 1994).

Many epidemiological studies have been carried out on Hanford workers over the years. The studies have consistently shown a statistically significant elevated risk of death from multiple myeloma associated with radiation exposure among male Hanford workers. The elevated risk was observed only among those workers with a total occupational exposure of 10 rad (approximately 10 rem) or more. Other studies also identified an elevated risk of death from pancreatic cancer, but a recent reanalysis indicated no such risk. Studies of female Hanford workers have shown an elevated risk of death from musculoskeletal system and connective tissue conditions. For a more-detailed description of the studies reviewed and their findings, as well as a discussion of the epidemiologic surveillance program implemented by DOE to monitor the health of current workers, refer to Section M.4.2 of the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a:M-224–M-230).

[2] 80.1 deaths per year per 100,000 people.

More recently, additional studies have been performed regarding Hanford mortality rates. One study completed in 2005 examined whether there are associations between occupational exposure to external ionizing radiation and mortality among Hanford workers. This study suggests that external radiation exposures of Hanford workers 55 years of age and older increases their risks of dying from lung cancer; owing to data limitations, however, the possible contributions of plutonium and smoking to this risk could not be directly estimated. Another study concluded that workers who have routine potential exposure to plutonium have lower mortality rates than other Hanford workers (NIOSH 2005).

3.2.10.4 Accident History

In the more than 15 years since weapons material production ceased at Hanford, there have been no nuclear-related accidents or accidental releases of hazardous or radioactive materials that caused injury or posed any threat to the offsite public. However, a number of incidents that had actual or potential health impacts on workers have occurred in the course of routine facility operations, decommissioning, and environmental remediation activities in and near the 200 Areas. The most notable of these was a May 1997 explosion caused by spontaneous reaction of nonradioactive chemicals left over from discontinued activities in the Plutonium Recovery Facility. Although no one was directly injured by the explosion and no radioactive materials were released to the environment (DOE 2000a:3-133), eight workers who may have been exposed to unidentified fumes later complained of symptoms that included headaches, dizziness, and an unidentified metallic taste. All were transferred to a nearby medical center where they were examined and released.

Other incidents with worker health implications over the period 2000 through 2007, as reflected in Occurrence Reporting and Processing System records (DOE 2007b, 2008b), include the following:

- Workers were potentially exposed to chromium while conducting welding operations (March 2003, October 2005, December 2006, and January 2007).
- A worker was exposed to lead while torch-cutting a pipe (August 2005).
- Workers received mild electrical shocks (January 2004, May 2005, and August 2005).
- Workers were exposed to carbon monoxide levels exceeding occupational limits at the CWC (August 2000) and WTP (February 2005).
- Two workers were exposed to plutonium and americium while performing radiological surveys in a high-contamination area at the 300 Area Remediation Project, resulting in a committed effective dose equivalent of 3 rem to one worker and 0.8 rem to the other (December 2004).
- A painter was overexposed to methylene chloride while cleaning painting equipment (October 2004).
- A worker was exposed to plutonium (an uptake of less than 0.5 millirem) at the Plutonium Finishing Plant while preparing waste for storage in a drum (July 2004).
- A worker received a 15-rem dose to an extremity from curium-244 at 244-CR vault, pit CR-002 while pulling a thermocouple (July 2004).
- A worker was potentially exposed to mercury from a manometer being removed in the 105-KE Basin (June 2004).
- Workers were exposed to unknown vapors/fumes in tank farms (March 2004).

- A worker injured an eye while manipulating metal stanchions (February 2004).
- Workers in the Plutonium Finishing Plant were exposed to toxic chemicals, including nitrobenzene (September 2002) and nitrogen oxides (March 2003).
- A worker was potentially exposed to asbestos fibers at Building 1717K (December 2002).
- Tank farm workers suffered respiratory irritation as a result of severe wind/dust following the 2000 Hanford 24 Command Fire (March 2001).
- Workers were exposed to high noise levels that exceeded the 8-hour time weighted average (March 2008).
- A worker fractured a bone in his hand while installing rebar at the Waste Treatment Plant (May 2008).

Since about 1987, exposure of tank farm workers to chemical vapors has been of concern at Hanford. The tanks are continuously vented to the atmosphere and inhalation is assumed to be the primary route of chemical exposure to workers during routine operations. Evaluations conducted at different times by the tank farms contractor, Hanford DOE officials, the Defense Nuclear Facilities Safety Board, the DOE Office of Independent Oversight and Performance Assurance, and the Office of the Inspector General have resulted in the implementation of physical (engineered) and administrative controls to reduce or eliminate the potential for worker chemical vapor exposures. The history of this issue and the actions taken to resolve it are described in Appendix K, Section K.2.1.2.3.

The most recent incident involving radiation and chemical exposures occurred in July 2007 (DOE 2007c). Approximately 322 liters (85 gallons) of highly radioactive mixed waste from tank 241-S-102 in the 200-West Area was spilled on the ground. Overpressurization of a hose in a dilution line was determined to be the cause. In the hours and days following the spill, a number of Hanford workers identified odors, experienced symptoms or health effects, or expressed concerns about their potential exposure to the waste chemicals from the spill. As of September 1, 2007, 24 workers had reported possible exposure to tank vapors resulting from the spill. The worker health impacts could be attributed to other causes, so it is unclear whether the spill directly contributed to these health effects. Because of the low concentrations and short duration of the event, overexposure or chronic health impacts are unlikely. Consequences of the tank 241-S-102 event could have been more severe if workers had been in the immediate vicinity of the spill at the time of the release, and thus had been exposed to higher radiation or chemical vapor concentrations for a longer period. The board reviewing the accident made a number of recommendations to help prevent future spills and to mitigate worker exposures through, among other things, improvement in safety programs and coordination of emergency and medical response.

In nearly all of these cases, the worker health impacts were minimal or temporary. Information concerning these and other safety-related events at Hanford and other sites is maintained in DOE's Occurrence Reporting and Processing System.

In addition to the incidents reported above, a report by the Government Accountability Project cited evidence of 45 chemical vapor exposure events that required medical attention for at least 67 workers over the period January 2002 to August 2003 (GAP 2003:11).

3.2.10.5 Emergency Preparedness

As required by DOE orders and policies, Hanford has established a comprehensive emergency management program that provides detailed, hazard-specific planning and preparedness measures to

minimize the health impacts of accidents involving loss of control over radioactive material or toxic chemicals. This emergency management program embodies the following principles:

- Identification and characterization of the hazardous substances
- Analysis of potential accidents and hazardous releases
- Prediction of consequences of the releases at various locations
- Planned response actions to minimize exposure of workers and the public to the hazard

Emergency response procedures are practiced and exercised regularly to ensure that optimum protective measures can be taken in response to most identified accident conditions and to provide the capability for flexible, effective responses to accidents that were not specifically considered in the emergency planning scenarios.

DOE-RL maintains the Hanford emergency plan and implementing procedures by which DOE and its contractors will respond in the event of an accident. DOE-RL also provides technical assistance to other Federal agencies and to state and local governments. Hanford contractors are responsible for maintaining emergency plans and response procedures for all facilities, operations, and activities under their jurisdiction and for implementing those plans and procedures during emergencies. The DOE-RL, contractor, and state and local government plans are fully coordinated and integrated. Emergency control centers have been established by DOE-RL and its contractors for the principal work areas to provide oversight and support to emergency response actions within those areas.

3.2.11 Environmental Justice

Under Executive Order 12898, DOE is responsible for identifying and addressing disproportionately high and adverse impacts on minority and low-income populations. As discussed in Appendix J, minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, or multiracial (with at least one race designated as a minority race under Council on Environmental Quality guidelines [CEQ 1997]). The Office of Management and Budget defines Hispanic or Latino as "a person of Cuban, Mexican, Puerto Rican, South or Central American or other Spanish culture or origin regardless of race"; therefore, all persons self-identified as Hispanic or Latino, regardless of race, are included in the "Hispanic or Latino" population. Persons whose incomes are below the Federal poverty threshold are designated as low-income. A community in the impacted area is designated minority or low-income if the percentage of minority or low-income persons in that area significantly exceeds the percentage of such persons in the general geographic area (defined here as the potentially affected counties and states) in which the impacted area is located. NRC guidance defines "significant" as 20 percentage points above the population of the general geographic area. Yet NRC criteria also allow for designation as a minority or low-income population if minority or low-income persons constitute more than 50 percent of the population of the impacted area (69 FR 52040). The NRC definition is used in this *TC & WM EIS*.

Council on Environmental Quality guidelines (CEQ 1997) recognize that many minority and low-income populations derive part of their sustenance from subsistence hunting, fishing, and gathering activities (sometimes for species unlike those consumed by the majority population) or depend on water supplies or other resources that are atypical or are used at different rates than they are by other groups. These differential patterns of resource use are to be identified where practical and appropriate. American Indians of various tribal affiliations live in the greater Columbia Basin, and several rely at least partly on natural resources for subsistence. For example, there is some dependence on natural resources for dietary subsistence by some members of the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Confederated Tribes and Bands of the Yakama Nation. American Indian tribes have historically lived on what is now Hanford and continue to live adjacent to the site. They fish on the

Columbia River and gather food resources near Hanford. Some tribes are also recognized to have cultural and religious ties to the site.

During preparation of this *TC & WM EIS*, risks and consequences of both normal operations and accidents were evaluated in terms of potential releases of contaminants from various candidate facilities throughout Hanford. The facilities in the 200 Areas at Hanford include STTS-East, STTS-West, and the HLW Vitrification Facility stack for the WTP facilities. Another potential release point is FFTF in the 400 Area at Hanford. In the analysis of the health impacts of normal operations and accidents, all persons living within 80 kilometers (50 miles) of these facilities were assumed to be potentially affected. For this environmental justice analysis, special emphasis was accorded minority and low-income populations shown to be at risk.

3.2.11.1 Minority Populations

3.2.11.1.1 General Site Description

Minority Populations Surrounding the Hanford Site in 2000

- Minority individuals constituted approximately 32 percent of the total population.
- Approximately 80 percent of the Minority population lived in four counties: Benton, Franklin, Grant, and Yakima.
- Hispanic or Latino individuals accounted for approximately 81 percent of the total minority population.

The area within an 80-kilometer (50-mile) radius of the candidate facilities at Hanford encompasses parts of 10 counties in two states: Adams, Benton, Franklin, Grant, Kittitas, Klickitat, Walla Walla, and Yakima Counties in Washington, and Morrow and Umatilla Counties in Oregon. Tables 3–15 and 3–16 provide, for 1990 and 2000, respectively, a breakdown of minority populations in the 10-county area and the two-state region. Over the 10-year period between 1990 and 2000, the total population of the 10-county area increased approximately 23 percent. During that decade, the total minority population in the area increased by approximately 87 percent; the number of people self-identified as Hispanic or Latino, by approximately 94 percent; and the American Indian and Alaska Native population, by approximately 24 percent. The two-state region of Oregon and Washington experienced trends in population growth similar to those observed in the potentially affected 10-county area. The total population increased by approximately 21 percent; the total minority population, by approximately 99 percent; people self-identified as Hispanic or Latino origin, by approximately 119 percent; and the American Indian and Alaska Native population, by approximately 15 percent.

Table 3–15. Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and the Two-State Region of Washington and Oregon in 1990

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White alone	448,454	79.3	6,801,354	88.2
Minority				
Black or African American[a]	6,239	1.1	195,979	2.5
American Indian and Alaska Native[a]	13,242	2.3	119,979	1.6
Asian or Pacific Islander[a]	7,564	1.3	280,227	3.6
Some other race[a]	69,713	12.3	167,104	2.2
White Hispanic	20,659	3.7	144,370	1.9
Total minority[b]	**117,417**	**20.7**	**907,659**	**11.8**
Total	**565,871**	**100.0**	**7,709,013**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals, regardless of race, who identified themselves as Hispanic or Latino, numbering 91,395 (16.2 percent of total population) in the counties surrounding the Hanford Site and 327,277 (4.2 percent of total population) in Washington and Oregon.

Source: Census 2007c.

Table 3–16. Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and the Two-State Region of Washington and Oregon in 2000

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White alone	475,146	68.4	7,510,106	80.6
Minority				
Black or African American[a]	7,308	1.1	245,929	2.6
American Indian and Alaska Native[a]	16,432	2.4	138,512	1.5
Asian[a]	8,869	1.3	423,685	4.5
Native Hawaiian and other Pacific Islander[a]	828	0.1	31,929	0.3
Some other race[a]	112,624	16.2	373,755	4.0
Two or more races[a]	20,717	3.0	318,264	3.4
White Hispanic	52,851	7.6	273,340	2.9
Total minority[b]	**219,629**	**31.6**	**1,805,414**	**19.4**
Total	**694,775**	**100.0**	**9,315,520**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals, regardless of race, who identified themselves as Hispanic or Latino, numbering 176,821 (25.5 percent of total population) in the counties surrounding the Hanford Site and 716,823 (7.7 percent of total population) in Washington and Oregon.

Source: Census 2007a.

3.2.11.1.2 200 Areas Descriptions

In 2000 approximately 488,900 people resided in the area within an 80-kilometer (50-mile) radius of the facilities in the 200 Areas—STTS-East, STTS-West, and the WTP. Minorities accounted for approximately 37 percent of the total population. Those who identified themselves as Hispanic or Latino accounted for approximately 84 percent of the minority population and 31 percent of the total population. Table 3–17 provides a breakdown of the populations within 80 kilometers (50 miles) of the 200 Areas for 2000.

Table 3–17. Populations Within 80 Kilometers of the 200 Areas at the Hanford Site in 2000

Population Group	Population	Percentage of Total
Nonminority		
White alone	308,103	63.0
Minority		
Black or African American[a]	5,516	1.1
American Indian and Alaska Native[a]	10,418	2.1
Asian[a]	6,700	1.4
Native Hawaiian and other Pacific Islander[a]	468	0.1
Some other race[a]	97,999	20.0
Two or more races[a]	15,820	3.2
White Hispanic	43,700	8.9
Total minority[b]	**180,794**	**37.0**
Total	**488,897**	**100.0**

a Includes individuals who identified themselves as Hispanic or Latino.

b Includes all individuals, regardless of race, who identified themselves as Hispanic or Latino, numbering 151,487 (31.0 percent of total population).

Note: To convert kilometers to miles, multiply by 0.6214. Total may not equal the sum of the contributions due to rounding.

Source: Census 2007a.

Figures 3–21 and 3–22 reflect the concentrations of various minority populations as a function of distance from the 200 Areas at Hanford in 2000. Block-group data generated from the U.S. Census Bureau's *Summary File 1* (Census 2007a) reflect a total population of 488,897 within an 80-kilometer (50-mile) radius of the 200 Areas. Outward from the 200 Areas, populations tended to increase sharply near the outskirts of the population centers of Richland, Kennewick/Pasco, and Yakima. It is estimated that 18 percent of the minority population lived within 40 kilometers (25 miles) of the 200 Areas and approximately 55 percent within 56 kilometers (35 miles). Approximately 31 percent of the total population living in the potentially affected 80-kilometer (50-mile) radius of the 200 Areas were self-identified as Hispanic or Latino.

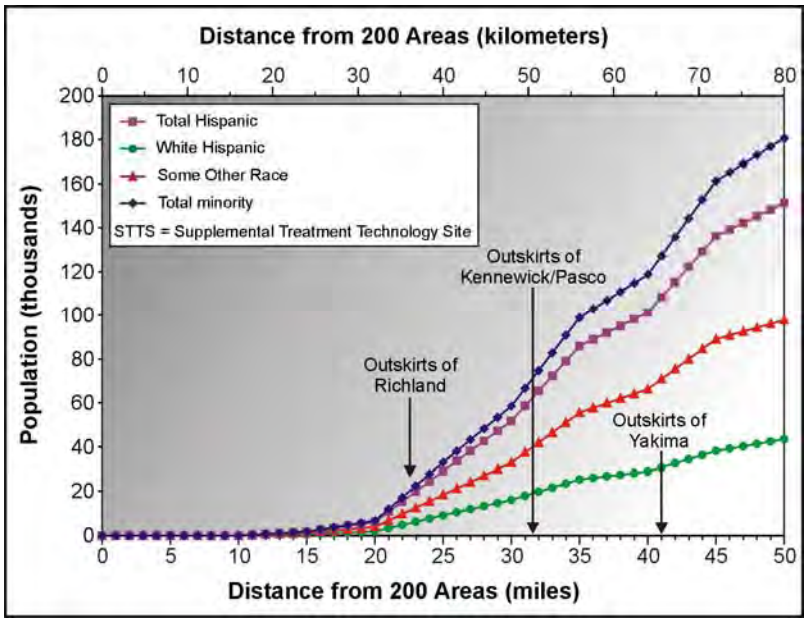


Figure 3–21. Cumulative Larger-Scale Minority Populations Surrounding the 200 Areas at the Hanford Site in 2000 as a Function of Distance

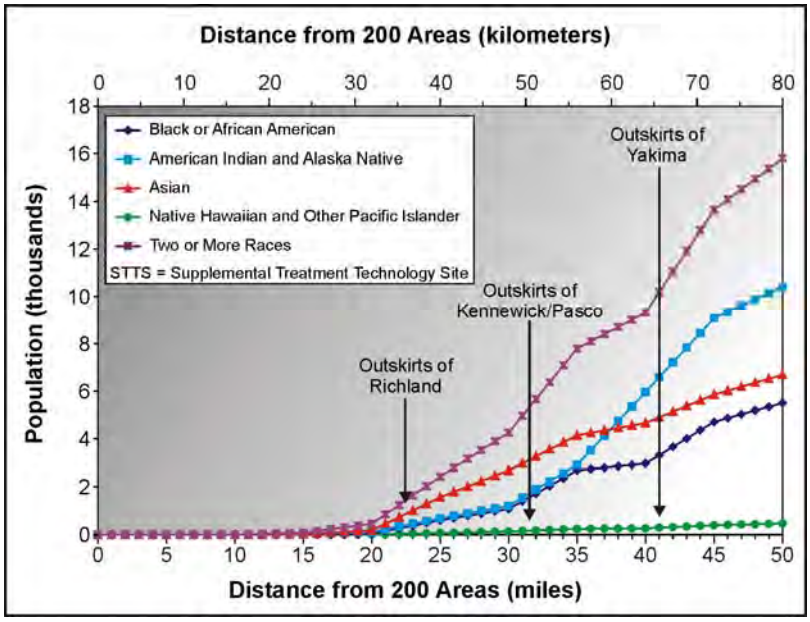


Figure 3–22. Cumulative Smaller-Scale Minority Populations Surrounding the 200 Areas at the Hanford Site in 2000 as a Function of Distance

Figure 3–23 shows minority and nonminority populations living in block groups surrounding the facilities in the 200 Areas in 2000. Over 90 percent of the minority populations lived in four Washington counties: Benton, Franklin, Grant, and Yakima; approximately one-half were concentrated in Yakima County. Of the 372 block groups surrounding the 200 Areas, 90 contain minority populations.

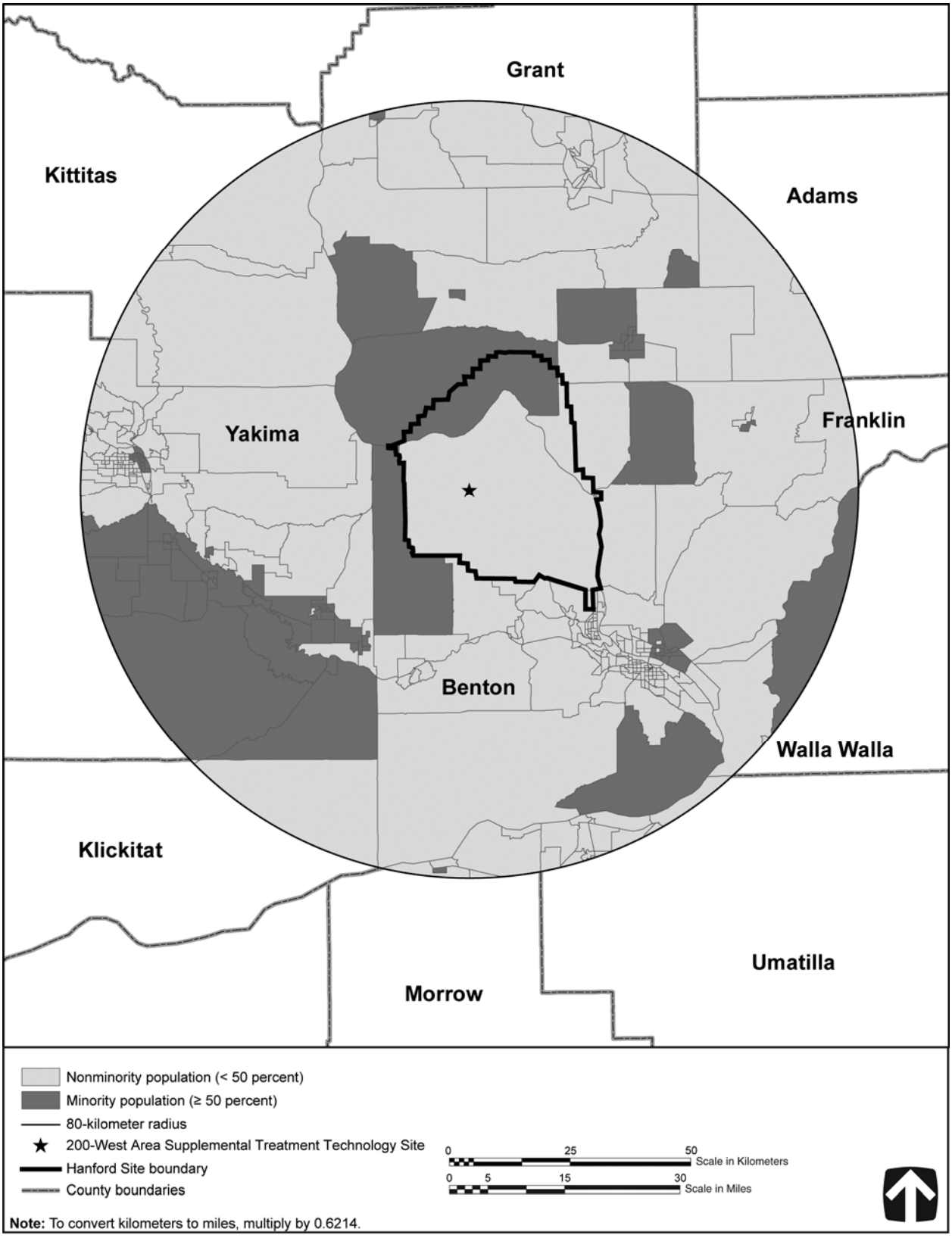


Figure 3–23. Minority and Nonminority Populations Living in Block Groups Surrounding the 200 Areas at the Hanford Site in 2000

3.2.11.1.3 400 Area Description

Approximately 357,400 people lived in the area within an 80-kilometer (50-mile) radius of the 400 Area at Hanford in 2000. In this area, minorities accounted for 37 percent of the total population. The largest minority group was Hispanic or Latino; they accounted for approximately 86 percent of the minority population and almost 32 percent of the total population. Table 3–18 provides a breakdown of the population within 80 kilometers (50 miles) of the 400 Area in 2000.

Table 3–18. Population Within 80 Kilometers of the 400 Area at the Hanford Site in 2000

Population Group	Population	Percentage of Total
Nonminority		
White alone	225,605	63.1
Minority		
Black or African American[a]	3,656	1.0
American Indian and Alaska Native[a]	5,383	1.5
Asian[a]	5,155	1.4
Native Hawaiian and other Pacific Islander[a]	317	0.1
Some other race[a]	73,810	20.7
Two or more races[a]	10,633	3.0
White Hispanic	32,642	9.1
Total minority[b]	**131,786**	**36.9**
Total	**357,391**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.
[b] Includes all individuals, regardless of race, who identified themselves as Hispanic or Latino, numbering 112,899 (31.6 percent of total population).
Note: To convert kilometers to miles, multiply by 0.6214. Total may not equal the sum of the contributions due to rounding.
Source: Census 2007a.

Figures 3–24 and 3–25 show the minority populations as a function of distance from the 400 Area at Hanford in 2000. Block-group data generated from the U.S. Census Bureau's *Summary File 1* (Census 2007a) reflect a total population of 357,391 surrounding the 400 Area. The significantly lower population here than in other areas in the environs of Hanford, as indicated in this *TC & WM EIS*, can be attributed to Yakima City falling outside the 80-kilometer (50-mile) radius. Sharp increases in population could be seen on the outskirts of Richland and Kennewick/Pasco and at a point approximately 64 kilometers (40 miles) from the 400 Area, most likely attributable to the population center of Hermiston, Oregon. Approximately 30 percent of the minority population in the vicinity of the 400 Area lived within 32 kilometers (20 miles) of it; approximately 50 percent lived within 47 kilometers (29 miles). It is estimated that 32 percent of the population living within 80 kilometers (50 miles) of the 400 Area were Hispanic or Latino.

Figure 3–26 shows minority and nonminority populations living in block groups surrounding the 400 Area at Hanford in 2000. Over 84 percent of the minority populations lived in four Washington counties: Benton, Franklin, Grant, and Yakima; approximately 33 percent were concentrated in Yakima County. Of the 298 block groups surrounding the 400 Area, 69 contain minority populations.

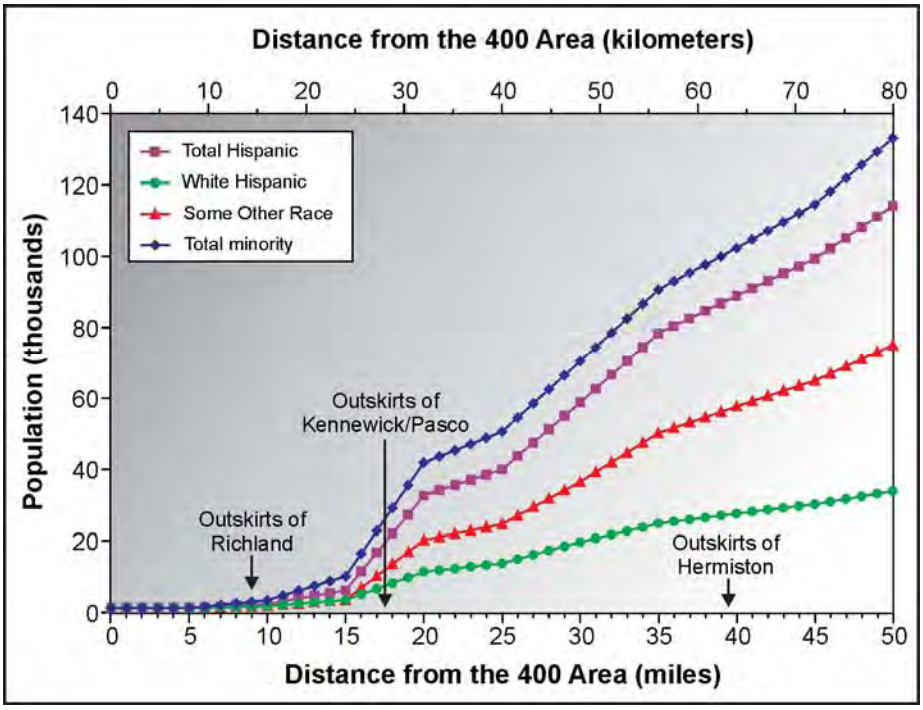


Figure 3–24. Cumulative Larger-Scale Minority Scale Populations Surrounding the 400 Area at the Hanford Site in 2000 as a Function of Distance

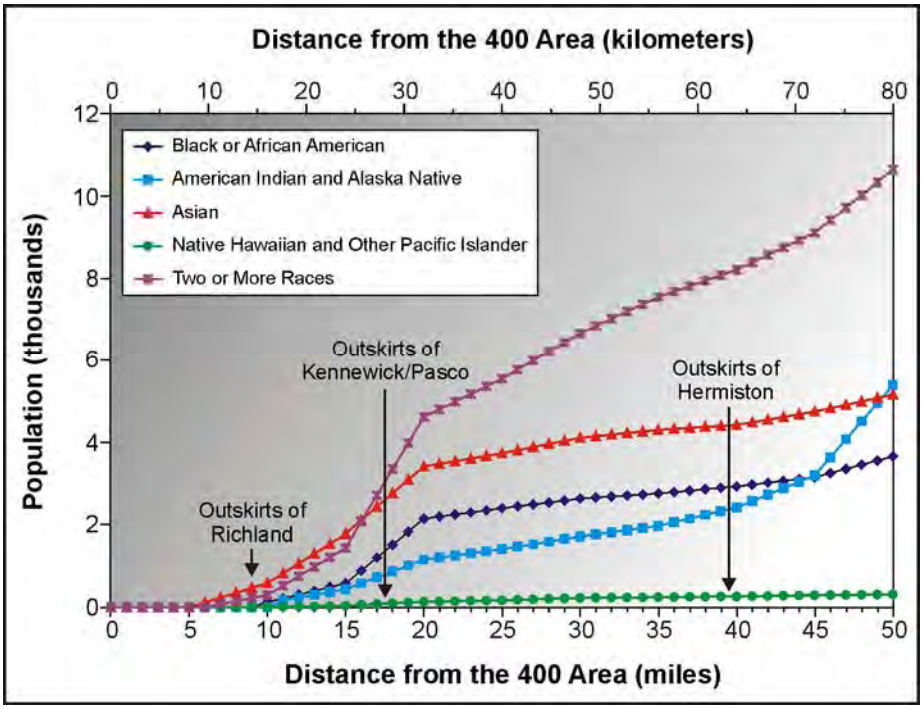


Figure 3–25. Cumulative Smaller-Scale Minority Populations Surrounding the 400 Area at the Hanford Site in 2000 as a Function of Distance

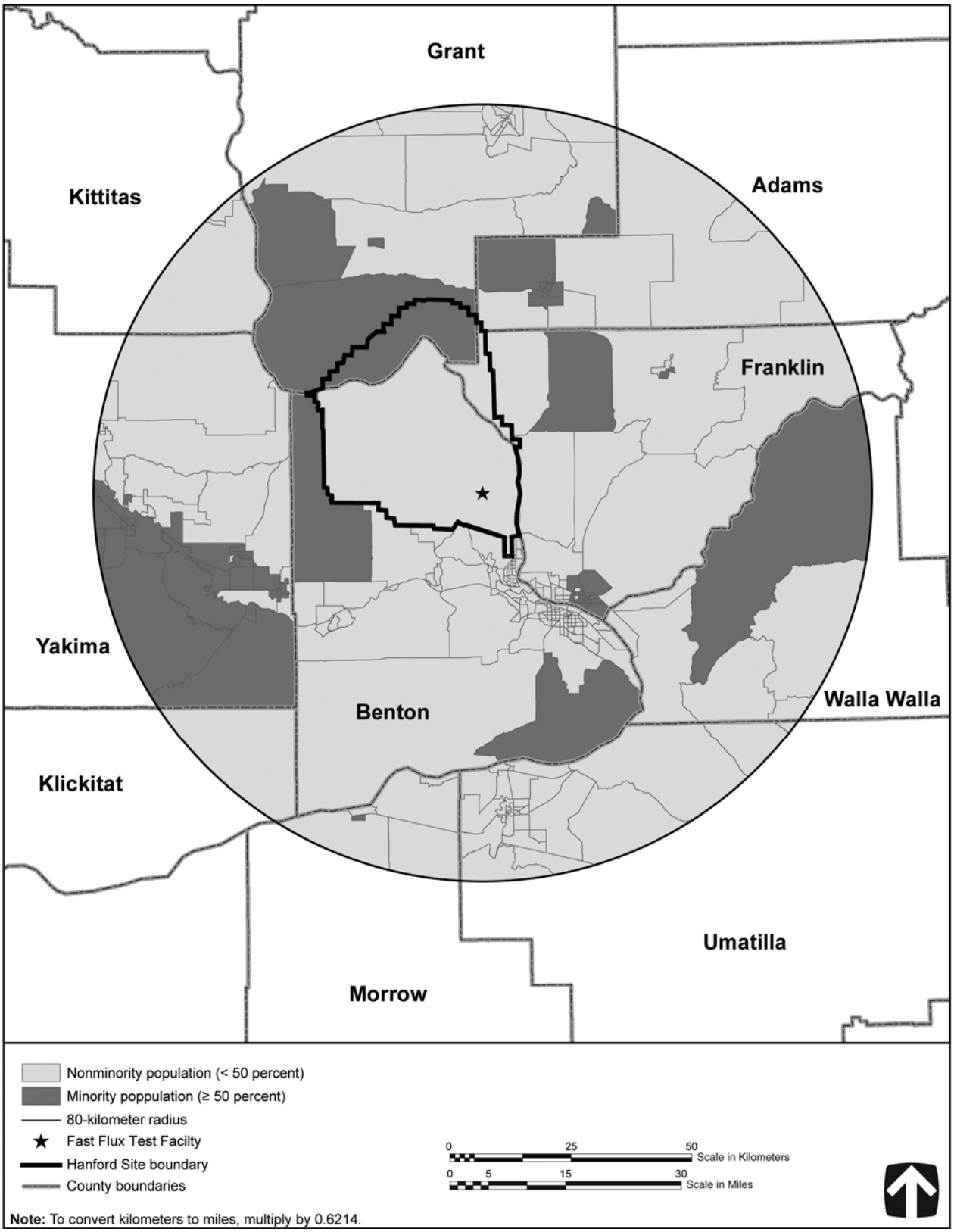


Figure 3–26. Minority and Nonminority Populations Living in Counties Surrounding the 400 Area at the Hanford Site in 2000

3.2.11.2 Low-Income Populations

Low-Income Populations Surrounding the Hanford Site in 2000

- Low-income persons constituted approximately 16 percent of the total population.
- Eighty percent of the low-income population lived in five counties: Benton, Franklin, Grant, Yakima, and Umatilla.
- Almost 40 percent of the low-income population lived in Yakima County.

3.2.11.2.1 General Site Description

Tables 3–19 and 3–20 show the total and low-income populations in the potentially affected 10-county area surrounding the candidate facilities at Hanford and in the two-state region of Washington and Oregon in 1989 and 1999, respectively. From 1989 to 1999, the total population of the 10-county area increased by approximately 39 percent, while the low-income population increased by approximately 27 percent. Over the same period, the two-state region of Washington and Oregon saw an increase in total population of approximately 21 percent, with an increase in low-income population of approximately 16 percent over the 10-year period.

Table 3–19. Total and Low-Income Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and in the Two-State Region of Washington and Oregon in 1989

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Total population[a]	551,346	100.0	7,516,910	100.0
Low-income population	96,773	17.6	862,800	11.5

[a] The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

Source: Census 2007d.

Table 3–20. Total and Low-Income Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and in the Two-State Region of Washington and Oregon in 1999

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Total population[a]	676,966	100.0	9,112,868	100.0
Low-income population	109,693	16.2	1,001,110	11.0

[a] The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

Source: Census 2007b.

3.2.11.2.2 200 Areas Description

Table 3–21 shows the total and low-income populations within 80 kilometers (50 miles) of the 200 Areas at Hanford in 1999. Low-income persons constituted approximately 17 percent of the total population. Over 90 percent of the low-income population lived in four counties: Benton, Franklin, Grant, and Yakima; approximately half were concentrated in Yakima County.

Figure 3–27 shows the total, low-income, and non-low-income populations as a function of distance from the 200 Areas at Hanford in 1999. Block-group data generated from the U.S. Census Bureau's *Summary File 3* (Census 2007b) reflected a total population of 481,350 within an 80-kilometer (50-mile) radius of the 200 Areas. Outward from the 200 Areas, populations tended to increase sharply near the outskirts of the population centers of Richland, Kennewick/Pasco, and Yakima.

Table 3–21. Total and Low-Income Populations Within 80 Kilometers of the 200 Areas at the Hanford Site in 1999

Population Group	Population	Percentage of Total
Total population[a]	481,350	100.0
Low-income population	79,964	16.6

[a] The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

Note: To convert kilometers to miles, multiply by 0.6214.

Source: Census 2007b.

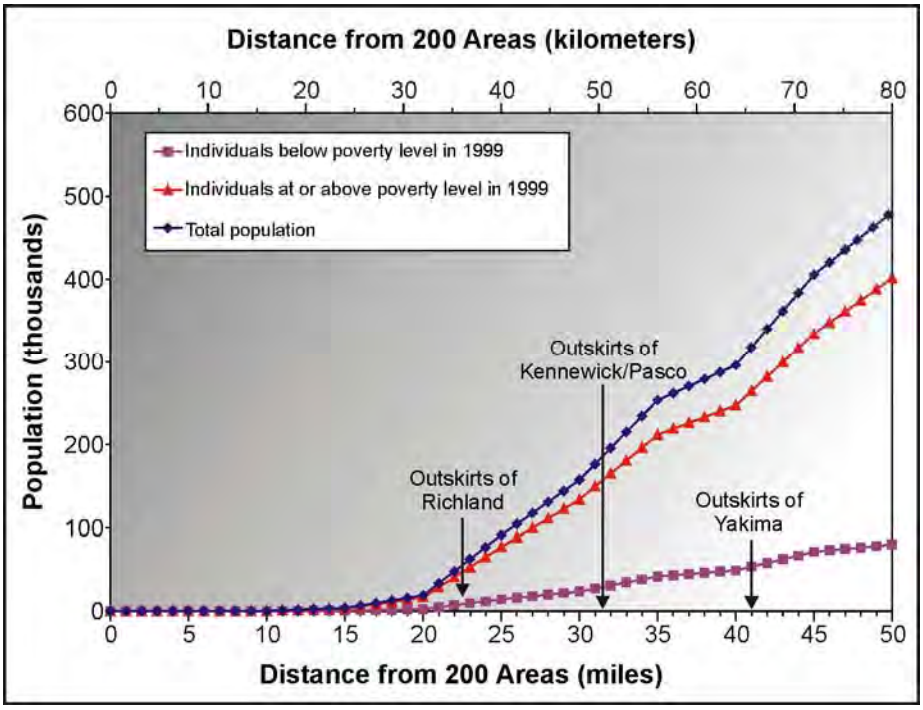


Figure 3–27. Cumulative Low-Income and Non-Low-Income Populations Surrounding the 200 Areas at the Hanford Site in 1999 as a Function of Distance

Figure 3–28 shows low-income and non-low-income populations living in the block groups surrounding the 200 Areas at Hanford in 1999. Of the 372 block groups surrounding the 200 Areas, 30 contain low-income populations.

3.2.11.2.3 400 Area Description

Table 3–22 shows the total and low-income populations within 80 kilometers (50 miles) of the 400 Area at Hanford in 1999. Low-income individuals constituted approximately 16 percent of the total population. Eighty-five percent lived in four counties: Benton, Franklin, Grant, and Yakima; 30 percent were concentrated in Yakima County.

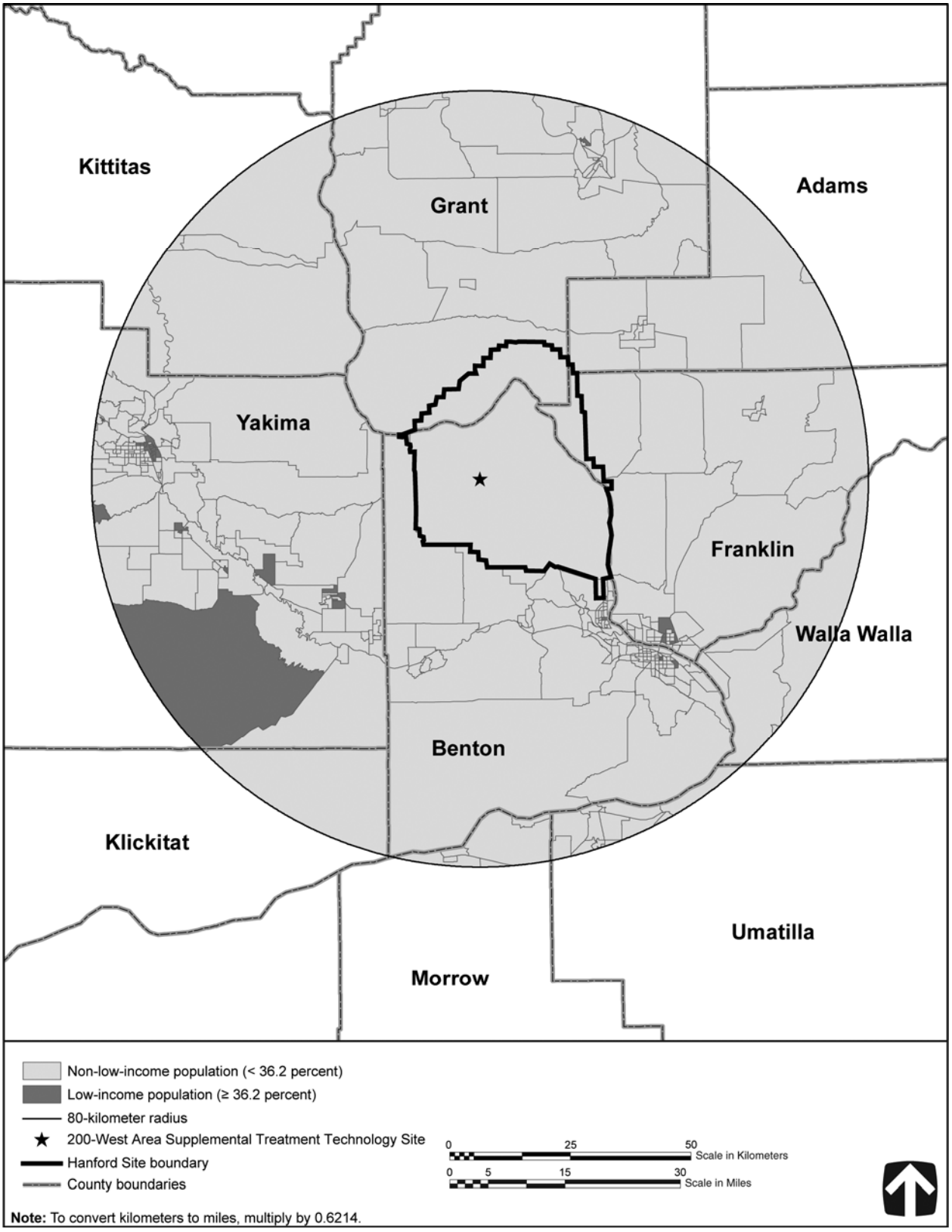


Figure 3–28. Low-Income and Non-Low-Income Populations Living in Block Groups Surrounding the 200 Areas at the Hanford Site in 1999

Table 3–22. Total and Low-Income Populations Within 80 Kilometers of the 400 Area at the Hanford Site in 1999

Population Group	Population	Percentage of Total
Total population[a]	351,886	100.0
Low-income population	55,234	15.7

[a] The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into include those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

Note: To convert kilometers to miles, multiply by 0.6214.
Source: Census 2007b.

Figure 3–29 illustrates the total, low-income, and non-low-income populations as a function of distance from the 400 Area in 1999. Block-group data generated from the U.S. Census Bureau's *Summary File 3* (Census 2007b) reflect a total population of 351,886 within an 80-kilometer (50-mile) radius of the 400 Area. Low-income individuals constituted approximately 16 percent of the total population in this area. Outward from the 400 Area, populations tended to increase sharply near the outskirts of population centers of Richland, Kennewick/Pasco, and Yakima.

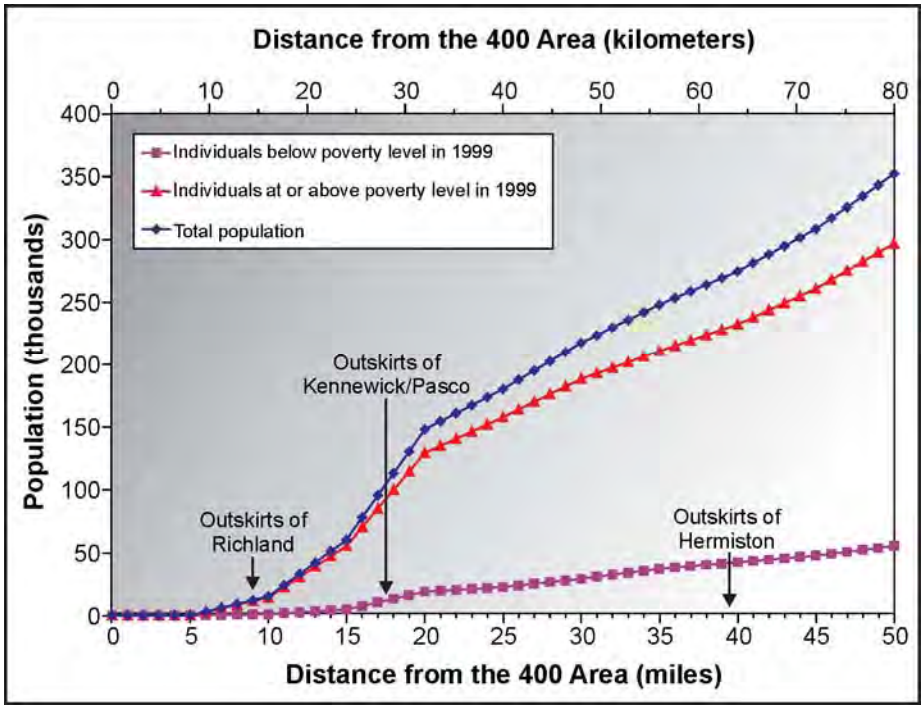


Figure 3–29. Cumulative Low-Income and Non-Low-Income Populations Surrounding the 400 Area at the Hanford Site in 1999 as a Function of Distance

Figure 3–30 shows low-income and non-low-income populations living in the block groups surrounding the 400 Area at Hanford in 1999. Of the 298 block groups surrounding the 400 Area, 17 contain minority populations.

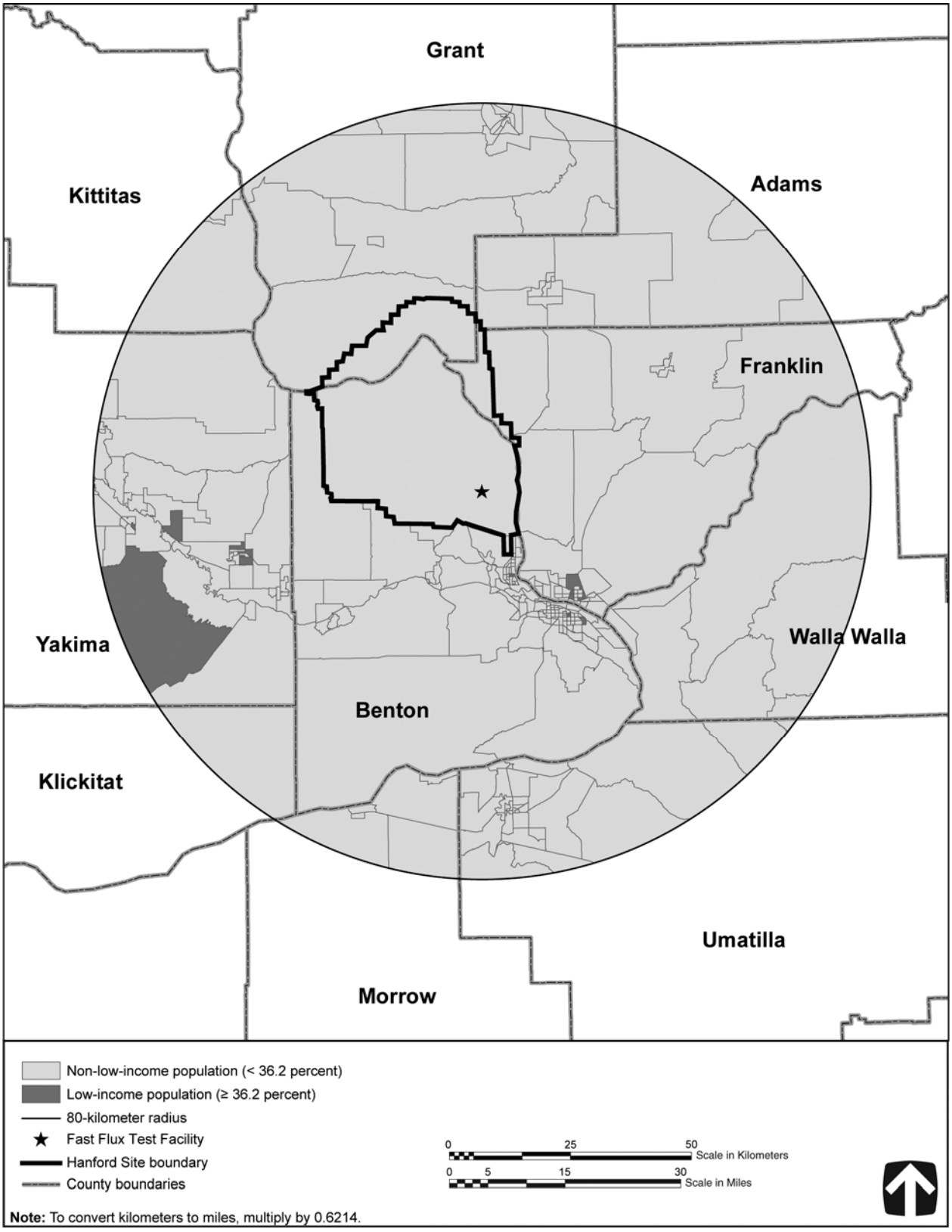


Figure 3–30. Low-Income and Non-Low-Income Populations Living in Block Groups Surrounding the 400 Area at the Hanford Site in 1999

3.2.12 Waste Management

Waste management includes minimization, characterization, treatment, storage, transportation, and disposal of waste generated from DOE activities, including management of waste in the 149 SSTs and 28 DSTs. The waste is managed using appropriate TSD technologies in compliance with all applicable Federal and state statutes and DOE orders. In support of the discussion that follows, data on the various technological aspects of waste management are provided in Appendix E.

3.2.12.1 Waste Inventories and Activities

Hanford manages the following types of waste: HLW, TRU waste, mixed TRU waste, LLW, mixed low-level radioactive waste (MLLW), hazardous waste, and nonhazardous waste. Radioactive waste may be contact-handled (CH) or remote-handled (RH). The CH waste has a dose rate lower than 200 millirem per hour when measured at the surface of the container and may be handled without shielding.[3] The RH waste classification applies to containers with a contact dose rate higher than 200 millirem per hour. RH waste requires the use of additional shielding and special facilities to protect workers (P.L. 102-579).

Information on the solid waste generated from activities at Hanford from 2000 through 2006 is provided in Table 3–23. Liquid waste quantities generated and stored within the tank farm system at Hanford from 2000 through 2006 are provided in Table 3–24. The tables show typical waste generation rates in recent years when no substantial waste generation from tank waste treatment and SST closure activities occurred. Projected waste generation shown in Table 3–25, includes the total volumes of waste that would be generated from 2006 through 2035. More-detailed descriptions of TRU waste, LLW, and MLLW management system capabilities at Hanford are included in Appendix E.

Table 3–23. Quantities of Solid Waste[a] Generated on the Hanford Site from 2000 Through 2006

Waste Category	Year						
	2000	2001	2002	2003	2004	2005	2006
	(kilograms)						
Mixed[b]	441,000	328,500	1,025,000	421,000	144,512	349,416	315,188
Radioactive[c]	700,000	1,675,200	1,588,000	758,000	906,591	1,188,212	465,340

[a] Includes containerized liquid waste but not waste in the tank farm system.

[b] Includes transuranic and low-level radioactive waste and has both radioactive and dangerous nonradioactive constituents.

[c] Categorized as transuranic and low-level radioactive waste.

Note: To convert kilograms to pounds, multiply by 2.2046.

Source: Poston et al. 2007.

[3] This legal definition of CH-TRU and RH-TRU waste is from the Waste Isolation Pilot Plant Land Withdrawal Act (P.L 102-579). The 200-millirem-per-hour dose rate at the surface of a container has its basis in transportation requirements and encompasses the assumption that a worker carrying packages with a surface dose rate of 200 millirem per hour for 30 minutes a day will not exceed the recommended local exposure of 100 millirem per day. The legal definition for a waste package emitting exactly 200 millirem per hour is ambiguous. TRU waste packages approaching the definitional limit (200 millirem per hour) are handled directly or remotely, depending on site-specific practices.

Table 3–24. Quantities of Liquid Waste[a] Generated and Stored Within the Tank Farm System on the Hanford Site During 2006 and Each of the Previous 6 Years

Type of Waste	Year						
	2000[b]	2001	2002	2003	2004	2005	2006
	(liters)						
Liquids added to double-shell tanks	8,920,000	2,980,000	9,280,000	9,710,000	3,316,000	3,668,000	3,547,000
Total waste in double-shell tanks (year end)	79,630,000	79,980,000	87,683,000	92,693,000	95,275,000	98,943,000	101,411,000
Liquid waste evaporated at 242-A Evaporator	2,580,000	2,580,000	1,578,000	4,720,000	734,000	706,700	1,052,000
Liquids pumped from single-shell tanks[b]	2,250,000	590,000	5,288,000	6,185,000	2,778,000	888,000	2,953,000[c]

[a] Liquid waste sent to underground double-shell storage tanks during these years, rounded to the nearest 1,000 liters. This does not include containerized (e.g., barreled) solid waste.

[b] Does not include dilution or flush water.

[c] Volume does include dilution or flush water.

Note: To convert liters to gallons, multiply by 0.26417.

Source: Poston et al. 2007.

Table 3–25. Projected Waste Generation 2006–2035[a]

Source	Mixed TRU Waste	LLW	MLLW	Hazardous Waste[a]	Nonradioactive/ Nonhazardous Waste[a]
	(cubic meters)				
Onsite, non-CERCLA	29,726	17,363	16,074	870	NR
Offsite	N/A	193[b]	N/A[b]	N/A	N/A
Total	**29,726**	**17,556**	**16,074**	**870**	**–**

[a] Hazardous and nonhazardous waste is shipped directly off site, and thus is generally not forecast.

[b] This does not include the 62,000 cubic meters of LLW and 20,000 cubic meters of MLLW from the Settlement Agreement between the U.S. Department of Energy and the State of Washington (*State of Washington v. Bodman*, Civil No. 2:03-cv-05018-AAM).

Note: To convert cubic meters to cubic feet, multiply by 35.315.

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; TRU=transuranic.

Source: Barcot 2005.

3.2.12.1.1 High-Level Radioactive Waste

HLW was generated from the reprocessing of SNF to recover uranium and plutonium generated in the production reactors. This radioactive waste is considered mixed waste because it also contains toxic and hazardous constituents subject to RCRA. It must be RH because of its high radiation levels. The waste, generated as liquids and sludges, was stored in underground tanks where the salts in the liquid precipitated out of solution as porous solids (called salt cake) and settled with the sludges in the bottom of the tanks. The liquid above the solids was pumped from the older SSTs into newer DSTs. The storage tanks are described in more detail in Chapter 2. The waste contained in the 177 underground storage tanks (149 SSTs and 28 DSTs) is managed by DOE as HLW to provide consistent protection of the environment, workers, and public.

In addition to this liquid and solid material managed as HLW, an inventory of encapsulated cesium and strontium, also managed as HLW, is stored in the Waste Encapsulation and Storage Facility in a

water-cooled pool (DOE 2000a:3-138). The Waste Encapsulation and Storage Facility provides safe storage and monitoring of radioactive cesium and strontium capsules. The facility contains seven hot cells and 12 storage/transfer pools. The current inventory consists of 1,312 cesium capsules, 23 overpacked cesium capsules, and 601 strontium capsules (Collins 2001:39). DOE is investigating the possibility of placing the capsules in dry storage.

The 242-A Evaporator is an RCRA-permitted facility in the 200-East Area that concentrates dilute liquid tank waste by evaporation. This reduces the volume of liquid waste sent to the DSTs for storage, and thus the need for more DSTs. One 242-A Evaporator campaign completed a cold-run campaign for training purposes and one waste campaign during 2006. The volume of waste treated was 2.095 million liters (553,400 gallons) of waste, thereby reducing the waste volume by 901,682 liters (238,200 gallons), or approximately 43 percent of the total volume. The volume of process condensate transferred to the LERF for subsequent treatment in the ETF was 1.249 million liters (330,000 gallons) (Poston et al. 2007). The evaporator has a capacity of 270,000 liters (71,000 gallons) per day. Concentrated waste is returned to the waste storage DSTs, and condensate, as LLW, is discharged to the ETF (DOE 2002c).

3.2.12.1.2 Low-Activity Waste

LAW is waste resulting from the reprocessing of SNF that is determined to be incidental to the reprocessing and, therefore, is not HLW. The waste is managed under DOE regulatory authority in accordance with the requirements for LLW or TRU waste, as appropriate. When determining whether waste from the reprocessing of SNF waste is HLW or another waste type, either the citation or the evaluation process as presented in DOE Manual 435.1-1, *Radioactive Waste Management Manual*, is used (DOE Manual 435.1-1). As described in Chapter 2, certain alternatives being considered in this *TC & WM EIS* follow from an assumption that some of the tank waste would be determined to be incidental and would be treated as LAW by vitrification in the WTP or by an alternative treatment technology such as bulk vitrification, cast stone, or steam reforming. Because LAW comes from tank waste designated as mixed waste, it would also be managed as MLLW. Vitrification treatment capacity for a portion of the LAW is currently being constructed in the WTP. Additional treatment is being analyzed in this *TC & WM EIS*. Hanford does not currently have disposal capability for LAW; however, the analysis allows for disposal of 213,000 cubic meters (7.52 million cubic feet) of WTP-vitrified LAW in an IDF.

3.2.12.1.3 Transuranic and Mixed Transuranic Waste

The waste contained in the 177 underground storage tanks (149 SSTs and 28 DSTs) is managed as HLW; however, the DOE Office of River Protection believes it can demonstrate that some of the tanks should be classified as containing TRU waste, based on the origin of the waste. Appendix E, Section E.1.2.3.11, covers this waste in more detail.

Not all currently generated CH-mixed TRU waste is tank-derived. Nontank waste is being placed in above-grade storage buildings at the 27,871-square-meter (300,000-square-foot) CWC in the 200-West Area (DOE 2002d). The wastes stored at the CWC are segregated to ensure compatibility of the contents of the various storage containers (e.g., acidic and basic materials are stored separately). All waste containers are CH, although some RH-TRU waste is stored at the CWC by shielding it to CH levels. The CWC can store as much as 20,796 cubic meters (734,418 cubic feet) of MLLW and TRU waste. Treatment reduces the amount of waste in storage and makes room for newly generated mixed waste. The dangerous waste designation of each container of waste is established at the point of origin from process knowledge or sample analysis. The current volume of waste stored at the CWC totals approximately 6,950 cubic meters (245,430 cubic feet) (Poston et al. 2007). The TRU waste will be maintained in storage until it is shipped to DOE's Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, for disposal (DOE 2002d).

Inspection, verification, opening, sampling of drum headspace gas, sorting, and limited treatment and repackaging of TRU waste containers are performed in the 2706-T Facility of the T Plant complex. The T Plant canyon and tunnel (221-T Building) are used for processing of CH and RH materials. Dry decontamination, inspection, segregation, verification, and repackaging of CH- and RH-TRU waste and large items of contaminated equipment are performed in the canyon. The 2706-T Facility provides verification, treatment, and repackaging of CH-TRU waste. Treatment processes consist of adding sorbent material to the waste matrix, neutralization of the waste, and the amalgamation of mercury and other metals (DOE 2002e).

The major function of WRAP is inspection, repackaging, and certification of CH-TRU waste to prepare it for transport and disposal at WIPP. The facility is also used to verify that LLW meets Hanford waste acceptance criteria and to characterize MLLW for quality assurance purposes. WRAP provides the capability for nondestructive examination and nondestructive assay of incoming waste. Nondestructive examination is an x-ray process used to identify the physical contents of the waste containers. Nondestructive assay is a neutron or gamma energy assay system used to determine radionuclide content and distribution. WRAP also has limited TRU waste and MLLW treatment capabilities, including deactivation, solidification or absorption of liquids, neutralization of corrosives, amalgamation of mercury and waste, microencapsulation, macroencapsulation, volume reduction by supercompaction, stabilization of reactive waste, and repackaging of waste. WRAP is designed to process 6,800 drums of TRU waste annually (DOE 2000a:3-139). This facility, which began operations in 1997, processed and shipped off site 586 cubic meters (20,694 cubic feet) of waste during 2006 (Poston et al. 2007).

Mobile TRU waste processing facilities or accelerated process lines have been proposed for Hanford to accelerate the rate at which TRU waste can be certified and shipped to WIPP. The functions of these facilities are similar to those of WRAP. They are expected to be developed in stages or modules so that the first module will process standard 208-liter (55-gallon) drums; a second module will process larger boxes. The mobile systems will provide an additional capacity to process about 4,000 CH-TRU drums per year. Units will be located outside near the CWC buildings on ground that has already been disturbed (DOE 2000b).

TRU waste disposal began in 1999 with the opening of WIPP, and Hanford began shipping waste to WIPP in July 2000. Waste to be shipped to WIPP must be certified according to the WIPP Waste Acceptance Criteria. WRAP was designed and built at Hanford to perform, among various other functions, certification of most CH-TRU waste for disposal at WIPP. Currently, CH-TRU waste drums are being removed from the CWC, certified at WRAP, and shipped to WIPP. WIPP is designed to annually receive and handle 14,160 cubic meters (500,000 cubic feet) of CH waste and 283 cubic meters (10,000 cubic feet) of RH waste. WIPP has a designated disposal capacity 175,600 cubic meters (6.2 million cubic feet) of TRU waste and sufficient capacity to handle the 7,080 cubic meters (250,000 cubic feet) of RH waste that was established in the ROD for WIPP as a total volume (46 FR 9162). As of January 2008, 53,001 cubic meters (1,871,713 cubic feet) of waste has been disposed of at WIPP (DOE 2008c). In 2006 Hanford carried out 69 shipments (508 cubic meters [17,940 cubic feet]) of waste to WIPP (McKenney 2006).

3.2.12.1.4 Low-Level Radioactive Waste

Radioactive materials handling may result in the contamination of various items and materials with LLW. At Hanford, solid LLW includes protective clothing, plastic sheeting, gloves, paper, wood, analytical waste, contaminated equipment, contaminated soil, nuclear reactor hardware, nuclear fuel hardware, and spent deionizer resin from the purification of water in radioactive material storage basins.

Hanford's solid LLW is sent to the LLBG 218-W-5, trenches 31 and 34 and the ERDF. The LLBGs are a landfill facility comprising eight separate waste disposal areas in the 200-East and 200-West Areas

(DOE 2003a:E-2). The LLBG cover a noncontiguous combined area of about 220 hectares (544 acres) (DOE 1997a). Two of these LLBGs are used for the disposal of LLW and MLLW (i.e., LLW with a dangerous waste component regulated by WAC 173-303). Seven LLBGs were previously used for disposal of LLW. TRU waste was placed in retrievable storage in four LLBGs; one LLBG (218-W-6) was never used. The LLBGs have been permitted under an RCRA Part A permit since 1985.

Three trenches receive mixed waste regulated by WAC 173-303. Trenches 31 and 34 in LLBG 218-W-5 are lined trenches with leachate collection and removal systems. Trench 94 in LLBG 218-E-12B is used for disposal of defueled U.S. Navy reactor compartments. LLW and TRU waste have been placed in the other LLBGs. TRU waste has not been placed in the LLBGs without specific DOE approval since August 19, 1987. The TRU waste was placed in a manner that allows for retrieval and/or removal in the future (Poston et al. 2007:6.24).

On June 23, 2004, DOE issued a ROD (69 FR 39449) for the Solid Waste Program at Hanford. Part of the ROD stated that DOE will dispose of LLW in lined disposal facilities. Only two of the LLBG trenches are lined (trenches 31 and 34); therefore, since that date, all LLW, as well as MLLW, is being placed in these two trenches. Disposal of U.S. Navy Reactor compartments in the LLBGs is not affected by this ROD (Poston et al. 2007:6.24).

Typically, the trenches (ditches) are about 12 meters (40 feet) wide at the base and are excavated to a depth of approximately 6 meters (20 feet). After they are filled with waste to the desired level, a 2.4-meter (8-foot) layer of soil is placed over the waste so the surface is near the original grade (DOE 1997b). The current combined packaged waste volume in trenches 31 and 34 is 4,301 cubic meters (151,886 cubic feet); however, some of the waste in these trenches has been radiologically stabilized in grout monoliths, which take up additional space. Taking the monoliths into account, the current realized disposal volume in the two trenches is approximately 5,620 cubic meters (198,465 cubic feet) (Poston et al. 2007).

Between 1962 and 1999, Hanford disposed of 283,000 cubic meters (9,994,145 cubic feet) of solid LLW in the LLBGs. The average rate of disposal of offsite waste is about 5,663 cubic meters (200,000 cubic feet) per year (DOE 2002f). In addition, 115 defueled U.S. Navy reactor compartments from nuclear-powered vessels have been disposed of (Poston et al. 2007:6.22).

Within the LLBGs, several techniques can be used to provide extra confinement for higher-activity LLW. These techniques include placement deep within the trench (ditch), burial in high-integrity containers, and in-trench grouting. Generally, high-integrity containers are used for RH-LLW and in-trench grouting for high-activity CH-LLW.

Both on- and offsite generators of LLW are required to meet specific criteria for their waste to be accepted for disposal at Hanford. Those criteria, defined in the *Hanford Site Solid Waste Acceptance Criteria* (Fluor Hanford 2005b) include requirements regarding the waste package, waste package contents, radionuclide content, physical size, and chemical composition. To verify that generators conform to the waste acceptance criteria, a random sample of incoming CH waste is periodically selected for verification at WRAP, the T Plant complex, or other appropriate locations. Verification of RH waste is typically conducted at the generating facility. Discovery of nonconforming waste can result in rejection of the waste and its return to the generator, or in the required removal or treatment of prohibited items at the generator's expense. Most LLW is stored for only short periods awaiting verification or disposal. LLW that requires some type of treatment before it can be disposed of is stored at the CWC. Three percent of the waste stored at the CWC is LLW (DOE 2002d).

LLW resulting from CERCLA cleanup activities is disposed of at the ERDF, which has been the central Hanford disposal site for contaminated waste generated during such activities since 1996. The ERDF,

near the 200-West Area, is an RCRA– and Toxic Substances Control Act–compliant landfill designed to provide disposal capacity for Hanford waste over the next 20 to 30 years. Constructed to RCRA Subtitle C Minimum Technology Requirements, the facility features a double liner and leachate collection system that constitute an effective barrier against contaminant migration to the environment. Environmental restoration waste disposed of in the ERDF includes soil, rubble, or other solid waste materials classified as hazardous waste, LLW, or mixed (combined hazardous and radioactive) waste (Poston et al. 2007).

There are currently six waste cells associated with the ERDF site. Cells 1 and 2 were the first constructed, and placement of waste in these cells is nearly complete. An interim cover has been placed over the parts of these two cells that have been brought up to grade. Construction of the other four cells—3, 4, 5, and 6—is now complete, and they are receiving waste; cells 7 and 8 are under construction.

During 2006, approximately 475,792 metric tons of remediation waste was disposed of at the facility. The total for the period from operations startup through 2006 was approximately 6.2 million metric tons. Under the 1995 EPA Superfund ROD (EPA 1995), expansion of the ERDF to as much as 414 hectares (1,024 acres) was authorized (Poston et al. 2007).

US Ecology, Inc., operates a licensed commercial LLBG on a site southwest of the 200-East Area that is leased to the State of Washington. This LLBG is not a DOE facility and is not considered part of DOE's Hanford operations (DOE 2000a:3-138).

3.2.12.1.5 Mixed Low-Level Radioactive Waste

Hanford's MLLW was generated from the operation, maintenance, and cleanout of reactors, chemical separation facilities, tank farms, and laboratories. MLLW contains the same types of contaminated materials as LLW; it typically consists of materials such as sludges, ashes, resins, paint waste, lead shielding, contaminated equipment, protective clothing, plastic sheeting, gloves, paper, wood, analytical waste, and contaminated soil. Hazardous components may include lead and other heavy metals; solvents; paints; oils and other hazardous organic materials; or components that exhibit characteristics of ignitability, corrosivity, toxicity, or reactivity as defined by "Dangerous Waste Regulations" (WAC 173-303). Hanford has some LLW that contains polychlorinated biphenyls, which are regulated under the Toxic Substances Control Act. Such waste is managed much like mixed waste is, and it is included in MLLW inventories and projections.

The CWC includes 12 small mixed waste storage buildings, 27 modules for low-flash-point MLLW, and 12 modules for alkali metals (DOE 2002d). During 2006, MLLW was treated and/or directly disposed of in trenches 31 and 34 and the ERDF. Specific operations included the following (Poston et al. 2007):

- MLLW totaling 670 cubic meters (23,660 cubic feet) was treated and disposed of in support of treatment objectives in Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement) Milestone M-91-42.

- MLLW totaling 154 cubic meters (5,438 cubic feet), or approximately 740 drum equivalents (based on a standard 208-liter [55-gallon] drum), was shipped from Hanford and nonthermally treated to RCRA land-disposal-restriction treatment standards by offsite commercial waste processors. The treated waste was returned to Hanford and disposed of in trenches 31 and 34.

- MLLW totaling 516 cubic meters (18,222 cubic feet), or approximately 2,481 drum equivalents, was shipped from Hanford and nonthermally treated to RCRA land-disposal-restriction treatment standards by offsite commercial waste processors. The treated waste was returned to Hanford and disposed of at the ERDF.

- MLLW totaling 239 cubic meters (8,440 cubic feet), or approximately 1,149 drum equivalents, was treated and disposed of in support of treatment objectives in Hanford Federal Facility Agreement and Consent Order Milestone M-91-12. This waste was shipped from Hanford and thermally treated to RCRA land-disposal-restriction treatment standards by offsite commercial waste processors. The treated waste was returned to Hanford and disposed of in trenches 31 and 34.

- MLLW totaling 79 cubic meters (103 cubic yards), or approximately 380 drum equivalents, was disposed of in trenches 31 and 34. This waste came from various Hanford generators and was either treated off site by commercial waste processors or, on site by the generator, or was not treated because it met land-disposal-restriction treatment standards in the "as-generated" state.

Immobilization or destruction of the hazardous component is generally required before most of the MLLW can be sent to a permitted land disposal facility. The current approach to treatment of MLLW at Hanford involves a combination of on- and offsite commercial treatment facilities. Hanford currently has limited capacity for MLLW treatment at facilities such as trenches 31 and 34 (Brockman 2008) WRAP, and the T Plant complex. WRAP, located near the CWC, also inspects, treats, and repackages MLLW to ensure that it meets the acceptance criteria of the appropriate disposal facility. MLLW received from offsite generators is expected to arrive in a regulatorily compliant form that is ready for disposal (DOE 2002g).

Miscellaneous dilute aqueous LLW and liquid MLLW are temporarily stored in the LERF until treated in the ETF. The ETF, in the 200-East Area, treats liquid effluent (wastewater) to remove toxic metals, radionuclides, and ammonia and to destroy organic compounds. The effluent comes from the 242-A Evaporator; the groundwater from the site pump-and-treat projects; and the leachate from onsite solid waste disposal facilities and a variety of other generators, including site cleanup facilities (DOE 2002d).

The LERF, in the 200-East Area, consists of three RCRA-compliant surface basins used to temporarily store process condensate from the 242-A Evaporator and other aqueous waste. The LERF ensures a steady flow and consistent pH of the feed to the ETF. Each basin has a maximum capacity of 29.5 million liters (7.8 million gallons). Generally, spare capacity is maintained to allow for control of any leak that should develop in an operating basin. Each basin is constructed of two flexible, high-density, polyethylene membrane liners. A system is provided to detect, collect, and remove leachate from between the primary and secondary liners. Moreover, a soil and bentonite clay barrier beneath the secondary liner guards against failure of the primary and secondary liners. Each basin has a floating membrane cover constructed of very low-density polyethylene to keep out windblown soil and weeds and to minimize evaporation of small amounts of organic compounds and tritium that may be present in the basin contents. The facility began operating in April 1994 and receives liquid waste from both RCRA- and CERCLA-regulated cleanup activities (Poston et al. 2007).

The volume of wastewater received for interim storage during 2006 was approximately 7.08 million liters (1.87 million gallons). Included were approximately 3.90 million liters (1.03 million gallons) of RCRA-regulated wastewater (primarily 242-A Evaporator process condensate and mixed-waste trench leachate) and approximately 3.19 million liters (843,000 million gallons) of CERCLA-regulated wastewater (primarily ERDF leachate). Most of the wastewater was received via pipeline direct from the originating facility. Approximately 1.77 million liters (468,000 gallons) of wastewater was received from various facilities via tanker trucks. The treated effluent is stored in tanks, sampled and analyzed, and discharged to the SALDS (also known as the 616-A crib). The volume of wastewater transferred to the ETF for treatment and disposal during 2006 was 15.6 million liters (4.12 million gallons) (Poston et al. 2007:6.24, 6.25).

The volume of wastewater being stored in the LERF at the end of 2006 was 31.42 million liters (8.30 million gallons). This included 8.10 million liters (2.14 million gallons) of RCRA-regulated wastewater and 23.32 million liters (6.16 million gallons) of CERCLA-regulated wastewater (Poston et al. 2007:6.25).

Commercial treatment services have been used to treat some Hanford MLLW streams. Two commercial contracts were placed for thermal and nonthermal treatment of Hanford MLLW in a demonstration project beginning in 2000. The demonstration project treated at least 1,600 cubic meters (56,500 cubic feet) of MLLW nonthermally to meet RCRA land-disposal-restriction treatment standards at the Pacific EcoSolutions Facility located in Richland, Washington. The treated waste was returned to Hanford and disposed of in trenches 31 and 34. A new nonthermal treatment contract begun in 2001 provides for the processing of a minimum of 600 cubic meters (21,200 cubic feet) and a maximum of 3,585 cubic meters (126,600 cubic feet) of MLLW over a 5-year period. The new contract allows for waste to be treated to RCRA land-disposal-restriction treatment standards at the Pacific EcoSolutions Facility and at Perma-Fix Environmental Services, located in Oak Ridge, Tennessee. The treated waste is returned to Hanford and disposed of in trenches 31 and 34 (Poston et al. 2006).

Trenches 31 and 34 are located in LLBG 218-W-5 in the 200-West Area. They are rectangular trenches with approximate floor dimensions of 76.2 by 30.5 meters (250 by 100 feet) and depths of 9.1 to 10.7 meters (30 to 35 feet). These trenches are RCRA-compliant, featuring double liners and leachate collection systems (DOE 2000a:3-139). The bottom and sides of the facilities are covered with a layer of soil 1 meter (3.3 feet) deep to protect the liner system during fill operations. A recessed section at the end of each excavation houses a sump for leachate collection. The leachate generated from operation of the lined MLLW disposal trenches is mostly rainwater or melted snow trapped by the collection systems. The liquid waste is removed from the lined trenches and trucked to the ETF, where it is treated along with other liquid MLLW (Poston et al. 2007:6.23).

The 400 Area waste management unit is located within the FFTF Property Protected Area and consists of two container storage units: the Fuel Storage Facility and the Interim Storage Area. The mixed waste stored in these two container storage units is limited exclusively to debris (e.g., piping, equipment, components) contaminated with elemental sodium and sodium hydroxide generated from FFTF deactivation activities in the FFTF Fuel Storage Facility and the 400 Area Interim Storage Area. Once this waste has been treated, removed, and disposed of, appropriate closure of the 400 Area waste management unit facilities will be done under applicable regulations.

3.2.12.1.6 Hazardous Waste

There are no treatment facilities for hazardous waste at Hanford; therefore, the waste is accumulated in satellite storage areas (for less than 90 days) or at interim RCRA-permitted facilities. The common practice for newly generated hazardous waste is to ship it off site using U.S. Department of Transportation-approved transporters for treatment, recycling, recovery, and disposal at RCRA-permitted commercial facilities (DOE 2000a:3-139).

3.2.12.1.7 Nonhazardous Waste

Sanitary wastewater is discharged to onsite treatment facilities such as septic tanks, subsurface soil adsorption systems, and wastewater treatment plants. These facilities treat an average of 600,000 liters (158,000 gallons) per day of sewage (DOE 2000a:3-139). Sewage at Hanford is treated by various means and in various systems. The sewer system in the 300 Area was recently connected to the City of Richland's system, thereby providing for treatment of that area's sewage at the municipal plant. Moreover, the 400 Area, which until recently used a septic tank and drain field, currently sends its sewage

for processing to the Energy Northwest sanitary sewer system. Sanitary waste in the 200 Areas is currently disposed of through septic tanks and drain fields (DOE 1999a:4-112).

The 200 Area TEDF collects the treated wastewater streams from various plants in the 200 Areas and disposes of the clean effluent at two 2-hectare (5-acre) ponds permitted by the State of Washington (DOE 2000a:3-139). The design capacity of the facility is approximately 13,000 liters (3,400 gallons) per minute (DOE 2002d).

Nonhazardous solid waste includes construction debris, office trash, cafeteria waste, furniture and appliances, nonradioactive friable asbestos, powerhouse ash, and nonradioactive/nonhazardous demolition debris (DOE 2000a:3-139). Such waste is disposed of at the Roosevelt Regional Landfill near Goldendale, Washington (Poston et al. 2006:6.17). Nonradioactive friable asbestos and medical waste are shipped off site for disposal at commercial facilities (DOE 2000a:3-139).

3.2.12.2 Waste Minimization

The Hanford Site Pollution Prevention Program is a comprehensive, continual effort to systematically reduce the quantity and toxicity of hazardous, radioactive, mixed, and sanitary wastes; conserve resources and energy; reduce hazardous substance use; and prevent or minimize pollutant releases to all environmental media from all operations and site cleanup activities. In accordance with sound environmental management practices, the pollution prevention program seeks to prevent pollution through establishing goals related to affirmative procurement (the purchase of environmentally preferable products containing recycled material), source reduction, and environmentally safe recycling. DOE Order 450.1, Change 2, *Environmental Protection Program*, was approved on December 7, 2005. Included in the revised order are new pollution prevention and environmental stewardship goals. These goals are implemented by Hanford Site contractors per the contract requirements document for the order.

DOE-RL is responsible for the Hanford pollution prevention program. The office provides program guidance for Hanford contractors. Integration activities are managed by Fluor Hanford, Inc., under the Project Hanford Management Contract. In 2006, Hanford recycled 1,115 metric tons of sanitary and hazardous wastes. Affirmative procurement at Hanford achieved 100 percent of the 2006 goal. Hanford generated 4,278 cubic meters (151,073 cubic feet) of cleanup and stabilization goal waste (i.e., LLW, MLLW, and hazardous waste) (Poston et al. 2007).

3.2.12.3 *Waste Management PEIS* Records of Decision

Decisions regarding management of the various waste types at Hanford were announced in a series of RODs following publication of the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (*Waste Management PEIS*) (DOE 1997b). The effects of these decisions for the waste types analyzed in this *TC & WM EIS* are shown in Table 3–26. The hazardous waste ROD was issued on July 30, 1998 (63 FR 41810); the HLW ROD, on August 12, 1999 (64 FR 46661); and the LLW and MLLW ROD, on February 18, 2000 (65 FR 10061). The TRU waste ROD was issued on January 20, 1998 (63 FR 3629) and modified on December 19, 2000 (65 FR 82985); July 13, 2001 (66 FR 38646); and August 27, 2002 (67 FR 56989).

Table 3–26. Preferred Treatment of Various Hanford Wastes as Stipulated in the *Waste Management PEIS* Records of Decision

Waste Type	Preferred Actions
High-level radioactive	DOE decided that Hanford should store its high-level radioactive waste on site pending the transfer of such waste to an HLW geologic repository.[a]
Low-level radioactive	DOE decided to treat Hanford's low-level radioactive waste on site. It also selected Hanford as one of the regional disposal sites for low-level radioactive waste.[b]
Mixed low-level radioactive	DOE decided to regionalize treatment of mixed low-level radioactive waste at Hanford. This entails onsite treatment of Hanford's own waste and possibly some mixed low-level radioactive waste generated at other sites. Hanford was selected as one of the regional disposal sites for mixed low-level radioactive waste.[b]
Transuranic and mixed transuranic	DOE decided that Hanford should prepare for storage and store its own transuranic waste and small quantities of transuranic waste from other sites, pending the disposal of such waste at the Waste Isolation Pilot Plant or another suitable geologic repository.[c]
Hazardous	DOE decided to continue using commercial facilities to treat Hanford's nonwastewater hazardous waste and onsite facilities to treat its wastewater hazardous waste.[d]

[a] 64 FR 46661.
[b] 65 FR 10061.
[c] 63 FR 3629, 65 FR 82985, 66 FR 38646, and 67 FR 56989.
[d] 63 FR 41810.

Key: DOE=U.S. Department of Energy; Hanford=Hanford Site; HLW=high-level radioactive waste; *Waste Management PEIS=Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste.*

According to the HLW ROD, immobilized HLW will be stored at the site of generation pending its transfer to an HLW geologic repository. As stipulated in the first TRU waste ROD, DOE will develop and operate mobile and fixed facilities to characterize TRU waste and prepare it for disposal at WIPP. Each DOE site that has or will generate TRU waste will, as needed, prepare its TRU waste for storage and store it on site. The LLW and MLLW ROD states that, for management of LLW, minimal treatment will be performed at all sites and disposal will continue, to the extent practicable, on site at INL, Los Alamos National Laboratory, the Oak Ridge Reservation (ORR), and the Savannah River Site (SRS). In addition, Hanford and the Nevada Test Site (NTS) will be available to all DOE sites for LLW disposal. MLLW will be treated at Hanford, INL, ORR, and SRS and will be disposed of at Hanford and NTS. Commercial facilities may also be used for the treatment and disposal of LLW and MLLW. The hazardous waste ROD states that most DOE sites will continue to use offsite facilities for the treatment and disposal of major portions of the nonwastewater hazardous waste, and that ORR and SRS will continue treating some of their own nonwastewater hazardous waste on site in existing facilities where this is economically favorable.

More-detailed information concerning DOE alternatives for the future configuration of waste management facilities at Hanford is presented in the *Waste Management PEIS* (DOE 1997b) and the HLW, TRU waste, hazardous waste, and LLW and MLLW RODs.

3.2.13 Spent Nuclear Fuel

The Nuclear Waste Policy Act of 1982, as amended, assigned the Secretary of Energy responsibility for developing a repository for disposal of HLW and SNF. When such a repository is available, SNF will be transferred from the various nuclear reactor sites to the repository for disposal. Until that repository is available, SNF will be stored in the reactor vessel or another acceptable containment, such as a dry cask storage system.

Several strategies for management—i.e., transportation and treatment or storage—of the SNF from FFTF have been evaluated in depth by DOE. The specific strategies and documentation thereof are as follows:

- As part of previous NEPA reviews, transportation and storage of FFTF fuel at either Hanford or INL (formerly Idaho National Engineering Laboratory) was evaluated in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995a) and ROD (60 FR 28680); the *Environmental Assessment – Shutdown of the Fast Flux Test Facility, Hanford Site, Richland Washington* (DOE 1995b) and Finding of No Significant Impact (DOE 1995c); and the *Environmental Assessment, Management of Hanford Site Non-defense Production Reactor Spent Nuclear Fuel, Hanford Site, Richland, Washington* (DOE 1997c) and Finding of No Significant Impact (DOE 1997d).

- Transportation and treatment of the FFTF sodium-bonded SNF at the Materials and Fuels Complex (MFC) was evaluated in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995a) and ROD (60 FR 28680), and the *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (DOE 2000b) and ROD (65 FR 56565).

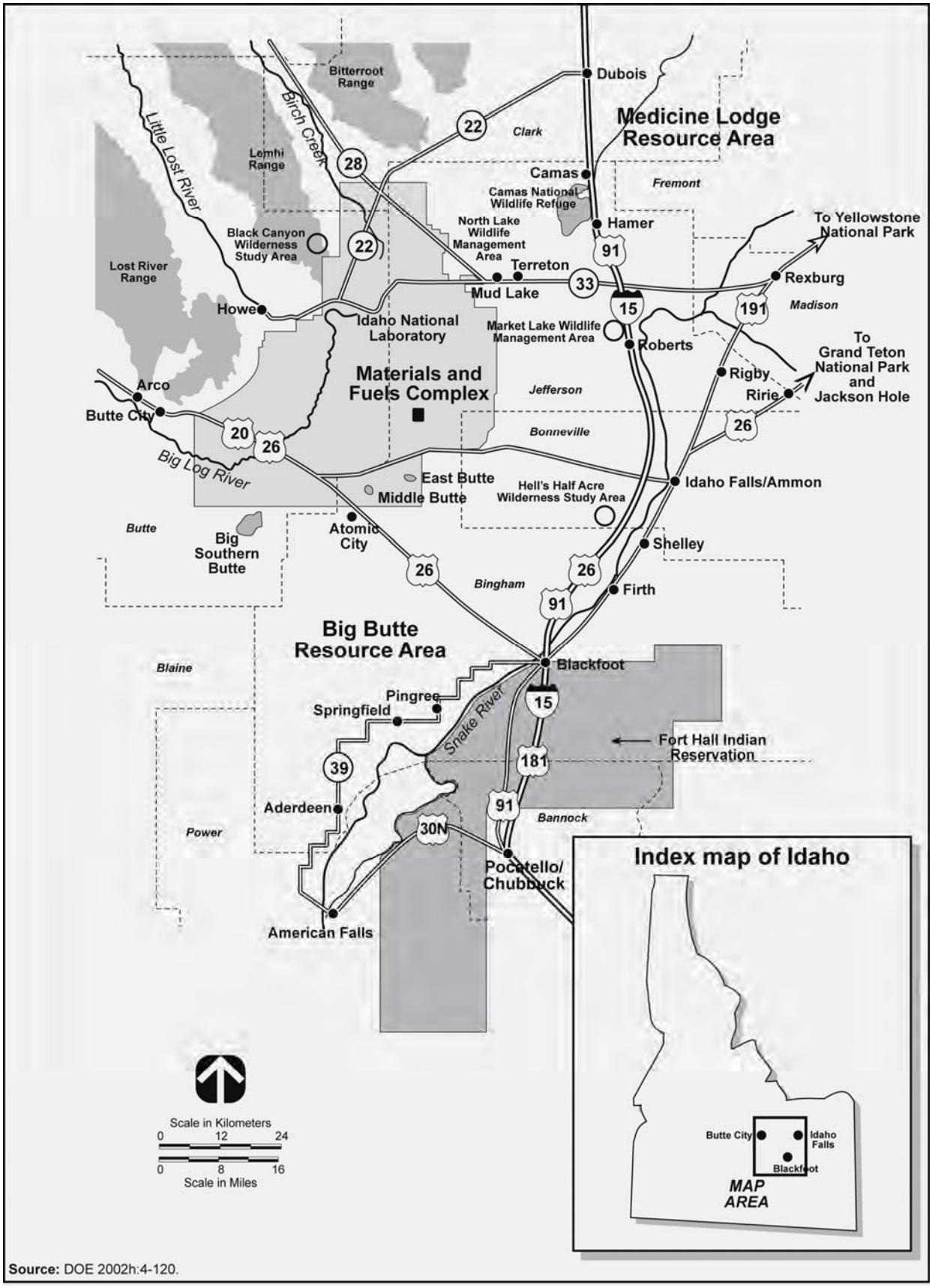
In December 2007 Hanford began to ship sodium-bonded SNF from FFTF to INL, and shipments were completed in April 2008 (Cary 2007). Since management and disposition of the FFTF fuel, including the FFTF sodium-bonded fuel, have already been addressed in the above NEPA documents (and decisions), it is not being addressed in this *TC & WM EIS*.

3.3 IDAHO NATIONAL LABORATORY

INL occupies 230,323 hectares (569,135 acres) in southeastern Idaho, the nearest boundary is 39 kilometers (24 miles) west of Idaho Falls, 40 kilometers (25 miles) northwest of Blackfoot, and 16 kilometers (10 miles) east of Arco (see Figure 3–31). Much of the current site was originally withdrawn from public domain in 1943 and commissioned by the U.S. Department of the Navy as the Naval Proving Ground. Presently INL is administered, managed, and controlled by DOE. Most of the site is within Butte County, but portions are also in Bingham, Jefferson, Bonneville, and Clark Counties. The site is roughly equidistant from Salt Lake City, Utah, and Boise, Idaho (O'Rourke 2006:4, 11).

There are 450 buildings and 2,000 support structures at INL, with more than 279,000 square meters (3 million square feet) of floor space in varying conditions of utility. INL has approximately 25,100 square meters (270,000 square feet) of covered warehouse space and an additional 18,600 square meters (200,000 square feet) of fenced yard space. The total area of the various machine shops is 3,035 square meters (32,665 square feet) (DOE 2000a:3-43).

Fifty-two research and test reactors have been used at INL over the years to test reactor systems, fuel and target design, and overall safety. One such facility, the Experimental Breeder Reactor I is a designated national historic landmark. It was the first reactor to achieve a self-sustaining chain reaction using plutonium as its principal fuel component. Various INL facilities are operated to support reactor operations. These facilities include HLW and LLW processing and storage sites; hot cells; analytical laboratories; machine shops; and laundry, railroad, and administrative facilities. Other activities include management of one of DOE's largest storage sites for LLW and TRU waste (DOE 2000a).



Source: DOE 2002h:4-120.

Figure 3–31. Idaho National Laboratory Vicinity

The MFC, located in the southeastern portion of INL, is about 61 kilometers (38 miles) west of the city of Idaho Falls. It is a testing center for advanced technologies associated with nuclear power systems and comprises 52 major buildings occupying 55,700 square meters (600,000 square feet) of floor space. Included are reactor buildings, laboratories, warehouses, technical and administrative support buildings, and craft shops (DOE 2002h). Five nuclear test reactors have operated at the MFC, although only one is currently active—a small reactor used for radiographic examination of experiments, waste containers, and SNF. Principal facilities at the MFC include the Fuel Manufacturing Facility, Assembly and Testing Facility, Transient Reactor Test Facility, Fuel Conditioning Facility, Hot Fuel Examination Facility, Zero Power Physics Reactor, and Experimental Breeder Reactor II (EBR-II).

3.3.1 Land Resources

The scope of the discussion of land resources in this *TC & WM EIS* is stipulated in Section 3.2.1.

3.3.1.1 Land Use

3.3.1.1.1 General Site Description

The Federal Government, the State of Idaho, and various private parties own lands immediately surrounding INL; BLM administers about 75 percent of the adjacent land. Regional land uses include grazing, wildlife management, mineral and energy production, recreation, and crop production (O'Rourke 2006:13). Small communities and towns near the INL boundaries include Mud Lake and Terreton to the east; Arco, Butte City, and Howe to the west; and Atomic City to the south. Two national natural landmarks border INL: Big Southern Butte (2.4 kilometers [1.5 miles] south) and Hell's Half Acre (2.6 kilometers [1.6 miles] southeast). A portion of Hell's Half Acre National Natural Landmark is designated as a Wilderness Study Area. The Black Canyon Wilderness Study Area is adjacent to INL, and the Craters of the Moon Wilderness Area is about 19 kilometers (12 miles) southwest of the site's western boundary. On November 9, 2000, the President signed a Presidential Proclamation that added 267,500 hectares (661,000 acres) to the 21,850-hectare (54,000-acre) Craters of the Moon National Monument, which encompasses this wilderness area.

Land use designations at INL include Facility Operations, Grazing, General Open Space, and Infrastructure (e.g., roads). Approximately 60 percent of the site is used for cattle and sheep grazing. Generalized land uses at INL and the surrounding vicinity are shown in Figure 3–32. Facility Operations include industrial and support operations associated with energy research and waste management activities. Land is also used for environmental research associated with the designation of INL as a National Environmental Research Park. During selected years, depredation hunts of game animals managed by the Idaho Department of Fish and Game are permitted in an area that extends 0.8 kilometers (0.5 miles) inside the INL boundary on portions of the northeastern and western borders of the site. Much of INL is open space that has not been designated for specific use. Some of this space serves as a buffer zone between INL facilities and other land uses. In 1999, 29,244 hectares (72,263 acres) of open space in the northwest corner of the site was designated as the INL Sagebrush-Steppe Ecosystem Reserve. This area represents one of the last sagebrush-steppe ecosystems in the United States and provides a home for a number of rare and sensitive species of plants and animals (O'Rourke 2006:26, 53). Approximately 2 percent of the total INL site area (4,600 hectares [11,400 acres]) is used for facilities and operations (DOE 2002h:4-123). Facilities are sited within a central core area of about 93,100 hectares (230,000 acres) (see Figure 3–32). Public access to most facilities is restricted. DOE land use plans and policies applicable to INL are discussed in the *Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report* (O'Rourke 2006).

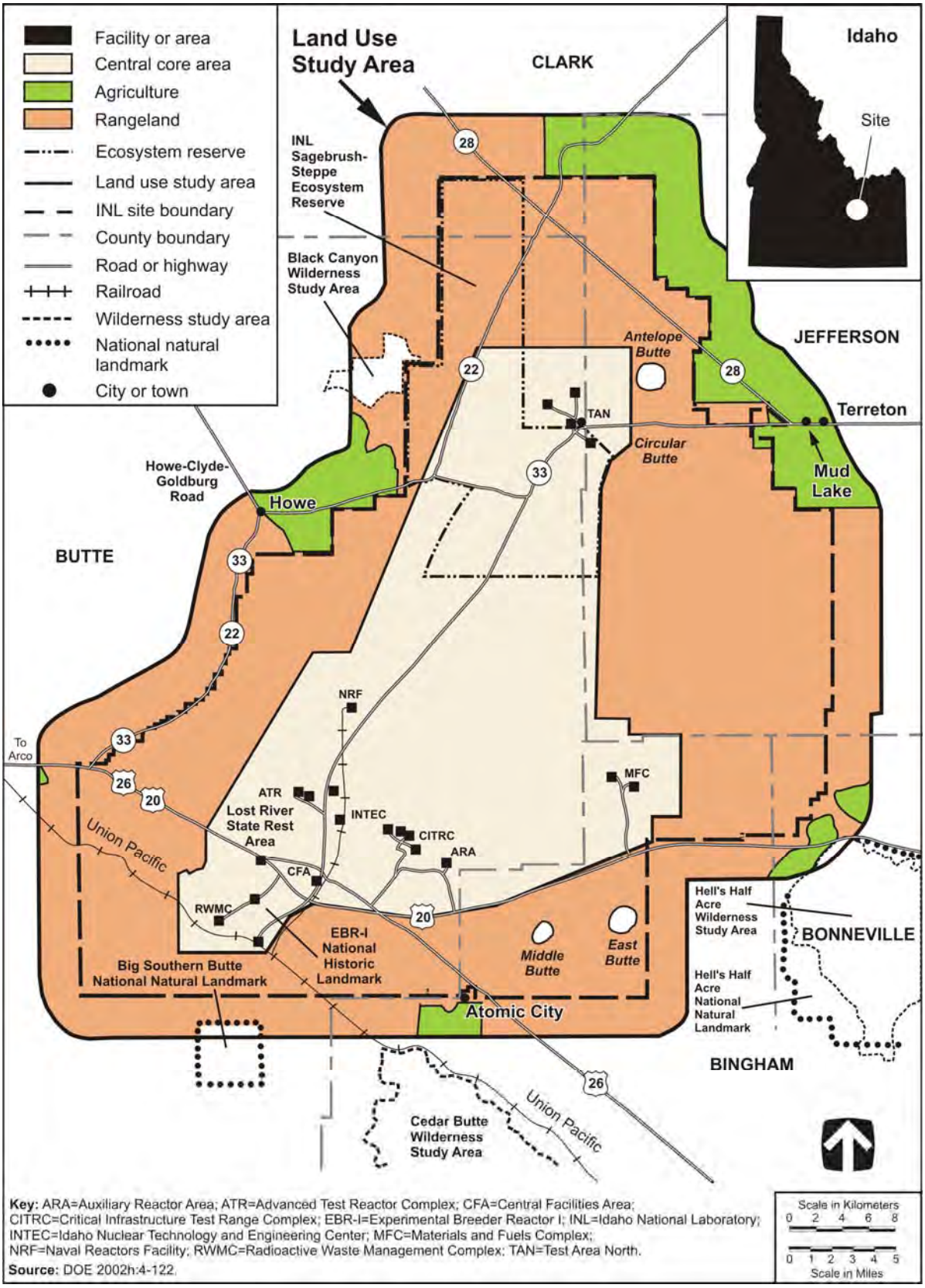


Figure 3–32. Land Use at Idaho National Laboratory and Vicinity

All county plans and policies encourage development adjacent to previously developed areas to minimize the need for infrastructure improvements and to avoid urban sprawl. Because INL is remote from most developed areas, its lands and adjacent areas are not likely to experience residential and commercial development, and no new development is planned near the site. Recreational and agricultural uses, however, are expected to increase in the surrounding area in response to greater demand for recreational areas and the conversion of rangeland to cropland (DOE 2002h:4-123).

As shown in Figure 3–31, the Fort Hall Reservation is southeast of INL. The Fort Bridger Treaty of July 3, 1868, secured this reservation as the permanent homeland of the Shoshone-Bannock Peoples. According to the treaty, tribal members reserved rights to hunting, fishing, and gathering on surrounding unoccupied lands of the United States. While INL is considered occupied land, it was recognized that certain areas of the INL site have significant cultural and religious significance to the tribes. A 1994 Memorandum of Agreement with the Shoshone-Bannock Tribes provides tribal members with access to the Middle Butte area to perform sacred or religious ceremonies or other educational or cultural activities. Further, in 2002, DOE and the Shoshone-Bannock Tribes signed an Agreement in Principle to continue to improve on the government-to-government relationship established in the Fort Bridger Treaty. This agreement also reaffirmed the Shoshone-Bannock Tribes' rights under the articles of the treaty and DOE trust responsibility to the tribes (DOE 2005a).

3.3.1.1.2 Materials and Fuels Complex

The total land area at the MFC, formerly Argonne National Laboratory-West, is 328 hectares (810 acres); however, site facilities are principally situated within about 20 hectares (50 acres), or 6 percent of the site. The MFC is 7 kilometers (4.3 miles) northwest of the nearest site boundary. Land within the fenced portion of the site has been heavily disturbed, with buildings, parking lots, and roadways occupying most areas and no natural habitat present. The Fuel Manufacturing Facility is within the main fenced portion of the site, while the Transient Reactor Test Facility is about 1.2 kilometers (0.75 miles) to the northeast. Land within the site will continue to be used for nuclear and nonnuclear scientific and engineering experiments for DOE, private industry, and academia (DOE 2002h:4-123).

3.3.1.2 Visual Resources

3.3.1.2.1 General Site Description

The Bitterroot, Lemhi, and Lost River Mountain ranges border INL on the north and west (see Figure 3–31). Volcanic buttes near the southern boundary of INL can be seen from most locations on the site. INL generally consists of open desert land covered by big sagebrush and grasslands. Uncultivated grazing range borders much of the site. There are a number of facility areas located throughout INL. Although INL has prepared a comprehensive land use and environmental stewardship plan, no specific visual resource standards have been established (O'Rourke 2006). INL facilities have the appearance of low-density commercial/industrial complexes that are widely dispersed throughout the site. Structure heights generally range from 3 to 30 meters (10 to 100 feet); a few stacks and towers reach 76 meters (250 feet). Although many INL facilities are visible from highways, most are more than 0.8 kilometers (0.5 miles) from public roads (DOE 2000a:3-46). The operational areas are well defined at night by security lights. Such light pollution is a key element of the nighttime visual environment surrounding INL facility complexes. However, given the distances between INL facility complexes across the site and the distances from public areas to INL facilities, this light does not substantially impair offsite visual observation of celestial features.

Public lands adjacent to INL are under BLM jurisdiction and have a VRM Class II rating. Undeveloped lands within INL have a VRM rating consistent with Classes II and III. Management activities within these classes may be seen, but should not dominate the view. The VRM class rating of developed areas

of the site is consistent with Class IV, indicating that management activities dominate the view and are the focus of viewer attention (BLM 1986:6, 7). The Black Canyon Wilderness Study Area adjacent to INL is under consideration by BLM for Wilderness Area designation. The Hell's Half Acre Wilderness Study Area is located 2.6 kilometers (1.6 miles) southeast of INL's eastern boundary. This area, famous for its lava flow and hiking trails, also is managed by BLM. The Craters of the Moon Wilderness Area is approximately 19 kilometers (12 miles) southwest of INL's western boundary (DOE 2000a:3-46).

3.3.1.2.2 Materials and Fuels Complex

Developed areas within the MFC are consistent with a VRM Class IV rating. The tallest structure at the MFC is the Fuel Conditioning Facility stack, which is 61 meters (200 feet) in height. The site is visible from U.S. Route 20. Facilities that stand out from the highway include the Transient Reactor Test Facility, Hot Fuel Examination Facility, EBR-II containment shell, and Zero Power Physics Reactor. Natural features of visual interest within a 40-kilometer (25-mile) radius of the MFC include East Butte at 9 kilometers (5.6 miles), Middle Butte at 11 kilometers (6.8 miles), Hell's Half Acre National Natural Landmark and Hell's Half Acre Wilderness Study Area at 15 kilometers (9.3 miles), Big Lost River at 19 kilometers (11.8 miles), and Big Southern Butte National Natural Landmark at 30 kilometers (18.6 miles) (DOE 2002h:4-124).

3.3.2 Infrastructure

The scope of the discussion of infrastructure in this *TC & WM EIS* is stipulated in Section 3.2.2. Characteristics of INL's utility and transportation infrastructure are described below and are summarized in Table 3–27. Section 3.3.9.4 provides further discussion of the local transportation infrastructure, and Section 3.3.12, a description of the site's waste management infrastructure.

Table 3–27. Idaho National Laboratory Sitewide Infrastructure Characteristics

Resource	Usage	Capacity
Transportation		
Roads (kilometers)	140[a]	N/A
Railroads (kilometers)	23	N/A
Electricity		
Energy (megawatt-hours per year)	159,767[b]	481,800
Peak load (megawatts)	36	55
Fuel		
Natural gas (cubic meters per year)	510,000[b]	N/A
Fuel oil (heating) (liters per year)	9,080,000[b]	(c)
Diesel fuel (liters per year)	2,050,000[b]	(c)
Gasoline (liters per year)	1,475,000[b]	(c)
Propane (liters per year)	577,000[b]	(c)
Water (liters per year)	4,200,000,000[b]	43,000,000,000[d]

[a] Includes asphalt-paved roads only.
[b] Average value for fiscal years 2001 through 2004.
[c] Limited only by the ability to ship resources to the site.
[d] Water right allocation.

Note: To convert kilometers to miles, multiply by 0.6214; cubic meters to cubic feet, multiply by 35.315; liters to gallons, by 0.26417.

Key: N/A=not applicable.

Source: DOE 2002a:4-65, 4-79, 2002h:4-124, 4-125, 2005b:90, 91.

3.3.2.1 Ground Transportation

3.3.2.1.1 General Site Description

Two interstate highways serve the INL regional area. Interstate 15, a north-south route that connects several cities along the Snake River, is approximately 40 kilometers (25 miles) east of INL. Interstate 86 intersects Interstate 15 approximately 64 kilometers (40 miles) south of INL and provides a primary linkage from Interstate 15 to points west. Interstate 15 and U.S. Route 91 are the primary access routes to the Shoshone-Bannock Reservation. U.S. Routes 20 and 26 are the main access routes to the southern portion of INL and the MFC (see Figure 3–32). Idaho State Routes 22, 28, and 33 pass through the northern portion of INL, and State Route 33 provides access to the northern INL facilities. The road network at INL provides for onsite ground transportation. From the 444 kilometers (276 miles) of roads on the site, about 140 kilometers (87 miles) of non-public paved surface roads have been developed (see Table 3–27). Most of the roads are adequate for the current level of normal transportation activity and could handle increased traffic volume (DOE 2002a:4-64).

The Union Pacific Railroad enters the southern portion of INL and provides rail service to the site. This branch connects with a DOE spur line at Scoville Siding, then links with developed areas within INL. There are 23 kilometers (14 miles) of railroad track at INL. Rail shipments to and from INL usually are limited to bulk commodities, SNF, and radioactive waste (DOE 2002a:4-65, 4-66).

3.3.2.1.2 Materials and Fuels Complex

The MFC can be accessed from U.S. Routes 20 and 26. A 4.8-kilometer-long (3-mile-long) paved road from U.S. Route 20 provides direct access to the MFC. No physical barriers are on the access road; however, signs indicate that access is restricted to official business, and the road can be easily blocked by security personnel. The site is also surrounded by 2 security fences for additional access control (ANL 2003:2).

3.3.2.2 Electricity

3.3.2.2.1 General Site Description

DOE presently contracts with the Idaho Power Company to supply electric power to INL. The contract allows for power demand of up to 45 megawatts, which can be increased to 55 megawatts by notifying Idaho Power in advance. Power demand above 55 megawatts is possible, but would have to be negotiated with the company (DOE 2002a:4-79). Power is generated by hydroelectric facilities along the Snake River in southern Idaho, and by large coal-fired, thermal-electric generating plants in southwestern Wyoming and northern Nevada. This power is supplied to INL through the Antelope substation, which is owned and maintained by Rocky Mountain Power. Power can be supplied to the Antelope substation from any of three sources: (1) through the Idaho Power 230-kilovolt Antelope line; (2) from Northwestern Energy (formerly Montana Power Company) through the Rocky Mountain Power 230-kilovolt Antelope-to-Anaconda line; and (3) through the Rocky Mountain Power 161-kilovolt Goshen-to-Antelope line. The Antelope substation transmits power through two 138-kilovolt lines to the Scoville substation 138-kilovolt bus (at the Central Facilities Area substation), which is the origin of the site's distribution system (ANL 2003:7). The INL transmission system is a 138-kilovolt, 105-kilometer (65-mile) dual-loop configuration that encompasses seven substations where the power is reduced to distribution voltages for use at the various INL facilities. The loop allows for a redundant power feed to all substations and facilities (ANL 2003:7; DOE 2002a:4-79).

Site electrical energy availability is about 481,800 megawatt-hours per year given the contract load limit of 55 megawatts (DOE 2002a:4-79) for 8,760 hours per year. Total INL electrical energy consumption averages 159,767 megawatt-hours annually (DOE 2005b:90). The recorded peak load for INL was about

36 megawatts (DOE 2002a:4-79); the contract-limited peak load capacity is 55 megawatts (see Table 3–27).

3.3.2.2.2 Materials and Fuels Complex

Electric power for the MFC is distributed via the EBR-II substation (ANL 2003:7). The MFC uses about 28,700 megawatt-hours of electricity annually (DOE 2002h:4-125).

3.3.2.3 Fuel

3.3.2.3.1 General Site Description

Fuel consumed at INL includes natural gas, fuel oil (heating fuel), diesel fuel, gasoline, and propane. All fuels are transported to the site for use and storage. Fuel storage is provided for each facility, and the inventories are restocked as necessary (DOE 2002h:4-125). INL sitewide fuel oil consumption averages 9.08 million liters (2.4 million gallons) annually (based on data for fiscal years 2001 through 2004), while natural gas consumption averages 510,000 cubic meters (18 million cubic feet) per year. Total diesel fuel consumption averages 2.05 million liters (541,500 gallons); total gasoline consumption, 1.475 million liters (389,700 gallons); and total propane consumption, 577,000 liters (152,400 gallons) annually (see Table 3–27) (DOE 2005b:91).

3.3.2.3.2 Materials and Fuels Complex

Fuel oil is used in four boilers at the MFC for heat and hot water. Total use is about 2 million liters (549,000 gallons) per year, down from a peak of 2.5 million liters (657,000 gallons) in 1995. Fuel oil usage varies with the severity of the winters (DOE 2002i:3-37). Natural gas is not available at the MFC.

3.3.2.4 Water

3.3.2.4.1 General Site Description

The Snake River Plain Aquifer is the source of all water used at INL. The water is provided by a system of about 30 wells, together with pumps and storage tanks. That system is administered by DOE, which holds the Federal Reserved Water Right of 43 billion liters (11.4 billion gallons) per year for the site (DOE 2002h:4-125). INL sitewide groundwater production and usage is approximately 4,200 million liters (1,100 million gallons) annually (see Table 3–27) (DOE 2005b:90).

3.3.2.4.2 Materials and Fuels Complex

The MFC water supply and distribution system is a combined fire-protection, potable, and service water system supplied via two onsite deep production wells. These deep wells (EBR-II No. 1 and EBR-II No. 2) have a pumping capacity of 3,400 liters (900 gallons) per minute or 1,790 million liters (473 million gallons) annually. Well water is pumped to a 757,000-liter (200,000-gallon) primary storage tank and then through the distribution system for its varied uses. A second 1,514,000-liter (400,000-gallon) water storage tank is reserved for fire protection and maintained at full capacity. The deep wells can be valved to either storage tank or directly to the distribution system. Currently, the MFC's water demand and usage from its two production wells is approximately 182 million liters (48 million gallons) annually (ANL 2003:7, 8).

3.3.3 Noise and Vibration

3.3.3.1 General Site Description

Major noise sources within INL include various industrial machines and equipment (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Most INL industrial facilities are far enough from the site boundary that noise levels from these sources are not measurable or are barely distinguishable from background noise levels at that boundary.

Existing INL-related noises of public significance result from the transportation of people and materials to and from the site and in-town facilities via buses, trucks, private vehicles, and freight trains. Noise measurements along U.S. Route 20, about 15 meters (50 feet) from the roadway, indicate that traffic sound levels range from 64 to 86 dBA, and that the primary source is buses (71 to 80 dBA). While few people reside within 15 meters (50 feet) of the roadway, INL traffic noise might be objectionable to members of the public residing near principal highways or busy bus routes. Noise levels along these routes may have decreased somewhat with reductions in employment and bus service at INL over the last few years. The acoustic environment along the INL site boundary is typical of a rural location removed from traffic noise; the average day-night sound level is in the range of 35 to 50 dBA. Playas and remote lava flows at INL are exposed to low ambient sound levels in the range of 35 to 40 dBA (Leonard 1993:3-18–3-21). Except for the prohibition of nuisance noise, neither the State of Idaho nor local governments have established regulations that specify acceptable community noise levels applicable to INL. The EPA guidelines for environmental noise protection recommend an average day-night sound level limit of 55 dBA to protect the public from the effects of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974:21, 29). Land use compatibility guidelines adopted by the Federal Aviation Administration and the Federal Interagency Committee on Urban Noise indicate that annual day-night average sound levels less than 65 dBA are compatible with residential land uses (14 CFR 150). These guidelines further indicate that levels up to 75 dBA are compatible with residential uses if suitable noise reduction features are incorporated into structures. It is expected that, for most residences near INL, day-night average sound levels are compatible with residential land use, although noise levels may be higher than 65 dBA for some residences along major roadways.

3.3.3.2 Materials and Fuels Complex

No distinguishing noise characteristics at the MFC have been identified. The MFC is 7 kilometers (4.3 miles) from the nearest site boundary, so the contribution from the area to noise levels at the site boundary is unmeasurable (DOE 2002h).

3.3.4 Air Quality

The scope of the discussion of air quality in this *TC & WM EIS* is stipulated in Section 3.2.4.

3.3.4.1 Nonradiological Releases

3.3.4.1.1 General Site Description

The climate at INL and the surrounding region is characterized as that of a semiarid steppe. The average annual temperature at INL (at the Central Facilities Area) is 5.6 °C (42 °F); average monthly temperatures range from a minimum of -8.8 °C (16.1 °F) in January to a maximum of 20 °C (68 °F) in July. The average annual precipitation is 22 centimeters (8.7 inches) (Clawson, Start, and Ricks 1989:55, 77). Prevailing winds at INL are southwest or northeast (DOE 1999c:4.7-1). The annual average windspeed is 3.4 meters per second (7.5 miles per hour) (DOE 1996a:3-112). Figures 3–33 and 3–34 show wind roses for the meteorological station at the MFC at 10-meter (33-foot) and 75-meter (250-foot) elevations,

respectively, for the period 1997 through 2006. Applicable NAAQS and Idaho State ambient air quality standards are presented in Table 3–28.

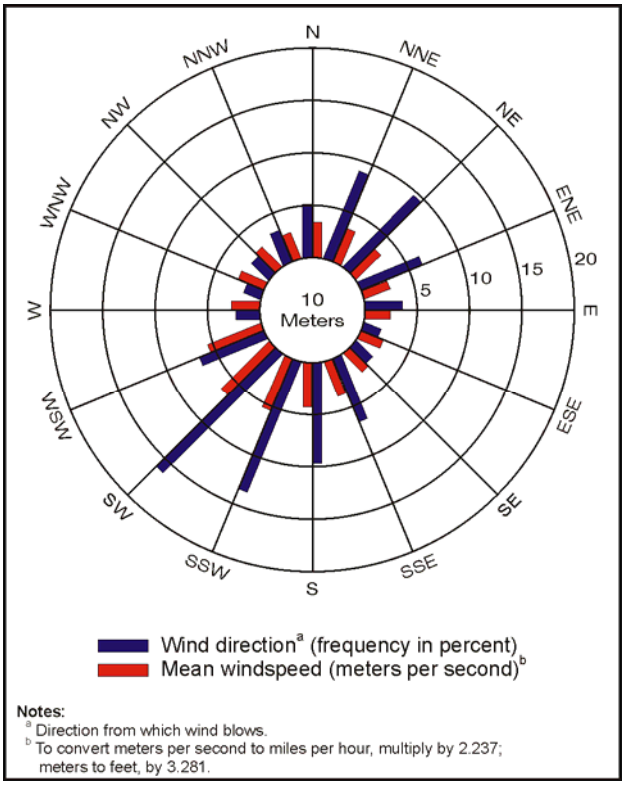


Figure 3–33. Wind Rose for the Materials and Fuels Complex Meteorological Station at Idaho National Laboratory, 1997–2006 (10-meter elevation)

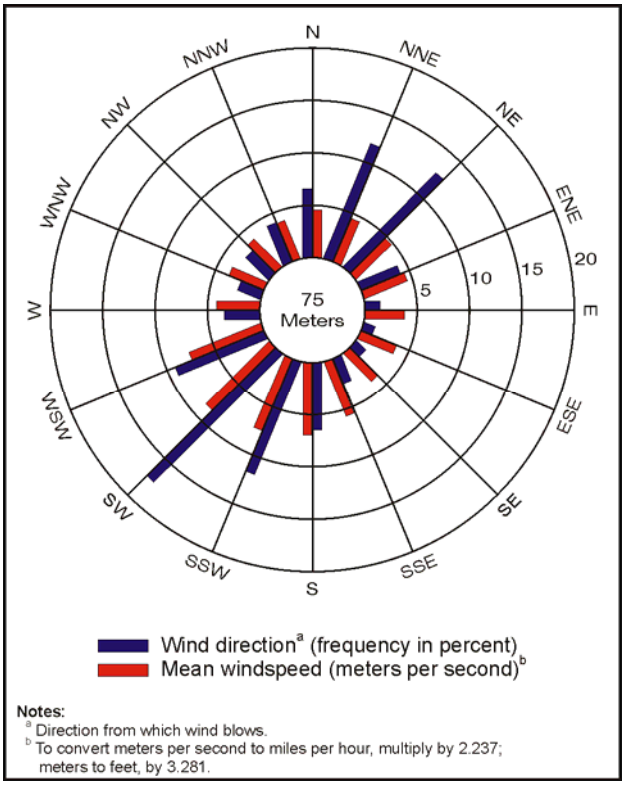


Figure 3–34. Wind Rose for the Materials and Fuels Complex Meteorological Station at Idaho National Laboratory, 1997–2006 (75-meter elevation)

The primary source of air pollutants at INL is the combustion of fuel oil for heating. Other emission sources include waste burning, industrial processes, stationary diesel engines, vehicles, and fugitive dust from waste burial and construction activities. Emissions for 2006 are presented in Table 3–29.

Routine offsite monitoring of nonradiological air pollutants is generally performed only for PM and nitrogen oxide. Monitoring for PM_{10} is performed at the site boundary and at communities beyond the boundary. In 2005, 61 samples were collected at Rexburg about 52 kilometers (32 miles) east of the site. The concentrations at Rexburg then ranged from 0 to 44.8 micrograms per cubic meter. Sixty 24-hour samples were collected at Blackfoot, with concentrations ranging from 0.07 to 42.4 micrograms per cubic meter. Fifty-nine 24-hour samples were collected at Atomic City, with concentrations ranging from 0.1 to 52.5 micrograms per cubic meter. All concentrations at these monitors were below the ambient standard (DOE 2006:4.24).

Monitoring for nitrogen dioxide has not been performed at onsite locations since 2003 (DOE 2006:3.5). In 2003 quarterly mean concentrations at the Van Buren Boulevard location ranged from 2.9 to 3.9 parts per billion (ppb), with an annual mean of 3.5 ppb. Quarterly means at the Experimental Field Station, determined from two quarters of data, ranged from 7.4 to 10.7 ppb, with a mean concentration of 9.1 ppb. The mean concentrations were well below the ambient standard of 54 ppb (DOE 2004:4.22).

Table 3–28. Modeled Nonradiological Ambient Air Pollutant Concentrations from Idaho National Laboratory Sources and Ambient Air Quality Standards

Pollutant	Averaging Period	More Stringent Standard[a]	INL Concentration[b]
		(micrograms per cubic meter)	
Carbon monoxide	8 hours	10,000[c]	71
	1 hour	40,000[c]	350
Lead	Quarterly	1.5[c]	0.0081
Nitrogen dioxide	Annual	100[c]	2.3
Ozone	8 hours	147[d]	(e)
	1 hour	235[f]	(e)
PM_{10}	Annual	50[f, g]	1.3
	24 hours	150[c]	20
$PM_{2.5}$	Annual	15[d]	1.3
	24 hours	35[d, g]	20[h]
Sulfur dioxide	Annual	80[c]	4.5
	24 hours	365[c]	32
	3 hours	1,300[c]	140

[a] The more stringent of the Federal and state standards is presented if both exist for the averaging period. National Ambient Air Quality Standards (40 CFR 50), other than those for ozone, particulate matter, and lead, and pollutants averaged annually, are not to be exceeded more than once per year. The annual arithmetic mean $PM_{2.5}$ standard is attained when the expected annual arithmetic mean concentration (3-year average) is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 98th percentile over 3 years of 24-hour average concentrations is less than or equal to the standard value. The 24-hour PM_{10} standard is met when the 99th percentile over 3 years of 24-hour concentrations is less than or equal to the standard value.

[b] Includes contributions from existing INL facilities with actual 1997 emissions, plus reasonably foreseeable sources such as the Advanced Mixed Waste Treatment Project and CPP-606 steam production boilers.

[c] Federal and state standard.

[d] Federal standard.

[e] Not directly emitted or monitored by the site.

[f] State standard.

[g] The U.S. Environmental Protection Agency recently revoked the annual PM_{10} standard and changed the 24-hour standard from 65 to 35 micrograms per cubic meter.

[h] Assumed to be the same as the concentration of PM_{10} because there are no specific data for $PM_{2.5}$.

Note: The State of Idaho also has ambient standards for fluorides. To convert cubic meters to cubic feet, multiply by 35.315.

Key: INL=Idaho National Laboratory; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: 40 CFR 50; 71 FR 61144; DOE 2002a:C.2-43; IDAPA 58.01.01.577.

Table 3–29. Air Pollutant Emissions at Idaho National Laboratory in 2006

Pollutant	Sources Other Than Materials and Fuels Complex	Materials and Fuels Complex
	(metric tons per year)	
Nitrogen dioxide	67	5.3
PM_{10}	2.5	0.27
Sulfur dioxide	7.1	1.9
Volatile organic compounds	1.8	0.05

Key: PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers.

Source: Depperschmidt 2007.

Some monitoring data have also been collected by the National Park Service at the Craters of the Moon Wilderness Area. The monitoring program has shown no exceedances of the 1-hour ozone standard, although there was some degradation in concentrations between 1993 and 2002 (NPS 2003:5). Concentrations in 2006 were about 50 percent of the ambient standard for 1-hour values and less than 60 percent of the 8-hour standard (EPA 2007). During the period of $PM_{2.5}$ monitoring, concentrations ranged from 0.409 to 25.1 micrograms per cubic meter (Johnson 2006:4.25).

3.3.4.1.2 Materials and Fuels Complex

The existing ambient air concentrations attributable to sources at INL, including the MFC, are presented in Table 3–28. These concentrations are based on dispersion modeling at the INL site boundary and public roads. The modeled pollutant concentrations presented in the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* for assessing cumulative impacts were adapted as a baseline. Sources considered included existing INL facilities with actual 1997 emissions, plus reasonably foreseeable sources such as the Advanced Mixed Waste Treatment Project (AMWTP) and the CPP-606 steam production boilers. To account for the contribution of the CPP-606 boilers, the cumulative concentrations for the Continued Operation Alternative evaluated in the aforementioned EIS were used as the baseline (DOE 2002a:C.2-43). Concentrations shown in Table 3–28 represent a small percentage of those established as ambient air quality standards. Given these limited contributions from INL sources and low background concentrations of criteria pollutants, it may be concluded that INL emissions should not result in air pollutant concentrations that violate the ambient air quality standards.

EPA has established PSD increments for certain pollutants such as sulfur dioxide, nitrogen dioxide, and PM. The increments specify a maximum allowable increase above a certain baseline concentration for a given averaging period and apply only to sources constructed or modified after a specified baseline date. These sources are known as increment-consuming sources, and the baseline date is the date of submittal of the first application for a PSD permit in a given area. Increment consumption for the CPP-606 boilers, for example, was analyzed in connection with its PSD permit application for INL (DOE 2002a).

EPA has also established PSD area classifications distinguished in terms of allowable increases in pollution. A PSD Class I area, for example, is one in which very little increase in pollution is allowed due to the pristine nature of the area; a Class II area, one in which moderate increases in pollution are allowed. The PSD Class I area nearest to INL is the Craters of the Moon Wilderness Area in Idaho, 53 kilometers (33 miles) west-southwest of the center of the site. There are no other Class I areas within 100 kilometers (62 miles) of INL. INL and its vicinity are classified as a Class II area. Current PSD increment consumptions in these Class I and Class II areas are stipulated in Tables 3–30 and 3–31, respectively.

Table 3–30. PSD Increment Consumption at Craters of the Moon Wilderness Area (Class I) by Existing (1996) and Projected Sources Subject to PSD Regulation

Pollutant	Averaging Period	Allowable PSD Increment[a]	Amount of PSD Increment Consumed
		(micrograms per cubic meter)	
Nitrogen dioxide	Annual	2.5	0.27
Respirable particulates[b]	Annual 24 hours	4 8	0.032 0.61
Sulfur dioxide	Annual 24 hours 3 hours	2 5 25	0.23 3.4 11

[a] All increments specified are State of Idaho standards (IDAPA 58.01.01.581).

[b] Data on particulate size are not available for most sources. For purposes of increment comparisons, however, it is conservatively assumed that all particulates emitted are of respirable size (i.e., 10 micrometers or less in diameter).

Note: Estimated increment consumption includes existing Idaho National Laboratory sources that are subject to PSD regulations, as well as the Idaho Nuclear Technology and Engineering Center CPP-606 boilers. Increment consumption was modeled using the CALPUFF model in screening mode. To convert cubic meters to cubic feet, multiply by 35.315.

Key: PSD=Prevention of Significant Deterioration.

Source: DOE 2002a:4–37.

Table 3–31. PSD Increment Consumption at Idaho National Laboratory Class II Areas by Existing (1996) and Projected Sources Subject to PSD Regulation

Pollutant	Averaging Period	Allowable PSD Increment[a]	Amount of PSD Increment Consumed
		(micrograms per cubic meter)	
Nitrogen dioxide	Annual	25	8.8
Respirable particulates[b]	Annual 24 hours	17 30	0.53 10
Sulfur dioxide	Annual 24 hours 3 hours	20 91 512	3.6 27 120

[a] All increments specified are State of Idaho standards (IDAPA 58.01.01.581).

[b] Data on particulate size are not available for most sources. For purposes of increment comparisons, however, it is conservatively assumed that all particulates emitted are of respirable size (i.e., 10 micrometers or less in diameter).

Note: Estimated increment consumption includes existing Idaho National Laboratory sources that are subject to PSD regulations, as well as the Idaho Nuclear Technology and Engineering Center CPP-606 boilers. Class II increment consumption was modeled using the ISCST3 dispersion model. To convert cubic meters to cubic feet, multiply by 35.315.

Key: PSD=Prevention of Significant Deterioration.

Source: DOE 2002a:4–38.

3.3.4.2 Radiological Releases

Primary releases of radiological air pollutants at INL and localized releases at the MFC are presented in Table 3–32. During 2006 an estimated 6,340 curies of radioactivity were released to the atmosphere from all INL sources. About 19 percent of this amount was from the MFC and about 22 percent from the Reactor Technology Complex (RTC). Approximately 57 percent was released from the Idaho Nuclear Technology and Engineering Center (INTEC) (DOE 2007d:4.5–4.9).

Routine monitoring for radiological air pollutants is performed at locations within, around, and distant from INL. The monitors are operated by the management and operations contractor and the environmental surveillance, education, and research contractor. The monitoring network maintained by the managing and operating contractor includes 17 onsite locations and 4 distant locations. The network maintained by the environmental surveillance, education, and research contractor includes 3 onsite

locations, 8 boundary locations, and 6 distant locations. The distant monitors are as far away as Jackson, Wyoming (175 kilometers [100 miles] east), and Craters of the Moon National Monument (50 kilometers [31 miles] west southwest). These monitoring programs and recent results of are described in Chapter 4 of the *Idaho National Laboratory Site Environmental Report, Calendar Year 2006* (DOE 2007d:4.15).

Table 3–32. Airborne Radiological Releases to the Environment at Idaho National Laboratory in 2006

Emission Type	Radionuclide[a]	Materials and Fuels Complex	Other Facilities[b]	Total
		(curies)		
Gases	Argon-41	1.52	5.40×10^{2}	5.42×10^{2}
	Krypton-85	1.22×10^{3}	3.20×10^{3}	4.42×10^{3}
Carbon-14, iodine, and hydrogen-3 (tritium) isotopes	Carbon-14	–	9.41×10^{-1}	9.41×10^{-1}
	Iodine-129	–	5.04×10^{-2}	5.04×10^{-2}
	Hydrogen-3 (tritium)	8.51	9.91×10^{2}	1.00×10^{3}
Airborne particulates	Americium-241	–	2.10×10^{-4}	2.10×10^{-4}
	Cesium-137	–	2.53×10^{-1}	2.53×10^{-1}
	Cobalt-60	–	2.15×10^{-2}	2.15×10^{-2}
	Neptunium-237	–	8.25×10^{-6}	8.25×10^{-6}
	Plutonium-238	–	2.01×10^{-4}	2.01×10^{-4}
	Plutonium-239	–	1.09×10^{-3}	1.09×10^{-3}
	Plutonium-240	–	4.58×10^{-4}	4.58×10^{-4}
	Plutonium-241	–	1.30×10^{-2}	1.30×10^{-2}
	Sodium-24	–	1.58×10^{-4}	1.58×10^{-4}
	Strontium-90[c]	6.09×10^{-6}	5.46×10^{-2}	5.46×10^{-2}
	Technetium-99	–	1.37×10^{-7}	1.37×10^{-7}
	Uranium-233	–	6.41×10^{-5}	6.41×10^{-5}
	Uranium-234	–	2.49×10^{-4}	2.49×10^{-4}
	Uranium-235	–	3.46×10^{-5}	3.46×10^{-5}
	Uranium-238	–	2.65×10^{-4}	2.65×10^{-4}
Other radionuclides		–	3.77×10^{2}	3.77×10^{2}
Total Releases		**1.23×10^{3}**	**5.11×10^{3}**	**6.34×10^{3}**

[a] Values are not corrected for decay after release.

[b] Includes the Central Facilities Area, Idaho Nuclear Technology and Engineering Center, Critical Infrastructure Test Range, Radioactive Waste Management Complex, Test Area North, Reactor Technology Complex, and Naval Reactors Facility.

[c] Parent-daughter equilibrium assumed.

Note: Dashed lines indicate virtually no releases.
Source: DOE 2007d:4.5–4.9.

3.3.5 Geology and Soils

The scope of the discussion of geology and soils in this *TC & WM EIS* is stipulated in Section 3.2.5.

3.3.5.1 General Site Description

3.3.5.1.1 Physiography and Structural Geology

INL occupies a rather flat area on the northwestern edge of the Eastern Snake River Plain, which is part of the Eastern Snake River Plain Physiographic Province. The area consists of a broad plain built up from the eruptions of multiple flows of basaltic lava over the past 4 million years. Four northwest-trending volcanic rift zones that cut across the Eastern Snake River Plain have been identified as the source areas for the most recent basaltic eruptions that occurred between 2,100 and 4 million years ago. The Eastern

Snake River Plain is bounded on the north and south by the north-to-northwest-trending mountains of the northern Basin and Range Physiographic Province, with peaks up to 3,660 meters (12,000 feet) in height that are separated by intervening basins filled with terrestrial sediments and volcanic rocks. The peaks are sharply separated from the intervening basins by late Tertiary to Quaternary normal faults. The basins are 5 to 20 kilometers (3 to 12 miles) wide and grade onto the Eastern Snake River Plain. Several northwest-trending front-range faults have been mapped in the immediate vicinity of INL. To the northeast, the Eastern Snake River Plain is bounded by the Yellowstone Plateau (ANL 2003:15, 16, 18; DOE 2002a:4-20, 4-21, 4-23). Figure 3–35 shows the major geologic features of INL and the vicinity.

The Yellowstone Plateau is a high volcanic plateau underlain by Pleistocene rhyolitic volcanic rock. Its elevation of about 2,100 to 2,600 meters (6,900 to 8,500 feet) is significantly higher than that of the Eastern Snake River Plain, but not as high as the mountain summits of the northern Basin and Range Province. The plateau is characterized by extremely high heat flow; very high temperatures at shallow depths, abundant hot-spring and geyser activity, and landforms controlled by thick rhyolitic lava flows. These characteristics reflect the recent volcanic activity in the area, spanning from several tens of thousands to 2 million years ago (ANL 2003:16).

The mountains northwest of the Eastern Snake River Plain and near INL are composed of thick sequences of late Precambrian through Pennsylvanian sedimentary strata, mostly limestones. They occurred within westward-dipping thrust sheets that formed during Mesozoic Era east-directed compression. The Eastern Snake River Plain formed as a result of interaction of the North American tectonic plate with a rising plume and hot mantle rocks, the so-called Yellowstone Hotspot. As the North American plate moved southwestward, its interaction with the hotspot produced the low-elevation, low-relief volcanic province that is the Eastern Snake River Plain. The crust of the INL area was directly above the hotspot about 4.3 to 6.5 million years ago (ANL 2003:16, 17).

The Arco Segment of the Lost River Fault is mapped as ending about 7 kilometers (4.3 miles) from the INL boundary. The Howe Segment of the Lemhi Fault ends near the northwest boundary of the site (see Figure 3–35). Both segments are considered capable or potentially active (DOE 2002h:4-130). A capable fault is one that has had movement at or near the surface at least once within the past 35,000 years or recurrent movement within the past 500,000 years (10 CFR 100).

3.3.5.1.2 Stratigraphy

The upper 1 to 2 kilometers (0.6 to 1.2 miles) of the crust beneath INL is composed of a sequence of Quaternary (recent to 2 million years old) basalt lava flows and poorly consolidated sedimentary interbeds that are collectively called the Snake River Group. The lava flows at the surface range from 2,100 to 2 million years old (DOE 2002a:4-20, 2002h:4-130). The sediments are composed of fine-grained silts that were deposited by wind; silts, sands, and gravels deposited by streams; and clays, silts, and sands deposited in lakes such as Mud Lake and its much larger ice-age predecessor, Lake Terreton. The accumulation of these materials in the Eastern Snake River Plain resulted in the observed sequence of interlayered basalt lava flows and sedimentary interbeds. Basaltic volcanism on the Eastern Snake River Plain has been a sporadic process. During the long periods of inactivity between volcanic events, sediments accumulated to thicknesses of less than 1 meter (3.3 feet) to greater than 60 meters (197 feet). During short periods of volcanic activity, several lava flows commonly accumulated to thicknesses reaching several tens of meters. Basalt lava flows were erupted from vents concentrated in the four volcanic rift zones and along the central axis of the Eastern Snake River Plain (the Axial Volcanic Rift Zone) (see Figure 3–35). The basalts, along with intercalated sediments, are underlain by a great thickness of rhyolitic volcanic rocks that erupted when the area was over the Yellowstone Hotspot more than 4 million years ago (ANL 2003:18). Figure 3–36 depicts the general stratigraphy beneath INL.

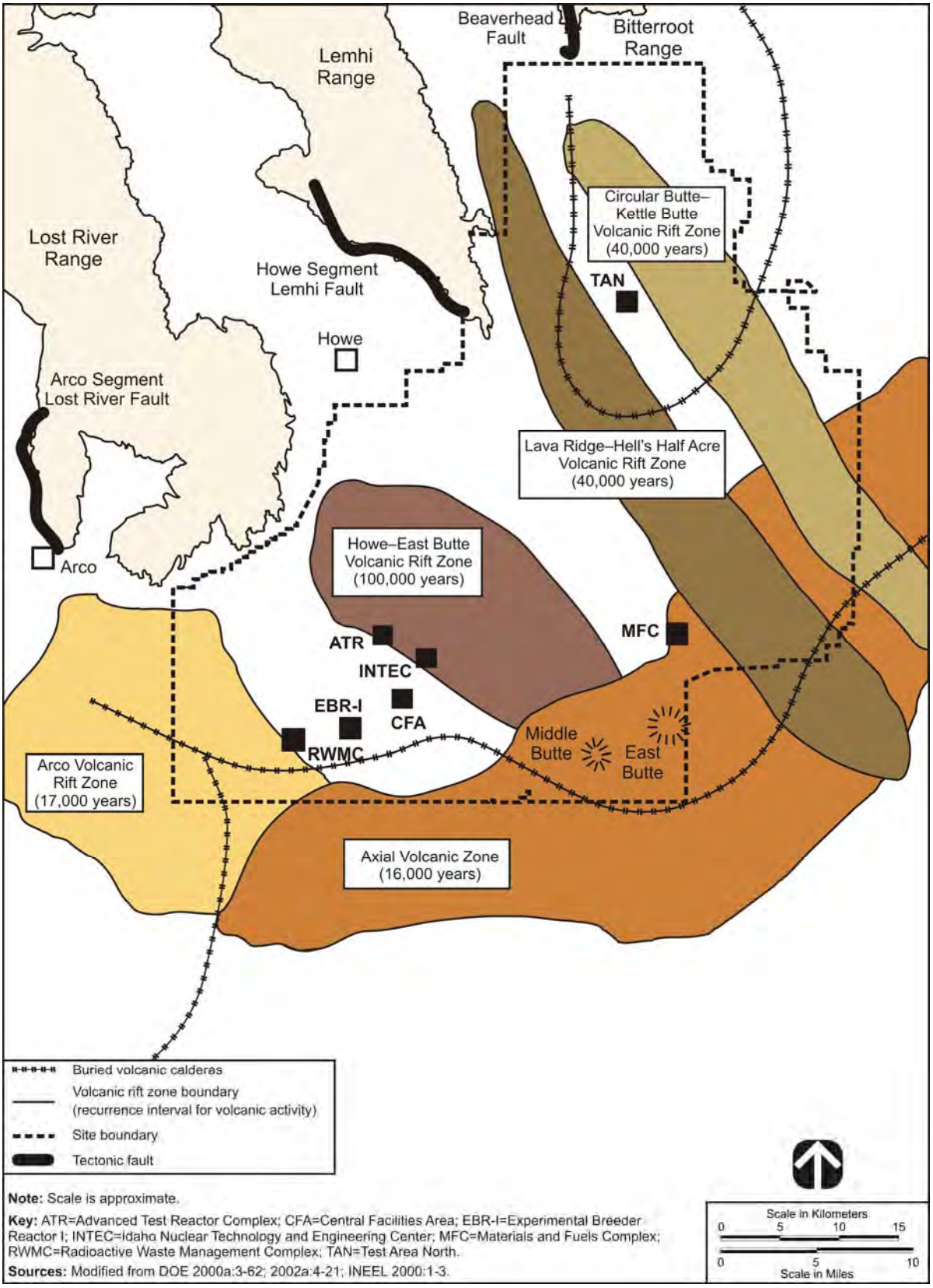


Figure 3–35. Major Geologic Features of Idaho National Laboratory

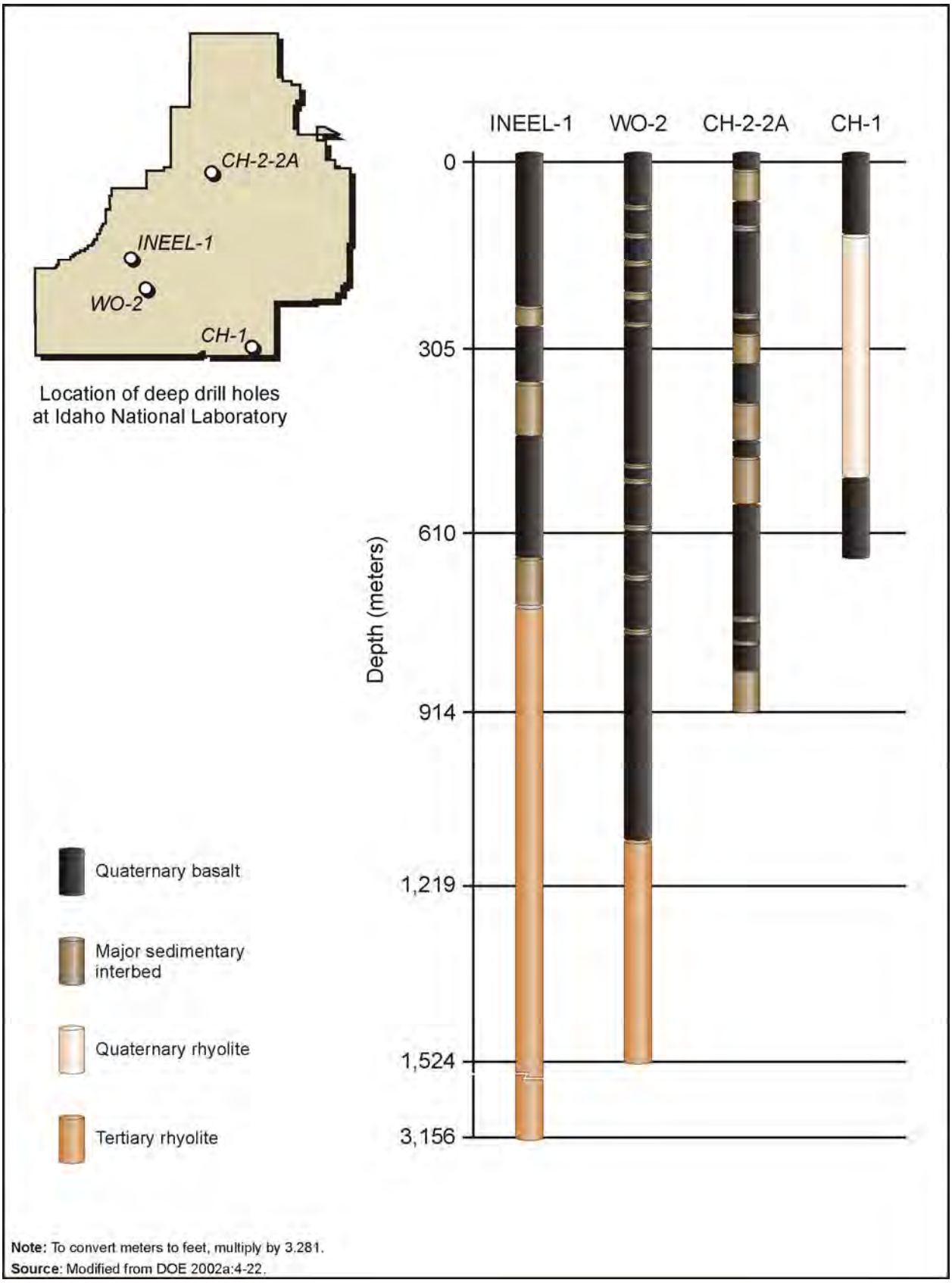


Figure 3–36. Lithologic Logs of Deep Drill Holes at Idaho National Laboratory

Several Quaternary rhyolite domes are located along the Axial Volcanic Rift Zone near the south and southeast borders of INL. Their names and ages are Big Southern Butte (300,000 years), a rhyolite dome near Cedar Butte (400,000 years), East Butte (600,000 years), Middle Butte (age unknown), and an unnamed butte near East Butte (1.2 million years). Paleozoic carbonate rocks (limestones), late-Tertiary rhyolitic volcanic rocks, and large alluvial fans occur in limited areas along the northwest margin of INL. A wide band of Quaternary mainstream alluvium (unconsolidated gravels and sands) extends along the course of Big Lost River from the southwestern corner of INL to the Big Lost River Sinks area in north-central INL. Lacustrine (lake) deposits of clays and sands in ice-age Lake Terreton occur in the northern part of INL. Beach sands deposited at the high stand of Lake Terreton were reworked by winds in late Pleistocene and Holocene ages to form large dune fields (eolian deposits) in the northeastern part of INL. Elsewhere on INL, the basaltic lava flows are variably covered with a thin veneer of eolian silt (loess), which can be up to several meters thick, but mostly ranges in thickness from 0 to 2 meters (6.6 feet) (ANL 2003:20).

3.3.5.1.3 Rock and Mineral Resources

Mineral resources within INL include sand, gravel, pumice, silt, clay, and aggregate (e.g., sand, gravel, crushed stone). These resources are extracted at several quarries or pits at INL and are used for road and new facility construction and maintenance, waste burial activities, and ornamental landscaping. The geologic history of the Eastern Snake River Plain makes the potential for petroleum production at INL very low. The potential for geothermal energy exists at INL and in parts of the Eastern Snake River Plain; however, a study conducted in 1979 identified no economically productive geothermal resources (DOE 2002a:4-23).

3.3.5.1.4 Seismicity and Geologic Hazards

The seismic characteristics of the Eastern Snake River Plain and the adjacent Basin and Range Province are different. The Eastern Snake River Plain has historically experienced infrequent small-magnitude earthquakes (DOE 2002a:4-20). In contrast, the major episode of Basin and Range faulting that began approximately 16 million years ago continues today (Rodgers et al. 2002). Since the installation of INL's seismic network in 1971, only 35 microearthquakes (magnitude of less than 2.0) have been detected within the Eastern Snake River Plain. However, INL's seismic stations record about 2,000 annually elsewhere in southeast Idaho (INL 2009a). Thus, the Eastern Snake River Plain and INL have lower seismicity than adjacent regions.

The largest historic earthquake near INL took place on October 28, 1983, about 90 kilometers (56 miles) northwest of the western site boundary, near Borah Peak in the Lost River Range (part of the Basin and Range Province). It occurred in the middle portion of the Lost River Fault. The earthquake had a surface-wave magnitude of 7.3 (moment magnitude of 7.0). An MMI of up to IX was assigned for effects at the event's epicenter (ANL 2003:22; DOE 2002h:4-132). The Advanced Test Reactor (ATR) within the INL RTC experienced an MMI of VI during this event, with no damage to the ATR found upon inspection (DOE 2002h:4-132). Since 1973, 25 earthquakes have been recorded within 100 kilometers (62 miles) of south-central INL, ranging in magnitude from 2.8 to 3.9. These represent minor earthquakes, with none centered closer than 76 kilometers (47 miles) from the south-central portion of the site. Most of the earthquakes had epicenters to the north and west of INL in the Basin and Range Province (USGS 2007c).

Earthquake-produced ground motion is expressed in units of percent *g* (force of acceleration relative to that of the Earth's gravity). Two differing measures of this motion are peak horizontal (ground) acceleration and response spectral acceleration. New seismic hazard metrics and maps developed by USGS and adapted for use in the *International Building Code* reflect maximum calculated ground motions of 0.2- and 1.0-second spectral accelerations for earthquakes with a 2 percent probability of

exceedance in 50 years—i.e., an annual probability of occurrence of about 1 in 2,500. Appendix F, Section F.5.2, of this *TC & WM EIS* provides a more-detailed explanation of the map parameters and their use. For south-central INL facilities, the calculated maximum considered earthquake ground motion is approximately 0.31 *g* for a 0.2-second spectral acceleration and 0.13 *g* for a 1.0-second spectral acceleration. The calculated peak ground acceleration for the given probability of exceedance at the site is approximately 0.13 *g* (USGS 2007d). An update to the INL seismic hazard evaluation was performed to recalculate design-basis earthquake spectra for key facilities in accordance with DOE standards. For this site-specific analysis, the calculated peak ground accelerations at the RTC for earthquakes with annual probabilities of occurrence of about 1 in 1,000 and 1 in 10,000 are 0.09 *g* and 0.19 *g*, respectively (INEEL 2000:ES-1). The *International Building Code* maximum considered earthquake values are cited to provide the reader with a general understanding of the seismic hazard as quantified by a well-accepted authority. However, for design of moderate- or high-hazard nuclear facilities, DOE prescribes seismic criteria that are more rigorous and provide a greater margin of safety than the values of the *International Building Code* cited here (see Appendix F, Section F.5.2).

INL lies in a region in which ground motions are controlled by fault-specific sources with estimated maximum earthquake magnitudes that have rather long recurrence intervals. The Borah Peak earthquake produced peak ground accelerations ranging from 0.022 *g* to 0.078 *g* across INL. Specifically, the ATR at the RTC experienced peak ground accelerations of 0.022 *g* to 0.030 *g* (INEEL 2005:2A-34; Jackson and Boatwright 1985:57). This caused the ATR protective systems to automatically scram (shut down) the reactor, as the seismic switches were designed to trip at a ground acceleration of 0.01 *g* (Gorman and Guenzler 1983:14). At the MFC, recorded peak ground accelerations ranged from 0.032 *g* to 0.048 *g* (Jackson and Boatwright 1985:57). Neither the ATR nor MFC facilities experienced structural or component damage from the Borah Peak earthquake (ANL 2003:22).

Earthquakes with moment magnitudes higher than 5.5 and associated strong ground shaking and surface fault rupture are not likely within the Eastern Snake River Plain, given the region's seismic history and geology. Moderate-to-strong ground shaking from earthquakes in the Basin and Range Province, however, could affect INL (DOE 2002a:4-23). Consequently, INL authorities have supported efforts to estimate, for all regional earthquake sources, the levels of ground shaking that are expected at INL facilities—specifically, estimates of the levels of ground shaking that would not be exceeded in specified time periods. A probabilistic ground-motion study for all facility areas was finalized in 2000. This study, which updated the 1996 INL sitewide seismic hazard evaluation, involved assessment of seismic hazard at five INL site areas using recently developed ground-motion attenuation relationships appropriate for INL (INEEL 2000). The INL ground-motion evaluation incorporated the results of all geologic, seismologic, and geophysical investigations conducted since the 1960s. The fault segments closest to INL facilities, the Lost River, Beaverhead, and Lemhi Faults, were studied in detail with a view to estimating their maximum earthquake magnitudes, their distances from INL facilities, and the timing and frequency of recent earthquakes. Results of these investigations indicated that these faults are capable of generating earthquakes of magnitude 6.6 to 7.2, and that the most recent earthquakes on the southernmost fault segments occurred more than 15,000 years ago. The data collected also continue to support historic observations that the alternating sequence of basalt and sedimentary interbeds composing the Eastern Snake River Plain tend to dampen seismic energy, resulting in reduced earthquake ground motions as compared to locations with uniform basaltic rock (INL 2009a).

Basaltic volcanic activity occurred over a period from about 2,100 to 4 million years ago in the INL site area. Although no eruptions have occurred on the Eastern Snake River Plain during recorded history, lava flows from the Hell's Half Acre lava field erupted near the southern INL boundary as recently as 5,400 years ago. The most recent eruptions within the area occurred about 2,100 years ago in an area 31 kilometers (19 miles) southwest of the site at the Craters of the Moon Wilderness Area. The estimated recurrence interval for volcanism associated with the five identified volcanic zones ranges from 16,000 to 100,000 years (DOE 2002a:4-25, 2002h:4-132). These zones are depicted in Figure 3–35.

Because the Yellowstone Hotspot is no longer present beneath the INL area, there is no threat of catastrophic volcanism such as at Yellowstone. The main volcanic threat at INL is from basaltic lava flows. INL seismic stations are located near or within identified volcanic rift zones to provide early warning of any signs of renewed volcanic activity (INL 2009a).

Seismicity concerns continue to influence facility design and construction at INL. Lessons learned from studies of INL seismic design-basis events are incorporated into facility architectural and engineering standards. New facilities and facility upgrades are designed in accordance with the requirements of applicable DOE standards and orders (DOE 2002a:4-24)—for example, DOE Order 420.1B, which requires that nuclear or nonnuclear facilities be designed, constructed, and operated so as to protect the public, workers, and the environment from the adverse impacts of natural phenomena hazards, including earthquakes. Furthermore, expected levels of earthquake ground motion as determined in the INL probabilistic seismic hazards assessment are now part of the seismic design criteria for new and existing facilities (INL 2009a).

3.3.5.1.5 Soils

Four basic soilscapes exist at INL: river-transported sediments deposited on alluvial plains, fine-grained sediments deposited into lake or playa basins, colluvial sediments originating from bordering mountains, and windblown sediments (silt and sand) over lava flows. The alluvial deposits follow the courses of the modern Big Lost River and Birch Creek. The playa soils are found in the north-central part of the site; the colluvial sediments, along the western edge of INL; and the windblown sediments, throughout the rest of the site. Surficial sediments range in thickness from less than 0.3 meters (1 foot) at basalt outcrops east of INTEC to 95 meters (312 feet) near the Big Lost River sinks. No soils designated as prime farmland exist within the INL boundaries (DOE 2002h:4-132).

3.3.5.2 Materials and Fuels Complex

The MFC is within a topographically closed basin of the Axial Volcanic Rift Zone. That zone has an estimated recurrence interval for volcanism of 16,000 years. The nearest capable fault is the Howe Segment of the Lemhi Fault, 31 kilometers (19 miles) northwest of the site (see Figure 3–35).

Low ridges of basalt found east of the area rise as high as 30 meters (100 feet) above the level of the plain. Sediments cover most of the underlying basalt on the plain, except where pressure ridges form basalt outcrops. Soils in the MFC area generally consist of light, well-drained, brown-gray, silty loams to brown, extremely stony loams. Soils are highly disturbed within developed areas of the site (DOE 2002h:4-132).

3.3.6 Water Resources

The scope of the discussion of water resources in this *TC & WM EIS* is stipulated in Section 3.2.6.

3.3.6.1 Surface Water

3.3.6.1.1 General Site Description

INL is in the Mud Lake–Lost River Basin (also known as the Pioneer Basin). This closed drainage basin includes three main streams—Big and Little Lost Rivers and Birch Creek (see Figure 3–37). These three streams are essentially intermittent and drain the mountain areas to the north and west of INL, although most flow is diverted for irrigation in the summer months before it reaches the site boundaries. Flow that

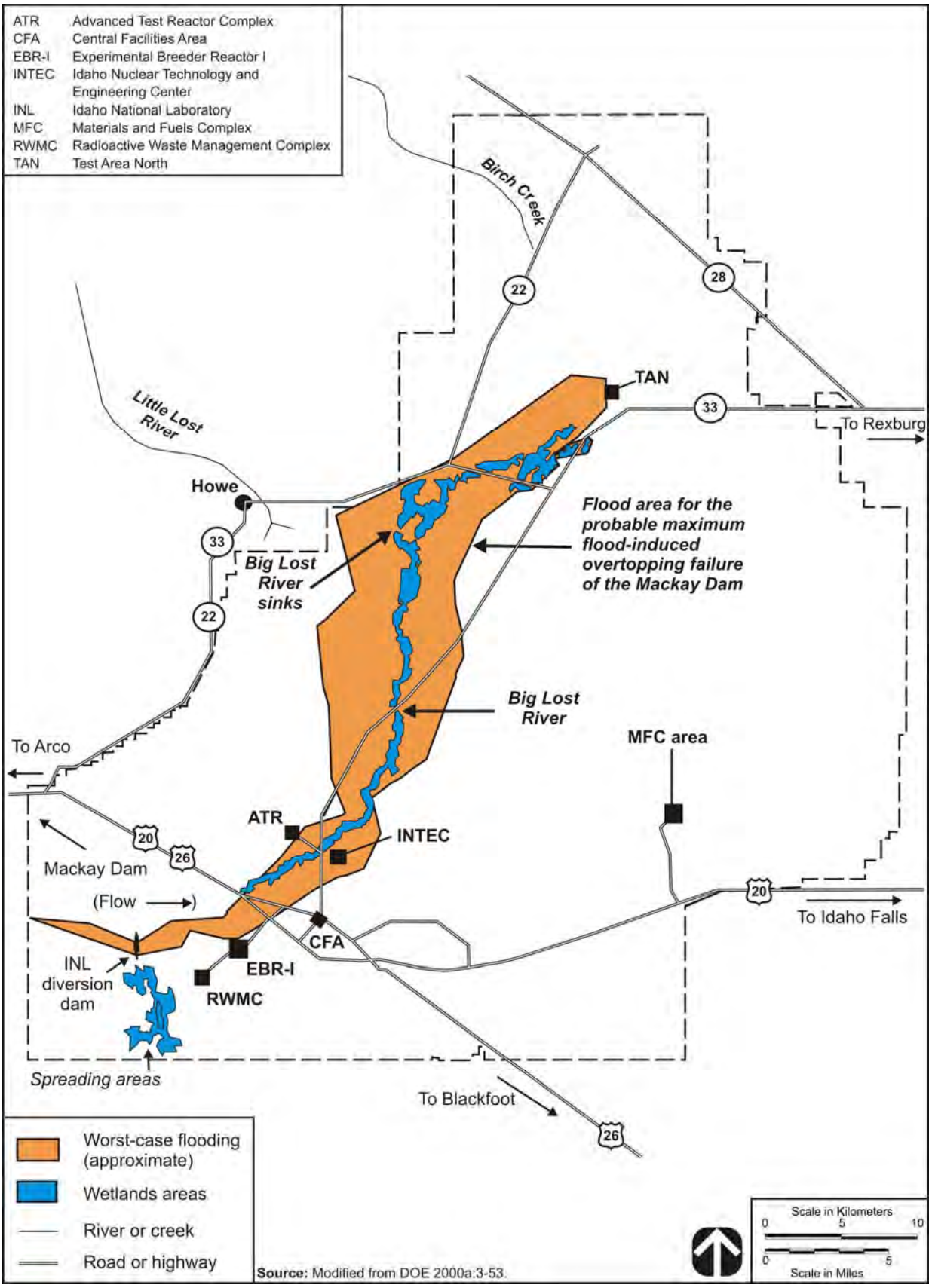


Figure 3–37. Surface-Water Features at Idaho National Laboratory

reaches INL infiltrates the ground surface along the length of the streambeds in the spreading areas at the southern end of INL and, if the streamflow is sufficient in the ponding areas (playas or sinks), in the northern portion of INL as well. During dry years, there is little or no surface-water flow on the INL site. Because the Mud Lake-Lost River Basin is a closed drainage basin, water does not flow off INL, but instead infiltrates the ground surface to recharge the aquifer or is consumed by evapotranspiration. Big Lost River flows southeast from Mackay Dam, past Arco, and onto the Snake River Plain. On the INL site near the southwestern boundary, a diversion dam prevents flooding of downstream areas during periods of heavy runoff by diverting water to a series of natural depressions or spreading areas (see Figure 3–37). During periods of high flow or low irrigation demand, Big Lost River continues northeastward past the diversion dam, passes within about 61 meters (200 feet) of INTEC, and ends in a series of playas 24 to 32 kilometers (15 to 20 miles) northwest of the MFC, where the water infiltrates the ground surface (DOE 2002a:4-40, 2002h:4-133).

Flow from Birch Creek and Little Lost River infrequently reaches INL. The waters in these streams are diverted in summer months for irrigation prior to reaching the site. Yet during periods of unusually high precipitation or rapid snowmelt, those waters can enter INL from the northwest and infiltrate the ground, recharging the underlying aquifer (DOE 2002a:4-40).

The only other surface-water bodies on the site are natural wetland-like ponds and manmade percolation and evaporation ponds (DOE 2002h:4-133). The latter are used for wastewater management at INL. Discharges to the ground surface are through infiltration ponds, trenches (ditches), and a sprinkler irrigation system. Infiltration ponds include the INTEC New Percolation Ponds, Test Area North/Technical Support Facility Sewage Treatment Plant Disposal Pond, RTC Cold Waste Pond, MFC Industrial Waste Pond and Ditch, and MFC Sanitary Lagoons. Wastewater at INTEC also is discharged to the INTEC Sewage Treatment Plant and associated infiltration trenches, and a sprinkler irrigation system at the Central Facilities Area that is used during the summer months to land-apply industrial and treated sanitary wastewater (DOE 2007d:5.2, 5.27).

Discharge of wastewater to the land surface is regulated under Idaho "Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater" (IDAPA 58.01.17). An approved Wastewater-Land Application Permit (WLAP) normally requires the monitoring of nonradioactive parameters in the influent waste, effluent waste, and groundwater, as applicable. WLAPs generally require compliance of specified groundwater monitoring wells with Idaho groundwater quality primary and secondary constituent standards (IDAPA 58.01.11). WLAPs specify annual discharge volume, application rates, and effluent quality limits. As required, an annual report is prepared and submitted to the Idaho Department of Environmental Quality (DOE 2006:5.3). The facilities covered by WLAPs include the Central Facilities Area Sewage Treatment Facility, the INTEC New Percolation Ponds, and the Test Area North/Technical Support Facility Sewage Treatment Facility. In addition, the RTC Cold Waste Pond has been authorized by the Idaho Department of Environmental Quality to operate under the Idaho WLAP rules, although no permit has been issued. Also, INL has submitted an application to the State of Idaho to obtain a WLAP for the MFC Industrial Waste Pond (DOE 2007d:5.3).

Water bodies in Idaho are designated by the Department of Environmental Quality for specific and varied uses to ensure protection of the water quality for such uses. Big Lost River, Little Lost River, and Birch Creek in the vicinity of INL have been designated as cold water aquatic communities available for use in salmonid spawning and primary contact recreation, and the Big Lost River sinks and channel and lowermost Birch Creek, as domestic water supplies and special resource waters (IDAPA 58.01.02). In general, the waters of Big Lost River, Little Lost River, and Birch Creek are similar in quality because they reflect the similar carbonate mineral compositions of the mountain ranges drained by them, as well as chemically similar irrigation water return flows. Neither surface water nor the effluents discharged directly to it are used for drinking water on the site, so there are no surface-water rights issues at INL.

Moreover, none of the rivers or streams on or near INL have been classified as Wild and Scenic (DOE 2002h:4-133, 4-135).

Based on a regulatory determination made in 2005, INL site industrial activities are no longer subject to NPDES permitting requirements due to the determination that no stormwater discharge from INL industrial activities is likely to reach streams. Similarly, the regulatory determination also reduced the area (stormwater corridor) under the purview of the NPDES Storm Water for Construction Activities Program (DOE 2006:2.13). Nonetheless, INL's General Permit for Storm Water Discharges from Construction Sites was issued in June 1993 and has been renewed twice since then. INL site contractors obtain coverage under the general permit for individual construction projects. Stormwater pollution plans are completed for individual construction projects. Inspections of construction sites are performed in accordance with permit requirements. Only construction projects that are determined to have a reasonable potential to discharge pollutants to a regulated surface water are required to have a stormwater pollution prevention plan and permit (DOE 2007d:2.10).

Surface-water locations outside of the INL boundary are sampled twice a year for gross alpha, gross beta, and tritium. In 2006, 3 surface-water samples from six offsite locations were collected along the Snake River. Gross alpha concentrations were not detected in any of those samples. Tritium was detected in two offsite surface-water samples, with a maximum concentration of 92.5 ± 29.7 picocuries per liter detected in the Hagerman, Idaho, area—well below the Idaho primary constituent standards and EPA MCL for tritium of 20,000 picocuries per liter. Gross beta concentrations were measured in all offsite surface-water samples. Detectable concentrations ranged from 1.64 ± 0.52 to 8.82 ± 0.57 picocuries per liter at Idaho Falls and Big Lost River, respectively. The maximum concentration is below the EPA gross beta screening level of 50 picocuries per liter in drinking water. Concentrations in this range are consistent with those measured in the past and cannot be differentiated from concentrations of natural decay products like thorium and uranium, which dissolve into water as it passes through the surrounding basalts of the Snake River Plain (DOE 2007d:6.32, 6.34).

Flooding of the Big Lost River was evaluated for its potential impact on INL facilities. Included was an evaluation of the impact of probable maximum flood due to the failure of Mackay Dam, 72 kilometers (45 miles) upstream of INL (see Figure 3–37). The maximum flood was assumed to result in the overtopping and rapid failure of Mackay Dam. This flood would result in a peak surface-water elevation at INTEC of 1,499 meters (4,917 feet)—the average elevation at that facility—as well as a peak flow of 1,892 cubic meters (66,830 cubic feet) per second in Big Lost River measured near INTEC. Thus, INTEC would be flooded. Moreover, because the ground surface at INL and INTEC is rather flat, the floodwaters would spread over a large area and pond in the lower-lying areas. Although predicted flood velocities would be fairly slow and water depths shallow, some facilities could be impacted. There is no record of historical flooding at INTEC from Big Lost River, although evidence of flooding in geologic time exists (DOE 2002a:4-42, 4-43). The INL diversion dam, constructed in 1958 and enlarged in 1984, was designed to secure INL from the 300-year flood (estimated peak flow of slightly above 142 cubic meters [5,000 cubic feet] per second) of Big Lost River by directing flow through a diversion channel into four spreading areas (DOE 2002h:4-135, 2005c:3-19). Effects of a systematic (noninstantaneous) failure of the diversion dam were included in the probable maximum flood analysis (DOE 2002a:4-42).

Other than natural topography, the primary choke points for probable maximum flood flows are the diversion dam on the INL site and the culverts near INTEC that allow Big Lost River to flow beneath Lincoln Boulevard between INTEC and the RTC. The probable maximum flood would quickly overtop the diversion dam. The Lincoln Boulevard culverts are capable of passing about 42 cubic meters (1,500 cubic feet) of floodwater per second (DOE 2002a:4-42).

A preliminary map of the 100-year floodplain for Big Lost River prepared by USGS and published in 1998 (from 1996 studies) indicated that INTEC may be subject to flooding from a 100-year flood. USGS

estimated the 100-year flow at approximately 206 cubic meters (7,260 cubic feet) per second at the Arco gauging station, 19 kilometers (12 miles) upstream of the INL diversion dam. This estimate and the resulting preliminary 100-year floodplain map assumed that the INL diversion dam did not exist and that some 29 cubic meters (1,040 cubic feet) of water per second would be captured by the diversion channel and flow to the spreading areas southwest of the diversion dam. The analysis also assumed the remaining 176 cubic meters (6,220 cubic feet) per second of flow would run down the Big Lost River channel on the INL site. Both a U.S. Army Corps of Engineers analysis and an INL geotechnical analysis concluded that the INL diversion dam could withstand flows up to 170 cubic meters (6,000 cubic feet) per second. Culverts running through the diversion dam could convey a maximum of an additional 34 cubic meters (1,200 cubic feet) per second, but their condition and capacity as a function of water elevation are unknown. A subsequent DOE-commissioned flood hazard study published in 1999 by the U.S. Bureau of Reclamation was used to produce floodplain maps from flow estimates of 93 cubic meters (3,270 cubic feet) per second for the 100-year flow and 116 cubic meters (4,086 cubic feet) per second for the 500-year Big Lost River flow. The flows and frequencies were based on stream gauge data and two-dimensional modeling constrained by geomorphic evidence. The data and models showed that small areas of the northern portion of INTEC could flood at the estimated 100- and 500-year flows (DOE 2002a:4-42–4-46).

Additional studies aimed at reducing the uncertainty in flood hazard estimates at INL were recently undertaken by both USGS and the U.S. Bureau of Reclamation because of the large difference in the earlier estimates. USGS, in cooperation with DOE, published a study in 2003 providing its new estimate of the 100-year peak flow for Big Lost River at INL. The estimate was based on analysis of recorded and estimated peak-flow data, long-term gauging station data, and documented conditions in the basin during historical high-flow periods. The analysis resulted in a 100-year peak-flow estimate of 118 cubic meters (4,170 cubic feet) per second near Arco and a flow of about 106 cubic meters (3,750 cubic feet) per second for Big Lost River immediately upstream from the INL diversion dam (Hortness and Rousseau 2003:2, 21, 22). The U.S. Bureau of Reclamation published its most recent estimate in 2005. This study used updated geologic and geomorphic mapping data and hydraulic modeling to improve paleohydrologic estimates used in the new flood-frequency analyses. The study yielded a 100-year peak-flow estimate of 87 cubic meters (3,072 cubic feet) per second at the INL diversion dam (Ostenaa and O'Connell 2005:iii, iv). These latest results indicate the potential for substantially less flooding at INL facilities than predicted by previous studies.

3.3.6.1.2 Materials and Fuels Complex

There are no named streams within the MFC area and no permanent natural surface-water features near the area. Neither the 100-year flood study nor flooding scenarios involving the failure of Mackay Dam on Big Lost River indicate that floodwaters would reach the MFC (see Figure 3–37).

Nevertheless, an unnamed dry streambed lies within several hundred feet of the Transient Reactor Test Facility Control Building adjacent to the main MFC site. As much as 1.5 million cubic meters (53 million cubic feet) of water could flow within a few hundred feet of that building during a 100-year storm if the worst-possible frozen ground conditions existed. In addition, a flood-control diversion dam is located about 0.8 meters (0.5 miles) south of the Hot Fuel Examination Facility. This dam was built to control surface-water flows from the south attributable to severe spring precipitation onto frozen ground. Water flowing from the south is diverted to the west and through a ditch that extends along the western boundary of the MFC site, discharging to the Industrial Waste Pond (ANL 2003:25).

Two small sewage lagoons and the Industrial Waste Pond are located outside the MFC boundary fence to the northwest. The 1-hectare (2.4-acre) Industrial Waste Pond is used for the disposal of industrial cooling water and stormwater emanating from the MFC facilities (ANL 2003:25).

3.3.6.2 Vadose Zone

3.3.6.2.1 General Site Description

The vadose zone at INL comprises the entire sequence of Quaternary-age basaltic lava flows and sedimentary interbeds that lie between the surface and the regional water table (top of the Snake River Plain Aquifer). Thus, the thickness of the vadose zone beneath INL ranges from about 61 meters (200 feet) in the northern part of the site to more than 274 meters (900 feet) in the southern portion of INL (ANL 2003:13).

This zone is important because chemical sorption to geologic materials in the vadose zone retards or prevents the downward movement of some contaminants. During dry conditions, the transport of contaminants downward toward the aquifer is very slow. Measurements taken at the Radioactive Waste Management Complex (RWMC) during unsaturated flow conditions indicated a downward infiltration rate ranging from 0.36 to 1.1 centimeters (0.14 to 0.43 inches) per year. In another study performed during near-saturated flow conditions in the same area, standing water infiltrated downward 2.1 meters (6.9 feet) in less than 24 hours (DOE 2002a:4-49).

3.3.6.2.2 Materials and Fuels Complex

The vadose zone beneath the MFC is approximately 213 meters (700 feet) thick and comprises the basalt flows and interbedded sediments characteristic of the Snake River Group. The geologic and groundwater environments of the MFC are further described in Sections 3.3.5.2 and 3.3.6.3.2, respectively.

3.3.6.3 Groundwater

3.3.6.3.1 General Site Description

The Snake River Plain Aquifer lies below the INL site. It covers an area of approximately 2.5 million hectares (6.1 million acres) in southeastern Idaho. Aquifer boundaries are formed by contact with less-permeable rocks at the margins of the Eastern Snake River Plain. These boundaries correspond to the mountains on the west and north and the Snake River on the east (ANL 2003:13). This aquifer is the major source of drinking water for southeastern Idaho and has been designated a Sole Source Aquifer by EPA (DOE 2002a:4-47, 2002h:4-135). Water storage in the aquifer is estimated at some 2,500 billion cubic meters (660,400 billion gallons), and irrigation wells can yield 26,000 liters (7,000 gallons) per minute (DOE 2002a:4-47). The aquifer is composed of numerous thin basalt flows, with interbedded sediments extending to depths in excess of 1,067 meters (3,500 feet) below the land surface. Figure 3–36 shows the relationship of these strata from boreholes drilled at INL. The interbeds accumulated over time as some basalt flows were exposed at the surface long enough to collect sediment. These sedimentary interbeds lie at various depths, with their distribution and continuity controlled by basalt flow topography, sediment input, and subsidence rate. In some instances, the process of sediment accumulation resulted in discontinuous distributions of fairly impermeable sedimentary interbeds, which led to a localized perching of groundwater. USGS has estimated that the thickness of the active portion of the Snake River Plain Aquifer at INL ranges between 76 and 250 meters (250 and 820 feet). Depth to the water table ranges from about 61 meters (200 feet) below land surface in the northern part of the site to more than 274 meters (900 feet) in the southern part (ANL 2003:13, 14).

Water movement regionally in the aquifer is mainly horizontal through basalt interflow zones, i.e., highly permeable rubble zones between basalt flows. Groundwater flow is primarily toward the southwest. Locally, the flow direction can be affected by recharge from rivers, surface-water spreading areas, and heterogeneities in the aquifer. Transmissivity in the aquifer ranges from roughly 100 to 10,000 square meters (1,000 to 100,000 square feet) per day and in places exceeds 100,000 square meters

(1 million square feet) per day (ANL 2003:14). Flow rates in the aquifer have been reported to range from about 1.5 to 6.1 meters (5 to 20 feet) per day (DOE 2002h:4-135).

The Big Lost River, the Little Lost River, and Birch Creek terminate at sinks on or near INL and recharge the aquifer. Recharge occurs through the surface of the Eastern Snake River Plain from flow in the channel of the Big Lost River and its diversion area. Additionally, recharge may occur from melting of local snowpacks during years in which snowfall accumulates on the Eastern Snake River Plain and from local agricultural irrigation activities (ANL 2003:15). Valley underflow from the mountains to the north and northeast of the Eastern Snake River Plain has also been cited as a source of recharge (DOE 2002a:4-47). Aquifer discharge is via large spring flows to the Snake River and pumping for irrigation. The aquifer discharges approximately 8,800 billion cubic meters (2,320 million gallons) of water annually to springs and rivers (ANL 2003:15). Major springs and seepages from the aquifer occur in the vicinity of the American Falls Reservoir (southwest of Pocatello) and the Thousand Springs area (near Twin Falls) between Milner Dam and King Hill (DOE 2002a:4-47).

Perched water occurs in the vadose zone at INL when sediments or dense basalt with low permeability impedes the downward flow of water to the aquifer (DOE 2002a:4–47). These perched water tables tend to slow the migration of pollutants to the Snake River Plain Aquifer. Other perched water tables detected beneath INTEC and the RTC are attributable mainly to disposal ponds (DOE 2002h:4–135).

INL has an extensive groundwater-quality monitoring network maintained by USGS. This network includes 171 observation or production wells in the Snake River Plain Aquifer and auger holes from which samples are collected and analyzed for selected organic, inorganic, and radioactive substances (DOE 2007d:3.7, 3.8).

Historical waste disposal practices have produced localized plumes of radiochemical and chemical constituents in the Snake River Plain Aquifer at INL. Of principal concern over the years have been the movements of the tritium and strontium-90 plumes. The general extent of these plumes beneath INL is shown in Figure 3–38. Nevertheless, no contaminant exceeded an EPA MCL in a well along the southern boundary of INL or downgradient of the site in the fiscal year 2006 groundwater monitoring. Within the areal extent of the plume, tritium was detected in two wells (USGS-104 and -106), which are guard wells located just south of the Central Facilities Area in the southern portion of INL. Both of these wells have a history of tritium detections. Over the past 20 years, both wells have exhibited a downward trend in tritium concentration. The tritium concentrations in these wells currently are less than 1,100 picocuries per liter and considerably less than the EPA MCL of 20,000 picocuries per liter (DOE 2007d:6.26, 6.29).

The INTEC facility used direct injection as a disposal method until 1984. This wastewater contained high concentrations of both tritium and strontium-90. Injection at INTEC was discontinued in 1984, and the injection well was sealed in 1990. Once direct injection ceased, wastewater from INTEC was directed to a pair of shallow percolation ponds, from which the water infiltrated into the subsurface. Disposal of low- and intermediate-level radioactive waste solutions to the percolation ponds ceased in 1993 with the installation of the Liquid Effluent Treatment and Disposal Facility. New INTEC percolation ponds went into operation in August 2002. The RTC also discharged contaminated wastewater, but mainly to a shallow percolation pond. This pond was replaced in 1993 by a flexible plastic (Hypalon®)-lined evaporation pond, which stopped the addition of tritium to groundwater (DOE 2007d:6.6, 6.7).

Concentrations of tritium in the area of aquifer contamination have continued to decrease. Two monitoring wells downgradient of the RTC (well 65) and INTEC (well 77) have continually shown the highest tritium concentrations in the aquifer over time and are considered representative of maximum concentration trends in the rest of the aquifer. The average tritium concentration in well 65 decreased

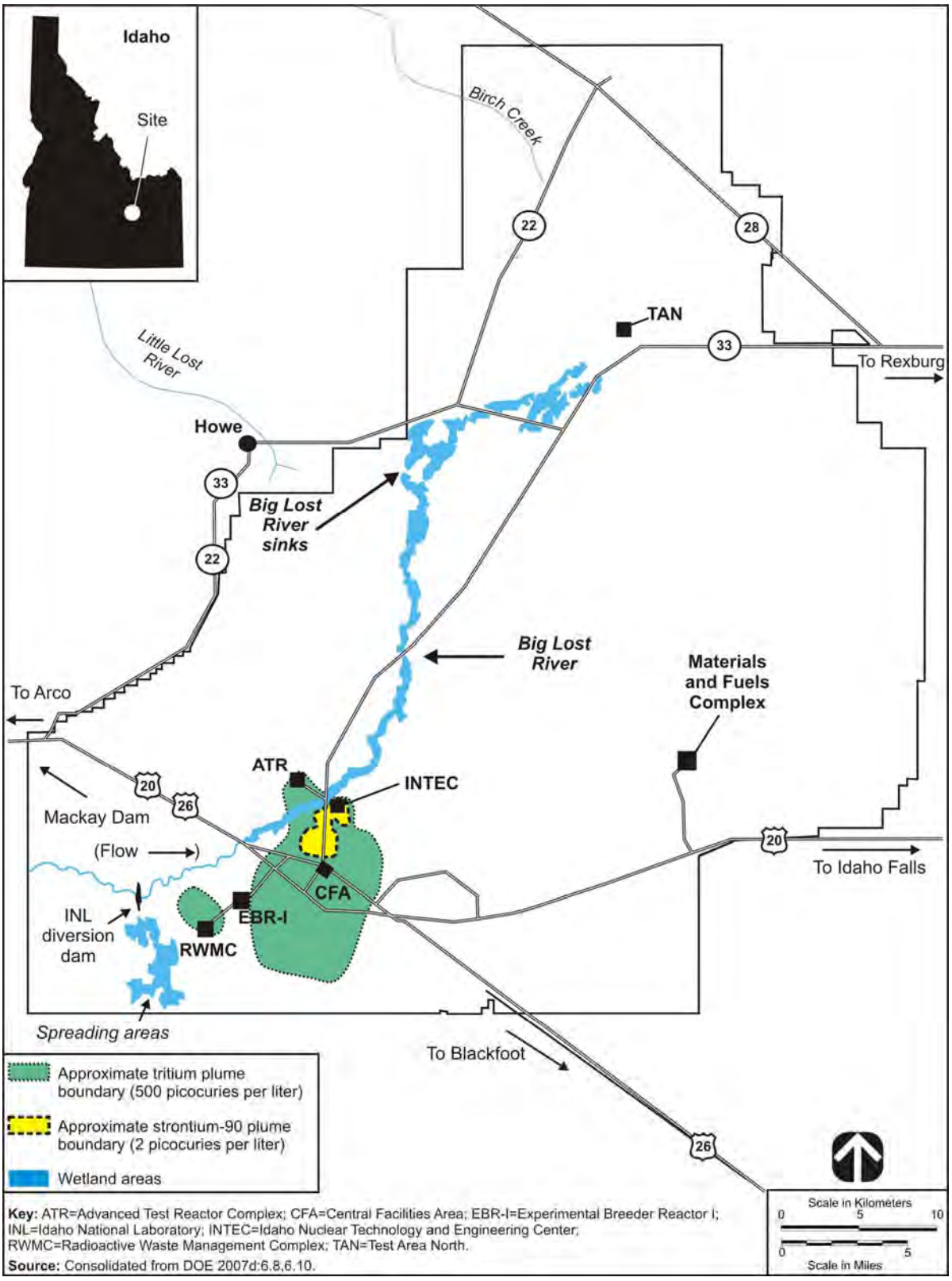


Figure 3–38. Extent of Tritium and Strontium-90 Plumes Within the Snake River Plain Aquifer at Idaho National Laboratory

from 7,200 ± 300 picocuries per liter in 2005 to 6,300 ± 600 picocuries per liter in 2006, tritium concentration results from well 77 south of INTEC were not received in time for comparison. The EPA MCL for tritium in drinking water is 20,000 picocuries per liter, which is the same as the Idaho groundwater primary constituent standard. Still, values in both wells 65 and 77 have remained below the 20,000-picocuries-per-liter standard in recent years as a result of radioactive decay, a decrease in tritium disposal rates, and dilution within the Snake River Plain Aquifer (DOE 2007d:6.7).

Strontium-90 contamination at INTEC is a remnant of the earlier injection of wastewater. At the RTC, by contrast, disposition of strontium-90 was via infiltration ponds. Strontium-90 at the RTC is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones; however, no strontium-90 contamination has been detected in the RTC vicinity. The area of the strontium-90 contamination from INTEC is approximately the same as it was in 1991. Concentrations in wells have remained fairly constant since 1989. In 2006, the average annual concentration in well 65 was undetectable as compared to the EPA MCL of 8 picocuries per liter. Results from well 77 were not received for comparison. No clear trend in strontium-90 concentrations over the last 10 years is apparent. Increases observed prior to the last few years were probably due in part to a lack of the recharge from the Big Lost River that typically acts to dilute the strontium-90. An increase in the disposal of other chemicals into INTEC percolation ponds also may have changed the affinity of strontium-90 for soil and rock surfaces, causing it to become more mobile (DOE 2007d:6.7-6.9).

From 1982 to 1985, INL used about 7.9 billion liters (2.1 billion gallons) per year from the Snake River Plain Aquifer, the only source of water at INL. This represents less than 0.3 percent of the groundwater withdrawn from that aquifer. Since 1950 DOE has held a Federal Reserved Water Right for the INL site that permits a pumping capacity of approximately 2.3 cubic meters (80 cubic feet) per second, with a maximum water consumption of 43 billion liters (11.4 billion gallons) per year. Total groundwater withdrawal at INL historically averages between 15 and 20 percent of that permitted amount. INL's production well system currently withdraws a total of about 4.2 billion liters (1.1 billion gallons) of water annually (see Section 3.3.2.4). Most of the groundwater withdrawn for use by INL facilities is returned to the subsurface via percolation ponds (DOE 2002h:4-136).

3.3.6.3.2 Materials and Fuels Complex

The depth of the Snake River Plain Aquifer water table beneath MFC ranges between 183 and 213 meters (600 to 700 feet), and groundwater flow is generally to the southwest across the site (ANL 2003:13, 14). All water used at the MFC is groundwater from the underlying aquifer and is withdrawn via two production wells (see Section 3.3.2.4.1).

The MFC samples five wells (four monitoring and one production) twice a year for radionuclides, metals, total organic carbon, total organic halogens, and water quality parameters as part of the CERCLA ROD for Waste Area Group (WAG) 9. Apparent detection of gross alpha, gross beta, and certain uranium isotopes in groundwater during fiscal year 2006 were low, and were found to be consistent with levels attributable to natural sources (DOE 2007d:6.27, 6.28).

3.3.7 Ecological Resources

The scope of the discussion of ecological resources in this *TC & WM EIS* is stipulated in Section 3.2.7.

3.3.7.1 Terrestrial Resources

3.3.7.1.1 General Site Description

INL lies in a cool desert ecosystem dominated by some of the best-condition shrub-steppe communities in the United States. Most land within the site is relatively undisturbed and provides important habitat for

species native to the region. Facilities and operating areas occupy 2 percent of INL; approximately 60 percent of the area on the periphery of the site is grazed by sheep and cattle. Although sagebrush communities occupy about 80 percent of INL, a total of 11 plant communities have been identified. Additionally, areas of lava and developed areas are present on the site (see Figure 3–39). These communities may be grouped into six types: shrub steppe; juniper woodlands; grasslands; playas, bare ground, and disturbed areas; lava; and wetlands. In total, 398 plant taxa have been documented at INL (DOE 2002h:3.64, 2002i).

Among the sensitive habitats on the INL site are the interspersions of low and big sagebrush communities in the northern portion of INL and the juniper communities in the northwestern and southeastern portions of the site. The former provide critical winter and spring range for greater sage grouse and pronghorn, while the latter are important to nesting raptors and songbirds. Riparian vegetation, primarily cottonwood and willow, along the Big Lost River and Birch Creek is also important nesting habitat for hawks, owls, and songbirds (DOE 2002h:4–136). Recently, approximately 29,244 hectares (72,263 acres) of open space in the north-central portion of the site was designated as the INL Sagebrush-Steppe Ecosystem Reserve. The area was set aside because it represents some of the last sagebrush-steppe habitat in the United States and provides habitat for numerous rare and sensitive plants and animals (O'Rourke 2006:26).

INL supports numerous animal species, including 740 insect, 1 amphibian, 9 reptile, 159 bird, and 37 mammal species (O'Rourke 2006:24). Common animals on the site include the short-horned lizard, Great Basin gopher snake, sage sparrow, Townsend's ground squirrel, and black-tailed jackrabbit. Important game animals include the greater sage grouse, mule deer, Rocky Mountain elk, and pronghorn. During some winters, 4,500 to 6,000 pronghorn, or about 30 percent of Idaho's total pronghorn population, may be found on INL. Although pronghorn may be found across INL at any time of the year, their important wintering areas are in the northeastern portion of the site, the area of the Big Lost River sinks, the west-central portion of the site along the Big Lost River, and the south-central portion of the site. Hunting Rocky Mountain elk and pronghorn is permitted only within 0.8 kilometers (0.5 miles) of the site boundary on INL lands adjacent to agricultural lands. Numerous raptors such as the golden eagle and prairie falcon, as well as carnivores such as the coyote and mountain lion, are also found on INL. A variety of migratory birds have been found on INL (DOE 2002h:3-64, 3-65).

3.3.7.1.2 Materials and Fuels Complex

The MFC is within one of several sagebrush communities found on INL (see Figure 3–39). While sagebrush is present on undeveloped portions of the site, developed areas are nearly devoid of vegetation and thus generally not as important to animals as the surrounding areas. Rocky Mountain elk and mule deer are the most important large mammals in the general site area, but many other species common to the region are also expected. The MFC wastewater pond acts as an important source of water for wildlife found in the site vicinity (DOE 2002h:4-138).

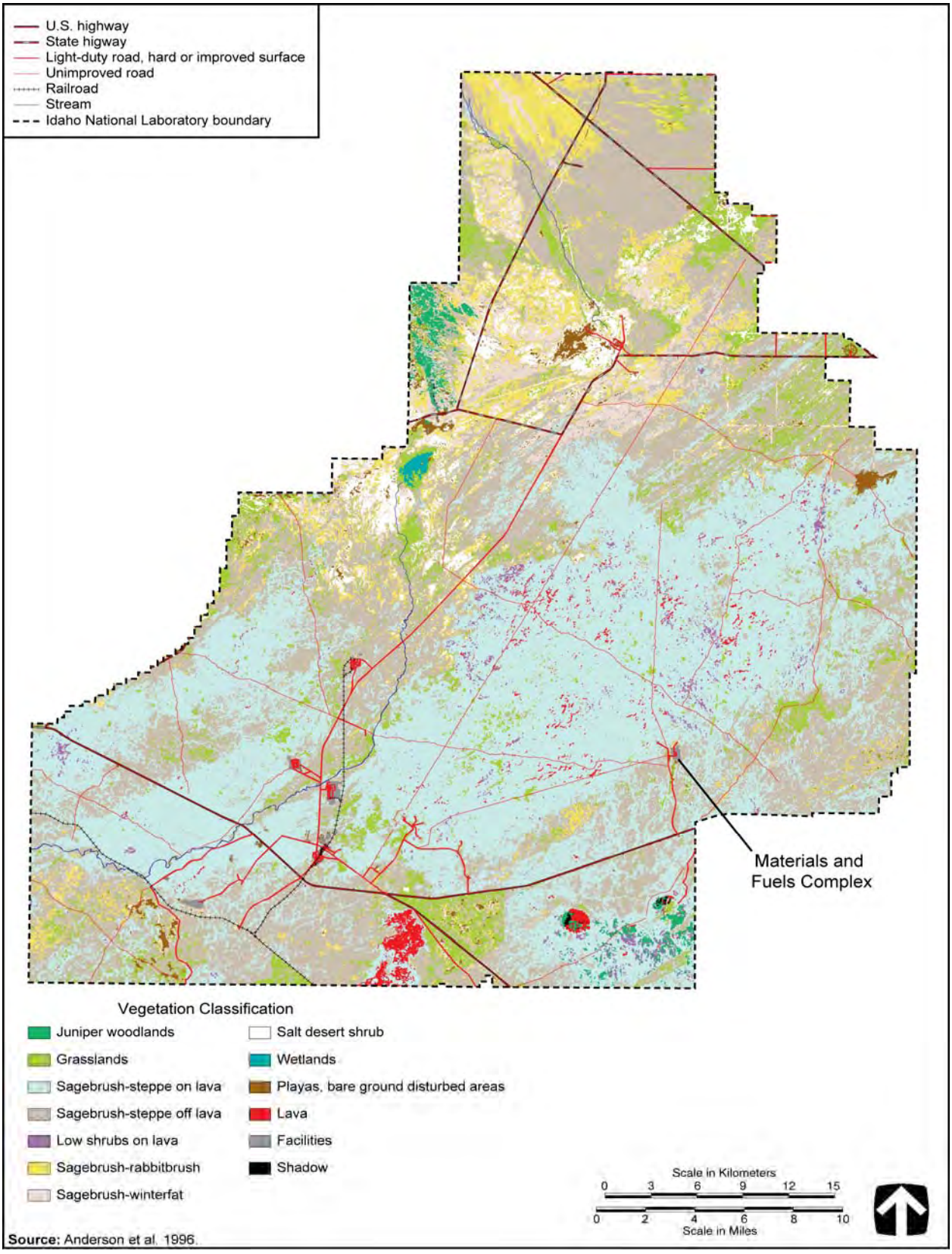


Figure 3–39. Vegetation Communities at Idaho National Laboratory

3.3.7.2 Wetlands

3.3.7.2.1 General Site Description

National wetland inventory maps have been completed by USFWS for most of INL. These maps indicate that there are 55 hectares (135 acres) of wetland areas within INL. The primary wetland areas are associated with the Big Lost River and the river's spreading areas and sinks, although smaller (less than about 0.4 hectares [1 acre]), isolated wetlands also occur intermittently. Wetlands associated with Big Lost River are classified as riverine/intermittent, indicating a defined stream channel with flowing water during only part of the year. The only areas of jurisdictional wetlands are the Big Lost River sinks (see Figure 3–37) (DOE 2002h:4-138; O'Rourke 2006:21).

3.3.7.2.2 Materials and Fuels Complex

Riparian vegetation exists along the Big Lost River, which is 18 kilometers (11 miles) west of the MFC; however, this vegetation is in poor condition because of only intermittent flows in recent years. The Big Lost River spreading areas and sinks are seasonal wetlands, respectively, 34 kilometers (21 miles) west-southwest and 23 kilometers (14 miles) northwest of the MFC. These areas provide more than 809 hectares (2,000 acres) of wetland habitat during wet years. Within the MFC itself, small areas of intermittent marsh occur along cooling-tower blowdown ditches (DOE 2002h:4-138).

3.3.7.3 Aquatic Resources

3.3.7.3.1 General Site Description

Aquatic habitat at INL is limited to the Big Lost River, the Little Lost River, Birch Creek, and a number of liquid waste disposal ponds. All three streams are intermittent and drain into four sinks in the north-central part of the site. Six species of fish have been observed within water bodies on site. Species observed in the Big Lost River include brook trout, rainbow trout, mountain whitefish, speckled dace, shorthead sculpin, and kokanee salmon. The Little Lost River and Birch Creek, southwest and northwest of the MFC, respectively, enter the site only during periods of high flow. The liquid waste disposal ponds on INL, while considered aquatic habitat, do not support fish (DOE 2002h:4-138).

3.3.7.3.2 Materials and Fuels Complex

There is no natural aquatic habitat in the vicinity of the MFC. The nearest such habitat is the Big Lost River, which is 19 kilometers (12 miles) west of the site. The MFC waste disposal ponds do not contain any fish populations, but do provide habitat for a variety of aquatic invertebrates (DOE 2002h:4-139).

3.3.7.4 Threatened and Endangered Species

3.3.7.4.1 General Site Description

Twenty federally and state-listed threatened and other special status species occur, or possibly occur, on the INL site (see Table 3–33). Federally listed plant and animal species include 1 threatened and 1 experimental, nonessential population. Idaho special status species include 2 threatened; 1 experimental, nonessential population; 2 priority; 3 sensitive; and 2 monitor. The bald eagle is listed by the state as threatened, but has been delisted in the lower 48 states by USFWS (72 FR 37346). It is seasonally common in the western and northern portions of the site. The gray wolf is listed by USFWS and Idaho as an experimental, nonessential population (USFWS 2009). Although it has been reported several times on the INL site (Shive 2007:15), its presence has not been confirmed. No critical habitat for threatened or endangered species, as defined in the Endangered Species Act, exists on the INL site.

Table 3–33. Idaho National Laboratory Threatened, Endangered, and Other Special Status Species

Common Name	Scientific Name	Status	
		Federal	State
Plants			
Cushion milkvetch	*Astragalus gilviflorus*		Priority 1
Lemhi milkvetch	*Astragalus aquilonius*		Sensitive
Puzzling halimolobos	*Halimolobos perplexa*		Monitor
Narrowleaf oxytheca	*Oxytheca dendroidea*		Sensitive
Nipple coryphantha	*Escobaria missouriensis*		Monitor
Spreading gilia	*Ipomopsis polycladon*		Priority 2
Ute ladies'-tresses	*Spiranthes diluvialis*	Threatened	Threatened
Winged-seed evening primrose	*Camissonia pterosperma*		Sensitive
Birds			
Bald eagle[a]	*Haliaeetus leucocephalus*		Threatened
Mammals			
Gray wolf	*Canis lupus*	Experimental, nonessential population	Experimental, nonessential population

[a] Removed, effective August 8, 2007, from the list of threatened wildlife in the lower 48 states (72 FR 37346).

Federal:

Candidate: Current information indicates the probable appropriateness of listing as endangered or threatened.

Experimental, Nonessential Population: A population authorized for release outside such species' current range, to be wholly separate geographically from nonexperimental populations of the same species. An experimental population that is not essential to the continued existence of a species shall be treated as a species proposed to be listed as endangered or threatened.

Threatened: Species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

State:

Sensitive: A state taxon with small populations or localized distributions within Idaho that presently do not meet the criteria for classification as Priority 1 or 2, but whose populations and habitats may be jeopardized without active management or removal of threats.

Monitor: Taxa that are common within a limited range or taxa that are uncommon but have no identifiable threats.

Priority 1: A taxon in danger of becoming extinct in Idaho in the foreseeable future if identifiable factors contributing to its decline continue to operate; these are taxa whose populations are present only at a critically low level or whose habitats have been degraded or depleted to a significant degree.

Priority 2: A state taxon likely to be classified as Priority 1 within the foreseeable future in Idaho if factors contributing to its population decline or habitat degradation or loss continue.

Threatened: Any native species likely to be classified as endangered within the foreseeable future throughout all or a significant portion of its Idaho range.

Note: The U.S. Fish and Wildlife Service does not currently distribute a list of species of concern for Idaho (Cheney 2008).

Source: IDGOSC 2008; INL 2009b; USFWS 2009.

3.3.7.4.2 Materials and Fuels Complex

Although no federally listed threatened or endangered animals have been observed in the immediate area of the MFC, several studies have documented the presence of other special status species. The Townsend's big-eared bat has been observed using nearby caves and foraging over water sources at INL. Given the proximity of the MFC to Rattlesnake Cave and the distance to another water source, it is highly likely that Townsend's big-eared bats frequently forage at the facility (Burandt 2008). Additionally, pygmy rabbits have been observed in the area of the MFC (Vilord et al. 2005). Surveys of federally or state-listed plants have not been conducted in the site vicinity.

A rattlesnake hibernaculum (a place to overwinter) is located a little over 1.6 kilometers (1 mile) south of the MFC. Concern for rattlesnakes within the state has grown in recent years, and, in fact, all reptiles receive protection in Idaho. It is possible that the Great Basin rattlesnake could migrate as far north as the MFC once they leave the hibernaculum in the spring (Jenkins and Peterson 2005:3, 4, 27).

3.3.8 Cultural and Paleontological Resources

INL has a well-documented record of cultural and paleontological resources due in part to a longstanding cultural resource management program outlined in the *Idaho National Laboratory Cultural Resource Management Plan* (DOE 2005a) and adopted by a programmatic agreement between DOE Idaho Operations Office (DOE-ID), the Idaho State Historic Preservation Office, and the Advisory Council on Historic Preservation. Past surveys have encompassed 8 to 10 percent of the INL site. These surveys have identified more than 2,200 prehistoric and historic archaeological resources and yielded an inventory of more than 200 DOE-administered buildings potentially eligible for inclusion in the National Register (O'Rourke 2006:28). In addition, consultations with local Shoshone-Bannock tribal members have served to identify TCPs.

Most cultural resource surveys have been in conjunction with major modification, demolition, or abandonment of site facilities. Approximately 40 to 50 specific projects are reviewed annually at INL for potential impacts on prehistoric and historic archaeological resources and TCPs. A similar number of project reviews are also performed to identify impacts on historic architectural properties.

Cultural sites were often occupied continuously or intermittently over substantial timespans. For this reason, a single location may have been used during both prehistoric and historic periods. In the discussions that follow, the numbers of prehistoric and historic resources are presented. The sum of these resources, however, may be greater than the total number of sites identified due to the dual-use history of various sites.

3.3.8.1 Prehistoric Resources

3.3.8.1.1 General Site Description

Prehistoric resources identified at INL are by definition physical properties reflecting human activities that predate written records; these generally reflect American Indian hunting and gathering activities. Approximately 1,980 prehistoric archaeological resources have been identified on INL. About half of these are isolates and half are sites (DOE 2005b). Most of the prehistoric sites are lithic scatters or locations (DOE 2002h:4-140). Resources appear to be concentrated along Big Lost River and Birch Creek, atop buttes, and within craters or caves. These include residential bases; campsites; caves; hunting blinds; rock alignments; and limited-activity locations such as lithic and ceramic scatters, hearths, and concentrations of fire-affected rock. Most sites at INL have not been formally evaluated for nomination to the National Register, but are considered to be potentially eligible. Given the rather high density of prehistoric sites at INL, additional sites are likely to be identified as surveys continue.

3.3.8.1.2 Materials and Fuels Complex

The most recent cultural resource survey conducted near the MFC took place in 1996 and covered an area to the south of the site that had been burned over by a wildfire and was proposed for revegetation. A total of 12 isolated finds and 2 archaeological sites were located. Isolated finds included items such as pieces of Shoshone brownware pottery and projectile points. The archaeological sites yielded collections of projectile points, scrapers, and volcanic glass flakes. Areas within the fenced portion of the MFC site are highly disturbed and are not likely to yield significant archaeological material (DOE 2002h:4-140, 4-141).

3.3.8.2 Historic Resources

3.3.8.2.1 General Site Description

Approximately 200 historic archaeological sites are known on INL, and at least 200 historic architectural properties have been identified during surveys of nearly 500 buildings administered by

DOE-ID (DOE 2005b). These resources represent European-American activities such as fur trapping and trading, immigration, transportation, mining, agriculture, and homesteading, as well as more-recent military, scientific, and engineering R&D activities. Examples of historic resources include Goodale's Cutoff (a spur of the Oregon Trail), remnants of homesteads and ranches, irrigation canals, and a variety of structures from the World War II era.

The Experimental Breeder Reactor I, the first reactor to achieve a self-sustaining chain reaction using plutonium instead of uranium as the principal fuel component, is listed in the National Register and is designated as a national historic landmark. Many other INL structures built between 1949 and 1974 are considered eligible for the National Register because of their exceptional scientific and engineering significance and their major role in the development of nuclear science and engineering since World War II. Additional historic sites are likely to exist in unsurveyed portions of INL (DOE 2002h:4-141).

3.3.8.2.2 Materials and Fuels Complex

A number of recent items, including farm implements, a belt buckle, broken glass, and a large scattering of cans, have been found in the MFC vicinity. Historic architectural properties are also present, including EBR-II, which has been designated as an American Nuclear Society Nuclear Historic Landmark (DOE 2002h:4.141). Future building surveys at the MFC are expected to result in the identification of additional historic architectural properties potentially eligible for nomination to the National Register.

3.3.8.3 American Indian Interests

3.3.8.3.1 General Site Description

TCPs at INL are associated with the two groups of nomadic hunters and gatherers that used the region at the time of European-American contact: the Shoshone and Bannock Tribes. Both of these used the area that now encompasses INL as they harvested plant and animal resources and obsidian from Big Southern Butte and Howe Point. Because the INL site is considered part of the Shoshone-Bannock Tribes' ancestral homeland, it contains many localities that are important for traditional, cultural, educational, and religious reasons. These include not only prehistoric archaeological sites that are important in the context of a religious or cultural heritage, but also features of the natural landscape and air, plant, water, and animal resources that have special significance (DOE 2002h:4-141).

DOE entered into an Agreement in Principle with the Shoshone-Bannock Tribes in 2002. In addition to defining a broad range of interests and working relationships and reaffirming the Tribes' rights under the Fort Bridger Treaty of 1868, the agreement devotes particular attention to the management of INL cultural resources. Its overall intent is to foster confidence on the part of the Shoshone-Bannock Tribes that INL cultural resources are managed in a spirit of protection and stewardship. To achieve this, the agreement provides for routine tribal participation in new and ongoing INL projects, with an open invitation to comment on, visit, observe, and assist in cultural resource management work (DOE 2005a; Ringe Pace et al. 2005).

3.3.8.3.2 Materials and Fuels Complex

Over the past two decades, efforts have been under way to assemble complete inventories of cultural resources in the vicinity of major operating facilities at INL, including MFC. Although prehistoric American Indian artifacts have been found in the MFC vicinity, areas within the fenced portion of the MFC site are highly disturbed and not likely to contain American Indian areas of interest (DOE 2000a:3-71).

3.3.8.4 Paleontological Resources

3.3.8.4.1 General Site Description

The region encompassing INL also has abundant and varied paleontological resources, including plant, vertebrate, and invertebrate remains in soils and lake and river sediments and organic materials found in caves and archaeological sites. Vertebrate fossils recovered from the Big Lost River floodplain consist of isolated bones and teeth from large mammals of the Pleistocene epoch, or Ice Age. These fossils were discovered during excavations and well-drilling operations. Fossils have been recorded in the vicinity of the Naval Reactors Facility. Occasional skeletal elements of fossil mammoth, horse, and camel have been retrieved from the Big Lost River diversion dam and the RWMC on the southwestern side of the INL site and from river and alluvial fan gravels and Lake Terreton sediments near Test Area North. A mammoth tooth dating from the Pleistocene epoch was recovered from the RTC. In total, 24 paleontological localities have been identified on INL (DOE 2002h:4-141, 4-142).

3.3.8.4.2 Materials and Fuels Complex

Paleontological resources were not found in the immediate MFC vicinity during a recent archaeological survey (DOE 2002h:4-142).

3.3.9 Socioeconomics

Statistics for population, the regional economy, housing, and local transportation have been developed for the ROI, a four-county area in Idaho (i.e., Bonneville, Bingham, Bannock, and Jefferson Counties), in which 92.3 percent of all INL employees reside (see Table 3–34).

Table 3–34. Distribution of Employees by Place of Residence in the Idaho National Laboratory Region of Influence in 2008

County	Number of Employees[a]	Total Site Employment (percent)
Bonneville	5,016	59.1
Bingham	1,276	15.0
Bannock	822	49.7
Jefferson	718	8.5
Total	**7,832**	**92.3**

[a] Number of employees includes contractors and subcontractors in the state of Idaho.

Source: Wiser 2008.

3.3.9.1 Regional Economic Characteristics

In November 2006 the civilian labor force in the ROI reached 123,824. The annual unemployment average in the four-county area at that time was 3.1 percent, slightly less than the annual unemployment average for Idaho (3.3 percent) (IDC&L 2007).

In 2005 trade, utilities, and transportation represented the largest sector of employment (21.9 percent). This was followed by government (19.0 percent) and professional and business services (13.4 percent). The totals for these employment sectors in Idaho were 19.8, 17.8, and 12.5 percent, respectively (IDC&L 2007). In 2008 INL employed 8,483 persons (Dahl 2008; Wiser 2008).

3.3.9.2 Demographic Characteristics

The 2000 population in the four-county ROI was 218,977. As depicted in the demographic profile presented as Table 3–35, the predominant population was white; of the minority populations, Hispanic or Latino and American Indian and Alaska Native were the largest groups.

Income information for the ROI in 2000 is provided in Table 3–36. As indicated, Bonneville County had the highest median household income of the four counties ($41,805) and the lowest percentage of persons (10.1) living below the poverty level. Bingham County had the lowest median household income ($36,423), but Bannock County had the largest number of individuals (13.9) living below the poverty level. The average median household income in the four counties was comparable to the median household income of the state of Idaho ($37,572) during the same time period.

Table 3–35. Demographic Profile of the Populations in the Idaho National Laboratory Socioeconomic Region of Influence in 2000

Population Group	Bannock County	Bingham County	Bonneville County	Jefferson County	Region of Influence
	Population (percentage of total)				
Nonminority					
White alone	67,636 (89.5)	32,824 (78.6)	74,461 (90.2)	16,955 (88.5)	191,876 (87.6)
Minority					
Black or African American[a]	446 (0.6)	70 (0.2)	403 (0.5)	53 (0.3)	972 (0.4)
American Indian and Alaska Native[a]	2,198 (2.9)	2,798 (6.7)	535 (0.6)	89 (0.5)	5,620 (2.6)
Asian[a]	748 (1.0)	236 (0.6)	675 (0.8)	44 (0.2)	1,703 (0.8)
Native Hawaiian and Other Pacific Islander[a]	122 (0.2)	13 (0.0)	56 (0.1)	15 (0.1)	206 (0.1)
Some Other Race[a]	1,568 (2.1)	3,320 (8.0)	3,073 (3.7)	1,294 (6.8)	9,255 (4.2)
Two or More Races[a]	1,496 (2.0)	895 (2.1)	1,206 (1.5)	254 (1.3)	3,851 (1.8)
White Hispanic	1,351 (1.8)	1,579 (3.8)	2,113 (2.6)	451 (2.4)	5,494 (2.5)
Total Minority	7,929 (10.5)	8,911 (21.4)	9,061 (9.8)	2,200 (11.5)	27,101 (12.4)
Total	**75,565**	**41,735**	**82,522**	**19,155**	**218,977**

[a] Includes individuals who identified themselves as Hispanic or Latino.

Source: Census 2007a.

Table 3–36. Income Information for the Idaho National Laboratory Region of Influence

Year 2000	Bannock County	Bingham County	Bonneville County	Jefferson County	Idaho State
Median household income	$36,683	$36,423	$41,805	$37,737	$37,572
Percent of persons below the poverty level	13.9	12.4	10.1	10.4	11.8

Source: Census 2007b.

3.3.9.3 Housing and Community Services

Table 3–37 presents information on housing availability in the ROI, as well as data on public education and community health-care services in the region. As indicated, in 2000 there were 80,176 housing units, and of these 93.7 percent were occupied and 6.3 percent vacant. Of the four counties, Bingham County had the highest vacancy rate at 6.9 percent, and Bonneville County, the lowest at 5.7 percent—both figures below the state vacancy percentage of 11.0. Home values were highest in Bonneville County, with a median value of $91,000, and lowest in Bingham County, where the median value was $81,700.

Table 3–37. Housing and Community Services in the Idaho National Laboratory Region of Influence

	Bannock County	Bingham County	Bonneville County	Jefferson County	Region of Influence
Housing, 2000[a]					
Total units	29,102	14,303	30,484	6,287	80,176
Occupied housing units	27,192	13,317	28,753	5,901	75,163
Vacant units	1,910	986	1,731	386	5,013
Vacancy rate (percent)	6.6	6.9	5.7	6.1	6.3
Median value[b]	$87,000	$81,700	$91,000	$89,400	$87,275
Public Education, 2005[c]					
Total enrollment	13,330	10,039	18,599	5,364	47,332
Student-to-teacher ratio	19.3	18.3	19.3	18.4	18.9
Community Health Care, 2005[d]					
Hospitals	2	3	3	0	8
Hospital beds per 1,000 persons	3.6	3.5	3.3	0	3.1
Physicians per 1,000 persons[e]	1.2	0.4	1.2	0.05	1.0

[a] Census 2007a, 2007b.
[b] Represents median value of all owner-occupied housing units.
[c] USDE 2007.
[d] IDHW 2005.
[e] Leonard 2005.

As also shown in the table, student enrollment in grades K–12 in the ROI in 2005 was 47,332. Bonneville County had the highest enrollment, and Jefferson County, the lowest. The average student-to-teacher ratio was 18.9 to 1, compared to the state of Idaho ratio of 17.9 to 1 (USDE 2007).

A total of eight hospitals served the ROI in 2005, with a ratio of 3.1 hospital beds per 1,000 people. In that year there was a ratio of 1.0 physician per 1,000 residents. Bannock and Bonneville Counties had the highest ratio (1.2), and Jefferson County, the lowest ratio (0.05) of physicians per 1,000 residents (IDHW 2005).

3.3.9.4 Local Transportation

Two interstate highways serve the INL region. Interstate 15, a north-south route that connects several cities along the Snake River, is approximately 40 kilometers (25 miles) east of INL and the MFC. Interstate 86 intersects Interstate 15 approximately 64 kilometers (40 miles) south of INL and provides a primary linkage from Interstate 15 to points west. Interstate 15 and U.S. Route 91 are the primary access routes to the Shoshone-Bannock Tribes' Fort Hall Reservation (DOE 2002a:4-64).

U.S. Routes 20 and 26 are the main access routes to the southern portion of INL, with U.S. Route 20 providing the most direct access to the MFC and to INL facilities to the west of the MFC. Idaho State Routes 22, 28, and 33 pass through the northern portion of INL, with State Route 33 providing access to the northern INL facilities (DOE 2002a:4–64). U.S. Routes 20 and 26 (two-lane, with a speed limit of 105 kilometers [65 miles] per hour) have the heaviest use because they provide direct links between INL and Idaho Falls and Blackfoot, Idaho. INL personnel living in Pocatello, Idaho, use Interstate 15 (four-lane, with a speed limit of 120 kilometers [75 miles] per hour) and U.S. Route 26 en route to and from the site. Those living in Mud Lake, Rexburg, and Terreton (north of the site) use State Route 33. These routes connect to INL's onsite road network, which consists of about 140 kilometers (87 miles) of paved roads (see Section 3.3.2.1.1). The paved public highways running through INL total an additional 145 kilometers (90 miles) of roadway (ANL 2003:9).

Major regional roadway segments serving INL have historically operated at Level of Service A, which is defined as free-flow traffic conditions (DOE 2002a:4–64). According to data from rural traffic flow mapping performed annually by the State of Idaho, annual average daily traffic (AADT) and associated levels of service on major roadway segments serving INL did not change substantially between 1996 and 2005. The AADT on U.S. Route 20 from Idaho Falls to INL was 1,900 in 2005 as opposed to 2,100 in 1996. Corresponding AADT changes observed on other roadway segments include the following: from INL west to Arco on U.S. Route 20, 1,500 in 2005 versus 1,900 in 1996; from Blackfoot, Idaho, to INL on U.S. Route 26, 2,000 in 2005 versus 1,400 in 1996; and from Mud Lake to INL on State Route 33, 680 in 2005 versus 600 in 1996 (ITD 2006). Peak hourly traffic can be assumed to be 15 percent of the AADT. Two-lane roads servicing INL are designed for approximately 1,000 vehicles per hour, in optimum weather conditions. The four-lane interstate can accommodate more than 2,000 vehicles per hour (ANL 2003:9).

DOE buses provide transportation between INL facilities and surrounding communities for DOE and contractor personnel. Extensive use of this system keeps automobile traffic light. The Mackay Branch Line of the Union Pacific Railroad, the major railroad in the area, services the southern portion of INL through the Scoville Spur. Freight services are received from the Union Pacific's main lines from Butte, Montana, on the north and Pocatello, Idaho, and Salt Lake City, Utah, on the south. Interconnections are made from these locations to areas throughout the United States. INL freight comes through Blackfoot, Idaho, on north-south track of the Union Pacific's Mackay Branch Line, 23 kilometers (14 miles) of which traverse the southern part of INL (ANL 2003:9, 10, 11). Rail shipments to and from INL usually are limited to bulk commodities, SNF, and radioactive waste (DOE 2002a:4–66). There are no navigable waterways within the area capable of accommodating waterborne transportation of material shipments to INL.

The cities of Idaho Falls and Pocatello both have airports with passenger and cargo service (ANL 2003:10). Idaho Falls Regional Airport services eastern Idaho, southern Montana, and western Wyoming. The airport is served by Skywest/Delta Airlines, which provides frequent daily flights to Salt Lake City, Utah; Horizon Air/Alaska Airlines, with daily flights to Boise, Idaho; Northwest Airlines, with daily flights to Minneapolis, Minnesota; and Allegiant Air, providing weekly service to Las Vegas, Nevada (CIF 2007). There is a helicopter pad on site at the MFC and at each of the other major INL facilities. A Federal Aviation Administration low-altitude airway crosses the southwest portion of INL in a northwestwardly direction (ANL 2003:10).

3.3.10 Existing Human Health Risk

The scope of the discussion of human health risk in this *TC & WM EIS* is stipulated in Section 3.2.10.

3.3.10.1 Radiation Exposure and Risk

Major sources and average levels of background radiation exposure of individuals in the INL vicinity are shown in Table 3–38. Annual background radiation doses to individuals are expected to remain constant over time. The population's total dose, in terms of person-rem, varies with the population size. Background radiation doses are unrelated to INL operations.

Table 3–38. Sources of Radiation Exposure of Individuals in the Idaho National Laboratory Vicinity Unrelated to Idaho National Laboratory Operations

Source	Effective Dose Equivalent (millirem per year)[a]
Natural Background Radiation	
External (terrestrial and cosmic)[b]	117
Internal (terrestrial and global cosmogenic)[c]	40
Radon in homes (inhaled)[c]	200
Other Background Radiation[c]	
Diagnostic x-rays and nuclear medicine	53
Consumer and industrial products	10
Other (air travel, weapons test fallout, etc.)	Less than or equal to 2
Total	422

[a] Averages for the United States.
[b] DOE 2007d:7.15.
[c] NCRP 1987.

Releases of radionuclides to the environment from operations provide another source of radiation exposure for individuals in the vicinity of INL. Types and quantities of radionuclides released from INL operations in 2006 are listed in the *Idaho National Laboratory Site Environmental Report, Calendar Year 2006* (DOE 2007d). The releases are summarized in Section 3.3.4.2 of this chapter. The doses to the public resulting from these releases are presented in Table 3–39. These doses fall within the radiological limits given in DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* and are much lower than those from background radiation.

Table 3–39. Radiation Doses to the Public from Idaho National Laboratory Normal Operations in 2006 (Total Effective Dose Equivalent)

Members of the Public	Atmospheric Releases		Liquid Releases		Total	
	Standard[a]	Actual	Standard[a]	Actual[b]	Standard[a]	Actual
Maximally exposed individual (millirem)	10	0.050	4	-	100	0.050
Population within 80 kilometers (person-rem)[c]	None	0.611	None	-	None	0.611
Average individual within 80 kilometers (millirem)[d]	None	0.0021	None	-	None	0.0021

[a] Stipulated in DOE Order 5400.5. As discussed in that order, the 10-millirem-per-year limit for airborne emissions is required by the Clean Air Act (40 CFR 61), and the 4-millirem-per-year limit is required by the Safe Drinking Water Act (40 CFR 141). The total dose of 100 millirem per year is the limit from all pathways combined.
[b] Not modeled in the Idaho National Laboratory site report (DOE 2007d:8.2).
[c] Based on an estimated population of 290,819 in 2006.
[d] Obtained by dividing the population dose by the estimated population.
Note: To convert kilometers to miles, multiply by 0.6214.
Source: DOE 2007d:8.7, 8.8.

Given a risk estimator of 600 cancer deaths per 1 million person-rem to the public (see Appendix K, Section K.1.1.3), the fatal cancer risk to the MEI due to radiological releases from INL operations in 2006 is estimated to be 3.0×10^{-8}. That is, the estimated probability of this person dying of cancer at some point in the future from radiation exposure associated with 1 year of INL operations is 1 in 33 million (it takes many years from the time of radiation exposure for a cancer to manifest itself). The hypothetical MEI is a person whose residence and lifestyle make it unlikely that any other member of the public would receive a higher radiological dose from INL releases. This person is assumed to be exposed to radionuclides in the air and on the ground from INL emissions and to ingest locally grown food.

According to the same risk estimator, 3.6×10^{-4} excess fatal cancers are projected in the population living within 80 kilometers (50 miles) of INL from normal operations in 2006. To place this number in perspective, it may be compared with the number of fatal cancers expected in the same population from all causes. The mortality rate associated with cancer for the entire U.S. population is 0.2 percent per year. On this basis, the number of fatal cancers expected from all causes in the population living within 80 kilometers (50 miles) of INL in 2006 would be 582. This number is much higher than the number of fatal cancers estimated from INL operations in 2006.

Members of the public may also be exposed to radioactivity through the consumption of wildlife that has access to INL. A member of the public would receive a maximum potential radiological dose of about 0.013 millirem per year from if eating 225 grams (8 ounces) of waterfowl that have used the radioactive wastewater ponds on the site. Only one game animal collected during 2006 had a detectable concentration of cesium-137 in the muscle, a concentration that could deliver a dose of approximately 0.007 millirem to someone who ate the entire muscle (up to 27,000 grams [952 ounces]) (DOE 2007d:8.10, 8.11).

INL workers receive the same dose as the general public from background radiation, but they also receive an additional dose from working in facilities with nuclear materials. The average dose to the individual worker and the cumulative dose to all workers at INL from operations in 2006 are presented in Table 3–40. Given a risk estimator of 0.0006 LCFs per person-rem among workers (see Appendix K, Section K.1.1.3), the projected number of fatal cancers among INL workers from normal operations in 2006 is 0.066.

Table 3–40. Radiation Doses to Workers from Idaho National Laboratory Normal Operations in 2006 (Total Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard[a]	Actual
Average radiation worker (millirem)	5,000	80
Total workers[b] (person-rem)	None	161.7

[a] No standard is specified for an "average radiation worker"; however, the maximum dose to a worker is limited as follows: The radiological limit for an individual worker is 5,000 millirem per year (10 CFR 835). However, the U.S. Department of Energy's (DOE's) goal is to maintain radiological exposure as low as is reasonably achievable. DOE has therefore established the Administrative Control Level of 2,000 millirem per year; the site contractor sets facility administrative control levels below the DOE level, with 500 millirem per year considered a reasonable goal for trained radiological workers.

[b] There were 2,023 workers with measurable doses in 2006.

Note: Total radiation worker dose presented in the table differs from that calculated from data shown due to rounding.

Source: 10 CFR 835.202; DOE Standard 1098–99; DOE 2007a:3-10.

3.3.10.2 Chemical Environment

The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals

that can be ingested; and other environmental media with which people may come in contact (e.g., soil through direct contact or via the food pathway).

Adverse health impacts on the public are minimized through administrative and design controls to decrease hazardous chemical releases to the environment and to achieve compliance with permit requirements. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts on the public may occur during normal operations at INL via inhalation of air containing hazardous chemicals released to the atmosphere by INL operations. Risks to public health from ingestion of contaminated drinking water or direct exposure are potential pathways; the water pathway is considered an unlikely source of exposure at INL because no surface water flows off the site and radioactive contaminants have not been found in drinking water (DOE 2007d:8.2).

Baseline air emission concentrations for air pollutants and their applicable standards are presented in Section 3.3.4 of this chapter. These concentrations are estimates of the highest existing offsite concentrations and represent the highest concentrations to which members of the public could be exposed. These concentrations are compared with applicable guidelines and regulations.

Chemical exposure pathways to INL workers during normal operations may include inhalation, the drinking of INL potable water, and physical contact with hazardous materials associated with work assignments. Workers are protected from hazards specific to the workplace through appropriate training, personal protective equipment, monitoring, and management controls. INL workers are also protected by adherence to Occupational Safety and Health Administration and EPA occupational standards that limit atmospheric and drinking water concentrations of potentially hazardous chemicals. Monitoring that reflects the frequency and amounts of chemicals used in the operational processes ensures that these standards are not exceeded. Additionally, DOE requirements ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm. Therefore, worker health conditions at INL are substantially better than required by standards.

3.3.10.3 Health Effect Studies

Epidemiological studies were conducted on communities surrounding INL to determine whether there were excess cancers in the general population. The studies discussed are representative of the health effects studies that have been performed for the impacts on the public and workers at INL. In 1991 INL completed a 3-year effort to evaluate historical releases of radioactive materials and potential doses to a hypothetical individual who may have resided at an offsite location with the highest concentration of airborne radionuclides. The evaluation found that "radiation doses from airborne releases over the operating history of INL were small compared to doses from background radiation" (CDC 2005a). No excess cancer mortality was reported, and although excess cancer incidence was observed, no association with INL was established. A study by the State of Idaho completed in June 1996 found excess brain cancer incidence in the six counties surrounding INL, but a followup survey concluded that there was nothing that clearly linked all these cases to one another or to any one thing (DOE 2002h:4.149).

Two recent health effects studies of INL-related impacts were conducted by agencies of the U.S. Department of Health and Human Services. The *Public Health Assessment: Idaho National Engineering and Environmental Laboratory*, performed by the Agency for Toxic Substances and Disease Registry, focused on INL (formerly the Idaho National Engineering and Environmental Laboratory) operations from 1987 to 2000. It was published in March 2004 and concluded that "under normal operating conditions, INL poses no past, current, or future apparent public health hazard for the surrounding community" (ATSDR 2004). A dose reconstruction was completed by the Centers for Disease Control and Prevention in 2004 as a follow-on to DOE's 1991 evaluation of potential doses from the Aircraft Nuclear Propulsion Program Initial Engine Test series and the Idaho Chemical Processing

Plant. The study by the Centers for Disease Control and Prevention also found that the calculated doses "were small and not sufficient to cause human health effects" (CDC 2005a).

Under a DOE-Centers for Disease Control and Prevention cooperative agreement, an epidemiological study evaluated a group of workers at DOE's Hanford, INL, and Oak Ridge sites for evidence of a connection between paternal exposure to ionizing radiation and childhood leukemia. This study yielded no evidence of such a link (Sever et al. 1997).

The National Institute for Occupational Safety and Health reported on an epidemiologic study of mortality and radiation-related risk of cancer among INL workers in 2005. The study concerned over 63,000 civilian workers employed at INL between 1949 and 1991. It concluded that mortality risk for most causes of death was lower among INL workers than the regional population; however, the cancer mortality rate was slightly elevated among workers, but for most cancer types was not likely related to ionizing radiation. The study showed some evidence between workplace radiation exposures and the risk of brain cancer, leukemia, and lymphatic cancers. The study also found elevated rates of mortality for asbestos-related diseases, particularly among asbestos workers (CDC 2005b).

In 1997, DOE began providing free medical screening for former and current workers at certain DOE sites, including INL. The goal of this program, which is ongoing, is to detect work-related illnesses at an early stage when medical intervention may be helpful. It also helps workers determine if a current health condition is the result of work-related exposure (WHPP 2008).

3.3.10.4 Accident History

Since the early 1950s there have been eight criticality accidents at INL (DOE 2002h:4-150). Those accidents occurred during processing, control-rod maintenance, critical experiment setups, and intentional destructive power excursions. Accidents connected with experiments typically involved power excursions that were significantly larger than expected. The accidents at the site resulted in various levels of radiation exposure to the involved workers and in impacts on equipment ranging from little or no damage to total loss. Exposure of the public from these accidents was minimal.

As described in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a), DOE conducted a historical dose evaluation study to estimate the offsite radiation doses for the entire operating history of INL (Wenzel, Peterson, and Dickson 1993). Radiological releases resulted from a variety of tests and experiments, as well as a few accidents. The study concluded that the offsite radiation doses from operations and accidents were small compared with doses from background radiation. Releases have declined in frequency and size since the time of the study; in fact, for more than a decade of INL operation, there have been no serious unplanned releases of radioactivity or other hazardous substances.

Incidents with worker health implications over the period 2000 through 2006, as identified through Occurrence Reporting and Processing System records (DOE 2007b), include the following:

- Potential worker exposure to asbestos during building maintenance activities (June 2006).
- Worker exposure to crystalline silica in excess of occupational safety limits during work with bentonite (June 2005).
- Exposure of two workers to noise levels above occupational safety limits during demolition activities (September 2005).
- Contamination of an extremity of a crane mechanic in the Graphite Storage Facility; he was successfully decontaminated (June 2002).

- Worker exposure to iron oxide and manganese in excess of occupational safety limits (2001).
- Worker exposure to plutonium in the CPP-602 Laboratory, resulting in a committed effective dose equivalent of 5 millirem (March 2000).
- Exposure of workers to unknown vapors/fumes in laboratory operations (April 2000).

3.3.10.5 Emergency Preparedness

Each DOE site has established an emergency management program that would be activated in the event of an accident. This program was developed and is maintained to ensure adequate response to most accident conditions and to provide response efforts for accidents not specifically considered. The emergency management program includes emergency planning, training, preparedness, and response.

Government agencies whose plans are interrelated with the *INL Emergency Plan for Action* include the State of Idaho; Bingham, Bonneville, Butte, Clark, and Jefferson Counties; the U.S. Bureau of Indian Affairs; and the Fort Hall Indian Reservation. INL contractors are responsible for responding to emergencies at their facilities. Specifically, the Emergency Action Director is responsible for recognition, classification, notification, and protective action recommendations. At INL, emergency preparedness resources include fire protection from onsite and offsite locations and radiological and hazardous chemical material response. Emergency response facilities include an emergency control center at each facility, at the INL Warning Communication Center, and at the INL Site Emergency Operations Center. Seven INL medical facilities are available to provide routine and emergency service. In addition, DOE has specified actions to be taken at all DOE sites to implement lessons learned from the emergency response to an accidental explosion at Hanford in May 1997.

3.3.11 Environmental Justice

The scope of the discussion of environmental justice in this *TC & WM EIS* is stipulated in Section 3.2.11.

3.3.11.1 Minority Populations

The 80-kilometer (50-mile) radius surrounding the MFC at INL encompasses parts of 14 counties: Bannock, Bingham, Blaine, Bonneville, Butte, Caribou, Clark, Custer, Fremont, Jefferson, Lemhi, Madison, Minidoka, and Power Counties in the state of Idaho. Tables 3–41 and 3–42 provide a breakdown of minority populations in the potentially affected counties and the state of Idaho in 1990 and 2000. The total population of the 14-county area experienced an increase of approximately 14 percent from 1990 to 2000. During that decade, the total minority population in that area increased by approximately 62 percent; individuals who self-identified as Hispanic or Latino, by approximately 64 percent; and the American Indian and Alaska Native population, by approximately 14 percent. From 1990 to 2000, the total population of Idaho increased approximately 29 percent. The total minority population in the state increased by approximately 98 percent; the American Indian and Alaska Native population, by approximately 28 percent; and people self-identified as Hispanic or Latino, by over 92 percent.

Table 3–41. Populations in Potentially Affected Counties Surrounding the Materials and Fuels Complex at the Idaho National Laboratory and in the State of Idaho in 1990

Population Group	Counties Around Materials and Fuels Complex		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White alone	262,826	91.1	928,661	92.2
Minority				
Black or African American[a]	897	0.3	3,370	0.3
American Indian and Alaska Native[a]	5,570	1.9	13,780	1.4
Asian or Pacific Islander[a]	2,349	0.8	9,365	0.9
Some other race[a]	10,664	3.7	29,783	3.0
White Hispanic	6,338	2.2	21,790	2.2
Total Minority[b]	**25,818**	**8.9**	**78,088**	**7.8**
Total	**288,644**	**100.0**	**1,006,749**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals, regardless of race, who identified themselves as Hispanic or Latino, numbering 17,705 (6.1 percent of total population) in the counties surrounding the Materials and Fuels Complex at the Idaho National Laboratory, and 52,927 (5.3 percent of total population) in Idaho.

Source: Census 2007c.

Table 3–42. Populations in Potentially Affected Counties Surrounding the Materials and Fuels Complex at the Idaho National Laboratory and in the State of Idaho in 2000

Population Group	Counties Around Materials and Fuels Complex		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White alone	286,567	87.3	1,139,291	88.0
Minority				
Black or African American[a]	1,162	0.4	5,456	0.4
American Indian and Alaska Native[a]	6,374	1.9	17,645	1.4
Asian[a]	2,179	0.7	11,889	0.9
Native Hawaiian and other Pacific Islander[a]	297	0.1	1,308	0.1
Some other race[a]	16,807	5.1	54,742	4.2
Two or more races[a]	5,529	1.7	25,609	2.0
White Hispanic	9,424	2.9	38,013	2.9
Total Minority[b]	**41,772**	**12.7**	**154,662**	**12.0**
Total	**328,339**	**100.0**	**1,293,953**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals, regardless of race, who identified themselves as Hispanic or Latino, numbering 28,950 (8.8 percent of total population) in the counties surrounding the Materials and Fuels Complex at the Idaho National Laboratory, and 101,000 (7.9 percent of total population) in Idaho.

Source: Census 2007a.

Approximately 206,000 people lived within an 80-kilometer (50-mile) radius of the MFC in 2000. In this area, minorities accounted for approximately 12 percent of the total population. Those who identified themselves as Hispanic or Latino were the largest minority group, constituting about 65 percent of the minority population and almost 8 percent of the total population. Table 3–43 shows a breakdown of the population within 80 kilometers (50 miles) of the MFC.

Table 3–43. Populations Within 80 Kilometers of the Materials and Fuels Complex at the Idaho National Laboratory in 2000

Population Group	Population	Percentage of Total
Nonminority		
White alone	180,787	87.8
Minority		
Black or African American[a]	677	0.3
American Indian and Alaska Native[a]	4,972	2.4
Asian[a]	1,435	0.7
Native Hawaiian and other Pacific Islander[a]	155	0.1
Some other race[a]	9,264	4.5
Two or more races[a]	3,257	1.6
White Hispanic	5,253	2.6
Total Minority[b]	**25,175**	**12.2**
Total	**205,962**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals, regardless of race, who identified themselves as Hispanic or Latino numbering 16,329 (7.9 percent of the total population).

Note: To convert kilometers to miles, multiply by 0.6214. Total may not equal the sum of the contributions due to rounding.

Source: Census 2007a.

Figures 3–40 and 3–41 illustrate minority populations as a function of distance from the MFC. Block-group data generated from the U.S. Census Bureau's *Summary File 1* (Census 2007a), reflect an estimated total population of 205,962 in 2000. Sharp spikes in populations can be seen around the outskirts of large population centers. However, large spikes did not occur until a point about 48 kilometers (30 miles) away, in the vicinity of Idaho Falls. The next significant jump occurred at approximately 72 kilometers (45 miles), near Pocatello. Approximately 10 percent of the minority population live within 45 kilometers (28 miles) of the MFC, and approximately 50 percent, within 56 kilometers (35 miles). It is estimated that 8 percent of the population living within the potentially affected 80-kilometer (50-mile) radius of the MFC were self-identified as Hispanic or Latino.

Figure 3–42 shows minority and nonminority populations living in block groups surrounding the MFC in 2000. Over 91 percent of the minority populations lived in four Idaho counties: Bannock, Bingham, Bonneville, and Jefferson; approximately 35 percent were concentrated in Bingham County. Of the 189 block groups surrounding the MFC, 11 contain minority populations.

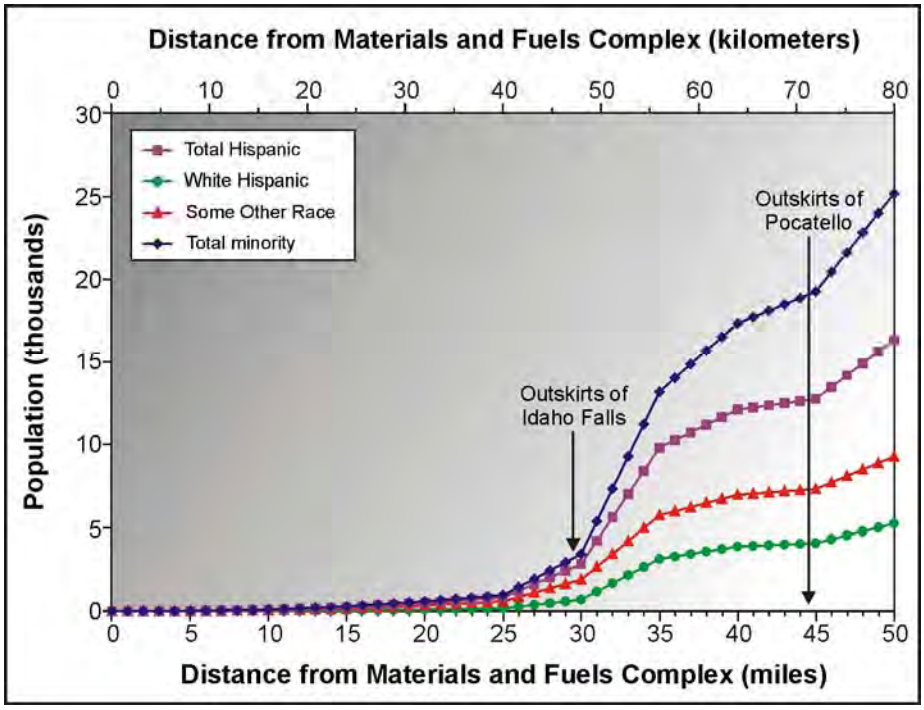


Figure 3–40. Cumulative Larger-Scale Minority Populations Surrounding the Materials and Fuels Complex at Idaho National Laboratory in 2000 as a Function of Distance

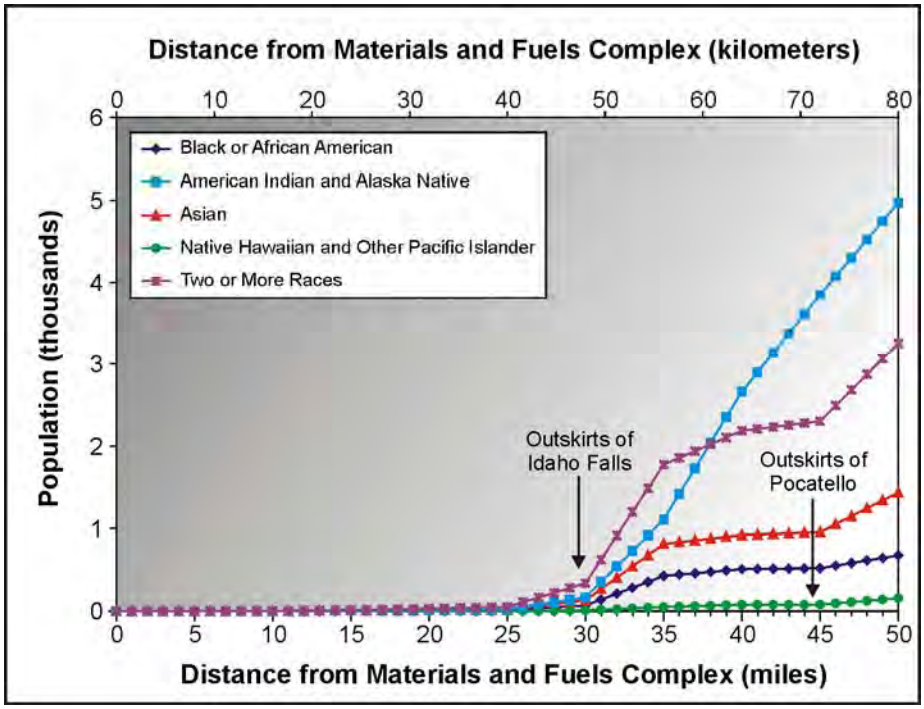


Figure 3–41. Cumulative Smaller-Scale Minority Populations Surrounding the Materials and Fuels Complex at Idaho National Laboratory in 2000 as a Function of Distance

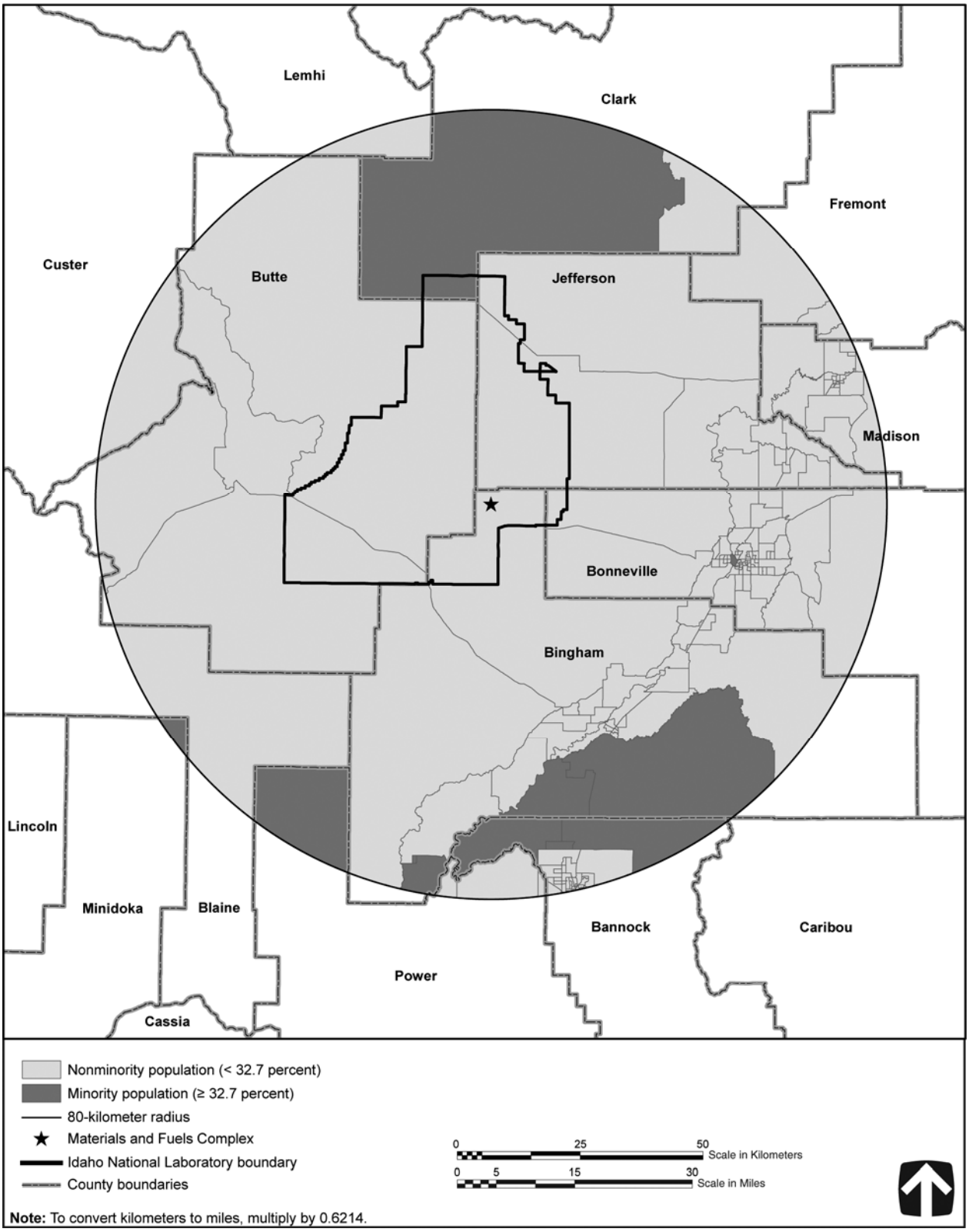


Figure 3–42. Minority and Nonminority Populations Living in Block Groups Surrounding the Materials and Fuels Complex at Idaho National Laboratory in 2000

3.3.11.2 Low-Income Populations

Tables 3–44 and 3–45 show the total and low-income populations in the 14-county area surrounding the MFC and in the state of Idaho in 1989 and 1999, respectively. From 1989 to 1999, the total population of the 14-county area surrounding INL increased by approximately 13 percent, while the low-income population increased by approximately 11 percent. Over the same period, the total population of Idaho increased by approximately 28 percent, and the low-income population, by approximately 14 percent.

Table 3–44. Total and Low-Income Populations in the Potentially Affected 14-County Area Surrounding Idaho National Laboratory and in the State of Idaho in 1989

Population Group	Idaho National Laboratory Environs		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Total population[a]	284,248	100.0	985,553	100.0
Low-income population	39,612	13.9	130,588	13.3

[a] The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income does not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

Source: Census 2007d.

Table 3–45. Total and Low-Income Populations in the Potentially Affected 14-County Area Surrounding Idaho National Laboratory and in the State of Idaho in 1999

Population Group	Idaho National Laboratory Environs		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Total population[a]	322,443	100.0	1,263,205	100.0
Low-income population	43,994	13.6	148,732	11.8

[a] The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income does not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

Source: Census 2007b.

Table 3–46 shows the total and low-income populations within 80 kilometers (50 miles) of the MFC. Low-income individuals constituted approximately 14 percent of the total population in 1999. Approximately 60 percent of the low-income population resided in Bonneville and Madison Counties; another 30 percent, in Bannock and Bingham Counties; and the remaining 10 percent, in Butte and Jefferson Counties.

Table 3–46. Total and Low-Income Populations Within 80 Kilometers of the Materials and Fuels Complex at Idaho National Laboratory in 1999

Population Group	Population	Percentage of Total
Total population[a]	202,718	100.0
Low-income population	27,606	13.6

[a] The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income does not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

Note: To convert kilometers to miles, multiply by 0.6214.

Source: Census 2007b.

Figure 3–43 shows the total, low-income, and non-low-income populations as a function of distance from the MFC. Block-group data generated from the U.S. Census Bureau's *Summary File 3* (Census 2007b) reflect a total population of 202,718 within an 80-kilometer (50-mile) radius of the MFC.

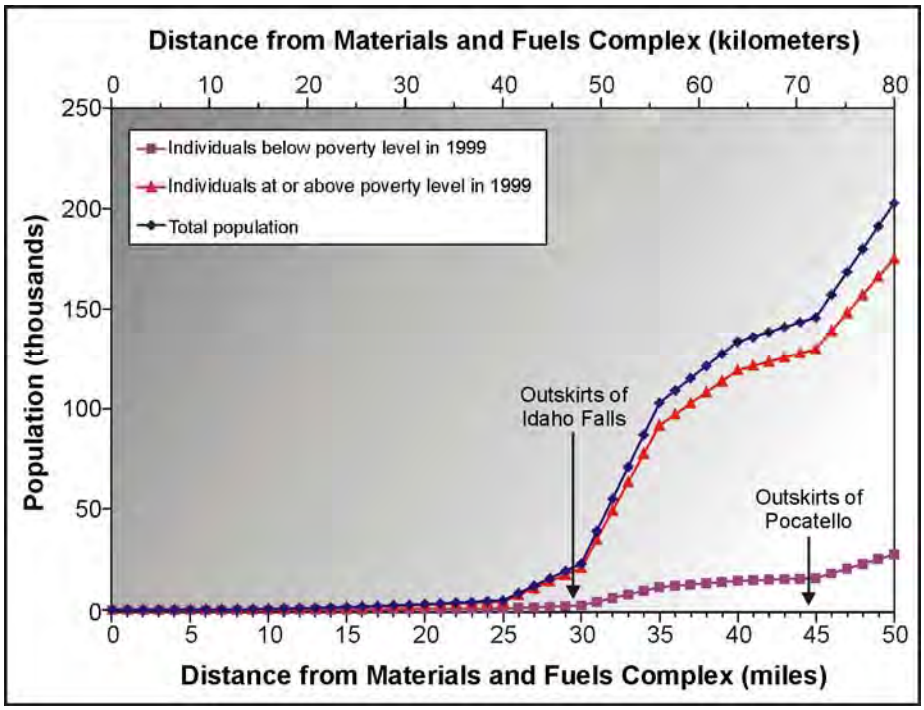


Figure 3–43. Low-Income and Non-Low-Income Populations Surrounding the Materials and Fuels Complex at Idaho National Laboratory in 1999 as a Function of Distance

Figure 3–44 shows low-income and non-low-income population living in the block groups surrounding the MFC at INL. Of the 189 block groups surrounding the MFC, 9 contain low-income populations.

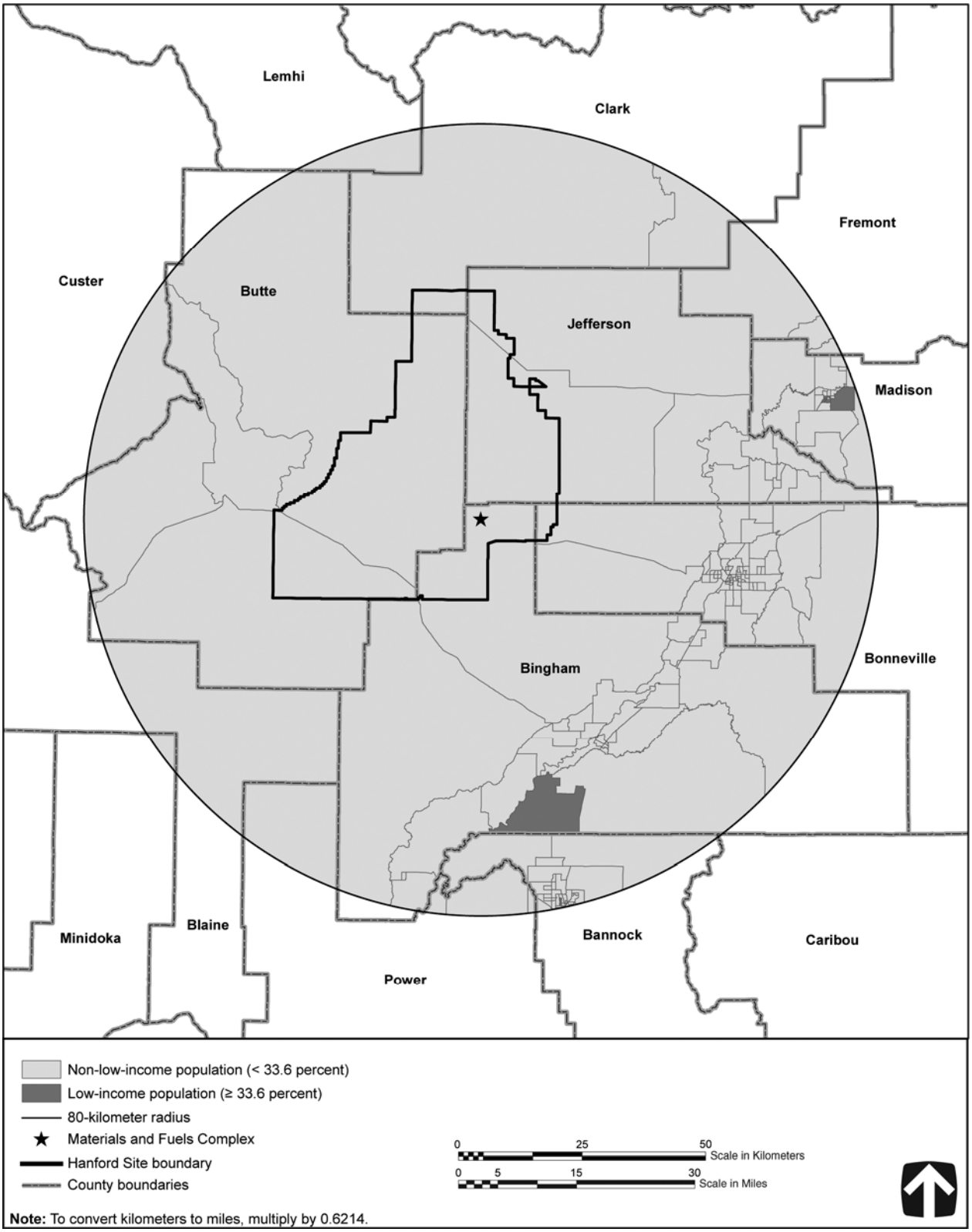


Figure 3–44. Total and Low-Income Populations Living in Block Groups Surrounding the Materials and Fuels Complex at Idaho National Laboratory in 1999

3.3.12 Waste Management

The scope of the discussion of waste management in this *TC & WS EIS* is stipulated in Section 3.2.12.

3.3.12.1 Waste Inventories and Activities

INL manages the following types of waste: HLW, TRU waste, LLW, MLLW, hazardous waste, and nonhazardous waste. Because there is no HLW, TRU waste, or mixed TRU waste associated with the activities being assessed at INL under the action alternatives, these waste types are not discussed in this *TC & WM EIS*. Waste generation rates and the inventory of stored waste from activities at INL are provided in Table 3–47. INL waste management facilities are summarized in Table 3–48.

Table 3–47. Waste Generation Rates and Inventories at Idaho National Laboratory in 2006

Waste Type	Generation Rate	Inventory[a]
	(cubic meters)	
Transuranic[b]	185.77	51,530
Low-level radioactive	11,002	3,268
Mixed low-level radioactive	26,675	3,191
Hazardous[c]	320	88
Nonhazardous[c]		
Liquid	78	25.81
Solid	456	55.21

[a] Real volumes have been reported, but it must be noted that some waste streams are significantly larger due to the abatement of decontamination and decommissioning activities.

[b] Volumes include transuranic and mixed transuranic waste combined.

[c] Generally, such waste is not held in long-term storage.

Note: To convert cubic meters to cubic yards, multiply by 1.308.
Source: Willcox 2007.

3.3.12.1.1 Low-Level Radioactive Waste

Approximately 8,680 cubic meters (306,531 cubic feet) of legacy and newly generated LLW were disposed of at the Subsurface Disposal Area in 2006. The Subsurface Disposal Area is a 39-hectare (97-acre) disposal area at INL containing buried hazardous and radioactive waste (DOE 2007d:3.19, 3.21). In 2006 approximately 11,002 cubic meters (388,525 cubic feet) of solid LLW was generated at INL (see Table 3–47).

Disposal of CH-LLW and open pit disposal of RH-LLW at the RWMC ceased September 30, 2008. The RH-LLW disposal vaults will remain open for the disposal of Naval Reactors RH-LLW through approximately the end of 2015 based on remaining disposal capacity. CH-LLW and RH-LLW previously disposed in the open pit at RWMC will be disposed at NTS. INL is currently evaluating and pursuing options for uninterrupted RH-LLW disposal capability beyond 2015.

Table 3–48. Waste Management Facilities at Idaho National Laboratory

Facility Name/Description	Facility Number	Process Design Capacity[a]	Status	Applicable Waste Types			
				TRU	LLW	MLLW	HAZ
Treatment Facility[a]							
NWCF Debris Treatment Process	CPP-659	60,020	Permitted			X	X
NWCF HEPA Filter Leach System	CPP-659	1,060	Permitted			X	X
Contaminated-Equipment Storage Building	MFC-794	56,780/Storage 1,666/Treatment	Permitted	X		X	X
Hot Fuel Examination Facility	MFC-785	40,598/Storage 1,666/Treatment	Permitted	X		X	X
Sodium Components Maintenance Shop	MFC-793	119,919/Storage 6,163/Treatment	Permitted			X	X
Transient Reactor Test Facility	MFC-720	26,649/Storage 1,666/Treatment	Permitted	X		X	X
Advanced Mixed Waste Treatment Project Waste Storage Facility	WMF-676	486,078	Permitted	X		X	
NWCF Storage	CPP-659	2,050,051 (containers) 791 cubic meters (waste pile)	Permitted			X	X
Radioactive Mixed Waste Staging Facility	CPP-1617	8,494,871	Permitted			X	X
SWEPP Storage Area	WMF-610	107,428/Storage 99,933/Treatment	Permitted	X	X	X	
Radioactive Scrap and Waste Facility	MFC-771	200,622	Permitted	X	X	X	X
Sodium Storage Building	MFC-703	181,696	Permitted			X	X
TSA Retrieval Enclosure Retrieval Modification Facility (includes the capacities for the TSA-1/TSA-R and TSA-2 storage units)	RWMC	16,810,415	Interim status	X		X	
Advanced Mixed Waste Treatment Project Waste Storage Facility	RWMC	76,791,396/Storage 99,933/Treatment	Permitted	X		X	
Fluorinel Dissolution Process Cell Container Storage	CPP-666	141,193	Permitted			X	X
Integrated Waste Treatment Unit	CPP-1696	640,766/Storage 19,078/Treatment	Permitted			X	
Sodium Process Facility Building	MFC-799	85,246/Storage 5,754/Treatment	Permitted			X	X
Experimental Breeder Reactor Complex	MFC	406,090/Storage 5.7 liters/day/tank	Permitted			X	

[a] Capacities expressed in liter unless otherwise noted.

Note: To convert liters to gallons multiply by 0.26417; cubic meters to cubic yards, multiply by 1.308.

Key: CPP=Chemical Processing Plant; HAZ=hazardous; HEPA=high-efficiency particulate air; LLW=low-level radioactive waste; MFC=Materials and Fuels Complex; MLLW=mixed low-level radioactive waste; NWCF=New Waste Calcining Facility; RWMC=Radioactive Waste Management Complex; SWEPP=Stored Waste Examination Pilot Plant; TRU=transuranic; TSA=Transuranic Storage Area; TSA-1=TSA Pad 1; TSA-2=TSA Pad 2; TSA-R=TSA Pad R; WMF=Waste Management Facility.

Source: INL 2008.

3.3.12.1.2 Mixed Low-Level Radioactive Waste

MLLW and polychlorinated biphenyl-contaminated LLW are stored at several onsite areas. Such waste is stored at the Radioactive Mixed Waste Staging Facility at INTEC and the RWMC. Smaller quantities are stored in various other facilities at INL, including the Radioactive Sodium Storage Facility and Radioactive Scrap and Waste Facility at the MFC.

As part of the *Idaho National Laboratory Site Treatment Plan* (DOE 2007e), a required plan for developing treatment capacities and technologies for each facility at which DOE generates or stores mixed waste, pursuant to RCRA, Section 3021(b), as amended by Section 105(b) of the Federal Facility Compliance Act, preferred options for treatment to eliminate the hazardous waste component of many types of MLLW have been identified. MLLW is or will be processed to RCRA land-disposal-restriction treatment standards through several treatment facilities. The specific facilities and their operational status are as follows: AMWTP, operational; debris treatment, operational; high-efficiency particulate air filter leaching, operational as needed; remote-handled waste disposition project, planned/DOE approved; Sodium Processing Facility, in standby; Sodium Component Maintenance Shop, operational. Commercial treatment facilities are also being considered, as appropriate. Currently, INL ships MLLW for treatment to the following Perma-Fix Environmental Services, Inc., treatment facilities: Perma-Fix Florida, Gainesville, Florida; Material & Energy Corporation and Diversified Scientific Services, Inc., Kingston, Tennessee; and Perma-Fix Northwest, Richland, Washington. Waste treated at these facilities is currently sent to NTS for disposal. A limited amount of MLLW is treated and disposed of at EnergySolutions of Utah.

The AMWTP characterizes and then sorts, sizes, repackages, and compacts mixed TRU waste. The AMWTP characterizes mixed waste from a soil covered berm. If during characterization, a retrieved container is assayed as not meeting the definition of TRU waste, it is determined to be mixed low-level waste. The overall goal of the AMWTP is to prepare TRU waste now buried or stored at INL for shipment to WIPP, a permanent geologic repository near Carlsbad, New Mexico. The facility will treat waste to meet the most current requirements, reduce waste volumes and life-cycle costs to DOE, and perform all tasks in a safe, environmentally compliant manner.

A contract for treatment services was awarded to British Nuclear Fuels Limited, Inc., in December 1996. British Nuclear Fuels Limited, Inc., completed construction of the AMWTP in December 2002, fulfilling a Settlement Agreement milestone. AMWTP retrieval operations commenced in March 2003, and treatment facility operations commenced in August 2004. The British Nuclear Fuels Limited, Inc., contract was terminated effective April 30, 2005, and Bechtel BWXT Idaho, LLC, assumed operation of the AMWTP on May 1, 2005. Certification of the treatment facility was obtained in May 2005, allowing for certification of treated TRU waste and shipment thereof to WIPP. Treated TRU waste was first shipped from the AMWTP to WIPP on May 31, 2005.

In 2006 approximately 26,675 cubic meters (104,673 cubic feet) of MLLW was inventoried at INL. In addition to this waste, approximately 3,191 cubic meters (12,522 cubic feet) of MLLW was generated in 2006 (see Table 3–47) (Willcox 2007). DOE assumes that new facilities would be constructed if additional MLLW treatment and disposal capacity were needed (DOE 2002a).

3.3.12.1.3 Hazardous Waste

Approximately 1 percent of the total waste generated at INL (not including liquid nonhazardous waste) is hazardous waste. The average hazardous waste generation rate for the 5-year period 2000 through 2004 was approximately 420 cubic meters (14,830 cubic feet) per year (DOE 2005b). The waste generator normally holds hazardous waste in a temporary accumulation area (the accumulation areas are not listed

in Table 3–48) until it is shipped directly to the offsite commercial treatment facility. Most of the hazardous waste generated annually at INL is transported off site for treatment and disposal. Offsite shipments are surveyed to determine that the waste has no radioactive content—i.e., that it is not mixed waste. Highly reactive or unstable materials such as waste explosives are addressed case by case and managed on or off site consistent with regulatory requirements.

The operation of the AMWTP and the steam reforming technology for processing mixed TRU/sodium-bearing waste at INTEC would increase this generation rate minimally—i.e., less than 1 percent (DOE 1999c, 2002a).

3.3.12.1.4 Nonhazardous Waste

Approximately 90 percent of the solid waste generated at INL is classified as industrial waste and is disposed of on site in a landfill complex in the Central Facilities Area or off site at the Bonneville County landfill. The onsite landfill complex contains separate areas for petroleum-contaminated media, industrial waste, and asbestos waste. The landfill covers 4.9 hectares (12 acres) and is being expanded by 91 hectares (225 acres) to provide capacity for at least 30 years. The average annual volume of waste disposed of from 2000 through 2004 was approximately 40,000 cubic meters (1.41 million cubic feet) (DOE 2005b).

Sewage is disposed of in surface impoundments. Wastewater in the impoundments is allowed to evaporate, and the resulting sludge is placed in the landfill. Solids are separated and reclaimed where possible.

3.3.12.2 Waste Minimization

DOE-ID has an active waste minimization and pollution prevention program to reduce the total amount of waste generated and disposed of at INL. Waste is eliminated through source reduction or material substitution; the recycling of potential waste materials that cannot be minimized or eliminated; and the treatment of all waste generated to reduce its volume, toxicity, or mobility prior to storage or disposal. DOE-ID published its first *Waste Minimization Plan* in 1990, defining specific goals, methodologies, responsibilities, and achievements of programs and organizations. INL now promotes the incorporation of pollution prevention in all planning activities, as well as the concept that pollution prevention is integral to mission accomplishment. The mission of the waste minimization and pollution prevention program is to reduce, reuse and recycle wastes generated and pollutants by implementing cost-effective pollution prevention techniques, practices, and policies. Pollution prevention is required by various federal statutes including, but not limited to the Pollution Prevention Act, RCRA, and Executive Order 13423. It is the policy of INL to incorporate pollution prevention into every activity onsite and in the Idaho Falls facilities. Pollution prevention is one of the key underpinnings of the INL Site Environmental Management System. It functions as an important preventive mechanism because generating less waste reduces waste management costs, compliance vulnerabilities, and the potential for releases to the environment. INL is promoting the inclusion of pollution prevention into all planning activities as well as the concept that pollution prevention is integral to mission accomplishment (DOE 2007d).

3.3.12.3 *Waste Management PEIS* Records of Decision

The *Waste Management PEIS* RODs affecting INL are shown in Table 3–49. Decisions on the various waste types were announced in a series of RODs following publication of the *Waste Management PEIS* (DOE 1997b). The hazardous waste ROD was published on August 5, 1998 (63 FR 41810), and the LLW and MLLW ROD was published on February 25, 2000 (65 FR 10061). The LLW and MLLW ROD states that, for the management of LLW, minimal treatment will be performed at all sites and onsite disposal will continue to the extent practicable at INL, Los Alamos National Laboratory, ORR, and SRS.

In addition, Hanford and NTS will be available to all DOE sites for LLW disposal. MLLW will be treated at Hanford, INL, ORR, and SRS and disposed of at Hanford and NTS. The hazardous waste ROD states that most DOE sites will continue to use offsite facilities for treatment and disposal of major portions of their nonwastewater hazardous waste, and ORR and SRS will continue treating some of their own nonwastewater hazardous waste on site in existing facilities, where this is economically feasible. More-detailed information concerning DOE's decisions for the future configuration of waste management facilities at INL is presented in the hazardous waste and LLW and MLLW RODs.

Table 3–49. *Waste Management PEIS* Records of Decision Affecting Idaho National Laboratory

Waste Type	Preferred Action
LLW	DOE has decided to treat and dispose of INL's LLW on and off site.[a]
MLLW	DOE has decided to regionalize treatment of MLLW at INL. This includes the onsite treatment of INL's waste and could include treatment of some MLLW generated at other sites.[a]
Hazardous	DOE has decided to continue to use commercial facilities for treatment of INL nonwastewater hazardous waste. DOE will also continue to use onsite facilities for wastewater hazardous waste.[b]

[a] 65 FR 10061.

[b] 63 FR 41810.

Key: DOE=U.S. Department of Energy; INL=Idaho National Laboratory; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; PEIS=programmatic environmental impact statement; and *Waste Management PEIS=Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*.

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CHAPTER 4
SHORT-TERM ENVIRONMENTAL CONSEQUENCES

Chapter 4 presents the potential short-term impacts on the existing natural and human environment and on human health of implementing reasonable alternatives for each of the following: (1) tank waste retrieval, treatment, and disposal and single-shell tank system closure at the Hanford Site (Hanford); (2) decommissioning of the Fast Flux Test Facility and auxiliary facilities and disposition of Hanford's inventory of radioactively contaminated bulk sodium; and (3) management of waste resulting from other Hanford activities and limited volumes from other U.S. Department of Energy sites. Impacts analyses of the alternatives and options considered for each of the three sets of proposed actions are presented separately in Sections 4.1, 4.2, and 4.3, respectively. Impact analyses are grouped first by resource area or discipline (e.g., land resources) and then by alternative so that impacts can be meaningfully compared across alternatives. All disciplines are analyzed in a manner commensurate with their importance and the expected level of impact on them under a specific alternative—the sliding-scale assessment approach. The combined impacts of implementing selected alternatives from each of the three sets of proposed actions are presented in Section 4.4. Cumulative impacts associated with the alternative combinations are presented in Chapter 6. Mitigation measures to reduce the potential for environmental impacts are summarized in Chapter 7, Section 7.1. Analyses of comparative impacts across the alternatives are presented in Chapter 7, Sections 7.2 through 7.4. A detailed discussion of each alternative is provided in Chapter 2, Section 2.5; a comparison of the environmental effects among alternatives is presented in Chapter 2, Section 2.6.

4.1 TANK CLOSURE ALTERNATIVES

This section describes the potential short-term environmental and human health impacts associated with implementation of each of the 11 Tank Closure alternatives considered in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* for retrieving and treating the tank waste inventory generated during the defense production years at the Hanford Site (Hanford). The impacts analysis also considers different closure scenarios associated with the single-shell tank (SST) system.

Tank Closure Alternative 1, No Action, reflects the environmental baseline against which the impacts of the other action alternatives can be compared. Under Alternative 1, the U.S. Department of Energy (DOE) has assumed for the purposes of analysis that construction of the River Protection Project Waste Treatment Plant (WTP) would be terminated in 2008. Therefore, it is expected that short-term incremental impacts would peak in the 2006–2008 timeframe during WTP construction. It is also expected that subsequent incremental impacts would be very small for most of the disciplines analyzed over the ensuing 100-year administrative control period assumed in the analysis. During this period, proposed activities would be conducted at existing facilities in developed areas; no new land disturbance would take place; proposed activities would be consistent with current operations; and routine gaseous and effluent emissions would generally continue in accordance with governing regulatory requirements, resulting in little incremental impact.

In contrast, Alternatives 2 through 6 involve the construction, subsequent operations, and eventual deactivation of new facilities over varying timeframes (ranging from 34 years to 161 years) in the 200-East and 200-West Areas of Hanford to support tank waste retrieval, treatment, and disposal. With the exception of Alternative 2A, each of these alternatives also analyzes closure of the Hanford SST system by means of either landfill closure (i.e., construction of a surface barrier) or selective or full clean closure (i.e., removal) of the SST system and associated waste and contaminated soils. Each of the 11 Tank Closure alternatives (Alternatives 1 through 6C) is described in detail in Chapter 2, Section 2.5.

4.1.1 Land Resources

In contrast to Alternative 1, Alternatives 2 through 6C involve the construction, subsequent operations, and eventual deactivation of new facilities over varying timeframes in the 200-East and 200-West Areas of Hanford to support tank waste retrieval, treatment, and disposal. The major new project facilities and

infrastructure components that would be constructed or upgraded to support the implementation of each Tank Closure alternative are summarized in Table 4–1. Facility locations and affected Hanford areas are depicted in Figures 4–1 and 4–2.

Table 4–1. Summary of Major New Facilities Required to Support Tank Closure Alternatives

Facility	Alternative										
	1	**2A**	**2B**	**3A**	**3B**	**3C**	**4**	**5**	**6A**	**6B**	**6C**
Bulk Vitrification Facility (200-East Area)				X							
Bulk Vitrification Facility (200-West Area)				X			X	X			
Canister Storage Building completion	a	X	X	X	X	X	X	X	X	X	X
Cast Stone Facility (200-East Area)					X		X	X			
Cast Stone Facility (200-West Area)					X						
Cesium and Strontium Capsule Processing Facility		X	X	X	X	X	X	X	X	X	X
Chemical wash system							X		X	X	
CH-Mixed TRU Waste Facilities				X	X	X	X	X			
Containment structures			X	X	X	X	X		X	X	X
Double-shell tanks (new)								X			
Double-shell tank replacement(s)		X[b]							X[c]		
Effluent Treatment Facility replacement(s)		X[b]	X	X	X	X	X	X	X[c]	X[d]	X
Hanford landfill barrier[e]								X			
HLW Debris Storage Facilities									X	X	
HLW Melter Interim Storage Facilities		X	X	X	X	X	X	X	X	X	X
IHLW Interim Storage Modules		X	X	X	X	X	X	X	X	X	X
IHLW Interim Storage Module replacement(s)									X[c]		
IHLW Shipping/Transfer Facility		X	X	X	X	X	X	X	X	X	X
IHLW Shipping/Transfer Facility replacement(s)									X[c]		
ILAW Interim Storage Facilities										X	X
LAW Vitrification Facility expansion			X							X	
Mobile retrieval systems		X	X	X	X	X	X	X	X	X	X
Modified RCRA Subtitle C barrier[e]			X	X	X	X	X				X
Modified sluicing retrieval systems		X	X	X	X	X	X	X			X
Preprocessing Facility									X	X	
RH-Mixed TRU Waste Facility				X	X	X	X	X			
Solid-Liquid Separations Facility (200-West Area)				X	X	X	X	X			
Steam Reforming Facility (200-West Area)						X					

Table 4–1. Summary of Major New Facilities Required to Support Tank Closure Alternatives *(continued)*

Facility	Alternative										
	1	**2A**	**2B**	**3A**	**3B**	**3C**	**4**	**5**	**6A**	**6B**	**6C**
Steam Reforming Facility (200-East Area)						X					
Sulfate Removal Facility								X			
TRU Waste Interim Storage Facility				X	X	X	X	X			
Underground transfer lines		X	X	X	X	X	X	X	X	X	X
Underground transfer line replacement		X[b]							X[c]		
Vacuum-based retrieval systems		X	X	X	X	X	X	X	X	X	X
Waste receiver facilities			X	X	X	X	X	X		X	X
Waste Treatment Plant completion[f]	a	X	X	X	X	X	X	X	X	X	X
Waste Treatment Plant replacement(s)		X[b]							X[c]		
242-A Evaporator replacement(s)		X[b]	X	X	X	X	X	X	X[c]	X	X

[a] Construction of the Waste Treatment Plant and Canister Storage Building would be terminated, and no tank waste would be retrieved and treated under this alternative

[b] The operating timeframe under this alternative requires a one-time total replacement of these facilities and associated infrastructure, except two replacements of the Effluent Treatment Facility.

[c] The operating timeframe under this alternative (Base and Option Cases) requires two replacements of the Waste Treatment Plant, three replacements of the IHLW Shipping/Transfer Facility and IHLW Interim Storage Modules, three replacements of 28 double-shell tanks, five replacements of the Effluent Treatment Facility, one replacement of the underground transfer lines and associated infrastructure, and six replacements of the 242-A Evaporator.

[d] The operating timeframe under this alternative (Base and Option Cases) requires three replacements of the Effluent Treatment Facility.

[e] The engineered landfill closure barrier would be a surface structure constructed in five "lobes"—three in the 200-West Area covering tank farms (1) T, TY, and TX (T barrier); (2) U (U barrier); and (3) SY, S, and SX (S barrier), and two much larger lobes in the 200-East Area covering tank farms; (4) B, BY, and BX (B barrier); and (5) AN, AZ, AX, AY, A, AW, AP, and C (A barrier). The barriers would also cover six sets of cribs and trenches (ditches) including the B Cribs, BX Trenches, BY Cribs, T Cribs, T Trenches, TX Trenches, and TY Cribs, with the T and TX Trenches considered one set.

[f] The completed Waste Treatment Plant would consist of two HLW and two LAW melters under Alternatives 2A, 3A, 3B, and 4; two HLW and three LAW melters under Alternative 5; two HLW and six LAW melters under Alternatives 2B, 6B, and 6C; and five HLW melters under Alternative 6A.

Note: See Figures 4–1 and 4–2 for locations.

Key: CH=contact-handled; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; RCRA=Resource Conservation and Recovery Act; RH=remote-handled; TRU=transuranic.

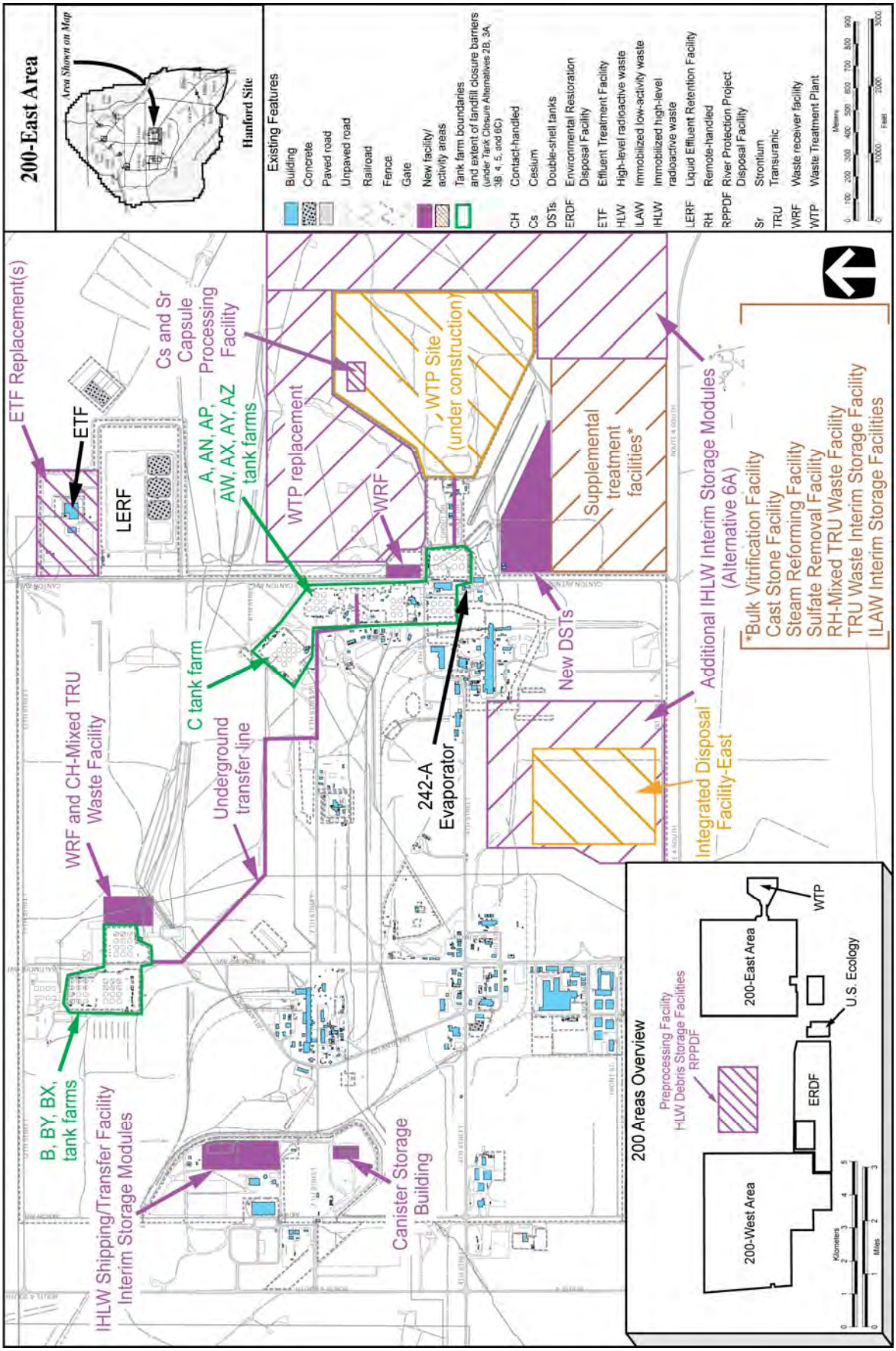


Figure 4–1. 200-East Area New Facility Locations and Affected Areas

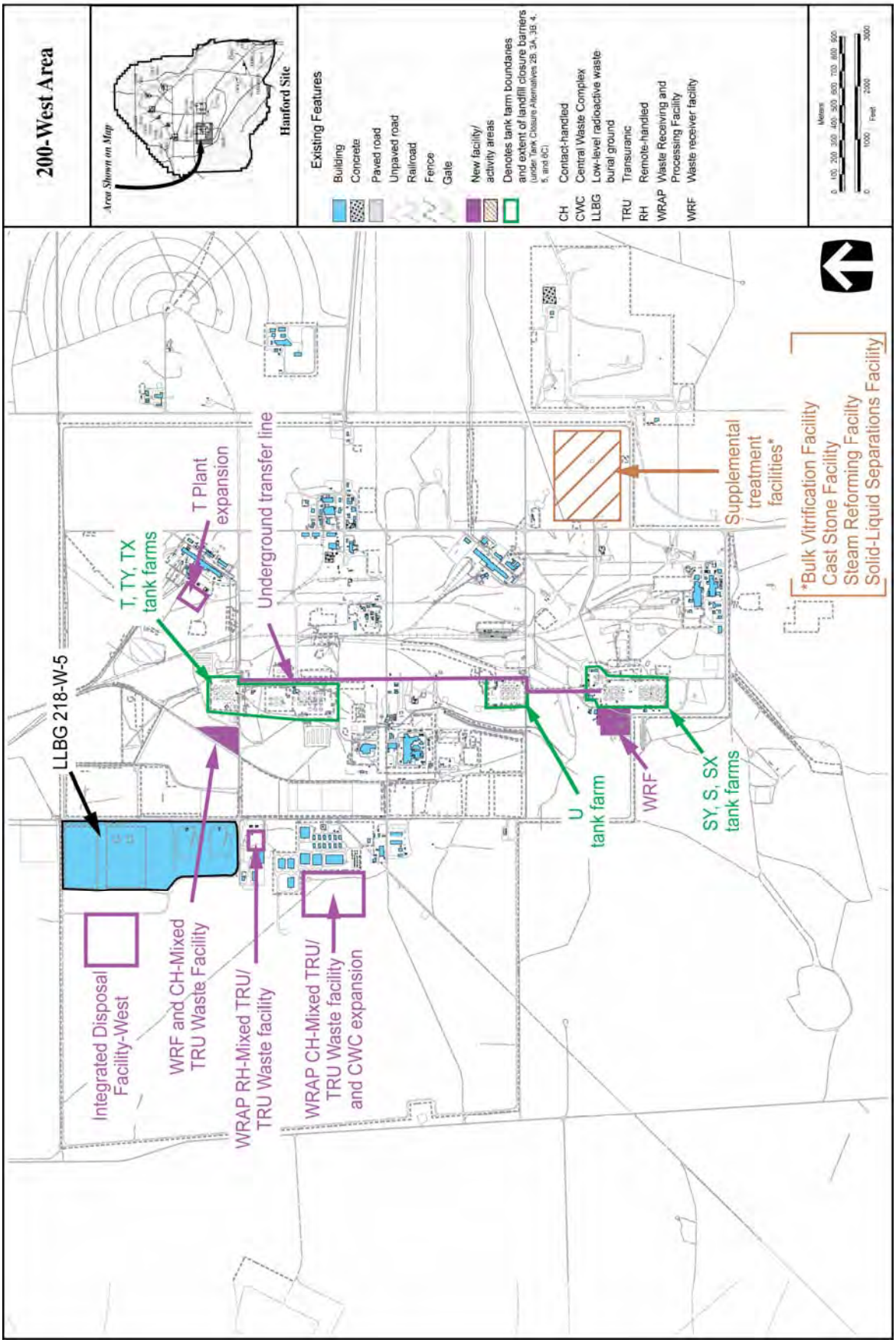


Figure 4–2. 200-West Area New Facility Locations and Affected Areas

4.1.1.1 Alternative 1: No Action

4.1.1.1.1 Land Use

Under the No Action Alternative, no new facility construction would be initiated within either the 200-East or 200-West Area. Construction of the WTP and Canister Storage Building would be terminated (see Chapter 2, Section 2.5.2.1). Ongoing tank system upgrades within existing facilities and related construction projects would also end. Thus, the present industrial status of the 200 Areas would remain unchanged, as would its land use designation as Industrial-Exclusive.

Implementation of this alternative would entail a commitment of land within the 200 Areas over the long term. The 17 hectares (42 acres) of land encompassing the existing 18 tank farms and six sets of cribs and trenches (ditches) (i.e., B Cribs, BX Trenches, BY Cribs, T Cribs and Trenches, TX Trenches, and TY Cribs) would be indefinitely committed to waste management use following the DOE 100-year administrative control period, as no tank waste would be retrieved, treated, or disposed of under this alternative.

The No Action Alternative would require that geologic material be excavated from the 926.3-hectare (2,289-acre) Borrow Area C for use in activities such as tank stabilization and WTP closure. The amount of material required would necessitate the development of 2 hectares (5 acres) of Borrow Area C. Borrow Area C has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)*, including the recent supplement analysis (DOE 1999, 2008) and Records of Decision (RODs) (64 FR 61615, 73 FR 55824).

4.1.1.1.2 Visual Resources

Implementation of the No Action Alternative would not result in new construction within the 200 Areas. Accordingly, the industrial appearance of the 200-East and 200-West Areas from State Route 240 and nearby higher elevations (i.e., Gable Mountain, Gable Butte, and Rattlesnake Mountain) would remain unchanged, as would the U.S. Bureau of Land Management (BLM) Visual Resource Management Class IV rating.

As noted above, 2 hectares (5 acres) of Borrow Area C would be excavated in connection with the No Action Alternative. Although development would not dominate the view from State Route 240 or nearby higher elevations, it would attract the attention of the viewer. Thus, the BLM visual resource management rating of Borrow Area C and the vicinity would change from Class II to Class III.

4.1.1.2 Alternative 2A: Existing WTP Vitrification; No Closure

4.1.1.2.1 Land Use

In addition to completing the WTP, a number of new facilities would be constructed under this alternative, as listed in Table 4–1. All of these facilities would be located either within or immediately adjacent to the 200-East or 200-West Area. In all cases, they would be located within the 5,064-hectare (12,513-acre) area of the 200 Area Plateau designated Industrial-Exclusive. In total, new facilities would occupy 32.3 hectares (79.9 acres), all but 3.2 hectares (8 acres) of which would be located within or adjacent to the 200-East Area (see Figures 4–1 and 4–2). Thus, about 0.6 percent of the land within the Industrial-Exclusive land area would be affected. During operations, impacts on land use would be minimal, as all activities would take place within the Industrial-Exclusive area.

Implementation of this alternative would entail a commitment of land within the Industrial-Exclusive land use zone over the long term. In addition to the 32.3 hectares (79.9 acres) of land that would be required for new facilities and infrastructure, 17 hectares (42 acres) of the land encompassing the existing 18 tank farms (including the six sets of cribs and trenches [ditches]) would be indefinitely committed to waste management use following the DOE 100-year administrative control period, as no SST system closure would take place under this alternative. Taken together, this would entail a total land commitment of 49.4 hectares (122 acres), or 1 percent of the area designated as Industrial-Exclusive.

Alternative 2A would require that geologic material be excavated from Borrow Area C for use in activities associated with new construction, tank waste disposal activities, and tank stabilization. The amount of material required would necessitate the development of 27.5 hectares (68 acres), or 3 percent of the area. Borrow Area C has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.2.2 Visual Resources

As all construction and operational activities associated with this alternative would occur either within or immediately adjacent to the 200-East and 200-West Areas, which are already developed as industrial sites, there would be little change in their overall visual character. There would be a negligible impact on the view from State Route 240, as the changes in the 200-East Area would not be visible from the roadway, and the only change in the 200-West Area would be construction of an underground transfer line. The views from nearby higher elevations (i.e., Gable Mountain, Gable Butte, and Rattlesnake Mountain), which are important to American Indians with cultural ties to Hanford, would also remain largely unchanged. Further, the overall BLM Visual Resource Management Class IV rating of the 200 Areas would not change under this alternative.

As noted above, 27.5 hectares (68 acres) of Borrow Area C would be excavated in connection with this alternative. Development of Borrow Area C would be readily visible from State Route 240 and Rattlesnake Mountain and would result in the BLM visual resource management rating changing from Class II to IV. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact.

4.1.1.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

4.1.1.3.1 Land Use

In addition to completing the WTP with expanded low-activity waste (LAW) vitrification capacity, a number of new facilities would be constructed under this alternative, as listed in Table 4–1. The 18 tank farms and six sets of cribs and trenches (ditches) would also be covered by modified Resource Conservation and Recovery Act (RCRA) Subtitle C landfill barriers (see Chapter 2, Section 2.5.2.2.2). All of these facilities would be located either within or immediately adjacent to the 200-East or 200-West Area and would be within the area designated as Industrial-Exclusive. In total, new facilities would occupy 16.2 hectares (40 acres)—12.5 hectares (30.9 acres) in or adjacent to the 200-East Area and 3.7 hectares (9.1 acres) in the 200-West Area (see Figures 4–1 and 4–2). Thus, about 0.3 percent of the land within the Industrial-Exclusive area would be affected. During the operational and closure phases of the project, impacts on land use would be minimal, as all activities would take place within the Industrial-Exclusive area.

Implementation of this alternative would entail a commitment of land designated as Industrial-Exclusive over the long term. In addition to the 16.2 hectares (40 acres) of land that would be committed to new facilities and infrastructure, an additional 84.2 hectares (208 acres) of land encompassed by the

boundaries of the five modified RCRA Subtitle C barriers would be indefinitely committed to waste management use following the DOE 100-year postclosure care period. Taken together, this would entail a total land commitment of 100 hectares (248 acres), or 2 percent of the area designated as Industrial-Exclusive.

Alternative 2B would require that geologic material be excavated from Borrow Area C for use in activities associated with construction of new facilities, disposal of tank waste, and placement of the modified RCRA Subtitle C barriers. The amount of material required would necessitate the development of 94.7 hectares (234 acres), or about 10 percent of the area. Although development of Borrow Area C would represent a change in the current land use, it has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.3.2 Visual Resources

In general, impacts on visual resources would be similar to those described in Section 4.1.1.2.2 under Alternative 2A; however, as part of landfill closure, containment structures would be built over the BX and SX tank farms in the 200-East and 200-West Areas to support removal of the upper 4.6 meters (15 feet) of contaminated soil. Upon completion of activities in these tank farms, both structures would be removed. Closure would also result in the tank farms being covered with modified RCRA Subtitle C barriers. The 200-East Area containment structure and closure barriers would be visible only from nearby higher elevations, while the 200-West Area containment structure and closure barriers would be visible from State Route 240 and nearby higher elevations. However, as the 200 Areas are currently industrial sites, the BLM Visual Resource Management Class IV rating would not change under this alternative.

Under this alternative, 94.7 hectares (234 acres) of Borrow Area C would be excavated. Development of Borrow Area C would be readily visible from State Route 240 and Rattlesnake Mountain and would result in the BLM visual resource management rating changing from Class II to IV. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact.

4.1.1.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

4.1.1.4.1 Land Use

In addition to completing the WTP, a number of new facilities would be constructed under this alternative as listed in Table 4–1. Also, a modified RCRA Subtitle C landfill barrier would be constructed over all 18 tank farms and six sets of cribs and trenches (ditches) (see Chapter 2, Section 2.5.2.3.1). Similar to the previously described alternatives, all facilities would be located within or adjacent to the 200-East and 200-West Areas and would be within the area designated as Industrial-Exclusive. In total, new facilities would occupy 17.4 hectares (43 acres)—13.2 hectares (32.7 acres) in or adjacent to the 200-East Area and 4.2 hectares (10.3 acres) in the 200-West Area (see Figures 4–1 and 4–2). Thus, about 0.3 percent of the land within the Industrial-Exclusive area would be affected. As all activities would take place within the Industrial-Exclusive area and only a small part of the area would be affected, impacts of this alternative on land use would be minimal.

Implementation of this alternative would entail a commitment of land designated as Industrial-Exclusive over the long term. In addition to the 17.4 hectares (43 acres) of land that would be committed to new facilities and infrastructure, an additional 84.2 hectares (208 acres) of land encompassed by the boundaries of the five modified RCRA Subtitle C barriers would be indefinitely committed to waste management use following the DOE 100-year postclosure care period. Taken together, this would entail a total land commitment of 102 hectares (251 acres), or 2 percent of the area designated as Industrial-Exclusive.

Under this alternative, it would be necessary to supply geologic material from Borrow Area C for the construction of facilities, the disposal of tank waste, and the placement of the modified RCRA Subtitle C barriers. In total, 101 hectares (249 acres), or about 11 percent of the land within Borrow Area C would be excavated. Borrow Area C has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.4.2 Visual Resources

Impacts on visual resources would be similar to those described in Section 4.1.1.3.2 under Alternative 2B. Construction, operations, and closure activities associated with this alternative would not greatly change the industrial nature of the view from State Route 240 or nearby higher elevations. Thus, the BLM Visual Resource Management Class IV rating for the 200 Areas would not change. Although an additional 6.1 hectares (15 acres) of land would be disturbed within Borrow Area C under this alternative, the visual impacts of developing the site would be similar to those described under Alternative 2B.

4.1.1.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

4.1.1.5.1 Land Use

Under this alternative, new facilities would be similar to those under Alternative 3A, except that Cast Stone Facilities would be built instead of Bulk Vitrification Facilities (see Table 4–1 and Chapter 2, Section 2.5.2.3.2). Similar to the previously described alternatives, all facilities would be located within or adjacent to the 200-East and 200-West Areas and would be within the area designated as Industrial-Exclusive. In total, new facilities under this alternative would occupy 18.3 hectares (45.2 acres)—13.7 hectares (33.8 acres) in or adjacent to the 200-East Area and 4.6 hectares (11.4 acres) in the 200-West Area (see Figures 4–1 and 4–2). Thus, about 0.4 percent of the land within the Industrial-Exclusive area would be affected.

Implementation of this alternative would entail a commitment of land designated as Industrial-Exclusive over the long term. In addition to the 18.3 hectares (45.2 acres) of land that would be committed to new facilities and infrastructure, an additional 84.2 hectares (208 acres) encompassed by the boundaries of the five modified RCRA Subtitle C barriers would be indefinitely committed to waste management use following the DOE 100-year postclosure care period. Taken together, this would entail a total land commitment of 102 hectares (253 acres), or 2 percent of the area designated Industrial-Exclusive.

Under Alternative 3B, 93.5 hectares (231 acres), or about 10 percent of Borrow Area C, would be excavated to supply the geologic material needed for new facilities' construction, tank waste disposal activities, and placement of the modified RCRA Subtitle C barriers. Although development of Borrow Area C would represent a change in the current land use, it has been designated as Conservation (Mining); thus, its use as a borrow pit would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.5.2 Visual Resources

Impacts on visual resources would be similar to those described in Section 4.1.1.4.2 under Alternative 3A. Construction, operations, deactivation, and closure activities associated with this alternative would not greatly change the industrial nature of the view from State Route 240 or nearby higher elevations. Thus, the BLM Visual Resource Management Class IV rating for the 200 Areas would not change. Although the land requirement in Borrow Area C would be slightly less (e.g., 1.2 hectares

[3 acres]) under Alternative 3B, visual impacts generally would be similar to those described under Alternative 3A.

4.1.1.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

4.1.1.6.1 Land Use

Under this alternative, new facilities would be similar to those under Alternative 3A, except that Steam Reforming Facilities would be built instead of Bulk Vitrification Facilities (see Table 4–1 and Chapter 2, Section 2.5.2.3.3). All facilities would be located within or adjacent to the 200-East and 200-West Areas and would be within the area designated as Industrial-Exclusive. In total, new facilities under this alternative would occupy 18.2 hectares (45 acres)—13.9 hectares (34.3 acres) in or adjacent to the 200-East Area and 4.3 hectares (10.7 acres) in the 200-West Area (see Figures 4–1 and 4–2). Thus, about 0.4 percent of the land within the Industrial-Exclusive area would be affected.

Implementation of this alternative would entail a commitment of land designated as Industrial-Exclusive over the long term. In addition to the 18.2 hectares (45 acres) of land that would be committed to new facilities and infrastructure, an additional 84.2 hectares (208 acres) encompassed by the boundaries of the five modified RCRA Subtitle C barriers would be indefinitely committed to waste management use following the DOE 100-year postclosure care period. Taken together, this would entail a total land commitment of 102 hectares (253 acres), or 2 percent of the area designated as Industrial-Exclusive.

Alternative 3C would require that geologic material be excavated from Borrow Area C for use in activities associated with construction of new facilities, disposal of tank waste, and placement of the modified RCRA Subtitle C barriers. The amount of material required would necessitate the development of 93.9 hectares (232 acres), or about 10 percent of the area. Borrow Area C has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.6.2 Visual Resources

Impacts on visual resources would be similar to those described in Section 4.1.1.4.2 under Alternative 3A. Construction, operations, deactivation, and closure activities associated with this alternative would not greatly change the industrial nature of the view from State Route 240 or nearby higher elevations. Thus, the BLM Visual Resource Management Class IV rating for the 200 Areas would not change. Since nearly the same amount of geologic material would be required under Alternative 3C (93.9 hectares [232 acres]) as under Alternative 2B (94.7 hectares [234 acres]), visual impacts would be similar to those described for Alternative 2B.

4.1.1.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies, Selective Clean Closure/Landfill Closure

4.1.1.7.1 Land Use

In addition to completing the WTP, a number of new facilities would be constructed under this alternative as listed in Table 4–1. Additionally, modified RCRA Subtitle C landfill barriers would be placed over the 10 tank farms that would not be clean-closed and six sets of cribs and trenches (ditches) (see Chapter 2, Section 2.5.2.4). Similar to the previously described alternatives, all facilities would be located within or adjacent to the 200-East and 200-West Areas and would be within the area designated as Industrial-Exclusive. In total, new facilities under this alternative would occupy 17.8 hectares (44.1 acres)—13.7 hectares (33.8 acres) in or adjacent to the 200-East Area and 4.2 hectares (10.3 acres) in the

200-West Area (see Figures 4–1 and 4–2). Thus, about 0.4 percent of the land within the Industrial-Exclusive land use designation would be affected. This loss would be slightly offset by the clean closure of the BX and SX tank farms, which would be potentially available for future use consistent with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824). As all activities would take place within the dedicated Industrial-Exclusive area and only a small part of the area would be affected, impacts of this alternative on land use would be minimal.

Implementation of this alternative would entail a commitment of land designated as Industrial-Exclusive over the long term. In addition to the 17.8 hectares (44.1 acres) of land that would be committed to new facilities and infrastructure, an additional 60.7 hectares (150 acres) of land encompassed by the boundaries of the modified RCRA Subtitle C barriers would be indefinitely committed to waste management use following the DOE 100-year postclosure care period. Taken together, this would entail a total land commitment of 78.5 hectares (194 acres), or about 1.6 percent of the area designated as Industrial-Exclusive.

Alternative 4 would require that geologic material be excavated from Borrow Area C for use in activities associated with construction of new facilities, disposal of tank waste, clean closure of the BX and SX tank farms, and placement of the modified RCRA Subtitle C barriers. The amount of material required would necessitate the development of 102 hectares (252 acres), or 11 percent of the area. Although development of Borrow Area C would represent a change in the current land use, it has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.7.2 Visual Resources

Impacts on visual resources would be similar to those described in Section 4.1.1.3.2 under Alternative 2B. Construction, operations, deactivation, and closure activities associated with this alternative would not greatly change the industrial nature of the view from State Route 240 or nearby higher elevations. Thus, the BLM Visual Resource Management Class IV rating for the 200 Areas would not change. Although an additional 7.3 hectares (18 acres) of land would be disturbed within Borrow Area C under this alternative, visual impacts also would be similar to those described under Alternative 3A.

4.1.1.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

4.1.1.8.1 Land Use

In addition to completing the WTP, a number of new facilities would be constructed under this alternative, as listed in Table 4–1. Additionally, Hanford landfill barriers would be placed over all 18 tank farms and six sets of cribs and trenches (ditches) (see Chapter 2, Section 2.5.2.5). Similar to the previously described alternatives, all facilities would be located within or adjacent to the 200-East and 200-West Areas and would be within the area designated as Industrial-Exclusive. In total, new facilities would occupy 20.2 hectares (49.9 acres)—16 hectares (39.6 acres) in or adjacent to the 200-East Area and 4.2 hectares (10.3 acres) in the 200-West Area (see Figures 4–1 and 4–2). Thus, about 0.4 percent of the land within the Industrial-Exclusive area would be affected. During the operational and closure phases of the project, impacts on land use would be minimal, as all activities would take place within the Industrial-Exclusive area.

Implementation of this alternative would entail a commitment of land designated as Industrial-Exclusive over the long term. In addition to the 20.2 hectares (49.9 acres) of land that would be committed to new facilities and infrastructure, an additional 84.2 hectares (208 acres) of land encompassed by the

boundaries of the five Hanford barriers would be indefinitely committed to waste management use following the DOE 100-year postclosure care period. Taken together, this would entail a total land commitment of 104 hectares (258 acres), or 2.1 percent of the area designated as Industrial-Exclusive.

This alternative would require that geologic material be excavated from Borrow Area C for use in activities associated with construction of new facilities, disposal of tank waste, and placement of the Hanford barriers. The amount of material required would necessitate the development of 118 hectares (291 acres), or about 13 percent of the area. Borrow Area C has been designated Conservation (Mining) and its use for this purpose would be in consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.8.2 Visual Resources

Impacts on visual resources would be similar to those described in Section 4.1.1.3.2 under Alternative 2B. Construction, operations, deactivation, and closure activities associated with this alternative would not greatly change the industrial nature of the view from State Route 240 or nearby higher elevations. Thus, the BLM Visual Resource Management Class IV rating for the 200 Areas would not change.

Under this alternative, 118 hectares (291 acres) of Borrow Area C would be excavated. Development of Borrow Area C would be readily visible from State Route 240 and Rattlesnake Mountain and would result in the BLM visual resource management rating changing from Class II to IV. Upon completion of work under this alternative, excavations in the Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact.

4.1.1.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.1.9.1 Land Use

4.1.1.9.1.1 Base Case

In addition to completing the WTP with expanded high-level radioactive waste (HLW) vitrification capacity, a number of new facilities would be constructed under this alternative as listed in Table 4–1. All of these facilities would be located within or adjacent to the 200-East Area and within the existing boundaries of the 200-West Area. Although most facilities would be located within the area designated as Industrial-Exclusive, a portion of the area needed for immobilized high-level radioactive waste (IHLW) Interim Storage Modules (i.e., 86.2 hectares [213 acres]) would be located outside of this area to the east. These facilities have been located in this area to facilitate movement of IHLW on site. In total, new facilities would occupy 210 hectares (519 acres)—207 hectares (511 acres) within or adjacent to the 200-East Area (both to the east and west) and 3.2 hectares (8 acres) in the 200-West Area (see Figures 4–1 and 4–2). Not including the land located outside of the Industrial-Exclusive area needed for the IHLW Interim Storage Modules, about 2.4 percent of the Industrial-Exclusive area would be affected under this alternative.

Although clean closure would permit unrestricted use of the tank farm sites, a 25.4-hectare (62.7-acre) modified RCRA Subtitle C landfill barrier would be placed over the six sets of cribs and trenches (ditches). Taken together with the land required for facility construction, this would entail a total land commitment of 236 hectares (582 acres), or about 4.7 percent of the area designated as Industrial-Exclusive. Actions taken under this alternative would not result in a change in the designation of the 200 Areas from Industrial-Exclusive. It is possible that the remediated tank farm areas could be used for construction of the HLW Debris Storage Facilities required under this alternative with the balance of these facilities constructed in the area just to the west of the 200-East Area; however, the land

values provided above assume these facilities would all be built between the 200-East and 200-West Areas.

To supply geologic material for use in activities associated with construction of new facilities, clean closure of the tank farms, disposal of tank waste, and placement of the modified RCRA Subtitle C landfill barrier, it would be necessary to excavate 494 hectares (1,220 acres) of Borrow Area C. This level of development would represent about 53 percent of Borrow Area C. Borrow Area C has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.9.1.2 Option Case

Impacts on land use would generally be similar to those described for Alternative 6A, Base Case. However, under the Option Case a modified RCRA Subtitle C landfill barrier would not be used to cover the six sets of cribs and trenches (ditches) since they would be removed and their deep plumes remediated. Thus, compared to the Base Case, an additional 25.4 hectares (62.7 acres) of land would become available for alternative uses in the future within the 200 Areas, or a total land commitment of 210 hectares (519 acres) under the option case (i.e., 41 percent of the area designated as Industrial-Exclusive). However, remediation of the deep plumes would necessitate the use of more fill material. Thus, it would be necessary to excavate more geologic material from Borrow Area C; specifically, 571 hectares (1,410 acres), or about 62 percent of the area would have to be developed.

4.1.1.9.2 Visual Resources

4.1.1.9.2.1 Base Case

As noted in Section 4.1.1.9.1.1, 210 hectares (519 acres) of land would be converted to industrial use under this alternative, with all but 3.2 hectares (8 acres) in or adjacent to the 200-East Area. Thus, although the overall appearance of the 200-West Area would not noticeably change, that of the 200-East Area and vicinity would. In terms of size, the most noticeable aboveground structures would be the HLW Debris Storage Facilities (52.2 hectares [129 acres]) and IHLW Interim Storage Modules (89.4 hectares [221 acres]), which would be located just to the west and east of the 200-East Area, respectively. These facilities would noticeably add to the overall industrial nature of the 200 Areas and would be visible from nearby higher elevations. The viewscape from these higher elevations is important to American Indians with cultural ties to Hanford. Closure activities would involve constructing containment structures over the tank farms. Structures within the 200-West Area would be visible from State Route 240 and nearby higher elevations, while those within and adjacent to the 200-East Area would be visible only from higher elevations. Containment structures would be removed upon completion of clean closure activities. Although there would be an overall increase in the industrial appearance of the 200 Areas, the BLM Visual Resource Management Class IV rating would not change.

As noted above, 494 hectares (1,220 acres) of Borrow Area C would be excavated in connection with this alternative. Development of Borrow Area C would be readily visible from State Route 240 and Rattlesnake Mountain and would result in the BLM visual resource management rating changing from Class II to IV. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact.

4.1.1.9.2.2 Option Case

Impacts on visual resources under the Option Case would be similar to those discussed above for the Base Case. Although land occupied by the cribs and trenches (ditches) would be available for alternative uses in the future, following their removal and remediation, the overall appearance of the 200 Areas from State

Route 240 or nearby higher elevations would not change significantly; the BLM Visual Resource Management Class IV rating would not change.

Remediation of the deep plumes associated with the cribs and trenches (ditches) under this case would result in the excavation of an additional 76.5 hectares (189 acres) of Borrow Area C compared with the Base Case. This excavation would further impact the view of the area from State Route 240 and nearby higher elevations, resulting in a BLM visual resource management rating change from Class II to Class IV (as is the situation for the Base Case). Similar to the Base Case, excavations in Borrow Area C would be recontoured and revegetated upon completion of work associated with this alternative.

4.1.1.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.1.10.1 Land Use

4.1.1.10.1.1 Base Case

In addition to completing the WTP with expanded LAW vitrification capacity, a number of new facilities would be constructed under this alternative, as listed in Table 4–1. As is the case under Alternative 5 (see Section 4.1.1.8.1), all facilities would be located within or adjacent to the 200-East and 200-West Areas and would be within the area designated as Industrial-Exclusive. In total, new facilities would occupy 117 hectares (288 acres)—113 hectares (279 acres) in or adjacent to the 200-East Area and 3.7 hectares (9.1 acres) in the 200-West Area (see Figures 4–1 and 4–2). Thus, about 2.3 percent of the land within the Industrial-Exclusive land use zone would be affected. During operations, impacts on land use would be minimal, as all activities would take place within the dedicated Industrial-Exclusive area.

Although clean closure would permit unrestricted use of the tank farm sites, the six sets of cribs and trenches [ditches] would still have a 25.4-hectare (62.7-acre) modified RCRA Subtitle C landfill barrier placed over them. Taken together with the land required for facility construction, this would entail a total land commitment of 142 hectares (351 acres), or 2.8 percent of the land designated as Industrial-Exclusive. Actions taken under this alternative would not result in a change in the designation of the 200 Areas from Industrial-Exclusive. It is possible that the remediated tank farm areas could be used for construction of the HLW Debris Storage Facilities required under this alternative with the balance of these facilities constructed in the area just to the west of the 200-East Area; however, the land values provided above assume these facilities would all be built between the 200-East and 200-West Areas.

This alternative would require that geologic material be excavated from Borrow Area C for use in activities associated with new facility construction, clean closure of the tank farms, and placement of the modified RCRA Subtitle C landfill barrier. The amount of material required would necessitate the development of 239 hectares (591 acres), or about 26 percent of the area. Although development of Borrow Area C would represent a change in the current land use, it has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.10.1.2 Option Case

Impacts on land use would generally be similar to those described above for Alternative 6B, Base Case (see Section 4.1.1.10.1.1). However, under the Option Case a modified RCRA Subtitle C landfill barrier would not be used to cover the six sets of cribs and trenches (ditches) since they would be removed and their deep plumes remediated. Thus, compared with the Base Case, an additional 25.4 hectares (62.7 acres) of land within the 200 Areas would become available for alternative uses in the future, or a total land commitment of 117 hectares (288 acres) under the option case (i.e., 2.3 percent of the area designated as Industrial-Exclusive). However, remediation of the deep plumes would necessitate the use

of more geologic material. Thus, the size of the excavated area within Borrow Area C would increase to 316 hectares (780 acres), or about 34 percent of the area, as compared to 239 hectares (591 acres) under the Base Case.

4.1.1.10.2 Visual Resources

4.1.1.10.2.1 Base Case

Impacts on visual resources would be similar to, but less than, those described in Section 4.1.1.9.2.1 for Alternative 6A, Base Case. This is because about one half as much land within the 200 Areas would be converted to industrial use under this alternative. Although there would be an overall increase in the industrial appearance of the 200 Areas as a result of actions taken under this case, the BLM Visual Resource Management Class IV rating would not change.

As noted above, 239 hectares (591 acres) of Borrow Area C would be excavated in connection with this alternative. Development of Borrow Area C would be readily visible from State Route 240 and Rattlesnake Mountain and would result in the BLM visual resource management rating changing from Class II to IV. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact.

4.1.1.10.2.2 Option Case

Impacts on visual resources under the Option Case would be similar to those discussed above for the Base Case. Although land occupied by the cribs and trenches (ditches) would be available for alternative uses in the future, following their removal and remediation, the overall appearance of the 200 Areas from State Route 240 or nearby higher elevations would not change significantly; the BLM Visual Resource Management Class IV rating would not change.

Remediation of the deep plumes associated with the cribs and trenches (ditches) under this case would result in the excavation of an additional 76.5 hectares (189 acres) within Borrow Area C compared with the Base Case. This excavation would further impact the view of the area from State Route 240 and nearby higher elevations, resulting in a BLM visual resource management rating change from Class II to Class IV (as is the situation for the Base Case). Upon completion of work associated with the Option Case, excavations in Borrow Area C would be recontoured and revegetated.

4.1.1.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

4.1.1.11.1 Land Use

In addition to completing the WTP with expanded HLW vitrification capacity, a number of new facilities would be constructed under this alternative, as listed in Table 4–1. All of these facilities would be located within or adjacent to the 200-East Area and within the existing boundaries of the 200-West Area. In all cases, facilities would be located within area designated as Industrial-Exclusive. In total, new facilities would occupy 61.1 hectares (151 acres)—57.5 hectares (142 acres) within or adjacent to the 200-East Area and 3.7 hectares (9.1 acres) in the 200-West Area (see Figures 4–1 and 4–2). Thus, 1.2 percent of the land within the Industrial-Exclusive land use designation would be affected. Implementation of this alternative would entail a commitment of land within the Industrial-Exclusive area over the long term. In addition to the 61.1 hectares (151 acres) of land that would be committed to new facilities and infrastructure, an additional 84.2 hectares (208 acres) of land encompassed by the boundaries of the five modified RCRA Subtitle C barriers would be indefinitely committed to waste management use. Taken together, this would entail a total land commitment of 145 hectares (359 acres), or about 2.9 percent of the Industrial-Exclusive area. Actions taken under this alternative would not result in a change in the 200 Areas' Industrial-Exclusive designation. It is possible that the remediated tank farms could be used

for construction of the HLW Debris Storage Facilities required under this alternative, with the balance of these facilities constructed in the area just to the west of the 200-East Area; however, the land values provided above assume these facilities would all be built between the 200-East and 200-West Areas.

Alternative 6C would require that geologic material be excavated from Borrow Area C for use in activities associated with new facility construction, closure of the BX and SX tank farms, and placement of a modified RCRA Subtitle C landfill barrier over the 18 tank farms and six sets of cribs and trenches (ditches). The amount of material required would necessitate the development of 104 hectares (257 acres), or about 11 percent of the area. Borrow Area C has been designated Conservation (Mining) and its use for this purpose would be consistent with the Hanford land use plan established in accordance with the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824).

4.1.1.11.2 Visual Resources

As noted above, 61.1 hectares (151 acres) of land would be converted to industrial use under this alternative, with all but 3.7 hectares (9.1 acres) in or adjacent to the 200-East Area. Thus, the overall appearance of the 200-East Area and vicinity would change, but that of the 200-West Area would not. In terms of size, the most noticeable aboveground structures would be the IHLW Interim Storage Modules (44.9 hectares [111 acres]). These facilities would add to the overall industrial nature of the 200-East Area and would be visible from nearby higher elevations. The viewscape from these higher elevations is important to American Indians with cultural ties to Hanford. Closure activities would involve constructing containment structures over the tank farms. Structures within the 200-West Area would be visible from State Route 240 and nearby higher elevations, while those within and adjacent to the 200-East Area would be visible only from higher elevations. Containment structures would be removed upon completion of clean closure activities. Although there would be an overall increase in the industrial appearance of the 200 Areas, the BLM Visual Resource Management Class IV rating would not change.

As noted above, 104 hectares (257 acres) of Borrow Area C would be excavated in connection with this alternative. Development of Borrow Area C would be readily visible from State Route 240 and Rattlesnake Mountain and would result in the BLM visual resource management rating changing from Class II to IV. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact.

4.1.2 Infrastructure

This subsection presents the potential impacts of the Tank Closure alternatives on key utility infrastructure resources including projected activity demands for electricity, fuel, and water over the timeframe considered for each alternative. For the purposes of analysis, project timeframes for each alternative include the active project phase (during which construction, operations, deactivation, and closure activities are assumed to be ongoing) and extend through the 100-year administrative control, institutional control, or postclosure care period, as applicable. Total and peak annual utility infrastructure requirements are projected for each Tank Closure alternative as well as for component project phases (e.g., construction, operations, deactivation, and closure, as applicable).

Assumptions for electricity demand include power to operate portable demolition equipment, work area lighting, and other items as part of facility construction as well as power to meet the much larger demands of operational facilities. During construction, deactivation, and closure, electrical power may be provided either via direct service connections and temporary connections, or via portable diesel- or gasoline-fired generators, especially in outlying portions of the 200 Areas. The projections include fuel consumption to power fuel-fired generators and heavy and mobile equipment to support all project phases under each alternative. It has been assumed for the purposes of analysis that liquid fuels are not capacity-limiting resources, as supplies would be replenished from offsite sources to support each alternative and provided

at the point of use on an as-needed basis. Facility operations would consume liquid fuels primarily to produce steam and hot water for facility processes, to provide space heating, and, to a lesser degree, to operate backup generators. In particular, the WTP steam plant would utilize diesel fuel for the production of high pressure steam as part of the waste vitrification processes.

Water would be required during construction for soil compaction, dust control, and possibly for work surface and equipment washdown. Standard construction practices dictate that, at least initially, construction water would be trucked to construction locations on an as-needed basis for these uses until water supply and wastewater treatment utilities are in place. Concrete and grout would be produced in onsite batch plants, which would require large volumes of water. By comparison, relatively little water would be required to meet the potable and sanitary needs of the construction workforce. During operations, water would be required to support process makeup requirements and facility cooling, as well as the potable and sanitary needs of the operations workforce and other uses. To stabilize and partially decontaminate waste treatment, retrieval, and disposal facilities, water would also be used during facility deactivation activities, but this requirement would be relatively small compared to operational and construction demands and for many closure activities, including construction of surface barriers.

Hanford's site utility infrastructure is described in Chapter 3, Section 3.2.2. Table 4–2 summarizes the projected utility infrastructure resource requirements under the Tank Closure alternatives. Projected demands for key utility infrastructure resources and impacts on the respective utility systems from implementation of each of the Tank Closure alternatives are further discussed in the following sections.

Table 4–2. Tank Closure Alternatives – Summary of Utility Infrastructure Requirements

Alternative	Activity Phase	Electricity (M megawatt-hours)	Diesel Fuel[a] (M liters)	Gasoline (M liters)	Water (M liters)
1	Construction	0.11	29.5	2.96	3,270
	Operations	0.000000015	5.93	0.0	0.0
	Deactivation[b]	0.0104	0.47	1.65	29.5
	Closure	N/A	N/A	N/A	N/A
	Total[c]	0.12	35.9	4.61	3,300
	Peak (Year)	0.035 (2008)	11.8 (2008)	1.0 (2008)	1,090 (2008)
2A	Construction	0.90	338	45.8	32,800
	Operations	34.2	4,380	160	170,000
	Deactivation	0.48	227	12.6	5,150
	Closure	0.0	1.89	0.005	29.3
	Total[c]	35.6	4,950	218	208,000
	Peak (Year)	0.56 (2078–2079)	112 (2078–2079)	5.33 (2023–2025)	3,720 (2065–2067)
2B	Construction	0.55	177	30.3	13,200
	Operations	15.9	3,480	107	70,600
	Deactivation	1.42	194	4.78	1,870
	Closure	0.022	185	14.5	677
	Total[c]	17.9	4,040	156	86,300
	Peak (Year)	1.16 (2040)	271 (2040)	8.18 (2040)	3,560 (2040)
3A	Construction	0.48	174	29.0	13,200
	Operations	12.1	1,390	66.0	60,500
	Deactivation	1.48	114	6.40	2,590
	Closure	0.022	185	14.5	677
	Total[c]	14.1	1,860	116	77,000
	Peak (Year)	0.78 (2040)	80.8 (2035–2036)	5.03 (2035–2036)	2,180 (2035–2036)

Table 4–2. Tank Closure Alternatives – Summary of Utility Infrastructure Requirements *(continued)*

Alternative	Activity Phase	Electricity (M megawatt-hours)	Diesel Fuel[a] (M liters)	Gasoline (M liters)	Water (M liters)
3B	Construction	0.48	170	28.7	13,200
	Operations	10.8	1,400	66.0	60,600
	Deactivation	0.84	114	6.40	2,590
	Closure	0.022	185	14.5	677
	Total[c]	12.1	1,860	116	77,000
	Peak (Year)	0.47 (2035–2038)	81.2 (2035–2036)	5.03 (2035–2036)	2,180 (2035–2036)
3C	Construction	0.49	175	29.5	13,200
	Operations	18.7	1,500	66.0	60,900
	Deactivation	0.89	114	6.40	2,610
	Closure	0.022	185	14.5	677
	Total[c]	20.1	1,980	116	77,300
	Peak (Year)	0.83 (2035–2038)	86.1 (2035–2036)	5.03 (2035–2036)	2,190 (2035–2036)
4	Construction	0.49	183	28.4	13,200
	Operations	12.6	1,560	71.0	65,800
	Deactivation	0.84	114	5.81	2,590
	Closure	0.88	190	27.9	655
	Total[c]	14.8	2,050	133	82,200
	Peak (Year)	0.55 (2038–2039)	76.2 (2038–2039)	10.9 (2043)	2,180 (2020–2021)
5	Construction	0.50	174	29.1	13,200
	Operations	10.5	3,550	68.9	76,000
	Deactivation	1.14	114	6.26	2,610
	Closure	0.025	268	19.2	760
	Total[c]	12.2	4,110	124	92,500
	Peak (Year)	0.62 (2024–2025)	229 (2029–2032)	5.89 (2029–2032)	3,800 (2029–2032)
6A, Base Case	Construction	1.80	671	77.6	28,600
	Operations	175	21,300	598	597,000
	Deactivation	6.0	718	22.2	17,300
	Closure	3.28	400	25.6	1,150
	Total[c]	186	23,100	723	644,000
	Peak (Year)	1.94 (2138)	234 (2138)	8.95 (2149–2150)	6,580 (2138)
6A, Option Case	Construction	1.80	671	77.6	28,600
	Operations	175	21,300	598	597,000
	Deactivation	6.0	718	22.2	17,300
	Closure	5.38	501	22.0	1,350
	Total[c]	188	23,200	720	644,000
	Peak (Year)	1.97 (2078)	237 (2078)	7.54 (2163)	6,580 (2138)
6B, Base Case	Construction	0.58	206	38.6	13,300
	Operations	16.3	3,560	146	76,200
	Deactivation	1.43	196	5.05	1,910
	Closure	2.85	400	25.6	1,150
	Total[c]	21.1	4,360	216	92,600
	Peak (Year)	1.24 (2040)	255 (2040)	6.56 (2040)	3,500 (2040)

Table 4–2. Tank Closure Alternatives – Summary of Utility Infrastructure Requirements *(continued)*

Alternative	Activity Phase	Electricity (M megawatt-hours)	Diesel Fuel[a] (M liters)	Gasoline (M liters)	Water (M liters)
6B, Option Case	Construction	0.58	206	38.6	13,300
	Operations	16.3	3,560	146	76,200
	Deactivation	1.43	196	5.05	1,910
	Closure	5.48	481	22.0	1,350
	Total[c]	23.8	4,440	212	92,800
	Peak (Year)	1.28 (2040)	259 (2040)	6.58 (2040)	3,500 (2040)
6C	Construction	0.55	179	30.3	13,200
	Operations	15.9	3,480	107	70,600
	Deactivation	1.42	194	4.78	1,870
	Closure	0.022	185	14.5	677
	Total[c]	17.9	4,040	156	86,300
	Peak (Year)	1.16 (2040)	271 (2040)	8.18 (2040)	3,560 (2040)

a Assumed to be inclusive of all Number 2 diesel fuel including road diesel and heating fuel oil.
b Reflects activities during the 100-year administrative control period for the No Action Alternative only.
c Totals may not equal the sum of the contributions due to rounding.
Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate. To convert liters to gallons, multiply by 0.26417.
Key: M=million; N/A=not applicable.
Source: SAIC 2007a.

4.1.2.1 Alternative 1: No Action

Under Alternative 1, peak utility infrastructure demands would occur over the first 3 years of the project period (assumed as 2006–2008) while construction of the WTP and related activities would be ongoing. Following termination of these activities at the end of 2008, the predicted demand from tank farm routine operations and related monitoring activities during the administrative control period provides the baseline against which the other alternatives can be most meaningfully compared. Table 4–2 summarizes the projected infrastructure resource requirements under Alternative 1.

4.1.2.1.1 Electricity

Under Alternative 1, peak annual electrical energy demand in 2008 would remain well within the 1.74 million megawatt-hour annual capacity (based on a peak load capacity of 199 megawatts) of the Hanford electric transmission system. Annual electrical energy demand over the subsequent 100-year administrative control period of 0.0001 million megawatt-hours would be a very small fraction (about 0.06 percent) of the 0.17 million megawatt-hours of electricity currently used annually at Hanford.

4.1.2.1.2 Fuel

Annualized liquid fuel consumption (diesel fuel and gasoline) of about 0.02 million liters (0.005 million gallons) during the 100-year administrative control period would be a small fraction (about 0.5 percent) of the 4.3 million liters (1.1 million gallons) of liquid fuels currently used annually at Hanford.

4.1.2.1.3 Water

Peak annual water requirements in 2008 would be well within the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System. Annualized water demands over the ensuing 100-year administrative control period of about 0.29 million liters (0.08 million gallons) would

also be a very small fraction (about 0.04 percent) of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford.

4.1.2.2 Alternative 2A: Existing WTP Vitrification; No Closure

Alternative 2A involves the construction, operation, and subsequent deactivation, as appropriate, of a number of new facilities, including replacement facilities, over an extended timeframe. The active project phase under Alternative 2A is 90 years, from 2006 through completion of WTP deactivation activities in 2095, excluding the subsequent 100-year administrative control period. Table 4–2 summarizes the projected infrastructure resource requirements under Alternative 2A. The annual average is the sum of the resource requirement divided by the duration of the alternative (in years).

4.1.2.2.1 Electricity

Electrical energy requirements under Alternative 2A would be dominated by operation of the WTP replacement, along with deactivation of the first WTP, in the 2078 through 2079 timeframe. The peak electrical energy demand of 0.56 million megawatt-hours (approximating an electric load of 64 megawatts) would be about 32 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.2.2 Fuel

Peak diesel fuel consumption under Alternative 2A would total 112 million liters (29.6 million gallons) in 2078–2079, with demand driven by deactivation of the first WTP. Gasoline demand would peak earlier, in 2023–2025, due to operation of the WTP and other facilities along with Effluent Treatment Facility (ETF) replacement construction.

4.1.2.2.3 Water

Water requirements under Alternative 2A would peak in the 2065–2067 timeframe primarily to support ongoing WTP operations, WTP replacement construction, and Borrow Area C operations. The projected peak water demand of 3,720 million liters (983 million gallons) would be about 20 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 16 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

The construction, operation, and deactivation of an expanded WTP, in concert with landfill closure activities under this alternative, would place the most demand on utility infrastructure. The active project phase under Alternative 2B is 40 years, from 2006 through completion of WTP deactivation, landfill closure, and most other activities in 2045, excluding the subsequent 100-year postclosure (landfill) care period. Table 4–2 summarizes the projected infrastructure resource requirements under Alternative 2B.

4.1.2.3.1 Electricity

Operation of the WTP and Cesium and Strontium Capsule Processing Facility, coinciding with grout facility operations and construction of surface barrier lobes for landfill closure, would dominate the electrical energy requirements. The peak electrical energy demand of 1.16 million megawatt-hours (approximating an electric load of 132 megawatts) in 2040 would be about 67 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.3.2 Fuel

Peak liquid fuel consumption under Alternative 2B would total about 279 million liters (73.7 million gallons) in 2040, with demands driven by the activities described above.

4.1.2.3.3 Water

Peak water requirements would also occur in 2040, dominated by peak operations coinciding with landfill closure activities. The projected peak water demand of 3,560 million liters (940 million gallons) would be about 19 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 16 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Alternative 3A involves construction, operation, and subsequent deactivation, as appropriate, of a number of new facilities over a 30-year timeframe. Construction, operation, and deactivation of the WTP, including the various waste retrieval and supplemental treatment facilities, in concert with landfill closure activities, would place the highest demand on utility infrastructure. The active project phase under Alternative 3A is 37 years, from 2006 through completion of WTP deactivation, landfill closure, and most other activities in 2041, excluding the subsequent 100-year postclosure (landfill) care period. Table 4–2 summarizes the projected infrastructure resource requirements under Alternative 3A.

4.1.2.4.1 Electricity

Operation of the Cesium and Strontium Capsule Processing Facility, combined with deactivation of the bulk vitrification and separations facilities and construction of surface barrier lobes for landfill closure, would dominate the peak electrical energy requirements. The peak electrical energy demand of 0.78 million megawatt-hours (approximating an electric load of 89 megawatts) in 2040 would be about 45 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.4.2 Fuel

Peak liquid fuel consumption under Alternative 3A would total about 85.8 million liters (22.7 million gallons) in the 2035 through 2036 timeframe. Peak demands would be driven by the WTP, supplemental treatment facility, and Borrow Area C operations, along with surface barrier construction activities.

4.1.2.4.3 Water

Peak water requirements would also occur in 2035–2036 under Alternative 3A, with demands dominated by facility operations and Borrow Area C operations and surface barrier construction. The projected peak water demand of 2,180 million liters (576 million gallons) would be about 12 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 10 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Construction, operation, and deactivation of the WTP, including the various waste retrieval and supplemental treatment facilities, in concert with landfill closure activities, would place the highest

demand on utility infrastructure. The active project phase under Alternative 3B is 37 years, from 2006 through completion of WTP deactivation, landfill closure, and most other activities in 2042, excluding the subsequent 100-year postclosure (landfill) care period. Overall, utility demands under this alternative would be very similar to those under Alternative 3A. Table 4–2 summarizes the projected infrastructure resource requirements under Alternative 3B.

4.1.2.5.1 Electricity

Total electrical energy requirements for implementation of Alternative 3B are projected to be somewhat less than those under Alternative 3A. Although total electrical energy requirements would be dominated by facility operations, led by the WTP and its subsequent deactivation, the operation of the nonthermal supplemental treatment facilities under this alternative would have a lower operational demand than the thermal supplemental treatment facilities considered under Alternative 3A. Peak projected electrical energy demand would occur over the 2035–2038 period, driven by ongoing operation of the WTP, Cast Stone Facilities, and Solid-Liquid Separations Facility, coinciding with grout facility operations and construction of landfill closure surface barrier lobes. The peak electrical energy demand of 0.47 million megawatt-hours (approximating an electric load of 54 megawatts) would be about 27 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.5.2 Fuel

Peak liquid fuel consumption under Alternative 3B would total about 86.2 million liters (22.8 million gallons) in the 2035–2036 timeframe. Peak demands would be driven by WTP and other facility operations along with operations of Borrow Area C and surface barrier construction activities.

4.1.2.5.3 Water

Peak water requirements would also occur in 2035–2036 under Alternative 3B. Peak demands under this alternative would correspond to facility operation activities coinciding with Borrow Area C operations and surface barrier construction activities. The projected peak water demand of 2,180 million liters (576 million gallons) would be about 12 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 10 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Similar to Alternatives 3A and 3B, construction, operation, and deactivation of the WTP, including the various waste retrieval and supplemental treatment facilities, in concert with landfill closure activities, would place the highest demand on utility infrastructure. The active project phase under Alternative 3C is 37 years, from 2006 through completion of WTP deactivation, landfill closure, and most other activities in 2042, excluding the subsequent 100-year postclosure (landfill) care period. Table 4–2 summarizes the projected infrastructure resource requirements under Alternative 3C.

4.1.2.6.1 Electricity

Total and peak electrical energy demands under this alternative would largely be dominated by operation of the WTP, Steam Reforming Facilities, Solid-Liquids Separations Facility, and grout facility; construction of landfill closure surface barrier lobes would be secondary contributors in the peak timeframe. Power demand would be greater under this alternative than under Alternatives 3A or 3B by virtue of the relatively greater energy demands of steam reforming supplemental treatment versus either bulk vitrification or cast stone supplemental treatments. The peak electrical energy demand of

0.83 million megawatt-hours (approximating an electric load of 95 megawatts) over the 2035–2038 timeframe would be about 48 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.6.2 Fuel

Peak liquid fuel consumption under Alternative 3C would total about 91.1 million liters (24.1 million gallons) in 2035–2036. As under Alternatives 3A and 3B, liquid fuel requirements would be driven by the facility and Borrow Area C operation requirements, coinciding with surface barrier construction activities.

4.1.2.6.3 Water

Peak water requirements would also occur in the 2035–2036 timeframe, driven by facility operations, with construction of landfill closure surface barrier lobes as a large contributor. The projected peak water demand of 2,190 million liters (579 million gallons) would be about 12 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 10 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Construction, operation, and deactivation of the WTP, including the various waste retrieval and supplemental treatment facilities, would place the highest demand on utility infrastructure. This alternative also represents a hybrid supplemental treatment approach relative to Alternatives 3A through 3C, involving both thermal and nonthermal treatment technologies. However, unlike the previously discussed alternatives, requirements for clean closure of just the BX and SX tank farms would increase usage of some utility resources and slightly extend the demand for utility infrastructure resources further into the future. The active project phase under Alternative 4 is 40 years, from 2006 through completion of WTP deactivation, landfill closure, and most other activities in 2045, excluding the subsequent 100-year postclosure (landfill) care period. Table 4–2 summarizes the projected total and annual average infrastructure resource requirements under Alternative 4.

4.1.2.7.1 Electricity

Electrical energy demand for various tank farm closure activities, including operation of the Preprocessing Facility (PPF) to support clean closure of the BX and SX tank farms and facility operations, led by the WTP, would result in peak requirements in 2038–2039. The peak electrical energy demand of 0.55 million megawatt-hours (approximating an electric load of 63 megawatts) would be about 32 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.7.2 Fuel

Peak diesel fuel consumption under Alternative 4 would total 76.2 million liters (20.1 million gallons) in 2038–2039. Peak demands would be driven by operation of the WTP and PPF, along with clean closure activities. Gasoline consumption would peak later, in 2043, due to operation of the Cesium and Strontium Capsule Processing Facility at the same time as PPF deactivation, as well as concurrent construction of surface barriers for landfill closure of the tank farms that would not be clean-closed.

4.1.2.7.3 Water

Peak water requirements would occur in 2020–2021 under this alternative due to facility operations coinciding with PPF construction. The projected peak water demand of 2,180 million liters (576 million gallons) would be about 12 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 10 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Construction and operation of an expanded WTP on an accelerated schedule and supplemental treatment facilities, in concert with landfill closure activities, would place the highest demand on utility infrastructure. The active project phase under Alternative 5 is 34 years, from 2006 through completion of WTP deactivation, landfill closure, and most other activities in 2039, excluding the subsequent 100-year postclosure (landfill) care period. Table 4–2 summarizes the projected total and annual average infrastructure resource requirements under Alternative 5.

4.1.2.8.1 Electricity

Facility operations, led by the WTP and Sulfate Removal Facility, would dominate the electrical energy requirements under Alternative 5; the electrical energy demand peak occurring in 2024–2025 would coincide with the projected startup of SST grouting operations, coinciding with WTP and supplemental treatment facility operations. The peak electrical energy demand of 0.62 million megawatt-hours (approximating an electric load of 71 megawatts) would be about 36 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.8.2 Fuel

Peak liquid fuel consumption under Alternative 5 would total about 235 million liters (62.1 million gallons) in the 2029–2032 timeframe, with demands driven by the activities described above, with the addition of Hanford surface barrier construction activities.

4.1.2.8.3 Water

Peak water requirements would also occur over the 2029–2032 timeframe, driven by facility operations, led by the WTP, along with Hanford surface barrier construction activities. The projected peak water demand of 3,800 million liters (1,000 million gallons) would be about 21 percent of the 18,500-million-liter (4,890-million-gallon) current annual capacity of the Hanford Export Water System and about 17 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

Under this alternative, three WTP facilities would be constructed, operated, and deactivated sequentially. A replacement facility would be under construction while the previous facility is still operating. Likewise, deactivation of the previous facility would occur when the replacement facility begins operation. These activity overlaps would compound utility infrastructure resource demands, along with clean closure activities, and peak activities would occur over a much longer timeframe, compared with the previously discussed alternatives. The active project phase under Alternative 6A is 161 years, from 2006 through completion of deactivation of the third WTP, completion of closure activities, and most other activities in 2166 under both the Base and Option Cases, excluding the subsequent

100-year institutional control period. The two different cases (Base and Option Cases) considered under Alternative 6A relate to landfill closure of six sets of cribs and trenches (ditches) in the B and T Areas under the Base Case versus their removal and clean closure under the Option Case. Table 4–2 summarizes the projected total and annual average infrastructure resource requirements under Alternative 6A.

4.1.2.9.1 Electricity

4.1.2.9.1.1 Base Case

As with the alternatives discussed previously, WTP activities would dominate the overall electrical energy requirements. The peak electrical energy demand under Alternative 6A, Base Case, would occur in 2138. This peak would be primarily due to ongoing WTP operations and construction of the second WTP replacement coinciding with deactivation of the first WTP replacement. The peak electrical energy demand of 1.94 million megawatt-hours (approximating an electric load of 221 megawatts) in 2138 would be about 111 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system. Total electricity consumption would also be much higher under Alternative 6A due to the much longer operating period of key facilities.

4.1.2.9.1.2 Option Case

Electrical energy requirements under Alternative 6A, Option Case, would be somewhat higher than those under the Base Case, with peak demands occurring in 2078. The difference would be due to the higher electricity demand to support concurrent WTP operations, WTP replacement construction, and WTP deactivation, plus the added demand of removing the B Area cribs and trenches (ditches) in the same timeframe under this option. The peak electrical energy demand of 1.97 million megawatt-hours (approximating an electric load of 225 megawatts) would be about 113 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.9.2 Fuel

4.1.2.9.2.1 Base Case

Peak diesel fuel consumption under Alternative 6A, Base Case, would total up to 234 million liters (61.8 million gallons) in 2138, corresponding with ongoing WTP operations and WTP replacement construction coinciding with deactivation of the first WTP replacement. Gasoline consumption would peak later, in 2149–2150, due to WTP operations combined with surface barrier construction for landfill closure of the B and T Area cribs and trenches (ditches).

4.1.2.9.2.2 Option Case

Peak and total liquid fuel consumption under Alternative 6A, Option Case, would be somewhat higher than the Base Case liquid fuel consumption, with peak diesel fuel demands also occurring in 2078 at 237 million liters (62.6 million gallons). Gasoline consumption would also peak later, in 2163, driven by Cesium and Strontium Capsule Processing Facility operations and deactivation of the PPF.

4.1.2.9.3 Water

4.1.2.9.3.1 Base Case

Peak water requirements under Alternative 6A, Base Case, would also occur in 2138, as described for the other utility resources. The projected peak water demand of up to 6,580 million liters (1,740 million

gallons) in 2138 would be about 36 percent of the 18,500-million-liter (4,890-million-gallon) current annual capacity of the Hanford Export Water System and about 29 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.9.3.2 Option Case

Peak and total water demand under Alternative 6A, Option Case, is projected to be nearly identical to that under the Base Case in magnitude and timing, except that water requirements for closure activities would be slightly higher.

4.1.2.10 Alternative 6B: All Vitrification with Separations; Clean Closure

The primary difference between Alternative 6A and Alternative 6B is that Alternative 6B accomplishes waste processing in a shorter timeframe using an expanded WTP and requiring no WTP replacements. The construction, operation, and deactivation of an expanded WTP, in concert with clean closure activities under this alternative, would place the most demand on utility infrastructure. The active project phase under Alternative 6B is 95 years, from 2006 through completion of deactivation of the PPF, completion of clean closure activities, and most other activities in 2100 under both the Base and Option Cases, excluding the subsequent 100-year institutional control period. The two cases (Base and Option Cases) considered under Alternative 6B relate to landfill closure of six sets of cribs and trenches (ditches) in the B and T Areas under the Base Case versus their removal and clean closure under the Option Case. Table 4–2 summarizes the projected infrastructure resource requirements under Alternative 6B.

4.1.2.10.1 Electricity

4.1.2.10.1.1 Base Case

Facility operations, led by the WTP and the Cesium and Strontium Capsule Processing Facility, coinciding with clean closure activities, would result in peak electrical energy demands in 2040 under Alternative 6B, Base Case. The peak electrical energy demand of 1.24 million megawatt-hours (approximating an electric load of 142 megawatts) in 2040 would be about 71 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.10.1.2 Option Case

Electrical energy requirements under Alternative 6B, Option Case, would be somewhat higher than those under the Base Case, but peak demands would also occur in 2040. The difference occurs due to the higher electricity demand to support the addition of clean closure of the six sets of cribs and trenches (ditches) under this option. The peak electrical energy demand of 1.28 million megawatt-hours (approximating an electric load of 146 megawatts) would be about 74 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.10.2 Fuel

4.1.2.10.2.1 Base Case

Peak liquid fuel consumption under Alternative 6B, Base Case, would total about 262 million liters (69.2 million gallons) in 2040, with demands driven by the activities described above for electricity.

4.1.2.10.2.2 Option Case

Peak and total liquid fuel consumption under Alternative 6B, Option Case, would be somewhat higher than consumption under the Base Case, with peak fuel demands also occurring in 2040 at 266 million liters (70.3 million gallons).

4.1.2.10.3 Water

4.1.2.10.3.1 Base Case

Peak water requirements under Alternative 6B, Base Case, would also occur in 2040, with the timing of the peak based on the activities discussed above. The projected peak water demand of up to 3,500 million liters (925 million gallons) in 2040 would be about 19 percent of the 18,500-million-liter (4,890-million-gallon) current annual capacity of the Hanford Export Water System and about 15 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.2.10.3.2 Option Case

Peak and total water demand under Alternative 6B, Option Case, is projected to be nearly identical to that under the Base Case in magnitude and timing, except that water requirements for closure activities would be slightly higher.

4.1.2.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

The construction, operations, and deactivation of an expanded WTP, in concert with landfill closure activities, would place the most demand on utility infrastructure. Infrastructure requirements under this alternative would mirror those under Alternative 2B, except that additional immobilized low-activity waste (ILAW) storage facilities would be needed under this alternative. The active project phase under Alternative 6C is 40 years, from 2006 through completion of WTP deactivation, landfill closure, and most other activities in 2045, excluding the subsequent 100-year postclosure (landfill) care period. Table 4–2 summarizes the projected total and annual average infrastructure resource requirements under Alternative 6C.

4.1.2.11.1 Electricity

WTP and Cesium and Strontium Capsule Processing Facility operations, coinciding with grout facility operations and construction of surface barrier lobes for landfill closure, would dominate the electrical energy requirements under Alternative 6C. The peak electrical energy demand of 1.16 million megawatt-hours (approximating an electric load of 132 megawatts) in 2040 would be about 67 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

4.1.2.11.2 Fuel

Peak liquid fuel consumption under Alternative 6C would total about 279 million liters (73.7 million gallons) in 2040, with demands driven by the activities described above.

4.1.2.11.3 Water

Peak water requirements would also occur in 2040, dominated by peak operations coinciding with landfill closure activities. The projected peak water demand of 3,560 million liters (940 million gallons) would be about 19 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford

Export Water System and about 16 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.1.3 Noise and Vibration

Facility construction, operations, deactivation, and closure activities, as applicable to each alternative, would result in minor noise impacts of employee vehicles, trucks, construction equipment, generators, and other equipment. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary. Heavy diesel equipment used for construction under most of the alternatives is expected to cause the highest noise levels. For example, if 150 items of construction equipment were operating at the WTP construction site with a sound pressure level of 88 decibels A-weighted (dBA) at 15.2 meters (50 feet), the contribution to the sound level at the nearest site boundary would be 18 dBA (SAIC 2007a). If the equipment operates during a normal daytime shift, the estimated maximum sound level at the site boundary would be well below the Washington State standard daytime maximum noise level limitation of 60 dBA for industrial sources impacting residential receptors (WAC 173-60).

Some disturbance of wildlife near the 200 Areas could occur as a result of noise from construction-type activities during construction, deactivation, and closure, as applicable to each alternative. Noise from operation activities is expected to be similar to existing activities in these areas and would result in little additional change in noise levels and impacts on wildlife. Mitigation of impacts on threatened and endangered species is discussed in Section 4.1.7.

Perceived Change in Sound Level

Change in Level	Perceived Change to the Human Ear
± 1 dB	Not perceptible
± 3 dB	Threshold of perception
± 5 dB	Clearly noticeable
± 10 dB	Twice (or half) as loud
± 20 dB	Fourfold change

Key: dB=decibel. **Source:** MPCA 1999:9.

The number of employee vehicles and trucks delivering materials for various phases of tank closure activities will vary over the duration of the project and by alternative. The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site.

Activities at Hanford associated with the Tank Closure alternatives that involve excavation, earthmoving, transporting fill material, and other vehicle traffic through Hanford could result in ground vibration that could affect operations of the Laser Interferometer Gravitational-Wave Observatory (LIGO). Most of the activities that have been identified to have impacts on this facility are activities in which heavy vehicles or large construction equipment is used. It is expected that blasting would also have an impact on this facility if it is required for mining. Although DOE will coordinate vibration-producing activities with LIGO, impacts of this type of activity associated with these Tank Closure alternatives are expected to result in some interference with the operations of this facility.

4.1.3.1 Alternative 1: No Action

Under Tank Closure Alternative 1, some routine operations and monitoring activities would continue. Activities under this Tank Closure alternative would result in some noise impacts of employee vehicles, trucks, and construction equipment. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be minor due to the distance to the Hanford boundary. Noise levels from tank closure activities would be reduced from the current levels. No additional disturbance of wildlife near the 200 Areas is expected to occur as a result of noise under this Tank Closure alternative.

4.1.3.2 Alternative 2A: Existing WTP Vitrification; No Closure

Construction, operation, and deactivation of facilities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur from 2078–2079, during WTP operations and deactivation (SAIC 2007a). The increase in the number of employee vehicles and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. The increase in employee and truck traffic from the discussion of local traffic (see Section 4.1.9) was compared to the existing average traffic volume (see Chapter 3, Section 3.2.9.4). For the purpose of comparison among the alternatives, the increase in traffic noise level can be estimated from the ratio of the projected traffic volume to the existing traffic volume (see Appendix F, Section F.3).

4.1.3.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be minor due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2040 during WTP operations and vacuum-based retrieval (VBR) system construction (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2035 during WTP operations and VBR system construction (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from

activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2035 during WTP operations and VBR system construction (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2035 during WTP operations and VBR system construction (SAIC 2007a). The increase in number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2019 during WTP operations and construction of the PPF and mobile retrieval system (MRS) (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur from 2029–2032

during WTP and VBR system operations (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.3.9.1 Base Case

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2138 during WTP operations and deactivation and HLW Interim Storage Facility operations (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.9.2 Option Case

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2041 during WTP operations, HLW Interim Storage Facility operations, and PPF construction (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.3.10.1 Base Case

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur from 2021–2022 during construction of the PPF, MRS, and WTP operations (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.10.2 Option Case

Facility construction, operation, and deactivation and tank farm closure activities under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur from 2021–2022 during construction of the PPF, MRS, and WTP operations (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.3.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

Facility construction, operation, and deactivation and tank farm closure under this Tank Closure alternative would result in minor noise impacts of employee vehicles, trucks, construction equipment and activity, generators, and process equipment operation as discussed above. The offsite noise levels from activities at the WTP and 200-East and 200-West Areas would be negligible due to the distance to the Hanford boundary.

Employee and truck traffic to deliver materials for various phases of tank closure activities will vary over the duration of the project. The highest number of employee trips is expected to occur in 2040 during WTP operations, routine operations, VBR system operations, and modified RCRA Subtitle C barrier construction (SAIC 2007a). The increase in the number of employee vehicle and truck trips is expected to result in a minor increase in traffic noise levels along routes to the site. This assessment and conclusion is similar to that previously described for Alternative 2A (see Section 4.1.3.2).

4.1.4 Air Quality

Activities under the various Tank Closure alternatives would result in some air quality impacts of air pollutant emissions from employee vehicles, trucks, and construction equipment and, as applicable under most Tank Closure alternatives, heating equipment, generators, and process equipment. Criteria pollutant concentrations for the activities associated with each Tank Closure alternative were modeled, and the year with peak concentrations for each alternative, pollutant, and averaging time was identified (see Appendix G). These concentrations are presented in Table 4–3 and compared with the ambient standards. The maximum concentrations that would result from these activities for each Tank Closure alternative would be below the ambient standards for the most part; exceptions include the 24-hour concentrations of particulate matter (PM) under most Tank Closure alternatives, the annual concentrations of PM with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) under Alternative 6A, the annual concentrations of PM with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) under most Tank Closure alternatives, and the 1-hour concentrations of carbon monoxide under several Tank Closure alternatives. The peak period identified under each alternative and the primary contributing activities are discussed for each Tank Closure alternative below. Maximum air quality impacts are expected to occur along State Route 240, along or near the Hanford boundary to the east and southeast, or along the Hanford Reach boundary to the west and southwest. The concentration estimates of PM are high as a result of the high estimated emissions. PM concentrations would be reduced by applying appropriate dust control measures (see Chapter 7, Section 7.1).

Table 4–3. Tank Closure Alternatives – Incremental Criteria Pollutant Concentrations

Pollutant and Averaging Period	Standard[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)												
		Alternatives												
		1	2A	2B	3A	3B	3C	4	5	6A Base Case	6A Option Case	6B Base Case	6B Option Case	6C
Carbon Monoxide														
8-hour	10,000[b]	3,410	6,010	5,840	8,880	9,160	9,120	5,550	7,620	5,330	3,800	5,290	5,290	5,640
1-hour	40,000[b]	23,300	**40,600**	36,300	**56,600**	**57,700**	**57,600**	35,700	**47,300**	31,900	22,400	34,200	34,200	33,600
Nitrogen Dioxide														
Annual	100[b]	8.56	18.4	20.4	17.9	18.1	18.1	13.1	21.1	19.3	14.9	14.2	14.7	20.4
PM_{10}[c]														
Annual	50[d]	5.32	15.5	34.8	34.8	34.8	34.7	23.3	35.8	39.1	38.7	37.2	15.3	35.4
24-hour	150[b]	**546**	**1,600**	**4,510**	**4,510**	**4,510**	**4,510**	**2,960**	**4,920**	**5,040**	**3,650**	**5,110**	**1,690**	**4,570**
Sulfur Dioxide														
Annual	50[d]	0.0134	0.0827	0.308	0.151	0.0952	0.0946	0.0939	0.152	0.0785	0.076	0.291	0.297	0.308
24-hour	260[d]	1.37	4.40	9.05	10.7	5.96	5.90	6.89	9.92	4.23	3.15	6.69	7.10	9.05
3-hour	1,300[b]	8.00	25.1	50.6	48.3	31.5	31.3	29.8	44.3	21.7	17.6	39.1	40.8	50.6
1-hour	660[d]	24.0	64.6	99.4	126	82.1	81.6	71.8	106	53.3	41.6	65.4	70.3	99.5

[a] The more stringent of the Federal and Washington State standards is presented if both exist for the averaging period. The National Ambient Air Quality Standards (40 CFR 50), other than those for ozone, particulate matter, lead, and those based on annual averages, are not to be exceeded more than once per year. The 24-hour PM_{10} standard is attained when the expected number of days with a 24-hour average concentration above the standard is less than or equal to 1. The annual arithmetic mean PM_{10} standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard. The annual $PM_{2.5}$ standard is met when the 3-year average of the annual means is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 3-year average of the 98th percentile 24-hour averages is less than or equal to the standard.

[b] Federal and Washington State standard.

[c] The Federal standards for $PM_{2.5}$ are 15 micrograms per cubic meter annual average and 35 micrograms per cubic meter 24-hour average. No specific data for $PM_{2.5}$ were available, but for the purpose of analysis concentrations were assumed to be the same as PM_{10}.

[d] Washington State standard.

Note: The National Ambient Air Quality Standards also includes standards for lead and ozone. No sources of lead emissions have been identified for the alternatives evaluated. Washington State also has ambient standards for fluorides. Concentrations in **bold** text indicate potential exceedance of the standard.

Key: PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: Appendix G, Section G.3.

Construction activities considered in estimating PM emissions include general construction equipment activity and windblown particulate from disturbed areas, resuspension of road dust, fuel combustion in construction equipment, and concrete batch plant operations. The emission factor used for these estimates is intended to provide a gross estimate of total suspended particulate emissions when more detailed engineering of a construction activity that would allow for a more refined estimate is not available. For the purpose of this analysis, emissions of PM_{10} and $PM_{2.5}$ from general construction activities were assumed to be the same as the total suspended particulate emissions. This results in a substantial overestimate of PM_{10} and $PM_{2.5}$ emissions. Further, the analysis did not consider emission controls that could be applied in the construction areas, as discussed in Chapter 7, Section 7.1. A refined analysis of emissions, based on more detailed engineering of the construction activities and application of appropriate control technologies, is expected to result in substantially lower estimates of emissions and ambient concentrations from the major construction activities under any of the Tank Closure alternatives.

Effects of Criteria Air Pollutants

Criteria air pollutants can harm health and the environment, and cause property damage. Below are the chief causes of concern by pollutant.

Carbon Monoxide – Can reduce oxygen delivered to the body. Poisonous to healthy people at high levels, and can affect people with heart disease. Affects the nervous system.

Nitrogen Dioxide – One of the main precursors to the formation of ground-level ozone. Contributes to the formation of acid rain and toxic chemicals, deterioration of water quality, impairment of visibility, and global warming.

Ozone – Can result in lung irritation, reduced lung capacity, or permanent lung damage; breathing difficulties; aggravated asthma; and increased susceptibility to respiratory illnesses. Can make sensitive plants more susceptible to damage and damage the appearance of other plants. Can reduce crop yields and forest growth.

Particulate Matter – Can result in increased respiratory symptoms, decreased lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in people with heart or lung disease. Fine particulate ($PM_{2.5}$) is a major cause of reduced visibility. Particulate matter can contribute to acidification of streams and lakes, changes in nutrient balance of coastal waters and larger river basins, depletion of nutrients in soil, damage to forests and crops, and damage to stone and other building materials.

Sulfur Dioxide – Contributes to the formation of acid rain which damages trees, crops, and buildings and makes soils, lakes, and streams acidic. Contributes to reduced visibility.

Lead – Damages organs, including the kidneys, liver, brain, and nerves, especially in infants and young children; harms animals and fish.

Source: EPA 2007.

The sulfur dioxide emission factor used for fuel-burning sources was based on equipment burning a distillate fuel with a sulfur content of about 0.0015 percent (15 parts per million [ppm]), which is being phased in beginning in 2007. No adjustment was made for more restrictive emission standards for nitrogen dioxide and PM, scheduled to be phased in beginning in 2007. In future years, pollutant emissions and impacts are expected to be smaller than estimated in this analysis, as better fuels, combustion technologies, emission controls, and alternative energy sources are developed.

The contributions to the total ambient concentrations from sources in the region and existing and reasonably anticipated sources at Hanford that are unrelated to tank closure are expected to change over the period of the activities evaluated in this environmental impact statement (EIS) and are addressed in the cumulative impacts section. The existing contributions of Hanford sources and regional monitored concentrations are discussed in Chapter 3, Section 3.2.4.

The Clean Air Act, as amended, requires that Federal actions conform to the host state's "state implementation plan" (see Appendix G, Section G.4). The final rule, "Determining Conformity of General Federal Actions to State or Federal Implementation Plans," requires a conformity determination for certain-sized projects in nonattainment areas. Hanford is within an area currently designated as

attainment for criteria air pollutants. Therefore, a conformity determination for these Tank Closure alternatives is not necessary to meet the requirements of the final rule (40 CFR 51.850–51.860).

Both carcinogenic and noncarcinogenic toxic pollutant concentrations were evaluated. The exposure of members of the public to airborne pollutants would be from process emissions released during operations and from equipment used during construction, operations, deactivation, and closure. Selected air toxics were modeled because they are representative of toxic constituents associated with emissions from operation of gasoline- and diesel-fueled equipment. Ammonia was also selected for modeling because of its relatively high concentration compared to other toxic constituents in the tank vapor spaces. Ammonia's concentration, combined with its toxicity, made it a good indicator constituent for the analysis; i.e., if ammonia was found to be within the acceptable source impact level, other toxics should be also. Maximum concentrations under each alternative and the Washington State acceptable source impact levels are presented in Table 4–4. These concentrations were below the acceptable source impact levels for all Tank Closure alternatives. The acceptable source impact levels are used by the state in the permitting process and represent concentrations sufficiently low to protect human health and safety from potential carcinogenic and other toxic effects (WAC 173-460).

For noninvolved workers at nearby facilities, the highest annual concentration of each toxic chemical was used to estimate the Hazard Quotient for each chemical, as described in Appendix G. The Hazard Quotients were summed to give the Hazard Index from noncarcinogenic chemicals associated with each Tank Closure alternative. A Hazard Index of less than 1.0 indicates that adverse health effects of non-cancer-causing agents are not expected. Hazard Indices for each alternative are summarized in Table 4–5. For carcinogens, the highest annual concentration was used to estimate the increased cancer risk from a chemical. Cancer risks from nonradiological toxic pollutant emissions under each Tank Closure alternative are summarized in Table 4–6.

Table 4–4. Tank Closure Alternative – Incremental Toxic Chemical Concentrations

Pollutant	Averaging Period	Acceptable Source Impact Level[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)												
			Alternatives												
			1	2A	2B	3A	3B	3C	4	5	6A Base Case	6A Option Case	6B Base Case	6B Option Case	6C
Ammonia	24-hour	100	26.1	19.6	11.7	11.9	11.9	12.0	11.8	12.0	10.2	9.91	11.9	11.9	11.4
Benzene	Annual	0.12	0.00264	0.00592	0.00456	0.00602	0.00627	0.00602	0.00344	0.00594	0.00479	0.00278	0.00460	0.00355	0.00458
1,3-Butadiene	Annual	0.0036	0.0000732	0.000160	0.000126	0.000146	0.000150	0.000146	0.000101	0.000149	0.000140	0.0000759	0.000132	0.0000938	0.000126
Formaldehyde	Annual	0.077	0.00238	0.00522	0.00406	0.00487	0.00503	0.00487	0.00317	0.00492	0.00447	0.00245	0.00426	0.00306	0.00406
Mercury	24-hour	0.17	0.0	0.00590	0.117	0.0169	0.00787	0.0129	0.0130	0.0182	0.00237	0.00236	0.117	0.117	0.117
Toluene	24-hour	400	1.69	4.07	3.40	5.78	6.03	5.78	2.77	5.19	3.50	2.34	3.73	2.58	3.40
Xylene	24-hour	1,500	0.506	1.22	1.03	1.71	1.78	1.71	0.825	1.55	1.07	0.676	1.13	0.769	1.03

[a] WAC 173-460.

Note: To convert cubic meters to cubic feet, multiply by 35.315.

Source: Appendix G, Section G.3.

Table 4–5. Tank Closure Alternatives – Nonradiological Airborne Toxic Chemical Hazard Index for the Nearest Noninvolved Worker

Chemical	Hazard Quotient												
	Alternatives												
	1	2A	2B	3A	3B	3C	4	5	6A Base Case	6A Option Case	6B Base Case	6B Option Case	6C
Ammonia	9.11×10^{-2}	1.13×10^{-1}	6.72×10^{-2}	6.90×10^{-2}	6.93×10^{-2}	6.97×10^{-2}	6.25×10^{-2}	7.20×10^{-2}	7.84×10^{-2}	7.35×10^{-2}	7.56×10^{-2}	7.31×10^{-2}	6.43×10^{-2}
Mercury	0.00	4.67×10^{-3}	7.15×10^{-2}	3.92×10^{-2}	7.15×10^{-3}	2.12×10^{-2}	1.63×10^{-2}	1.91×10^{-2}	2.14×10^{-3}	2.13×10^{-3}	7.15×10^{-2}	7.15×10^{-2}	7.15×10^{-2}
Toluene	5.95×10^{-5}	7.98×10^{-4}	5.66×10^{-4}	6.70×10^{-4}	6.97×10^{-4}	7.13×10^{-4}	6.30×10^{-4}	7.86×10^{-4}	1.99×10^{-3}	1.54×10^{-3}	1.02×10^{-3}	9.28×10^{-4}	5.00×10^{-4}
Xylene(s)	8.94×10^{-4}	1.16×10^{-2}	8.30×10^{-3}	9.79×10^{-3}	1.02×10^{-2}	1.04×10^{-2}	9.26×10^{-3}	1.15×10^{-2}	2.89×10^{-2}	2.24×10^{-2}	1.50×10^{-2}	1.37×10^{-2}	7.70×10^{-3}
Hazard Index	9.20×10^{-2}	1.30×10^{-1}	1.48×10^{-1}	1.19×10^{-1}	8.73×10^{-2}	1.02×10^{-1}	8.87×10^{-2}	1.03×10^{-1}	1.11×10^{-1}	9.96×10^{-2}	1.63×10^{-1}	1.59×10^{-1}	1.44×10^{-1}

Source: Appendix G, Section G.3.

Table 4–6. Tank Closure Alternatives – Nonradiological Airborne Toxic Chemical Cancer Risk for the Nearest Noninvolved Worker

Chemical	Cancer Risk												
	Alternatives												
	1	2A	2B	3A	3B	3C	4	5	6A Base Case	6A Option Case	6B Base Case	6B Option Case	6C
Benzene	3.71×10^{-7}	3.22×10^{-6}	2.76×10^{-6}	3.06×10^{-6}	3.17×10^{-6}	3.21×10^{-6}	2.90×10^{-6}	3.50×10^{-6}	8.34×10^{-6}	6.77×10^{-6}	5.33×10^{-6}	4.86×10^{-6}	2.63×10^{-6}
1,3-Butadiene	3.96×10^{-8}	2.41×10^{-7}	2.48×10^{-7}	2.61×10^{-7}	2.68×10^{-7}	2.69×10^{-7}	2.87×10^{-7}	2.89×10^{-7}	6.50×10^{-7}	5.57×10^{-7}	5.07×10^{-7}	4.63×10^{-7}	2.43×10^{-7}
Formaldehyde	5.59×10^{-7}	3.70×10^{-6}	3.64×10^{-6}	3.87×10^{-6}	3.98×10^{-6}	4.00×10^{-6}	4.18×10^{-6}	4.33×10^{-6}	9.88×10^{-6}	8.35×10^{-6}	7.33×10^{-6}	6.69×10^{-6}	3.54×10^{-6}

Source: Appendix G, Section G.3.

4.1.4.1 Alternative 1: No Action

Criteria pollutant concentrations from activities under Tank Closure Alternative 1 are presented in Table 4–3. The peak concentrations occur in 2008 for carbon monoxide and nitrogen dioxide and from 2006–2008 for PM and sulfur dioxide. The peak period concentration would result primarily from WTP construction activities and tank upgrade construction. Maximum air quality impacts of PM_{10} would occur south of State Route 240 and 1,000 meters (0.6 miles) southeast of the site boundary. Figure 4–3 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

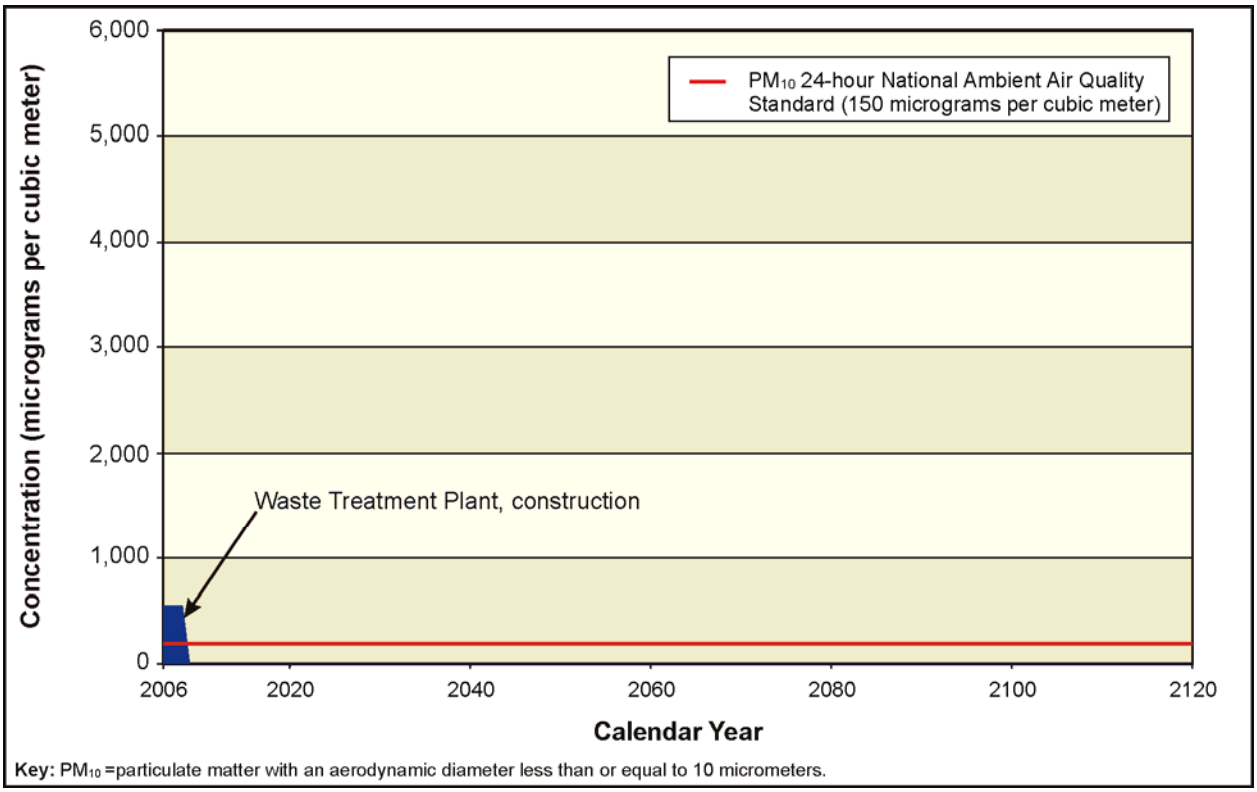


Figure 4–3. Tank Closure Alternative 1 PM_{10} Maximum 24-Hour Concentration

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

4.1.4.2 Alternative 2A: Existing WTP Vitrification; No Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 2A are presented in Table 4–3. The peak concentrations occur from 2065–2066 for all criteria pollutants. The peak period concentrations would result primarily from WTP replacement construction and Borrow Area C operations, except for sulfur dioxide, which would result from WTP operations and replacement construction and for carbon monoxide, which would result from WTP replacement construction and 242-A Evaporator replacement construction. Maximum air quality impacts of PM_{10} would occur south of State Route 240 (24-hour average) and southeast near the site boundary. Figure 4–4 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

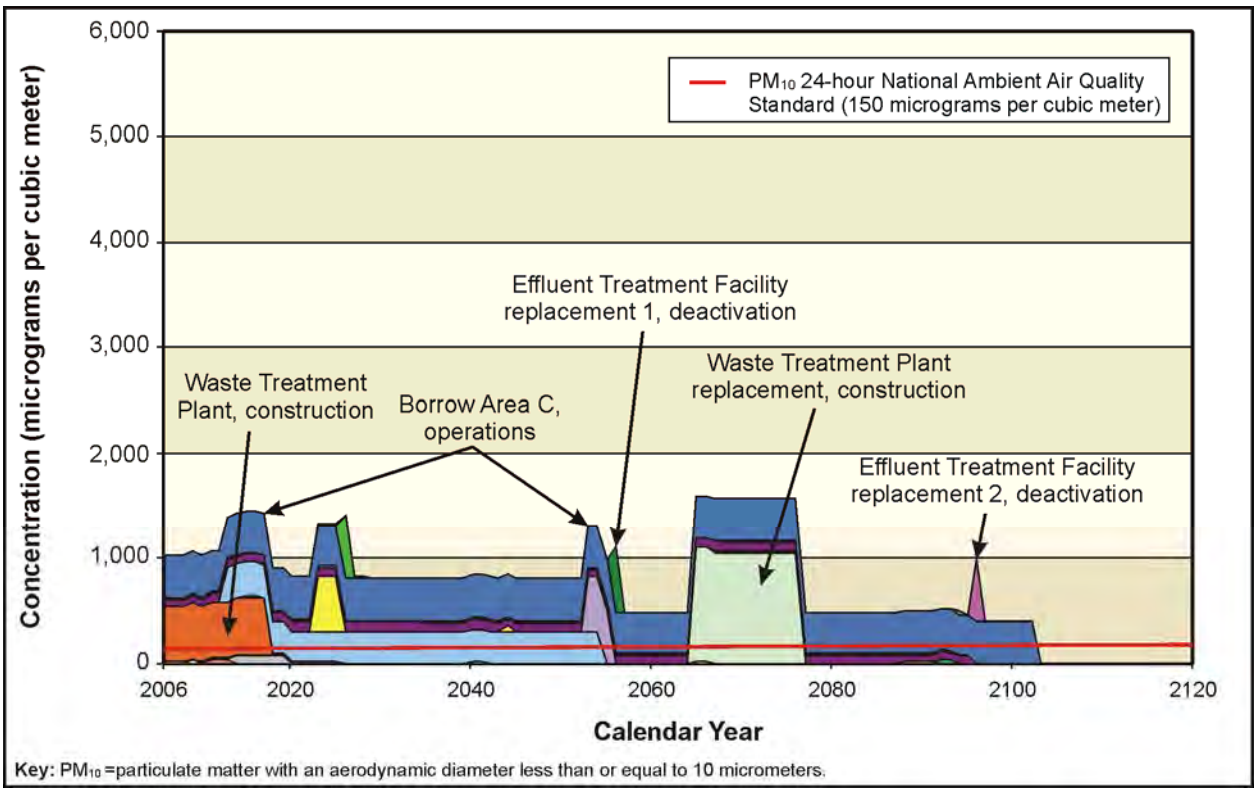


Figure 4–4. Tank Closure Alternative 2A PM_{10} Maximum 24-Hour Concentration

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

4.1.4.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 2B are presented in Table 4–3. The peak concentrations occur in 2040 for all criteria pollutants except the carbon monoxide 1-hour average, which occurs from 2015–2016. The peak period PM_{10} concentration would result primarily from modified RCRA Subtitle C barrier placement and Borrow Area C operations. Maximum air quality impacts of PM_{10} would occur to the south along State Route 240 and to the southeast along the Hanford boundary. Figure 4–5 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

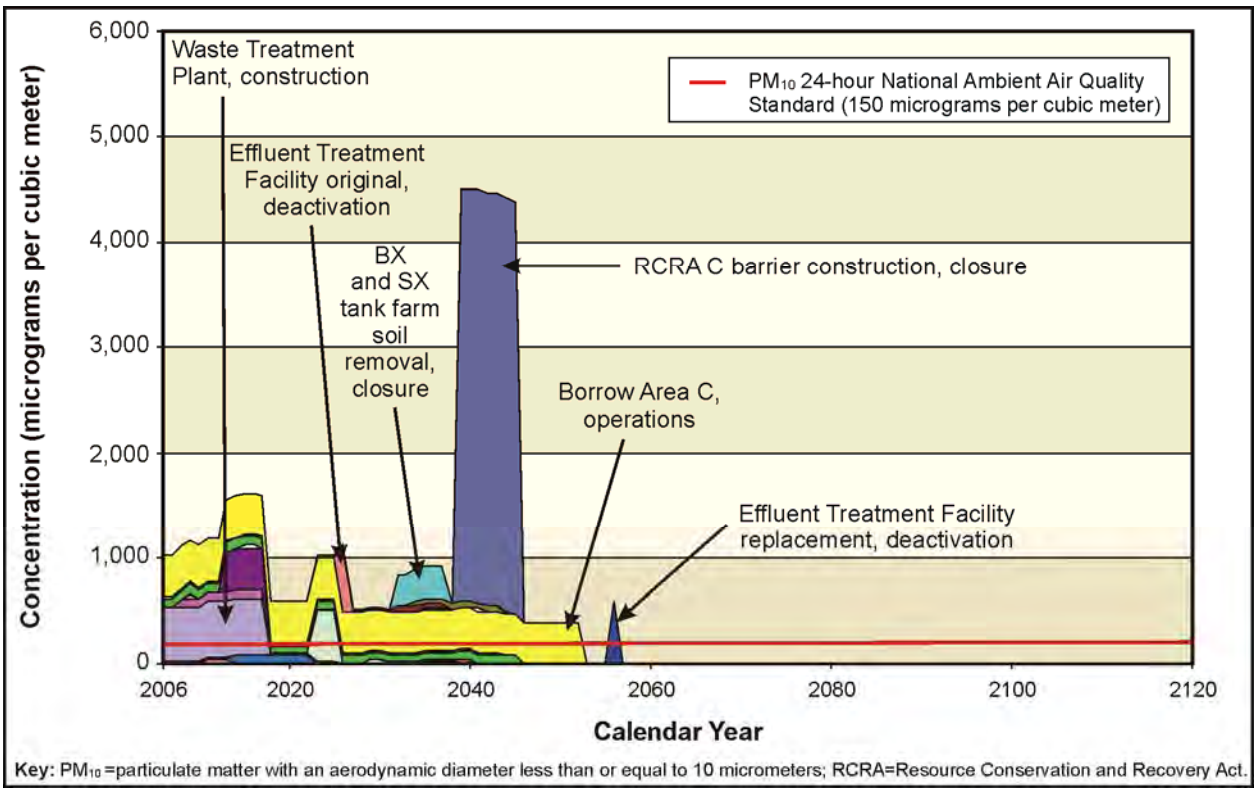


Figure 4–5. Tank Closure Alternative 2B PM_{10} Maximum 24-Hour Concentration

4.1.4.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 3A are presented in Table 4–3. The peak concentrations occur from 2035–2036 for carbon monoxide, sulfur dioxide, and nitrogen dioxide, and in 2039 for PM. The peak period concentration would result primarily from modified RCRA Subtitle C barrier construction for nitrogen dioxide and PM; from Cesium and Strontium Capsule Processing Facility construction and modified RCRA Subtitle C barrier construction for carbon monoxide; and from Cesium and Strontium Capsule Processing Facility construction, WTP operations, and Bulk Vitrification Facility operations for sulfur dioxide. Other periods of PM_{10} exceeding standards occur through year 2052. Figure 4–6 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

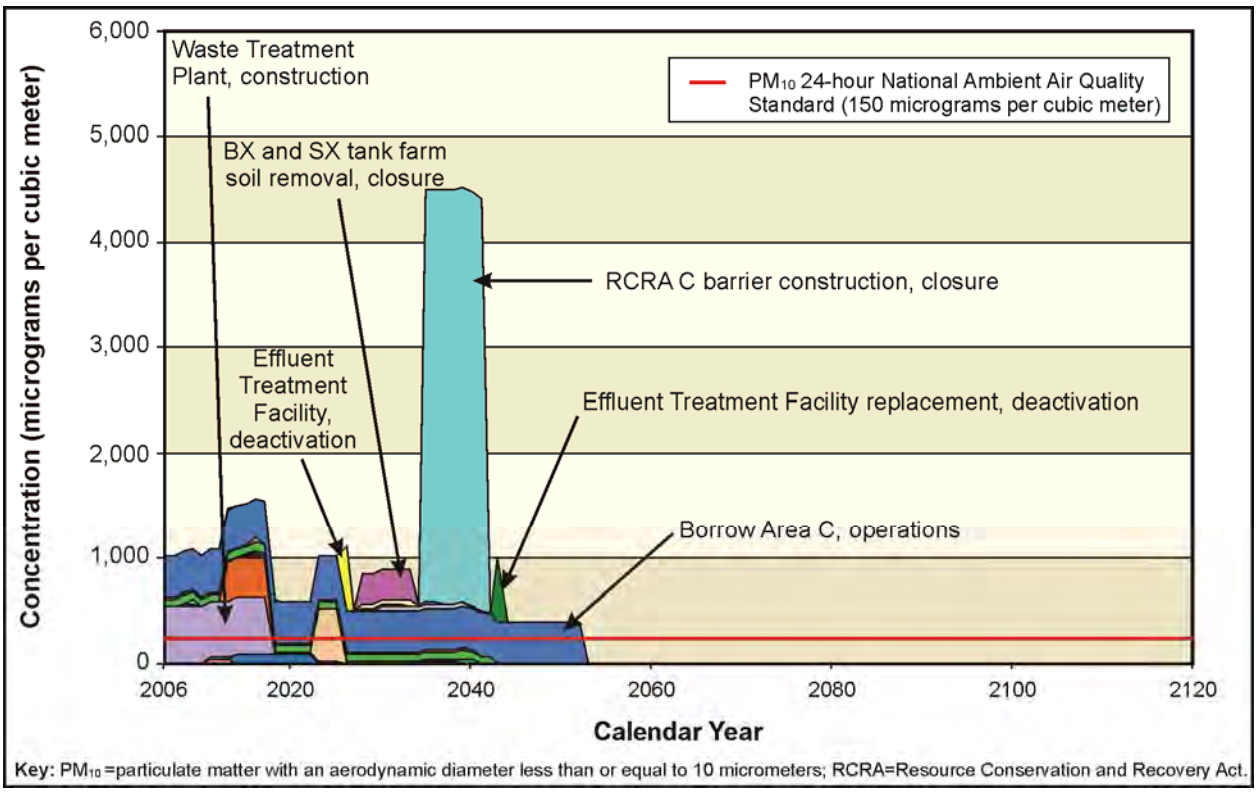


Figure 4–6. Tank Closure Alternative 3A PM_{10} Maximum 24-Hour Concentration

4.1.4.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 3B are presented in Table 4–3. The peak concentrations occur from 2035–2036 for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and in 2039 for PM. The peak period concentration would result primarily from modified RCRA Subtitle C barrier construction and Borrow Area C operations for PM; from Cesium and Strontium Capsule Processing Facility deactivation, WTP operations, and modified RCRA Subtitle C barrier construction for sulfur dioxide; from Cesium and Strontium Capsule Processing Facility construction and modified RCRA Subtitle C barrier construction for carbon monoxide; and from modified RCRA Subtitle C barrier construction for nitrogen dioxide. Other periods of PM_{10} exceeding standards occur from 2006 through 2052. Figure 4–7 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

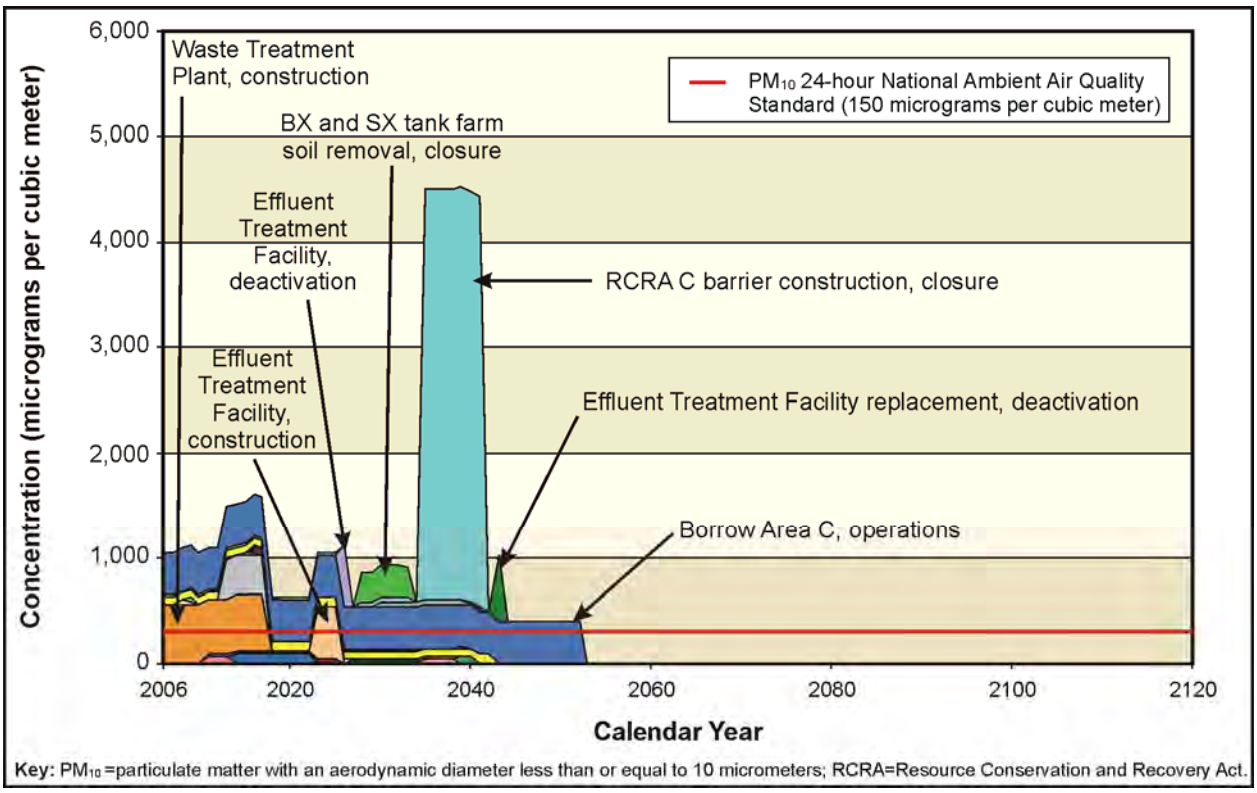


Figure 4–7. Tank Closure Alternative 3B PM_{10} Maximum 24-Hour Concentration

4.1.4.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 3C are presented in Table 4–3. The peak concentrations occur from 2035–2036 for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and in 2039 for PM. The peak period concentration would result primarily from modified RCRA Subtitle C barrier construction and Borrow Area C operations for PM; from Cesium and Strontium Capsule Processing Facility construction, WTP operations, and modified RCRA Subtitle C barrier construction for sulfur dioxide; from modified RCRA Subtitle C barrier construction for nitrogen dioxide; and from Cesium and Strontium Capsule Processing Facility construction and modified RCRA Subtitle C barrier construction for carbon monoxide. The peak period concentration would result primarily from WTP operations for sulfur dioxide. Other periods of PM_{10} exceeding standards occur from 2006 through 2052. Figure 4–8 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

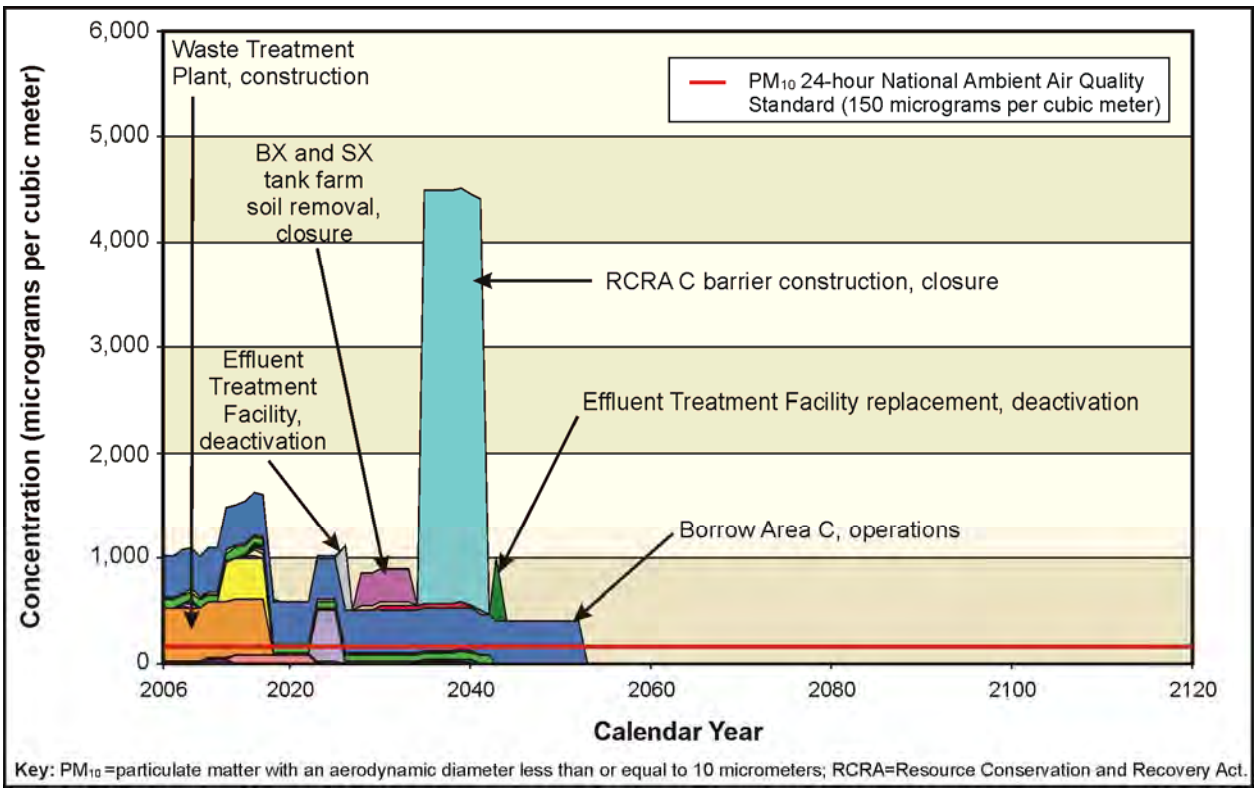


Figure 4–8. Tank Closure Alternative 3C PM_{10} Maximum 24-Hour Concentration

4.1.4.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 4 are presented in Table 4–3. The peak concentrations occur in 2016 for carbon monoxide, from 2038–2039 for nitrogen dioxide and sulfur dioxide, and in 2042 for PM. The peak period concentration would result primarily from WTP construction for carbon monoxide, from modified RCRA Subtitle C barrier construction for nitrogen dioxide and PM, and from WTP and Bulk Vitrification Facility operations and modified RCRA Subtitle C barrier construction for sulfur dioxide. Other periods of PM_{10} exceeding standards occur from 2006 through 2052. Figure 4–9 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

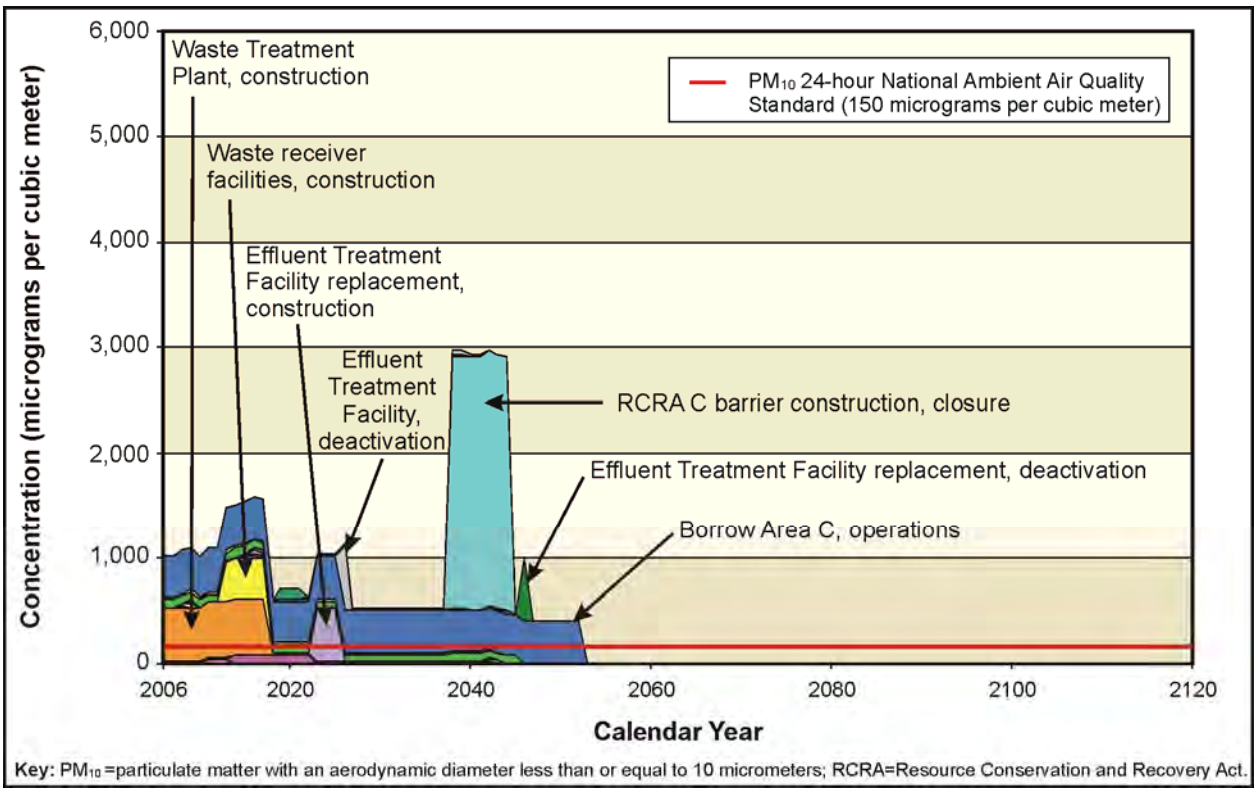


Figure 4–9. Tank Closure Alternative 4 PM_{10} Maximum 24-Hour Concentration

4.1.4.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 5 are presented in Table 4–3. The peak concentrations occur from 2029–2032 for the carbon monoxide 8-hour average, nitrogen dioxide, and sulfur dioxide; in 2016 for the carbon monoxide 1-hour average; and in 2037 for PM. The peak period concentration would result primarily from Hanford barrier construction for carbon monoxide 8-hour average, nitrogen dioxide, and PM; from WTP, tank upgrade, and Sulfate Removal Facility construction for carbon monoxide 1-hour average; and from WTP and Bulk Vitrification Facility operations and Hanford barrier construction for sulfur dioxide. Other periods of PM_{10} exceeding standards occur through year 2052. Figure 4–10 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

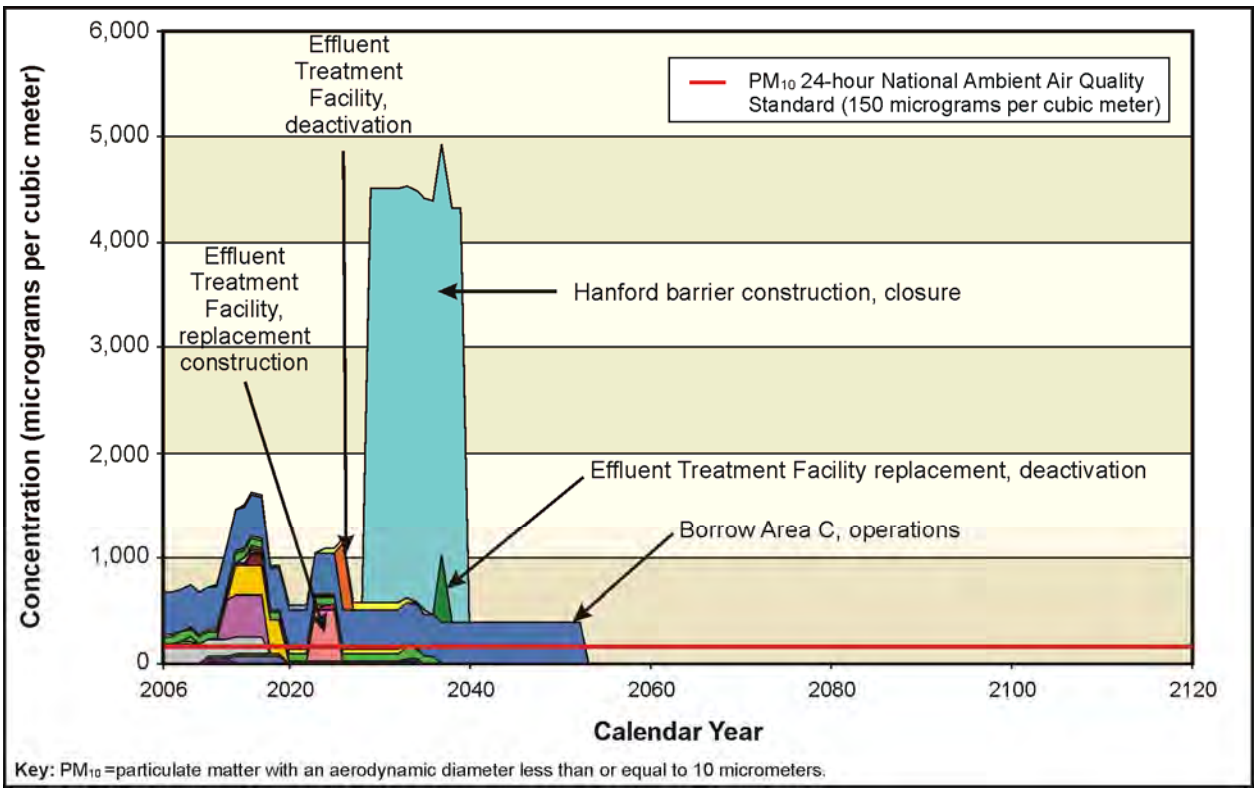


Figure 4–10. Tank Closure Alternative 5 PM_{10} Maximum 24-Hour Concentration

4.1.4.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.4.9.1 Base Case

Criteria pollutant concentrations from activities under Tank Closure Alternative 6A, Base Case, are presented in Table 4–3. The peak concentrations occur from 2149–2150 for carbon monoxide, nitrogen dioxide, PM, and sulfur dioxide. The peak period concentration would result primarily from modified RCRA Subtitle C barrier construction for carbon monoxide, nitrogen dioxide, PM, and sulfur dioxide. Other periods of PM_{10} exceeding standards occur through year 2197. Figure 4–11 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

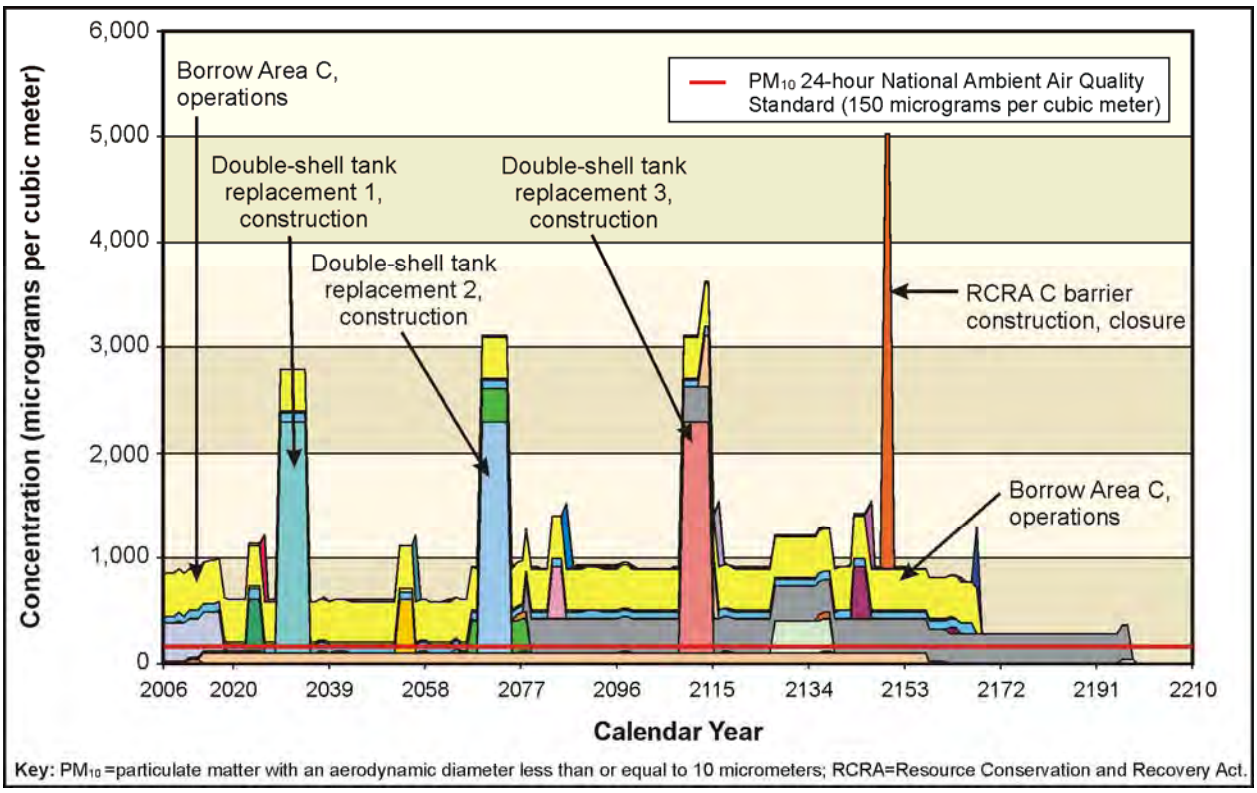


Figure 4–11. Tank Closure Alternative 6A, Base Case, PM_{10} Maximum 24-Hour Concentration

4.1.4.9.2 Option Case

Criteria pollutant concentrations from activities under Tank Closure Alternative 6A, Option Case, are presented in Table 4–3. The peak concentrations occur from 2113–2114 for carbon monoxide and PM, from 2158–2161 for sulfur dioxide (1-hour, 3-hour, and annual averages), in 2115 for sulfur dioxide (24-hour average), and from 2069–2074 for nitrogen dioxide. The peak period concentration would result primarily from ETF and double-shell tank (DST) replacement construction for carbon monoxide and PM, from ETF replacement construction and WTP operations for sulfur dioxide (24-hour average), from WTP operations for sulfur dioxide (1-hour, 3-hour, and annual averages), and from DST and WTP replacement construction and WTP operations for nitrogen dioxide. Other periods of PM_{10} exceeding standards occur through year 2197. Figure 4–12 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

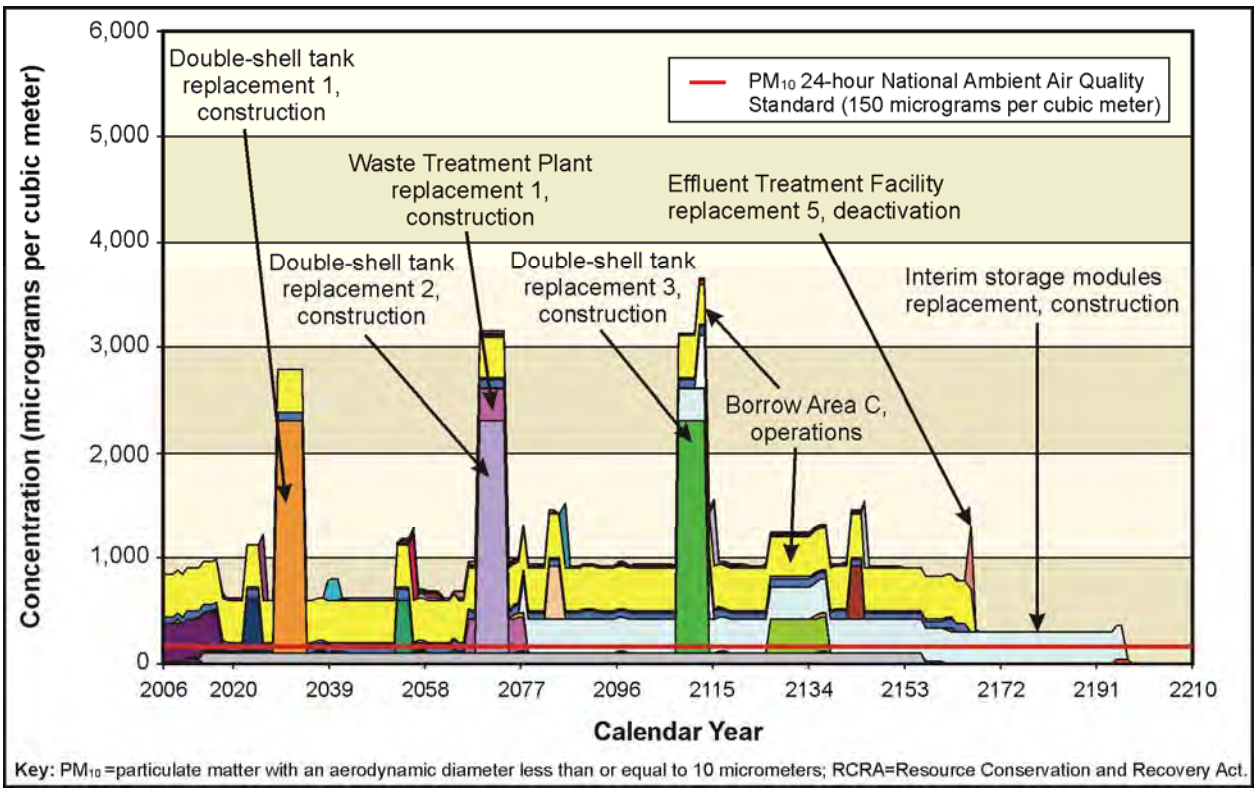


Figure 4–12. Tank Closure Alternative 6A, Option Case, PM_{10} Maximum 24-Hour Concentration

4.1.4.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.4.10.1 Base Case

Criteria pollutant concentrations from activities under Tank Closure Alternative 6B, Base Case, are presented in Table 4–3. The peak concentrations occur in 2016 for carbon monoxide, in 2101 for nitrogen dioxide and PM, and in 2040 for sulfur dioxide. The peak period concentration resulted primarily from WTP, tank upgrade, and 242-A Evaporator construction for carbon dioxide; from modified RCRA Subtitle C barrier construction for nitrogen dioxide and PM; and from WTP and WTP Cesium and Strontium Capsule Processing Facility operations for sulfur dioxide. Other periods of PM_{10} exceeding standards occur through year 2102. Figure 4–13 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

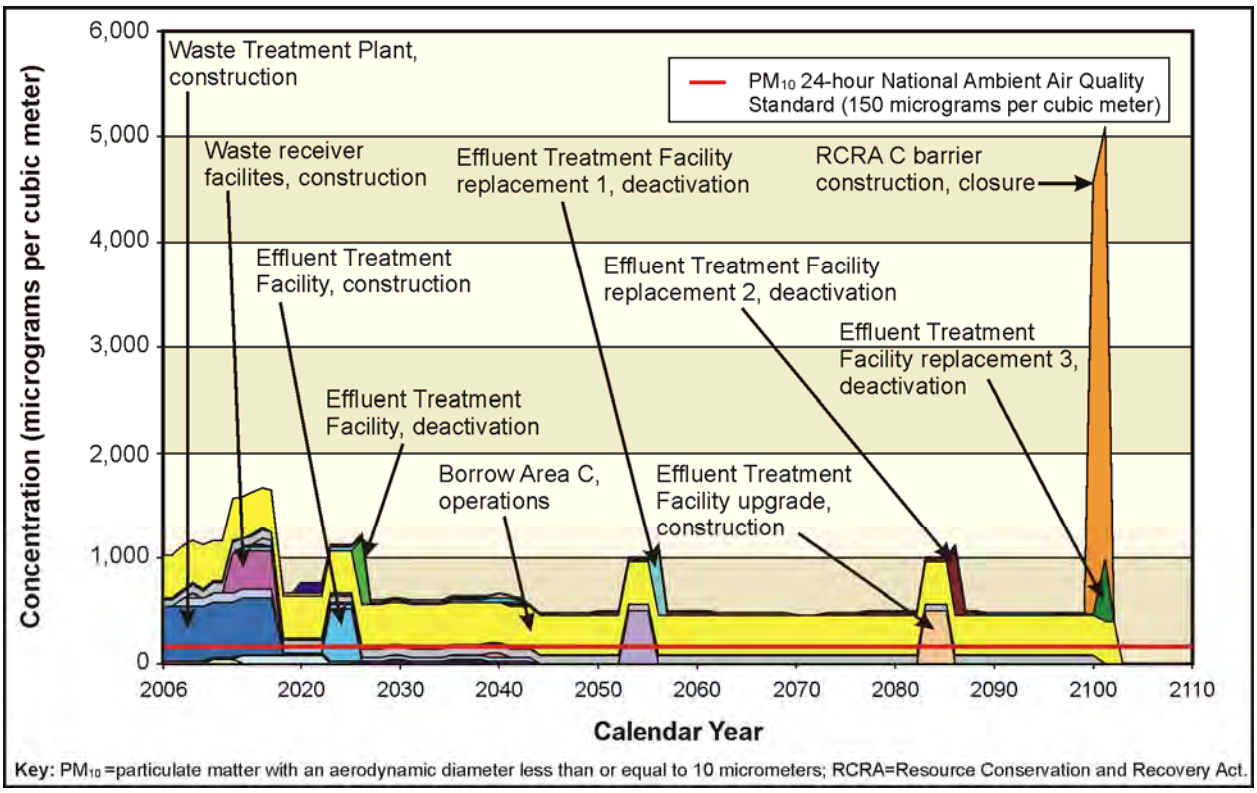


Figure 4–13. Tank Closure Alternative 6B, Base Case, PM_{10} Maximum 24-Hour Concentration

4.1.4.10.2 Option Case

Criteria pollutant concentrations from activities under Tank Closure Alternative 6B, Option Case, are presented in Table 4–3. The peak concentrations occur in 2016 for carbon monoxide and PM and in 2040 for nitrogen dioxide and sulfur dioxide. The peak period concentration would result primarily from WTP construction for carbon monoxide, from WTP and waste receiver facility (WRF) construction and Borrow Area C operations for PM, and from WTP and WTP Cesium and Strontium Capsule Processing Facility operations for nitrogen dioxide and sulfur dioxide. Other periods of PM_{10} exceeding standards occur through year 2102. Figure 4–14 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

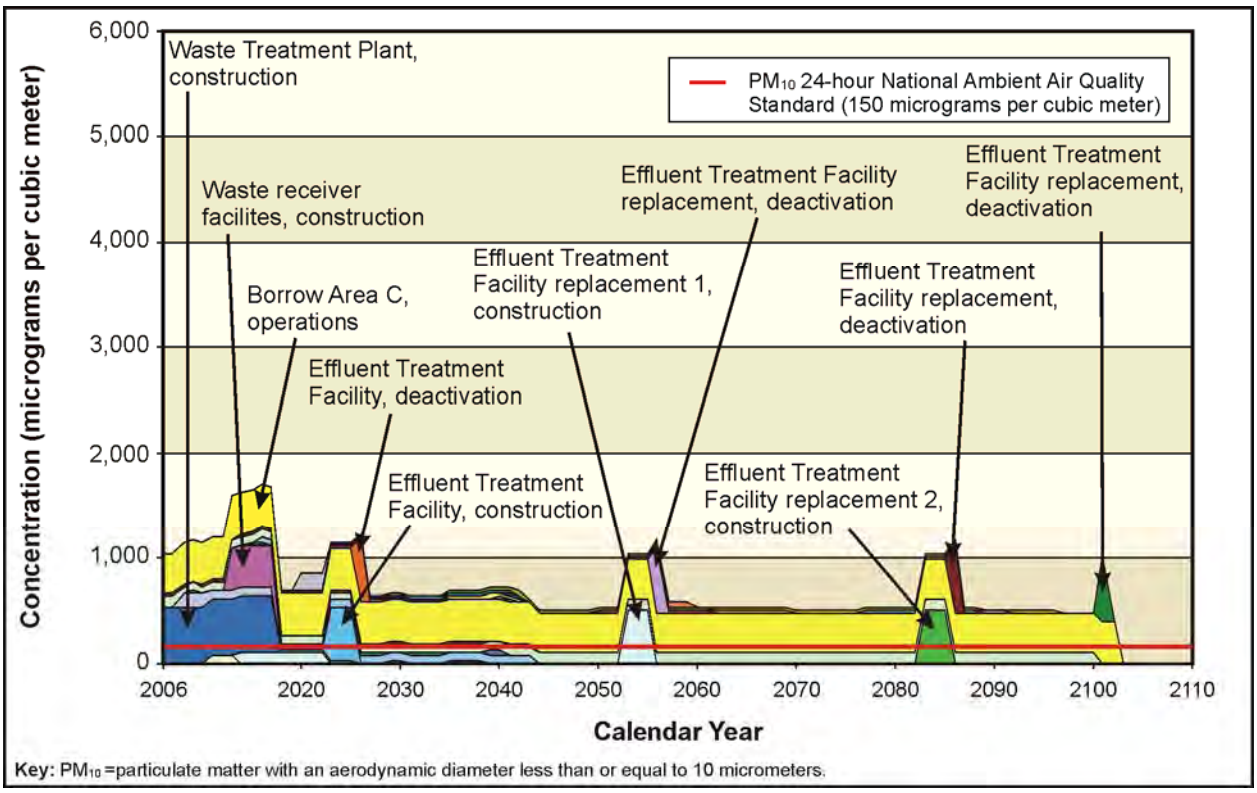


Figure 4–14. Tank Closure Alternative 6B, Option Case, PM_{10} Maximum 24-Hour Concentration

4.1.4.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

Criteria pollutant concentrations from activities under Tank Closure Alternative 6C are presented in Table 4–3. The peak concentrations occur in 2040 for carbon monoxide, nitrogen dioxide, PM, and sulfur dioxide. The peak period concentration would result primarily from modified RCRA Subtitle C barrier construction for carbon monoxide, nitrogen dioxide, and PM and from WTP and WTP Cesium and Strontium Capsule Processing Facility operations and modified RCRA Subtitle C barrier construction for sulfur dioxide. Other periods of PM_{10} exceeding standards occur through year 2052. Figure 4–15 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities to these concentrations.

Maximum concentrations for carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–4. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–5 and 4–6.

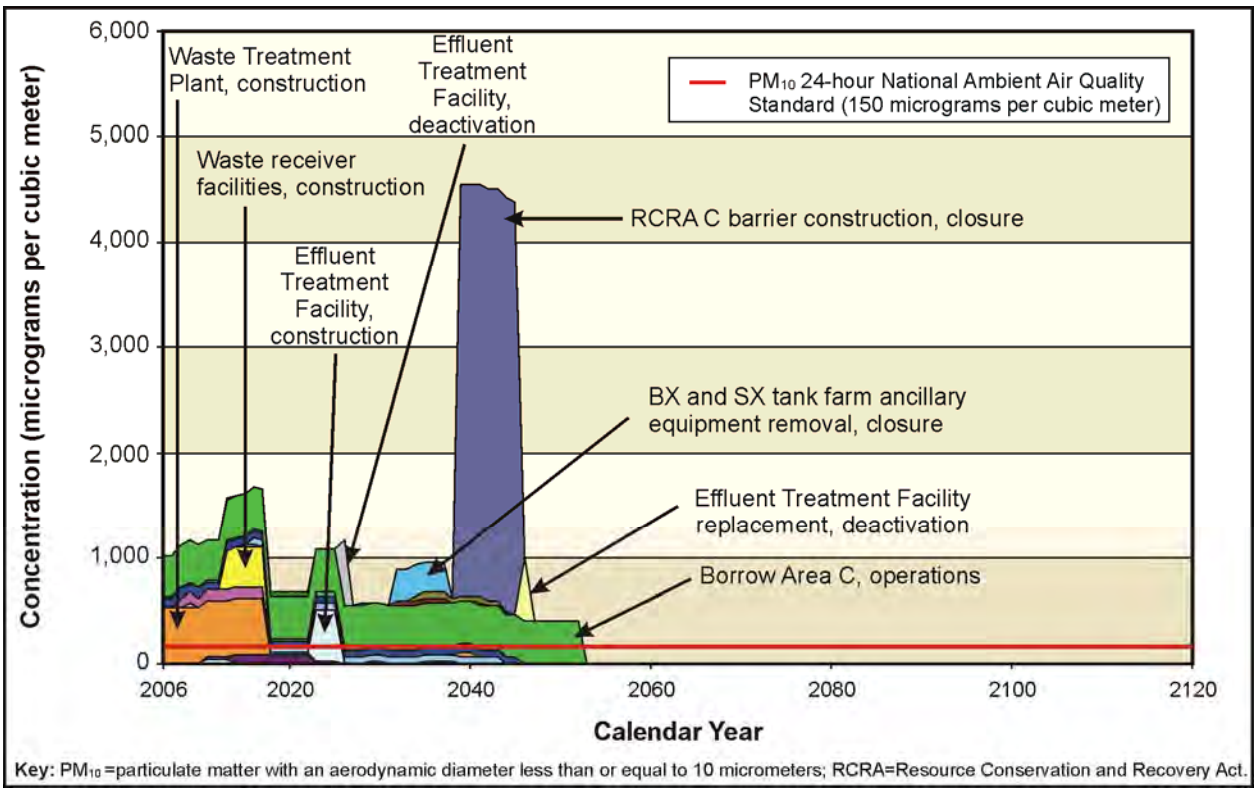


Figure 4–15. Tank Closure Alternative 6C PM_{10} Maximum 24-Hour Concentration

4.1.5 Geology and Soils

Impacts on geology and soils under the Tank Closure alternatives generally are expected to be directly proportional to the total area of land disturbed by site grading, soil compaction, and depth of excavation associated with construction of new facilities to support tank farm closure activities. These impacts would be associated with site excavation work and grading in preparation for constructing building foundations, roadways, parking areas, and laydown areas. Impacts would also include disturbance from trenching and excavation work to install piping, utilities, and other conveyances between buildings and other facilities, as well as disturbance due to exhumation of contaminated soils and other media associated with tank closure.

Under the Tank Closure alternatives, excavation depths for facility construction are not expected to exceed about 12 meters (40 feet) and would be limited by the depth of excavation needed to pour concrete for the walls and basements of the Vitrification Facility melter bays within the WTP. Excavation for most facilities is expected to be less than 3 meters (10 feet). Gravel, sand, and silt deposits of the Hanford formation, which compose the uppermost strata across the 200 Areas, are up to 65 meters (213 feet) thick across the 200 Areas, so the lateral and vertical extent of this unit would not be greatly impacted by facility construction. Uncontaminated soils and sediments excavated during facility construction would typically be stockpiled on site for future construction uses, such as foundation backfill.

Although site construction for the WTP is ongoing, denuded surface soils and unconsolidated sediments in excavations to support tank waste retrieval, treatment, and disposal and excavations and cut slopes for other facilities would be subject to wind and water erosion if left exposed over an extended period of time. Adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. To reduce the risk from exposing contaminated soils, areas in which new facilities would be constructed under this alternative would be surveyed prior to any ground disturbance. Any contamination would be remediated as necessary. After construction, disturbed areas would either lie within the footprint of the new buildings or be covered by other impervious or semipervious surfaces, or excavations would be backfilled and revegetated and would not be subject to long-term soil erosion.

Consumption of geologic resources, including rock, mineral, and soil resources, to support facility construction, operations, and deactivation, as applicable, would constitute the major indirect impact on geologic and soil resources from implementation of Tank Closure alternatives, as summarized in Table 4–7. Varying quantities of geologic resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; and, most substantially, tank farm closure. Geologic resources, including relatively large volumes of gravel, sand, and silt, are available from the suprabasalt sediments and associated soils at Hanford. Rock, in the form of basalt, is also plentiful. As discussed in the *Environmental Assessment, Use of Existing Borrow Areas, Hanford Site, Richland, Washington* (DOE 2001a), a number of active gravel and sand pits and two rock quarries at Hanford have been identified for use in providing a continual supply of borrow materials for new facility construction, maintenance of existing facilities, and fill and capping material for remediation and other sites. Of the two active quarries on the site, quarry No. 2 (referred to as "Borrow Area C" in this EIS), located due south of the 200-West Area just south of State Route 240, has large volumes of basalt and sand (DOE 2001a:1-1, 3-1–3-4). This approximately 930-hectare (2,300-acre) borrow area has been designated for use in providing necessary materials including rock riprap (basalt), aggregate (gravel and sand), and soil (silt and loam) to support tank farm closure and supporting activities as described in this EIS (DOE 2003a:5-3, 6-15, 6-21, 6-46, 6-73).

In addition, gravel pit No. 30, which is located between the 200-East and 200-West Areas, has been and would continue to be used to provide aggregate (gravel and sand) for operation of onsite concrete batch plants to support new facility construction, including those at the WTP adjacent to the 200-East Area. Cement (a product of limestone and other minerals) to feed the batch plants would continue to be procured via offsite sources. Additional borrow materials would also be required for site grading, backfilling excavations, and other uses and could be obtained from either Borrow Area C or gravel pit No. 30.

Geologic resources would also be required for the production of grout. Grout, principally composed of cement, fly ash, sand, and sodium bentonite clay mixed with water, would be used to varying degrees under all Tank Closure alternatives; uses include filling and stabilizing tanks and associated ancillary equipment within each tank farm and filling ancillary equipment outside the landfill closure barrier lobes that would be constructed under all alternatives except Alternative 2A. Boxes into which removed ancillary equipment would be placed for disposal would also be filled with grout. Cement, fly ash, and sodium bentonite would be obtained off site from local, commercial sources. Sand for the grout mixture would be obtained from Borrow Area C (DOE 2003a:6-1–6-55).

Table 4–7. Summary of Major Geologic and Soil Resource Impact Indicators and Requirements

Parameter/ Resource	Tank Closure Alternatives										
	1	**2A**	**2B**	**3A**	**3B**	**3C**	**4**	**5**	**6A Base Case, *Option Case***	**6B Base Case, *Option Case***	**6C**
New, permanent land disturbance[a]	2	59.8	111	118	112	112	120	138	704 *781*	356 *433*	165
Construction materials											
Concrete	33,400	612,000	403,000	388,000	387,000	396,000	495,000	368,000	10,400,000 *10,500,000*	1,390,000 *1,510,000*	780,000
Cement[b]	8,270	146,000	96,700	93,900	93,500	95,400	120,000	87,800	2,550,000 *2,580,000*	340,000 *369,000*	190,000
Sand[b]	16,200	297,000	196,000	188,000	188,000	192,000	240,000	178,000	5,070,000 *5,130,000*	675,000 *732,000*	378,000
Gravel[b]	21,100	388,000	255,000	246,000	245,000	251,000	313,000	233,000	6,620,000 *6,690,000*	880,000 *954,000*	494,000
Other borrow materials[c]											
Rock/basalt	0	9,630	12,800	12,800	12,800	12,800	12,800	9,630	671,000 *671,000*	12,800 *12,800*	12,800
Sand	187	1,250	3,750	3,750	3,750	3,750	3,750	3,750	1,250 *1,250*	1,250 *1,250*	3,750
Gravel	246	5,630	8,470	8,470	8,470	8,470	11,400	8,470	11,000 *11,000*	8,910 *8,910*	8,470
Soil (specification backfill)	55,100	550,000	782,000	748,000	748,000	748,000	1,960,000	221,000	9,320,000 *13,100,000*	8,550,000 *12,300,000*	782,000
Operations materials											
Cement	0	0	0	0	27,700[d]	0	17,700[d]	17,700[d]	0	0	0
Sand	0	0	0	148,000[e]	0	0	50,200[e]	50,200[e]	0	0	0
Soil	0	0	0	187,000[e]	0	0	63,100[e]	63,100[e]	0	0	0
Kaolin clay/iron oxide	0	0	0	0	0	210,000[f]	0	0	0	0	0
Closure-specific materials											
Grout[g]	0	100	796,000	796,000	796,000	796,000	721,000	791,000	237,000 *788,000*	237,000 *788,000*	796,000
Cement	0	10.0	13,200	13,000	13,200	13,200	20,500	12,600	28,000 *93,000*	28,000 *93,000*	13,200
Sand[h]	0	50.1	774,000	774,000	774,000	774,000	661,000	772,000	116,000 *384,000*	116,000 *384,000*	774,000

Table 4–7. Summary of Major Geologic and Soil Resource Impact Indicators and Requirements (*continued*)

Parameter/ Resource	Tank Closure Alternatives										
	1	2A	2B	3A	3B	3C	4	5	6A Base Case, ***Option Case***	6B Base Case, ***Option Case***	6C
Barrier materials	0	0	2,300,000[i]	2,300,000[i]	2,300,000[i]	2,300,000[i]	1,280,000[i]	3,830,000[j]	689,000[k] *0*	689,000[k] *0*	2,300,000[i]
Total[l]	92,800	1,250,000	4,330,000	4,610,000	4,280,000	4,290,000	4,660,000	5,380,000	22,500,000 *26,000,000*	10,900,000 *14,400,000*	4,750,000

[a] Reflects land area assumed to be permanently disturbed for new facilities. The value also includes land area excavated in Borrow Area C or elsewhere to supply geologic materials listed in the table.
[b] Component of concrete.
[c] Resources for miscellaneous uses not exclusively tied to facility construction, operations, or closure, such as site grading and backfill for excavations.
[d] Resources to support Cast Stone Facility operations in addition to fly ash and blast furnace slag additives that would not be procured from onsite deposits.
[e] Resources to support Bulk Vitrification Facility operations.
[f] Resources to support Steam Reforming Facility operations in addition to other materials; reported in total metric tons.
[g] Grout comprises cement, sand, fly ash, and other materials.
[h] Principal component of grout that would be obtained from onsite deposits.
[i] Volume includes soil, sand, gravel, rock, and asphalt for construction of modified Resource Conservation and Recovery Act Subtitle C barriers for landfill closure of all tank farms and six sets of cribs and trenches (ditches), except under Alternative 4, in which the BX and SX tank farms are clean-closed rather than landfill-closed.
[j] Volume includes soil, sand, gravel, rock, and asphalt for construction of Hanford barriers for landfill closure of all tank farms and six sets of cribs and trenches (ditches).
[k] Volume includes soil, sand, gravel, rock, and asphalt for construction of modified Resource Conservation and Recovery Act Subtitle C barriers for landfill closure of the six sets of cribs and trenches (ditches) in the B and T Areas.
[l] Excludes concrete, cement, grout, and kaolin clay/iron oxide. Totals may not equal the sum of the contributions due to rounding.

Note: All values are expressed in cubic meters except land disturbance, which is in hectares. Values presented in the table have been rounded to no more than three significant digits, where appropriate. To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471.

Source: SAIC 2007a.

Materials would also be required for construction of barriers for landfill closure of the Hanford tank farms. These engineered barriers would be composed of layers of topsoil in the upper part, underlain by layers of sand, gravel, asphalt, and/or riprap in the lower part. The structures would be constructed in lobes that would range from the approximately 2.7-meter-thick (9-foot-thick) modified RCRA Subtitle C barriers that would be constructed under Alternatives 2B, 3A–3C, 4, and 6C to the more robust, 4.6-meter-thick (15-foot-thick) Hanford barrier that would be constructed under Alternative 5. Under Alternatives 6A and 6B, Base Cases, a modified RCRA Subtitle C barrier of very limited extent would be constructed for landfill closure of just the six sets of cribs and trenches (ditches) in the B and T Areas. These structures are further described in Chapter 2, Section 2.3.4.1. For postclosure care of the landfills, sodium bentonite clay or grout would be required for completion of groundwater monitoring wells (DOE 2003a:6-86, 6-87).

Development of Borrow Area C, using modern open-pit excavation techniques (with excavations averaging 4.6 meters [15 feet] deep) and allocating 20 percent of the total site for cut-slope maintenance, haul roads, stockpile and buffer areas, could yield a conservative estimate of 34.3 million cubic meters (44.9 million cubic yards) of borrow material to address geologic resource requirements discussed above. In addition, gravel pit No. 30, located between the 200-East and 200-West Areas, is an approximately 54-hectare (134-acre) borrow site containing a large quantity of aggregate suitable for multiple uses (DOE 2001a:3-4, A-3). Aggregate reserves at gravel pit No. 30 are estimated at 15.3 million cubic meters (20 million cubic yards) of material (DOE 1999:D-4), for a total of 49.6 million cubic meters (55 million cubic yards) of borrow materials available on site. To access Borrow Area C, a 2.0-kilometer-long (1.25-mile-long) paved haul road was completed in 2006 from State Route 240 and the intersection of Beloit Avenue south to Borrow Area C to enable the transport of excavated borrow materials to points of use across Hanford. It has been assumed for the purposes of analysis that gravel pit No. 30 and Borrow Area C would be available and would be operated for as long as necessary to support the active project phase associated with each Tank Closure alternative.

Facilities constructed to support tank waste retrieval, treatment, and disposal would be deactivated as they are no longer needed. This activity is not expected to directly impact geology and soils, as facilities would not be demolished or destroyed, and no additional land disturbance should be required. Waste materials and contaminated media would be removed from deactivated facilities and properly disposed of, and, therefore, would not be disposed of in an unabated manner where they could contaminate geologic materials or underlying groundwater.

The following sections present projected impacts on geologic and soil resources specific to implementation of each of the Tank Closure alternatives, as well as the effects of geologic conditions on proposed project activities.

4.1.5.1 Alternative 1: No Action

WTP construction and ongoing tank farm facility upgrades and associated construction activities would continue through 2008 under Alternative 1, at which time WTP construction would be terminated. As the WTP site is already disturbed, construction activities through 2008 would have a negligible incremental impact on geologic strata and soils. However, an area of 17 hectares (42 acres), consisting of the 18 tank farms, would be indefinitely committed to waste management use (see Section 4.1.1.1.1). Ongoing tank system upgrades would be confined to developed areas. In addition to cement, sand, and gravel used principally for concrete production, construction activities through 2008 would require additional geologic resources, including borrow materials for site grading, backfilling, and other uses, as shown in Table 4–7.

Total geologic resource requirements under Alternative 1 are projected to be 92,800 cubic meters (121,000 cubic yards), with little or no geologic resources expected to be required during the

100-year administrative control period. Excavation of about 2 hectares (5 acres) of Borrow Area C would be required to supply this volume of geologic material. However, it is expected that this volume would continue to be supplied by gravel pit No. 30, which has sufficient reserves to supply this relatively small demand volume without use of Borrow Area C, as further described in Section 4.1.5.

Hazards from large-scale geologic conditions at Hanford are summarized in Chapter 3, Section 3.2.5.1.4 and were previously analyzed in the *Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility* (DOE 2000). Review of the previous analyses, as well as data presented in this EIS, indicates that ground shaking of Modified Mercalli Intensity (MMI) V to VII associated with postulated earthquakes (see Appendix F, Table F–7) would have the potential to affect the integrity of inadequately designed or nonreinforced structures and cause moderate damage in some other structures. Analysis of a beyond-design-basis accident triggered by an earthquake-induced tank dome collapse has been considered, with the result incorporated by reference in Section 4.1.11.1.

4.1.5.2 Alternative 2A: Existing WTP Vitrification; No Closure

Construction of new facilities to support tank waste retrieval, treatment, and disposal under Alternative 2A would permanently disturb about 32.3 hectares (79.9 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities (see Section 4.1.1.2.1 and Table 4–1). An additional 27.5 hectares (68 acres) would also be excavated in Borrow Area C, for a total of 59.8 hectares (148 acres) of new, permanent land disturbance. An additional 17 hectares (42 acres) of land, consisting of the 18 tanks farms and adjacent areas, would remain in waste management use. Other direct impacts on geology and soils under Alternative 2A, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5; excavation depths are not expected to exceed about 12 meters (40 feet) and would generally be less than 3 meters (10 feet).

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources. The surficial soils, unconsolidated strata, and underlying basaltic bedrock of the 200 Areas are present elsewhere in the region and at Hanford. However, relatively large quantities of geologic resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; and waste retrieval activities over the active phase of this alternative. In addition to cement, sand, and gravel used principally for concrete production, additional geologic resources in the form of borrow materials would be required for site grading, backfilling, and other uses, as shown in Table 4–7 and further described in Section 4.1.5. Total geologic resource requirements under Alternative 2A are projected to be 1,250,000 cubic meters (1,640,000 cubic yards). This volume is not expected to deplete locally available deposits or material stockpiles because reserves of aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5.

Hazards from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions with the potential to affect new facilities in the 200 Areas are summarized in Chapter 3, Section 3.2.5.1.4. Maximum considered earthquake ground motions for Hanford encompass those that may cause substantial structural damage to buildings (equivalent to an MMI of VII and up), thus presenting safety concerns for occupants. Ground shaking of MMI VII associated with postulated earthquakes is possible and supported by the historical record for the region. However, this level of ground motion is expected to primarily affect the integrity of inadequately designed or nonreinforced structures (see Appendix F, Table F–7). All facilities would be designed, constructed, and operated in compliance with applicable DOE orders, requirements, and governing standards established to protect public and worker health and the environment. DOE Order 420.1B requires that nuclear and nonnuclear facilities be designed,

constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. As further described in Appendix F, Section F.5.2, the order stipulates natural phenomena hazards mitigation for DOE facilities and specifically provides for reevaluation and upgrade of existing DOE facilities when there is a significant degradation in the safety basis for the facility. An analysis of potential effects of a beyond-design-basis earthquake on human health and the environment is provided in Section 4.1.11.2.

4.1.5.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Construction of new facilities to support tank waste retrieval, treatment, and disposal and landfill closure under Alternative 2B would permanently disturb about 16.2 hectares (40 acres) of land. Most of this activity would take place within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities with expanded LAW vitrification capacity (see Section 4.1.1.3.1 and Table 4–1). An additional 94.7 hectares (234 acres) would also be excavated in Borrow Area C, for a total of 111 hectares (274 acres) of new, permanent land disturbance.

The type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5 and Section 4.1.5.2 under Alternative 2A; excavation depths are not expected to exceed about 12 meters (40 feet) and would be less than 3 meters (10 feet) for most activities. However, the total scale of direct impacts associated with new facility construction would generally be greater than under Alternative 2A, due to the addition of the expanded LAW Vitrification Facility melter bays and activities associated with landfill closure of the SST system. Specifically, to support landfill closure of the tank farms under this alternative, a portable grout production facility would be required in both the 200-East and 200-West Areas to fill and stabilize tanks and ancillary equipment in each area (DOE 2003a:6-9). Domed containment structures would also be erected over both the BX and SX tank farms in the 200-East and 200-West Areas, respectively, to support removal of the upper 4.6 meters (15 feet) of contaminated soils.

The upper 4.6 meters (15 feet) of soils and encountered ancillary equipment within the BX and SX tank farms would then be excavated and removed for disposal as mixed low-level radioactive waste (MLLW) in the River Protection Project Disposal Facility (RPPDF). Waste generation and management activities under this alternative are further discussed in Section 4.1.14.3. The excavations would be backfilled with clean soil from Borrow Area C (DOE 2003a:6-90–6-95).

Construction of the modified RCRA Subtitle C barrier would then commence. To effect landfill closure of the SST system, the engineered barrier would be emplaced in five separate lobes to cover all 18 tank farms and the six sets of cribs and trenches (ditches) associated with the B and T tank farms. Surface clearing, grading, and grubbing work associated with emplacement of the engineered surface barrier lobes would likely encompass all other site construction activities from a soil erosion perspective, as relatively large areas of denuded soils would be exposed at one time. However, the depth of excavation would not exceed that necessary to achieve uniform topography upon which to emplace barrier layers. Also, landfill construction and barrier layer placement would occur in the later stages of the waste retrieval and treatment phases of this alternative after most other construction activities have been completed. Regardless, standard best management practices for soil erosion and sediment control would be employed, including watering to control fugitive dust over the estimated 7-year construction period (DOE 2003a:6-73–6-74).

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources. The surficial soils, unconsolidated strata, and underlying basaltic bedrock of the 200 Areas are present elsewhere in the region and at Hanford. However, relatively large quantities of geologic resources would be required under this alternative to support ongoing facility

construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; and, most substantially, tank farm landfill closure, as shown in Table 4–7 and further described in Section 4.1.5.

Total geologic resource requirements under Alternative 2B are projected to be 4,330,000 cubic meters (5,660,000 cubic yards). This volume is not expected to deplete locally available deposits or material stockpiles because reserves of aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Construction of new facilities to support tank waste retrieval, treatment and disposal, and landfill closure under Alternative 3A would permanently disturb about 17.4 hectares (43 acres) of land. Most of this activity would occur within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities. Also, a Bulk Vitrification Facility and facilities for mixed transuranic (TRU) waste supplemental treatment would be constructed under this alternative in or adjacent to the 200-East and 200-West Areas (see Section 4.1.1.4.1 and Table 4–1). An additional 101 hectares (249 acres) would also be excavated in Borrow Area C, for a total of 118 hectares (292 acres) of new, permanent land disturbance. Nevertheless, the type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5 and Section 4.1.5.3 under Alternative 2B; excavation depths are not expected to exceed about 12 meters (40 feet) and would be less than 3 meters (10 feet) for most activities. Further, activity-specific impacts under this alternative related to landfill closure of the SST system would be the same as those described in Section 4.1.5.3 under Alternative 2B. However, the total scale of direct impacts under this alternative would be greater than under Alternative 2B due to the construction of supplemental treatment facilities combined with landfill closure of the SST system.

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources for the reasons previously described in Section 4.1.5.3. In addition to relatively large quantities of a number of geologic resources required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; and, most substantially, tank farm closure (see Table 4–7), soil and/or sand would also be used in the bulk vitrification process to form glass and to stabilize bulk vitrification waste form roll-off boxes prior to disposal (DOE 2003b:6-70, 6-74). Due to the larger demands for construction-related uses and materials for bulk vitrification operations, total geologic resource requirements under Alternative 3A are projected to be 4,610,000 cubic meters (6,030,000 cubic yards). This volume is not expected to deplete locally available deposits or material stockpiles because reserves of aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Construction of new facilities to support tank waste retrieval, treatment, and disposal and landfill closure under Alternative 3B would permanently disturb 18.3 hectares (45.2 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities. Also, a Cast Stone Facility and facilities for mixed TRU waste supplemental treatment would be constructed in or adjacent to the 200-East and 200-West Areas Section 4.1.1.5.1 and Table 4–1). An additional 93.5 hectares (231 acres) would also be excavated in Borrow Area C, for a total of 112 hectares (276 acres) of new, permanent land disturbance.

The type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5 and Section 4.1.5.4 under Alternative 3A; excavation depths are not expected to exceed about 12 meters (40 feet) and would be less than 3 meters (10 feet) for most activities. Further, activity-specific impacts under this alternative related to landfill closure of the SST system would be similar to those generally described in Section 4.1.5 and Section 4.1.5.3 under Alternative 2B. Overall, the total scale of direct impacts under this alternative would be very similar to those under Alternative 3A.

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources for the reasons previously described in Section 4.1.5.3. As under Alternative 3A, relatively large quantities of a number of geologic resources or products made from rock and mineral resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; and, most substantially, tank farm closure (see Table 4–7). For this alternative, use of the cast stone supplemental treatment technology would reduce the demand for clean soil and sand as compared with Alternative 3A, as the cast stone process would immobilize tank waste utilizing fly ash and blast furnace slag (both industrial waste products) derived from local offsite and regional sources and Portland cement (produced from limestone and other minerals) (DOE 2003b:6-94, 6-95, 6-111–6-113). Due to smaller demands for supplemental treatment operations associated with cast stone as compared with bulk vitrification, total geologic resource requirements under Alternative 3B are projected to be 4,280,000 cubic meters (5,600,000 cubic yards). This volume is not expected to deplete locally available deposits or material stockpiles because reserves of aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5.

Design consideration of hazards with potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Construction of new facilities to support tank waste retrieval, treatment, and disposal and landfill closure under Alternative 3C would permanently disturb about 18.2 hectares (45 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities. Also, a Steam Reforming Facility and facilities for mixed TRU waste supplemental treatment would be constructed in or adjacent to both the 200-East and 200-West Areas (see Section 4.1.1.6.1 and Table 4–1). An additional 93.9 hectares (232 acres) would also be excavated in Borrow Area C, for a total of 112 hectares (277 acres) of new, permanent land disturbance. The type and intensity of anticipated direct impacts on geology and soils, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5 and Section 4.1.5.4 under Alternative 3A; excavation depths are not expected to exceed

about 12 meters (40 feet) and would be less than 3 meters (10 feet) for most activities. Further, activity-specific impacts under this alternative related to landfill closure of the SST system would be the same as those described in Section 4.1.5.3 under Alternative 2B. Overall, the total scale of direct impacts under this alternative would be very similar to those under Alternative 3A.

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources for the reasons previously described in Section 4.1.5.2. As under Alternatives 3A and 3B, relatively large quantities of a number of geologic resources or products made from rock and mineral resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; and, most substantially, tank farm closure (see Table 4–7). Under this alternative, geologic resources utilized in the steam reforming supplemental treatment process would be limited to iron oxide and kaolin clay, which would be obtained from offsite regional sources (DOE 2003b:6-37, 6-38, 6-45, 6-61).

Similar to Alternative 3B, total geologic resource requirements under Alternative 3C are projected to be 4,290,000 cubic meters (5,610,000 cubic yards). This volume is not expected to deplete locally available deposits or material stockpiles because reserves of aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Construction of new facilities to support tank waste retrieval, treatment, and disposal and tank farm closure under Alternative 4 would permanently disturb about 17.8 hectares (44.1 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities. Also, a Cast Stone Facility would be constructed adjacent to the 200-East Area, while a Bulk Vitrification Facility would be constructed in the 200-West Area. Facilities for mixed TRU waste supplemental treatment would also be constructed, as well as a PPF for treatment of highly contaminated rubble, soil, and equipment from selective clean closure of the BX and SX tank farms (see Section 4.1.1.7.1 and Table 4–1). An additional 102 hectares (252 acres) would also be excavated in Borrow Area C, for a total of 120 hectares (296 acres) of new, permanent land disturbance.

The type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5 and Sections 4.1.5.4 through 4.1.5.6 under Alternatives 3A through 3C. However, while activity-specific impacts related to landfill closure of the SST system would be similar to those described in Section 4.1.5.3 under Alternative 2B, selective clean closure of the BX and SX tank farms would involve deep excavation work that would entail additional direct and indirect impacts under this alternative.

As under Alternatives 2B, 3A, 3B, and 3C, a portable grout production facility would be required in both the 200-East and 200-West Areas to fill and stabilize tanks and ancillary equipment in each area (DOE 2003a:6-9). Domed containment structures would also be temporarily erected over both the BX and SX tank farms in the 200-East and 200-West Areas, respectively, to support clean closure, encompassing excavation and removal of contaminated soils, tanks, and associated ancillary equipment within these areas.

In support of clean closure of the BX and SX tank farms, excavation to a depth of about 20 meters (65 feet) below land surface or 3 meters (10 feet) below the base elevations of the waste tanks would be required at a minimum. This excavation depth is expected to be sufficient to remove soils and sediments contaminated by retrieval-related leaks, as well as contamination from historic waste releases that have accumulated horizontally on compacted strata beneath the waste tanks. For some tank sites, excavation to depths of up to 78 meters (255 feet) below land surface may be required to remediate contaminant plumes from past-practice discharges that have migrated through the vadose zone soils and sediments and possibly to the water table.

To accomplish excavation of the magnitude required for clean closure, work would proceed by first filling each tank with a 0.3-meter (1-foot) layer of grout to stabilize the residual waste and reduce worker exposure. Jet-grouted pile (retaining) walls that extend down the length of each tank elevation to a depth of about 38 meters (125 feet) would then be installed. This would be followed by erection of the containment structure. Closure operations would then proceed by excavating and removing soils and ancillary equipment, including demolition and removal of the tank structures, tank slabs, and footings. Excavated soils would be characterized and transported either directly to the RPPDF or to the PPF for treatment prior to final disposal as MLLW. Ancillary equipment and tank debris would also be sent to the PPF for treatment prior to onsite disposal. Final closure of the BX and SX tank farms would involve filling the open excavations with clean soil derived from Borrow Area C (DOE 2003c:3–8, 13, 17). Waste generation and management activities under this alternative are further discussed in Section 4.1.14.7.

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources for the main reasons previously described in Section 4.1.5.2. As under Alternatives 3A through 3C, relatively large quantities of a number of geologic resources or products made from rock and mineral resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; supplemental treatment operations; and, most substantially, tank farm closure (see Table 4–7). Under this alternative, the additional demand for borrow material for backfill of excavations in the BX and SX tank farms would be partly compensated by the fact that construction of the landfill closure barrier would require less resources as compared with Alternatives 2B through 3C. Total geologic resource requirements under Alternative 4 are projected to be 4,660,000 cubic meters (6,100,000 cubic yards). This volume is not expected to deplete locally available deposits or material stockpiles because reserves of aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Construction of new facilities to support tank waste retrieval, treatment, and disposal and landfill closure under Alternative 5 would permanently disturb about 20.2 hectares (49.9 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities. Also, a Cast Stone Facility would be constructed adjacent to the 200-East Area, while a Bulk Vitrification Facility would be constructed in the 200-West Area. Facilities for mixed TRU waste supplemental treatment would also be constructed. To support accelerated treatment under this alternative, new DSTs and a Sulfate Removal Facility would be built (see Section 4.1.1.8.1 and Table 4–1). An additional 118 hectares (291 acres) would also be excavated in Borrow Area C, for a total of 138 hectares (341 acres) of new, permanent land disturbance.

The type and intensity of anticipated direct impacts on geology and soils, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5 and Section 4.1.5.4 under Alternative 3A; excavation depths are not expected to exceed about 12 meters (40 feet) and would be less than 3 meters (10 feet) for most activities. Further, activity-specific impacts under this alternative related to landfill closure of the SST system would be somewhat greater than those described in Section 4.1.5.3 under Alternative 2B. Specifically, instead of construction of a modified RCRA Subtitle C barrier as under Alternatives 2B through 3C, a more robust Hanford barrier with a 4.6-meter (15-foot) thickness would be constructed under Alternative 5 for landfill closure of the tank farms. As under the other landfill closure alternatives, a portable grout production facility would be required in both the 200-East and 200-West Areas to fill and stabilize tanks and ancillary equipment in each area (DOE 2003a:6-9). In contrast, there would be no contaminated soil removal at any tank farm under this alternative, and ancillary equipment outside the barrier lobes would be neither removed nor grouted.

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources for the main reasons previously described in Section 4.1.5.2 As under Alternatives 3A through 3C, relatively large quantities of a number of geologic resources or products made from rock and mineral resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; supplemental treatment operations; and, most substantially, tank farm closure (see Table 4–7). Under this alternative, while there would be no additional demand for borrow material for backfill of tank farm excavations, construction of the thicker Hanford barrier across all tank farms would drive an overall greater demand for geologic resources as compared with the previous alternatives. Total geologic resource requirements under Alternative 5 are projected to be 5,380,000 cubic meters (7,040,000 cubic yards). This volume is not expected to deplete locally available deposits or material stockpiles because reserves of aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5.

4.1.5.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.5.9.1 Base Case

Construction of new facilities to support tank waste retrieval, treatment, disposal; and clean closure of the SST system; and landfill closure of six sets of cribs and trenches (ditches) under Alternative 6A, Base Case would permanently disturb about 210 hectares (519 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities with expanded HLW vitrification and associated IHLW canister storage capacity. Also, due to the longer timeframe required to process all tank waste under this alternative, a number of facilities would have to be replaced over time, including the WTP.

For clean closure activities, domed containment structures would also be temporarily erected over each tank farm in the 200-East and 200-West Areas to facilitate excavation and removal of contaminated soils, tanks, and associated ancillary equipment within these areas. Finally, a PPF for treatment of highly contaminated deep soils generated during clean closure activities would also be constructed to the west of the 200-East Area (see Section 4.1.1.9.1.1 and Table 4–1). An additional 494 hectares (1,220 acres) would also be excavated in Borrow Area C, for a total of 704 hectares (1,740 acres) of new, permanent land disturbance.

The type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would be similar to those generally described in Section 4.1.5. Still, the potential for soil erosion would increase from site activities under all Tank Closure alternatives, but the potential would be somewhat greater under this alternative due to the much

greater land area disturbed. Also, while excavation depths for new facility construction would generally not be expected to exceed about 12 meters (40 feet) for the WTP HLW melter bays, clean closure of the SST system farm would involve deep excavation work at all tank farm locations. To be specific, deep soil removal, including excavation to a depth of about 20 meters (65 feet) below land surface or 3 meters (10 feet) below the base elevations of the waste tanks would be required at a minimum. This excavation depth is expected to be sufficient to remove soils and sediments contaminated by retrieval-related leaks, as well as contamination from historic waste releases that have accumulated horizontally on compacted strata beneath the waste tanks. For some tank sites, excavation to depths of up to 78 meters (255 feet) below land surface may be required to remediate contaminant plumes from past-practice discharges that have migrated through the vadose zone soils and sediments and possibly to the water table.

To accomplish excavation of the magnitude required for clean closure, work would proceed by first filling each tank with a 0.3-meter (1-foot) layer of grout to stabilize the residual waste and reduce worker exposure. Jet-grouted pile (retaining) walls that extend down the length of each tank elevation to a depth of about 38 meters (125 feet) would then be installed. This installation would be followed by erection of the containment structure. Closure operations would then proceed by excavating and removing soils and ancillary equipment, including demolition and removal of the tank structures, tank slabs, and footings. Excavated soils, with the exception of tank bottom soils managed as HLW, would be characterized and transported either directly to the RPPDF or to the PPF for treatment prior to final disposal as MLLW. Highly and moderately contaminated ancillary equipment and tank debris and intermixed soil would be packaged in shielded boxes and transported to onsite HLW Debris Storage Facilities. Final closure of the tank farms would involve filling the open excavations with clean soil derived from Borrow Area C (DOE 2003c:3-8, 13, 17). Waste generation and management activities under this alternative are further discussed in Section 4.1.14.9.1.

As an additional closure action under this alternative, a modified RCRA Subtitle C barrier of very limited extent would be constructed for landfill closure of the six sets of cribs and trenches (ditches) in the B and T Areas that are located outside the areas that would be clean-closed (see Section 4.1.5).

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources for the main reasons previously described in Section 4.1.5. However, large quantities of a number of geologic resources or products made from rock and mineral resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; and, most substantially, tank farm clean closure (see Table 4–7). In addition to geologic resources to support facility construction, large volumes of borrow materials would be required for site grading, backfilling (particularly for tank excavations), and other uses. Total geologic resource requirements under Alternative 6A, Base Case, are projected to be 22,500,000 cubic meters (29,400,000 cubic yards). While this volume could deplete immediately available stockpiles, it is not expected to deplete onsite reserves because aggregate and other borrow materials available onsite from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5. Similar materials are also widely available in the region, and offsite commercial quarries could supplement onsite sources if needed.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.9.2 Option Case

Construction of new facilities to support tank waste retrieval, treatment, and disposal and clean closure of the SST system and the six sets of cribs and trenches (ditches) under Alternative 6A, Option Case, would permanently disturb about 210 hectares (519 acres) of land. Construction requirements and associated

impacts on geology and soils would be very similar to those described in Section 4.1.5.9.1 under Alternative 6A, Base Case, although a larger PPF would be constructed under this case. Further, a larger volume of material and associated land area totaling 571 hectares (1,410 acres) would be excavated in Borrow Area C to support remediation activities, for a total of 781 hectares (1,930 acres) of new, permanent land disturbance. The type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5. Tank farm closure activities would essentially be the same as described in Section 4.1.5.9.1 under Alternative 6A, Base Case, with one major exception. Under Alternative 6A, Option Case, the six sets of cribs and trenches (ditches) in the B and T Areas would be clean-closed along with all SSTs, instead of landfill-closed as under the Base Case. This would require additional excavation work and soil removal in areas adjacent to the B and T tank farms.

Total geologic resource requirements under Alternative 6A, Option Case, are projected to be 26 million cubic meters (34 million cubic yards). While this demand volume could deplete immediately available stockpiles during the course of project implementation, it is not expected to deplete onsite reserves because aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5. Similar materials are also widely available in the region, and offsite commercial quarries could supplement onsite sources if needed.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.5.10.1 Base Case

Construction of new facilities to support tank waste retrieval, treatment, and disposal; clean closure of the SST system; and landfill closure of the six sets of cribs and trenches (ditches) under Alternative 6B, Base Case, would permanently disturb about 117 hectares (288 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities with expanded LAW vitrification capacity.

To support clean closure activities, domed containment structures would also be temporarily erected over each tank farm in the 200-East and 200-West Areas to facilitate excavation and removal of contaminated soils, tanks, and associated ancillary equipment within these areas. Finally, a PPF for treatment of highly contaminated deep soils generated during clean closure activities would also be constructed to the west of the 200-East Area (see Section 4.1.1.10.1.1 and Table 4–1). An additional 239 hectares (591 acres) would also be excavated in Borrow Area C, for a total of 356 hectares (879 acres) of new, permanent land disturbance.

Construction requirements and associated impacts on geology and soils would be somewhat greater than those described in Section 4.1.5.3 under Alternative 2B as additional ILAW Interim Storage Facilities would be required under this alternative. The type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5; excavation depths are not expected to exceed about 12 meters (40 feet) and would be less than 3 meters (10 feet) for most activities. Additionally, activity-specific impacts under this alternative related to clean closure of the SST system and landfill closure of the six sets of cribs and trenches (ditches) in the B and T Areas would essentially be the same as those described in Section 4.1.5.9.1 under Alternative 6A, Base Case. Overall, even with clean closure as a component of this alternative, the total scale of direct impacts under this alternative

would be much less than under Alternative 6A due to the smaller scale of new facility construction required, which is comparable to but still greater than that under Alternative 2B.

Construction activities and subsequent operations would not preclude the use of rare or otherwise valuable geologic or soil resources for the main reasons previously described in Section 4.1.5. However, large quantities of a number of geologic resources or products made from rock and mineral resources would be required for ongoing facility construction; upgrades to existing facilities, including the 200 Area tank farms; waste retrieval activities; and, most substantially, tank farm clean closure (see Table 4–7). As under Alternative 6A, large volumes of borrow materials would be required for site grading, backfilling (particularly for tank excavations), and other uses in addition to geologic resources to support facility construction. Total geologic resource requirements under Alternative 6B, Base Case, are projected to be 10,900,000 cubic meters (14,300,000 cubic yards). While this demand volume could deplete immediately available stockpiles during the course of project implementation, it is not expected to deplete onsite reserves because aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5. Similar materials are also widely available in the region, and offsite commercial quarries could supplement onsite sources if needed.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.10.2 Option Case

Construction of new facilities to support tank waste retrieval, treatment, and disposal and clean closure of the SST system and the six sets of cribs and trenches (ditches) under Alternative 6B, Option Case, would permanently disturb about 117 hectares (288 acres) of land. Construction requirements and associated impacts on geology and soils would be very similar to those described in Section 4.1.5.10.1 under Alternative 6B, Base Case; however, a larger PPF would also be constructed as compared to the Base Case. An additional 316 hectares (780 acres) would also be excavated in Borrow Area C, for a total of 433 hectares (1,070 acres) of new, permanent land disturbance. The type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5. Tank farm closure activities would essentially be the same as described in Section 4.1.5.9.1 under Alternative 6A, Base Case, with one major exception. Under Alternative 6B, Option Case, the six sets of cribs and trenches (ditches) in the B and T Areas would be clean-closed along with all SSTs, instead of landfill-closed as under the Base Case. This would require additional excavation work and soil removal and replacement in areas adjacent to the B and T tank farms.

Total geologic resource requirements under Alternative 6B, Option Case, are projected to be 14,400,000 cubic meters (18,800,000 cubic yards). While this demand volume could deplete immediately available stockpiles during the course of project implementation, it is not expected to deplete onsite reserves because aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5. Similar materials are also widely available in the region, and offsite commercial quarries could supplement onsite sources if needed.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.5.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

Construction of new facilities to support tank waste retrieval, treatment, and disposal and landfill closure of the SST system and the six sets of cribs and trenches (ditches) under Alternative 6C would permanently disturb about 61.1 hectares (151 acres) of land. Most of this activity would be located within or adjacent to the 200-East or 200-West Area and would include completion of WTP construction activities with expanded HLW vitrification capacity (see Section 4.1.1.11.1 and Table 4–1).

Construction requirements and associated impacts on geology and soils would be somewhat greater than those described in Section 4.1.5.3 under Alternative 2B as additional ILAW Interim Storage Facilities would be required under this alternative. Additionally, impacts and activities associated with removal of the upper 4.6 meters (15 feet) of contaminated soil in the BX and SX tank farms and subsequent emplacement of a modified RCRA Subtitle C barrier for landfill closure of all 18 tank farms and the six sets of cribs and trenches (ditches) associated with the B and T tank farms would be the same as described in Section 4.1.5.3. Further, an additional 104 hectares (257 acres) would also be excavated in Borrow Area C, for a total of 165 hectares (408 acres) of new, permanent land disturbance. Otherwise, the type and intensity of anticipated direct impacts on geology and soils under this alternative, including factors that could lead to increased wind and water erosion, would generally be similar to those described in Section 4.1.5.

Total geologic resource requirements under Alternative 6C are projected to be 4,750,000 cubic meters (6,200,000 cubic yards). While this demand volume could deplete immediately available stockpiles during the course of project implementation, it is not expected to deplete onsite reserves because aggregate and other borrow materials available on site from gravel pit No. 30 and Borrow Area C are estimated to total 49.6 million cubic meters (55 million cubic yards), as further described in Section 4.1.5. Similar materials are also widely available in the region, and offsite commercial quarries could supplement onsite sources if needed.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.1.5.2 under Alternative 2A.

4.1.6 Water Resources

This subsection presents the potential direct, short-term impacts of implementing the Tank Closure alternatives on water resources encompassing surface water, the vadose zone, and groundwater. Potential short-term impacts of facility construction, operations, deactivation, and closure activities are analyzed over the active project phase for each alternative, extending through the 100-year administrative control, institutional control, or postclosure care period, as applicable, for each alternative. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.

Under the Tank Closure alternatives, direct impacts on surface water, the vadose zone, and groundwater would be similar in nature; any variability would be related to the intensity and duration of the activities conducted under each alternative. Generally, facility construction activities are not expected to have any direct impact on surface-water features, including the Columbia River, as there are no natural, perennial surface-water drainages on the Central Plateau of Hanford. While several manmade ponds and impoundments are located in the 200 Areas, including the two Treated Effluent Disposal Facility (TEDF) disposal ponds and the three Liquid Effluent Retention Facility (LERF) impoundments adjacent to the 200-East Area, these ponds and impoundments would not be directly impacted by construction activities. Also, no portion of the 200 Areas lies within a floodplain. Although the southwest corner of the 200-West Area is within the probable maximum flood zone of Cold Creek, no facilities would be constructed there under any Tank Closure alternative.

While portions of the probable maximum flood zone associated with Cold Creek lie within the confines of Borrow Area C, production operations associated with material extraction to support tank closure and waste management activities would be conducted to avoid impacting the watercourse and associated floodplain. Any changes in the extent and nature of predicted mining that could impact the floodplain would be evaluated, and a floodplain assessment would be prepared as required by Executive Order 11988, *Floodplain Management*, and Federal regulations (10 CFR 1022).

All construction- and closure-related land disturbances, especially for new facility construction, would expose soils and sediments to possible erosion by infrequent, heavy rainfall or by wind. While unlikely to reach surface-water features as discussed above, stormwater runoff from exposed areas could convey soil, sediments, and other pollutants (e.g., construction waste materials and spilled materials, such as petroleum, oils, and lubricants from construction equipment) from construction footprint and laydown areas. Nevertheless, appropriate soil erosion and sediment control measures and spill prevention and waste management practices would be employed to minimize suspended sediment, the transport of other deleterious materials, and potential water-quality impacts. Further, all construction and other ground-disturbing activities would be conducted in accordance with current National Pollutant Discharge Elimination System (NPDES) and state waste discharge general permits for stormwater discharges associated with construction activities, issued by the Washington State Department of Ecology (Ecology). The NPDES permit specifically requires the development and implementation of a stormwater pollution prevention plan.

Once completed, new facilities, including the WTP and other tank waste retrieval, treatment, and storage/disposal facilities, would incorporate appropriate stormwater management controls to collect, convey, and detain stormwater from buildings and other impervious surfaces so as to minimize the impacts of onsite hydrology and soil erosion. Hanford's NPDES Storm Water Multi-Sector General Permit would cover stormwater discharges associated with industrial activity and, as necessary, stormwater discharges would be covered under state waste discharge permits for discharges to the ground.

Under normal operations associated with waste retrieval, treatment, and disposal and tank closure, facility design combined with adherence to spill prevention and emergency response plans and procedures would help to ensure that involved hazardous substances, including spills, should they occur, do not reach soils or surfaces where they could be conveyed to surface water or groundwater. For construction, operations, deactivation, and closure activities, adherence to best management practices and other preventive measures under applicable permits and compliance plans would be coordinated by DOE with those measures in similar sitewide pollution prevention plans.

Direct, short-term impacts of tank closure activities, including tank waste retrieval, treatment, and disposal and SST system closure, to the vadose zone and underlying groundwater would mainly be limited to SST leaks that could be induced by waste retrieval activities under all alternatives, with the exception of Alternative 1, No Action.

Projected impacts on water resources specific to implementation of each of the Tank Closure alternatives are presented in the following sections.

4.1.6.1 Alternative 1: No Action

4.1.6.1.1 Surface Water

No additional direct impacts on surface water or groundwater availability or quality resources are expected in the short term under Alternative 1, as ongoing tank farm facility upgrades and associated construction activities would not result in any additional land disturbance in the 200 Areas. Sanitary and industrial wastewater generation in the 200 Areas is expected to decrease with the termination of WTP construction. It was assumed that existing facilities, or their equivalents, would continue to be available

to manage liquid waste generated under this alternative, with any necessary operational-life extensions or replacements completed as needed. Specifically, sanitary wastewater would continue to be managed via existing 200 Area collection and treatment facilities. Nonhazardous process wastewater would continue to be discharged to the TEDF in the 200-East Area, while any dilute, radioactive liquid effluents would continue to be managed in the 200 Area LERF prior to treatment in the ETF (DOE 2003d:6-10). The State-Approved Land Disposal Site (SALDS), located north of the 200-West Area, is the ultimate discharge point for liquid waste after passing through the LERF/ETF system. Waste management is further discussed in Section 4.1.14. Additional water use associated with the proposed facility upgrades and WTP construction would peak in 2008 and then fall to pre-WTP activity levels, as quantified in Section 4.1.2.1. In total, water use to support activities under this alternative has been conservatively estimated at 3,300 million liters (872 million gallons).

4.1.6.1.2 Vadose Zone and Groundwater

This alternative would result in impacts on groundwater quality over the long term only; no short-term impacts would occur because no tank waste retrieval would be performed. The SSTs, DSTs, and miscellaneous underground storage tanks (MUSTs) would fail over time, resulting in the release of their contents to the vadose zone and unconfined aquifer system. These releases would add to the range of 2.84–3.97 million liters (750,000–1,050,000 gallons) of waste estimated to have leaked to the vadose zone to date. Ultimately, these contaminants would be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.1.

4.1.6.2 Alternative 2A: Existing WTP Vitrification; No Closure

4.1.6.2.1 Surface Water

Facility construction activities and normal facility operation are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 2A for the same reasons as previously described in Section 4.1.6.

There would be no direct discharge of effluents to either surface water or groundwater during construction, operations, and deactivation under Alternative 2A. Nonhazardous sanitary wastewater (sewage) would be managed via appropriate sanitary wastewater collection and treatment systems. During the early phases of new facility construction, it has been assumed that portable toilet facilities would be provided for construction personnel, with collected waste disposed of at offsite contractor facilities, as is standard construction practice. During facility operations and deactivation, sanitary wastewater would be disposed of via the dedicated sanitary sewer or septic/drain field system serving a particular facility. A dedicated sanitary sewage collection, treatment, and drain field disposal system will serve the WTP complex. Industrial wastewater effluent may be generated as a result of some construction activities, including facility commissioning, but would mainly consist of process effluents from the WTP. Nonhazardous process wastewater would be discharged to the TEDF in the 200-East Area, while radioactive liquid effluents would be discharged to the 200 Area LERF prior to treatment in the ETF (DOE 2003b:6-10). It was assumed that these facilities, or their equivalents, would continue to be available to manage process liquids generated under this alternative, with any necessary operational-life extensions or replacements completed as needed. Due to the relatively long treatment timeframe associated with this alternative, it would be necessary to replace the ETF twice and the 242-A Evaporator once. Waste generation and management activities under this alternative are further discussed in Section 4.1.14.

Water would be required during construction for soil compaction, dust control, concrete production, and possibly for work surface and equipment washdown. During operations, water would be required to support process makeup requirements and facility cooling, as well as the potable and sanitary needs of the

operations workforce and other uses. Water would also be used during facility deactivation activities to stabilize and partially decontaminate waste treatment, retrieval, and disposal facilities, but this requirement would be relatively small compared to operational and construction demands. In total, water use to support activities under this alternative has been conservatively estimated at 208,000 million liters (55,000 million gallons), with a peak demand of 3,720 million liters (983 million gallons). While some water use would occur through 2193 associated with the DOE administrative control period, this water demand would primarily occur during the 88-year facility construction, waste retrieval, and waste treatment phases. This peak demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.2.

4.1.6.2.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative. As described in Section 4.1.5.2, the depth of excavation for facility construction would not exceed about 12 meters (40 feet), and the depth of the water table in the unconfined aquifer beneath the 200 Areas averages more than 50 meters (160 feet). As such, construction dewatering should not be required for any proposed activities under this alternative. Also, construction activities would be conducted so as to avoid contaminated geologic media in the vadose zone.

In addition, there would be no direct discharge of effluents to either surface water or groundwater during construction, operations, and deactivation. Sanitary wastewater, nonhazardous process wastewater, and radioactive liquid effluents would be discharged to permitted onsite treatment facilities, as discussed in Section 4.1.6.2.1 above. The only potential effect of these discharges on groundwater would be to maintain or possibly expand the groundwater mounds (i.e., locally elevated water table areas) that exist beneath the TEDF ponds adjacent to the 200-East Area and the WTP site and beneath the SALDS located north of the 200-West Area. The latter is the ultimate discharge point for treated effluent passing through the LERF and the ETF.

During normal operations, the main direct impact on the vadose zone and groundwater in the 200 Areas would be due to leaks from the tank systems during retrieval operations. Leaks are projected to occur due to liquid volume additions (mainly water) under pressure during retrieval. Under this alternative, DOE would utilize a combination of retrieval technologies, including modified sluicing, VBR, and the MRS. The scope of waste retrieval operations is further described in Chapter 2, Section 2.3.1.1. The MRS would be used in tanks that are assumed or have been confirmed to have leaked in the past, as it introduces sluice liquid in a controlled fashion while pumping out the resulting waste slurry at approximately the same rate as liquid is introduced. Thus, this system minimizes increases in liquid volume within the tank during retrieval. Nevertheless, for purposes of analysis, it was assumed that each of the 149 SSTs would leak an average of 15,000 liters (4,000 gallons) during retrieval to the surrounding soils and sediments within the vadose zone (DOE 2003e:4-8–4-11). These releases would add to the range of 2.84–3.97 million liters (750,000–1,050,000 gallons) of waste estimated to have leaked to the vadose zone to date and could contribute to groundwater contaminant migration over the long term.

Although tank waste retrieval would result in removal of 99 percent of the tank waste by volume as proposed under this alternative, residual tank waste inventories would have the potential to result in impacts on groundwater quality over the long term. Even after implementation of corrective action measures to fill deteriorating tanks with grout or gravel, Hanford SSTs, DSTs, and MUSTs would fail over time, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants would be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.2.

4.1.6.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

4.1.6.3.1 Surface Water

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 2B for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, to ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF and the 242-A Evaporator would each be replaced once. Waste generation and management activities are further discussed in Section 4.1.14.3.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. Under this alternative, excavation work associated with emplacement of the modified RCRA Subtitle C barrier for landfill closure of the SST system and the six sets of cribs and trenches (ditches) would add to the water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 86,300 million liters (22,800 million gallons), with a peak demand of 3,560 million liters (940 million gallons). While some water use may occur through 2145 associated with the DOE postclosure care period, water demand would be concentrated during the 40-year facility construction, waste retrieval, waste treatment, and SST system closure phases. This peak demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.3.

4.1.6.3.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative for the same reasons as previously described in Section 4.1.6.2.2. The exception under this alternative involves closure activities, including removal and disposal of the upper 4.6 meters (15 feet) of contaminated soils and encountered ancillary equipment within the BX and SX tank farms.

Furthermore, potential impacts of the discharge of facility effluents to permitted onsite treatment facilities would be similar to those described in Section 4.1.6.2.2. Waste generation and management activities are further discussed in Section 4.1.14.3.

Although tank waste retrieval would result in removal of 99 percent of the tank waste by volume, residual tank waste inventories would have the potential to result in impacts on groundwater quality over the long term. In the short term, leaks could occur due to liquid volume additions (mainly water) under pressure during tank waste retrieval activities, as further described in Section 4.1.6.2.2 under Alternative 2A. As a short-term measure following retrieval, individual SSTs and DSTs in each tank farm would be stabilized by filling them with cement grout, followed by emplacement of a landfill barrier over the tank farms under this alternative. The modified RCRA Subtitle C barrier lobes would serve to impede the movement of residual contaminants from the tanks to the vadose zone and associated contaminants in the vadose zone, principally by retarding surface-water infiltration. The modified RCRA Subtitle C barrier is designed for a 500-year performance period. Nevertheless, this barrier would degrade over time, allowing infiltration and contaminant migration, and the SSTs, DSTs, and MUSTs would fail, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.3.

4.1.6.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

4.1.6.4.1 Surface Water

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 3A for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Any potential for direct or indirect impacts on stormwater or surface-water quality would be very similar to Alternative 2B, as the total land area that would be disturbed is similar, despite the addition of Bulk Vitrification Facilities under this alternative.

Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, to ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF and the 242-A Evaporator would be replaced once. Waste generation and management activities are further discussed in Section 4.1.14.4.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. As under Alternative 2B (see Section 4.1.6.3.1), excavation work associated with emplacement of the modified RCRA Subtitle C barrier for landfill closure of the SST system and the six sets of cribs and trenches (ditches) in the B and T Areas under this alternative would add to the water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 77,000 million liters (20,300 million gallons), with a peak demand of 2,180 million liters (576 million gallons), which is less than the estimated requirements under Alternatives 2A and 2B. While some water use may occur through 2141 associated with the DOE postclosure care period, this water demand would primarily occur during the 36-year facility construction, waste retrieval, waste treatment, and SST system closure phases. This demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.4.

4.1.6.4.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative for the same reasons as previously described in Section 4.1.6.2.2. As under Alternative 2B, the exception under this alternative would involve closure activities, including removal and disposal of the upper 4.6 meters (15 feet) of contaminated soils and encountered ancillary equipment within the BX and SX tank farms.

Furthermore, potential impacts of the discharge of facility effluents to permitted onsite treatment facilities would be similar to those described in Section 4.1.6.2.2. Waste generation and management activities are further discussed in Section 4.1.14.4.

As under the previous alternatives, tank waste retrieval activities would result in removal of 99 percent of the tank waste by volume under this alternative. The residual tank waste inventories would still have the potential to result in impacts on groundwater quality over the long term. In the short term, leaks could occur due to liquid volume additions (mainly water) under pressure during tank waste retrieval activities, as further described in Section 4.1.6.2.2 under Alternative 2A. As a short-term measure following retrieval, individual SSTs and DSTs in each tank farm would be stabilized by filling them with cement grout, followed by emplacement of a landfill barrier over the tank farms under this alternative. The modified RCRA Subtitle C barrier system would serve to impede the movement of residual contaminants from the tanks to the vadose zone and associated contaminants in the vadose zone, principally by retarding surface-water infiltration. The modified RCRA Subtitle C barrier is designed for a

500-year performance period. Nevertheless, this barrier would degrade over time, allowing infiltration and contaminant migration, and the SSTs, DSTs, and MUSTs would fail, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.4.

4.1.6.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

4.1.6.5.1 Surface Water

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 3B for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Any potential for direct or indirect impacts on stormwater or surface-water quality would be very similar to Alternatives 2B and 3A as the total land area that would be disturbed would be similar, despite the addition of Cast Stone Facilities under this alternative.

Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, to ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF and the 242-A Evaporator would each be replaced once. Waste generation and management activities are further discussed in Section 4.1.14.5.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. As under Alternative 2B (see Section 4.1.6.3.1), excavation work associated with emplacement of the modified RCRA Subtitle C barrier for landfill closure of the SST system and the six sets of cribs and trenches (ditches) in the B and T Areas under this alternative would add to the water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 77,000 million liters (20,300 million gallons), with a peak demand of 2,180 million liters (576 million gallons), which is less than the estimated requirements under Alternatives 2A and 2B and the same as under Alternative 3A. While some water use may occur through 2141 associated with the DOE postclosure care period, this water demand would primarily occur during the 36-year facility construction, waste retrieval, waste treatment, and SST system closure phases. This demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface-water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.5.

4.1.6.5.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative for the same reasons as previously described in Section 4.1.6.2.2. As under Alternative 2B, the exception under this alternative would involve closure activities, including removal and disposal of the upper 4.6 meters (15 feet) of contaminated soils and encountered ancillary equipment within the BX and SX tank farms.

Furthermore, potential impacts of the discharge of facility effluents to permitted onsite treatment facilities would be similar to those described in Section 4.1.6.2.2. Waste generation and management activities are further discussed in Section 4.1.14.5.

As under the previous alternatives, tank waste retrieval activities would result in removal of 99 percent of the tank waste by volume under this alternative. The residual tank waste inventories would still have the

potential to result in impacts on groundwater quality over the long term. In the short term, leaks could occur due to liquid volume additions (mainly water) under pressure during tank waste retrieval activities, as further described in Section 4.1.6.2.2 under Alternative 2A. As a short-term measure following retrieval, individual SSTs and DSTs in each tank farm would be stabilized by filling them with cement grout, followed by emplacement of a landfill barrier over the tank farms under this alternative. The modified RCRA Subtitle C barrier system would serve to impede the movement of residual contaminants from the tanks to the vadose zone and associated contaminants in the vadose zone, principally by retarding surface-water infiltration. The modified RCRA Subtitle C barrier is designed for a 500-year performance period. Nevertheless, this barrier would degrade over time, allowing infiltration and contaminant migration, and the SSTs, DSTs, and MUSTs would fail, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.5.

4.1.6.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

4.1.6.6.1 Surface Water

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 3B for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Any potential for direct or indirect impacts on stormwater or surface-water quality would be very similar to Alternatives 2B, 3A, and 3B as the total land area that would be disturbed would be similar, despite the addition of Steam Reforming Facilities under this alternative.

Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, to ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF and the 242-A Evaporator would each be replaced once. Waste generation and management activities are further discussed in Section 4.1.14.6.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. As under Alternative 2B (see Section 4.1.6.3.1), excavation work associated with emplacement of the modified RCRA Subtitle C barrier for landfill closure of the SST system and the six sets of cribs and trenches (ditches) in the B and T Areas under this alternative would add to the water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 77,300 million liters (20,400 million gallons), with a peak demand of 2,190 million liters (579 million gallons), which is less than the estimated requirements under Alternatives 2A and 2B and just slightly more than under Alternatives 3A and 3B. While some water use may occur through 2141 associated with the DOE postclosure care period, this water demand would primarily occur during the 36-year facility construction, waste retrieval, waste treatment, and SST system closure phases. This demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.6.

4.1.6.6.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative for the same reasons as previously described in Section 4.1.6.2.2. As under Alternative 2B, the exception under this alternative would involve closure activities, including removal and disposal of the upper 4.6 meters (15 feet) of contaminated soils and encountered ancillary equipment within the BX and SX tank farms.

Furthermore, potential impacts of the discharge of facility effluents to permitted onsite treatment facilities would be similar to those described in Section 4.1.6.2.2. Waste generation and management activities are further discussed in Section 4.1.14.6.

As under the previous alternatives, tank waste retrieval activities would result in removal of 99 percent of the tank waste by volume under this alternative. The residual tank waste inventories would still have the potential to result in impacts on groundwater quality over the long term. In the short term, leaks could occur due to liquid volume additions (mainly water) under pressure during tank waste retrieval activities, as further described in Section 4.1.6.2.2 under Alternative 2A. As a short-term measure following retrieval, individual SSTs and DSTs in each tank farm would be stabilized by filling them with cement grout, followed by emplacement of a landfill barrier over the tank farms under this alternative. The modified RCRA Subtitle C barrier system would serve to impede the movement of residual contaminants from the tanks to the vadose zone and associated contaminants in the vadose zone, principally by retarding surface-water infiltration. The modified RCRA Subtitle C barrier is designed for a 500-year performance period. Nevertheless, this barrier would degrade over time, allowing infiltration and contaminant migration, and the SSTs, DSTs, and MUSTs would fail, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.6.

4.1.6.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

4.1.6.7.1 Surface Water

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 4 for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Any potential for direct or indirect impacts on stormwater or surface-water quality would be very similar to Alternatives 2B, 3A, 3B, and 3C as the total land area that would be disturbed would be similar and would include construction of Bulk Vitrification and Cast Stone Facilities in addition to construction of a new PPF to process waste generated from selective clean closure activities under this alternative.

Nevertheless, effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, to ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF and the 242-A Evaporator would each be replaced once. Operation of the PPF for treatment of waste generated as a result of clean closure actions would also generate effluents. Concentrated hazardous constituents and radionuclides from this process would be returned to the WTP influent for eventual vitrification (DOE 2003c:9, 10). Waste generation and management activities under this alternative are further discussed in Section 4.1.14.7.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. As under Alternative 2B (see Section 4.1.6.3.1), excavation work associated with emplacement of the modified RCRA Subtitle C barrier for landfill closure of the SST system and the six sets of cribs and trenches (ditches) in the B and T Areas, plus clean closure of the BX and SX tank farms under this alternative, would add to the water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 82,200 million liters (21,700 million gallons), with a peak demand of 2,180 million liters (576 million gallons), which is greater overall than Alternatives 2B, 3A, 3B, and 3C, largely due to a higher treatment operations demand under this alternative. While some water use may occur through 2144 associated with the DOE postclosure care period, this water demand would primarily occur during the 39-year facility construction, waste retrieval, waste treatment, and SST system and tank farm closure

phases. This demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.7.

4.1.6.7.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative for the same reasons as previously described in Section 4.1.6.2.2. However, to implement selective clean closure at the BX and SX tank farms sites, excavation to depths of up to 78 meters (255 feet) below land surface may be required, particularly in the BX tank farm, to remediate contaminant plumes from past-practice discharges that have migrated through the vadose zone soils and sediments and possibly to the water table. This would have a beneficial impact by stemming further contaminant migration from these sources (see Section 4.1.5.7). Construction dewatering would likely be necessary in some tank farm excavations to allow clean closure to proceed, and, depending on the amount of pumping required, dewatering activities may have a local effect on groundwater flow and existing contaminant plumes beneath the tank farms. Also, the water would require special handling and treatment. Therefore, this groundwater would be conveyed to onsite ETFs for processing.

Furthermore, potential impacts of the discharge of facility effluents to permitted onsite treatment facilities would be similar to those described in Section 4.1.6.2.2. Sanitary wastewater, nonhazardous process wastewater, and radioactive liquid effluents would be discharged to permitted onsite treatment facilities, as discussed above in Section 4.1.6.7.1. Waste generation and management activities are further discussed in Section 4.1.14.7.

Although tank waste retrieval would result in removal of 99.9 percent of the tank waste by volume in contrast to 99 percent under the previously discussed action alternatives, residual tank waste inventories would have the potential to result in impacts on groundwater quality over the long term. In the short term, leaks could occur due to liquid volume additions (mainly water) under pressure during tank waste retrieval activities, as further described in Section 4.1.6.2.2 under Alternative 2A. As a short-term measure following retrieval, individual SSTs and DSTs in each tank farm would be stabilized by filling them with cement grout, followed by emplacement of a landfill barrier over the tank farms. Under this alternative, the modified RCRA Subtitle C barrier lobes placed over each tank farm that would not be clean-closed would serve to impede the movement of residual contaminants from the tanks to the vadose zone and associated contaminants in the vadose zone, principally by retarding surface-water infiltration. The modified RCRA Subtitle C barrier is designed for a 500-year performance period. Nevertheless, this barrier would degrade over time, allowing infiltration and contaminant migration, and the Hanford SSTs, DSTs, and MUSTs would fail, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.7.

4.1.6.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

4.1.6.8.1 Surface Water

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 5 for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Any potential for direct or indirect impacts on stormwater or surface-water quality would be somewhat greater than Alternatives 2B, 3A, 3B, 3C, and 4 due to the slightly larger land area that would be disturbed under this alternative, which includes construction of

Bulk Vitrification and Cast Stone Facilities in addition to a Sulfate Removal Facility to support accelerated waste treatment under this alternative.

Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, to ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF and the 242-A Evaporator would be replaced once. Waste generation and management activities are further discussed in Section 4.1.14.8.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. In contrast to Alternatives 2B through 4, wherein a modified RCRA Subtitle C barrier would be constructed (see Section 4.1.6.3.1), excavation work associated with emplacement of the more robust Hanford barrier under this alternative would add to the amount of water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 92,500 million liters (24,400 million gallons), with a peak demand of 3,800 million liters (1,000 million gallons). While some water use may occur through 2139 associated with the DOE postclosure care period, this water demand would primarily occur during the 34-year facility construction, waste retrieval, and waste treatment phases and extend through landfill closure. This demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.8.

4.1.6.8.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative for the same reasons as previously described in Section 4.1.6.2.2, as there would be no contaminated soil removal in the BX and SX tank farms prior to emplacement of the landfill closure barrier.

Furthermore, potential impacts of the discharge of facility effluents to permitted onsite treatment facilities would be similar to those described in Section 4.1.6.2.2. Waste generation and management activities are further discussed in Section 4.1.14.8.

To expedite waste treatment and tank farm closure, tank waste retrieval activities would result in removal of 90 percent of the tank waste by volume under this alternative. The residual tank waste inventories would still have the potential to result in impacts on groundwater quality over the long term. In the short term, leaks could occur due to liquid volume additions (mainly water) under pressure during tank waste retrieval activities, as further described in Section 4.1.6.2.2 under Alternative 2A. As a short-term measure following retrieval, individual SSTs and DSTs in each tank farm would be stabilized by filling them with cement grout, followed by emplacement of a landfill barrier over the tank farms. As opposed to the modified RCRA Subtitle C barrier proposed under Alternatives 2B through 4 and 6C, the more robust Hanford barrier, which is designed for a 1,000-year performance period, would be used for landfill closure (DOE 2003a:6-64). This would help compensate for the lower volume of tank waste retrieved under this alternative. The Hanford barrier would serve to impede the movement of residual contaminants from the tanks to the vadose zone and associated contaminants in the vadose zone, principally by retarding surface-water infiltration. Nevertheless, the Hanford barrier would still degrade over time, allowing infiltration and contaminant migration, and the SSTs, DSTs, and MUSTs would fail, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.8.

4.1.6.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.6.9.1 Surface Water

4.1.6.9.1.1 Base Case

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 6A, Base Case, for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Nevertheless, the potential for direct or indirect impacts on stormwater or surface-water quality would be highest under this alternative as compared with the previously discussed alternatives, due to the substantially larger land area that would be disturbed from new facility construction and then converted to impervious surface. This increased potential would be reduced by the much longer timeframe over which construction and operations activities would take place as compared to the previously discussed alternatives.

Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, due to the relatively long operational timeframe to complete waste treatment, the ETF would be replaced five times and the 242-A Evaporator would be replaced six times to ensure the availability of treatment facilities to process liquid waste generated under this alternative. PPF operation for treatment of waste generated as a result of clean closure actions would also generate effluents. A portion of the ensuing waste streams would be solidified for onsite disposal, while concentrated hazardous constituents and radionuclides from this process would be vitrified, with the resulting PPF glass waste form also disposed of on site. Waste generation and management activities are further discussed in Section 4.1.14.9.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. In contrast to the previously described alternatives, complete clean closure of the SST system under this alternative and emplacement of the modified RCRA Subtitle C barrier for landfill closure of the six sets of cribs and trenches (ditches) in the B and T Areas would add to the water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 644,000 million liters (170,000 million gallons), with a peak demand of 6,580 million liters (1,740 million gallons), which is an nearly order of magnitude greater than the previously described alternatives due to HLW waste treatment operations occurring over a relatively long period of time. While some water use may occur through 2250 associated with the DOE postclosure care period for the B and T Areas, this water demand would primarily occur during the 159-year facility construction, waste retrieval, waste treatment, and facility deactivation and closure phases. Given the relatively long timeframe over which this demand would occur, this demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.9.3.

4.1.6.9.1.2 Option Case

Potential direct and indirect impacts of tank closure related facility construction, waste retrieval, waste treatment, and facility deactivation and closure activities on surface-water resources would be similar to those discussed in Section 4.1.6.9.1.1 under Alternative 6A, Base Case. One exception is that under Alternative 6A, Option Case, the six sets of cribs and trenches (ditches) in the B and T Areas would be removed instead of landfill-closed as under Alternative 6A, Base Case. Removal would require construction and operation of a larger PPF to process the added waste from clean closure of the cribs and trenches (ditches). It is estimated that removal would result in additional water use of approximately 200 million liters (52.8 million gallons) associated with the closure phase of this option as compared with Alternative 6A, Base Case, as well as the generation of additional effluents from the PPF. Nevertheless,

removal is not expected to have any additional impact on surface water and water quality, and effluents generated by facility operations under this option would be managed in a similar manner to that described in Section 4.1.6.2.1.

4.1.6.9.2 Vadose Zone and Groundwater

4.1.6.9.2.1 Base Case

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative. However, to implement selective clean closure under this alternative, excavation to depths of up to 78 meters (255 feet) below land surface may be required, particularly in the B tank farm, to remediate contaminant plumes from past-practice discharges that have migrated through the vadose zone soils and sediments and possibly to the water table (see Section 4.1.5.9.1). Excavation and remediation would have a beneficial impact by stemming further contaminant migration from the tank farms. Construction dewatering would likely be necessary in some tank farm excavations to allow clean closure to proceed, and, depending on the amount of pumping required, dewatering activities might have a local effect on groundwater flow and existing contaminant plumes beneath the tank farms. Also, the water would require special handling and treatment. Therefore, this groundwater would be conveyed to onsite ETFs for processing.

There would be no direct discharge of effluents to either surface water or groundwater during construction, operations, deactivation, or closure. Sanitary wastewater, nonhazardous process wastewater, and radioactive liquid effluents would be discharged to permitted onsite treatment facilities, as discussed above in Section 4.1.6.9.1.1 and in Section 4.1.6.2.1. The only potential effect of these discharges on groundwater would be to maintain or possibly expand the groundwater mounds (i.e., locally elevated water table areas) that exist beneath the TEDF ponds adjacent to the 200-East Area and the WTP site and beneath the SALDS located north of the 200-West Area. The latter is the ultimate discharge point for treated effluent passing through the LERF and the ETF.

During normal operations, the main direct impact on the vadose zone and groundwater in the 200 Areas would be due to leaks from the tank systems during retrieval operations. Leaks are projected to occur due to liquid volume additions (mainly water) under pressure during retrieval as further described in Section 4.1.6.2.2 under Alternative 2. Nonetheless, clean closure of all 12 SST farms under this alternative, coupled with deep soil removal, would measurably reduce the long-term risk to groundwater quality. Clean closure would not eliminate all contamination stemming from historic tank waste operations, such as historic releases to cribs and trenches (ditches), which have already moved downgradient in the vadose zone and in the unconfined aquifer system beneath Hanford. Also, landfill closure of the six sets of cribs and trenches (ditches) in the B and T Areas would delay, but not prevent, future migration of contaminants from these sources. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.9.

4.1.6.9.2.2 Option Case

Direct, short-term impacts of tank closure activities, including facility construction, tank waste retrieval, waste treatment operations, and SST system clean closure, on the vadose zone and groundwater under this option would be very similar to but ultimately less than those described in Section 4.1.6.9.2.1 under Alternative 6A, Base Case. While direct disturbance of the vadose zone and unconfined aquifer would be temporarily greater under this option in association with the removal of the six sets of cribs and trenches (ditches) in the B and T Areas, this action would essentially remove this source of contamination from further impacting the underlying groundwater over the long term. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.9.

4.1.6.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.6.10.1 Surface Water

4.1.6.10.1.1 Base Case

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 6B, Base Case, for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. Nevertheless, the potential for direct or indirect impacts on stormwater or surface-water quality would be relatively high under this alternative as compared with all of the previously discussed alternatives, with the exception of Alternative 6A, Base Case, due to the substantially larger land area that would be disturbed from new facility construction and then converted to impervious surface.

Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. However, to ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF would be replaced twice and the 242-A Evaporator would be replaced once. As under Alternative 6A (see Section 4.1.6.9.1.1), PPF operation for treatment of waste generated as a result of clean closure actions would also generate effluents. A portion of the ensuing waste streams would be solidified for disposal on site, while concentrated hazardous constituents and radionuclides from this process would be vitrified, with the resulting PPF glass waste form also disposed of on site. Waste generation and management activities are further discussed in Section 4.1.14.10.

Water would be required to support new facility construction, facility operations, and facility deactivation as summarized in Section 4.1.6.2.1. While SST system closure activities would be the same as under Alternative 6A, Base Case (see Section 4.1.6.9.1.1), overall water requirements for new facility construction and waste treatment operations would be an order of magnitude lower under this alternative than under Alternative 6A, Base Case. In total, water use to support activities under this alternative has been conservatively estimated at 92,600 million liters (24,500 million gallons), with a peak demand of 3,500 million liters (925 million gallons). While some water use may occur through 2201 associated with the DOE postclosure care period for the B and T Areas, this water demand would primarily occur during the 95-year facility construction, waste retrieval, waste treatment, and facility deactivation and closure phases. This demand is substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact the availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.10.3.

4.1.6.10.1.2 Option Case

Potential direct and indirect impacts of tank closure related facility construction, waste retrieval, facility treatment, facility deactivation, and closure activities on surface-water resources would be similar to those discussed in Section 4.1.6.10.1.1 under Alternative 6B, Base Case. One exception is that under Alternative 6B, Option Case, the six sets of cribs and trenches (ditches) in the B and T Areas would be removed instead of landfill-closed as under Alternative 6A, Base Case. This removal would require construction and operation of a larger PPF to process the added waste from clean closure of the cribs and trenches (ditches). It is estimated that clean closure would result in additional water use of approximately 200 million liters (52.8 million gallons) associated with the closure phase of this option as compared with Alternative 6B, Base Case, as well as the generation of additional effluents from the PPF. Nevertheless, removal is not expected to have any additional impact on surface water and water quality, and effluents generated by facility operations under this option would be managed in a similar manner to that described in Section 4.1.6.2.1.

4.1.6.10.2 Vadose Zone and Groundwater

4.1.6.10.2.1 Base Case

Direct, short-term impacts of tank closure activities under this alternative case would be very similar, if not identical, to those described in Section 4.1.6.9.2.1 under Alternative 6A, Base Case because waste retrieval and tank closure actions, including clean closure of the SST system and landfill closure of the six sets of cribs and trenches (ditches) in the B and T Areas, would be identical under this alternative case. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.10.

4.1.6.10.2.2 Option Case

Under this alternative option, direct, short-term impacts of tank closure activities on the vadose zone and groundwater would be very similar to but ultimately less than those described in Section 4.1.6.9.2.1 under Alternative 6A, Base Case, and essentially identical to Alternative 6A, Option Case (see Section 4.1.6.9.2.2). While direct disturbance of the vadose zone and unconfined aquifer would be temporarily greater under this option in association with the removal of the six sets of cribs and trenches (ditches) in the B and T Areas, this action would essentially remove this source of contamination from further impacting the underlying groundwater over the long term. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.10.

4.1.6.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

4.1.6.11.1 Surface Water

Facility construction activities and normal facility operations are not expected to have any direct impact on surface-water features or surface-water quality under Alternative 6C for the same reasons as previously described in Sections 4.1.6 and 4.1.6.2.1. In general, effects on surface-water resources would be very similar to those described under Alternative 2B (see Section 4.1.6.3.1). While additional ILAW Interim Storage Facilities would be constructed and operated under this alternative, they are not expected to have any incremental impact on surface water. Effluents generated by facility operations would be managed in a similar manner to that described in Section 4.1.6.2.1. To ensure the availability of treatment facilities to process liquid waste generated under this alternative, the ETF and the 242-A Evaporator would be replaced once under this alternative, as also required under Alternative 2B. Waste generation and management activities are further discussed in Section 4.1.14.11.

Water would be required to support new facility construction, facility operations, and facility deactivation as previously summarized in Section 4.1.6.2.1. Under this alternative, excavation work associated with emplacement of the modified RCRA Subtitle C barrier for landfill closure of the SST system and six sets of cribs and trenches (ditches) would add to the water required for dust control and soil compaction. In total, water use to support activities under this alternative has been conservatively estimated at 86,300 million liters (22,800 million gallons), with a peak demand of 3,560 million liters (940 million gallons). While some water use may occur through 2145 associated with the DOE postclosure care period, this water demand would primarily occur during the 40-year facility construction, waste retrieval, waste treatment, and SST system closure phases. This demand would be substantially less than the production capacity of the Hanford Export Water System, which withdraws water from the Columbia River, and it is not expected to greatly impact availability of surface water for downstream users. The impact of this water demand on Hanford's utility infrastructure is further detailed in Section 4.1.2.11.

4.1.6.11.2 Vadose Zone and Groundwater

Facility construction is unlikely to have any direct impact on groundwater hydrology or existing contaminant plumes under this alternative for the same reasons as previously described in Section 4.1.6.2.2. The exception under this alternative would involve closure activities, including removal and disposal of the upper 4.6 meters (15 feet) of contaminated soils and encountered ancillary equipment within the BX and SX tank farms.

Furthermore, potential impacts of the discharge of facility effluents to permitted onsite treatment facilities would be similar to those described in Section 4.1.6.2.2. Waste generation and management activities are further discussed in Section 4.1.14.11.

Although tank waste retrieval would result in removal of 99 percent of the tank waste by volume, residual tank waste inventories would have the potential to result in impacts on groundwater quality over the long term. In the short term, leaks could occur due to liquid volume additions (mainly water) under pressure during tank waste retrieval activities, as further described in Section 4.1.6.2.2 under Alternative 2A. As a short-term measure following retrieval, individual SSTs and DSTs in each tank farm would be stabilized by filling them with cement grout, followed by emplacement of a landfill barrier over the tank farms under this alternative. The modified RCRA Subtitle C barrier lobes would serve to impede movement of residual contaminants from the tanks to the vadose zone and associated contaminants in the vadose zone principally by retarding surface-water infiltration. The modified RCRA Subtitle C barrier is designed for a 500-year performance period. Nevertheless, this barrier would degrade over time (following the end of DOE administrative control), allowing infiltration and contaminant migration, and the SSTs, DSTs, and MUSTs would fail, resulting in release of their contents to the vadose zone and unconfined aquifer system. Ultimately, these contaminants could be discharged to the Columbia River. Long-term impacts on water resources, including contamination releases to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.1.1.11.

4.1.7 Ecological Resources

4.1.7.1 Alternative 1: No Action

Under the No Action Alternative, there would be no new construction within the 200 Areas, although some work would take place within previously disturbed areas. Thus, there would be no additional impact on terrestrial resources, wetlands, aquatic resources, or threatened and endangered species under this alternative.

This alternative would require that 2 hectares (5 acres) within Borrow Area C be excavated to supply geologic material for use in activities such as the stabilization of tanks and closure of the WTP. Due to the limited area to be disturbed, impacts on terrestrial resources would be minimal. Since there are no wetlands or aquatic resources within Borrow Area C, these resources would not be affected. Surveys have identified Piper's daisy (state sensitive), stalked-pod milkvetch (state watch), crouching milkvetch (state watch), and the long-billed curlew (state monitor) within Borrow Area C. Because of the limited area to be disturbed, impacts on these species are expected to be minimal. A mitigation action plan would be prepared prior to excavation of Borrow Area C if conflicts with any of these species are likely. Due to the greater amount of land to be disturbed under the action alternatives, ecological impacts resulting from excavation of Borrow Area C are addressed in more detail below (see Section 4.1.7.2).

4.1.7.2 Alternative 2A: Existing WTP Vitrification; No Closure

4.1.7.2.1 Terrestrial Resources

As noted in Section 4.1.1.2.1, 32.3 hectares (79.9 acres) would be disturbed by construction of new facilities within the 200 Areas under this alternative. Of this total, 29.1 hectares (71.9 acres) within the 200-East Area and 3.2 hectares (8 acres) would be developed within the 200-West Area. The only new construction to take place within the 200-West Area is an underground transfer line that would be built along existing roads and, thus, would have a negligible impact on terrestrial resources. Within and adjacent to the 200-East Area, most new facilities would be built within disturbed areas and would also have a negligible impact on terrestrial resources. However, the underground transfer line, new DSTs, and replacement WTP would disturb 14.2 hectares (35 acres) of big sagebrush habitat. Late successional sagebrush habitat is considered a Level III resource under the *Hanford Site Biological Resources Management Plan* (DOE 2001b:4.11). The loss of 1.2 hectares (3 acres) of sagebrush habitat resulting from construction of the 200-East Area portion of the underground transfer line would not be mitigable; however, Hanford guidance may require the replacement of other sagebrush habitat at a ratio ranging from 1:1 to 3:1 (DOE 2003f:20, 21, 31). Specific measures to be taken in connection with mitigating the loss of sagebrush habitat would be set forth in a mitigation action plan prior to construction.

Microbiotic crusts, which are expected to occur only on undisturbed sites within the 200 Areas, would be destroyed by new construction. Thus, including both sagebrush and non-sagebrush habitat, up to 16.2 hectares (40 acres) of crusts could be destroyed. There would be no impact on terrestrial plant communities from operations.

Wildlife potentially affected by the construction of new facilities under this alternative could include the mule deer, coyote, northern pocket gopher, sage sparrow, and western meadowlark. As the sage sparrow is listed as a candidate species, it is discussed in Section 4.1.7.2.4. Ground disturbance would result in the loss of less-mobile species such as small mammals and reptiles, including their nests and young. Larger, more mobile species, such as many mammals and birds, would be displaced to similar surrounding habitat. Their ultimate survival would depend on whether the areas into which they moved were at their carrying capacity (i.e., contained the maximum number of the individual animals that the habitat is capable of supporting). If construction took place during the breeding season for ground-nesting birds, generally between March and July, the eggs and nests of these birds could be destroyed and the adults displaced. Mitigation undertaken in connection with the disturbance of sagebrush habitat would help maintain wildlife populations dependent on this important community. Although Hanford is on the Pacific Flyway, construction would not impact any bodies of water or wetlands; thus waterfowl would not be affected under this alternative.

Wildlife could also be affected by noise and human disturbance during construction. The most obvious reaction would be a startle or fright response resulting from transient, unexpected noise. Such noise could cause animals to flee the area. If construction were to take place near a highway, this could lead to increased mortality from collisions with motor vehicles. Lower, more constant noise levels may cause wildlife to temporarily avoid the construction zone. It is also likely that some animals would adapt to the lower noise levels during construction. Human disturbance, such as movement of construction workers or equipment outside of the work zone, could result in indirect effects on wildlife. As with noise disturbance, this could cause some animals to move from the area, while others would be able to adapt. Proper maintenance of equipment and clearly marking construction work zones to prevent intrusion into areas not slated for development would help prevent these impacts. Also, implementation of a spill prevention and control plan would help reduce potential impacts on terrestrial resources.

Operations would have a negligible impact on terrestrial animals provided proper mitigation measures are taken, such as limiting unnecessary noise by properly maintaining equipment and keeping workers from

intruding into undeveloped areas. As is the case during construction, proper handling of petroleum products and chemicals to prevent or rapidly clean up spills would minimize impacts on wildlife. As the 200 Areas are already illuminated at night, additional lighting associated with the operation of new facilities should have a negligible impact on nocturnal animals or those active during dusk or dawn (e.g., effects on navigation or predator/prey relationships).

Under Alternative 2A, 27.5 hectares (68 acres) of Borrow Area C would be excavated to supply needed geologic material. As noted in Chapter 3, Section 3.2.7.1, the two major plant communities present within the area are cheatgrass-bluegass (782 hectares [1,933 acres]) and needle-and-thread grass/Indian ricegrass (107 hectares [265 acres]) (see Chapter 3, Figure 3–19). The latter represents an unusual and relatively pristine community type at Hanford and thus is considered a more highly valued community than the former. It is not possible to determine specific impacts on ecological resources from developing Borrow Area C since the particular portion of the site from which geologic material would be excavated is not known. However, most of Borrow Area C can be developed without significant adverse impacts on species or habitats (Sackschewsky and Downs 2007:8). To the extent that it is possible, the needle-and-thread grass/Indian ricegrass community should be avoided during excavation. A mitigation action plan would be developed prior to excavation.

4.1.7.2.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200-East Area, 200-West Area, or Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north. Implementation of this alternative would not impact any site wetlands.

4.1.7.2.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations, they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.2.

4.1.7.2.4 Threatened and Endangered Species

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas or Borrow Area C; therefore, impacts on this group of plants and animals are not expected under this alternative.

A number of state-listed, special status species have been observed within areas that would be disturbed by construction under Alternative 2A. Two state-listed species were observed near or along the 200-East Area underground transfer line. The black-tailed jackrabbit (state candidate) has been observed near the underground transfer line route and Piper's daisy (state sensitive) was identified on the edge of sagebrush habitat along the route. Thus, construction of the underground transfer line has the potential to disturb both of these listed species. Two listed plants, stalked-pod milkvetch and crouching milkvetch (both state watch), were observed within the area where the replacement WTP and new DSTs would be placed. Due to the presence of sagebrush habitat within these areas, other special status species could potentially be present.

Although mitigation would not be required for the state watch species, they should be considered during project planning. Impacts on state candidate and sensitive species, which are considered Level III resources under the *Hanford Site Biological Resources Management Plan*, require mitigation where impacts would occur. When avoidance and minimization are not possible or are insufficient, mitigation

via rectification or compensation is recommended (DOE 2001b:4.9, 8.11). A comprehensive mitigation action plan, which would deal with the loss of listed species (as well as sagebrush habitat), would be developed prior to construction. Operations of new facilities within the 200 Areas are not expected to impact any federally or state-listed species.

As noted in Chapter 3, Section 3.2.7.4.4, surveys have identified Piper's daisy, stalked-pod milkvetch, crouching milkvetch, and the long-billed curlew (state monitor) within the boundaries of Borrow Area C. Mitigation requirements for Piper's daisy and the two species of milkvetch are addressed above. Although avoidance and minimization of impacts on state monitor species is recommended, mitigation is not required (DOE 2001b:4.11). A mitigation action plan would be developed prior to excavation.

4.1.7.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

4.1.7.3.1 Terrestrial Resources

As noted in Section 4.1.1.3.1, 16.2 hectares (40 acres) would be disturbed by construction of new facilities within the 200 Areas under this alternative. Of this total, 12.5 hectares (30.9 acres) would be developed within the 200-East Area and 3.7 hectares (9.1 acres) within the 200-West Area. The only new construction to take place within the 200-West Area is an underground transfer line that would be built along existing roads and, thus, would have a negligible impact on terrestrial resources. Within the 200-East Area, an underground transfer line would disturb 3.2 hectares (8 acres) of undisturbed land, 1.2 hectares (3 acres) of which is sagebrush habitat. The loss of this sagebrush habitat would not be mitigable. Since all other new facilities constructed within the 200-East Area would be built within disturbed areas, they would have a negligible impact on terrestrial resources.

Under this alternative, closure would involve removal of soil from around the BX tank farm in the 200-East Area and the SX tank farm in the 200-West Area and covering all 18 tank farms and six sets of cribs and trenches (ditches) with landfill barriers. As barriers would ultimately cover the BX and SX tank farms, the impact of soil removal is not addressed separately. Because land at the tank farms has been disturbed from past and present operations, no sagebrush habitat is present. Thus, placement of landfill closure barriers over these areas would have negligible impacts on terrestrial resources. Upon completion, the barriers would be planted with a mixture of grasses.

This alternative would have a negligible impact on site wildlife, although any loss of sagebrush habitat has the potential to impact certain species, such as the sage sparrow. While some members of smaller, less-mobile species could be lost during construction of new facilities, most animals are expected to disperse to surrounding areas. Although the revegetated landfill closure barriers would provide some habitat for terrestrial species, their overall value would be minimal because to limit root penetration they would be maintained as grasslands. Operational impacts on terrestrial resources would be similar to those addressed in Section 4.1.7.2.1.

Under Alternative 2B, 94.7 hectares (234 acres) of Borrow Area C would be excavated to supply needed geologic material. Overall, impacts on terrestrial resources from the excavation of geologic material from the area would be similar to those described above under Alternative 2A.

4.1.7.3.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas or Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.3.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.3.

4.1.7.3.4 Threatened and Endangered Species

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas or Borrow Area C; therefore, impacts on this group of plants and animals are not expected under this alternative.

Two state-listed species were observed near or along the 200-East Area underground transfer line. The black-tailed jackrabbit (state candidate) and Piper's daisy (state sensitive) have been identified along the route of the 200-East Area underground transfer line and could be disturbed by construction. Since other proposed facilities associated with this alternative would be constructed on disturbed land, there is little potential to disturb special status species. Mitigation requirements, including preparation of a mitigation action plan, would be similar to those discussed in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on special status species resulting from excavation of geologic material from 94.7 hectares (234 acres) in Borrow Area C generally would be similar to those described under Alternative 2A (see Section 4.1.7.2.4). As is the case under Alternative 2A specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.7.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

4.1.7.4.1 Terrestrial Resources

As noted in Section 4.1.1.4.1, 17.4 hectares (43 acres) would be needed for construction of new facilities within the 200 Areas under this alternative. Of this total, 13.2 hectares (32.7 acres) would be needed within the 200-East Area and 4.2 hectares (10.3 acres) within the 200-West Area. Most new facilities would be built on previously disturbed land and would therefore have a negligible impact on terrestrial resources. However, within and adjacent to the 200-East Area, new facilities would impact 3.6 hectares (8.8 acres) of sagebrush habitat. Within the 200-West Area, new facilities would be constructed on 0.4 hectares (1.1 acres) of such habitat within the 200-West Area Supplemental Treatment Technology Site (STTS-West). Sagebrush habitat disturbed by the 200-East underground transfer line and in the 200-West Area would not be mitigable. Also, mitigation would not be required within the 200-East Area Supplemental Treatment Technology Site (STTS-East) since the loss of sagebrush habitat does not meet the minimum mitigation threshold (5 hectares [12.5 acres]) (DOE 2003f:20, 21).

Impacts on terrestrial resources during operations would be similar to those described in Section 4.1.7.2.1; impacts on terrestrial resources during closure would be similar to those described in Section 4.1.7.3.1.

Under Alternative 3A, 101 hectares (249 acres) of Borrow Area C would be excavated to supply needed geologic material. Overall, impacts on terrestrial resources from the excavation of geologic material from the area would be similar to those described above under Alternative 2A.

4.1.7.4.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas or Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.4.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations, they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.4.

4.1.7.4.4 Threatened and Endangered Species

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas or Borrow Area C; therefore, impacts on this group of plants and animals are not expected under this alternative.

Under this alternative, a number of state-listed, special status species have been observed in areas where new facilities would be built and therefore could be impacted by construction activities. The stalked-pod milkvetch and crouching milkvetch (both state watch) have been observed in STTS-East, while the loggerhead shrike (Federal species of concern and state candidate) and sage sparrow (state candidate) have been observed within STTS-West. Due to the presence of sagebrush habitat within this area, other special status species could potentially be present. The black-tailed jackrabbit (state candidate) and Piper's daisy (state sensitive) were observed along the route of the 200-East Area underground transfer line. Mitigation requirements, including preparation of a mitigation action plan, would be similar to those discussed in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on special status species resulting from excavation of geologic material from 101 hectares (249 acres) in Borrow Area C generally would be similar to those described under Alternative 2A (see Section 4.1.7.2.4). As is the case under Alternative 2A, specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.7.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

4.1.7.5.1 Terrestrial Resources

As noted in Section 4.1.1.5.1, 18.3 hectares (45.2 acres) would be needed for construction of new facilities within the 200 Areas under this alternative. Of this total, 13.7 hectares (33.8 acres) would be developed within the 200-East Area and 4.6 hectares (11.4 acres) within and adjacent to the 200-West

Area. As is the case under Alternative 3A, most new facilities would be built within disturbed areas and would therefore have a negligible impact on terrestrial resources. However, within and adjacent to the 200-East Area, new facilities would impact a total of 4 hectares (9.9 acres) of sagebrush habitat. Within the 200-West Area, construction would take place on 0.9 hectares (2.2 acres) of sagebrush habitat within STTS-West. The loss of sagebrush habitat associated with construction of the 200-East Area underground transfer line and facilities in STTS-West would not be mitigable. Also, mitigation would not be required within STTS-East since the loss of sagebrush habitat does not meet the minimum mitigation threshold (5 hectares [12.5 acres]) (DOE 2003f:20, 21).

Impacts on terrestrial resources during operations would be similar to those described in Section 4.1.7.2.1 and those during closure in Section 4.1.7.3.1.

Under Alternative 3B, 93.5 hectares (231 acres) of Borrow Area C would be excavated to supply needed geologic material. Overall impacts on terrestrial resources from the excavation of geologic material from the area would be similar to those described above under Alternative 2A.

4.1.7.5.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2.2, there are no wetlands within the 200 Areas or Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.5.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.5.

4.1.7.5.4 Threatened and Endangered Species

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas or Borrow Area C; therefore, impacts on this group of plants and animals are not expected under this alternative.

Although slightly more land would be required under Alternative 3B than under Alternative 3A, construction would take place within the same general areas. Thus, potential impacts on state-listed, special status species would be similar to those discussed in Section 4.1.7.4.4. Mitigation requirements, including preparation of a mitigation action plan, would be similar to those discussed in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on special status species resulting from excavation of geologic material from 93.5 hectares (231 acres) in Borrow Area C would be similar to those described under Alternative 2A since nearly the same area would be disturbed (see Section 4.1.7.2.4). As is the case under Alternative 2A, specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.7.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

4.1.7.6.1 Terrestrial Resources

As noted in Section 4.1.1.6.1, 18.2 hectares (45 acres) would be needed for construction of new facilities within the 200 Areas under this alternative. Of this total, 13.9 hectares (34.3 acres) would be disturbed within and adjacent to the 200-East Area and 4.3 hectares (10.7 acres) within the 200-West Area. As is the case under Alternative 3A, most new facilities would be built within disturbed areas and would therefore have a negligible impact on terrestrial resources. However, in the 200-West Area, new facilities would be constructed on 0.6 hectares (1.5 acres) of sagebrush habitat within STTS-West. Facilities within and adjacent to the 200-East Area would impact 4.2 hectares (10.4 acres) of sagebrush habitat. The loss of sagebrush habitat associated with construction of the 200-East Area underground transfer line and facilities in STTS-West would not be mitigable. Also, mitigation would not be required within STTS-East since the loss of sagebrush habitat does not meet the minimum mitigation threshold (5 hectares [12.5 acres]) (DOE 2003f:20, 21).

Impacts on terrestrial resources during operations would be similar to those described in Section 4.1.7.2.1 and those during closure in Section 4.1.7.3.1.

Under Alternative 3C, 93.9 hectares (232 acres) of Borrow Area C would be excavated to supply needed geologic material. Overall impacts on terrestrial resources from the excavation of geologic material from the area would be similar to those described above under Alternative 3A.

4.1.7.6.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas and Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.6.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.6.

4.1.7.6.4 Threatened and Endangered Species

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas or Borrow Area C; therefore, impacts on this group of plants and animals are not expected under this alternative.

Although slightly more land would be required under this alternative than under Alternative 3A, construction would take place within the same general areas. Thus, potential impacts on state-listed, special status species would be similar to those discussed in Section 4.1.7.4.4. Mitigation requirements, including preparation of a mitigation action plan, would be similar to those discussed in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on special status species resulting from excavation of geologic material from 93.9 hectares (232 acres) in Borrow Area C generally would be similar to those described under Alternative 2A (see Section 4.1.7.2.4). As is the case under Alternative 2A, specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.7.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

4.1.7.7.1 Terrestrial Resources

As noted in Section 4.1.1.7.1, 17.8 hectares (44.1 acres) would be needed for construction of new facilities within the 200 Areas under this alternative. Of this total, 13.7 hectares (33.8 acres) would be needed within adjacent to the 200-East Area and 4.2 hectares (10.3 acres) within the 200-West Area. Most new facilities would be built within disturbed areas and would therefore have a negligible impact on terrestrial resources. However, within and adjacent to the 200-East Area, new facilities would impact a total of 4 hectares (9.9 acres) of sagebrush habitat. Within the 200-West Area, new facilities would be constructed on 0.4 hectares (1.1 acres) of sagebrush habitat. The loss of sagebrush habitat associated with construction of the 200-East Area underground transfer line and facilities in STTS-West would not be mitigable. Also, mitigation would not be required within STTS-East since the loss of sagebrush habitat does not meet the minimum mitigation threshold (5 hectares [12.5 acres]) (DOE 2003f:20, 21).

Impacts on terrestrial resources during operations would be similar to those described in Section 4.1.7.2.1; impacts on terrestrial resources during closure would be similar to those described in Section 4.1.7.3.1. While clean closure of the BX and SX tank farms and six sets of cribs and trenches (ditches) has the potential to increase wildlife habitat provided that native plant communities have been reestablished, being in the highly developed 200 Areas the remediated areas could also be used for other industrial purposes.

Under Alternative 4, 102 hectares (252 acres) of Borrow Area C would be excavated to supply needed geologic material. Overall impacts on terrestrial resources from the excavation of geologic material from the area would be similar to those described above under Alternative 3A.

4.1.7.7.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas and Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.7.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.7.

4.1.7.7.4 Threatened and Endangered Species

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas and Borrow Area C; therefore, impacts on this group of plants and animals are not expected under this alternative.

Facilities built under Alternative 4 would disturb about the same amount of land within the same areas (i.e., the 200-East underground transfer line, STTS-East, and STTS-West) as is the case under Alternative 3A. Thus, potential impacts on state-listed, special status species would be similar to those discussed in Section 4.1.7.4.4. Mitigation requirements, including preparation of a mitigation action plan, would be similar to those discussed in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on special status species resulting from excavation of geologic material from 102 hectares (252 acres) in Borrow Area C generally would be similar to those described under Alternative 2A (see Section 4.1.7.2.4). As is the case under Alternative 2A, specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.7.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

4.1.7.8.1 Terrestrial Resources

As noted in Section 4.1.1.8.1, 20.2 hectares (49.9 acres) would be needed for construction of new facilities within the 200 Areas under this alternative. Of this total, 16 hectares (39.6 acres) within or adjacent to the 200-East Area and 4.2 hectares (10.3 acres) within the 200-West Area would be disturbed. Most new facilities would be built within disturbed areas and would therefore have a negligible impact on terrestrial resources. However, within and adjacent to the 200-East Area, new facilities would impact a total of 4 hectares (9.9 acres) of sagebrush habitat, and within the 200-West Area, new facilities would be constructed on 0.4 hectares (1.1 acres) of sagebrush habitat. The loss of sagebrush habitat associated with construction of the 200-East Area underground transfer line and facilities in STTS-West would not be mitigable. Also, mitigation would not be required within STTS-East since the loss of sagebrush habitat does not meet the minimum mitigation threshold (5 hectares [12.5 acres]) (DOE 2003f:20, 21).

Under Alternative 5, 118 hectares (291 acres) of Borrow Area C would be excavated to supply needed geologic material. Overall impacts on terrestrial resources from the excavation of geologic material from the area would be similar to those described above under Alternative 2A (see Section 4.1.7.2.1).

4.1.7.8.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas and Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.8.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.8.

4.1.7.8.4 Threatened and Endangered Species

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas and Borrow Area C; therefore, impacts on this group of plants and animals are not expected under this alternative.

Although slightly more land would be required under Alternative 5 compared with Alternative 3A, construction would take place within the same general areas. Thus, potential impacts on state-listed, special status species would be similar to those discussed in Section 4.1.7.4.4. Mitigation requirements, including preparation of a mitigation action plan, would be similar to those discussed in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on state-listed, special status species resulting from excavation of geologic material from 118 hectares (291 acres) in Borrow Area C generally would be similar to those described under Alternative 2A (see Section 4.1.7.2.4). As is the case under Alternative 2A, specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.7.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.7.9.1 Terrestrial Resources

4.1.7.9.1.1 Base Case

As noted in Section 4.1.1.9.1, under this alternative, 210 hectares (519 acres) would be needed for construction of new facilities within the 200 Areas. Of this total, 207 hectares (511 acres) would be required within or adjacent to the 200-East Area and 3.2 hectares (8 acres) within the 200-West Area. Most of the land (i.e., 182 hectares [450 acres]) within or adjacent to the 200-East Area that would be used for new construction contains sagebrush habitat, while sagebrush habitat would not be affected in the 200-West Area. The loss of sagebrush habitat associated with construction of the 200-East Area underground transfer line and facilities in STTS-West would not be mitigable; however, Hanford guidance may require the replacement of other sagebrush habitat at a ratio ranging from 1:1 to 3:1 (DOE 2003f:20, 21, 31). Specific measures to be taken in connection with mitigating this loss would be set forth in a mitigation action plan prior to construction.

Implementation of this alternative would result in impacts on wildlife similar in nature to those described in Section 4.1.7.2.1; however, due to the greater extent of habitat destruction, the extent of the impacts would be greater. Since the tank farms would undergo clean closure, the area occupied by the farms would be available for unrestricted use. If that use involved revegetation with native species, there would be an opportunity to increase terrestrial habitat in the area, including sagebrush habitat. Operational impacts on terrestrial resources would be somewhat greater than those addressed in Section 4.1.7.2.1.

Under Alternative 6A, Base Case, 494 hectares (1,220 acres) of Borrow Area C would be excavated to supply needed geologic material. As noted in Chapter 3, Section 3.2.7.1, the two major communities present within the area are Sandberg's bluegrass/cheatgrass (782 hectares [1,933 acres]) and needle-and-thread grass/Indian ricegrass (107 hectares [265 acres]) (see Chapter 3, Figure 3–19). The latter represents an unusual and relatively pristine community type at Hanford and thus is considered a more highly valued community than the former. It is not possible to determine specific impacts on ecological resources of developing Borrow Area C since the area(s) from which different types of geologic material would be excavated is not known. However, since approximately 53.1 percent of Borrow Area C would

be developed, it is likely that at least some of the more highly valued needle-and-thread grass/Indian ricegrass community would be impacted. To the extent that it is possible, the needle-and-thread grass/Indian ricegrass community should be avoided.

4.1.7.9.1.2 Option Case

Impacts on terrestrial resources under this option would generally be similar to those described for the Base Case (see Section 4.1.7.9.1.1), including the loss of 182 hectares (450 acres) of sagebrush habitat. However, under the Option Case, a modified RCRA Subtitle C landfill barrier would not be used to cover the six sets of cribs and trenches (ditches) since they would be removed and their deep plumes remediated. Thus, compared with the Base Case, an additional 25.4 hectares (62.7 acres) of land would become available for alternative uses in the future, including possible restoration of shrub-steppe habitat.

The Option Case would require that 571 hectares (1,410 acres) of land be excavated within Borrow Area C to supply needed geologic material. Although somewhat more habitat would be disturbed, impacts on ecological resources, including the highly valued needle-and-thread grass/Indian ricegrass community, would be similar to those described above for the Base Case.

4.1.7.9.2 Wetlands

4.1.7.9.2.1 Base and Option Cases

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas or Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of either the Base or Option Case would not impact any site wetlands.

4.1.7.9.3 Aquatic Resources

4.1.7.9.3.1 Base and Option Cases

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.9.

4.1.7.9.4 Threatened and Endangered Species

4.1.7.9.4.1 Base Case

Under this alternative, a number of state-listed, special status species have been observed within areas that would be disturbed by construction. The black-tailed jackrabbit (state candidate) and Piper's daisy (state sensitive) have been identified along the route of the 200-East Area underground transfer line. Two listed plants, stalked-pod milkvetch and crouching milkvetch (both state watch), were observed in the area where the IHLW Interim Storage Modules (and replacements), replacement WTP, and new DSTs would be built. Due to the presence of sagebrush habitat within these areas, other special status species could potentially be present. Also, under this alternative the PPF and Packaged HLW Debris Storage Facility would be constructed between the 200-East Area and 200-West Areas. The loggerhead shrike, black-tailed jackrabbit, sage sparrow, and crouching milkvetch have all been observed within this area. Mitigation measures, including the preparation of a mitigation action plan, would be similar to those described in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers over the six sets of cribs and trenches (ditches) during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

As noted in Section 4.1.7.2.4, surveys have identified Piper's daisy (state sensitive), stalked-pod milkvetch, crouching milkvetch, and the long-billed curlew (state monitor) within the boundaries of Borrow Area C. Due to the extent of development under this alternative it is highly likely that one or all of these species could be impacted by the excavation of geologic material. Mitigation measures related to special status species are addressed in Section 4.1.7.2.4 and would include the preparation of a mitigation action plan prior to site development.

4.1.7.9.4.2 Option Case

Impacts on special status species generally would be similar to those described above for the Base Case; however, since an additional 76.5 hectares (189 acres) would be excavated within Borrow Area C, potential impacts on state-listed species would be greater.

4.1.7.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.7.10.1 Terrestrial Resources

4.1.7.10.1.1 Base Case

As noted in Section 4.1.1.10.1, under this alternative 117 hectares (288 acres) would be needed for construction of new facilities within the 200 Areas. Of this total, 113 hectares (279 acres) would be required within or adjacent to the 200-East Area and 3.7 hectares (9.1 acres) within the 200-West Area. Most of the land (i.e., 100 hectares [248 acres]) within or adjacent to the 200-East Area has not been disturbed; all but 2 hectares (5 acres) is sagebrush habitat. Only previously disturbed areas would be utilized in the 200-West Area. The loss of sagebrush habitat associated with construction of the 200-East Area underground transfer line and facilities in STTS-West would not be mitigable; however, Hanford guidance may require the replacement of other sagebrush habitat at a ratio ranging from 1:1 to 3:1 (DOE 2003f:20, 21, 31). Specific measures to be taken in connection with mitigating the loss of sagebrush habitat would be set forth in a mitigation action plan prior to construction.

Under this option, the tank farms would undergo clean closure; thus, the area occupied by these farms would be available for unrestricted use. If that use involved revegetation with native species, there would be an opportunity to increase terrestrial habitat in the area, including sagebrush habitat. Operational impacts would be similar to those addressed in Section 4.1.7.2.1.

Under Alternative 6B, Base Case, 239 hectares (591 acres) of Borrow Area C would be excavated to supply needed geologic material. Impacts on terrestrial resources from the excavation of geologic material from the area would be similar to but somewhat less than those described for the Base Case of Alternative 6A (see Section 4.1.7.9.1.1).

4.1.7.10.1.2 Option Case

Impacts on terrestrial resources under this case would generally be similar to those described for the Base Case (see Section 4.1.7.9), including the loss of 98.3 hectares (243 acres) of sagebrush habitat. However, under the Option Case, a modified RCRA Subtitle C landfill barrier would not be used to cover the six sets of cribs and trenches (ditches) since they would be removed and their deep plumes remediated. Thus, compared with the Base Case, an additional 25.4 hectares (62.7 acres) of land would become available for alternative uses in the future, including possible restoration of shrub-steppe habitat.

Under the Option Case, 316 hectares (780 acres) would need to be excavated from Borrow Area C to supply geologic material. Since this land represents about 34.1 percent of Borrow Area C as compared with 20 percent for the Base Case, potential impacts on the highly valued needle-and-thread grass/Indian ricegrass community would be greater. To the extent that it is possible, the needle-and-thread grass/Indian ricegrass community should be avoided.

4.1.7.10.2 Wetlands

4.1.7.10.2.1 Base and Option Cases

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas and Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.10.3 Aquatic Resources

4.1.7.10.3.1 Base and Option Cases

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.10.

4.1.7.10.4 Threatened and Endangered Species

4.1.7.10.4.1 Base Case

Under this alternative, a number of state-listed, special status species have been observed within areas that would be disturbed by construction. The black-tailed jackrabbit (state candidate) and Piper's daisy (state sensitive) have been identified along the route of the 200-East Area underground transfer line. Two listed plants, stalked-pod milkvetch and crouching milkvetch (both state watch), were observed within the area where the ILAW Storage Facility would be built. Due to the presence of sagebrush habitat within this area, other special status species could potentially be present. Also, under this alternative the Packaged HLW Debris Storage Facility would be constructed between the 200-East and 200-West Areas. The loggerhead shrike, black-tailed jackrabbit, sage sparrow, and crouching milkvetch have all been observed within this area. Mitigation measures, including the preparation of mitigation action plan, would be similar to those described in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers over the six sets of cribs and trenches (ditches) during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on state-listed special status species resulting from excavation of geologic material from 239 hectares (591 acres) in Borrow Area C generally would be similar to those described under Alternative 6A (see Section 4.1.7.9.4). As is the case under Alternative 6A, specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.7.10.4.2 Option Case

Impacts on special status species would be similar to those noted above for the Base Case although a greater potential exists to affect these species within Borrow Area C due to the greater area of habitat disturbed (i.e., 316 hectares [780 acres] versus 239 hectares [591 acres]).

4.1.7.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

4.1.7.11.1 Terrestrial Resources

As noted in Section 4.1.1.11.1, under this alternative, 61.1 hectares (151 acres) would be disturbed by construction of new facilities within the 200 Areas. Of this total, 57.5 hectares (142 acres) within or adjacent to the 200-East Area and 3.7 hectares (9.1 acres) within the 200-West Area would be utilized. Most of the land (i.e., 46.1 hectares [114 acres]) within or adjacent to the 200-East Area that would be used for new construction contains sagebrush habitat, while only previously disturbed areas would be affected in the 200-West Area; The loss of sagebrush habitat associated with construction of the 200-East Area underground transfer line would not be mitigable; however, Hanford guidance may require the replacement of other sagebrush habitat at a ratio of 3:1 (DOE 2003f:20, 21, 31). Specific measures to be taken in connection with mitigating the loss of sagebrush habitat would be set forth in a mitigation action plan prior to construction.

Construction and operational impacts of this alternative on wildlife would be similar to those described in Section 4.1.7.2.1. Impacts on terrestrial resources during closure would be similar to those described in Section 4.1.7.3.1.

Under Alternative 6C, a total of 104 hectares (257 acres) of Borrow Area C would be excavated to supply needed geologic material. Impacts on terrestrial resources from the excavation of geologic material from the area would be similar to those described above under Alternative 2A (see Section 4.1.7.2.1).

4.1.7.11.2 Wetlands

As noted in Chapter 3, Section 3.2.7.2, there are no wetlands within the 200 Areas and Borrow Area C, although West Lake is located about 4.8 kilometers (3 miles) to the north of the 200 Areas. Implementation of this alternative would not impact any site wetlands.

4.1.7.11.3 Aquatic Resources

The five ponds associated with the LERF and the TEDF, which are located within and adjacent to the 200-East Area, would not be directly affected by construction of any of the new facilities planned for the area. During operations they would receive effluent discharges. As noted in Chapter 3, Section 3.2.7.3.2, these ponds do not support fish populations but are accessible to wildlife. There are no aquatic resources within Borrow Area C. Potential indirect impacts on Columbia River aquatic resources of air emissions and groundwater are addressed in Chapter 5, Section 5.1.3.11.

4.1.7.11.4 Threatened and Endangered Species

Under this alternative, a number of state-listed, special status species have been observed within areas that would be disturbed by construction. The black-tailed jackrabbit (state candidate) and Piper's daisy (state sensitive) have been identified along the route of the 200-East Area underground transfer line. Two listed plants, stalked-pod milkvetch and crouching milkvetch (both state watch), were observed within the area where the ILAW Storage Facility would be built. Due to the presence of sagebrush habitat within this area, other special status species could potentially be present. Mitigation measures, including the preparation of mitigation action plan, would be similar to those described in Section 4.1.7.2.4.

The operation of new facilities is not expected to impact any listed species. Placement of landfill barriers over the 18 tank farms and six sets of cribs and trenches (ditches) during closure also is not expected to disturb any listed species, as none have been identified in the affected areas.

Impacts on state-listed, special status species resulting from excavation of geologic material from 104 hectares (257 acres) in Borrow Area C generally would be similar to those described under Alternative 2A (see Section 4.1.7.2.4). As is the case under Alternative 2A, specific impacts cannot be identified since the exact areas to be excavated are not known. A mitigation action plan would be developed prior to excavation.

4.1.8 Cultural and Paleontological Resources

4.1.8.1 Alternative 1: No Action

Under Alternative 1, No Action, no new facilities would be constructed within either the 200-East or 200-West Area and construction of the WTP and Canister Storage Building would be terminated. The survey and geology of the 200-East and 200-West Areas indicate that the potential for subsurface archaeological resources is low; therefore, cultural resource monitoring would not be needed (Brockman 2007:Enclosure 2).

The No Action Alternative would require a commitment of land within the 200 Areas over the long term. Additionally, 2 hectares (5 acres) of geological material would be excavated from Borrow Area C for use in stabilization of tanks and closure of the WTP. The survey and geology of Borrow Area C indicate that subsurface cultural deposits have no potential or a low potential of being present. The location of excavation activities in Borrow Area C would determine where cultural monitoring would be required (Brockman 2007:Enclosure 2).

4.1.8.1.1 Prehistoric Resources

As noted in Chapter 3, Section 3.10.1.2, the prehistoric White Bluffs Road, which was in use prior to exploration and settlement of the area, traverses the northwest portion of the 200-West Area in a southwest to northeast direction. The only other prehistoric resources found in the 200 Areas were two cryptocrystalline flakes (i.e., fragments chipped from a rock core during tool making) found northwest of White Bluffs Road and one cryptocrystalline projectile point base located just to the east of the 200-East Area. Since there will be no new construction under this alternative, prehistoric resources will not be disturbed.

If prehistoric resources were discovered during the excavation of geologic material from Borrow Area C, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.1.2 Historic Resources

Historic artifacts found within or adjacent to the 200-East Area include a number of historic cans and bottles. These artifacts would not be affected under this alternative. There would be no impact on White Bluffs Road or other early historic artifacts within the 200-West Area, as all such resources are located in the northwest part of the area and would not be affected by construction of the underground transfer line. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. Mitigation of the Atmospheric Dispersion Grid has been completed in accordance with the *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan* (Marceau 1998). As is the case for

prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.1.3 American Indian Interests

Under this alternative, no resources would be directly affected by project-related facilities. White Bluffs Road would not be impacted by construction of the underground transfer line. The two cryptocrystalline flakes and the projectile point base found in the 200 Areas were collected and curated by site archaeologists upon discovery. Rattlesnake Mountain, Gable Mountain, and Gable Butte, all of which are important to American Indians for religious and other cultural purposes, would not be directly affected under this alternative. As noted in Section 4.1.1.2.2, the industrial appearance of the 200-East and 200-West Areas from State Route 240 and nearby higher elevations would remain largely unchanged. The 2 hectares (5 acres) of Borrow Area C that would be excavated would be noticeable from these higher elevations, although this development would not dominate the view. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.1.4 Paleontological Resources

There would be no impacts on paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were discovered during the excavation of geologic material from Borrow Area C, procedures are in place to properly manage the discovery site.

4.1.8.2 Alternative 2A: Existing WTP Vitrification; No Closure

4.1.8.2.1 Prehistoric Resources

Under Alternative 2A, there would be no impact on known prehistoric resources. If prehistoric resources were discovered during the excavation of geologic material from Borrow Area C, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.2.2 Historic Resources

Under Alternative 2A, there would be no impact on White Bluffs Road or other known early historic artifacts within the 200-West Area, as all such resources are located in the northwest part of the area and would not be affected by construction of the underground transfer line. As is the case for prehistoric resources, if historic resources were discovered during the excavation of geologic material from Borrow Area C, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.2.3 American Indian Interests

Under this alternative, no resources would be directly affected by project-related facilities. The construction of the underground transfer line and changes in the 200-East Area would not be visible from State Route 240. Rattlesnake Mountain, Gable Mountain, and Gable Butte, all of which are important to American Indians for religious and other cultural purposes, would not be affected under this alternative, and, as noted in Section 4.1.1.3.2, the view from these places would remain largely unchanged. However, the 27.5 hectares (68 acres) excavated from Borrow Area C would be readily visible from State Route 240 and Rattlesnake Mountain. Upon completion of work, Borrow Area C would be revegetated, lessening the visual impact. As is the case for prehistoric and historic resources, if any artifacts that have importance to American Indians were discovered during excavation of geologic material from Borrow

Area C, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.2.4 Paleontological Resources

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were discovered during excavation of geologic material from Borrow Area C, procedures are in place to properly manage the discovery site.

4.1.8.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

4.1.8.3.1 Prehistoric Resources

Under Alternative 2B, there would be no impact on known prehistoric resources. If prehistoric resources were discovered during construction or excavation of geologic material from Borrow Area C, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.3.2 Historic Resources

Under Alternative 2B, there would be no impact on White Bluffs Road or other known early historic artifacts within the 200-West Area, as all such resources are located in the northwest part of the area and would not be affected by construction of the underground transfer line. As is the case for prehistoric resources, if historic resources were discovered during construction or excavation, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.3.3 American Indian Interests

Under this alternative, visual impacts would be similar to those described in Section 4.1.8.2.3 under Alternative 2A; however, as part of landfill closure, the 200-East and 200-West Area containment structures and closure barriers would be visible from nearby higher elevations Rattlesnake Mountain, Gable Mountain, and Gable Butte, all of which are important to American Indians for religious and other cultural purposes. The view from these places would remain largely unchanged. Under this alternative, 94.7 hectares (234 acres) of Borrow Area C would be excavated. The development of Borrow Area C would be readily visible from these sites. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impacts. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.3.4 Paleontological Resources

There would be no impacts on paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction or excavation, procedures are in place to properly manage the discovery site.

4.1.8.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

4.1.8.4.1 Prehistoric Resources

Under Alternative 3A, existing prehistoric resources would not be affected. If prehistoric resources were discovered during construction or excavation, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.4.2 Historic Resources

Under this alternative, there would be no impact on White Bluffs Road or other early historic artifacts within the 200-East and 200-West Areas, as none are located within areas to be disturbed by new facilities. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the case for prehistoric resources, if historic resources were discovered during excavation or construction, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.4.3 American Indian Interests

Under this alternative, visual impacts would be similar to Alternative 2B as described in Section 4.1.8.3.3. Construction and closure activities would not greatly change the industrial nature of the view from State Route 240 and nearby higher elevations. An additional 6.1 hectares (15 acres) of land would be disturbed within Borrow Area C, and the visual impacts would be similar to those described under Alternative 2B. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.4.4 Paleontological Resources

There would be no impacts on paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

4.1.8.5.1 Prehistoric Resources

Under Alternative 3B, known prehistoric resources would not be affected. If prehistoric resources were discovered during excavation or construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.5.2 Historic Resources

Under this alternative, there would be no impact on White Bluffs Road or known early historic artifacts within the 200-East and 200-West Areas, as none are located within the construction or excavation areas. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the

case for prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.5.3 American Indian Interests

Impacts on American Indian interests for this alternative would be similar to those described under Alternative 2B. Closure activities would not greatly change the industrial view of nearby higher elevations. The land requirement in Borrow Area C would be slightly less than under Alternative 3B (e.g., 1.2 hectares [3 acres]) but visual impacts would be similar (see Section 4.1.1.3.2). As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.5.4 Paleontological Resources

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

4.1.8.6.1 Prehistoric Resources

Under Alternative 3C, known prehistoric resources would not be affected. If prehistoric resources were discovered during construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.6.2 Historic Resources

Under this alternative, there would be no impact on White Bluffs Road or known early historic artifacts within the 200-East or 200-West Area, as all such resources are located in the northwest part of the area and would not be affected by construction or excavation. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the case for prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.6.3 American Indian Interests

Under this alternative, visual impacts would be similar to those in Section 4.1.8.3.3 under Alternative 2B. Construction, operations, deactivation and closure activities would not greatly change the industrial nature of the view and approximately the same amount of geologic material would be required in Borrow Area C. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.6.4 Paleontological Resources

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

4.1.8.7.1 Prehistoric Resources

Under Alternative 4, known prehistoric resources would not be affected. If prehistoric resources were discovered during construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.7.2 Historic Resources

Under this alternative, there would be no impact on White Bluffs Road or other known early historic artifacts within the 200-East or 200-West Area, as all such resources are located in the northwest part of the area and would not be affected by construction or excavation. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the case for prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.7.3 American Indian Interests

Under this alternative, visual impacts would be similar to those described in Section 4.1.8.3.3 under Alternative 2B. Although an additional 7.3 hectares (18 acres) of land within Borrow Area C would be disturbed, the view would remain largely unchanged. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.7.4 Paleontological Resources

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

4.1.8.8.1 Prehistoric Resources

Under Alternative 5, known prehistoric resources would not be affected if prehistoric resources were discovered during construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.8.2 Historic Resources

Under this alternative, there would be no impact on White Bluffs Road or other known early historic artifacts within the 200-East or 200-West Area, as all such resources are located in the northwest part of the area and would not be affected by construction or excavation. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the case for prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.8.3 American Indian Interests

The impacts on American Indian interests under this alternative would be similar to those under Alternative 2B for construction, operations, deactivation, and closure activities. The industrial nature of the view from State Route 240 and higher elevations would not greatly change.

Under this alternative, 118 hectares (291 acres) of Borrow Area C would be excavated. Development of Borrow Area C would be visible from Rattlesnake Mountain and result in the BLM visual resource management rating changing from Class II to Class IV (see Section 4.1.1.8.2). Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.8.4 Paleontological Resources

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.8.9.1 Prehistoric Resources

4.1.8.9.1.1 Base Case

Under Alternative 6A, Base Case, prehistoric resources would not be affected. If prehistoric resources were discovered during construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.9.1.2 Option Case

As with the Base Case, under Alternative 6A, Option Case, known prehistoric resources would not be affected. If prehistoric resources were discovered during excavation of this alternative, appropriate measures would be implemented.

4.1.8.9.2 Historic Resources

4.1.8.9.2.1 Base Case

There would be no impact on White Bluffs Road or other known early historic artifacts within the 200-East and 200-West Areas, as all such resources are located in the northwest part of the area and would not be affected by construction or excavation. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the case for prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.9.2.2 Option Case

As noted in Section 4.1.8.9.2.1 above, Alternative 6A, Option Case, would not affect historic resources.

4.1.8.9.3 American Indian Interests

4.1.8.9.3.1 Base Case

Under this alternative case, 210 hectares (519 acres) would be converted to industrial use. The majority of this land would be adjacent to the 200-East Area. Facilities constructed would noticeably add to the industrial nature of the 200 Areas and would be visible from nearby higher elevations (see Section 4.1.1.10.2.1). The viewscape from these higher elevations is important to American Indians with cultural ties to Hanford.

In addition, 494 hectares (1,220 acres) of Borrow Area C would be excavated in connection with this alternative. This would be visible from Rattlesnake Mountain, an area of cultural significance to the American Indians. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.9.3.2 Option Case

Activities and impacts under the Option Case would be similar to those discussed above under the Base Case. Remediation of the deep plumes would require more fill material. It would be necessary to excavate an additional 76.5 hectares (189 acres) of Borrow Area C compared with the Base Case. This excavation would cause a greater impact on the view from higher elevations such as Rattlesnake Mountain. As noted in the Base Case, excavations in Borrow Area C would be recontoured and revegetated upon completion of work, thereby lessening the visual impact. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.9.4 Paleontological Resources

4.1.8.9.4.1 Base Case

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.9.4.2 Option Case

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.8.10.1 Prehistoric Resources

4.1.8.10.1.1 Base Case

Under Alternative 6B, Base Case, known prehistoric resources would not be affected. If prehistoric resources were discovered during construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.10.2 Option Case

Similar to Alternative 6B, Base Case, prehistoric resources would not be affected under the Option Case.

4.1.8.10.3 Historic Resources

4.1.8.10.3.1 Base Case

There would be no impact on White Bluffs Road or other known early historic artifacts within the 200-East or 200-West Area, as all such resources are located in the northwest part of the area and would not be affected by construction or excavation. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the case for prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.10.3.2 Option Case

Similar to the Base Case, historic structures would not be affected under the Option Case.

4.1.8.10.4 American Indian Interests

4.1.8.10.4.1 Base Case

Under Alternative 6B, Base Case, there would be an overall increase in the industrial appearance of the 200 Areas, although less than half as much land within the 200 Areas would be converted to industrial use. The BLM Visual Resource Management Class IV rating would not change. Approximately

239 hectares (591 acres) of Borrow Area C would be excavated. This would be visible from Rattlesnake Mountain, and thus would have an impact on the viewscape. The BLM visual resource management rating would change from Class II to Class IV. Upon completion of the work, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.10.4.2 Option Case

Activities and visual impacts would be similar to those noted in the Base Case above. Remediation of the deep plumes would result in an additional 76.5 hectares (189 acres) within Borrow Area C compared with the Base Case. This would further impact the view from State Route 240 and nearby higher elevations.

4.1.8.10.5 Paleontological Resources

4.1.8.10.5.1 Base Case

There would be no impacts on known paleontological resources under this alternative case, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.10.5.2 Option Case

There would be no impacts on known paleontological resources under this alternative case, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.8.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

4.1.8.11.1 Prehistoric Resources

Under Alternative 6C, known prehistoric resources would not be affected. If prehistoric resources were discovered during construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

4.1.8.11.2 Historic Resources

Under this alternative, there would be no impact on White Bluffs Road or other known early historic artifacts within the 200-East and 200-West Areas, as all such resources are located in the northwest part of the area and would not be affected by construction or excavation. Buildings associated with the Manhattan Project and Cold War era are found within both the 200-East and 200-West Areas; however, none of these structures would be affected under this alternative. As is the case for prehistoric resources, if historic resources were discovered, procedures are in place to properly identify, evaluate, record, curate, and manage the discovery site.

4.1.8.11.3 American Indian Interests

Under Alternative 6C, newly constructed aboveground facilities would add to the overall industrial view from the higher elevations, such as Rattlesnake Mountain, which is important to American Indians with cultural ties to Hanford. Although the overall view would change, the BLM Visual Resource Management Class IV rating would not change. In addition, 104 hectares (257 acres) of Borrow Area C would be excavated. This would also be visible from Rattlesnake Mountain and would result in the BLM visual resource management rating changing from Class II to Class IV. Upon completion of work under this alternative, excavations in Borrow Area C would be recontoured and revegetated, thereby lessening the visual impact. As is the case for prehistoric and historic resources, if any artifacts were discovered during construction that have importance to American Indians, procedures are in place to properly manage the discovery site. If there were visual impacts on American Indian interests, appropriate mitigation measures would be developed in consultation with area tribes.

4.1.8.11.4 Paleontological Resources

There would be no impacts on known paleontological resources under this alternative, as no such resources have been discovered within the 200 Areas. As is the case for other cultural resources, if any paleontological resources were found during construction, procedures are in place to properly manage the discovery site.

4.1.9 Socioeconomics

The potential primary (direct) and secondary (indirect) impacts of all tank closure activities on employment, regional demographics, housing and community services, and local transportation were analyzed for this section of the EIS. The potential primary impacts were set forth by analyzing projected changes in employment (in terms of full-time equivalents [FTEs]) and truck activity related to the activities in each alternative (see Appendix I). The projected changes in employment and truck activity have the potential to generate economic impacts that may affect the need for housing units, public services, and local transportation in the region.

Projected changes in employment would likely result in additional, secondary changes in employment, salaries, and expenditures in the area, as well as changes in demands for social services. Analysis of these potential secondary economic and social impacts across the alternatives was conducted using a blended multiplier develop by the U.S. Department of Commerce, Bureau of Economic Analysis's Regional Input-Output Modeling System specifically for the Tri-Cities area, which is made up of Richland, Pasco, and Kennewick. The multiplier used was a blend of the new industrial and commercial construction multiplier and the engineering and architectural services multiplier. The value of the blended multiplier was approximately 1.75, meaning that for each full-time worker employed in support of tank closure activities, approximately three-quarters of an additional full-time job could be created elsewhere in the regional economy (Perteet, Thomas/Lane, and SCM 2001).

When calculating workforce estimates, partial FTE employee quantities were rounded up to the nearest whole FTE. The resulting conservative workforce estimates represent the upper limit of workforce requirements. For each type of activity (e.g., construction, operations, closure), a peak workforce estimate was calculated and the year(s) in which the peak occurred was noted. Since each activity type may peak during different years, the totals do not add up, as they represent different time periods.

The projected workforce estimates could also potentially impact the local commuter traffic. A 2005 commuter survey found that 88 percent of the employees commuting to Hanford do so in single-occupancy vehicles, while 12 percent of the vehicles were carpools or vanpools (two or more persons) (BFCOG 2006). It was assumed that employees would commute to work in vehicles with an

average of 1.25 passengers each (Malley 2007). In addition, the number of calculated truck trips associated with the various activities was rounded up to the nearest whole trip.

Common Socioeconomic Impacts

The potential socioeconomic impacts from the alternatives below have many commonalities based on the activities associated with them. The construction, operations, and deactivation of the WTP and its replacements most often dominate the employment requirements for many of the Tank Closure alternatives.

As can be seen in Figure 4–16, each alternative includes at least one peak employment period generally followed by an employment decline. Most alternatives include several growth periods with a leveling off in between. Most alternatives also include reduced workforce estimates for the final years to provide administrative controls of remaining facilities and postclosure care. During the high employment periods, an increase in the projected workforce would result in some in-migration of workers from outside the region and their associated secondary impacts on the local economy. The number of immigrating workers accompanied by their families and their associated family sizes would affect the predicted impacts for most public services.

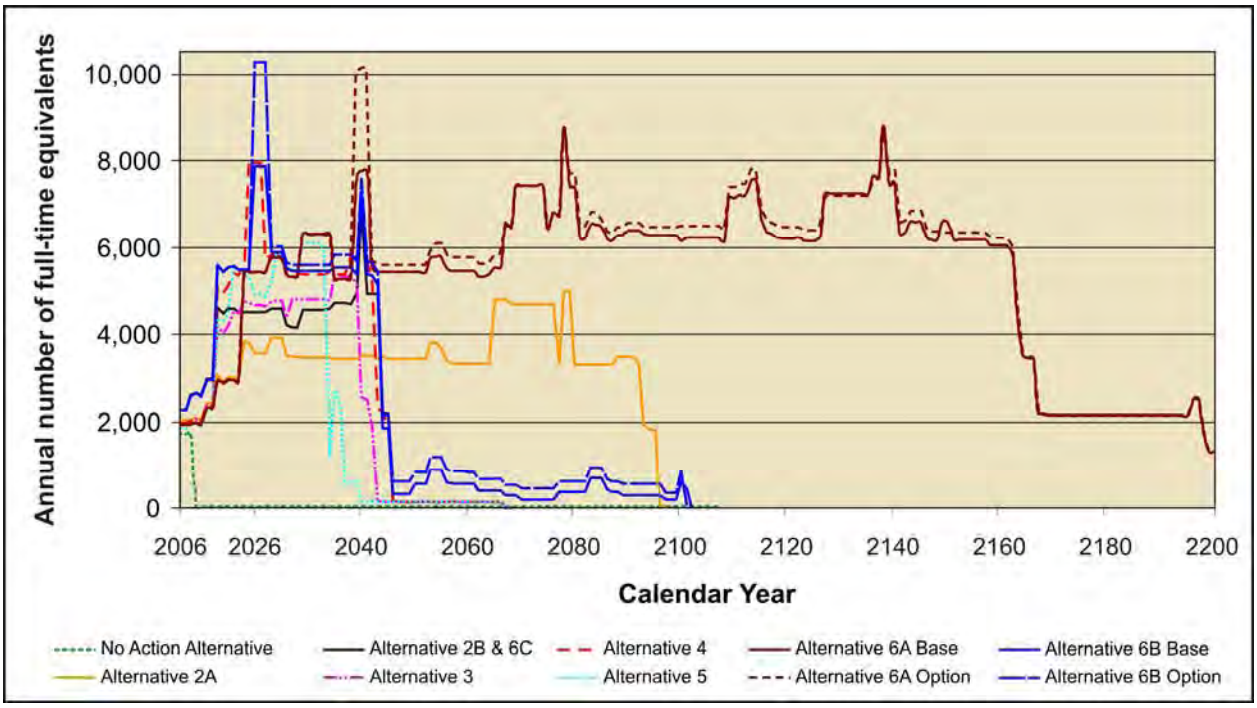


Figure 4–16. Tank Closure Alternatives – Annual Workforce Estimates (2006–2200)

After some peak employment periods, sharp drops in onsite employment might occur. These reductions could also potentially reduce the number of indirect jobs in the region supporting Hanford activities. If these workers are unable to find employment in other industries, they could move out of the region, thereby reducing the overall regional population and decreasing the demand for housing and community services (Perteet, Thomas/Lane, and SCM 2001:3-4).

In the area of transportation, annual workforce estimates impact commuter traffic whether or not workers are new to the community, since they all use local roads to access the project site. Increased traffic from both higher employment and additional truck shipments would result in additional impacts on the local transportation system. The current roadway system has no additional capacity during the commute hours, so all workforce increases would impact the major commute routes. These impacts could include

increased degradation of the roadways, increased congestion, and the need for increased maintenance to the roadways.

4.1.9.1 Alternative 1: No Action

Under Alternative 1, the No Action Alternative, total onsite employment as shown in Figure 4–16 would remain steady (1,730 FTEs) to 2008, then drop immediately to 15 FTEs needed to cover administrative controls for 100 years through 2107. Over 50 percent of the workforce (906 FTEs) during the peak years would be from construction activities (see Table 4–8) associated with the WTP. In addition to the direct employment associated with the No Action Alternative, approximately 1,300 indirect positions would likely be created as a secondary impact on the region in the peak years.

Table 4–8. Tank Closure Alternative 1 Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2006–2008	1,070
Operations	2006–2008	651
Deactivation	2008–2107	15

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

4.1.9.1.1 Regional Economic Characteristics

The No Action Alternative would have an immediate short-term effect on the regional economy. The 1,730 jobs would be approximately 1.4 percent of the projected labor force in the region of influence (ROI) (120,000 jobs in 2008). For comparison, in 2006 the employment of approximately 10,000 people at Hanford was about 10 percent of those employed in the Hanford ROI. Reduction in onsite employment and expenditures in 2009 would reduce the number of indirect jobs in the region supporting Hanford activities. If these workers are unable to find employment in other industries, they could move out of the region, thereby reducing the overall regional population and decreasing the demand for housing and community services.

4.1.9.1.2 Demographic Characteristics

The in-migration of workers to support construction of the WTP would increase rapidly during the early years of the project. The differential between the WTP impact and the baseline regional labor force projection would then get smaller, approaching zero with time. Therefore, any changes in demographic characteristics of the Tri-Cities area and the Hanford ROI would be largely reversed by implementation of Alternative 1.

4.1.9.1.3 Housing and Community Services

As construction on the WTP ceases in 2008, any demand for new housing and community services would also cease. Reduced demand for housing by construction and operations workers would likely reduce the cost and increase availability of houses and rental units.

4.1.9.1.4 Local Transportation

The traffic associated with the WTP, including both commuter and local truck traffic, would impact the local transportation system. Currently there is no excess capacity on the major Hanford commute routes during the peak commute hours. Under Washington State law, Benton and Franklin Counties and the cities of Kennewick, Pasco, Richland, and West Richland must adopt commute trip reduction (CTR)

program plans for major employers. The intent of the CTR plan is to reduce commutes by workers from their homes to major work sites during the peak period of 6:00 A.M. to 9:00 A.M. on weekdays. Construction work sites are generally excluded under the law, provided the construction duration is less than 2 years. The ongoing construction of the Hanford WTP would likely not be exempt. The current anticipated deadline for the Tri-Cities CTR plan is February 2009, and the ordinance deadline is September 2009 (BFCOG 2006:2-5, 2-6). As construction on the WTP ceases, traffic levels on roads in the region are also expected to be substantially reduced.

4.1.9.1.4.1 Commuter Traffic

Before termination of construction activities in 2008, about 1,700 employees would be commuting to the 200 Areas for activities associated with tank farm operations and WTP construction. Assuming an average of 1.25 persons per passenger vehicle, this could represent about 1,400 passenger vehicles per day commuting to the site. From 2009 through 2107, administrative controls would require about 15 FTEs. Therefore, commuter traffic to the 200-East and 200-West Areas at that time would decrease substantially as compared with recent levels.

4.1.9.1.4.2 Truck Traffic

The heaviest period of offsite truck activity would occur from 2006 through 2008 during construction of the WTP, prior to termination of activities in 2008. Around 1,000 trips per year (4 trips per day) would be required to deliver materials to the site. Onsite truck trips would also occur during construction of the WTP (over 20 trips per day). During the 100-year administrative control period, it is projected that there would be about 1 trip per year from offsite trucks delivering diesel fuel and gasoline to the site.

4.1.9.2 Alternative 2A: Existing WTP Vitrification; No Closure

Under Alternative 2A, near-term employment would increase to and then remain steady at or above 3,000 FTEs through 2064. The total onsite workforce would increase by nearly 50 percent starting in 2065, increasing to a peak of 4,920 FTEs in 2078 and 2079 (see Figure 4–16). From 2080 through 2092, the total onsite workforce would again be steady at or above 3,000 FTEs. The workforce employment for the remaining years would steadily decrease until 2097, when only 15 FTEs would be required to cover administrative controls. The existence of these direct jobs would be expected to result in the creation of another 3,700 indirect positions in the ROI during the peak years.

Under this alternative, the employment period would be dominated by construction and operations at the WTP. Construction of the WTP (2006 through 2017) and its replacement facility (2065 through 2076) dominate the construction workforce of up to 1,880 FTEs. From 2053 through 2076, over half of the roughly 3,010 FTE operations workers would be employed at the WTP (see Figure 4–17). The deactivation of the WTP and its replacement facility dominates the deactivation workforce as well with a projection of approximately 1,700 FTEs from 2078 through 2079 and again from 2094 through 2095 (see Table 4–9).

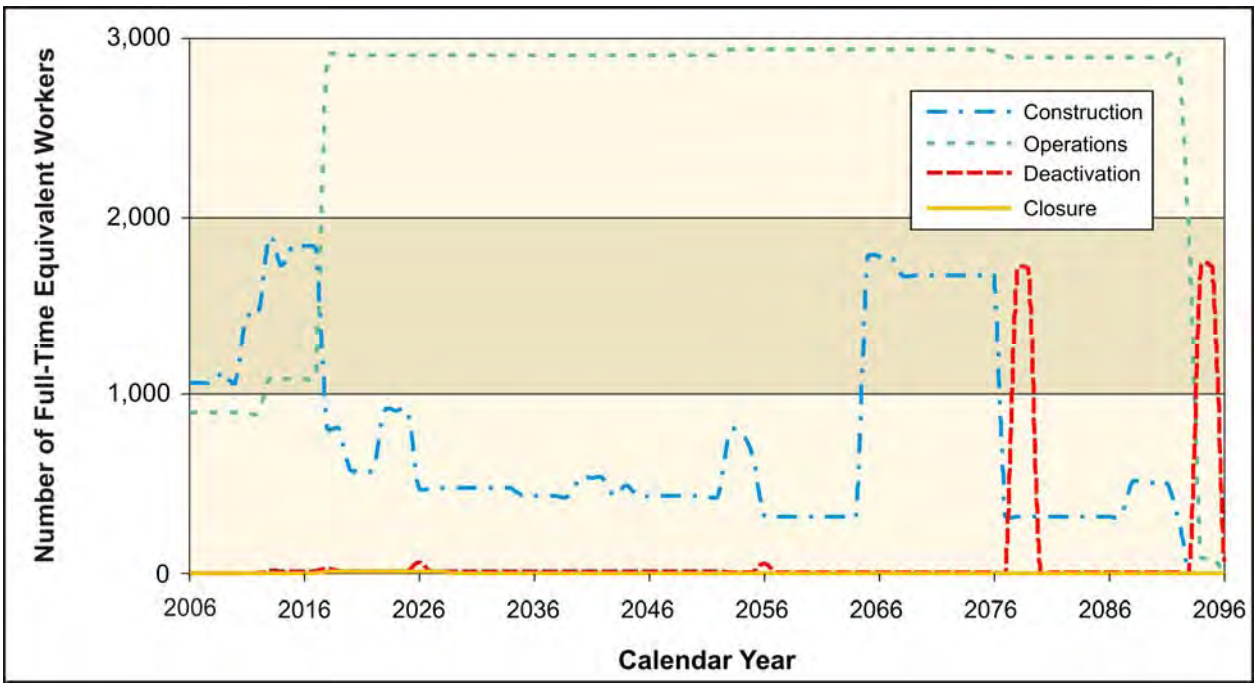


Figure 4–17. Tank Closure Alternative 2A Annual Estimated Onsite Full-Time Equivalent Workforce Requirements (2006–2096)

Table 4–9. Tank Closure Alternative 2A Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2013–2017 2065–2076	1,730–1,880 1,670–1,780
Operations	2018–2092	2,970–3,010
Deactivation	2078–2079 2094–2095	1,710 1,720–1,730
Closure	2018–2028	9

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

4.1.9.2.1 Regional Economic Characteristics

The peak workforce estimate of 4,920 jobs under Alternative 2A would occur in 2078 and 2079. This estimate is approximately 1.8 percent of the projected labor force in the ROI (267,000 in 2078) as compared with 10 percent in 2006. Nevertheless, implementing Alternative 2A could alter the economic characteristics of the region by increasing demands for goods and services in the Tri-Cities area over an extended period of time (i.e., approximately 90 years) due to increases in expenditures, income, and employment, both direct and indirect, at Hanford.

4.1.9.2.2 Demographic Characteristics

While the alternative would draw some workers from the local labor force, the continuing demand for operations workers under this alternative would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter the demographic characteristics of the region.

4.1.9.2.3 Housing and Community Services

Implementation of this alternative would increase the demand for housing and would impact schools and other community services within the Hanford ROI. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollments are expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.2.4 Local Transportation

Implementation of this alternative is expected to have an impact on the local transportation system, especially during the commute periods. It is expected that all new commute period trips would impact the regionally established level of service (LOS), reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.2.4.1 Commuter Traffic

Under Alternative 2A, the near-term peak years of construction and operations activity would begin in 2013. The projected increase in commuter traffic to the site would be primarily due to construction and operations at the WTP and other facilities. These activities could ultimately increase the number of site personnel to almost 4,920 FTEs annually in 2078 and 2079. Assuming an average of 1.25 persons per passenger vehicle, this could represent up to 4,000 passenger vehicles per day commuting to the site during peak years.

4.1.9.2.4.2 Truck Traffic

The number of annual offsite truck trips is projected to average over 2,000 trips per year (10 trips per day) from 2011 through 2095. The peak years for offsite truck traffic under Alternative 2A would be from 2065 through 2079, averaging around 3,400 trips per year. During that time, construction of the replacement WTP would account for the major portion of offsite truck traffic—3,920 peak truck trips (15 trips per day) in 2078 and 2079.

Onsite truck traffic supporting similar activities would peak from 2011 through 2017, requiring an average of about 15,500 truck trips per year (60 trips per day) to move concrete aggregate materials and other borrow materials on site. Onsite truck traffic would peak again from 2065 through 2076, with an average of about 12,600 truck trips per year (48 trips per day) from construction of the replacement WTP.

4.1.9.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Under Alternative 2B, the total workforce requirements would increase until 2013, when it would remain steady at or above 4,000 FTEs (see Figure 4–16). Peak employment would occur in 2040, when onsite employment would reach 6,860 FTEs. As a result of this increase in direct employment, an additional 5,130 indirect jobs would be projected in this peak year. Direct employment projections would then decrease significantly until 2047, when operations workers would make up the bulk (120 out of 123 FTEs) of the employment requirements. The workforce employment requirements would then remain steady until 2068, when three FTEs would be needed for postclosure care of the site.

As shown in Figure 4–18, the total workforce projection would be dominated (over 70 percent) first by construction workers from 2013 through 2017, followed by operations workers through 2043. As under Alternative 2A, construction and operations workers for the WTP would be the major workforce during this time period. Of the 5,540 FTE peak operations workforce (see Table 4–10), 70 percent would be employed at the WTP and its supplemental operations. In addition, deactivation of the WTP in 2044 and 2045 dominates the workforce requirements, with a projection of over 1,500 FTEs. From 2039 through 2045, construction of the modified RCRA Subtitle C barrier over the SSTs dominates the peak closure workforce of 412 FTEs.

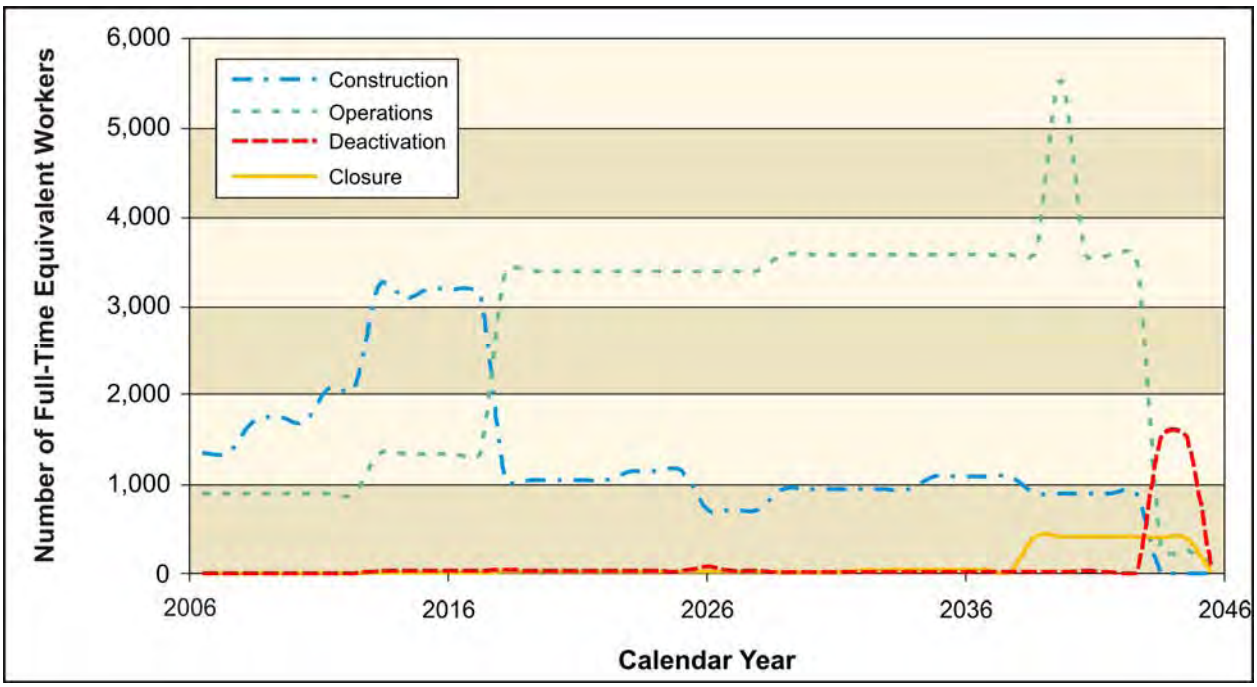


Figure 4–18. Tank Closure Alternative 2B Annual Estimated Onsite Full-Time Equivalent Workforce Requirements (2006–2046)

Table 4–10. Tank Closure Alternative 2B Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2013–2017	3,090–3,240
Operations	2018–2043	3,400–5,540
Deactivation	2044–2045	1,530–1,540
Closure	2039–2045	394–412

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

4.1.9.3.1 Regional Economic Characteristics

The near-term impact under Alternative 2B on economic conditions within the ROI would exceed those impacts under Alternative 2A. The peak workforce estimate of 6,860 FTEs in 2040, would occur much earlier than the peak under Alternative 2A of 4,920 FTEs in 2078–2079. This estimate would be approximately 3.6 percent of the projected labor force in the ROI (189,000 in 2040) as compared with approximately 10 percent in 2006. Implementing Alternative 2B could temporarily (30 years) increase demands for goods and services in the Tri-Cities area due to increases in expenditures, income, and employment, both direct and indirect, at Hanford. The increase in demand would be followed by an abrupt decrease in expenditures, income, and employment.

4.1.9.3.2 Demographic Characteristics

While this alternative would draw some workers from the local labor force, the continuing demand for operations workers under this alternative would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter

the demographic characteristics of the region. More workers would be required over a longer period of time under this alternative compared with Alternative 2A.

4.1.9.3.3 Housing and Community Services

Implementation of this alternative would increase the demand for housing and would impact schools and other community services within the ROI, exceeding the demands of Alternative 2A. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollment is expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.3.4 Local Transportation

As under Alternative 2A, implementation of this alternative is expected to have an impact on the local transportation system, especially during the commute periods. It is expected that all new commute period trips would impact the regionally established LOS, reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.3.4.1 Commuter Traffic

Under Alternative 2B, the peak years of construction and operations activity at the site would begin in 2013. The projected increase in commuter traffic to and from the site would be primarily due to activities from the expanded WTP. These and other activities would increase the number of site personnel to about 6,900 FTEs in 2040. Assuming an average of 1.25 persons per passenger vehicle, this could represent up to 5,500 commuter vehicles per day commuting to and from the site during the peak years.

4.1.9.3.4.2 Truck Traffic

From 2006 through 2017, the number of annual offsite truck trips is projected to be small, ranging from 1,100 to 2,900 (4 to 11 trips per day). The heaviest period of offsite truck activity would occur from 2018 through 2043 to mainly support WTP operations. It is projected that an average of 6,760 truck trips per year (26 trips per day) would be needed for daily operations at the WTP and the tank-filling grout facility. At its peak in 2040, there would be an estimated 12,400 truck trips per year (48 trips per day).

Onsite trucking would increase during the construction period from 2011 through 2017. During that time, construction of the IHLW Shipping/Transfer Facility and IHLW Interim Storage Modules, the WTP, and WRFs would account for the major portion of onsite truck traffic—18,800 peak truck trips in 2015 and 2016. Onsite truck traffic would average around 17,400 truck trips per year (67 trips per day) during this construction period. Onsite truck traffic would be the heaviest from 2039 through 2045, averaging around 53,800 truck trips per year (207 trips per day). This period of onsite truck activity would support closure activities under Alternative 2B. At its peak from 2039 through 2043, closure activities, led by construction of the modified RCRA Subtitle C landfill barrier, would require an estimated 56,500 truck trips per year (217 trips per day).

4.1.9.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Under Alternative 3A, total onsite employment would increase until 2013, when it would remain steady at or above 4,000 FTEs, peaking at 5,330 FTEs in 2035 (see Figure 4–16). This increase in direct employment would result in the creation of another approximately 4,000 indirect jobs in the ROI in the peak year. Employment projections would then decrease significantly until 2044, when operations workers would make up the bulk (120 out of 123 FTEs) of the employment requirements. The

employment requirements would then remain steady until 2068, when three FTEs would be needed for postclosure care of the site.

Under this alternative, construction employment would almost triple by the time it peaks in 2016 at 3,010 FTEs (see Table 4–11). The operations workforce would increase until 2018, remaining above 3,000 FTEs from 2018 through 2039, as shown in Figure 4–19. Almost half of these workers (1,700 FTEs) would be employed at the WTP during this period. The workforce required for deactivation of the WTP would peak in 2041 at 1,860 FTEs. Closure workforce requirements would remain steady until 2035, when requirements would increase to approximately 400 FTEs for 7 years.

Table 4–11. Tank Closure Alternative 3A Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2013 2016–2017	2,750 2,940–3,010
Operations	2018–2039	3,480–3,700
Deactivation	2041–2042	1,700–1,860
Closure	2035–2041	394–412

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

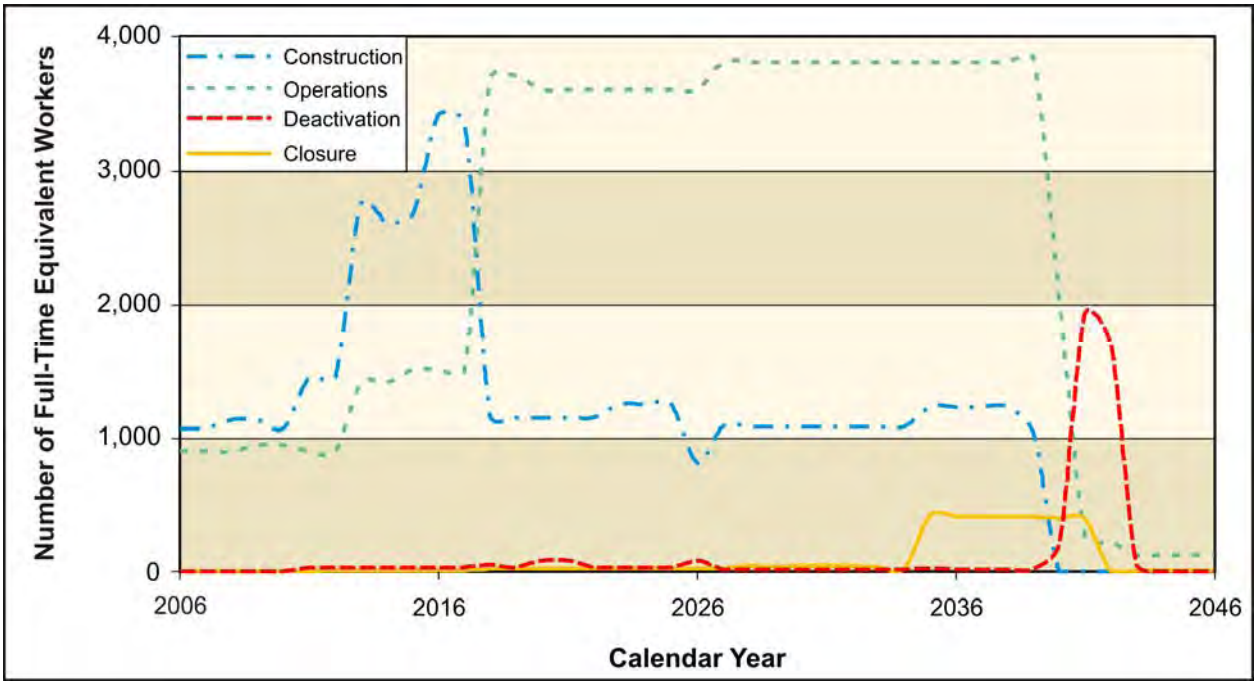


Figure 4–19. Tank Closure Alternatives 3A, 3B, and 3C Annual Estimated Onsite Full-Time Equivalent Workforce Requirements (2006–2046)

4.1.9.4.1 Regional Economic Characteristics

The peak workforce estimate of 5,330 FTEs under Alternative 3A would occur in 2035. This estimate represents approximately 3.0 percent of the projected labor force in the ROI (179,000 FTEs in 2035). The near-term impacts on economic conditions could alter the economic characteristics of the region by

temporarily (for 30 years) increasing demands for goods and services in the Tri-Cities area due to increases in expenditures, income, and employment, both direct and indirect, at Hanford. The increase in demand would be followed by an abrupt decrease in expenditures, income, and employment beginning in 2043.

4.1.9.4.2 Demographic Characteristics

While the alternative would draw some workers from the local labor force, the continuing demand for operations workers under this alternative would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter the demographic characteristics of the region.

4.1.9.4.3 Housing and Community Service

Implementation of this alternative would increase the demand for housing and would impact schools and other community services within the Hanford ROI. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollment is expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.4.4 Local Transportation

Implementation of Alternative 3A is expected to have an impact on the local transportation system, especially during the commute periods. The local transportation system has additional capacity during noncommute periods, but has no additional capacity during the morning and afternoon peaks. It is expected that all new commute period trips would impact the regionally established LOS, reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.4.4.1 Commuter Traffic

Under Alternative 3A, the construction and operations activity at the site would remain steady from 2013 through 2039. The projected increase in commuter traffic to and from the site during this period would be primarily due to construction of the WTP, the WRF, and retrieval systems. These activities would increase the number of site personnel to over 5,300 FTEs in 2035. Assuming an average of 1.25 persons per passenger vehicle, the increased traffic could represent a peak of about 4,300 commuter vehicles per day traveling to and from the site.

4.1.9.4.4.2 Truck Traffic

From 2006 through 2017, the number of annual offsite truck trips is projected to be small, ranging from 1,100 to 3,000 trips per year (4 to 12 trips per day). The heaviest period of offsite truck activity would occur from 2018 through 2039 during operations of the WTP, Bulk Vitrification Facilities, and grout facilities. It is projected that an average of 5,300 truck trips per year (20 trips per day) would be required to ship in materials during that period. At its peak in 2035 and 2036, there would be an estimated 6,300 truck trips per year (24 trips per day).

Onsite trucking would be at its highest from 2035 through 2041 due to the movement of concrete aggregate materials and other borrow materials that support closure activities, the process of filling the SSTs with grout, construction of a modified RCRA Subtitle C barrier, and the transport of resources needed for daily operations at the Bulk Vitrification Facilities. Onsite truck traffic would average around 55,500 truck trips per year (213 per day) during this period.

4.1.9.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

The socioeconomic impacts of implementing Alternative 3B would be virtually identical to those impacts of implementing Alternative 3A. This alternative uses the cast stone process in place of the bulk vitrification process as a supplemental treatment. All activities related to the cast stone process would be carried out in the same years as the bulk vitrification process and are only differentiated by workforce requirements. In addition to the direct employment associated with this alternative, approximately 3,900 indirect positions would likely be created in the peak year.

Figure 4–19 presents the workforce increases and decreases associated with Alternative 3B. Construction, operations, and deactivation of the Cast Stone Facilities in the 200-East and 200-West Areas would have smaller employment requirements than the Bulk Vitrification Facilities under Alternative 3A, resulting in slightly lower peak FTE employment projections (see Table 4–12).

Table 4–12. Tank Closure Alternative 3B Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2013 2016–2017	2,750 2,870–2,940
Operations	2018–2039	3,400–3,630
Deactivation	2041–2042	1,700–1,820
Closure	2035–2041	394–412

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

The total workforce estimate peaks in 2035 (5,260 FTEs) under Alternative 3B. As this total workforce estimate is only 75 FTEs less than under Alternative 3A, the impacts on the economic and demographic characteristics and housing and community services under Alternative 3B would be similar to those impacts described under Alternative 3A.

4.1.9.5.1 Local Transportation

Implementation of Alternative 3B is expected to have an impact on the local transportation system similar to the impact of Alternative 3A, especially during the commute periods. Under Alternative 3B, the construction and operations activity at the site would remain steady from 2013 through 2039, similar to Alternative 3A. Assuming an average of 1.25 persons per passenger vehicle, the increased traffic could represent a peak of about 4,200 commuter vehicles per day traveling to and from the site.

4.1.9.5.1.1 Truck Traffic

From 2006 through 2017, the number of annual offsite truck trips is projected to be small, ranging from 1,100 to 2,900 (4 to 11 trips per day). Similar to Alternative 3A, the heaviest period of offsite truck activity would occur from 2018 through 2039 during operations of the WTP and Cast Stone Facilities. It is projected that an average of 8,500 truck trips per year (33 trips per day) would be required to ship in materials during this period. At its peak in 2035 and 2036, there would be an estimated 9,500 truck trips per year (37 trips per day).

Similar to Alternative 3A, onsite trucking would be at its highest from 2035 through 2041, averaging around 54,000 truck trips per year (208 trips per day) during this period. This period of onsite truck activity would support closure activities under Alternative 3B.

4.1.9.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

The socioeconomic impacts of implementing Alternative 3C would be virtually identical to those impacts of implementing Alternative 3A. This alternative uses the steam reforming process in place of the bulk vitrification process as a supplemental treatment. All activities related to the steam reforming process would be carried out in the same years as the bulk vitrification process and are only differentiated by workforce requirements.

Figure 4–19 presents the workforce increases and decreases associated with Alternative 3C. Construction, operation, and deactivation of the Steam Reforming Facilities in the 200-East and 200-West Areas would have larger employment requirements than the Bulk Vitrification Facilities under Alternative 3A, resulting in higher peak FTE employment projections (see Table 4–13).

Table 4–13. Tank Closure Alternative 3C Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2013 2016–2017	2,750 3,360–3,420
Operations	2018–2039	3,600–3,830
Deactivation	2041–2042	1,700–1,930
Closure	2035–2041	394–412

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

The total workforce estimate peaks in 2035 (5,460 FTEs) under Alternative 3C. As this total workforce estimate is only 130 FTEs more than under Alternative 3A, the impacts on the economic and demographic characteristics and housing and community services under Alternative 3C would be similar to those impacts described under Alternative 3A. In addition to the direct employment associated with this alternative, approximately 4,100 indirect jobs would likely be created in the peak year.

4.1.9.6.1 Local Transportation

Implementation of Alternative 3C is expected to have an impact on the local transportation system similar to the impact under Alternative 3A, especially during the commute periods. Under Alternative 3C, the construction and operations activity at the site would remain steady from 2013 through 2039, similar to Alternative 3A. Assuming an average of 1.25 persons per passenger vehicle, the increased traffic could represent a peak of over 4,300 commuter vehicles per day traveling to and from the site.

4.1.9.6.1.1 Truck Traffic

From 2006 through 2017, the number of annual offsite truck trips is projected to be small, ranging from 1,100 to 3,200 (4 to 12 trips per day). Similar to Alternative 3A, truck traffic would then increase until the heaviest period of offsite truck activity (2018 through 2039), which would occur during operations of the WTP and Steam Reforming Facilities. It is projected that an average of 36,000 truck trips per year

(138 trips per day) would be required to ship in materials during that time. At its peak from 2035 through 2036, there would be an estimated 37,000 truck trips per year (142 trips per day).

Similar to Alternative 3A, onsite trucking would be at its highest from 2035 through 2041, averaging around 54,000 truck trips per year (208 trips per day) during this period. This period of onsite truck activity would support closure activities under Alternative 3C.

4.1.9.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Under Alternative 4, total onsite employment would steadily increase, more than doubling by 2013 and reaching a peak of 8,000 FTEs in 2019 (see Figure 4–16). Total employment projections would then remain steady at or above 5,000 FTEs through 2042. This would be followed by a sharp decrease in the workforce until 2047, when operations workers would make up the bulk (120 out of 123 FTEs) of the employment requirements. The workforce employment requirements would then remain steady until 2068, when only three FTEs would be needed for postclosure care of the site. The existence of these direct jobs would be expected to result in the creation of almost 6,000 indirect jobs in the ROI in the peak year.

Under this alternative, construction employment would more than triple by the time it reaches its peak of 3,380 FTEs in 2016 (see Table 4–14 and Figure 4–20), shortly thereafter dropping and remaining steady at over 1,000 FTEs until 2042. The operations workforce would increase until 2018, remaining around 4,000 FTEs until 2042. The workforce required for deactivation of the WTP (1,700 FTEs) would not occur until 2044 and 2045. The workforce required to construct the PPF, which supports tank farm clean closure, would makeup the bulk (2,390 FTEs) of the peak closure workforce requirements in 2019.

Table 4–14. Tank Closure Alternative 4 Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2013 2016–2017	3,150 3,310–3,380
Operations	2018–2042	3,700–4,020
Deactivation	2044–2045	1,700–1,710
Closure	2019–2021	2,410

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

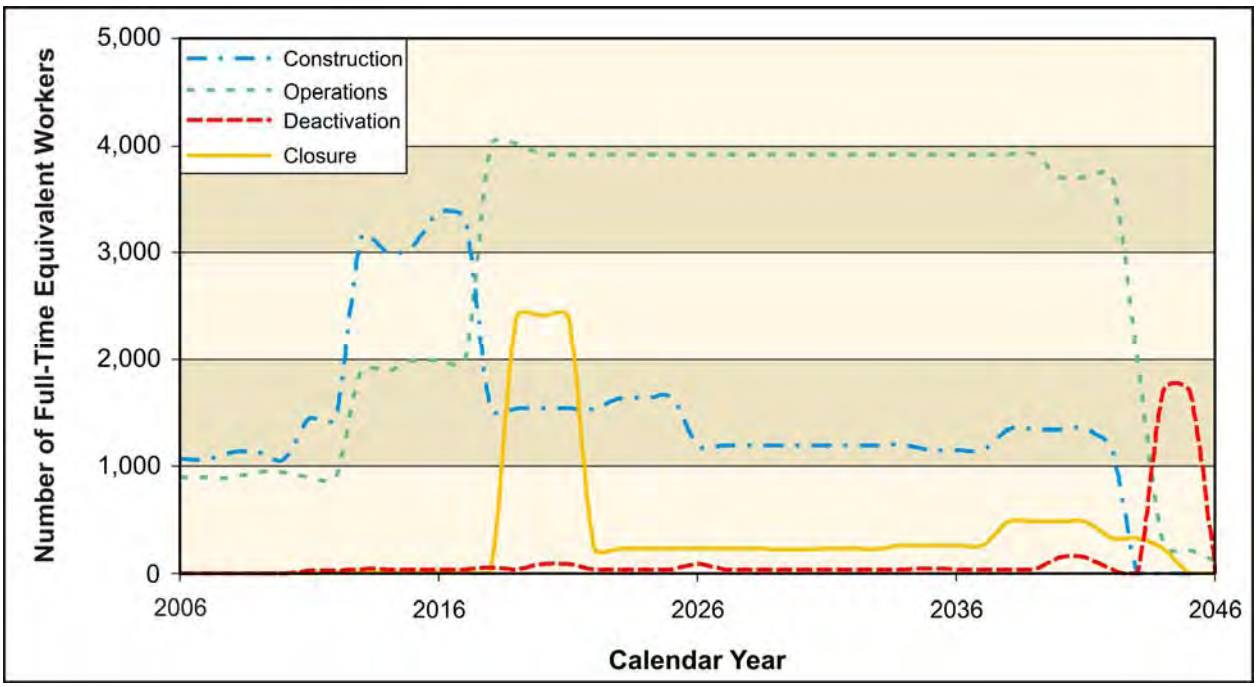


Figure 4–20. Tank Closure Alternative 4 Annual Estimated Onsite Full-Time Equivalent Workforce Requirements (2006–2046)

4.1.9.7.1 Regional Economic Characteristics

The near-term impacts on economic conditions within the ROI under Alternative 4 would exceed those of many of the other alternatives. The peak workforce estimate of 8,000 FTEs would be mostly operations workers (4,020 FTEs). This peak workforce would be approximately 5.5 percent of the projected labor force in the ROI (146,000 FTEs in 2019) compared with approximately 10 percent in 2006. Implementing Alternative 4 would alter the economic characteristics of the region by temporarily (30 years) increasing demands for goods and services in the Tri-Cities area due to increases in expenditures, income, and employment, both direct and indirect, at Hanford. The increase in demand would be followed by an abrupt decrease in expenditures, income, and employment beginning in 2046.

4.1.9.7.2 Demographic Characteristics

While the alternative would draw some workers from the local labor force, the continuing demand for operations workers would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter the demographic characteristics of the region.

4.1.9.7.3 Housing and Community Services

Implementation of this alternative would increase the demand for housing and would impact schools and other community services within the ROI. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollment is expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.7.4 Local Transportation

Implementation of this alternative is expected to have an impact on the local transportation system, especially during the commute periods. The local transportation system has additional capacity during noncommute periods, but has no additional capacity during the morning and afternoon peaks. It is

expected that all new commute period trips would impact the regionally established LOS, reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.7.4.1 Commuter Traffic

Under Alternative 4, the peak years of construction and operations activity at the site would occur from 2013 through 2042. The projected increase in commuter traffic to and from the site would be primarily due to construction and subsequent operations of the WTP, WRF, and retrieval systems. These and other activities would increase the number of site personnel to almost 8,000 FTEs in 2019. Assuming an average of 1.25 persons per passenger vehicle, this could represent up to 6,400 commuter vehicles per day traveling to and from the site during the peak years.

4.1.9.7.4.2 Truck Traffic

From 2006 through 2017, an average of approximately 2,200 offsite truck trips per year (9 trips per day) is projected to ship in construction materials primarily for construction of the WTP and the IHLW Shipping/Transfer Facility. The heaviest period of offsite truck activity would occur from 2018 through 2043 during construction of the WRFs; operations of the WTP, Bulk Vitrification Facility, and Cast Stone Facility; and various closure activities. It is projected that an average of 8,800 truck trips per year (34 trips per day) would be required to ship in construction materials and equipment for the removal of tanks, ancillary equipment, and soils in support of clean closure of the BX and SX tank farms. At its peak in 2043, there would be an estimated 16,600 truck trips per year (64 trips per day).

Onsite trucking would be at its highest from 2038 through 2044, averaging 40,000 truck trips per year (154 trips per day) during this period. This period of onsite truck activity would support closure activities under Alternative 4, including clean closure of the BX and SX tank farms and construction of the first four lobes of the modified RCRA Subtitle C barrier for landfill closure of the remaining tank farms in the SST system.

4.1.9.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

The total onsite employment under Alternative 5 would steadily increase until 2013, when onsite employment would more than double (see Figure 4–16). Total employment requirements would then remain above 4,000 FTEs through 2033, ranging from 4,330 to 6,100 FTEs. The total workforce requirements during that time period would include several significant increases. In 2016, the total employment requirements would increase by 23 percent over the previous year; in 2024, requirements would increase by 12 percent; and in 2029, requirements would increase by 11 percent. In 2034, there would begin a sharp decrease in total employment, falling steadily until 2040, when operations workers would make up the bulk (120 out of 123 FTEs) of the employment requirements. By 2068, only a handful of workers (three FTEs) would be needed for postclosure care of the site. In addition to the direct employment associated with this alternative, approximately 4,600 indirect positions would likely be created as a secondary impact on the ROI in the peak years.

Under this alternative, the construction workforce would more than quadruple by the time it reaches its peak of 3,890 FTEs in 2016 (see Table 4–15). From 2023 through 2033, construction workforce requirements would remain above 1,000 FTEs, dropping to 0 in 2035. The operations workforce requirements would increase from 2018 through 2033 to over 3,800 FTEs. The operations activities at the WTP, for retrieval systems and other activities, would require a shorter time period than under the other alternatives. The deactivation workforce requirements would peak in 2035 (2,040 FTEs), of which the majority (1,700 FTEs) would be required for deactivating the WTP. Closure workforce requirements would remain small, ranging from 0 to 21 FTEs until 2029, when requirements would increase to over 400 FTEs for a period of 11 years (see Figure 4–21).

Table 4–15. Tank Closure Alternative 5 Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2016–2017	3,830–3,890
Operations	2018–2033	3,850–4,150
Deactivation	2035	2,040
Closure	2029–2039	418–438

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

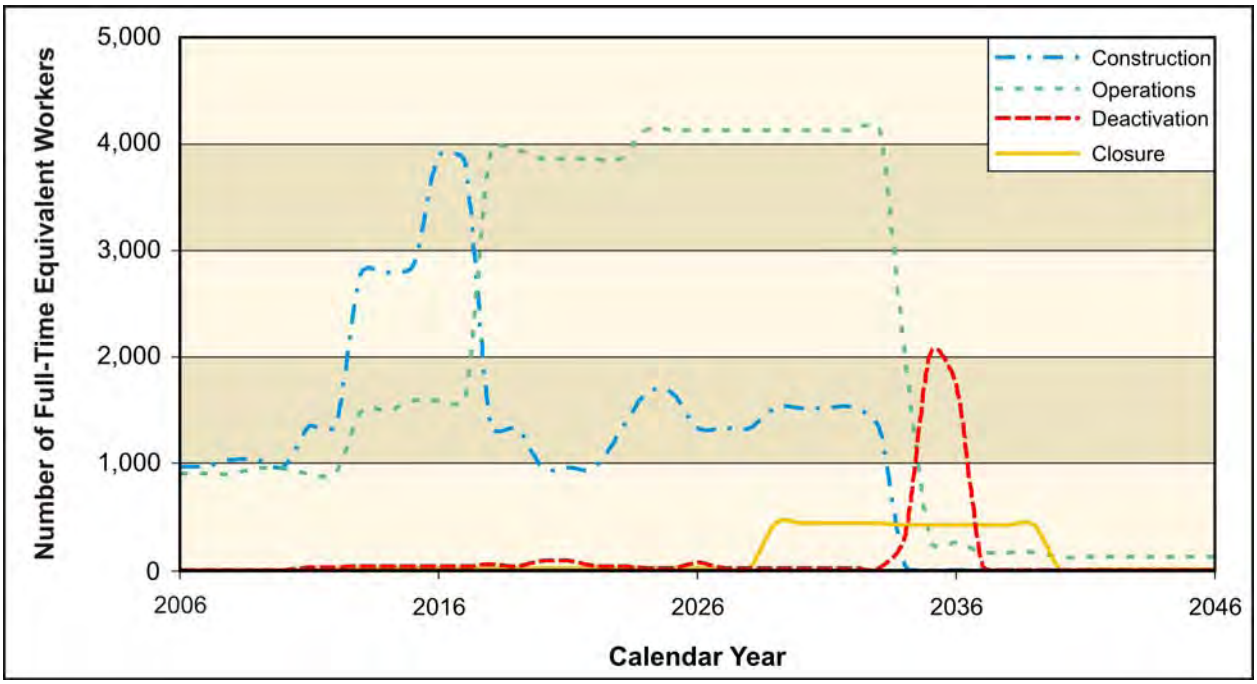


Figure 4–21. Tank Closure Alternative 5 Annual Estimated Onsite Full-Time Equivalent Workforce Requirements (2006–2046)

4.1.9.8.2 Regional Economic Characteristics

The peak workforce estimate of 6,100 FTEs (from 2029 through 2032) represents approximately 3.7 percent of the projected labor force in the ROI (166,000 in 2029). Nevertheless, implementing Alternative 5 would alter the economic characteristics of the region by temporarily (20 years) increasing demands for goods and services in the Tri-Cities area due to increases in expenditures, income, and employment, both direct and indirect, at Hanford. The increase in demand would be followed by an abrupt decrease in expenditures, income, and employment.

4.1.9.8.3 Demographic Characteristics

While the alternative would draw some workers from the local labor force, the demand for operations workers under this alternative would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter the demographic characteristics of the region.

4.1.9.8.4 Housing and Community Services

Implementation of this alternative would increase the demand for housing and would impact schools and other community services within the Hanford ROI. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollment is expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.8.5 Local Transportation

Implementation of this alternative is expected to have an impact on the local transportation system, especially during the commute periods. The local transportation system has additional capacity during noncommute periods, but has no additional capacity during the morning and afternoon peaks. It is expected that all new commute period trips would impact the regionally established LOS, reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.8.5.1 Commuter Traffic

Under Alternative 5, the peak years of construction and operations activity at the site would occur from 2016 through 2033. The projected increase in commuter traffic to and from the site would be primarily due to construction of the WTP, WRF, and retrieval systems. These activities would increase the number of site personnel to over 6,000 FTEs from 2029 through 2032. Assuming an average of 1.25 persons per passenger vehicle, this personnel increase could represent about 4,900 commuter vehicles per day traveling to and from the site.

4.1.9.8.5.2 Truck Traffic

From 2006 through 2017, an average of 2,300 offsite truck trips per year (9 trips per day) is projected to ship construction materials primarily for construction of the WTP, the IHLW Shipping/Transfer Facility, and the TRU Waste Interim Storage Facility. The heaviest period of offsite truck activity would occur from 2018 through 2033. It is projected that an average of 13,900 truck trips per year (53 trips per day) would be required during construction of the WTP and the new DSTs; operations of the WTP, Sulfate Removal Facility, Bulk Vitrification Facility, and Cast Stone Facility; and various closure activities. At its peak from 2029 through 2032, there would be an estimated 14,700 truck trips per year (57 trips per day).

Onsite trucking would be at its highest from 2029 through 2039 and would average around 54,500 truck trips per year (210 trips per day). This period of onsite truck activity under Alternative 5 would support closure activities led by construction of the Hanford landfill barrier and would peak from 2029 through 2032 at an estimated 60,800 truck trips per year (234 trips per day).

4.1.9.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

Alternatives 6A, Base and Option Cases, would differ only in the intensity of some closure activities. Under both alternatives, near-term employment would steadily increase for both cases until 2018, when total employment requirements would almost double to 5,430 FTEs (see Figure 4–16). The total onsite workforce would remain at or above 5,000 FTEs until 2163. During this time period, in both cases there would be a large number of significant increases and subsequent decreases in total onsite workforce requirements. These large spikes in total workforce requirements would potentially occur from 2029 through 2034, from 2039 through 2041, from 2069 through 2074, in 2078, from 2109 through 2114, and in 2138. Under Alternative 6A, Base Case, the peak of 8,500 FTEs would occur in the 2138 spike. Alternative 6A, Option Case, would have a peak in 2041 with a high of 10,100 FTEs. Beginning in 2162, there would be a sharp decrease (over 60 percent) in total employment, leveling out at over 2,100 FTEs in

2168. The existence of these direct jobs would be expected to result in the creation of up to 7,600 additional indirect jobs in the peak years.

Under this alternative, more than 4,600 FTEs operations workers would make up the bulk of the total onsite employment requirements from 2018 through 2162 (see Figure 4–22). Almost half of these operations workers (2,170 FTEs) would be employed at the WTP. In both cases, the construction workforce would experience 11 spikes (short-term annual increase and subsequent decrease in employment) involving more than a 15 percent change in workforce requirements. The largest of these spikes would peak in 2041, 2078, 2113–2114, and 2136–2138 (see Table 4–16). The bulk of the deactivation workforce requirements would occur during the deactivation of the WTP (1,210 FTEs) and its replacement facilities from 2078–2080, 2138–2140, and 2164–2166. The closure workforce would remain under 200 FTEs under Alternative 6A, Base Case, except from 2039–2041 and 2149–2150. Under Alternative 6A, Option Case, the closure workforce requirements after the peak in 2041 would more than double those under Alternative 6A, Base Case, ranging from 212 to 503 FTEs.

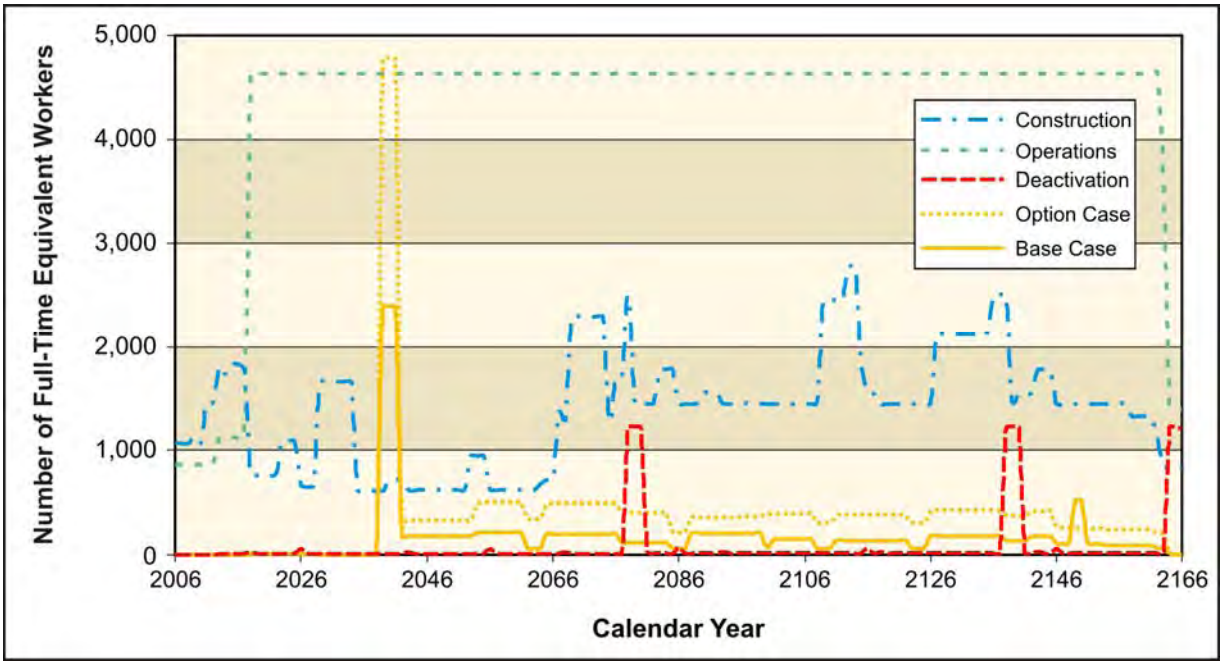


Figure 4–22. Tank Closure Alternative 6A, Base/Option Case, Annual Estimated Onsite Full-Time Equivalent Workforce Requirement (2006–2166)

Table 4–16. Tank Closure Alternative 6A, Base/Option Case, Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Base Case Workforce Peak or Peak Range (FTEs)	Option Case Workforce Peak or Peak Range (FTEs)
Construction	2013–2017	1,730–1,830	Same
	2029–2034	1,660	
	2078	2,510	
	2113–2114	2,780	
	2136–2138	2,500	
Operations	2018–2162	4,630–4,660	Same
Deactivation	2078–2080	1,230	Same
	2138–2140	1,230	
	2164–2166	1,220–1,230	
Closure	2039–2041	2,390	4,800
	2149–2150	515	N/A

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent; N/A=not applicable.
Source: Appendix I; SAIC 2007a.

4.1.9.9.1 Regional Economic Characteristics

4.1.9.9.1.1 Base Case

Implementing Alternative 6A, Base Case, would alter the economic characteristics of the region by increasing demands for goods and services in the Tri-Cities area over an extended period of time (i.e., approximately 150 years) due to increases in expenditures, income, and employment, both direct and indirect, at Hanford. The peak workforce estimates of up to 8,500 FTEs occur in 2078 and 2138. These peaks represent approximately 3.2 and 2.2 percent, respectively, of the projected labor force in the ROI (267,000 in 2078 and 390,000 in 2138). The peaks would be followed by abrupt decreases in expenditures, income, and employment.

4.1.9.9.1.2 Option Case

The socioeconomic impacts of implementing the Option Case would be higher than those impacts of implementing the Base Case. The higher number of closure workers in the Option Case is double those in the Base Case. The peak workforce estimate in 2041 (10,100 FTEs) represents 5.3 percent of the projected labor force in the ROI (191,000 in 2041).

4.1.9.9.2 Demographic Characteristics

4.1.9.9.2.1 Base and Option Cases

While this alternative would draw some workers from the local labor force, the continuing demand for operations workers would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter the demographic characteristics of the region. The impacts on the demographic characteristics of the ROI would be virtually the same for the Base and Option Cases. The increased number of closure workers in the Option Case represents a 6 percent increase in the total number of workers over the Base Case.

4.1.9.9.3 Housing and Community Services

BASE AND OPTION CASES

Implementation of this alternative would increase the demand for housing and would impact schools and other community services within the ROI. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollment is expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.9.4 Local Transportation

Implementation of Alternative 6A is expected to have an impact on the local transportation system, especially during the commute periods. The local transportation system has additional capacity during noncommute periods, but has no additional capacity during the morning and afternoon peaks. It is expected that all new commute period trips would impact the regionally established LOS, reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.9.4.1 Commuter Traffic

BASE AND OPTION CASES

Under Alternative 6A, the near-term peak years of activity at the site would occur from 2039 through 2041. The projected increase in commuter traffic to and from the site would be primarily due to the operation of the WTP and Interim Storage Facility, as well as construction of the PPF. These activities would increase the number of site personnel to over 10,100 FTEs in 2041 under Alternative 6A, Option Case. Assuming an average of 1.25 persons per passenger vehicle, this personnel increase could represent over 8,100 commuter vehicles per day traveling to and from the site. Under Alternative 6A, Base Case, up to 6,800 commuter vehicles could travel to and from the site each day.

4.1.9.9.4.2 Truck Traffic

BASE AND OPTION CASES

In both cases, an average of 1,600 offsite truck trips per year (6 trips per day) is projected from 2006 through 2017 to ship in construction materials, primarily for construction projects. The heaviest period of offsite truck activity would occur during periods of IHLW Interim Storage Module construction, WTP operations and deactivation, and closure activities. From 2018 through 2163, it is projected that an average of 8,800 (under Alternative 6A, Base Case) and 10,600 (under Alternative 6A, Option Case) truck trips per year (34 and 41 trips per day, respectively) would be required to ship in materials to support facility operations and tank farm clean closure activities. Under Alternative 6A, Base Case, the peak would occur in 2138 with a projected 15,000 truck trips per year (58 trips per day). Under Alternative 6A, Option Case, the peak would occur in 2078 with an estimated 18,500 truck trips per year (71 trips per day).

Onsite trucking under Alternative 6A, Base Case, would be at its highest from 2149 through 2150 due to construction of the modified RCRA Subtitle C barrier for landfill closure of the remaining tank farms in the SST system. At its peak, there would be an estimated 76,800 truck trips per year (295 trips per day). Under Alternative 6A, Option Case, the peak would occur in 2137 with up to 63,300 onsite truck trips per year (243 trips per day). These periods of onsite truck activity would support IHLW Interim Storage Modules and closure activities under Alternative 6A.

4.1.9.10 Alternative 6B: All Vitrification with Separations; Clean Closure

As with Alternative 6A, the impacts under Alternative 6B, Base and Option Cases, would differ only in the intensity of some closure workforce employment projections (see Figure 4–16). Under both alternatives, total employment projections would steadily increase, almost doubling by 2013. Under Alternative 6B, Base Case, the peak of 7,870 FTEs would be in 2021 and 2022. Alternative 6B, Option Case, has the highest total onsite workforce projection of all Tank Closure alternatives, reaching a peak of over 10,000 FTEs in 2021 and 2022. As a result of these increases in employment, up to 7,600 additional indirect jobs are projected in the peak years. Employment projections in both the Base and Option Cases would then decrease to remain steady at or above 5,000 FTEs until a short spike in employment in 2040. The total onsite workforce projections would then sharply decrease until 2046. From 2046 until 2096, total onsite workforce projections would range from 200 to 882 FTEs under Alternative 6B, Base Case, and from 454 to 1,170 FTEs under Alternative 6B, Option Case. Beginning in 2102 under Alternative 6B, Base Case, only 3 FTEs would be needed for postclosure care of the site.

Under Alternative 6B, construction workers would dominate the workforce as they more than double by 2013 and remain above 3,500 FTEs until 2017 (see Figure 4–23). The largest contributor (1,190 FTEs) to the workforce at this time would be employed at the WTP. The construction workforce would then decrease until 2044 when only 4 FTEs would be required, except for two 3-year construction periods for

the ETF replacements (2053–2055 and 2083–2085 as shown in Table 4–17) when construction workforce requirements would briefly increase to 333 FTEs. Beginning in 2018, operations workers would make up the bulk of the employment requirements, remaining steady at 3,910 FTEs except for a spike up to 5,880 FTEs in 2039 and 2040. The deactivation workforce requirements would peak in 2044, the majority (1,530 FTEs) would be required for deactivating the WTP. After a spike from 2020 through 2022, the closure workforce would range from 59 to 333 FTEs under Alternative 6B, Base Case, and from 313 to 586 FTEs under Alternative 6B, Option Case.

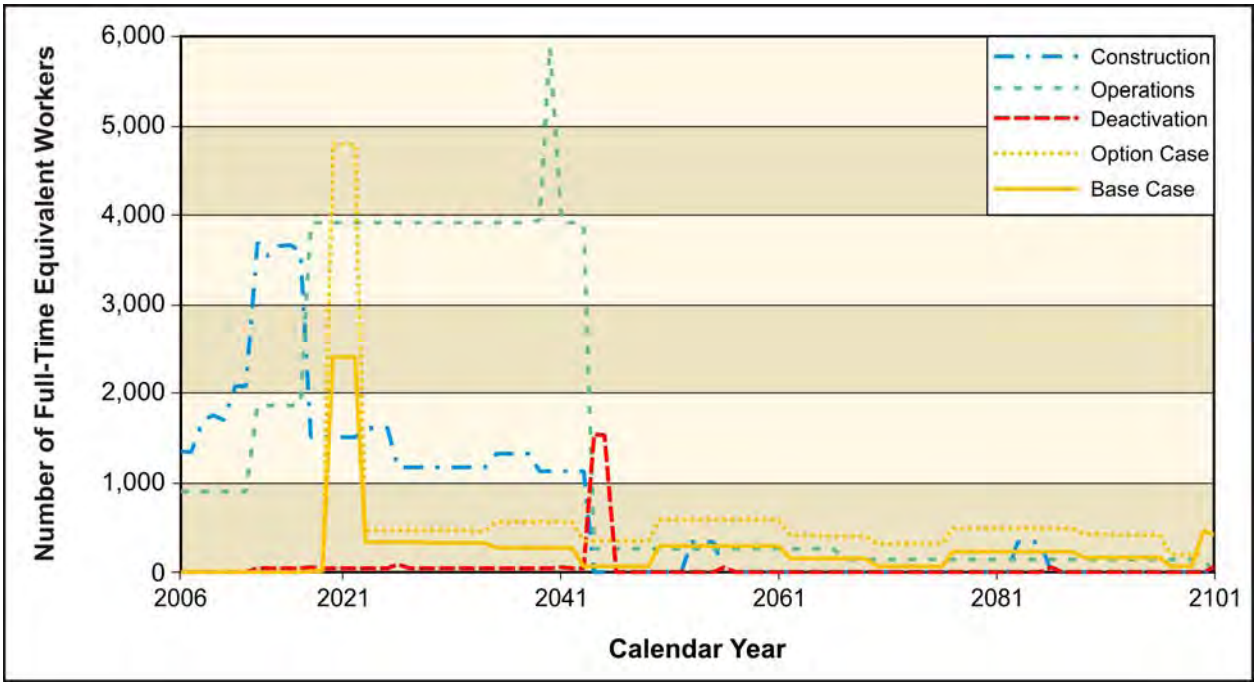


Figure 4–23. Tank Closure Alternative 6B, Base/Option Case, Annual Estimated Onsite Full-Time Equivalent Workforce Requirements (2006–2101)

Table 4–17. Tank Closure Alternative 6B, Base/Option Case, Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Base Case Workforce Peak or Peak Range (FTEs)	Option Case Workforce Peak or Peak Range (FTEs)
Construction	2013–2017 2053–2055 2083–2085	3,550–3,690 333 333	Same
Operations	2018–2043	3,910–5,880	Same
Deactivation	2044–2045	1,530–1,540	Same
Closure	2020–2022 2100–2101	2,400 414–468	4,790 N/A

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent; N/A=not applicable.
Source: Appendix I; SAIC 2007a.

The socioeconomic impacts of implementing the Base and Option Cases of this alternative would be similar. All construction, operations, and deactivation activities would be during the same time periods and involve the identical workforce for both cases. The closure activities are projected to include higher workforce estimates (approximately double those in the Base Case) under the Option Case.

4.1.9.10.1 Regional Economic Characteristics

4.1.9.10.1.1 Base Case

Implementing the Base Case under Alternative 6B would alter the economic characteristics of the region by increasing demands for goods and services in the Tri-Cities area over an extended period of time (i.e., approximately 90 years) due to increases in expenditures, income, and employment, both direct and indirect, at Hanford. The peak workforce estimates, up to 7,870 FTEs, occur from 2020 through 2022 and in 2040. These near-term peaks represent approximately 5.2 and 4.2 percent, respectively, of the projected labor force in the ROI (150,000 in 2021 and 189,000 in 2040).

4.1.9.10.1.2 Option Case

The socioeconomic impacts of implementing the Option Case would be higher than those impacts from implementing the Base Case. The higher number of closure workers in the Option Case is almost double those in the Base Case. The peak workforce estimate in 2021 and 2022 (10,300 FTEs) represents 6.8 percent of the projected labor force in the ROI.

4.1.9.10.2 Demographic Characteristics

4.1.9.10.2.1 Base and Option Cases

While the alternative would draw some workers from the local labor force, the demand for operations workers under this alternative would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter the demographic characteristics of the region. The increased number of closure workers in the Option Case during the later years (after 2045) represents from one-third to over double the total number of workers in the Base Case. Nevertheless, the impacts on the demographic characteristics of the ROI would be virtually the same for the Base and Option Cases, as the total workforce is small compared to the projected labor force in the ROI (201,000 in 2046).

4.1.9.10.3 Housing and Community Service

BASE AND OPTION CASES

Implementation of Alternative 6B would increase the demand for housing and would impact schools and other community services within the ROI. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollment is expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.10.4 Local Transportation

Implementation of this alternative is expected to have an impact on the local transportation system, especially during the commute periods. The local transportation system has additional capacity during noncommute periods, but has no additional capacity during the morning and afternoon peaks. It is expected that all new commute period trips would impact the regionally established LOS, reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.10.4.1 Commuter Traffic

BASE AND OPTION CASES

Under Alternative 6B, the peak years of construction and operations activity at the site would occur from 2013 through 2043. The projected increase in commuter traffic to and from the site during this period

would be primarily due to construction and operation of the expanded WTP and retrieval systems. These activities would increase the number of site personnel to over 10,200 FTEs from 2020 through 2022, under Alternative 6B, Option Case. Assuming an average of 1.25 persons per passenger vehicle, this personnel increase could represent over 8,200 commuter vehicles per day traveling to and from the site. Under the Base Case during the same time period (2020–2022), up to 6,300 commuter vehicles could travel to and from the site each day.

4.1.9.10.4.2 Truck Traffic

BASE AND OPTION CASES

Under both cases, an average of over 2,200 offsite truck trips per year (9 trips per day) from 2006 through 2017 is projected to ship in construction materials, primarily for construction projects. The heaviest period of offsite truck activity would occur from 2018 through 2043 during WTP operations and closure activities. At its peak in 2040, there would be an estimated 17,200 (under Alternative 6B, Base Case) and 21,600 (under Alternative 6B, Option Case) truck trips per year (66 and 83 trips per day, respectively).

Onsite trucking under the Alternative 6B, Base Case, would be at its highest in 2100 due to construction of the modified RCRA Subtitle C barrier for landfill closure of the remaining tank farms in the SST system. At its peak, there would be an estimated 48,800 truck trips (188 trips per day). Under Alternative 6B, Option Case, the peak would occur from 2053 through 2055 with up to 44,700 truck trips per year (172 trips per day). These periods of onsite truck activity would support closure activities under Alternative 6B.

4.1.9.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

Under Alternative 6C, total onsite workforce requirements would be essentially the same as under Alternative 2B (see Figure 4–16). The construction workforce of 11 FTEs from 2016 through 2043 needed for the ILAW Canister Storage Building would be required under Alternative 6C only. Peak employment numbers and years (see Table 4–18 and Figure 4–24) would be identical to those under Alternative 2B.

Table 4–18. Tank Closure Alternative 6C Peak Annual Estimated Workforce Requirements

Work Activity	Peak Year(s)	Workforce Peak or Peak Range (FTEs)
Construction	2013–2017	3,090–3,240
Operations	2018–2043	3,400–5,540
Deactivation	2044–2045	1,530–1,540
Closure	2039–2045	394–412

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: FTE=full-time equivalent.
Source: Appendix I; SAIC 2007a.

4.1.9.11.1 Regional Economic Characteristics

The near-term impact from implementing Alternative 6C would alter the economic characteristics of the region by temporarily (30 years) increasing demands for goods and services in the Tri-Cities area due to increases in expenditures, income, and employment, both direct and indirect, at Hanford. The peak workforce estimate of 6,870 FTEs would occur in 2040. This estimate would be approximately 3.6 percent of the projected labor force in the ROI (189,000 in 2040), compared with approximately 10 percent in 2006. The increase in demand would be followed by an abrupt decrease in expenditures, income, and employment.

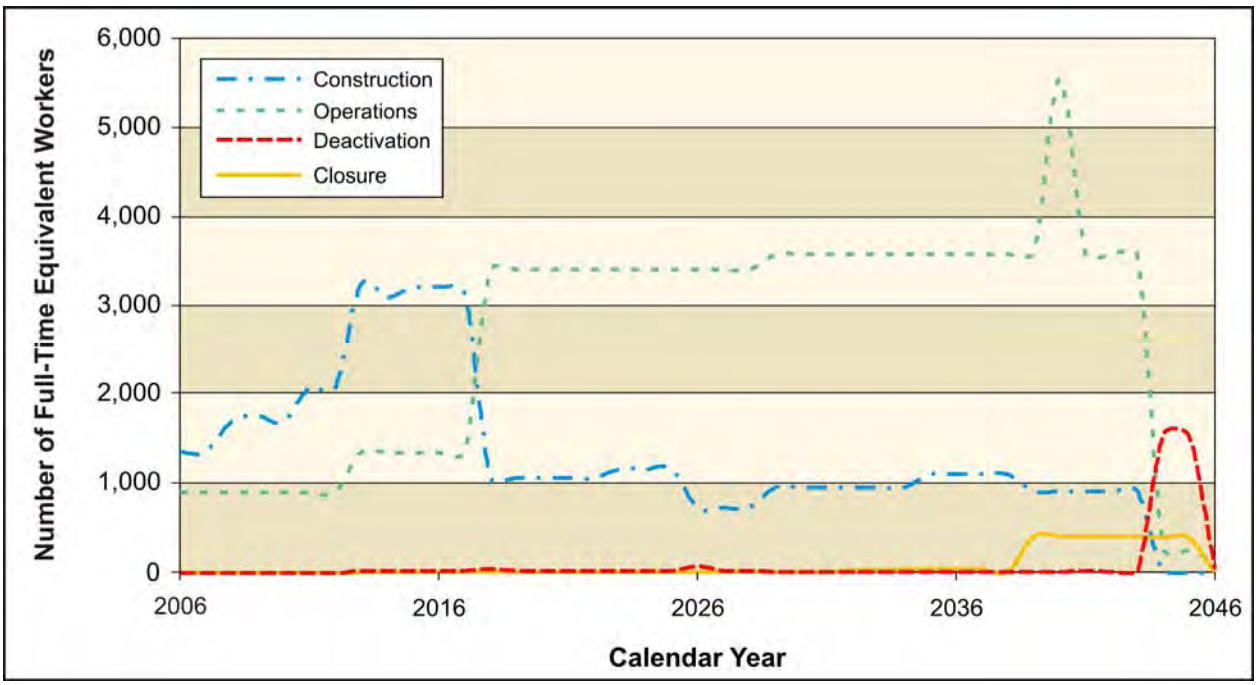


Figure 4–24. Tank Closure Alternative 6C Annual Estimated Onsite Full-Time Equivalent Workforce Requirements (2006–2046)

4.1.9.11.2 Demographic Characteristics

While this alternative would draw some workers from the local labor force, the continuing demand for operations workers would draw from outside the region. The in-migration of new workers and their families would increase the overall population within the Tri-Cities area and could alter the demographic characteristics of the region.

4.1.9.11.3 Housing and Community Services

Implementation of this alternative would increase the demand for housing and would impact schools and other community services within the ROI. The demand for housing by construction and operations workers would impact the cost and availability of houses and rental units. School enrollment is expected to increase, and utilities and police and fire services may need to be expanded.

4.1.9.11.4 Local Transportation

Implementation of this alternative is expected to have an impact on the local transportation system, especially during the commute periods. The local transportation system has additional capacity during noncommute periods, but has no additional capacity during the morning and afternoon peaks. It is expected that all new commute period trips would impact the regionally established LOS, reducing it below the minimum acceptable ("D") LOS (Perteet, Thomas/Lane, and SCM 2001).

4.1.9.11.5 Commuter Traffic

Under Alternative 6C, the peak years of construction and operations activity at the site would begin in 2013. The projected increase in commuter traffic to and from the site would be primarily due to activities from the expanded WTP. These and other activities would increase the number of site personnel to about 6,900 FTEs in 2040. Assuming an average of 1.25 persons per passenger vehicle, this personnel increase could represent about 5,500 commuter vehicles per day traveling to and from the site.

4.1.9.11.5.1 Truck Traffic

From 2006 through 2017, an average of 2,200 offsite truck trips per year (8 trips per day) is projected to ship in construction materials. The heaviest period of offsite truck activity would occur from 2018 through 2043 during construction of the WRFs and the IHLW Interim Storage Modules, operations of the WTP, and some closure activities. It is projected that an average of 7,400 truck trips per year (28 trips per day) would be required to ship in materials during this time. At its peak in 2040, there would be an estimated 13,000 truck trips per year (50 trips per day).

Onsite trucking would be at its highest during the period of modified RCRA Subtitle C landfill barrier construction, supplemented by trucks needed for construction of the ILAW Interim Storage Facility and the onsite movement of concrete aggregate materials, other borrow materials, and excavated soil supporting closure activities under Alternative 6C. This period of onsite truck activity would require an estimated 56,800 truck trips per year (218 trips per day) during its peak from 2039 through 2045.

4.1.10 Public and Occupational Health and Safety—Normal Operations

Activities to retrieve and treat tank waste and close tank farms could result in radiological and chemical exposures. Details of the assessment methodology for determining radiation exposure to workers and members of the public are presented in Appendix K. Radiological impacts are presented for three public receptors: the general population (approximately 463,000[1]), living within 80 kilometers (50 miles) of the Hanford 200 Areas, a maximally exposed individual (MEI) living near Hanford, and an onsite MEI. Impacts on the general population are evaluated for a residential scenario whereby people are exposed to radioactive materials emitted from project facilities. Radiation exposure occurs through inhalation, direct exposure to the radiological plume and material deposited on the ground, and ingestion of contaminated products from animals raised locally and fruits and vegetables grown in a family garden (DOE 1995). Impacts on the offsite MEI are evaluated for a scenario that includes the same exposure pathways assumed for the general population, but with an increased amount of time spent outdoors and a higher rate of contaminated food consumption. Impacts on the onsite MEI, identified as a member of the public who works at the Columbia Generating Station or LIGO, would be from inhalation and exposure to the plume and material deposited on the ground. Doses are presented as the total effective dose equivalent.

The radiological impacts on members of the public are presented for each alternative in terms of impacts over the life of the project (operational life of the project during which there are radiological air emissions) and peak annual impacts. Impacts over the life of the project are the total estimated radiological doses incurred by members of the public over the duration of an alternative. The peak annual impacts are the estimated annual radiological doses incurred by members of the public during the year(s) of largest radiological dose. For all alternatives, the dose to an onsite MEI was less than the dose to an offsite MEI located near the Hanford boundary; this is because the onsite MEI would be exposed for a shorter time (only during the workday) and through fewer pathways (e.g., no ingestion pathway).

In addition to members of the public, workers directly involved in the activities associated with each alternative and nearby noninvolved workers may receive radiological doses or chemical exposures. Doses to an involved worker are calculated based on an FTE. It is assumed for purposes of this dose evaluation that an FTE involved worker has a 2,080-hour work year. In practice, the number of workers who receive a radiation dose may be larger than the number assumed in this analysis, resulting in a smaller average dose per worker. A noninvolved worker is a person working at the site who is incidentally exposed due to the radiological air emissions associated with the alternatives considered.

[1] The approximate population is based on populations of 447,354, 451,556, and 488,897 people residing within 80 kilometers (50 miles) of the WTP, STTS-East, and STTS-West, respectively.

The location selected for the noninvolved worker is a facility that is expected to be staffed on a daily basis that is near the assumed emission sources.

Impacts of radionuclide releases from each facility involved in the Tank Closure alternatives are evaluated for construction, operations, deactivation and cleanup, and postclosure care, as applicable to each alternative. Based on the data presented in the following subsections, radiation exposure to members of the public is not expected to result in a latent cancer fatality (LCF) in the population within an 80-kilometer (50-mile) radius under Alternatives 1, 2B, 3B, 3C, 4, 5, and 6C, while 1 LCF might occur under Alternatives 2A, 3A, 6A (both the Base and Option Cases), and 6B (both the Base and Option Cases). The cumulative impacts associated with these alternatives in combination with Fast Flux Test Facility (FFTF) decommissioning, waste management operations, and other onsite, local, and regional activities are discussed in Chapter 6.

Under all Tank Closure alternatives except Alternative 1, during the year of maximum impact, the MEI would be about 19.1 kilometers (11.9 miles) east-southeast of the 200 Areas. Under Alternative 1, the MEI would be to the east-northeast, about 11 kilometers (6.8 miles) from the 200 Areas. The dose to the MEI over the life of the project is not expected to exceed 20 millirem for any of the alternatives; on an annual basis, the dose to the MEI is expected to be well below the regulatory limit of 10 millirem per year (40 CFR 61.90–61.97). Americium-241, carbon-14, cesium-137, strontium-90, and plutonium-239 and -240 emitted from the WTP would be the primary contributors of the dose to members of the public over the life of the project under the Tank Closure action alternatives. The onsite MEI would receive an annual dose of less than 0.1 millirem.

Maximum annual impacts calculated for all Tank Closure alternatives except Alternative 1 would be determined by the treatment at the WTP of the materials from the strontium and cesium capsules. As currently described in the alternatives, all of the strontium and cesium would be processed in a 1-year timeframe following completion of tank waste processing. Under all alternatives, the year of strontium and cesium processing is the year of maximum impact on the public from radiological air emissions. An alternate management strategy of distributing the treatment of the strontium and cesium materials over a period of years would reduce maximum annual impacts.

The potential dose to a noninvolved worker would result from exposure to, and inhalation of, radiological contaminants released to the atmosphere from tank farm management, tank waste retrieval and treatment, and tank closure activities. The highest radiological releases associated with the tank closure activities would be from the WTP and 200 Area fugitive emissions and diffuse sources. In the 200-East Area, the noninvolved worker was assumed to be at the 242-A Evaporator, 600 meters (2,000 feet) north-northwest of the 200-East Area source. In the 200-West Area, the noninvolved worker was assumed to be at the Environmental Restoration Disposal Facility (ERDF), about 1.1 kilometers (3,600 feet) east of the 200-West Area source. Radiation doses to noninvolved workers are calculated to remain below 1 millirem per year.

Based on the data presented in the following subsections, the average radiation dose to an FTE worker would be below the Administrative Control Level of 500 millirem per year (DOE 2006a, 2007a) under Alternatives 1, 2A, 2B, 3A, 3B, 3C, 5, and 6C. The annual administrative control level could be exceeded on the basis of exposure of an average FTE worker if Alternatives 4, 6A or 6B (both the Base and Option Cases) were implemented because these alternatives include exhumation of tank farms and contaminated soil underlying the tanks, activities that would result in comparatively large worker doses per hour worked.

Worker doses should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit them. Due to the number of years required to complete some alternatives, the dose over the life of the project would be distributed over several generations of workers. Also,

worker dose would be limited to less than 5 rem total effective dose equivalent per year (10 CFR 835). This regulatory limit would be further constrained by the application of administrative controls. DOE Standard 1098-99, *Radiological Control*, recommends that the annual dose not exceed 2 rem unless explicitly authorized by DOE management and that the dose generally be controlled at a level of 500 millirem (0.5 rem) per year.

In practice, worker exposure would be controlled by use of engineering and administrative controls to keep doses below administrative limits and as low as reasonably achievable. With the large amount of work resulting in exposure to radiation, all alternatives except Alternative 1 would result in large doses to the worker population that would in turn result in the probability of LCFs occurring in the worker population. Potential doses and resulting LCFs to involved workers should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit individual worker dose, as discussed in Section 4.1.10.2.2. In summary, radiation doses to individual workers would be managed and mitigated to minimize impacts. Such measures are not taken into account in this analysis.

4.1.10.1 Alternative 1: No Action

4.1.10.1.1 Radiological Impacts on the Public

Table 4–19 presents estimated doses to the general population and the MEI under Alternative 1. Activities under this alternative that would have radiological air emissions would occur from 2006 to 2107. Due to the long timeframe involved, the doses over the life of the project would not be received by the same members of the population or the same MEI, but are presented to provide a basis for comparison with other alternatives.

Table 4–19. Tank Closure Alternative 1 Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
General population		**Dose (person-rem)**	**Number of Latent Cancer Fatalities[b]**	**Year of Maximum Impact**	**Dose (person-rem per year)**	**Number of Latent Cancer Fatalities[b]**
	WTP	0			0	
	200-East Area	310			3.2	
	200-West Area	290			3.1	
	Total	600	0 (4×10^{-1})	2008	6.3	0 (4×10^{-3})
Maximally exposed individual		**Dose[c] (millirem)**	**Lifetime Risk of a Latent Cancer Fatality[d]**	**Year of Maximum Impact**	**Dose (millirem per year)**	**Lifetime Risk of a Latent Cancer Fatality[d]**
	WTP	0			0	
	200-East Area	7.7			0.083	
	200-West Area	3.9			0.042	
	Total	12	7×10^{-6}	2008	0.13	8×10^{-8}
Onsite MEI	Total	1.8	1×10^{-6}	2008	0.018	1×10^{-8}

a Impacts accrued over the operational life of the project analyzed in this alternative.

b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The MEI dose from 70 years of exposure at the average dose rate would be 8.0 millirem, with a corresponding lifetime risk of an LCF of 5×10^{-6}; the onsite MEI dose from 40 years of exposure would be 0.71 millirem, with a lifetime LCF risk of 4×10^{-7}.

d Probability of an LCF in the MEI is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.
Source: Appendix K, Section K.2.1.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 600 person-rem[2] and the MEI would receive a dose of 12 millirem. Using the risk factor of 0.0006 LCFs per rem (DOE 2003h), no LCFs would be expected in the general population as a result of this alternative. There would be a probability of 7×10^{-6}, or 1 chance in 140,000, of the MEI developing an LCF, assuming the same MEI was exposed over the life of the project. Radiological air emissions would remain fairly constant over the duration of the alternative, not accounting for radioactive decay, with an annual population dose of 6.3 person-rem and an annual MEI dose of 0.13 millirem. The primary contributor to offsite doses would be tank farm emissions of uranium and, to a lesser extent, hydrogen-3 (tritium).

An onsite MEI who spends a normal workday at the Columbia Generating Station would receive a maximum annual dose of 0.018 millirem. The increased risk of an LCF from this dose would be 1×10^{-8} (1 in 93 million).

4.1.10.1.2 Radiological Impacts on Workers

Table 4–20 presents dose and risk estimates for an involved and noninvolved FTE workers. The average annual FTE radiation worker dose would be 140 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 5,700 millirem, which corresponds to a risk of 3×10^{-3} (1 chance in 300) of developing an LCF.

Table 4–20. Tank Closure Alternative 1 Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	140 millirem	9×10^{-5}
Impact over life of project[b]	5,700 millirem	3×10^{-3}
Life-of-Project Worker Population	280 person-rem	0 (2×10^{-1})
Noninvolved Worker (Year of Maximum Impact)		
At the 242-A Evaporator (2008)[c]	0.25 millirem	2×10^{-7}
At the Environmental Restoration Disposal Facility (2008)[d]	0.71 millirem	4×10^{-7}

a For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

b Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

c The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

d The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 102 years of occupational exposure under this alternative is estimated to be 280 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, no LCFs would be expected as a result of the dose associated with this

[2] Person-rem=a unit of collective radiation dose applied to populations or groups of individuals; that is, a unit for expressing the dose when summed across all persons in a specified population or group.

alternative. A majority of the worker dose under this alternative (190 person-rem, or 68 percent) would be associated with 100 years of administrative control of the tank farms.

Estimated doses and risks to the noninvolved workers at the 242-A Evaporator or the ERDF in the year of maximum impact are shown in Table 4–20. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.2 Alternative 2A: Existing WTP Vitrification; No Closure

4.1.10.2.1 Radiological Impacts on the Public

Table 4–21 presents estimated doses to the general population and the MEI under Alternative 2A. Activities that would have radiological air emissions would occur from 2006 to 2193. Due to the long timeframe involved, doses over the life of the project would not be received by the same members of the population or the same MEI, but are presented to provide a basis for comparison with other alternatives.

Table 4–21. Tank Closure Alternative 2A Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
General population		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
	WTP	450			60	
	200-East Area	320			0.00000053	
	200-West Area	310			0	
	Total	1,100	1 (6×10^{-1})	2093	60	0 (4×10^{-2})
Maximally exposed individual		Dose[c] (millirem)	Lifetime Risk of a Latent Cancer Fatality[d]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[d]
	WTP	7.3			1.4	
	200-East Area	8.3			0.0000000078	
	200-West Area	4.2			0	
	Total	20	1×10^{-5}	2093	1.4	8×10^{-7}
Onsite MEI	Total	2.6	2×10^{-6}	2093	0.058	4×10^{-8}

a Impacts accrued over the operational life of the project analyzed in this alternative.

b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The MEI dose from 70 years of exposure at the average dose rate would be 7.4 millirem, with a corresponding lifetime risk of an LCF of 4×10^{-6}; the onsite MEI dose from 40 years of exposure would be 0.55 millirem, with a lifetime LCF risk of 3×10^{-7}.

d Probability of an LCF in the MEI is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 1,100 person-rem. Doses from this alternative could result in 1 LCF in the general population. For purposes of comparison with other alternatives, a dose is calculated for an MEI although the same individual could not be exposed over the duration of this alternative. The MEI would receive a dose of 20 millirem. There would be a probability of 1×10^{-5}, or 1 chance in 100,000, of the MEI developing an LCF, assuming the same MEI was exposed over the life of the project. The main sources of radiological air emissions would be the WTP during its operations from 2018 to 2093 and fugitive and diffuse

emissions from tank farms continuing at a low level over the administrative control period that extends to 2193. The year of maximum impact would be 2093, with a population dose of 60 person-rem and an MEI dose of 1.4 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.058 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 29 million).

4.1.10.2.2 Radiological Impacts on Workers

Table 4–22 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 170 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 6,900 millirem, which corresponds to a risk of 4×10^{-3} (1 chance in 250) of developing an LCF.

Table 4–22. Tank Closure Alternative 2A Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	170 millirem	1×10^{-4}
Impact over life of project[b]	6,900 millirem	4×10^{-3}
Life-of-Project Worker Population	23,000 person-rem	13
Noninvolved Worker (Years of Maximum Impact)		
At the 242-A Evaporator (2094–2095)[c]	0.30 millirem	2×10^{-7}
At the Environmental Restoration Disposal Facility (2094–2095)[d]	0.71 millirem	4×10^{-7}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 188 years of occupational exposure under this alternative is estimated to be 23,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, an estimated 13 LCFs would occur in the worker population. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. Due to the number of years required to complete this alternative, the total dose would be distributed over several generations of workers. A majority of the collective worker dose under this alternative (19,000 person-rem, or 84 percent) would be associated with operations of the WTP, routine tank farm operations, and operations of the ETF. Even though the large worker population dose implies a number of LCFs, the operational controls used by DOE and its contractors would limit the dose that individual workers would receive and, therefore, their risk of an LCF.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the year of maximum impact are shown in Table 4–22. Doses to noninvolved workers would be a small fraction of the Administrative Control Level of 500 millirem per year.

4.1.10.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

4.1.10.3.1 Radiological Impacts on the Public

Table 4–23 presents estimated doses to the general population and the MEI under Alternative 2B. Activities that would have radiological air emissions would occur from 2006 to 2045.

Table 4–23. Tank Closure Alternative 2B Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
General population		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
	WTP	450			76	
	200-East Area	6.0			0.17	
	200-West Area	5.7			0.16	
	Total	460	0 (3×10^{-1})	2040	76	0 (5×10^{-2})
Maximally exposed individual		Dose (millirem)	Lifetime Risk of a Latent Cancer Fatality[c]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[c]
	WTP	8.9			1.7	
	200-East Area	0.15			0.0041	
	200-West Area	0.086			0.0024	
	Total	9.2	5×10^{-6}	2040	1.7	1×10^{-6}
Onsite MEI	Total	1.0	6×10^{-7}	2040	0.097	6×10^{-8}

[a] Impacts accrued over the operational life of the project analyzed in this alternative.

[b] The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[c] Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 460 person-rem, and the MEI would receive a dose of 9.2 millirem. No LCFs would be expected in the population as a result of the population dose. There would be a probability of 5×10^{-6}, or 1 chance in 200,000, of the MEI developing an LCF. The main source of radiological air emissions would be the WTP during its operations from 2018 to 2043. Fugitive and diffuse emission of uranium from tank farms and other sources in the 200 Areas would also be significant contributors to dose over the life of the project. The year of maximum impact would be 2040, with a population dose of 76 person-rem and an MEI dose of 1.7 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.097 millirem. The increased risk of an LCF from this dose would be 6×10^{-8} (1 in 17 million).

4.1.10.3.2 Radiological Impacts on Workers

Table 4–24 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 160 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years

would receive a dose of 6,400 millirem, which corresponds to a risk of 4×10^{-3} (1 chance in 250) of developing an LCF.

The total effective dose equivalent to the involved worker population from the 61 years of occupational exposure under this alternative is estimated to be 11,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 7 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. A majority of the collective worker dose under this alternative (7,600 person-rem, or 69 percent) would be associated with operations of the WTP, routine tank farm operations, and operations of the ETF.

Table 4–24. Tank Closure Alternative 2B Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	160 millirem	1×10^{-4}
Impact over life of project[b]	6,400 millirem	4×10^{-3}
Life-of-Project Worker Population	11,000 person-rem	7
Noninvolved Worker (Years of Maximum Impact)		
At the 242-A Evaporator (2040)[c]	0.29 millirem	2×10^{-7}
At the Environmental Restoration Disposal Facility (2040)[d]	0.0042 millirem	2×10^{-9}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated for table entries due to rounding.
Source: Appendix K, Section K.2.1.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the year of maximum impact are shown in Table 4–24. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

4.1.10.4.1 Radiological Impacts on the Public

Table 4–25 presents estimated doses to the general population and the MEI under Alternative 3A. Activities that would have radiological air emissions would occur from 2006 to 2042. No radiological air emissions are expected during the remainder of the project.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 570 person-rem, and the MEI would receive a dose of 14 millirem. Doses under this alternative would likely result in no LCFs in the general population. There would be a probability of 8×10^{-6}, or 1 chance in 125,000, of the MEI developing an LCF. The main source of radiological air emissions contributing to offsite doses would be the WTP during its operations from 2018 to 2040. Another significant contribution to offsite doses would be carbon-14 emissions from operations of the Bulk

Vitrification Facilities. The year of maximum impact would be 2040, with a population dose of 61 person-rem and an MEI dose of 1.4 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.058 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 29 million).

Table 4–25. Tank Closure Alternative 3A Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
General Population		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
	WTP	360			60	
	200-East Area	100			0.42	
	200-West Area	100			0.45	
	Total	570	0 (3×10^{-1})	2040	61	0 (4×10^{-2})
Maximally Exposed Individual		Dose (millirem)	Lifetime Risk of a Latent Cancer Fatality[c]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[c]
	WTP	5.7			1.4	
	200-East Area	5.4			0.015	
	200-West Area	2.7			0.0086	
	Total	14	8×10^{-6}	2040	1.4	8×10^{-7}
Onsite MEI	Total	0.93	6×10^{-7}	2040	0.058	4×10^{-8}

[a] Impacts accrued over the operational life of the project analyzed in this Tank Closure alternative.

[b] The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[c] Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

4.1.10.4.2 Radiological Impacts on Workers

Table 4–26 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 160 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 6,300 millirem, which corresponds to a risk of 4×10^{-3} (1 chance in 250) of developing an LCF.

The total effective dose equivalent to the involved worker population from the 61 years of occupational exposure under this alternative is estimated to be 10,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 6 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. A majority of the collective worker dose under this alternative (5,800 person-rem, or 58 percent) would be associated with operations of the WTP, routine tank farm operations, and operations of the ETF. Approximately 1,200 person-rem, or 12 percent, of the collective worker dose would result from closure activities such as removal of contaminated soil from BX and SX tank farms, decontamination and decommissioning activities, and installation of a modified RCRA Subtitle C barrier over the tank farms.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–26. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

Table 4–26. Tank Closure Alternative 3A Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	160 millirem	1×10^{-4}
Impact over life of project[b]	6,300 millirem	4×10^{-3}
Life-of-Project Worker Population	10,000 person-rem	6
Noninvolved Worker (Years of Maximum Impact)		
At the 242-A Evaporator (2040)[c]	0.18 millirem	1×10^{-7}
At the Environmental Restoration Disposal Facility (2018–2019)[d]	0.14 millirem	9×10^{-8}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

4.1.10.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

4.1.10.5.1 Radiological Impacts on the Public

Table 4–27 presents estimated doses to the general population and the MEI under Alternative 3B. Activities that would have radiological air emissions would occur from 2006 to 2042. No radiological air emissions are expected during the period of institutional control following tank closure that extends to 2141.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 380 person-rem, and the MEI would receive a dose of 7.1 millirem. No LCFs would be expected in the general population as a result of this alternative. There would be a probability of 4×10^{-6}, or 1 chance in 250,000, of the MEI developing an LCF. The main source of radiological air emissions would be the WTP during its operations from 2018 to 2040. Lower radiological emissions would come from the nonthermal supplementary treatment technology of this alternative and result in lower offsite dose impacts as compared with the thermal supplementary treatment technologies of Alternatives 3A and 3C. The year of maximum impact would be 2040, with a population dose of 60 person-rem and an MEI dose of 1.4 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.058 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 29 million).

Table 4–27. Tank Closure Alternative 3B Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
General Population		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
	WTP	360			60	
	200-East Area	7.2			0.000062	
	200-West Area	5.6			0.0018	
	Total	380	0 (2×10^{-1})	2040	60	0 (4×10^{-2})
Maximally Exposed Individual		Dose (millirem)	Lifetime Risk of a Latent Cancer Fatality[c]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[c]
	WTP	6.8			1.4	
	200-East Area	0.16			0.0000014	
	200-West Area	0.083			0.000023	
	Total	7.1	4×10^{-6}	2040	1.4	8×10^{-7}
Onsite MEI	Total	0.90	5×10^{-7}	2040	0.058	4×10^{-8}

a Impacts accrued over the operational life of the project analyzed in this alternative.
b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).
c Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.
Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.
Source: Appendix K, Section K.2.1.

4.1.10.5.2 Radiological Impacts on Workers

Table 4–28 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 160 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 6,300 millirem, which corresponds to a risk of 4×10^{-3} (1 chance in 250) of developing an LCF.

Table 4–28. Tank Closure Alternative 3B Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	160 millirem	9×10^{-5}
Impact over life of project[b]	6,300 millirem	4×10^{-3}
Life-of-Project Worker Population	10,000 person-rem	6
Noninvolved Worker (Year[s] of Maximum Impact)		
At the 242-A Evaporator (2040)[c]	0.17 millirem	1×10^{-7}
At the Environmental Restoration Disposal Facility (2018–2019)[d]	0.0042 millirem	3×10^{-9}

a For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).
b Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.
c The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.
d The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.
Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 61 years of occupational exposure under this alternative is estimated to be 10,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 6 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. A majority of the collective worker dose under this alternative (5,800 person-rem, or 58 percent) would be associated with operations of the WTP, routine tank farm operations, and operations of the ETF. Approximately 1,200 person-rem, or 12 percent, of the collective worker dose would result from closure activities such as removal of contaminated soil from BX and SX tank farms, decontamination and decommissioning activities, and installation of a modified RCRA Subtitle C barrier over the tank farms.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–28. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

4.1.10.6.1 Radiological Impacts on the Public

Table 4–29 presents estimated doses to the general population and the MEI under Alternative 3C. Activities that would have radiological air emissions would occur from 2006 to 2042. No radiological air emissions are expected during the period of institutional control following tank closure that extends to 2141.

Table 4–29. Tank Closure Alternative 3C Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
General Population	WTP	360			60	
	200-East Area	100			0.42	
	200-West Area	100			0.45	
	Total	570	0 (3×10^{-1})	2040	61	0 (4×10^{-2})
		Dose (millirem)	**Lifetime Risk of a Latent Cancer Fatality[c]**	**Year of Maximum Impact**	**Dose (millirem per year)**	**Lifetime Risk of a Latent Cancer Fatality[c]**
Maximally Exposed Individual	WTP	5.7			1.4	
	200-East Area	5.4			0.015	
	200-West Area	2.7			0.0086	
	Total	14	8×10^{-6}	2040	1.4	8×10^{-7}
Onsite MEI	Total	0.93	6×10^{-7}	2040	0.058	4×10^{-8}

a Impacts accrued over the operational life of the project analyzed in this alternative.

b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 570 person-rem, and the MEI would receive a dose of 14 millirem. No LCFs would be expected in the general population as a result of this alternative. There would be a probability of 8×10^{-6}, or 1 chance in 125,000, of the MEI developing an LCF. The main source of radiological air emissions would be the WTP during its operations from 2018 to 2039. The year of maximum impact would be 2040, with a population dose of 61 person-rem and an MEI dose of 1.4 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.058 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 29 million).

4.1.10.6.2 Radiological Impacts on Workers

Table 4–30 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 160 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 6,400 millirem, which corresponds to a risk of 4×10^{-3} (1 chance in 250) of developing an LCF.

Table 4–30. Tank Closure Alternative 3C Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	160 millirem	1×10^{-4}
Impact over life of project[b]	6,400 millirem	4×10^{-3}
Life-of-Project Worker Population	11,000 person-rem	6
Noninvolved Worker (Year[s] of Maximum Impact)		
At the 242-A Evaporator (2040)[c]	0.18 millirem	1×10^{-7}
At the Environmental Restoration Disposal Facility (2018–2019)[d]	0.14 millirem	9×10^{-8}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 61 years of occupational exposure under this alternative is estimated to be 11,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 6 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. A majority of the collective worker dose under this alternative (5,800 person-rem, or 53 percent) would be associated with operations of the WTP, routine tank farm operations, and operations of the ETF. Approximately 1,200 person-rem, or 11 percent, of the collective worker dose would result from closure activities such as removal of contaminated soil from BX and SX tank farms, decontamination and decommissioning activities, and installation of a modified RCRA Subtitle C barrier over the tank farms.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–30. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

4.1.10.7.1 Radiological Impacts on the Public

Table 4–31 presents estimated doses to the general population and the MEI under Alternative 4. Activities that would have radiological air emissions would occur from 2006 to 2045. No radiological air emissions are expected during the period of institutional control following tank closure that extends to 2144.

Table 4–31. Tank Closure Alternative 4 Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
General Population	WTP	370			60	
	200-East Area	12			0.023	
	200-West Area	110			0.023	
	Total	490	0 (3×10^{-1})	2043	60	0 (4×10^{-2})
		Dose (millirem)	**Lifetime Risk of a Latent Cancer Fatality[c]**	**Year of Maximum Impact**	**Dose (millirem per year)**	**Lifetime Risk of a Latent Cancer Fatality[c]**
Maximally Exposed Individual	WTP	6.4			1.4	
	200-East Area	0.35			0.00045	
	200-West Area	2.6			0.00027	
	Total	9.3	6×10^{-6}	2043	1.4	8×10^{-7}
Onsite MEI	Total	0.93	6×10^{-7}	2043	0.058	4×10^{-8}

[a] Impacts accrued over the operational life of the project analyzed in this alternative.

[b] The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[c] Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the operational life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 490 person-rem, and the MEI would receive a dose of 9.3 millirem. No LCFs would be expected in the general population as a result of this alternative. There would be a probability of 6×10^{-6}, or 1 chance in 167,000, of the MEI developing an LCF. The main sources of radiological air emissions would be the WTP and the supplemental treatment facilities during their operations from 2009 to 2030. The year of maximum impact would be 2043, with a population dose of 60 person-rem and an MEI dose of 1.4 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.058 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 29 million).

4.1.10.7.2 Radiological Impacts on Workers

Table 4–32 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 520 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 21,000 millirem, which corresponds to a risk of 1×10^{-2} (1 chance in 100) of developing an LCF. The high average FTE worker dose would be due to the exhumation of BX and SX tank farms and the underlying contaminated soils. As noted in Section 4.1.10, work would be controlled in accordance with regulations and worker protection practices to maintain worker doses below established limits so an actual worker would not receive the doses calculated for the average FTE worker.

Table 4–32. Tank Closure Alternative 4 Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	520 millirem	3×10^{-4}
Impact over life of project[b]	21,000 millirem	1×10^{-2}
Life-of-Project Worker Population	43,000 person-rem	26
Noninvolved Worker (Year[s] of Maximum Impact)		
At the 242-A Evaporator (2043)[c]	0.18 millirem	1×10^{-7}
At the Environmental Restoration Disposal Facility (2034–2039)[d]	0.20 millirem	1×10^{-7}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 61 years of occupational exposure under this alternative is estimated to be 43,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 26 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. A majority of the collective worker dose under this alternative (32,000 person-rem, or 74 percent) would be associated with deep soil removal from SX tank farm.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–32. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

4.1.10.8.1 Radiological Impacts on the Public

Table 4–33 presents estimated doses to the general population and the MEI under Alternative 5. Activities that would have radiological air emissions would occur from 2006 to 2036. No radiological air

emissions are expected during operations or deactivation of storage facilities or during the period of institutional control following tank closure that extends to 2139.

Table 4–33. Tank Closure Alternative 5 Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
General Population	WTP	360			60	
	200-East Area	6.0			0.00003	
	200-West Area	95			0.56	
	Total	460	0 (3×10^{-1})	2034	61	0 (4×10^{-2})
		Dose (millirem)	**Lifetime Risk of a Latent Cancer Fatality[c]**	**Year of Maximum Impact**	**Dose (millirem per year)**	**Lifetime Risk of a Latent Cancer Fatality[c]**
Maximally Exposed Individual	WTP	6.9			1.4	
	200-East Area	0.14			0.00000069	
	200-West Area	1.8			0.011	
	Total	8.9	5×10^{-6}	2034	1.4	8×10^{-7}
Onsite MEI	Total	0.84	5×10^{-7}	2034	0.058	4×10^{-8}

[a] Impacts accrued over the operational life of the project analyzed in this alternative.

[b] The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[c] Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the operational life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 460 person-rem, and the MEI would receive a dose of 8.9 millirem. No LCFs would be expected in the general population as a result of this alternative. There would be a probability of 5×10^{-6}, or 1 chance in 200,000, of the MEI developing an LCF. The main source of radiological air emissions would be the WTP, which includes the contribution from sulfate removal associated with pretreatment under this alternative. Another large source of radiological air emissions would be Bulk Vitrification Facility operations in the 200-West Area. The year of maximum impact would be 2034, with a population dose of 61 person-rem and an MEI dose of 1.4 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.058 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 29 million).

4.1.10.8.2 Radiological Impacts on Workers

Table 4–34 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 150 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 5,900 millirem, which corresponds to a risk of 4×10^{-3} (1 chance in 250) of developing an LCF.

Table 4–34. Tank Closure Alternative 5 Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	150 millirem	9×10^{-5}
Impact over life of project[b]	5,900 millirem	4×10^{-3}
Life-of-Project Worker Population	8,800 person-rem	5
Noninvolved Worker (Year[s] of Maximum Impact)		
At the 242-A Evaporator (2034)[c]	0.17 millirem	1×10^{-7}
At the Environmental Restoration Disposal Facility (2018–2019)[d]	0.18 millirem	1×10^{-7}

a For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

b Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

c The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

d The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 61 years of occupational exposure under this alternative is estimated to be 8,800 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 5 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. The largest contributor to the collective worker dose under this alternative (3,200 person-rem, or 37 percent) would be operations of the WTP.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–34. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.10.9.1 Radiological Impacts on the Public

4.1.10.9.1.1 Base Case

Table 4–35 presents estimated doses to the general population and the MEI under Alternative 6A, Base Case. Activities under this case that would have radiological air emissions would occur from 2006 to 2168. Due to the long timeframe involved, the doses over the life of the project would not be received by the same members of the population or the same MEI, but are presented to provide a basis for comparison with other alternatives.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 560 person-rem, and the MEI would receive a dose of 11 millirem. No LCFs would be expected in the general population as a result of this alternative. There would be a probability of 7.0×10^{-6}, or 1 chance in 140,000 of the MEI developing an LCF. The main source of radiological air emissions would be the WTP during its operations from 2018 to 2163. The year of maximum impact would be 2163, with a population dose of 60 person-rem and an MEI dose of 1.4 millirem.

Table 4–35. Tank Closure Alternative 6A, Base Case, Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
General Population	WTP	460			60	
	200-East Area	93			0.097	
	200-West Area	1.8			0.076	
	Total	560	0 (3×10^{-1})	2163	60	0 (4×10^{-2})
		Dose[c] (millirem)	Lifetime Risk of a Latent Cancer Fatality[d]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[d]
Maximally Exposed Individual	WTP	9.2			1.4	
	200-East Area	2.3			0.0021	
	200-West Area	0.025			0.0011	
	Total	11	7×10^{-6}	2163	1.4	8×10^{-7}
Onsite MEI	Total	1.2	7×10^{-7}	2163	0.059	4×10^{-8}

a Impacts accrued over the operational life of the project analyzed in this alternative.

b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The MEI dose from 70 years of exposure at the average dose rate would be 4.9 millirem, with a corresponding lifetime risk of an LCF of 3×10^{-6}; the onsite MEI dose from 40 years of exposure would be 0.28 millirem, with a lifetime LCF risk of 2×10^{-7}.

d Probability of an LCF in the MEI is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.059 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 28 million).

4.1.10.9.1.2 Option Case

Table 4–36 presents estimated doses to the general population and the MEI under Alternative 6A, Option Case. Activities under this case that would have radiological air emissions would occur from 2006 to 2168. As with the Base Case, due to the long timeframe involved, the doses over the life of the project would not be received by the same members of the population or the same MEI, but are presented to provide a basis for comparison with other alternatives.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 760 person-rem, and the MEI would receive a dose of 15 millirem. Doses in this case could result in 1 LCF in the general population. There would be a probability of 9×10^{-6}, or 1 chance in 110,000, of the MEI developing an LCF. The main source of radiological air emissions would be the WTP during its operations from 2018 to 2163. The higher dose over the life of the project of the Option Case compared with the Base Case under Alternative 6A is primarily due to excavating the B and T Area cribs and trenches (ditches) and processing the contaminated soil in the PPF. The year of maximum impact would be 2163, with a population dose of 60 person-rem and an MEI dose of 1.4 millirem.

Table 4–36. Tank Closure Alternative 6A, Option Case, Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
General Population		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
	WTP	460			60	
	200-East Area	150			0.16	
	200-West Area	150			0.14	
	Total	760	1 (5×10^{-1})	2163	60	0 (4×10^{-2})
Maximally Exposed Individual		Dose[c] (millirem)	Lifetime Risk of a Latent Cancer Fatality[d]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[d]
	WTP	7.6			1.4	
	200-East Area	4.9			0.0032	
	200-West Area	2.6			0.0017	
	Total	15	9×10^{-6}	2163	1.4	8×10^{-7}
Onsite MEI	Total	1.3	8×10^{-7}	2163	0.059	4×10^{-8}

a Impacts accrued over the operational life of the project analyzed in this alternative.

b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The MEI dose from 70 years of exposure at the average dose rate would be 6.5 millirem, with a corresponding lifetime risk of an LCF of 4×10^{-6}; the onsite MEI dose from 40 years of exposure would be 0.32 millirem, with a lifetime LCF risk of 2×10^{-7}.

d Probability of an LCF in the MEI is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.059 millirem. The increased risk of an LCF from this dose would be 4×10^{-8} (1 in 28 million).

4.1.10.9.2 Radiological Impacts on Workers

4.1.10.9.2.1 Base Case

Table 4–37 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 420 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 17,000 millirem, which corresponds to a risk of 1×10^{-2} (1 chance in 100) of developing an LCF. The high average FTE worker dose would be due to exhumation of tank farms and underlying contaminated soils. As noted in Section 4.1.10, work would be controlled in accordance with regulations and worker protection practices to maintain worker doses below established limits so an actual worker would not receive the doses calculated for the average FTE worker.

Table 4–37. Tank Closure Alternative 6A, Base Case, Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	420 millirem	2×10^{-4}
Impact over life of project[b]	17,000 millirem	1×10^{-2}
Life-of-Project Worker Population	120,000 person-rem	72
Noninvolved Worker (Year[s] of Maximum Impact)		
At the 242-A Evaporator (2163)[c]	0.18 millirem	1×10^{-7}
At the Environmental Restoration Disposal Facility (2054–2061)[d]	0.075 millirem	4×10^{-8}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 257 years of occupational exposure under this alternative is estimated to be 120,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 72 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. A large contributor to the collective worker dose (38,000 person-rem or 32 percent) under this alternative would be the WTP's 146 years of operation. Another large contributor to collective worker dose (69,000 person-rem, or 58 percent) would be associated with operations of the PPF and deep soil removal from T, TX, and SX tank farms.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–37. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.9.2.2 Option Case

Table 4–38 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 400 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 16,000 millirem, which corresponds to a risk of 1×10^{-2} (1 chance in 100) of developing an LCF. The high average FTE worker dose would be due to exhumation of tank farms and underlying contaminated soils. Although exhuming the B and T Area cribs and trenches (ditches) would add to the collective worker dose, the associated dose rate for this work would be comparatively low, thus lowering the average FTE worker dose. As noted in Section 4.1.10, work would be controlled in accordance with regulations and worker protection practices to maintain worker doses below established limits so an actual worker would not receive the doses calculated for the average FTE worker.

Table 4–38. Tank Closure Alternative 6A, Option Case, Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	400 millirem	2×10^{-4}
Impact over life of project[b]	16,000 millirem	1×10^{-2}
Life-of-Project Worker Population	120,000 person-rem	75
Noninvolved Worker (Year[s] of Maximum Impact)		
At the 242-A Evaporator (2163)[c]	0.18 millirem	1×10^{-7}
At the Environmental Restoration Disposal Facility (2138–2140)[d]	0.20 millirem	1×10^{-7}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 257 years of occupational exposure under this alternative is estimated to be 120,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 75 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. A large contributor to the collective worker dose (38,000 person-rem or 32 percent) under this alternative would be the WTP's 146 years of operation. Another large contributor to collective worker dose (73,000 person-rem, or 61 percent) is associated with operations of the PPF and deep soil removal from T, TX, and SX tank farms.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–38. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.10.10.1 Radiological Impacts on the Public

4.1.10.10.1.1 Base Case

Table 4–39 presents estimated doses to the general population and the MEI under Alternative 6B, Base Case. Activities that would have radiological air emissions would occur from 2006 to 2100. Due to the long timeframe involved, the doses over the life of the project would not be received by the same members of the population or the same MEI, but are presented to provide a basis for comparison with other alternatives.

Table 4–39. Tank Closure Alternative 6B, Base Case, Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
General Population	WTP	450			74	
	200-East Area	75			1.3	
	200-West Area	75			1.1	
	Total	600	0 (4×10^{-1})	2040	76	0 (5×10^{-2})
Maximally Exposed Individual		Dose[c] (millirem)	Lifetime Risk of a Latent Cancer Fatality[d]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[d]
	WTP	8.1			1.6	
	200-East Area	2.3			0.032	
	200-West Area	1.3			0.016	
	Total	12	7×10^{-6}	2040	1.7	1×10^{-6}
Onsite MEI	Total	1.2	7×10^{-7}	2040	0.096	6×10^{-8}

a Impacts accrued over the operational life of the project analyzed in this alternative.

b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The MEI dose from 70 years of exposure at the average dose rate would be 8.7 millirem, with a corresponding lifetime risk of an LCF of 5×10^{-6}; the onsite MEI dose from 40 years of exposure would be 0.49 millirem, with a lifetime LCF risk of 3×10^{-7}.

d Probability of an LCF in the MEI is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 600 person-rem, and the MEI would receive a dose of 12 millirem. No LCFs would be expected in the general population as a result of this alternative. There would be a probability of 7×10^{-6}, or 1 chance in 143,000, of the MEI developing an LCF. The main source of the doses would be radiological air emissions from the WTP during its operations from 2018 to 2043. The year of maximum impact would be 2040, with a population dose of 76 person-rem and an MEI dose of 1.7 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.096 millirem. The increased risk of an LCF from this dose would be 6×10^{-8} (1 in 17 million).

4.1.10.10.1.2 Option Case

Table 4–40 presents estimated doses to the general population and the MEI for the Alternative 6B, Option Case. Activities that would have radiological air emissions would occur from 2006 to 2100. Due to the long timeframe involved, the doses over the life of the project would not be received by the same members of the population or the same MEI, but are presented to provide a basis for comparison with other alternatives.

Table 4–40. Tank Closure Alternative 6B, Option Case, Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
General Population		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
	WTP	450			74	
	200-East Area	130			2.2	
	200-West Area	130			1.8	
	Total	710	0 (4×10^{-1})	2040	78	0 (5×10^{-2})
Maximally Exposed Individual		Dose[c] (millirem)	Lifetime Risk of a Latent Cancer Fatality[d]	Year of Maximum Impact	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[d]
	WTP	7.3			1.6	
	200-East Area	4.2			0.046	
	200-West Area	2.2			0.022	
	Total	14	8×10^{-6}	2040	1.7	1×10^{-6}
Onsite MEI	Total	1.3	8×10^{-7}	2040	0.098	6×10^{-8}

[a] Impacts accrued over the operational life of the project analyzed in this alternative.

[b] The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[c] Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The MEI dose from 70 years of exposure at the average dose rate would be 10 millirem, with a corresponding lifetime risk of an LCF of 6×10^{-6}; the onsite MEI dose from 40 years of exposure would be 0.54 millirem, with a lifetime LCF risk of 3×10^{-7}.

[d] Probability of an LCF in the MEI is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 710 person-rem, and the MEI would receive a dose of 14 millirem. No LCFs would be expected in the general population as a result of this alternative. There would be a probability of 8×10^{-6}, or 1 chance in 125,000, of the MEI developing an LCF. The main source of the doses would be radiological air emissions from the WTP during its operations from 2018 to 2043. The higher dose over the life of the project of the Option Case compared with the Base Case under Alternative 6B is primarily due to excavating the B and T Area cribs and trenches (ditches) and processing the contaminated soil in the PPF. The year of maximum impact would be 2040, with a population dose of 78 person-rem and an MEI dose of 1.7 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.098 millirem. The increased risk of an LCF from this dose would be 6×10^{-8} (1 in 17 million).

4.1.10.10.2 Radiological Impacts on Workers

4.1.10.10.2.1 Base Case

Table 4–41 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 870 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 35,000 millirem, which corresponds to a risk of 2×10^{-2} (1 chance in 50) of developing an LCF. The high average FTE worker dose would be due

to exhumation of tank farms and underlying contaminated soils. The average FTE worker dose would be higher under Alternative 6B (Base Case and Option Case) because of the shorter duration of the project. Activities with lower average dose rates under Alternative 6A go on for a much longer time; the effect is a lower average dose across the entire project. As noted in Section 4.1.10, work would be controlled in accordance with regulations and worker protection practices to maintain worker doses below established limits so an actual worker would not receive the doses calculated for the average FTE worker.

Table 4–41. Tank Closure Alternative 6B, Base Case, Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	870 millirem	5×10^{-4}
Impact over life of project[b]	35,000 millirem	2×10^{-2}
Life-of-Project Worker Population	82,000 person-rem	49
Noninvolved Worker (Year of Maximum Impact)		
At the 242-A Evaporator (2040)[c]	0.33 millirem	2×10^{-7}
At the Environmental Restoration Disposal Facility (2040)[d]	0.11 millirem	7×10^{-8}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 96 years of occupational exposure under this alternative is estimated to be 82,000 person-rem. The lower collective worker dose under Alternative 6B (both cases) compared with Alternative 6A would primarily be due to the shorter period of WTP and routine tank farm operations. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 49 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. Large contributors to the worker population dose under this alternative (69,000 person-rem, or 84 percent) would be operations of the PPF and deep soil removal from T, TX, and SX tank farms.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–41. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.10.2.2 Option Case

Table 4–42 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 790 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 32,000 millirem, which corresponds to a risk of 2×10^{-2} (1 chance in 50) of developing an LCF. The high average FTE worker dose would be due to exhumation of tank farms and underlying contaminated soils. Although exhuming the B and T Area cribs and trenches (ditches) would add to the collective worker dose, the associated dose rate for this work

would be comparatively low, thus lowering the average FTE worker dose. As noted in Section 4.1.10, work would be controlled in accordance with regulations and worker protection practices to maintain worker doses below established limits so an actual worker would not receive the doses calculated for the average FTE worker.

Table 4–42. Tank Closure, Alternative 6B, Option Case, Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	790 millirem	5×10^{-4}
Impact over life of project[b]	32,000 millirem	2×10^{-2}
Life-of-Project Worker Population	85,000 person-rem	51
Noninvolved Worker (Year of Maximum Impact)		
At the 242-A Evaporator (2040)[c]	0.40 millirem	2×10^{-7}
At the Environmental Restoration Disposal Facility (2040)[d]	0.28 millirem	2×10^{-7}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project dose is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

The total effective dose equivalent to the involved worker population from the 96 years of occupational exposure under this alternative is estimated to be 85,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 51 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit individual worker dose, as discussed in Section 4.1.10. Large contributors to the worker population dose under this alternative (71,000 person-rem, or 84 percent) would be operations of the PPF and deep soil removal from T, SX, and TX tank farms.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the years of maximum impact are shown in Table 4–42. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

4.1.10.11.1 Radiological Impacts on the Public

Table 4–43 presents estimated doses to the general population and the MEI under Alternative 6C. Activities that would have radiological air emissions would occur from 2006 to 2045.

Table 4–43. Tank Closure Alternative 6C Normal Operations Public Health Impacts of Atmospheric Radionuclide Releases

Receptor	Facility	Impacts over Life of Project[a]		Peak Annual Impacts		
		Dose (person-rem)	Number of Latent Cancer Fatalities[b]	Year of Maximum Impact	Dose (person-rem per year)	Number of Latent Cancer Fatalities[b]
General Population	WTP	450			74	
	200-East Area	6.0			0.17	
	200-West Area	5.7			0.16	
	Total	460	0 (3×10^{-1})	2040	74	0 (4×10^{-2})
		Dose (millirem)	**Lifetime Risk of a Latent Cancer Fatality[c]**	**Year of Maximum Impact**	**Dose (millirem per year)**	**Lifetime Risk of a Latent Cancer Fatality[c]**
Maximally Exposed Individual	WTP	8.8			1.6	
	200-East Area	0.15			0.0041	
	200-West Area	0.086			0.0024	
	Total	9.1	5×10^{-6}	2040	1.6	1×10^{-6}
Onsite MEI	Total	1.0	6×10^{-7}	2040	0.094	6×10^{-8}

[a] Impacts accrued over the operational life of the project analyzed in this alternative.

[b] The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[c] Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: MEI=maximally exposed individual; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.2.1.

Over the life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 460 person-rem, and the MEI would receive a dose of 9.1 millirem. Using the risk factor of 0.0006 LCFs per rem (DOE 2003h), no LCFs would be expected in the general population as a result of this alternative. There would be a probability of 5×10^{-6}, or 1 chance in 200,000, of the MEI developing an LCF. The main source of radiological air emissions would be the WTP during its operations from 2018 to 2043. The year of maximum impact would be 2040, with a population dose of 74 person-rem and an MEI dose of 1.6 millirem.

An onsite MEI who spends a normal workday at LIGO would receive a maximum annual dose of 0.094 millirem. The increased risk of an LCF from this dose would be 6×10^{-8} (1 in 18 million).

4.1.10.11.2 Radiological Impacts on Workers

Table 4–44 presents dose and risk estimates for an involved and noninvolved FTE worker. The average annual FTE radiation worker dose would be 160 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over the course of 40 years would receive a dose of 6,400 millirem, which corresponds to a risk of 4×10^{-3} (1 chance in 250) of developing an LCF.

The total effective dose equivalent to the involved worker population from the 61 years of occupational exposure under this alternative is estimated to be 11,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem to this population dose yields an estimate of 7 LCFs. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. The largest contributor to the worker population dose under this alternative (6,300 person-rem, or 57 percent) is associated with operations at the WTP.

Table 4–44. Tank Closure Alternative 6C Normal Operations Radiological Impacts on Workers

Receptor	Dose	Latent Cancer Fatality Risk[a]
Average Involved Full-Time Equivalent Worker		
Average annual impact	160 millirem	1×10^{-4}
Impact over life of project[b]	6,400 millirem	4×10^{-3}
Life-of-Project Worker Population	11,000 person-rem	7
Noninvolved Worker (Year of Maximum Impact)		
At the 242-A Evaporator (2040)[c]	0.28 millirem	2×10^{-7}
At the Environmental Restoration Disposal Facility (2040)[d]	0.0042 millirem	2×10^{-9}

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

[b] Impact over the life of the project is the average dose a full-time equivalent radiation worker would receive working on this project. It is determined by multiplying the average annual dose by an assumed career length of 40 years.

[c] The dose to a noninvolved worker at the 242-A Evaporator would be due to releases from the Waste Treatment Plant and other 200-East Area sources.

[d] The dose to a noninvolved worker at the Environmental Restoration Disposal Facility would be due to releases from 200-West Area sources.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.1.

Estimated doses and risks to noninvolved workers at the 242-A Evaporator and the ERDF in the year of maximum impact are shown in Table 4–44. Doses to noninvolved workers would be a small fraction of the DOE-recommended Administrative Control Level of 500 millirem per year.

4.1.10.12 Worker Chemical Risks

Workers involved in performing activities associated with the storage, retrieval, and processing of tank waste and the closure of tank farm facilities could be exposed to chemical vapors. Chemical exposure is a concern because the tanks are continuously vented to the atmosphere, and workers would need to access parts of the tank farm system to monitor or retrieve the waste. The primary route of chemical exposure to workers during routine operations is assumed to be inhalation.

Estimates of worker exposure to chemicals and the resulting health effects are highly dependent on modeling assumptions. If a worker is assumed to be very close to the chemical emission point, the predicted consequences might vary from zero to extreme (severe, irreversible health effects), depending on the assumed duration of the release and exposure and the location of the worker with respect to the emission point and wind direction. Therefore, no attempt is made to estimate involved worker exposure to chemical releases associated with routine operations.

Based on historic reports of effects of tank farm exposures, workers exposed to tank farm vapors during waste retrieval, waste treatment, and tank closure activities could experience headaches, burning sensations in the nose and throat, nausea, and impaired pulmonary function. Past experience implies that if these impacts were experienced, they would be transient and have no long-lasting deleterious effects. To avoid this potential health risk, workers in certain areas of the tank farms would be required to use supplied-air respirators. Through compliance with applicable requirements and the scrutiny provided by internal and external review of chemical exposure issues, it is expected that involved worker exposure would be maintained below the thresholds identified by the Occupational Safety and Health Administration and the American Conference of Governmental Industrial Hygienists.

4.1.11 Public and Occupational Health and Safety—Facility Accidents

This section addresses potential impacts on workers and the public associated with potential accidents under the alternatives. For each alternative, radiological impacts of postulated accident scenarios are quantified for an MEI living near Hanford, the offsite population as a whole, and a noninvolved worker. Hazardous chemical impacts are also evaluated. For an involved worker, accident consequences have not been quantified. While involved workers are expected to be near the Hanford tank farms during routine tank farm operations, as is the case under Alternative 1, No Action, or in the WTP or other waste treatment facilities during facility operations, their number and location relative to a postulated accident are not known. In the event of an accident involving chemicals or radioactive materials, workers near an accident could be at risk of serious injury or fatality. Safety procedures, safety equipment, and protective barriers are typical features that would prevent or minimize worker impacts. Additionally, following initiation of accident/site emergency alarms, workers in adjacent areas of the facility would evacuate in accordance with the technical area and facility emergency operating procedures and training. Therefore, involved worker impacts are not discussed further relative to the alternatives. The impacts of selected intentional acts of destruction scenarios are addressed in Appendix K, Section K.3.11.

There would be no radiological accidents associated with facility construction, including construction of the WTP, under any action alternative. Further, any hazardous chemical accidents associated with facility construction would be typical of those normally associated with industrial construction materials, hazards, and practices. Projected operational accident consequences of each alternative are presented in the following sections. Details of the methodology for assessing the potential impacts on workers and the public associated with postulated accidents are presented in Appendix K, Section K.3.

4.1.11.1 Alternative 1: No Action

4.1.11.1.1 Radiological Impacts of Airborne Releases

Under Tank Closure Alternative 1, reasonably foreseeable accidents that could occur include (1) hydrogen burn in a waste storage tank and (2) tank dome collapse. The accident selected to represent a severe accident is the seismically induced waste tank dome collapse.

The consequences of a seismically induced waste tank dome collapse, if it were to occur, are shown in Table 4–45. The annual risks of LCFs for this accident are shown in Table 4–46. The radiological accident cancer risks from inhalation for a 100-year campaign period would be 6×10^{-9} for the MEI, 3×10^{-5} for the offsite population, and 7×10^{-6} for the noninvolved worker.

Table 4–45. Tank Closure Alternative 1 Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}

a The alphanumeric code following the accident's title (i.e., TK53) corresponds with the code in the accident's description in Appendix K, Section K.3.4.

b Increased likelihood of latent cancer fatality for an individual, assuming the accident occurs.

c Based on a population of 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area (see Appendix K, Section K.2.1.3.1.2).

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Table 4–46. Tank Closure Alternative 1 Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}

[a] The alphanumeric code following the accident's title (i.e., TK53) corresponds with the code in the accident's description in Appendix K, Section K.3.4.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on a population of 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area (see Appendix K, Section K.2.1.3.1.2).

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Source: Appendix K, Section K.3.7.1.

4.1.11.1.2 Hazardous Chemical Impacts

Various hazardous chemicals exist in the waste tanks. Since the chemicals that exist in the tank waste are mixed with the radioactive material, any accident event would be expected to release both hazardous chemicals and radioactive materials. Due to the quantity and nature of the radioactive material in the waste tanks, the human health consequences of an accidental release would be dominated by the impacts of the radioactive components. Therefore, hazardous chemical human health impacts are not analyzed separately.

4.1.11.2 Alternative 2A: Existing WTP Vitrification; No Closure

4.1.11.2.1 Radiological Impacts of Airborne Releases

Table 4–47 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–48 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

Table 4–47. Tank Closure Alternative 2A Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (1×10^{-4})	0.043	3×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Table 4–48. Tank Closure Alternative 2A Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	5×10^{-4}	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–48) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–47).

Under Tank Closure Alternative 2A, operations would continue for a project period of 76 years; during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–48, the risk to the offsite population and onsite workers during this 75-year project period would be an increase of 1 in the number of LCFs in the offsite population and a 1×10^{-4} and 6×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

4.1.11.2.2 Hazardous Chemical Impacts

Various hazardous chemicals exist in the waste tanks and others are used in the tank closure and waste treatment processes. The chemicals that exist in the tank waste are mixed with the radioactive material; thus any accident event would be expected to release both hazardous chemicals and radioactive materials. Due to the quantity and nature of the radioactive material in the waste tanks, the human health consequences of an accidental release would be dominated by the impacts of the radioactive components. Therefore, hazardous chemical human health impacts of concern are primarily associated with the tank closure and waste treatment processes.

Two chemicals used in the WTP processes, nitric acid and ammonia, whose impacts are considered representative of the impacts that may result from the accidental release of any other chemical associated with the tank closure and treatment processes, have been selected for accident analysis. The selection of these two chemicals is based on their large inventories, potential for release, chemical properties, and human health effects. For both chemicals, an accident scenario is postulated in which a break in a tank or piping occurs, allowing the chemical to be released over a short period. The cause of the break could be mechanical failure, corrosion, mechanical impact, malevolent act, or natural phenomenon. The frequency of these types of events is in the range of 0.001 to 0.01 per year. The nitric acid forms a pool within a berm surrounding the storage tank and evaporates, forming a plume that disperses into the environment. Ammonia is stored as a liquid under pressure and is released from its storage tank in a gaseous form. In both cases, the plume moves away from the point of release in the direction of the prevailing wind and potentially impacts workers and the public.

Table 4–49 shows the estimated concentrations of each chemical at specified distances for comparison with the 60-minute Acute Exposure Guideline Levels (AEGLs) 2 and 3 (EPA 2007). The levels of concern for ammonia are 160 ppm for AEGL-2 and 1,100 ppm for AEGL-3. The levels of concern for nitric acid are 24 ppm for AEGL-2 and 92 ppm for AEGL-3. The results indicate that AEGL-2 and AEGL-3 thresholds are not exceeded beyond the nearest site boundary. For the noninvolved worker 100 meters (110 yards) from the accident, both the AEGL-2 and AEGL-3 thresholds would be exceeded for the ammonia release but not for the nitric acid release.

Table 4–49. Tank Closure Alternatives Chemical Impacts of Accidents

Chemical	Quantity Released (gallons)	AEGL-2[a]		AEGL-3[b]		Concentration (ppm)	
		Limit (ppm)	Distance to Limit (meters)	Limit (ppm)	Distance to Limit (meters)	Noninvolved Worker at 100 meters	Nearest Site Boundary at 8,600 meters
Ammonia	11,500	160	2,450	1,100	730	41,000	27.0
Nitric acid	17,000	24	<30	92	<30	4.7	0.004

[a] AEGL-2 is the airborne concentration (expressed as ppm or milligrams per cubic meter) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape (EPA 2007).

[b] AEGL-3 is the airborne concentration (expressed as ppm or milligrams per cubic meters) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death (EPA 2007).

Note: To convert gallons to liters, multiply by 3.7854; meters to yards, by 1.0936.

Key: AEGL=Acute Exposure Guideline Level; ppm=parts per million.

Source: Appendix K, Section K.3.9.1.

4.1.11.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

4.1.11.3.1 Radiological Impacts of Airborne Releases

Table 4–50 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–51 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

Table 4–50. Tank Closure Alternative 2B Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.000043	3×10^{-8}	0.57	0 (3×10^{-4})	0.13	8×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop –unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Table 4–51. Tank Closure Alternative 2B Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	5×10^{-4}	1×10^{-11}	0 (2×10^{-7})	4×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "Z×Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–51) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–50).

Under Tank Closure Alternative 2B, operations would continue for a project period of 26 years, during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–51, the risk to the offsite population and onsite workers during this 26-year project period would be no (4×10^{-1}) increase in the number of LCFs in the offsite population and a 3×10^{-5} and 2×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

4.1.11.3.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

4.1.11.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

4.1.11.4.1 Radiological Impacts of Airborne Releases

Table 4–52 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–53 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–53) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–52).

Under Tank Closure Alternative 3A, operations would continue for a project period of 23 years, during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–53, the risk to the offsite population and onsite workers during this 22-year project period would be no increase (4×10^{-1}) in the number of LCFs in the offsite population and a 3×10^{-5} and 2×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

4.1.11.4.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

Table 4–52. Tank Closure Alternative 3A Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	7×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	6×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (1×10^{-4})	0.043	3×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Bulk vitrification waste receipt tank failure – unmitigated (200-East Area) (BV61)	0.000000028	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	0.0000035	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0000022	1×10^{-9}	0.0029	0 (2×10^{-5})	0.0025	1×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0000066	4×10^{-9}	0.030	0 (2×10^{-5})	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

a The alphanumeric code following in the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

b Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

c Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.
Source: Appendix K, Section K.3.7.1.

Table 4–53. Tank Closure Alternative 3A Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	5×10^{-4}	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Bulk vitrification waste receipt tank failure – unmitigated (200-East Area) (BV61)	5×10^{-4}	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	5×10^{-4}	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	5×10^{-4}	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	5×10^{-4}	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

a The alphanumeric code following in the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

b Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

c Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.
Source: Appendix K, Section K.3.7.1.

4.1.11.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

4.1.11.5.1 Radiological Impacts of Airborne Releases

Table 4–54 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–55 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K,

Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

Table 4–54. Tank Closure Alternative 3B Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feeder preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (1×10^{-4})	0.043	3×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	0.000000028	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Cast stone feed receipt tank failure – unmitigated (200-West Area) (CS71)	0.0000035	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0000022	1×10^{-9}	0.029	0 (2×10^{-5})	0.0025	1×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0000066	4×10^{-9}	0.030	0 (2×10^{-5})	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Table 4–55. Tank Closure Alternative 3B Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	5×10^{-4}	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	5×10^{-4}	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Cast stone feed receipt tank failure – unmitigated (200-West Area) (CS71)	5×10^{-4}	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	5×10^{-4}	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	5×10^{-4}	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the scenario's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–55) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–54).

Under Tank Closure Alternative 3B, operations would continue for a project period of 23 years; during this time period, workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–55, the risk to the offsite population and onsite workers during this 22-year project period would be no increase (4×10^{-1}) in the number of LCFs in the offsite population and a 3×10^{-5} and 2×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

4.1.11.5.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

4.1.11.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

4.1.11.6.1 Radiological Impacts of Airborne Releases

Table 4–56 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–57 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–57) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–56).

Under Tank Closure Alternative 3C, operations would continue for a project period of 23 years, during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–57, the risk to the offsite population and onsite workers during this 22-year project period would be no increase (4×10^{-1}) in the number of LCFs in the offsite population and a 3×10^{-5} and 2×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

Table 4–56. Tank Closure Alternative 3C Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (1×10^{-4})	0.043	3×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Steam reforming feed receipt tank failure – unmitigated (200-East Area) (SRF1)	0.000000028	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Steam reforming feed receipt tank failure – unmitigated (200-West Area) (SRF1)	0.0000035	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0000022	1×10^{-9}	0.029	0 (2×10^{-5})	0.0025	1×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0000066	4×10^{-9}	0.030	0 (2×10^{-5})	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Table 4–57. Tank Closure Alternative 3C Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT 23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	5×10^{-4}	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Steam reforming feed receipt tank failure – unmitigated (200-East Area) (SRF1)	5×10^{-4}	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Steam reforming feed receipt tank failure – unmitigated (200-West Area) (SRF1)	5×10^{-4}	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	5×10^{-4}	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	5×10^{-4}	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

a The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day" read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

b Increased risk of a latent cancer fatality, taking into account the probability (frequency) of the accident.

c Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

4.1.11.6.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

4.1.11.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

4.1.11.7.1 Radiological Impacts of Airborne Releases

Table 4–58 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–59 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–59) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–58).

Under Tank Closure Alternative 4, operations would continue for a project period of 26 years, during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–59, the risk to the offsite population and onsite workers during this 26-year project period would be no increase (4×10^{-1}) in the number of LCFs in the offsite population and a 3×10^{-5} and 2×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

4.1.11.7.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

Table 4–58. Tank Closure Alternative 4 Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (1×10^{-4})	0.043	3×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	0.000000028	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	0.0000035	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0000022	1×10^{-9}	0.029	0 (2×10^{-5})	0.0025	1×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0000066	4×10^{-9}	0.030	0 (2×10^{-5})	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Table 4–59. Tank Closure Alternative 4 Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	5×10^{-4}	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	5×10^{-4}	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	5×10^{-4}	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	5×10^{-4}	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	5×10^{-4}	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.
Source: Appendix K, Section K.3.7.1.

4.1.11.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

4.1.11.8.1 Radiological Impacts of Airborne Releases

Table 4–60 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–61 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

Table 4–60. Tank Closure Alternative 5 Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (45 MTG/day)	0.000021	1×10^{-8}	0.29	0 (2×10^{-4})	0.065	4×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×45 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	0.000000028	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	0.0000035	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0000022	1×10^{-9}	0.029	0 (2×10^{-5})	0.0025	1×10^{-6}
Mixed TRU waste/ MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0000066	4×10^{-9}	0.030	0 (2×10^{-5})	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Table 4–61. Tank Closure Alternative 5 Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (45 MTG/day)	5×10^{-4}	6×10^{-12}	0 (9×10^{-8})	2×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×45 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	5×10^{-4}	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	5×10^{-4}	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	5×10^{-4}	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	5×10^{-4}	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; PT=Pretreatment; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–61) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 chance in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–60).

Under Tank Closure Alternative 5, operations would continue for a project period of 17 years, during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–61, the risk to the offsite population and onsite workers during this 16-year project period would be no increase (3×10^{-1}) in the number of LCFs in the offsite population and a 2×10^{-5} and 1×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

4.1.11.8.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios are expected to be the same as those described in **Section 4.1.11.2.2** for Alternative 2A.

4.1.11.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.11.9.1 Radiological Impacts of Airborne Releases

4.1.11.9.1.1 Base Case

Table 4–62 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–63 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–63) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-4} per year) in the number of LCFs (i.e., about 1 in 4,200 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 2×10^{-8} per year (i.e., about 1 in 55 million per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 1×10^{-4} per year (i.e., about 1 in 9,000 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–62).

Under Tank Closure Alternative 6A, operations would continue for a project period of 146 years; during this time period, workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–63, the risk to the offsite population and onsite workers during this 145-year project period would be no increase (4×10^{-1}) in the likelihood of an LCF in the offsite population, a 3×10^{-6} increase in the likelihood of an LCF for the MEI, and a 2×10^{-2} increase in the likelihood of an LCF for the noninvolved worker.

4.1.11.9.1.2 Option Case

The radiological impacts of accident airborne releases associated with the Option Case would be the same as those associated with the Base Case.

Table 4–62. Tank Closure Alternative 6A Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (15 MTG/day)	0.029	2×10^{-5}	380	0 (2×10^{-1})	83	1×10^{-1}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (15 MTG/day)	0.046	3×10^{-5}	620	0 (4×10^{-1})	160	2×10^{-1}
Seismically induced WTP collapse and failure – unmitigated (WT41) (15×0 MTG/day)	0.058	4×10^{-5}	780	0 (5×10^{-1})	180	2×10^{-1}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on a population of 451,556 persons residing within 80 kilometers (50 miles) of the 200-East Area.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Table 4–63. Tank Closure Alternative 6A Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (15 MTG/day)	5×10^{-4}	9×10^{-9}	0 (1×10^{-4})	5×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (15 MTG/day)	5×10^{-4}	1×10^{-8}	0 (2×10^{-4})	9×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (15×0 MTG/day)	5×10^{-4}	2×10^{-8}	0 (2×10^{-4})	1×10^{-4}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on a population of 451,556 persons residing within 80 kilometers (50 miles) of the 200-East Area.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

4.1.11.9.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios Base and Option Cases are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

4.1.11.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.11.10.1 Radiological Impacts of Airborne Releases

4.1.11.10.1.1 Base Case

Table 4–64 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–65 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–65) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–64).

Under Tank Closure Alternative 6B, operations would continue for a project period of 26 years, during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–65, the risk to the offsite population and onsite workers during this 26-year project period would be no increase (4×10^{-1}) in the number of LCFs in the offsite population and a 3×10^{-5} and 2×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

Table 4–64. Tank Closure Alternative 6B Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.000043	3×10^{-8}	0.57	0 (3×10^{-4})	0.13	8×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on a population of 451,556 persons residing within 80 kilometers (50 miles) of the 200-East Area.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

4.1.11.10.1.2 Option Case

The radiological impacts from accident airborne releases associated with the Option Case would be the same as those associated with the Base Case.

4.1.11.10.2 Hazardous Chemical Impacts

4.1.11.10.2.1 Base and Option Cases

Potential human health impacts of postulated chemical release scenarios for the Base and Option Cases are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

Table 4–65. Tank Closure Alternative 6B Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	5×10^{-4}	1×10^{-11}	0 (2×10^{-7})	4×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on a population of 451,556 persons residing within 80 kilometers (50 miles) of the 200-East Area.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

4.1.11.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

4.1.11.11.1 Radiological Impacts of Airborne Releases

Table 4–66 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–67 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the range of impacts of reasonably foreseeable accidents that could occur at the facilities. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

Table 4–66. Tank Closure Alternative 6C Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatalities[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (3×10^{-3})	1.4	8×10^{-4}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (6×10^{-2})	24	3×10^{-2}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	5×10^{-4}	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (9×10^{-2})	33	4×10^{-2}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	1×10^{-5}	250	0 (1×10^{-1})	63	8×10^{-2}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.000043	3×10^{-8}	0.57	0 (3×10^{-4})	0.13	8×10^{-5}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	4.3	3×10^{-3}	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (6×10^{-4})	0.22	1×10^{-4}
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (2×10^{-3})	0.91	5×10^{-4}

[a] The alphanumeric code following the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more), where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–67) is the seismically induced WTP collapse and failure (accident WT41). For this accident, the risk to the offsite population would be no increase (2×10^{-2} per year) in the number of LCFs (i.e., about 1 in 60 per year of an LCF in the population). For the offsite MEI, the risk of an increase in likelihood of an LCF would be 1×10^{-6} per year (i.e., about 1 in 770,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the risk of an increase in likelihood of an LCF would be 8×10^{-3} per year (i.e., about 1 in 130 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. If this accident were to occur, it would also have the highest consequences (see Table 4–66).

Table 4–67. Tank Closure Alternative 6C Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	1.1×10^{-2}	8×10^{-9}	0 (4×10^{-5})	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	1×10^{-4}	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
PT Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	5×10^{-4}	3×10^{-7}	0 (4×10^{-3})	2×10^{-3}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	5×10^{-4}	3×10^{-9}	0 (5×10^{-5})	2×10^{-5}
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	5×10^{-4}	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	5×10^{-4}	1×10^{-11}	0 (2×10^{-7})	4×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	5×10^{-4}	1×10^{-6}	0 (2×10^{-2})	8×10^{-3}
Seismically induced waste tank dome collapse – unmitigated (TK53)	5×10^{-4}	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	1×10^{-3}	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following in the accident's title (e.g., TK51), corresponds with the code in the accident's description in Appendix K, Section K.3.4. The term "*Z*×*Y* MTG/day," read as "*Z* by *Y* MTG/day," refers to a WTP design capacity of *Z* MTG/day of HLW and *Y* MTG/day of LAW; for example, 6×30, 6×45, 6×90, or 15×0 MTG/day.

[b] Increased risk of a latent cancer fatality to the individual, taking into account the probability (frequency) of the accident.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MTG/day=metric tons of glass per day; PT=Pretreatment; WTP=Waste Treatment Plant.

Source: Appendix K, Section K.3.7.1.

Under Alternative 6C, operations would continue for a project period of 26 years, during which workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident WT41) in Table 4–67, the risk to the offsite population and onsite workers during this 26-year project period would be no increase (4×10^{-1}) in the number of LCFs in the offsite population and a 3×10^{-5} and 2×10^{-1} increased likelihood of an LCF for the MEI and noninvolved worker, respectively.

4.1.11.11.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios are expected to be the same as those described in Section 4.1.11.2.2 for Tank Closure Alternative 2A.

4.1.11.12 Intentional Destructive Acts

This section addresses potential impacts of intentional destructive acts at tank farm and WTP facilities. To protect against such actions, safeguards and security measures are employed at all DOE facilities. In accordance with DOE orders, DOE conducts vulnerability assessments and risk analyses of facilities and equipment under its jurisdiction to evaluate the physical protection elements, technologies, and administrative controls needed to protect DOE assets. DOE also protects against espionage, sabotage,

and theft of radiological, chemical, or biological materials; classified information and matter; non-nuclear weapon components; and critical technologies. Before startup of any new or substantially modified operations, DOE would conduct an indepth, site-specific safeguards and security inspection to ensure that existing programs satisfy DOE requirements. Any inadequacies would be resolved before startup of operations. Release scenarios and impacts resulting from intentional destructive acts may be similar to a number of the accident scenarios analyzed in this EIS. Additional scenarios representing intentional destructive acts that may not be represented by the accident analyses were also considered. The potential for and consequences of the intentional destructive act scenarios are essentially the same under each of the alternatives, with the exception of Alternative 1: No Action, for which the scenarios involving the WTP would not apply.

Explosive Device in Underground Waste Tank. It was postulated that intentionally initiated explosions occur that displace a large portion of the soil overburden, breach the tank dome, and disperse a portion of the tank waste into the atmosphere. In accordance with the recommendation from *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Vol. 1, *Analysis of Experimental Data* (DOE Handbook 3010-94), the respirable release would be less than the TNT [trinitrotoluene]-equivalent weight of the explosive charge. Analysis results indicate that the radiological impacts of an explosive device in an underground waste tank would be about four times greater than the impacts of the most severe accident scenario that involves the same inventory of radioactive material (TK53, seismically induced waste tank dome collapse). The offsite population dose is estimated to be 3.8 person-rem, with no (2×10^{-3}) additional LCFs as a result. The MEI dose would be 0.00083 rem, which corresponds to an increased risk of an LCF of 5×10^{-7}. The noninvolved worker dose would be 0.88 rem, which corresponds to an increased risk of an LCF of 5×10^{-4}.

Aircraft or Ground Vehicle Impact on WTP. A vehicle or aircraft crash and/or explosions initiated by an insider were postulated. It was assumed that these acts would be sufficiently energetic to breach a portion of the HLW Vitrification Facility exterior wall and the radiation shield wall that protects the two HLW melter feed preparation vessels. For purposes of this analysis, it was postulated that the two vessels are breached, causing the contents to spill into the cell. At the same time, aircraft or vehicle fuel was assumed to enter the cell and burn. The spilled radioactive waste slurry was assumed to heat to the boiling point, and radioactive material was assumed to be released to the environment through holes in the building walls. Analysis results indicate that the radiological impacts would be less than one-tenth of those calculated for the most severe accident scenario that involves the same inventory of radioactive material (WT41, seismically induced WTP collapse and failure – unmitigated). The offsite population dose was estimated to be 3,400 person-rem, which would result in 2 additional LCFs. The MEI dose would be 0.25 rem with an increased risk of an LCF of 2×10^{-4}. The noninvolved worker dose would be 860 rem, which could result in a near-term fatality.

Intentional Breach of WTP Ammonia Tank. An intentional destructive act was postulated whereby an explosion causes massive damage to the WTP ammonia tank. The entire 43,500 liters (11,500 gallons) of liquid ammonia were assumed to vaporize over a period of 1 minute. Under this scenario, exposed persons could experience life-threatening health effects or death at distances up to 8 kilometers (5 miles), about 10 times farther than for the accident scenario that involves the same chemical inventory (tank failure with release of entire contents in 30 minutes).

The impacts and mitigation of intentional destructive acts are discussed in more detail in Appendix K, Section K.3.11.

4.1.12 Public and Occupational Health and Safety—Transportation

A number of factors affect the risk of transporting radioactive materials. These factors are predominantly categorized as radiological or nonradiological impacts. Radiological impacts are those associated with

the accidental release of radioactive materials and the effects of low levels of radiation emitted during normal, or incident-free, transportation. Nonradiological impacts are those associated with transportation, regardless of the nature of the cargo, such as accidents resulting in death or injury when there is no release of radioactive material.

Packages containing radioactive materials emit low levels of radiation during incident-free transportation. The amount of radiation emitted depends on the kind and amount of material being transported. U.S. Department of Transportation (DOT) regulations require that packages containing radioactive materials have sufficient radiation shielding to limit the radiation to an acceptable level of 10 millirems per hour at 2 meters (6.6 feet) from the transporter. For incident-free transportation, the potential human health impacts of the radiation field surrounding the transportation packages were estimated for transportation workers and the general population along the route (off traffic, or off-link), people sharing the route (in traffic or on-link), people at rest areas, and at stops along the route. The Radioactive Material Transportation (RADTRAN 5) computer program (Neuhauser and Kanipe 2003) was used to estimate the impacts on transportation workers and populations, as well as the impact on an MEI (a person stuck in traffic, a gas station attendee, an inspector, etc.) who could be a worker or a member of the public.

Transportation accidents involving radioactive materials present both nonradiological and radiological risks to workers and the public. Nonradiological impacts of potential transportation accidents include traffic accident fatalities. A release of radioactive material during transportation accidents would occur only when the package carrying the material is subjected to accident forces that exceed the package design standard. The impact of a specific radiological accident is expressed in terms of probabilistic risk, which is defined as the accident probability (i.e., accident frequency) multiplied by the accident consequences. The overall risk is obtained by summing the individual risks from all accident severities, irrespective of their likelihood of occurrence. The analysis of accident risks takes into account a spectrum of accident severities ranging from high-probability accidents of low severity (e.g., fender bender) to hypothetical high-severity accidents that have a low probability of occurrence. Only as a result of a severe fire and/or a powerful collision, which are of extremely low probability, could a transportation package of the type used to transport radioactive material off site under the alternatives of this EIS be damaged to the extent that there could be a release of radioactivity to the environment with significant consequences.

In addition to calculating the radiological risks that would result from all accidents during transportation of radioactive waste, DOE assessed the highest consequences of a maximum reasonably foreseeable accident with a radioactive release frequency greater than 1×10^{-7} (1 in 10 million) per year along the route. The consequences of the maximum reasonably foreseeable accident were determined for prevailing atmospheric conditions. The analysis used the Risks and Consequences of Radiological Material Transport (RISKIND) computer program to estimate doses to individuals and populations (Yuan et al. 1995).

Incident-free health impacts and radiological accident health impacts are expressed in terms of additional LCFs, and nonradiological accident risk is expressed as additional immediate (traffic) fatalities. LCFs associated with radiological exposure were estimated by multiplying the occupational (worker) and public dose by 0.0006 LCFs per person-rem of exposure.

In determining transportation risks, per-shipment risk factors were calculated for the incident-free and radiological accident conditions using the RADTRAN 5 computer program (Neuhauser and Kanipe 2003) in conjunction with the Transportation Routing Analysis Geographic Information System (TRAGIS) computer program (Johnson and Michelhaugh 2003) to choose transportation routes in accordance with DOT regulations. The TRAGIS program calculates transportation routes in terms of distances traveled in rural, urban, and suburban areas. It provides population density estimates for each area based on the 2000

census along the routes to determine population radiological risk factors. For incident-free operations, the affected population includes individuals living within 800 meters (0.5 miles) of each side of the road or rail line. For radiological accident conditions, the affected population includes individuals living within 80 kilometers (50 miles) of the accident, and the MEI is assumed to be an individual located 100 meters (330 feet) directly downwind from the accident. Additional details on the analysis approach and on modeling and parameter selections are provided in Appendix H.

Table 4–68 provides the estimated number of waste shipments under each alternative by waste type. A shipment is defined as the amount of waste transported on a single truck or a single railcar.

Table 4–68. Tank Closure Alternatives – Estimated Number of Radioactive Waste Shipments

Alternative	Number of Shipments									
	Offsite Shipments		Onsite Shipments							
	CH-TRU Waste[a]	RH-TRU Waste[a]	IHLW[b]	ILAW Glass	Bulk Vit Waste	Cast Stone Waste	Steam-Reformed Waste	CH-TRU Waste	RH-TRU Waste	Other Wastes[c]
2A	N/A	N/A	12,340	92,250	N/A	N/A	N/A	N/A	N/A	30
2B	N/A	N/A	12,340	92,250	N/A	N/A	N/A	N/A	N/A	23,581
3A	170	3,397	9,040	28,510	6,030	N/A	N/A	178	728	23,558
3B	170	3,397	9,040	28,510	N/A	23,270	N/A	178	728	23,558
3C	170	3,397	9,040	28,510	N/A	N/A	57,980	178	728	23,558
4	172	3,427	11,140	28,730	2,380	14,380	N/A	180	735	85,573
5	155	3,090	8,140	31,100	2,150	8,060[d]	N/A	162	663	10
6A-Base	N/A	N/A	171,670	670	N/A	N/A	N/A	N/A	N/A	254,559
6A-Option	N/A	N/A	171,670	18,290	N/A	N/A	N/A	N/A	N/A	254,680
6B-Base	N/A	N/A	12,340	93,670	N/A	N/A	N/A	N/A	N/A	254,581
6B-Option	N/A	N/A	12,340	111,290	N/A	N/A	N/A	N/A	N/A	254,658
6C	N/A	N/A	12,340	92,250	N/A	N/A	N/A	N/A	N/A	23,581

[a] Values are for truck shipments. Rail shipments are one-half of the values given.
[b] The IHLW canisters include 340 cesium and strontium high-level radioactive waste canisters.
[c] Other wastes include high-activity waste (equipment and soils), contaminated soil and grout from the Preprocessing Facility, and end-of-life WTP LAW melters, as applicable.
[d] This number includes 6,120 shipments of sulfated grout.

Key: CH=contact-handled; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; N/A=not applicable; RH=remote-handled; TRU=transuranic; Vit=vitrification; WTP=Waste Treatment Plant.
Source: Appendix H, Section H.7.1.

Table 4–69 summarizes the total offsite and onsite transportation impacts expected under each Tank Closure alternative. This table shows that the dose to the population along the offsite routes (see column 6 of Table 4–69: offsite rows) is expected to be between the lowest expected dose of about 172 person-rem under Tank Closure Alternative 5, and the highest expected dose of about 191 person-rem, associated with the transport of TRU waste to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, under Tank Closure Alternative 4. The additional LCFs that would be expected from such exposures to the general population would be less than 1 for all alternatives, ranging from 1.0×10^{-1} to 1.1×10^{-1}. Similarly, the lowest expected dose to the crew transporting wastes to offsite disposal facilities (see column 4 of Table 4–69: offsite rows) would be under Alternative 5 (about 569 person-rem), while the highest would be under Alternative 4 (about 631 person-rem). The additional LCFs expected among the exposed transportation crews would be less than 1 ranging from 3.4×10^{-1} to 3.8×10^{-1}. Under all alternatives, no combination of transports (off site and on site) would be expected to result in an LCF among the exposed population or transportation crews. The expected number of traffic fatalities from accidents involving radioactive material transport is 0 (0.22). Considering that the durations of alternatives range from 20 to over 150 years, and the average traffic fatalities in the United States is about 40,000 per year, the expected risk of traffic fatality is small.

Table 4–69. Tank Closure Alternatives – Risks of Transporting Radioactive Waste

Alternative	Transport	Number of Shipments[a]	Incident-Free				Accident		
			Crew		Population				
			Dose (person-rem)	Risk[b]	Dose (person-rem)	Risk[b]	Rad. Risk[b, c]	Non-rad. Risk[b]	One-Way Offsite Travel (10^6 km)
2A[c]	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	105,000	260	1.56×10^{-1}	72.5	4.40×10^{-2}	1.2×10^{-11}	0.028	N/A
2B[c]	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	128,000	262	1.57×10^{-1}	72.5	4.40×10^{-2}	5.5×10^{-8}	0.034	N/A
3A	Off site	3,570	625	3.70×10^{-1}	189	1.10×10^{-1}	8.6×10^{-4}	0.22	11.0
	On site	68,000	217	1.30×10^{-1}	158	9.50×10^{-2}	9.1×10^{-7}	0.018	N/A
3B	Off site	3,570	625	3.70×10^{-1}	189	1.10×10^{-1}	8.6×10^{-4}	0.22	11.0
	On site	85,300	464	2.79×10^{-1}	76.6	4.60×10^{-2}	9.1×10^{-7}	0.023	N/A
3C	Off site	3,570	625	3.70×10^{-1}	189	1.10×10^{-1}	8.6×10^{-4}	0.22	11.0
	On site	120,000	600	3.60×10^{-1}	148	8.90×10^{-2}	9.1×10^{-7}	0.033	N/A
4	Off site	3,600	631	3.80×10^{-1}	191	1.10×10^{-1}	8.7×10^{-4}	0.22	11.1
	On site	143,000	456	2.73×10^{-1}	115	6.90×10^{-2}	1.4×10^{-6}	0.039	N/A
5	Off site	3,250	569	3.40×10^{-1}	172	1.00×10^{-1}	7.8×10^{-4}	0.20	10.0
	On site	50,300	222	1.33×10^{-1}	85.1	5.10×10^{-2}	7.7×10^{-7}	0.013	N/A
6A-Base	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	427,000	450	2.70×10^{-1}	60.4	3.60×10^{-2}	2.0×10^{-6}	0.096	N/A
6A-Option	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	445,000	498	2.99×10^{-1}	73.6	4.40×10^{-2}	2.0×10^{-6}	0.101	N/A
6B-Base	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	361,000	560	3.36×10^{-1}	88.9	5.30×10^{-2}	2.0×10^{-6}	0.100	N/A
6B-Option	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	378,000	608	3.65×10^{-1}	102	6.10×10^{-2}	2.0×10^{-6}	0.105	N/A
6C	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	128,000	262	1.57×10^{-1}	72.5	4.40×10^{-2}	5.5×10^{-8}	0.034	N/A

[a] Offsite shipments are based on truck transport of transuranic waste (current practice for transport to Waste Isolation Pilot Plant).
[b] Risk is expressed in terms of latent cancer fatalities, except for the nonradiological, where it refers to the number of accident fatalities.
[c] To calculate accident population dose (person-rem), divide the values in this column by 0.0006. For additional insight on how this dose is calculated, see the text in Section 4.1.12.
Note: To convert kilometers to miles, multiply by 0.6214. Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: km=kilometers; N/A=not applicable; rad.=radiological.
Source: Appendix H, Section H.7.1.

The risks to different receptors under incident-free transportation conditions were estimated on a per-trip or per-event basis, as it is unlikely that the same person would be exposed to multiple events; for those that could have multiple exposures, the dose over the duration of transportation activities could be calculated by multiplying by the number of events or trips. The dose to the maximally exposed transportation worker is discussed for each alternative below. For a receptor who is a member of the public residing along a transportation route, the dose over the duration of transportation activities would depend on the number of truck or rail shipments passing a particular point and would be independent of the actual route being considered. The maximum dose to this resident, if all the materials are shipped along this route, would be about 1 millirem for all action alternatives. Refer to Appendix H, Table H–9, for additional results.

Table 4–70 summarizes the impacts of transporting nonradioactive feed and support materials required to construct new facilities, as well as materials required to immobilize, vitrify, or solidify the liquid waste and transport it to storage or burial locations. The construction materials considered are concrete, cement, sand/gravel/dirt, asphalt, steel, and piping. The materials required for waste solidification and transport include glass formers, fly ash, blast furnace slag, canisters, cylinders, and boxes. The table shows the impacts in terms of total kilometers, accidents, and fatalities for each alternative. The results in Table 4–70 indicate that for the Tank Closure alternatives, the potential for traffic fatalities is the largest under Alternative 6A, Option Case, with the potential for six fatalities followed by Alternative 3C and Alternative 6A, Base Case, with the potential for approximately three fatalities. Considering that the duration of Alternative 6A is over 150 years, the estimated annual fatality is very small.

Table 4–70. Tank Closure Alternatives – Estimated Impacts of Construction and Operational Material Transport

Alternative	Total Distance Traveled (kilometers)	Number of Accidents	Number of Traffic Fatalities
1	1.04×10^6	0.13	0.009
2A	49.5×10^6	6.08	0.41
2B	65.0×10^6	7.99	0.54
3A	67.2×10^6	7.52	0.51
3B	94.3×10^6	11.6	0.78
3C	407×10^6	50.1	3.38
4	120×10^6	14.8	1.00
5	88.0×10^6	10.8	0.73
6A-Base	385×10^6	47.4	3.20
6A-Option	767×10^6	94.3	6.37
6B-Base	140×10^6	17.3	1.16
6B-Option	273×10^6	33.6	2.26
6C	71.1×10^6	8.75	0.59

Note: To convert kilometers to miles, multiply by 0.6214. Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Source: Appendix H, Section H.8.

4.1.12.1 Alternative 1: No Action

Under Tank Closure Alternative 1, transportation impacts would be limited to those activities involving transport of construction materials from onsite, local, or regional locations to Hanford to support construction activities through 2008, tank farm infrastructure and tank upgrades, and administrative control activities. The transportation impacts of these activities would be 1.04 million kilometers (0.65 million miles) traveled, 0 (0.13) traffic accidents, and 0 (0.009) traffic fatalities (see Table 4–70).

4.1.12.2 Alternative 2A: Existing WTP Vitrification; No Closure

Under this alternative, no offsite radioactive waste shipments would be made. However, 105,000 truck shipments would be made to transport radioactive wastes to onsite storage and burial grounds (see Table 4–69).

4.1.12.2.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities on site under this alternative has been estimated at about 260 person-rem (see column 4 of Table 4–69); the dose to the public would be about

73 person-rem (see column 6 of Table 4–69). Accordingly, incident-free transportation of radioactive material would result in 0 (1.6×10^{-1}) LCFs among transportation workers and 0 (4.4×10^{-2}) LCFs in the total affected population over the duration of transportation activities. LCFs associated with radiological exposure were estimated by multiplying the occupational (worker) and public dose by 6.0×10^{-4} LCFs per person-rem. Note that the maximum annual dose to a transportation crew member would be 100 millirem, unless the individual is a trained radiation worker, in which case the maximum annual dose would be 2 rem (DOE Standard 1098-99). The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure is 1.2×10^{-3}. Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

4.1.12.2.2 Impacts of Accidents During Transportation

As stated earlier, two sets of analyses were performed for the evaluation of transportation accident impacts: impacts of maximum reasonably foreseeable accidents and impacts of all foreseeable accidents (total transportation accidents).

Because no offsite radioactive waste shipments would be made under this alternative, the maximum reasonably foreseeable offsite transportation accident would have a probability of occurrence of less than 1 in 10 million per year. Therefore, no further impacts analysis has been performed.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 0.00000002 person-rem, resulting in 1.2×10^{-11} LCFs, and traffic accidents resulting in 0 (0.03) fatalities.

4.1.12.2.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The impacts in terms of total distance traveled, accidents, and traffic fatalities under this alternative would be 49.5 million kilometers (30.8 million miles), 6 (6.08) accidents, and 0 (0.41) fatalities over the entire duration, from construction through deactivation. Considering that the duration of this alternative is about 75 years, the estimated annual impact is very small.

4.1.12.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Under this alternative, no offsite radioactive waste shipments would be made. However, 128,000 truck shipments would be made to transport various radioactive wastes to onsite storage and burial grounds (see Table 4–69).

4.1.12.3.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities on site under this alternative has been estimated at about 262 person-rem; the dose to the public would be about 73 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (1.6×10^{-1}) LCFs among transportation workers and 0 (4.4×10^{-2}) LCFs in the total affected population over the duration of transportation activities.

4.1.12.3.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident under this alternative has a probability of occurrence of less than 1 in 10 million per year. The consequences of such an accident are similar to those described under Alternative 2A.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population (on site) of 0.000092 person-rem, resulting in 5.5×10^{-8} LCFs, and traffic accidents resulting in 0 (0.03) fatalities.

4.1.12.3.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and feed materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be about 65 million kilometers (40.4 million miles) traveled, 8 (7.99) accidents, and 1 (0.54) fatality over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Under this alternative, about 3,570 truck[3] shipments of remote-handled (RH-) and contact-handled (CH-) TRU waste would be made to WIPP. In addition, 68,000 truck shipments would be made on site to transport various radioactive wastes to local storage and burial grounds. The total distance traveled on public roads and rail carrying radioactive waste materials would be about 11 million kilometers (6.8 million miles) (see Table 4–69).

4.1.12.4.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities (both off site and on site) under this alternative has been estimated at about 842 person-rem; the dose to the public would be about 347 person-rem. Accordingly, incident-free transportation of radioactive material would result in 1 (5.0×10^{-1}) LCF among transportation workers and 0 (2.1×10^{-1}) LCFs in the total affected population over the duration of transportation activities. Note that the maximum annual dose to a transportation crew member would be 100 millirem, unless the individual is a trained radiation worker, in which case the maximum annual dose would be 2 rem (DOE Standard 1098-99). The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure is 1.2×10^{-3}. Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

4.1.12.4.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) involves a shipment of RH-TRU waste. The consequences of such an accident in terms of population dose in the rural, suburban, and urban zones are 0.38, 16.2, and 110 person-rem, respectively. The likelihood of occurrence of such consequences over the entire duration of transport is less than 1.6×10^{-3}, 3.2×10^{-5}, and 9.4×10^{-7} in rural, suburban, and urban zones, respectively. This accident could result in a dose of 0.027 rem to an individual hypothetically exposed to the accident plume for 2 hours at a distance of 100 meters (330 feet), with a corresponding LCF risk of 1.6×10^{-5}.

[3] Truck transportation is the preferred mode for transporting TRU waste to WIPP (DOE 1997).

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 1.43 person-rem, resulting in 8.6×10^{-4} LCFs, and traffic accidents resulting in 0 (0.24) fatalities. Nearly all of the risks would result from shipping waste to WIPP.

4.1.12.4.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be 67.2 million kilometers (41.8 million miles) traveled, 8 (7.52) accidents, and 1 (0.51) fatality over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Under this alternative, about 3,570 truck shipments of RH- and CH-TRU waste would be made to WIPP. In addition, 85,300 truck shipments would be made on site to transport various radioactive wastes to local storage and burial grounds. The total distance traveled on public roads and rail carrying radioactive waste materials would be about 11 million kilometers (6.8 million miles) (see Table 4–69).

4.1.12.5.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities (both off site and on site) under this alternative has been estimated at about 1,089 person-rem; the dose to the public would be about 266 person-rem. Accordingly, incident-free transportation of radioactive material would result in 1 (6.5×10^{-1}) LCF among transportation workers and 0 (1.6×10^{-1}) LCFs in the total affected population over the duration of transportation activities. Note that the maximum annual dose to a transportation crew member would be 100 millirem, unless the individual is a trained radiation worker, in which case the maximum annual dose would be 2 rem (DOE Standard 1098-99). The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure is 1.2×10^{-3}. Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

4.1.12.5.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) involves a shipment of RH-TRU waste. The consequences of such an accident are similar to those described under Tank Closure Alternative 3A.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 1.43 person-rem, resulting in 8.6×10^{-4} LCFs, and traffic accidents resulting in 0 (0.24) fatalities. Nearly all of the risks would result from shipping waste to WIPP.

4.1.12.5.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be 94.3 million kilometers (58.6 million miles) traveled, 12 (11.6) accidents, and 1 (0.78) fatality over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Under this alternative, about 3,570 truck shipments of RH- and CH-TRU waste would be made to WIPP. In addition, 120,000 truck shipments would be made on site to transport various radioactive wastes to local storage and burial grounds. The total distance traveled on public roads and rail carrying radioactive waste materials would be about 11 million kilometers (6.8 million miles) (see Table 4–69).

4.1.12.6.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities (both off site and on site) under this alternative has been estimated at about 1,225 person-rem; the dose to the public would be about 337 person-rem. Accordingly, incident-free transportation of radioactive material would result in 1 (7.3×10^{-1}) LCF among transportation workers and 0 (2.0×10^{-1}) LCFs in the total affected population over the duration of transportation activities. As stated earlier, note that the maximum annual dose to a transportation crew member would be 100 millirem, unless the individual is a trained radiation worker, in which case the maximum annual dose would be 2 rem (DOE Standard 1098-99). The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure is 1.2×10^{-3}. Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

4.1.12.6.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) involves a shipment of RH-TRU waste. The consequences of such an accident are similar to those described under Tank Closure Alternative 3A.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 1.43 person-rem, resulting in 8.6×10^{-4} LCFs, and traffic accidents resulting in 0 (0.25) fatalities. Nearly all of the risks would result from shipping waste to WIPP.

4.1.12.6.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be about 407 million kilometers (253 million miles) traveled, 50 (50.1) accidents, and 3 (3.38) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Under this alternative, about 3,600 truck shipments of TRU waste would be made to WIPP. In addition, 143,000 truck shipments would be made on site to transport various radioactive wastes to local storage and burial grounds. The total distance traveled on public roads and rail carrying radioactive waste materials would be about 11.1 million kilometers (6.9 million miles) (see Table 4–69).

4.1.12.7.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities (both off site and on site) under this alternative has been estimated at about 1,087 person-rem; the dose to the public would be about 306 person-rem. Accordingly, incident-free transportation of radioactive material would result in

1 (6.5×10^{-1}) LCF among transportation workers and 0 (1.8×10^{-1}) LCFs in the total affected population over the duration of transportation activities. As stated earlier, note that the maximum annual dose to a transportation crew member would be 100 millirem, unless the individual is a trained radiation worker, in which case the maximum annual dose would be 2 rem (DOE Standard 1098-99). The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure is 1.2×10^{-3}. Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

4.1.12.7.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) involves a shipment of RH-TRU waste. The consequences of such an accident are similar to those described under Tank Closure Alternative 3A.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 1.45 person-rem, resulting in 8.7×10^{-4} LCFs, and traffic accidents resulting in 0 (0.26) fatalities. Nearly all of the risks would result from shipping waste to WIPP.

4.1.12.7.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be about 120 million kilometers (74.7 million miles) traveled, 15 (14.8) accidents, and 1 (1.00) fatality over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Under this alternative, 3,245 truck shipments of TRU waste would be made to WIPP. In addition, 50,285 truck shipments would be made on site to transport various radioactive wastes to local storage and burial grounds. The total distance traveled on public roads and rail carrying radioactive waste materials would be about 10 million kilometers (6.2 million miles) (see Table 4–69).

4.1.12.8.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities (both off site and on site) under this alternative has been estimated at about 791 person-rem; the dose to the public would be about 257 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (4.7×10^{-1}) LCFs among transportation workers and 0 (1.5×10^{-1}) LCFs in the total affected population over the duration of transportation activities.

4.1.12.8.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) involves a shipment of RH-TRU waste. The consequences of such an accident are similar to those described under Tank Closure Alternative 3A.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 1.3 person-rem, resulting in 7.8×10^{-4} LCFs, and traffic accidents resulting in 1 (0.74) fatality. Nearly all of the risks would result from shipping waste to WIPP.

4.1.12.8.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be about 88 million kilometers (54.7 million miles) traveled, 11 (10.8) accidents, and 0 (0.21) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

Under both the Base Case and Option Case of this alternative, no offsite radioactive waste shipments would be made. However, about 427,000 and 445,000 truck shipments would be made on site to transport various radioactive wastes to local storage and burial grounds, under the Base Case and Option Case, respectively (see Table 4–69).

4.1.12.9.1 Impacts of Incident-Free Transportation

4.1.12.9.1.1 Base Case

The dose to transportation workers from all transportation activities on site under this alternative has been estimated at about 450 person-rem; the dose to the public would be about 60 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (2.7×10^{-1}) LCFs among transportation workers and 0 (3.6×10^{-2}) LCFs in the total affected population over the duration of transportation activities.

4.1.12.9.1.2 Option Case

The dose to transportation workers from all transportation activities (on site) under this alternative has been estimated at about 498 person-rem; the dose to the public would be about 74 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (3.0×10^{-1}) LCFs among transportation workers and 0 (4.4×10^{-2}) LCFs in the total affected population over the duration of transportation activities.

4.1.12.9.2 Impacts of Accidents During Transportation

4.1.12.9.2.1 Base Case

Because no offsite radioactive waste shipments would be made under this alternative, the maximum reasonably foreseeable offsite transportation accident would have a probability of occurrence of less than 1 in 10 million per year. Therefore, no further impacts analysis has been performed.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 0.0033 person-rem, resulting in 2.0 × 10-6 LCFs, and traffic accidents resulting in 0 (0.10) fatalities, under both the Base and Option Cases.

4.1.12.9.2.2 Option Case

The consequences of the maximum reasonably foreseeable accident and total transportation accident risks are similar to those described under the Base Case.

4.1.12.9.3 Impacts of Construction and Operational Material Transport

4.1.12.9.3.1 Base Case

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be about 385 million kilometers (239 million miles) traveled, 47 (47.4) accidents, and 3 (3.2) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.9.3.2 Option Case

The impacts of transporting construction materials and materials for the production and transport of waste were evaluated. The transportation impacts under this alternative would be about 767 million kilometers (477 million miles) traveled, 94 (94.3) accidents, and 6 (6.37) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.10 Alternative 6B: All Vitrification with Separations; Clean Closure

Under both cases of this alternative, no offsite radioactive waste shipments would be made. However, about 361,000 and 378,000 truck shipments would be made on site to transport various radioactive wastes to local storage and burial grounds under the Base Case and Option Case, respectively (see Table 4–69).

4.1.12.10.1 Impacts of Incident-Free Transportation

4.1.12.10.1.1 Base Case

The dose to transportation workers from all transportation activities on site under this alternative has been estimated at about 560 person-rem; the dose to the public would be about 89 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (3.4×10^{-1}) LCFs among transportation workers and 0 (5.3×10^{-2}) LCFs in the total affected population over the duration of transportation activities.

4.1.12.10.1.2 Option Case

The dose to transportation workers from all transportation activities on site under this alternative has been estimated at about 608 person-rem; the dose to the public would be about 102 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (3.7×10^{-1}) LCFs among transportation workers and 0 (6.1×10^{-2}) LCFs in the total affected population over the duration of transportation activities.

4.1.12.10.2 Impacts of Accidents During Transportation

4.1.12.10.2.1 Base Case

The maximum reasonably foreseeable offsite transportation accident and its consequences are similar to those described under Alternative 6A (see Section 4.1.12.9.2).

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 0.0033 person-rem, resulting in 2.0×10^{-6} LCFs, and traffic accidents resulting in 0 (0.10) fatalities, under both the Base and Option Cases.

4.1.12.10.2.2 Option Case

The consequences of the maximum reasonably foreseeable accident and the estimates of the total transportation accident risks are similar to those provided under the Base Case.

4.1.12.10.3 Impacts of Construction and Operational Material Transport

4.1.12.10.3.1 Base Case

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be about 140 million kilometers (87 million miles) traveled, 17 (17.3) accidents, and 1 (1.16) fatality over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.10.3.2 Option Case

The impacts of transporting construction materials and materials for the production and transport of waste were evaluated. The transportation impacts under this alternative would be about 273 million kilometers (170 million miles) traveled, 34 (33.6) accidents, and 2 (2.26) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.12.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

Under this alternative, no offsite radioactive waste shipments would be made. However, 128,000 truck shipments would be made to transport various radioactive wastes to local storage facilities and burial grounds (see Table 4–69).

4.1.12.11.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities on site under this alternative has been estimated at about 262 person-rem; the dose to the public would be about 73 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (1.6×10^{-1}) LCFs among transportation workers and 0 (4.4×10^{-2}) LCFs in the total affected population over the duration of transportation activities.

4.1.12.11.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident and its consequences are similar to those described under Alternative 2B (see Section 4.1.12.3.2).

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 0.000092 person-rem, resulting in 5.5×10^{-8} LCFs, and traffic accidents resulting in 0 (0.03) fatalities.

4.1.12.11.3 Impacts of Construction and Operational Material Transport

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and feed materials for the production and transport of waste (e.g., glass-forming materials, grout, fly ash, containers, boxes, and canisters) were evaluated. The transportation impacts under this alternative would be 71.1 million kilometers (44.2 million miles) traveled, 9 (8.75) accidents, and 1 (0.59) fatality over the entire duration, from construction through deactivation and closure (see Table 4–70).

4.1.13 Environmental Justice

Per Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, DOE seeks to ensure that no group of people bear a disproportionate share of negative environmental consequences resulting from the proposed actions under the Tank Closure alternatives and options. This section addresses potential short-term impacts on minority, American Indian, Hispanic or Latino, and low-income populations. Access to Hanford is restricted to the public, so the majority of impacts would be associated with onsite activities and would not affect populations residing off site; thus the potential for environmental justice concerns is small. Resource areas that could potentially be impacted and that may also affect populations residing off site include public and occupational health and safety, including normal operations and facility accidents; and air quality. These impacts were analyzed because of their potential for environmental justice concerns in the short term. Definitions of terms associated with environmental justice and a description of the analysis methodology used are included in Appendix J.

4.1.13.1 Alternative 1: No Action

Section 4.1.10.1.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 1. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological air emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–71 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Tank Closure Alternative 1 would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–71. Tank Closure Alternative 1 Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	1.1	1.4
American Indian	0.75	1.3
Hispanic or Latino	1.1	1.4
Low-income	1.1	1.3

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.1.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Tank Closure Alternative 1, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately two orders of magnitude

less than the total dose received by the MEI from the general population. Therefore, Alternative 1 would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.1.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 1. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 1 would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts under Tank Closure Alternative 1 are discussed in Section 4.1.4.1. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.1 discusses the potential human health risks of transporting construction materials from onsite, local, or regional locations to Hanford. The impacts of transporting construction materials to Hanford under this alternative would be very small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.2 Alternative 2A: Existing WTP Vitrification; No Closure

Section 4.1.10.2.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 2A. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological air emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–72 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 2A would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–72. Tank Closure Alternative 2A Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	2.1	2.5
American Indian	1.4	2.4
Hispanic or Latino	2.0	2.5
Low-income	2.0	2.4

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.2.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 2A. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 2A, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 2A would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.2.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 2A. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 2A would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.2. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.2 discusses the potential human health risks of transporting radioactive waste on site at Hanford and construction materials from onsite, local, or regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Section 4.1.10.3.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 2B. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–73 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between the average individual total doses. Therefore, Alternative 2B would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–73. Tank Closure Alternative 2B Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	0.92	1.1
American Indian	0.62	1.0
Hispanic or Latino	0.92	1.1
Low-income	0.91	1.1

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.3.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 2B. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 2B, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 2B would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.3.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 2B. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 2B would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.3. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.3 discusses the potential human health risks of transporting radioactive waste on site at Hanford and construction materials from onsite, local, or regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Section 4.1.10.4.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 3A. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–74 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 3A would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–74. Tank Closure Alternative 3A Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	1.1	1.3
American Indian	0.73	1.3
Hispanic or Latino	1.1	1.3
Low-income	1.1	1.3

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.4.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 3A. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 3A, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 3A would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.4.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 3A. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Tank Closure Alternative 3A would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.4. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.4 discusses the potential human health risks of transporting radioactive waste on site at Hanford and mixed TRU waste to WIPP, as well as the risks of transporting construction materials from onsite, local, or regional locations to Hanford. Examination of the radiological transport risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Section 4.1.10.5.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 3B. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–75 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 3B would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–75. Tank Closure Alternative 3B Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	0.75	0.90
American Indian	0.50	0.85
Hispanic or Latino	0.75	0.88
Low-income	0.74	0.86

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.5.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 3B. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 3B, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 3B would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.5.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 3B. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 3B would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.5. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority,

American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.5 discusses the potential human health risks of transporting radioactive waste on site at Hanford and mixed TRU waste to WIPP, as well as the risks of transporting construction materials from onsite, local, or regional locations to Hanford. Examination of the radiological transport risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Section 4.1.10.6.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 3C. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–76 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 3C would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–76. Tank Closure Alternative 3C Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	1.1	1.3
American Indian	0.73	1.3
Hispanic or Latino	1.1	1.3
Low-income	1.1	1.3

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.6.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 3C. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 3C, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the

general population. Therefore, Alternative 3C would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.6.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 3C. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 3C would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.6. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.6 discusses the potential human health risks of transporting radioactive waste on site at Hanford and mixed TRU waste to WIPP, as well as the risks of transporting construction materials from onsite, local, or regional locations to Hanford. Examination of the radiological transport risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Section 4.1.10.7.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 4. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–77 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 4 would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–77. Tank Closure Alternative 4 Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	0.95	1.1
American Indian	0.64	1.1
Hispanic or Latino	0.95	1.1
Low-income	0.92	1.1

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.7.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 4. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 4, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 4 would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.7.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 4. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 4 would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.7. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.7 discusses the potential human health risks of transporting radioactive waste on site at Hanford and mixed TRU waste to WIPP, as well as the risks of transporting construction materials from onsite, local, or regional locations to Hanford. Examination of the radiological transport risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Section 4.1.10.8.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 5. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to

radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–78 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 5 would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–78. Tank Closure Alternative 5 Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	0.88	1.1
American Indian	0.60	1.0
Hispanic or Latino	0.89	1.1
Low-income	0.87	1.0

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.8.1 discusses radiological on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 5. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 5, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 5 would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.8.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 5. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 5 would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.8. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.8 discusses the potential human health risks of transporting radioactive waste on site at Hanford and mixed TRU waste to WIPP, as well as the risks of transporting construction materials from onsite, local, or regional locations to Hanford. Examination of the radiological transport risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority and low-income populations residing along the transportation routes.

4.1.13.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.13.9.1 Base Case

Section 4.1.10.9.1.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 6A, Base Case. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–79 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 6A, Base Case, would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–79. Tank Closure Alternative 6A, Base Case, Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	1.2	1.3
American Indian	0.81	1.3
Hispanic or Latino	1.2	1.3
Low-income	1.2	1.3

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.9.1.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 6A, Base Case. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 6A, Base Case, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 6A, Base Case, would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.9.1.1 discusses radiological impacts for airborne releases for facility accidents under Tank Closure Alternative 6A, Base Case. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 6A, Base Case, would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.9.1. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.9 discusses the potential human health risks of transporting radioactive waste on site at Hanford and construction materials from offsite local and regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impacts of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority and low-income populations residing along the transportation routes.

4.1.13.9.2 Option Case

Section 4.1.10.9.1.2 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 6A, Option Case. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–80 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 6A, Option Case would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–80. Tank Closure Alternative 6A, Option Case, Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	1.5	1.8
American Indian	0.99	1.7
Hispanic or Latino	1.5	1.8
Low-income	1.5	1.7

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.9.1.2 discusses radiological impacts on the offsite MEI at the far side of Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 6A, Option Case. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 6A, Option Case, the total dose received by an individual residing at the point of

greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 6A, Option Case, would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.9.1.2 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 6A, Option Case. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 6A, Option Case, would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.9.2. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.9 discusses the potential human health risks of transporting radioactive waste on site at Hanford and construction materials from offsite local and regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impact of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority and low-income populations residing along the transportation routes.

4.1.13.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.13.10.1 Base Case

Section 4.1.10.10.1.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 6B, Base Case. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–81 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 6B, Base Case, would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–81. Tank Closure Alternative 6B, Base Case, Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

Subset Population	Individual Average Dose (millirem)	
	Subset Population	Remainder of Population
Minority	1.2	1.4
American Indian	0.75	1.3
Hispanic or Latino	1.2	1.4
Low-income	1.2	1.4

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.10.1.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 6B, Base Case. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 6B, Base Case, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 6B, Base Case, would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.10.1.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 6B, Base Case. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 6B, Base Case, would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.10.1. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.10 discusses the potential human health risks of transporting radioactive waste on site at Hanford and construction materials from onsite, local, or regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impact of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.10.2 Option Case

Section 4.1.10.10.1.2 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 6B, Option Case. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by

external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–82 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between average individual total doses. Therefore, Alternative 6B, Option Case, would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–82. Tank Closure Alternative 6B, Option Case, Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	1.4	1.6
American Indian	0.92	1.6
Hispanic or Latino	1.4	1.6
Low-income	1.4	1.6

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.10.1.2 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 6B, Option Case. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 6B, Option Case, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 6B, Option Case, would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.10.1.2 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 6B, Option Case. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 6B, Option Case, would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.10.2. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.10 discusses the potential human health risks of transporting radioactive waste on site at Hanford and construction materials from onsite, local, or regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the

transportation routes. The impact of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.1.13.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

Section 4.1.10.11.1 discusses short-term impacts on the public resulting from normal operations under Tank Closure Alternative 6C. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–83 summarizes the average individual total doses for the life of the project under this alternative. There are no appreciable differences between these average individual total doses. Therefore, Alternative 6C would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Table 4–83. Tank Closure Alternative 6C Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

	Individual Average Dose (millirem)	
Subset Population	**Subset Population**	**Remainder of Population**
Minority	0.92	1.1
American Indian	0.62	1.0
Hispanic or Latino	0.91	1.1
Low-income	0.90	1.1

Source: Appendix J, Section J.5.6.1.1.

Section 4.1.10.11.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Tank Closure Alternative 6C. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Alternative 6C, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 6C would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations.

Section 4.1.11.11.1 discusses radiological impacts of airborne releases for facility accidents under Tank Closure Alternative 6C. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 6C would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to accident consequences.

Air quality impacts are discussed in Section 4.1.4.11. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.1.12.11 discusses the potential human health risks of transporting radioactive waste on site at Hanford and construction materials from onsite, local, or regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The impact of transporting construction materials to Hanford would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority and low-income populations residing along the transportation routes.

4.1.14 Waste Management

This section evaluates the impacts of waste generation associated with the various Tank Closure alternatives on the waste management infrastructure at Hanford. As summarized in Section 4.3 and detailed in Chapter 2, Waste Management alternatives were developed to manage the various waste volumes projected to be generated under the alternatives for Tank Closure, FFTF Decommissioning, and Waste Management. Section 4.3.14 of this EIS evaluates the impacts of waste generation associated with the construction, operations, deactivation, and closure of the waste management facilities.

The following analysis is consistent with DOE policy and DOE Manual 435.1-1 that DOE radioactive waste shall be treated, stored, and, in the case of low-level radioactive waste (LLW), disposed of at the site where the waste is generated, if practical, or at another DOE facility. The analysis of these Tank Closure alternatives is based on disposal of LLW, MLLW, and WTP LAW melters at Hanford. However, if DOE determines that use of Hanford's or another DOE site's waste management facilities is not practical or cost-effective, DOE may approve the use of non-DOE (i.e., commercial) facilities to store, treat, and dispose of such waste.

Included in this section is a discussion of the waste inventories generated under each of the Tank Closure alternatives. The inventories are divided into primary waste and secondary waste. Appendix D describes the development of the contaminant inventories of these waste streams.

PRIMARY WASTE

Under all Tank Closure alternatives except Alternative 1, No Action, primary waste would be produced. This primary waste could include HLW, including IHLW canisters, IHLW cesium and strontium canisters, other HLW, and in the case of Alternatives 6A and 6B, LAW melters; treated LAW, including ILAW canisters, bulk vitrification glass, cast stone, sulfate grout, steam reforming product, RH-TRU waste, and CH-TRU waste; and melters including IHLW melters, LAW melters, and PPF melters.

HIGH-LEVEL RADIOACTIVE WASTE

Under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, 5, 6A (Base and Option Cases), 6B (Base and Option Cases), and 6C, HLW would result as part of the retrieval of the tank waste.

Waste in the form of liquid, salt cake, and sludge is stored in 177 large and 61 smaller underground storage tanks in the Hanford 200 Areas. Most of the waste in the tanks is categorized as HLW, although some tanks are currently considered to contain only mixed TRU waste. Operationally, the tank farms are managed as if all of the waste were HLW. Waste retrieved from the storage tanks would be processed in the WTP Pretreatment Facility to separate it into a high-activity stream containing most of the

radionuclides requiring long-term isolation and a low-activity stream containing most of the waste volume and the remaining radionuclides. In the WTP, the high-activity stream would be mixed with glass-forming materials and heated in an HLW melter to form a molten glass. The molten glass would then be poured into stainless steel canisters, where it would solidify into a solid form called IHLW. These alternatives would treat and dispose of existing waste and additional waste generated from the processing of the HLW.

However, under Tank Closure Alternatives 6A, 6B and 6C, all of the tank farm waste would be managed as if it were HLW. Under Alternative 6A all waste would be treated in HLW melters without pretreatment. Under Alternatives 6B and 6C, the LAW stream that is separated in the Pretreatment Facility would be sent to a separate vitrification facility, the LAW Vitrification Facility. The molten glass from the LAW melter would be poured into canisters of a different design than those used for high-activity waste (see Chapter 2, Section 2.3.2.1), where it would solidify into ILAW glass. The ILAW glass would be managed as HLW and placed into storage.

DOE expects that the IHLW canisters, and in the case of Tank Closure Alternatives 6A, 6B, and 6C, a portion of the LAW melters, would be stored on site.

Storage of IHLW and ILAW would require ongoing facility maintenance and monitoring. Storage of IHLW and ILAW canisters is expected to result in no releases to the environment. Facilities with sufficient canister storage capacity would be constructed on site; impacts of constructing and operating storage facilities for IHLW and ILAW canisters are evaluated in the appropriate sections of this EIS.

Also under Tank Closure Alternatives 6A, 6B and 6C, all SSTs and associated ancillary equipment would be removed and considered HLW. The additional HLW would be stored on site in shielded boxes. Impacts of constructing and operating facilities with sufficient storage capacity are evaluated in the appropriate sections of this EIS. Storage of this HLW is expected to result in no releases to the environment; it would require ongoing facility maintenance and monitoring.

CESIUM AND STRONTIUM CAPSULES

The cesium and strontium capsules were generated at Hanford during the 1970s and 1980s, when cesium and strontium isotopes were separated from other tank waste, converted to cesium chloride and strontium fluoride, and then encapsulated for long-term storage. Currently, there are 1,335 cesium capsules and 601 strontium capsules stored in the Waste Encapsulation and Storage Facility (WESF) pool cells. Most of the capsules are composed of an inner and outer capsule. Under all Tank Closure alternatives except Alternative 1, the cesium and strontium capsules would be processed for de-encapsulating and preparing the waste into a suitable WTP slurry feed. The waste slurry would then be stored in a DST prior to treatment through the WTP. This EIS analyzes the immobilization of the cesium and strontium slurry feed as a separate, 1-year long WTP campaign; however, the cesium and strontium slurry feed could be mixed with the late-stage tank waste feed for consistency.

Under Tank Closure Alternative 1, the cesium and strontium capsules would be stored indefinitely in the WESF, in a manner similar to the present; therefore, construction of a Cesium and Strontium Capsule Processing Facility would be unnecessary. Under all other alternatives analyzed in this EIS, the cesium and strontium waste would be vitrified in the WTP. The immobilization of cesium and strontium capsule waste would take place during a separate campaign, after the treatment of all tank HLW is completed in the WTP. The cesium and strontium WTP campaign is expected to add 1 year of processing time to the WTP HLW melters. The Cesium and Strontium Capsule Processing Facility would be built such that processing of cesium canisters could begin approximately 14 months prior to the completion of the WTP's processing of tank HLW.

Based on estimated production rates, the Cesium and Strontium Capsule Processing Facility would require 26 months to de-encapsulate all cesium and strontium capsules and prepare the cesium and strontium slurry feed. The WTP requires an estimated 12 months to vitrify the slurry feed. Thus, to maintain a continuous WTP feed, the Cesium and Strontium Capsule Processing Facility must begin operations 14 months in advance of the cesium and strontium campaign and pre-store this WTP feed in the DSTs. It is estimated that an additional 340 canisters would be produced during the cesium and strontium treatment campaign (CEES 2006).

TREATED LOW-ACTIVITY TANK WASTE

Under Tank Closure Alternatives 2A and 2B, the LAW that is separated in the WTP Pretreatment Facility would be sent to the LAW Vitrification Facility for treatment, where it would be treated to create an immobilized waste form, ILAW. The impacts of providing treatment are evaluated in the appropriate sections of this EIS. The ILAW glass would be sent directly to an onsite Integrated Disposal Facility (IDF), a permitted landfill at Hanford with separate, expandable cells—one for the disposal of LLW and another for the disposal of MLLW. The disposal facility would include an RCRA-compliant liner and leachate collection system; upon closure it would be covered with a modified RCRA Subtitle C barrier (see Appendix E, Section E.3.4.1). The facility would be similar in configuration to the ERDF.

Under Tank Closure Alternatives 3A, 3B, 3C, and 4, additional waste forms other than ILAW glass would be created from immobilizing tank LAW using the supplemental treatment technologies of bulk vitrification (Alternative 3A), cast stone (Alternative 3B), or steam reforming (Alternative 3C) (see Chapter 2, Section 2.3.2), or both bulk vitrification and cast stone (Alternative 4). The LAW stream treated in the supplemental treatment facilities would result from the pretreatment separation of tank waste into high- and low-activity waste streams. In the 200-East Area, the separation would occur in the WTP Pretreatment Facility; in the 200-West Area, it would occur in a Solid-Liquid Separations Facility. A Bulk Vitrification Facility, a Cast Stone Facility, or a Steam Reforming Facility would be built in both the 200-East and 200-West Areas; in the case of Alternative 4, a Cast Stone Facility would be built in the 200-East Area and a Bulk Vitrification Facility would be built in the 200-West Area. Facilities with sufficient treatment capacity to immobilize the LAW would be provided under each of these technologies. The WTP and bulk vitrification glass, cast stone waste, or steam reforming waste would be sent directly to an onsite IDF. The disposal facility would include an RCRA-compliant liner and leachate collection system; upon closure it would be capped with a modified RCRA Subtitle C barrier (see Appendix E, Section E.3.4.1). The facility would be similar in configuration to the ERDF. The impacts of providing treatment are evaluated in the appropriate sections of this EIS. There would be no impacts on the existing Hanford waste management system. Some of the other tank waste, currently considered to be TRU waste, would be processed to become a solid mixed TRU waste form that would meet the WIPP waste acceptance criteria.

Under Tank Closure Alternative 5, the LAW would be treated the same as Alternative 4 with an additional pretreatment step in the Pretreatment Facility that would yield a grouted sulfate waste. Like Alternative 4, some of the tank waste would be processed to cast stone waste and some to bulk vitrification glass. The LAW stream that is separated in the Pretreatment Facility would be further processed to remove sulfate (see Chapter 2, Section 2.3.2.6). The sulfate waste stream would be solidified with cementitious material to create a grouted sulfate waste form. The remaining LAW stream would be sent to and processed in the LAW Vitrification Facility. Sufficient treatment capacity to immobilize the sulfate waste stream and the LAW would be provided under this Tank Closure alternative. The impacts of providing treatment are evaluated in the appropriate sections of this EIS. The ILAW glass, bulk vitrification glass, and cast stone waste and the grouted sulfate waste would be sent directly to an onsite IDF. The disposal facility would include an RCRA-compliant liner and leachate collection system; upon closure it would be capped with a modified RCRA Subtitle C barrier (see Appendix E, Section E.3.4.1). The facility would be similar in configuration to the ERDF.

Under Tank Closure Alternatives 6B and 6C, the LAW stream that is separated in the Pretreatment Facility would be managed as HLW, as discussed above under "High-Level Radioactive Waste."

WASTE TREATMENT PLANT MELTERS

Under all alternatives except Alternative 1, WTP HLW melters, LAW melters and, in the case of Alternatives 6A, 6B, and 6C, PPF melters would become a waste stream following service. WTP HLW and LAW melters that reach the end of their useful lives or fail may be treated by size reduction before being disposed of or placed in storage. Because WTP melters would be minimally treated (size reduction) before disposal or storage, impacts of this waste treatment on the existing Hanford waste management system would be negligible.

It is anticipated that the HLW melters would require long-term storage. The LAW melters would be disposed of as MLLW under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4 and 5, and as HLW under Alternatives 6B and 6C. Storage of HLW melters is expected to result in no releases to the environment. Impacts of constructing and operating facilities with sufficient storage capacity under these Tank Closure alternatives for the WTP HLW and LAW melters are evaluated in the appropriate sections of this EIS. For more on WTP melters, see Appendix E, Section E.1.2.4.4.

The LAW melters that are disposed of as MLLW would be disposed of in an RCRA-compliant, onsite IDF. The impacts of providing disposal capacity in an IDF are included in the disposal capacities of the corresponding Waste Management alternatives. Long-term impacts of radiological and chemical releases from disposed LAW melters on groundwater quality and human health are evaluated in Chapter 5, Sections 5.1.1 and 5.1.2. For more on LAW melters, see Appendix E, Section E.1.2.4.4.

The PPF melters generated from processing soils contaminated by past tank leaks would be disposed of on site in an IDF. Disposal of the PPF melters is included in the disposal capacity of the corresponding Waste Management alternatives. Long-term impacts of PPF melter disposal on groundwater quality and human health are evaluated in Chapter 5, Sections 5.1.1 and 5.1.2.

MIXED TRANSURANIC WASTE

Under Tank Closure Alternatives 3A, 3B, 3C, 4, and 5, some of the waste stored in tanks in the 200 Area, currently considered mixed TRU waste (see Chapter 2, Section 2.3.2.4), is expected to have a low activity level, allowing it to be managed as CH-waste. This waste would be treated and packaged using mobile units provided by this project. The remainder of the TRU waste has a high level of activity, necessitating use of a shielded facility and remote processing for treatment. A single facility for remotely processing the high-activity waste would be constructed in the 200-East Area. Impacts of constructing and operating facilities with additional TRU waste treatment and certification capacity are evaluated in the appropriate sections of this EIS.

The *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement (WIPP SEIS-II)* analyzed the receipt and disposal at WIPP of 57,000 cubic meters (75,000 cubic yards) of CH-TRU waste and 29,000 cubic meters (38,000 cubic yards) of RH-TRU waste from Hanford (DOE 1997:S-10). The CH-TRU and RH-mixed TRU waste generated from solidifying tank waste under these Tank Closure alternatives would be within the WIPP-analyzed capacities allocated to Hanford. As reported in the *WIPP SEIS-II*, the Consultation and Cooperation Agreement with the State of New Mexico currently limits the volume of RH-TRU waste shipped to WIPP from all DOE sites to 7,080 cubic meters (9,261 cubic yards) (DOE 1997:S-7).

SECONDARY WASTE

Under all Tank Closure alternatives, secondary waste would be produced. This secondary waste could include LLW (including closure waste), MLLW (including closure waste), mixed TRU waste, hazardous waste, nonhazardous waste, and liquid process waste; Alternatives 6A, 6B, and 6C would produce PPF glass, another form of secondary waste.

LOW-LEVEL AND MIXED LOW-LEVEL RADIOACTIVE WASTES

The secondary LLW (e.g., personal protective equipment, tools, filters, empty containers) would be generated during routine operations and the administrative control period. LLW is typically not treated or only minimally treated (e.g., compacted) before disposal. Therefore, this waste treatment would cause no impacts on the Hanford waste management system. The LLW would be sent directly to disposal. Therefore, long-term storage facilities would not be required.

The secondary MLLW (e.g., personal protective equipment, tools, job waste, and soil in the case of closure activities) would be generated during operations, deactivation and closure. Using a combination of on and offsite capabilities, secondary MLLW would be treated to meet an RCRA land disposal restriction treatment standards prior to disposal.

Also included as MLLW are the PPF glass canisters that are generated from the treatment of the soils in the PPF under Alternatives 6A and 6B. The process would generate a liquid waste stream that has the radionuclides and chemicals removed from the soils. A melter cell would be installed in the PPF to process this liquid waste into a PPF glass suitable for onsite disposal. This waste would be disposed of as MLLW onsite in an IDF. The long-term impacts on groundwater and human health of radiological and chemical releases from the PPF glass are evaluated in Chapter 5, Sections 5.1.1 and 5.1.2.

Under Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C, Waste Management Alternative 2, Disposal Group 1, or Waste Management Alternative 3, Disposal Group 1, would be chosen for the disposal of treated LAW (except for Alternative 6C) and all other LLW and MLLW. As described under Waste Management Alternative 2, an IDF would be constructed and operated in the 200-East Area IDF (IDF-East) for the disposal of tank waste and all other LLW and MLLW; under Waste Management Alternative 3, two IDFs would be constructed and operated: IDF-East for tank waste only and a 200-West Area IDF (IDF-West) for the other LLW and MLLW. The RPPDF would be constructed and operated for disposal of equipment and soils that are not highly contaminated but result from clean closure activities. Under Waste Management Alternative 2, Disposal Group 1, IDF-East and RPPDF operations would be completed in 2050, with IDF capacity at 1.2 million cubic meters (42 million cubic feet) and RPPDF capacity at 1.08 million cubic meters (38.1 million cubic feet). Under Waste Management Alternative 3, Disposal Group 1, IDF-East, IDF-West, and RPPDF operations would be completed in 2050. The IDF-East's capacity would be at 1.08 million cubic meters (38.1 million cubic feet), IDF-West's at 90,000 cubic meters (3.2 million cubic feet), and the RPPDF's at 1.08 million cubic meters (38.1 million cubic feet). Under Waste Management action Alternatives 2 and 3, the IDF(s) and RPPDF would be covered with engineered modified RCRA Subtitle C barriers to reduce water infiltration and potential for intrusion. A 100-year postclosure care period would follow.

Under Tank Closure Alternatives 2A and 6B, Waste Management Alternative 2, Disposal Group 2, or Waste Management Alternative 3, Disposal Group 2, would be chosen for disposal of treated LAW (except for Alternative 6B) and all other LLW and MLLW. As described under Waste Management Alternative 2, IDF-East would be constructed and operated for the disposal of tank waste and all other LLW and MLLW; under Waste Management Alternative 3, two IDFs would be constructed and operated: IDF-East for tank waste only and IDF-West for the other LLW and MLLW. Under Alternative 6B, the RPPDF would be constructed and operated for disposal of equipment and soils resulting from clean closure activities. Under Waste Management Alternative 2, Disposal Group 2, IDF-East and RPPDF

operations would be completed in 2100, with IDF capacity at 425,000 cubic meters (15 million cubic feet) and RPPDF capacity at 8.37 million cubic meters (296.6 million cubic feet). Under Waste Management Alternative 3, Disposal Group 2, IDF-East and RPPDF operations would be completed in 2100, and the IDF-West operations in 2050. The IDF-East's capacity would be at 340,000 cubic meters (12 million cubic feet), IDF-West's at 90,000 cubic meters (3.2 million cubic feet), and the RPPDF's capacity at 8.37 million cubic meters (296.6 million cubic feet). Under both Waste Management action alternatives, the IDF(s) and RPPDF would be covered with engineered modified RCRA Subtitle C barriers to reduce water infiltration and potential for intrusion. A 100-year postclosure care period would follow.

Under Tank Closure Alternative 6A, Waste Management Alternative 2, Disposal Group 3, or Waste Management Alternative 3, Disposal Group 3, would be chosen for disposal of tank waste and all other LLW and MLLW. As described under Waste Management Alternative 2, IDF-East would be constructed and operated for the disposal of tank waste and all other LLW and MLLW; under Waste Management Alternative 3, two IDFs would be constructed and operated: IDF-East for tank waste only and IDF-West for the other LLW and MLLW. Under Alternative 6C, the RPPDF would be constructed and operated for disposal of equipment and soils resulting from clean closure activities. Under Waste Management Alternative 2, Disposal Group 3, IDF-East and RPPDF operations would be completed in 2100, with IDF capacity at 425,000 cubic meters (15 million cubic feet) and RPPDF capacity at 8.37 million cubic meters (296.6 million cubic feet). Under Waste Management Alternative 3, Disposal Group 3, IDF-East and RPPDF operations would be completed in 2165, and IDF-West operations in 2050. IDF-East's capacity would be at 340,000 cubic meters (12 million cubic feet), IDF-West's at 90,000 cubic meters (3.2 million cubic feet), and the RPPDF's at 8.37 million cubic meters (296.6 million cubic feet). Under both Waste Management Alternatives 2 and 3, the IDF(s) and RPPDF would be covered with engineered modified RCRA Subtitle C barriers to reduce water infiltration and potential for intrusion. A 100-year postclosure care period would follow.

Under Tank Closure Alternatives 1, 2, and 3, trenches 31 and 34 in the existing low-level radioactive waste burial grounds (LLBGs) would continue to receive LLW and MLLW from onsite, non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) generators. Under Tank Closure Alternative 1, waste would be received until 2035, and under Tank Closure Alternatives 2 and 3, waste would be received until filled to capacity but not later than 2050. No construction activities would be necessary because the trenches are in current operation.

MIXED TRANSURANIC WASTE

Secondary mixed TRU waste (e.g., equipment, tools, filters, and empty containers) would be generated during waste retrieval and operations of treatment facilities and tanks.

Under all Tank Closure alternatives except Alternative 1, Waste Management Alternatives 2 and 3 analyze the management of mixed TRU waste at Hanford, including the secondary mixed TRU waste generated under the Tank Closure alternatives. Waste Management Alternatives 2 and 3 analyze the construction and operations of a new storage facility in Building 2403-WD that has a capacity of 17,500 drums, as well as two expansions of Waste Receiving and Processing Facility (WRAP): (1) additional LLW, MLLW, and CH-TRU waste processing capability at the Central Waste Complex (CWC) to match existing capability at the current WRAP, assuming the current rate of 300 containers per month for LLW, MLLW, and CH-TRU waste processing needs would be doubled; and (2) RH-TRU waste processing capability at WRAP, assuming this expansion is required and would match the current WRAP throughput of 300 containers per month using two full-shift operations. The secondary mixed TRU waste would be treated if necessary, packaged, certified (at WRAP or a mobile facility) for disposal at WIPP, and placed into storage.

It is anticipated that TRU waste would be disposed of at WIPP. The *WIPP SEIS-II* analyzed the receipt and disposal at WIPP of 57,000 cubic meters (75,000 cubic yards) of CH-TRU waste and 29,000 cubic meters (38,000 cubic yards) of RH-TRU waste from Hanford (DOE 1997:S-10). The 206 cubic meters (290 cubic yards) of TRU waste generated under the Tank Closure alternatives would be within the capacity allocated to Hanford and less than the amount evaluated in this EIS.

HAZARDOUS WASTE

Hazardous waste is dangerous waste as defined in the *Washington Administrative Code* (WAC 173-303). Hazardous waste generated during construction and operations would be packaged in DOT-approved containers and shipped off site to permitted commercial recycling, treatment, and disposal facilities. Hanford shipped 182,177 kilograms (408,186 pounds) of hazardous waste off site in 2005 (Poston et al. 2006). Under all Tank Closure alternatives except Alternative 1, during the period of active construction, operations, and closure, the average annual hazardous waste generation rate would include two peak years with generation of approximately 31,500 cubic meters (41,202 cubic yards). Management of the additional waste generated under the Tank Closure alternatives would require additional planning, coordination, and establishment of satellite accumulation areas, but because the waste would be treated and disposed of at offsite commercial facilities, the additional waste load would have a minor impact at Hanford.

NONHAZARDOUS WASTE

Any nonhazardous solid waste generated during facility construction, operations, deactivation, and closure under the Tank Closure alternatives would be packaged and transported in conformance with standard industrial practice. Solid waste such as office paper, metal cans, and plastic and glass bottles that can be recycled would be sent off site for that purpose. The remaining nonhazardous solid waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

LIQUID PROCESS WASTE

Process waste, including liquid secondary LLW, would be generated by the activities performed to retrieve, separate, and treat tank waste. Process liquids with substantial levels of radioactivity would be returned to the DST system for management. Dilute process waste such as cooling waters or steam condensates would be routed to the Hanford facilities whose mission it is to manage such wastes. It is assumed that the ETF and the TEDF, or their equivalents, would continue to be available to manage dilute process liquids generated under the Tank Closure alternatives. Wastewater management is further discussed in Section 4.1.6.

WASTE MINIMIZATION

In 2006, Hanford recycled 1,115 metric tons of sanitary and hazardous wastes. Affirmative procurement at Hanford achieved 100 percent of the 2006 goal. Hanford generated 4,278 cubic meters (151,073 cubic feet) of cleanup and stabilization goal waste (i.e., LLW, MLLW, and hazardous waste) (Poston et al. 2006).

All Tank Closure alternatives would result in additional waste generation. Closure and cleanup waste generation activities would be scrutinized to identify opportunities for waste minimization at Hanford. Waste would be minimized where feasible by (1) reusing or recycling material; (2) processing waste to reduce its quantity, volume, or toxicity; (3) substituting materials or processes that generate hazardous waste with others that result in less hazardous waste; and (4) segregating waste materials to prevent contamination of nonradioactive and nonhazardous materials.

4.1.14.1 Alternative 1: No Action

This section describes the impacts of Tank Closure Alternative 1 on the waste management system at Hanford. As described in Chapter 2, Section 2.4.2, no new facilities would be constructed to process tank waste. Activities under way to construct the WTP and Canister Storage Building would be terminated. The environmental and socioeconomic impacts of ongoing activities and subsequent administrative control activities are evaluated in the applicable sections of this EIS.

Under this Tank Closure alternative, Waste Management Alternative 1, No Action, would be chosen. The scope of Waste Management Alternative 1 is based on the requirements of the Settlement Agreement signed on January 6, 2006, by DOE, Ecology, and the Washington State Attorney General's Office (*State of Washington v. Bodman*, Civil No. 2:03-cv-05018-AAM), the January 6, 2006, Memorandum of Understanding between DOE and Ecology (DOE and Ecology 2006), and the June 30, 2004, "Record of Decision for the *Solid Waste Program, Hanford Site, Richland, WA:* Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant" (69 FR 39449).

4.1.14.1.1 Waste Inventories

Table 4–84 presents the estimated waste volumes generated under Tank Closure Alternative 1.

4.1.14.1.2 High-Level Radioactive Waste

Under Tank Closure Alternative 1, the WTP would not be completed. Therefore, no IHLW canisters would be generated. The waste in the DSTs and SSTs would continue to be monitored over a 100-year administrative control period.

4.1.14.1.3 Treated Low-Activity Tank Waste

The low-activity fraction of the tank waste would not be separated under this alternative. Therefore, no treated low-activity, tank-derived waste would be generated.

4.1.14.1.4 Waste Treatment Plant Melters

The WTP for vitrifying HLW and tank LAW would not be completed under Tank Closure Alternative 1. Therefore, no WTP melters requiring storage or disposal would be generated.

4.1.14.1.5 Secondary Waste

4.1.14.1.5.1 Mixed Transuranic Waste

Secondary mixed TRU waste would not be generated by cessation of current WTP construction or by routine operations and monitoring activities that would occur during the administrative control period.

4.1.14.1.5.2 Low-Level Radioactive Waste

As shown in Table 4–84, 35 cubic meters (46 cubic yards) of LLW would be generated under Tank Closure Alternative 1; this amount is consistent with that accounted for under Waste Management Alternative 1. The waste would be processed at the CWC and would be disposed of in LLBG 218-W-5 trenches 31 and 34. No barriers would be constructed over trenches 31 and 34, the CWC, WRAP, or the T Plant complex. There would be a 100-year administrative control period through 2135.

Table 4–84. Tank Closure Alternative 1 Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation	
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year
High-level radioactive waste							
IHLW (0 canisters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Treated low-activity tank waste							
ILAW (0 canisters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bulk vitrification	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cast stone	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Steam reforming	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RH-TRU waste	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CH-TRU waste	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WTP melters							
HLW melters (0 melters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LAW melters (0 melters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Secondary waste							
LLW	N/A	21	14	N/A	35	2008	9
MLLW	N/A	21	N/A	N/A	21	2006–2008	7
Mixed TRU waste	N/A	N/A	N/A	N/A	N/A	N/A	0
Hazardous waste[a]	12	N/A	N/A	N/A	12	2006–2008	4
Nonradioactive-nonhazardous waste[b]	N/A	N/A	307	N/A	307	2008–2107	3
Liquid LLW (liters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[a] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[b] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: CH=contact-handled; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; RH=remote-handled; TRU=transuranic; WTP=Waste Treatment Plant.

Source: SAIC 2007a, 2008.

4.1.14.1.5.3 Mixed Low-Level Radioactive Waste

Secondary MLLW would be generated during the period of routine operations. Mixed waste would require treatment to meet land disposal restriction requirements prior to disposal. The amount of MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 1.

4.1.14.1.5.4 Hazardous Waste

Hazardous waste generated during the cessation of construction would be packaged in DOT-approved containers and shipped off site to permitted commercial recycling, treatment, and disposal facilities.

4.1.14.1.5.5 Nonhazardous Waste

A small amount (307 cubic meters [402 cubic yards]) of nonhazardous waste would be generated from cessation of current WTP construction or by routine operations and monitoring activities that would occur during the administrative control period. This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.1.5.6 Liquid Process Waste

No liquid process waste would be generated from cessation of current WTP construction or by routine operations and monitoring activities that would occur during the administrative control period.

4.1.14.2 Alternative 2A: Existing WTP Vitrification; No Closure

4.1.14.2.1 Waste Inventories

Table 4–85 presents the estimated waste volumes generated under Alternative 2A.

4.1.14.2.2 High-Level Radioactive Waste

As shown in Table 4–85, 14,220 cubic meters (18,600 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

4.1.14.2.3 Treated Low-Activity Tank Waste

As shown in Table 4–85, the 212,891 cubic meters (278,000 cubic yards) of ILAW glass that would be generated under this Tank Closure alternative is within the capacity of Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2.

4.1.14.2.4 Waste Treatment Plant Melters

As shown in Table 4–85, the volume of HLW melters generated is 3,677 cubic meters (4,810 cubic yards). DOE expects that the HLW melters would be stored on site.

The volume of LAW melters generated under this Tank Closure alternative would be 7,699 cubic meters (10,070 cubic yards). This amount is within the capacity of Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2.

Table 4–85. Tank Closure Alternative 2A Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)[a]
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (12,000 canisters)	N/A	14,220	N/A	N/A	14,220	2018–2092	190	N/A
Cesium and strontium (340 canisters)[b]	N/A	400	N/A	N/A	400	2093	400	N/A
Treated low-activity tank waste								
ILAW (92,250 canisters)	N/A	212,891	N/A	N/A	212,891	2018–2092	2,839	212,891
WTP melters								
HLW melters (30 melters)	N/A	3,677	N/A	N/A	3,677	Various	245	N/A
LAW melters (30 melters)	N/A	7,699	N/A	N/A	7,699	Various	513	7,699
Secondary waste								
LLW	N/A	31,762	1,237	1,332	34,331	2018–2028	536	34,331
MLLW	N/A	31,779	3,269	4,206	39,254	2078–2079	840	39,254
Mixed TRU waste	N/A	219	N/A	N/A	219	2053–2092	3	N/A
Hazardous waste[c]	178	63,340	15,686	N/A	79,203	2092–2093	31,380	N/A
Nonradioactive-nonhazardous waste[d]	N/A	254	1,853	540	2,647	2094	320	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF capacities: Waste Management Alternative 2, Disposal Group 2: 200-East Area 425,000 m^3 Waste Management Alternative 3, Disposal Group 2: 200-East Area 1,080,000 m^3, 200-West Area 90,000 m^3					Total waste to IDF(s): 284,175 m^3			

[a] Construction of the RPPDF is not required for this Tank Closure alternative.

[b] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.

[c] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[d] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.2.5 Secondary Waste

4.1.14.2.5.1 Mixed Transuranic Waste

As shown in Table 4–85, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.2.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Table 4–85, Tank Closure Alternative 2A accounts for the disposal of 34,331 cubic meters (44,905 cubic yards) of LLW and 39,254 cubic meters (51,344 cubic yards) of MLLW that would be generated by the tank closure program. LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF(s) are evaluated under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2.

4.1.14.2.5.3 Hazardous Waste

As shown in Table 4–85, a total of 79,203 cubic meters (103,598 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2092–2093), hazardous waste would be generated at 31,380 cubic meters (41,045 cubic yards) per year.

4.1.14.2.5.4 Nonhazardous Waste

As shown in Table 4–85, the estimated volume of nonhazardous waste would be 2,647 cubic meters (3,462 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.2.5.5 Liquid Process Waste

As shown in Table 4–85, the estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,560 gallons). This waste would be treated on site.

4.1.14.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

4.1.14.3.1 Waste Inventories

Table 4–86 presents the estimated waste volumes generated under Alternative 2B. Under this Tank Closure alternative, closure activities would include the removal of ancillary equipment and the top 4.6 meters (15 feet) of soil from two tank farms. This tank closure waste would be disposed of in the new RPPDF.

4.1.14.3.2 High-Level Radioactive Waste

As shown in Table 4–86, 14,220 cubic meters (18,600 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

Table 4–86. Tank Closure Alternative 2B Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (12,000 canisters)	N/A	14,220	N/A	N/A	14,220	2018–2039	646	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2040	400	N/A
Treated low-activity tank waste								
ILAW (92,250 canisters)	N/A	212,891	N/A	N/A	212,891	2018–2043	8,188	212,891 (IDF)
WTP melters								
HLW melters (11 melters)	N/A	1,348	N/A	N/A	1,348	Various	245	N/A
LAW melters (31 melters)	N/A	8,007	N/A	N/A	8,007	Various	1,540	8,007 (IDF)
Secondary waste								
LLW	N/A	27,553	968	9,175	37,696	2040	2,801	37,696 (IDF)
MLLW	N/A	27,512	2,869	6,576	36,957	2040	3,022	36,957 (IDF)
Closure LLW[b]	N/A	N/A	N/A	679	679	2038–2040	226	679 (RPPDF)
Closure MLLW[c]	N/A	N/A	N/A	467,955	467,955	2032–2037	77,993	467,955 (RPPDF)
Mixed TRU waste	N/A	206	N/A	N/A	206	2029–2043	8	N/A
Hazardous waste[d]	165	63,304	15,686	106	79,262	2039–2040	31,393	N/A
Nonradioactive-nonhazardous waste[e]	N/A	254	1,342	677	2,273	2044	594	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 1: IDF-E 1,200,000 m^3, RPPDF 1,080,000 m^3 Waste Management Alternative 3, Disposal Group 1: IDF-E 1,080,000 m^3, IDF-W 90,000 m^3, RPPDF 1,030,000 m^3					Total waste to IDF(s)/RPPDF: 295,551 m^3/468,634 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.

[b] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.

[c] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.

[d] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[e] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.3.3 Treated Low-Activity Tank Waste

As shown in Table 4–86, the 212,891 cubic meters (278,461 cubic yards) of ILAW glass that would be generated under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Long-term impacts of radiological and chemical releases from disposed ILAW are evaluated in Sections 4.3.2.6.3 and 4.3.2.13, respectively.

4.1.14.3.4 Waste Treatment Plant Melters

As shown in Table 4–86, the volume of LAW melters generated under this Tank Closure alternative would be 8,007 cubic meters (10,473 cubic yards); this volume is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. As shown in Table 4–86, the volume of IHLW melters generated under this Tank Closure alternative would be 1,348 cubic meters (1,763 cubic yards). DOE expects that the HLW melters would be stored on site.

4.1.14.3.5 Secondary Waste

4.1.14.3.5.1 Mixed Transuranic Waste

As shown in Table 4–86, the 206 cubic meters (270 cubic yards) of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternatives 2 and 3; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.3.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Table 4–86, Tank Closure Alternative 2B accounts for the disposal of 37,696 cubic meters (49,306 cubic yards) of LLW, 679 cubic meters (888 cubic yards) of LLW generated by tank closure, and 36,957 cubic meters (48,340 cubic yards) of MLLW generated by tank closure. LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.3.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the removal of ancillary equipment and the excavation of contaminated soil to a depth of approximately 4.6 meters (15 feet) from selected tank farms. This large quantity of tank closure MLLW (467,955 cubic meters [612,085 cubic yards]) is included as a waste stream under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1, for disposal in a new disposal facility, the RPPDF, located between the 200-East and 200-West Areas, after confirming that the waste stream meets the appropriate land disposal restriction treatment standards, such as the alternative soil treatment standards (40 CFR 268.49). Land use, transportation, groundwater, and long-term human health impacts of closure waste disposal in the RPPDF under this Tank Closure alternative are evaluated in the appropriate sections of this EIS.

4.1.14.3.5.4 Hazardous Waste

A total of 79,262 cubic meters (103,675 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2039–2040), hazardous waste would be generated at 31,393 cubic meters (41,062 cubic yards) per year.

4.1.14.3.5.5 Nonhazardous Waste

The estimated volume of nonhazardous waste would be 2,273 cubic meters (2,973 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.3.5.6 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,560 gallons). This waste would be treated on site.

4.1.14.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

4.1.14.4.1 Waste Inventories

Table 4–87 presents the estimated waste volumes generated under Alternative 3A. Under this Tank Closure alternative, closure activities would include the removal of ancillary equipment and the top 4.6 meters (15 feet) of soil from two tank farms. This tank closure waste would be disposed of in the new RPPDF.

4.1.14.4.2 High-Level Radioactive Waste

As shown in Table 4–87, 10,310 cubic meters (13,486 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

4.1.14.4.3 Treated Low-Activity Tank Waste

As shown in Table 4–87, the 168,518 cubic meters (220,422 cubic yards) of ILAW generated by the two treatment processes under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Long-term impacts of radiological and chemical releases from WTP and bulk vitrification glass on groundwater quality and human health are evaluated in Sections 4.4.1.6.3 and 4.4.1.13, respectively.

4.1.14.4.3.1 Mixed Transuranic Waste

The 1,500 cubic meters (1,962 cubic yards) of CH-mixed and 2,140 cubic meters (2,800 cubic yards) of RH-mixed TRU waste generated from solidifying tank waste under this Tank Closure alternative would be within the WIPP-analyzed capacities allocated to Hanford.

Table 4–87. Tank Closure Alternative 3A Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (12,000 canisters)	N/A	10,310	N/A	N/A	10,310	2018–2039	469	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2040	400	N/A
Treated low-activity tank waste								
ILAW (28,510 canisters)	N/A	65,780	N/A	N/A	65,780	2018–2039	2,990	65,780 (IDF)
Bulk vitrification	N/A	102,738	N/A	N/A	102,738	2018–2039	4,670	102,738 (IDF)
CH-TRU waste	N/A	1,500	N/A	N/A	1,500	2009–2010	750	N/A
RH-TRU waste	N/A	2,140	N/A	N/A	2,140	2015–2019	428	N/A
WTP melters								
HLW melters (9 melters)	N/A	1,103	N/A	N/A	1,103	Various	245	N/A
LAW melters (9 melters)	N/A	2,258	N/A	N/A	2,258	Various	513	2,258 (IDF)
Secondary waste								
LLW	N/A	17,429	1,980	9,175	28,584	2035	1,750	28,584 (IDF)
MLLW	N/A	31,248	3,922	6,576	41,746	2040	2,501	41,746 (IDF)
Closure LLW[b]	N/A	N/A	N/A	679	679	2034–2036	679	679 (IDF)
Closure MLLW[c]	N/A	N/A	N/A	467,955	467,955	2028–2033	77,993	467,955(RPPDF)
Mixed TRU waste	N/A	206	N/A	N/A	206	2027–2039	9	206 (RPPDF)
Hazardous waste[d]	206	63,306	15,686	106	79,304	2039–2040	31,397	N/A
Nonradioactive-nonhazardous waste[e]	N/A	254	1,089	677	2,021	2041	356	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 1: IDF-E 1,200,000 m^3, RPPDF 1,030,000 m^3 Waste Management Alternative 3, Disposal Group 1: IDF-E 1,080,000 m^3, IDF-W 90,000 m^3, RPPDF 1,080,000 m^3					Total waste to IDF(s)/RPPDF: 241,786 m^3/468,161 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.
[b] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.
[c] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.
[d] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.
[e] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: CH=contact handed; HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; RH=remote-handled; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.4.4 Waste Treatment Plant Melters

As shown in Table 4–87 the volume of LAW melters generated under this Tank Closure alternative would be 2,258 cubic meters (2,954 cubic yards); this volume is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

As shown in Table 4–87, the volume of HLW melters generated under this Tank Closure alternative would be 1,348 cubic meters (1,763 cubic yards). DOE expects that the HLW melters would be stored on site.

4.1.14.4.5 Secondary Waste

4.1.14.4.5.1 Mixed Transuranic Waste

As shown in Table 4–87, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.4.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Table 4–87, Tank Closure Alternative 3A accounts for the disposal of 28,584 cubic meters (37,388 cubic yards) of LLW, 679 cubic meters (888 cubic yards) of LLW generated by tank closure, and 41,966 cubic meters (54,892 cubic yards) of MLLW generated by tank closure. LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.4.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the removal of ancillary equipment and the excavation of contaminated soil to a depth of approximately 4.6 meters (15 feet) from selected tank farms. This large quantity of tank closure MLLW (525,297 cubic meters [687,089 cubic yards]) is included as a waste stream under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1, for disposal in a new disposal facility, the RPPDF, located between the 200-East and 200-West Areas, after confirming that the waste stream meets the appropriate land disposal restriction treatment standards, such as the alternative soil treatment standards (40 CFR 268.49).

4.1.14.4.5.4 Hazardous Waste

A total of 79,304 cubic meters (103,730 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2039–2040), hazardous waste would be generated at 31,397 cubic meters (41,067 cubic yards) per year.

4.1.14.4.5.5 Nonhazardous Waste

The estimated volume of nonhazardous waste would be 2,021 cubic meters (2,644 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.4.5.6 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,560 gallons). This waste would be treated on site.

4.1.14.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

4.1.14.5.1 Waste Inventories

Table 4–88 presents the estimated waste volumes generated under Alternative 3B. Under this Tank Closure alternative, closure activities would include the removal of ancillary equipment and the top 4.6 meters (15 feet) of soil from two tank farms. This tank closure waste would be disposed of in the new RPPDF.

4.1.14.5.2 High-Level Radioactive Waste

As shown in Table 4–88, 10,310 cubic meters (13,486 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

4.1.14.5.3 Treated Low-Activity Tank Waste

As shown in Table 4–88, the 298,461 cubic meters (390,387 cubic yards) of ILAW generated by the two treatment processes under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.5.3.1 Mixed Transuranic Waste

Under this Tank Closure alternative, 1,500 cubic meters (1,962 cubic yards) of CH-mixed and 2,140 cubic meters (2,800 cubic yards) of RH-mixed TRU waste would be generated. This volume would be within the WIPP-analyzed capacities allocated to Hanford.

4.1.14.5.4 Waste Treatment Plant Melters

As shown in Table 4–88, the 2,258 cubic meters (2,954 cubic yards) of LAW melters generated under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

As shown in Table 4–88, the volume of HLW melters generated under this Tank Closure alternative would be 1,103 cubic meters (1,443 cubic yards). DOE expects that the HLW melters would be stored on site.

Table 4–88. Tank Closure Alternative 3B Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (8,700 canisters)	N/A	10,310	N/A	N/A	10,310	2018–2039	469	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2040	400	N/A
Treated low-activity tank waste								
ILAW (28,510 canisters)	N/A	65,780	N/A	N/A	65,780	2018–2039	2,990	65,780 (IDF)
Cast stone	N/A	232,781	N/A	N/A	232,781	2018–2039	10,581	232,781 (IDF)
CH-TRU waste	N/A	1,500	N/A	N/A	1,500	2009–2010	750	N/A
RH-TRU waste	N/A	2,140	N/A	N/A	2,140	2015–2019	428	N/A
WTP melters								
HLW melters (9 melters)	N/A	1,103	N/A	N/A	1,103	Various	245	N/A
LAW melters (9 melters)	N/A	2,258	N/A	N/A	2,258	Various	513	2,258 (IDF)
Secondary waste								
LLW	N/A	10,928	2,019	9,175	22,121	2040	1,681	22,121 (IDF)
MLLW	N/A	24,559	4,006	6,576	35,141	2040	2,548	35,141 (IDF)
Closure LLW[b]	N/A	N/A	N/A	679	679	2028–2033	226	679 (RPPDF)
Closure MLLW[c]	N/A	N/A	N/A	467,955	467,955	2034–2036	76,895	467,955 (RPPDF)
Mixed TRU waste	N/A	206	N/A	N/A	206	2027–2039	9	N/A
Hazardous waste[d]	206	63,306	15,686	106	79,304	2039–2040	31,397	N/A
Nonradioactive-nonhazardous waste[e]	N/A	N/A	698	677	1,375	2041	343	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 1: IDF-E 1,200,000 m^3, RPPDF 1,030,000 m^3 Waste Management Alternative 3, Disposal Group 1: IDF-E 1,080,000 m^3, IDF-W 90,000 m^3, RPPDF 1,080,000 m^3					Total waste to IDF(s)/RPPDF: 358,082 m^3/468,634 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.

[b] Closure LLW is the waste from the decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.

[c] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.

[d] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[e] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: CH=contact-handled; HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; RH=remote-handled; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.5.5 Secondary Waste

4.1.14.5.5.1 Mixed Transuranic Waste

As shown in Table 4–88, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.5.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Table 4–88, Tank Closure Alternative 3B accounts for the disposal of 22,121 cubic meters (28,934 cubic yards) of LLW, 679 cubic meters (888 cubic yards) of LLW generated by tank closure, and 35,201 cubic meters (46,043 cubic yards) of MLLW generated by tank closure. LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.5.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the removal of ancillary equipment and the excavation of contaminated soil to a depth of approximately 4.6 meters (15 feet) from selected tank farms. This large quantity of tank closure MLLW (467,955 cubic meters [612,085 cubic yards]) is included as a waste stream under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1, for disposal in a new disposal facility, the RPPDF, located between the 200-East and 200-West Areas, after confirming that the waste stream meets the appropriate land disposal restriction treatment standards, such as the alternative soil treatment standards (40 CFR 268.49). Land use, transportation, groundwater, and long-term human health impacts of closure waste disposal in the RPPDF under this Tank Closure alternative are evaluated in the appropriate sections of this *TC & WM EIS*.

4.1.14.5.5.4 Hazardous Waste

A total of 79,304 cubic meters (103,730 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2039–2040), hazardous waste would be generated at 31,397 cubic meters (41,067 cubic yards) per year.

4.1.14.5.5.5 Nonhazardous Waste

The estimated volume of nonhazardous waste would be 1,375 cubic meters (1,799 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.5.5.6 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,560 gallons). This waste would be treated on site.

4.1.14.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

4.1.14.6.1 Waste Inventories

Table 4–89 presents the estimated waste volumes generated under Alternative 3C. Under this Tank Closure alternative, closure activities would include the removal of ancillary equipment and the top 4.6 meters (15 feet) of soil from two tank farms. This tank closure waste would be disposed of in the new RPPDF.

4.1.14.6.2 High-Level Radioactive Waste

As shown in Table 4–89, 10,310 cubic meters (13,486 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

4.1.14.6.3 Treated Low-Activity Tank Waste

As shown in Table 4–89, the 326,700 cubic meters (427,324 cubic yards) of ILAW generated by the two treatment processes under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Long-term impacts of radiological and chemical releases from WTP and steam reforming waste on groundwater quality and human health are evaluated in Sections 4.4.2.6.3 and 4.4.2.13, respectively.

4.1.14.6.3.1 Mixed Transuranic Waste

The 1,500 cubic meters (1,962 cubic yards) of CH-mixed and 2,140 cubic meters (2,799 cubic yards) of RH-mixed TRU waste generated from solidifying tank waste under this Tank Closure alternative would be within the WIPP-analyzed capacities allocated to Hanford.

4.1.14.6.4 Waste Treatment Plant Melters

As shown in Table 4–89, the 2,258 cubic meters (2,954 cubic yards) of LAW melters generated under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

As shown in Table 4–89, the volume of HLW melters generated under this Tank Closure alternative would be 1,103 cubic meters (1,443 cubic yards). DOE expects that the HLW melters would be stored on site.

Table 4–89. Tank Closure Alternative 3C Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (8,700 canisters)	N/A	10,310	N/A	N/A	10,310	2018–2039	469	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2040	400	N/A
Treated low-activity tank waste								
ILAW (28,510 canisters)	N/A	65,780	N/A	N/A	65,780	2018–2039	2,990	65,780 (IDF)
Cast stone	N/A	260,920	N/A	N/A	260,920	2018–2039	11,860	260,920 (IDF)
CH-TRU waste	N/A	1,500	N/A	N/A	1,500	2009–2010	750	N/A
RH-TRU waste	N/A	2,140	N/A	N/A	2,140	2015–2019	428	N/A
WTP melters								
HLW melters (9 melters)	N/A	1,103	N/A	N/A	1,103	Various	245	N/A
LAW melters (9 melters)	N/A	2,258	N/A	N/A	2,258	Various	513	2,258 (IDF)
Secondary waste								
LLW	N/A	10,700	1,980	9,175	21,854	2040	1,670	21,854 (IDF)
MLLW	N/A	10,885	3,648	6,576	21,109	2040	2,175	21,109 (IDF)
Closure LLW[b]	N/A	N/A	N/A	679	679	2034–2036	226	679 (RPPDF)
Closure MLLW[c]	N/A	N/A	N/A	467,955	467,955	2028–2033	77,993	467,955 (RPPDF)
Mixed TRU waste	N/A	206	N/A	N/A	206	2027–2039	9	N/A
Hazardous waste[d]	165	63,306	16,052	106	79,670	2039–2040	31,410	N/A
Nonradioactive-nonhazardous waste[e]	N/A	254	765	677	1,697	2041	377	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 1: IDF-E 1,200,000 m^3, RPPDF 1,030,000 m^3 Waste Management Alternative 3, Disposal Group 1: IDF-E 1,100,000 m^3, IDF-W 90,000 m^3, RPPDF 1,080,000 m^3					Total waste to IDF(s)/RPPDF: 371,922 m^3/468,634 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.

[b] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.

[c] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.

[d] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[e] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: CH=contact-handled; HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; RH=remote-handled; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.6.5 Secondary Waste

4.1.14.6.5.1 Mixed Transuranic Waste

As shown in Table 4–89, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.6.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Table 4–89, Tank Closure Alternative 3C accounts for the disposal of 21,854 cubic meters (28,585 cubic yards) of LLW, 679 cubic meters (888 cubic yards) of LLW generated by tank closure, and 21,109 cubic meters (27,611 cubic yards) of MLLW generated by tank closure. LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.6.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the removal of ancillary equipment and the excavation of contaminated soil to a depth of approximately 4.6 meters (15 feet) from selected tank farms. This large quantity of tank closure MLLW (467,955 cubic meters [612,085 cubic yards]) is included as a waste stream under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1, for disposal in a new disposal facility, the RPPDF, located between the 200-East and 200-West Areas, after confirming that the waste stream meets the appropriate land disposal restriction treatment standards, such as the alternative soil treatment standards (40 CFR 268.49). Land use, transportation, groundwater, and long-term human health impacts of closure waste disposal in the RPPDF under this Tank Closure alternative are evaluated in the appropriate sections of this EIS.

4.1.14.6.5.4 Hazardous Waste

A total of 79,670 cubic meters (104,208 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2092–2093), hazardous waste would be generated at 31,410 cubic meters (41,804 cubic yards) per year.

4.1.14.6.5.5 Nonhazardous Waste

The estimated volume of nonhazardous waste would be 1,697 cubic meters (2,220 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.6.5.6 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,560 gallons). This waste would be treated on site.

4.1.14.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

4.1.14.7.1 Waste Inventories

Table 4–90 presents the estimated waste volumes generated under Alternative 4. Under this Tank Closure alternative, closure activities would include removal from two tank farms of tanks and soils beneath the tanks that have been contaminated by past tank leaks. Some of these wastes would be sent to the PPF for treatment prior to disposal. The liquid waste streams from the treatment would be routed to the WTP and incorporated into the IHLW and ILAW glass streams. The majority of the waste volume from the closure wastes would be disposed of in the RPPDF.

4.1.14.7.2 High-Level Radioactive Waste

As shown in Table 4–90, 12,800 cubic meters (16,742 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

4.1.14.7.3 Treated Low-Activity Tank Waste

As shown in Table 4–90, the 248,131 cubic meters (324,555 cubic yards) of ILAW generated by the three treatment processes under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.7.3.1 Mixed Transuranic Waste

The 1,510 cubic meters (1,975 cubic yards) of CH-mixed and 2,160 cubic meters (2,825 cubic yards) of RH-mixed TRU waste generated from solidifying tank waste under this Tank Closure alternative would be within the WIPP-analyzed capacities allocated to Hanford.

4.1.14.7.4 Waste Treatment Plant Melters

As shown in Table 4–90, the 2,566 cubic meters (3,356 cubic yards) of LAW melters generated under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

As shown in Table 4–90, the volume of HLW melters generated under this Tank Closure alternative would be 1,226 cubic meters (1,604 cubic yards). DOE expects that the HLW melters would be stored on site.

Table 4–90. Tank Closure Alternative 4 Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (10,800 canisters)	N/A	12,800	N/A	N/A	12,800	2018–2042	512	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2043	400	N/A
Treated low-activity tank waste								
ILAW (28,730 canisters)	N/A	63,825	N/A	N/A	63,825	2018–2042	2,553	63,825 (IDF)
Cast stone	N/A	143,771	N/A	N/A	143,771	2018–2039	6,535	143,771 (IDF)
Bulk vitrification	N/A	40,535	N/A	N/A	40,535	2018–2039	1,843	40,535 (IDF)
CH-TRU waste	N/A	1,510	N/A	N/A	1,510	2009–2010	755	N/A
RH-TRU waste	N/A	2,160	N/A	N/A	2,160	2015–2019	432	N/A
WTP melters								
HLW melters (10 melters)	N/A	1,226	N/A	N/A	1,226	Various	245	N/A
LAW melters (10 melters)	N/A	2,566	N/A	N/A	2,566	Various	513	2,566 (IDF)
Secondary waste								
LLW	N/A	14,927	2,586	24,451	41,964	2043	2,452	41,964 (IDF)
MLLW	N/A	14,634	5,083	23,777	43,495	2043	7,644	43,495 (IDF)
Closure LLW[b]	N/A	N/A	N/A	2,402	2,402	2022–2033	200	2,402 (RPPDF)
Closure MLLW[c]	N/A	N/A	N/A	1,013,034	1,013,034	2034–2041	100,575	1,013,034 (RPPDF)
Mixed TRU waste	N/A	412	N/A	N/A	412	2013–2042	14	N/A
Hazardous waste[d]	224	63,865	15,686	128	79,903	2042–2043	31,414	N/A
Nonradioactive-nonhazardous waste[e]	N/A	254	937	701	1,891	2044	317	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 1: IDF-E 1,200,000 m^3, RPPDF 1,030,000 m^3 Waste Management Alternative 3, Disposal Group 1: IDF-E 1,080,000 m^3, IDF-W 90,000 m^3, RPPDF 1,080,000 m^3					Total waste to IDF(s)/RPPDF: 336,156 m^3/1,015,436 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.
[b] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.
[c] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.
[d] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.
[e] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.
Key: CH=contact-handled; HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; RH=remote-handled; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.
Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.7.5 Secondary Waste

4.1.14.7.5.1 Mixed Transuranic Waste

As shown in Table 4–90, the 412 cubic meters (539 cubic yards) of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.7.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Table 4–90, Tank Closure Alternative 4 accounts for the disposal of 41,694 cubic meters (54,535 cubic yards) of LLW, 2,402 cubic meters (3,141 cubic yards) of LLW generated by tank closure, and 43,495 cubic meters (56,891 cubic yards) of MLLW generated by tank closure. LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.7.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the clean closure of BX and SX tank farms. This large quantity of tank closure MLLW (approximately 1.01 million cubic meters [1.32 million cubic yards]) is included as a waste stream under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1, for disposal of in a new disposal facility, the RPPDF, located between the 200-East and 200-West Areas, after confirming that the waste stream meets the appropriate land disposal restriction treatment standards, such as the alternative soil treatment standards (40 CFR 268.49). Land use, transportation, groundwater, and long-term human health impacts of closure waste disposal in the RPPDF under this Tank Closure alternative are evaluated in the appropriate sections of this EIS.

4.1.14.7.5.4 Hazardous Waste

A total of 79,903 cubic meters (104,513 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2042–2043), hazardous waste would be generated at 31,414 cubic meters (41,090 cubic yards) per year.

4.1.14.7.5.5 Nonhazardous Waste

The estimated volume of nonhazardous waste would be 1,891 cubic meters (2,473 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.7.5.6 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be approximately 9,691 liters (approximately 2,650 gallons). This waste would be treated on site.

4.1.14.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

4.1.14.8.1 Waste Inventories

Table 4–91 presents the estimated waste volumes generated under Tank Closure Alternative 5. Under this Tank Closure alternative, the SST system at Hanford would be closed as an RCRA hazardous waste landfill unit under WAC-173-303 and DOE Order 435.1 as applicable, or decommissioned under DOE Order 430.1B. No contaminated soil would be removed at the BX or SX tank farm.

4.1.14.8.2 High-Level Radioactive Waste

As shown in Table 4–91, 9,240 cubic meters (12,086 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

4.1.14.8.3 Treated Low-Activity Tank Waste

As shown in Table 4–91, the 178,235 cubic meters (233,131 cubic yards) of ILAW generated by the four treatment processes under this Tank Closure alternative is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Long-term impacts of radiological and chemical constituents from the ILAW glass, bulk vitrification glass, cast stone waste, and sulfate grout waste on groundwater quality and human health are evaluated in Sections 4.6.6.3 and 4.6.13, respectively.

4.1.14.8.3.1 Mixed Transuranic Waste

Under this alternative, 1,360 cubic meters (1,779 cubic yards) of CH-mixed and 1,940 cubic meters (2,538 cubic yards) of RH-mixed TRU waste would be generated. This amount is within the WIPP-analyzed capacities allocated to Hanford.

4.1.14.8.4 Waste Treatment Plant Melters

As shown in Table 4–91, the volume of LAW melters generated under this Tank Closure alternative would be 2,464 cubic meters (3,223 cubic yards); this volume is included in the capacity of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

As shown in Table 4–91, the volume of HLW melters generated under this Tank Closure alternative would be 858 cubic meters (1,122 cubic yards). DOE expects that the HLW melters would be stored on site.

Table 4–91. Tank Closure Alternative 5 Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (7,800 canisters)	N/A	9,240	N/A	N/A	9,240	2018–2033	578	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2034	400	N/A
Treated low-activity tank waste								
ILAW (31,100 canisters)	N/A	71,765	N/A	N/A	71,765	2018–2033	4,485	71,765 (IDF)
Bulk vitrification	N/A	36,595	N/A	N/A	36,595	2018–2033	2,287	36,595 (IDF)
Cast stone	N/A	50,041	N/A	N/A	50,041	2018–2033	3,128	50,041 (IDF)
Sulfate grout	N/A	19,835	N/A	N/A	19,835	2018–2033	1,240	19,835 (IDF)
CH-TRU waste	N/A	1,360	N/A	N/A	1,360	2009–2010	680	N/A
RH-TRU waste	N/A	1,940	N/A	N/A	1,940	2015–2019	389	N/A
WTP melters								
HLW melters (10 melters)	N/A	858	N/A	N/A	858	Various	245	N/A
LAW melters (10 melters)	N/A	2,464	N/A	N/A	2,464	Various	770	2,464 (IDF)
Secondary waste								
LLW	N/A	14,792	2,129	3,748	20,669	2020–2021	1,938	20,669 (IDF)
MLLW	N/A	14,643	4,288	3,665	22,596	2034	2,554	22,596 (IDF)
Closure MLLW[b]	N/A	N/A	3,058	N/A	3,058	2012–2022	278	3,058 (IDF)
Mixed TRU waste	N/A	183	N/A	N/A	183	2024–2033	10	N/A
Hazardous waste[c]	204	63,243	15,686	48	79,181	2033–2034	31,403	N/A
Nonradioactive-nonhazardous waste[d]	N/A	254	1,633	138	2,025	2035	409	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2012–2022	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 1: IDF-E 1,200,000 m^3, RPPDF 1,030,000 m^3 Waste Management Alternative 3, Disposal Group 1: IDF-E 1,080,000 m^3, IDF-W 90,000 m^3, RPPDF 1,080,000 m^3					Total waste to IDF(s)/RPPDF: 227,023 m^3/0 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.

[b] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.

[c] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[d] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: CH=contact-handled; HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; RH=remote-handled; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.8.5 Secondary Waste

4.1.14.8.5.1 Mixed Transuranic Waste

As shown in Table 4–91, 183 cubic meters (239 cubic yards) of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternatives 2 and 3; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.8.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Table 4–91, Tank Closure Alternative 5 accounts for the disposal of 20,669 cubic meters (27,035 cubic yards) of LLW and 22,596 cubic meters (29,556 cubic yards) of MLLW generated by tank closure. LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.8.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, ancillary equipment would not be removed and soil would not be excavated from tank farms. The quantity of MLLW (3,058 cubic meters [3,400 cubic yards]) generated by decontamination and decommissioning of the structures over the tank farms is included as a waste stream under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1, for disposal in a new disposal facility, the RPPDF, located between the 200-East and 200-West Areas, after confirming that the waste stream meets the appropriate land disposal restriction treatment standards, such as the alternative soil treatment standards (40 CFR 268.49). Land use, transportation, groundwater, and long-term human health impacts of closure waste disposal in the RPPDF under this Tank Closure alternative are evaluated in the appropriate sections of this EIS.

4.1.14.8.5.4 Hazardous Waste

A total of 79,181 cubic meters (103,569 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2033–2034), hazardous waste would be generated at 31,403 cubic meters (41,075 cubic yards) per year.

4.1.14.8.5.5 Nonhazardous Waste

The estimated volume of nonhazardous waste would be 2,025 cubic meters (2,649 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.8.5.6 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,650 gallons). This waste would be treated on site.

4.1.14.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

4.1.14.9.1 Waste Inventories

4.1.14.9.1.1 Base and Option Cases

Tables 4–92 and 4–93 present the estimated waste volumes generated under Tank Closure Alternative 6A, Base Case and Option Case, respectively. Under this Tank Closure alternative, closure activities include clean closure of all 12 SST farms in the 200-East and 200-West Areas. Clean closure of the tank farms would encompass extensive tank and ancillary equipment removal, all of which would be dispositioned as HLW.

Tank closure waste that is not being treated as HLW would be disposed of in the new RPPDF, to be located between the 200-East and 200-West Areas. The RPPDF would be similar to the IDF(s).

4.1.14.9.2 High-Level Radioactive Waste

4.1.14.9.2.1 Base and Option Cases

As shown in Tables 4–92 and 4–93, under both the Base Case and the Option Case, 203,060 cubic meters (265,603 cubic yards) of IHLW canisters, 400 cubic meters (523 cubic yards) of cesium and strontium canisters, and 337,264 cubic meters (441,141 cubic yards) of additional HLW would be generated. DOE expects that the IHLW canisters would be stored on site. The additional HLW would be stored on site in shielded boxes.

4.1.14.9.3 Treated Low-Activity Tank Waste

4.1.14.9.3.1 Base and Option Cases

Under this alternative the tank waste stream would not be separated in the Pretreatment Facility and all waste would be managed as HLW.

4.1.14.9.4 Waste Treatment Plant Melters

4.1.14.9.4.1 Base and Option Cases

As shown in Tables 4–92 and 4–93, the volume of HLW melters generated under this Tank Closure alternative would be 17,773 cubic meters (23,247 cubic yards) under both the Base Case and Option Case. DOE expects that the HLW melters would be stored on site.

Also shown in Tables 4–92 and 4–93, the volume of PPF melters generated under this Tank Closure alternative is 3,064 cubic meters (4,007 cubic yards) under the Base Case and 17,895 cubic meters (23,407 cubic yards) under the Option Case. This amount is included in the IDF capacities of Waste Management Alternative 2, Disposal Group 3, and Waste Management Alternative 3, Disposal Group 3. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 3, and Waste Management Alternative 3, Disposal Group 3.

Table 4–92. Tank Closure Alternative 6A, Base Case, Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (171,300 canisters)	N/A	203,060	N/A	N/A	203,060	2018–2162	1,411	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2163	400	N/A
Other HLW	N/A	N/A	N/A	337,264	337,264	2088–2099	6,413	N/A
WTP melters								
HLW melters (145 melters)	N/A	17,773	N/A	N/A	17,773	Various	613	N/A
PPF melters (25 melters)	N/A	N/A	N/A	3,064	3,064	Various	123	3,064 (IDF)
Secondary waste								
PPF glass (670 canisters)	N/A	N/A	N/A	1,540	1,540	2042–2162	13	1,540 (IDF)
LLW	N/A	17,917	5,205	70,292	93,415	2163	1,113	93,415 (IDF)
MLLW	N/A	15,909	21,056	72,851	109,816	2138–2140	3,161	109,816 (IDF)
Closure LLW[b]	N/A	N/A	N/A	4,071	4,071	c	194	4,071 (RPPDF)
Closure MLLW[d]	N/A	N/A	N/A	2,410,289	2,410,289	2054–2061	90,124	2,410,289 (RPPDF)
Mixed TRU waste	N/A	530	N/A	N/A	530	2013–2162	4	N/A
Hazardous waste[e]	2,771	64,186	15,686	317	82,960	2162–2163	31,394	N/A
Nonradioactive-nonhazardous waste[f]	N/A	254	13,608	2,576,490	2,590,351	2088–2099	44,060	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 3: IDF-E 425,000 m^3, RPPDF 8,330,000 m^3 Waste Management Alternative 3, Disposal Group 3: IDF-E 340,000 m^3, IDF-W 90,000 m^3, RPPDF 8,370,000 m^3					Total waste to IDF(s)/RPPDF: 207,835 m^3/2,414,360 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.

[b] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.

[c] Peak generation coincides with deactivation of the containment structures during 2062–2064; 2085–2087; 2108–2110; 2123–2125; 2138–2140; 2146–2148; and 2162–2164.

[d] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.

[e] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[f] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

Table 4–93. Tank Closure Alternative 6A, Option Case, Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (171,300 canisters)	N/A	203,060	N/A	N/A	203,060	2018–2162	1,411	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2163	400	N/A
Other HLW	N/A	N/A	N/A	337,264	337,264	2088–2099	6,413	N/A
WTP melters								
HLW melters (145 melters)	N/A	17,773	N/A	N/A	17,773	Various	613	N/A
PPF melters (25 melters)	N/A	N/A	N/A	17,895	17,895	Various	735	17,895 (IDF)
Secondary waste								
PPF glass (670 canisters)	N/A	N/A	N/A	42,210	42,210	2042–2162	349	42,210 (IDF)
LLW	N/A	17,917	5,808	114,378	138,103	2138–2140	1,732	138,103 (IDF)
MLLW	N/A	15,909	20,454	116,507	152,869	2146–2148	3,182	152,869 (IDF)
Closure LLW[b]	N/A	N/A	N/A	5,428	5,428	2085–2087 2146–2148	420	5,428 (RPPDF)
Closure MLLW[c]	N/A	N/A	N/A	8,307,641	8,307,641	2054–2061	175,229	8,307,641 (RPPDF)
Mixed TRU waste	N/A	530	N/A	N/A	530	2013–2162	4	N/A
Hazardous waste[d]	2,771	64,186	15,686	430	83,073	2162–2163	31,394	N/A
Nonradioactive-nonhazardous waste[e]	N/A	254	13,608	3,237,069	3,250,930	2065–2076	52,123	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 3: IDF-E 425,000 m^3, RPPDF 8,330,000 m^3 Waste Management Alternative 3, Disposal Group 3: IDF-E 340,000 m^3, IDF-W 90,000 m^3, RPPDF 8,370,000 m^3					Option Case total waste to IDF(s)/RPPDF: 351,078 m^3/ 8,313,070 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.
[b] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.
[c] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.
[d] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.
[e] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.9.5 Secondary Waste

4.1.14.9.5.1 Mixed Transuranic Waste

As shown in Tables 4–92 and 4–93, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 3, and Waste Management Alternative 3, Disposal Group 3; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.9.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Tables 4–92 and 4–93, under Tank Closure Alternative 6A, 93,415 cubic meters (122,187 cubic yards) of LLW would be generated under the Base Case and 138,103 cubic meters (180,639 cubic yards) of LLW, under the Option Case; 4,071 cubic meters (5,325 cubic yards) of closure LLW would be generated under the Base Case and 5,428 cubic meters (7,100 cubic yards) of closure LLW, under the Option Case; and 109,816 cubic meters (143,639 cubic yards) of MLLW would be generated under the Base Case and 152,869 cubic meters (199,953 cubic yards) of MLLW, under the Option Case by tank closure.

LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 3, and Waste Management Alternative 3, Disposal Group 3. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 3, and Waste Management Alternative 3, Disposal Group 3.

4.1.14.9.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the removal of ancillary equipment and the excavation of contaminated soil from selected tank farms. This large quantity of tank closure waste includes approximately 2.41 million cubic meters (approximately 3.15 million cubic yards) of MLLW under the Base Case and approximately 8.31 million cubic meters (approximately 10.87 million cubic yards) of MLLW under the Option Case. Under both cases, the contaminated soil would be disposed of in the RPPDF. Land use, transportation, groundwater, and long-term human health impacts of disposing of the closure wastes in the RPPDF under this Tank Closure alternative are evaluated under Waste Management Alternative 2, Disposal Group 3, and Waste Management Alternative 3, Disposal Group 3.

PPF treatment of the soils would generate 1,540 cubic meters (2,014 cubic yards) of PPF glass under the Base Case and 42,210 cubic meters (55,210 cubic yards) under the Option Case. These canisters would be disposed of in an onsite IDF.

4.1.14.9.5.4 Hazardous Waste

A total of 82,960 cubic meters (108,512 cubic yards) of hazardous waste under the Base Case and 83,073 cubic meters (108,660 cubic yards) under the Option Case would be generated during construction and operations. For two peak years (2039–2040), hazardous waste would be generated at 31,394 cubic meters (41,063 cubic yards) per year under either case.

4.1.14.9.5.5 Nonhazardous Waste

The estimated volume of nonhazardous waste would be approximately 2.59 million cubic meters (approximately 3.39 million cubic yards) under the Base Case and approximately 3.25 million cubic meters (approximately 4.25 million cubic yards) under the Option Case. This waste will be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.9.5.6 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,650 gallons) under both the Base Case and the Option Case. This waste would be treated on site.

4.1.14.10 Alternative 6B: All Vitrification with Separations; Clean Closure

4.1.14.10.1 Waste Inventories

4.1.14.10.1.1 Base and Option Cases

Tables 4–94 and 4–95 present the estimated waste volumes generated under Tank Closure Alternative 6B under the Base Case and Option Case, respectively. Under this Tank Closure alternative, closure activities include clean closure of all 12 SST farms in the 200-East and 200-West Areas following deactivation. Clean closure of the tank farms would encompass extensive tank and ancillary equipment removal, all of which would be dispositioned as HLW.

Tank closure waste that is not being treated as HLW would be disposed of in the new RPPDF, to be located between the 200-East and 200-West Areas. The RPPDF would be similar to the IDF(s).

4.1.14.10.2 High-Level Radioactive Waste

4.1.14.10.2.1 Base and Option Cases

As shown in Tables 4–94 and 4–95, under both the Base Case and the Option Case, 14,220 cubic meters (18,600 cubic yards) of IHLW canisters, 400 cubic meters (523 cubic yards) of cesium and strontium canisters, and 337,264 cubic meters (441,141 cubic yards) of additional HLW would be generated. DOE expects that the IHLW canisters would be stored on site. The additional HLW would be stored on site in shielded boxes.

4.1.14.10.3 Treated Low-Activity Tank Waste

4.1.14.10.3.1 Base and Option Cases

The LAW stream that is separated in the Pretreatment Facility would be managed as HLW under this Tank Closure alternative.

Table 4–94. Tank Closure Alternative 6B, Base Case, Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (2,000 canisters)	N/A	14,220	N/A	N/A	14,220	2018–2039	646	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2040	400	N/A
ILAW (93,000 canisters)[b]	N/A	214,610	N/A	N/A	214,610	2018–2043	8,254	N/A
Other HLW	N/A	N/A	N/A	337,264	337,264	2023–2051	11,129	N/A
WTP melters								
HLW melters (11 melters)	N/A	1,348	N/A	N/A	1,348	Various	245	N/A
LAW melters (31 melters)	N/A	8,007	N/A	N/A	8,007	Various	1,540	N/A
PPF melters (16 melters)	N/A	N/A	N/A	1,961	1,961	Various	123	1,961 (IDF)
Secondary waste								
PPF glass (670 canisters)	N/A	N/A	N/A	1,540	1,540	2023–2099	20	1,540 (IDF)
LLW	N/A	27,809	1,574	70,398	99,781	2040	2,912	99,781 (IDF)
MLLW	N/A	27,818	3,944	72,745	104,507	2040	2,978	104,507 (IDF)
Closure LLW[c]	N/A	N/A	N/A	4,071	4,071	d	388	4,071 (RPPDF)
Closure MLLW[e]	N/A	N/A	N/A	2,410,289	2,410,289	2035–2042	124,353	2,410,289 (RPPDF)
Mixed TRU waste	N/A	412	N/A	N/A	412	2013–2043	13	N/A
Hazardous waste[f]	1,013	63,864	15,686	317	80,880	2039–2040	31,431	N/A
Nonradioactive-nonhazardous waste[g]	N/A	254	976	2,479,172	2,480,402	2023–2028	68,393	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 2: IDF-E 425,000 m^3, RPPDF 8,330,000 m^3 Waste Management Alternative 3, Disposal Group 2: IDF-E 340,000 m^3, IDF-W 90,000 m^3, RPPDF 8,370,000 m^3					Base Case total waste to IDF(s)/RPPDF: 207,789 m^3/ 2,414,360 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.
[b] All ILAW to be managed as HLW.
[c] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.
[d] Peak occurs twice: 2043–2045 and 2097–2099.
[e] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.
[f] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.
[g] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

Table 4–95. Tank Closure Alternative 6B, Option Case, Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (12,000 canisters)	N/A	14,220	N/A	N/A	14,220	2018–2039	678	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2040	400	N/A
ILAW (93,000 canisters)[b]	N/A	214,610	N/A	N/A	214,610	2018–2043	8,255	N/A
Other HLW	N/A	N/A	N/A	337,264	337,264	2023–2034	11,129	N/A
WTP melters								
HLW melters (11 melters)	N/A	1,348	N/A	N/A	1,348	Various	245	N/A
LAW melters (31 melters)	N/A	8,007	N/A	N/A	8,007	Various	1,540	N/A
PPF melters (93 melters)	N/A	N/A	N/A	11,399	11,399	Various	735	11,399 (IDF)
Secondary waste								
PPF glass (18,292 canisters)	N/A	N/A	N/A	42,212	42,212	2023–2099	548	42,212 (IDF)
LLW	N/A	27,809	1,574	114,378	143,761	2040	3,632	143,761 (IDF)
MLLW	N/A	27,818	3,944	116,507	148,269	2040	3,703	148,269 (IDF)
Closure LLW[c]	N/A	N/A	N/A	5,428	5,428	2097–2099	614	5,428 (RPPDF)
Closure MLLW[d]	N/A	N/A	N/A	8,307,641	8,307,641	2035–2042	226,520	8,307,641 (RPPDF)
Mixed TRU waste	N/A	412	N/A	N/A	412	2013–2043	13	N/A
Hazardous waste[e]	1,013	63,864	15,686	430	80,992	2039–2040	31,431	N/A
Nonradioactive-nonhazardous waste[f]	N/A	254	1,202	3,237,069	3,238,525	2050–2061	79,616	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 2: IDF-E 425,000 m^3, RPPDF 8,330,000 m^3 Waste Management Alternative 3, Disposal Group 2: IDF-E 340,000 m^3, IDF-W 90,000 m^3, RPPDF 8,370,000 m^3					Option Case total waste to IDF(s)/RPPDF: 345,641 m^3/ 8,313,070 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.
[b] All ILAW to be managed as HLW.
[c] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal is complete.
[d] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.
[e] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.
[f] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.
Key: HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.
Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.10.4 Waste Treatment Plant Melters

4.1.14.10.4.1 Base and Option Cases

As shown in Tables 4–94 and 4–95, the volume of HLW melters generated under this Tank Closure alternative would be 1,348 cubic meters (1,763 cubic yards) under both the Base Case and Option Case. The volume of LAW melters generated under this Tank Closure alternative would be 8,007 cubic meters (10,473 cubic yards) under both the Base Case and Option Case. DOE expects that the HLW and LAW melters would be stored on site.

Also shown in Tables 4–94 and 4–95, the volume of PPF melters generated under this Tank Closure alternative is 1,961 cubic meters (2,565 cubic yards) under the Base Case and 11,399 cubic meters (14,910 cubic yards) under the Option Case. This amount is included in the IDF capacities of Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2.

4.1.14.10.5 Secondary Waste

4.1.14.10.5.1 Mixed Transuranic Waste

As shown in Tables 4–94 and 4–95, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2; therefore, this volume should not impact existing TRU waste treatment and storage facilities and would be within the capacity allocated to Hanford for disposal at WIPP (DOE 1997:S-10).

4.1.14.10.5.2 Low-Level and Mixed Low-Level Radioactive Wastes

As shown in Tables 4–94 and 4–95, under Tank Closure Alternative 6B, LLW and MLLW volumes generated by tank closure under the Base and Option Cases, respectively, would be 99,781 and 143,761 cubic meters (130,514, and 188,040 cubic yards) of LLW; 4,071 and 5,428 cubic meters (5,325 and 7,100 cubic yards) of closure LLW; and 104,507 and 148,269 cubic meters (136,695 and 193,935 cubic yards) of MLLW.

LLW and MLLW would be disposed of in an IDF. The amount of LLW and MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2. Therefore, no long-term storage capacity would be needed; the impacts of treating and disposing of this waste in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2.

4.1.14.10.5.3 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the removal of ancillary equipment and the excavation of contaminated soil from selected tank farms. This large quantity of tank closure waste includes approximately 2.41 million cubic meters (approximately 3.15 million cubic yards) of MLLW under the Base Case and approximately 8.31 million cubic meters (approximately 10.87 million cubic yards) of MLLW under the Option Case. Under both cases, the contaminated soil would be disposed of in the RPPDF. Land use, transportation, groundwater, and long-term human health impacts of disposing of the closure wastes in the RPPDF under this Tank Closure alternative are evaluated under Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2.

PPF treatment of the soils would generate 1,540 cubic meters (2,014 cubic yards) of PPF glass under the Base Case and 42,212 cubic meters (55,213 cubic yards) under the Option Case. These canisters would be disposed of in an onsite IDF.

4.1.14.10.5.4 Mixed Transuranic Waste

As shown in Tables 4–94 and 4–95, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 2, and Waste Management Alternative 3, Disposal Group 2; therefore, this volume should not impact existing TRU waste treatment and storage facilities.

4.1.14.10.5.5 Hazardous Waste

A total of 80,880 cubic meters (105,791 cubic yards) of hazardous waste under the Base Case and 80,992 cubic meters (105,938 cubic yards) under the Option Case would be generated during construction and operations. For two peak years (2039–2040), hazardous waste would be generated at 31,431 cubic meters (41,112 cubic yards) per year under either case.

4.1.14.10.5.6 Nonhazardous Waste

The estimated volume of nonhazardous waste would be approximately 2.48 million cubic meters (approximately 3.24 million cubic yards) under the Base Case and approximately 3.24 million cubic meters (approximately 4.24 million cubic yards) under the Option Case. This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.10.5.7 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,650 gallons) under both the Base Case and the Option Case. This waste would be treated on site.

4.1.14.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

4.1.14.11.1 Waste Inventories

Table 4–96 presents the estimated waste volumes generated under Alternative 6C. Under this Tank Closure alternative, closure activities include removal of ancillary equipment and the top 4.6 meters (15 feet) of soil from two tank farms. This tank closure waste would be disposed of in the new RPPDF, to be located between the 200-East and 200-West Areas. The RPPDF would be similar to the IDF(s).

4.1.14.11.2 High-Level Radioactive Waste

As shown in Table 4–96, 14,220 cubic meters (18,600 cubic yards) of IHLW canisters and 400 cubic meters (523 cubic yards) of cesium and strontium canisters would be generated. DOE expects that the IHLW canisters would be stored on site.

4.1.14.11.3 Treated Low-Activity Tank Waste

The LAW stream that is separated in the Pretreatment Facility would be managed as HLW under this Tank Closure alternative.

Table 4–96. Tank Closure Alternative 6C Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation		Total Waste Volume to IDF(s)/RPPDF
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Waste Volume/Year	
High-level radioactive waste								
IHLW (12,000 canisters)	N/A	14,220	N/A	N/A	14,220	2018–2039	646	N/A
Cesium and strontium (340 canisters)[a]	N/A	400	N/A	N/A	400	2040	400	N/A
ILAW (92,500 canisters)[b]	N/A	212,891	N/A	N/A	212,891	2018–2043	8,188	N/A
WTP melters								
HLW melters (11 melters)	N/A	1,348	N/A	N/A	1,348	Various	245	N/A
LAW melters (31 melters)	N/A	8,007	N/A	N/A	8,007	Various	1,540	8,007 (IDF)
Secondary waste								
LLW	N/A	27,553	968	6,169	34,690	2040	2,818	34,690 (IDF)
MLLW	N/A	27,512	2,869	9,634	40,015	2040	3,022	40,015 (IDF)
Closure LLW[b]	N/A	N/A	N/A	53	53	2038–2040	18	53 (RPPDF)
Closure MLLW[c]	N/A	N/A	N/A	467,955	467,955	2032–2037	77,993	525,297 (RPPDF)
Mixed TRU waste	N/A	206	N/A	N/A	206	2029–2043	8	N/A
Hazardous waste[d]	635	63,304	15,686	106	79,732	2039–2040	31,410	N/A
Nonradioactive-nonhazardous waste[e]	N/A	254	1,342	677	2,273	2044	594	N/A
Liquid LLW (liters)	N/A	N/A	N/A	9,691	9,691	2018–2028	881	N/A
IDF and RPPDF capacities: Waste Management Alternative 2, Disposal Group 1: IDF-E 1,200,000 m^3, RPPDF 1,030,000 m^3 Waste Management Alternative 3, Disposal Group 1: IDF-E 1,100,000 m^3, IDF-W 90,000 m^3, RPPDF 1,080,000 m^3					Total waste to IDF(s)/RPPDF: 82,713 m^3/468,008 m^3			

[a] Disposition of the cesium and strontium capsules will be determined under a separate National Environmental Policy Act process. However, for the purposes of analysis, they are assumed to be HLW.

[b] Closure LLW is the waste from decontamination and decommissioning of the containment structure over the tank farms after soil removal was complete.

[c] Closure MLLW includes soil, rubble, and equipment removed during closure of the tank farms.

[d] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[e] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; IDF-E=200-East Area Integrated Disposal Facility; IDF-W=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; m^3=cubic meters; MLLW=mixed low-level radioactive waste; N/A=not applicable; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Appendix E, Table E–10; SAIC 2007a, 2008.

4.1.14.11.4 Waste Treatment Plant Melters

As shown in Table 4–96, the volume of HLW melters generated under this Tank Closure alternative would be 1,348 cubic meters (1,763 cubic yards). The volume of LAW melters generated under this Tank Closure alternative would be 8,007 cubic meters (10,473 cubic yards). DOE expects that the HLW melters would be stored on site. The LAW melters would be disposed of in an IDF. This amount is included in the IDF capacities of Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are included under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.11.5 Secondary Waste

4.1.14.11.5.1 Mixed Transuranic Waste

As shown in Tables 4–94 and 4–95, the estimated volume of mixed TRU waste would be less than the waste volume assumed under both Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1; therefore, this volume should not impact existing TRU waste treatment and storage facilities.

4.1.14.11.5.2 Low-Level Radioactive Waste

As shown in Table 4–96, under Tank Closure Alternative 6C, 34,690 cubic meters (45,375 cubic yards) of LLW and 53 cubic meters (69 cubic yards) of closure LLW would be generated. The amount of LLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1. Therefore, the impacts of providing disposal capacity in an IDF are evaluated under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1.

4.1.14.11.5.3 Mixed Low-Level Radioactive Waste

As shown in Table 4–96, under Tank Closure Alternative 6C, 40,015 cubic meters (52,340 cubic yards) of MLLW would be generated. The amount of MLLW generated under this Tank Closure alternative is consistent with that accounted for under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1; therefore, the impacts of treating and disposing of this waste in an onsite IDF have already been evaluated.

4.1.14.11.5.4 Closure Mixed Low-Level Radioactive Waste

Under this Tank Closure alternative, large quantities of MLLW would be generated by the removal of ancillary equipment and the excavation of contaminated soil to a depth of approximately 4.6 meters (15 feet) from selected tank farms. This large quantity of tank closure MLLW (467,955 cubic meters [612,085 cubic yards]) is included as a waste stream under Waste Management Alternative 2, Disposal Group 1, and Waste Management Alternative 3, Disposal Group 1, for disposal in the RPPDF.

4.1.14.11.5.5 Hazardous Waste

A total of 79,732 cubic meters (104,289 cubic yards) of hazardous waste would be generated during construction and operations. For two peak years (2039–2040), hazardous waste would be generated at 31,410 cubic meters (41,084 cubic yards) per year.

4.1.14.11.5.6 Nonhazardous Waste

The estimated volume of nonhazardous waste would be 2,273 cubic meters (2,973 cubic yards). This waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

4.1.14.11.5.7 Liquid Process Waste

The estimated volume of low-level radioactive liquid process waste would be 9,691 liters (2,650 gallons). This waste would be treated on site.

4.1.15 Industrial Safety

Illness, injury, and death are possible outcomes of any industrial accident. The accepted standard for measuring the outcome of an industrial accident is the total recordable cases (TRCs) of illness, injury and death. This section addresses potential impacts of illness, injury and death associated with implementation of each of the alternatives. Appendix K, Section K.4 contains a description of the technique used to calculate the TRCs and fatalities, as well as definitions and other information used to perform this analysis.

A review of the data from 2001 through 2006 indicates that occupational injuries and illnesses incurred at Hanford have decreased. The TRC (2.0) rate for the DOE Office of River Protection was chosen because the work conducted up to this point is expected to be similar to work in the future. It is also expected that the safety practices, programs and procedures will remain in place in the future. The DOE and contractor fatality incident rate was chosen because it is representative of all work conducted by the DOE. Table 4–97 provides a list of relevant TRC and fatality rates used in this analysis. These rates are the DOE Office of River Protection and DOE-wide data as reported in Computerized Accident/Incident Reporting System, and private industry data maintained by the U.S. Bureau of Labor Statistics.

Table 4–97. Total Recordable Cases and Fatality Incident Rates

Labor Category	Total Recordable Case Rate[a]	Fatality Rate[b]
DOE and contractor	1.88	0.26
Construction (DOE and contractor)	2.4	0.0
Operations/production (DOE and contractor)	1.3	0.0
DOE Office of River Protection	2.0	0.0
Idaho Operations Office	1.5	0.0
Private industry (BLS)	5.0	4.0
Construction (private industry) (BLS)	6.7	11.8

[a] Average illness and injury cases per 200,000 labor hours from 2001–2006.
[b] Average fatality rate per 100,000 employee years from 2001–2006.
Key: BLS=U.S. Bureau of Labor Statistics; DOE=U.S. Department of Energy.
Source: BLS 2008, 2009; DOE 2007a, 2007b.

Using these incidence rates and the projected labor hours, occupational safety impacts associated with each of the alternatives were determined (see Table 4–98). The number of cases associated with alternatives having less construction activities could be slightly overstated. Conversely, the number of cases associated with alternatives having a larger component of construction activity (e.g., Alternatives 6A and 6B) could be slightly understated.

Table 4–98. Tank Closure Alternatives – Industrial Safety Impacts

Alternative	Labor Category	Million Labor Hours	Total Recordable Case Rate per 100 Workers per Year	Projected Total Recordable Cases	Fatality Rate per 100,000 Workers per Year	Projected Fatalities
1	Construction	8.80	2.0	88.0	0.26	0.0114
	Operations	4.52	2.0	45.2	0.26	0.0059
	Deactivation	3.0	2.0	30.0	0.26	0.0039
	Closure	0	2.0	0.0	0.26	0.0
1 Total		16.3		163		0.02
2A	Construction	183	2.0	1,830	0.26	0.24
	Operations	502	2.0	5,020	0.26	0.65
	Deactivation	18.9	2.0	189	0.26	0.025
	Closure	0.27	2.0	2.7	0.26	0.0004
2A Total		704		7,040		0.92
2B	Construction	144	2.0	1,440	0.26	0.19
	Operations	235	2.0	2,350	0.26	0.31
	Deactivation	7.86	2.0	78.6	0.26	0.01
	Closure	7.48	2.0	74.8	0.26	0.01
2B Total		394		3,940		0.52
3A	Construction	128	2.0	1,280	0.26	0.17
	Operations	212	2.0	2,120	0.26	0.28
	Deactivation	9.41	2.0	94.1	0.26	0.01
	Closure	7.48	2.0	74.8	0.26	0.01
3A Total		357		3,570		0.46
3B	Construction	127	2.0	1,270	0.26	0.17
	Operations	209	2.0	2,090	0.26	0.27
	Deactivation	9.24	2.0	92.4	0.26	0.01
	Closure	7.48	2.0	74.8	0.26	0.01
3B Total		353		3,530		0.46
3C	Construction	130	2.0	1,300	0.26	0.17
	Operations	218	2.0	2,180	0.26	0.28
	Deactivation	9.71	2.0	97.1	0.26	0.01
	Closure	7.48	2.0	74.8	0.26	0.01
3C Total		365		3,650		0.47
4	Construction	156	2.0	1,560	0.26	0.20
	Operations	254	2.0	2,540	0.26	0.33
	Deactivation	10.3	2.0	103	0.26	0.01
	Closure	34.3	2.0	343	0.26	0.04
4 Total		455		4,550		0.58
5	Construction	128	2.0	1,280	0.26	0.17
	Operations	183	2.0	1,830	0.26	0.24
	Deactivation	10.1	2.0	101	0.26	0.01
	Closure	11.0	2.0	110	0.26	0.01
5 Total		332		3,320		0.43
6A Base	Construction	730	2.0	7,300	0.26	0.95
	Operations	1,730	2.0	17,300	0.26	2.25
	Deactivation	26.7	2.0	267	0.26	0.03
	Closure	59.7	2.0	597	0.26	0.08
6A Base Total		2,550		25,500		3.31
6A Option	Construction	730	2.0	7,300	0.26	0.95
	Operations	1,730	2.0	17,300	0.26	2.25
	Deactivation	26.7	2.0	267	0.26	0.03
	Closure	134	2.0	1,340	0.26	0.17
6A Option Total		2,620		26,200		3.40
6B Base	Construction	178	2.0	1,780	0.26	0.23
	Operations	277	2.0	2,770	0.26	0.36
	Deactivation	9.05	2.0	90.5	0.26	0.01
	Closure	54.8	2.0	548	0.26	0.07

Table 4–98. Tank Closure Alternatives – Industrial Safety Impacts *(continued)*

Alternative	Labor Category	Million Labor Hours	Total Recordable Case Rate per 100 Workers per Year	Projected Total Recordable Cases	Fatality Rate per 100,000 Workers per Year	Projected Fatalities
6B Base Total		519		5,190		0.67
6B Option	Construction	178	2.0	1,780	0.26	0.23
	Operations	277	2.0	2,770	0.26	0.36
	Deactivation	9.05	2.0	90.50	0.26	0.01
	Closure	112	2.0	1,120	0.26	0.15
6B Option Total		576		5,760		0.75
6C	Construction	145	2.0	1,450	0.26	0.19
	Operations	235	2.0	2,350	0.26	0.31
	Deactivation	7.86	2.0	78.6	0.26	0.01
	Closure	7.48	2.0	74.8	0.26	0.01
6C Total		395		3,950		0.52

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate. Totals may not equal the sum of the contributions due to rounding.
Source: Labor hours compiled from Appendix I.

As shown in Figure 4–25, the greatest industrial safety impacts are associated with alternatives having the greatest number of labor hours.

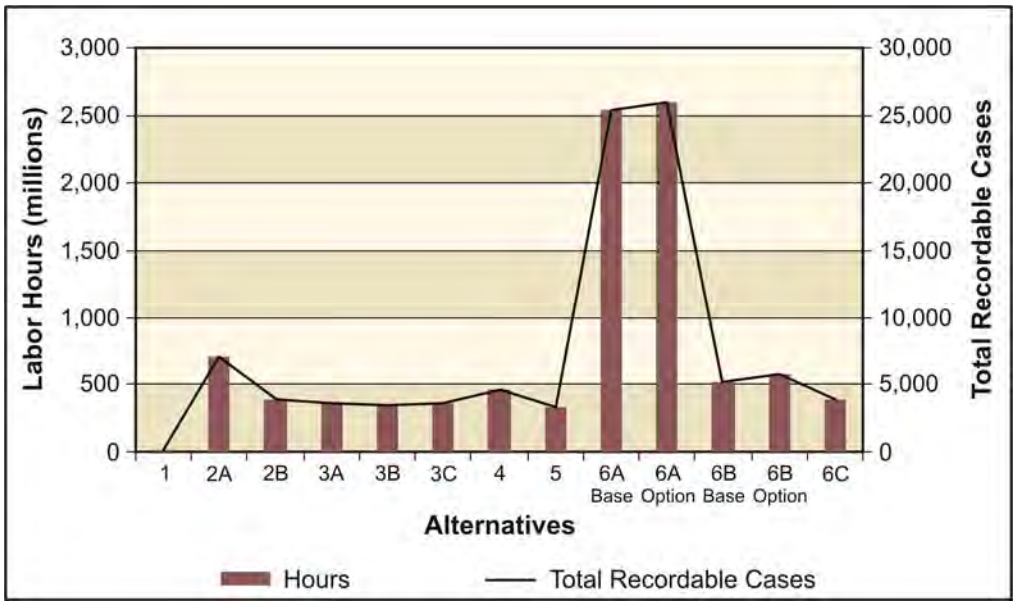


Figure 4–25. Total Recordable Cases and Labor Hours by Alternative

4.1.15.1 Alternative 1: No Action

It is anticipated that there would be less than 200 TRCs and no fatalities.

4.1.15.2 Alternative 2A: Existing WTP Vitrification; No Closure

Projected impacts on worker safety under this alternative are 7,040 TRCs. A fatality as a result of an occupation accident is not anticipated. A value greater than one in the "Projected Fatalities" column of Table 4–98 indicates a death is anticipated. This value is based on the incidence rates (deaths per 100,000 workers per year) recorded from 2001 through 2006. This alternative would require about 704 million labor hours, with the significant portion taking place during the peak periods of the construction and operations phases.

4.1.15.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

During all phases of the alternative, the projected impact is 3,940 TRCs; no fatalities are anticipated. The greatest number of labor hours would be spent during the construction and operations phases.

4.1.15.4 Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

There is a total of 357 million labor hours for this alternative during all phases (construction, operations, decommissioning, and closure) of the project. Using the selected TRC rate for illness and injury, 3,566 cases are anticipated. No fatalities are anticipated during any phase of this alternative.

4.1.15.5 Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Under this alternative, 353 million hours of work would occur during the construction, operations, deactivation, and closure phases. Using the selected incidence rates for illness and injury, it is anticipated that 3,525 TRCs would occur; no fatalities are projected.

4.1.15.6 Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Using the selected incidence rates for illness and injury, it is anticipated that 3,650 TRCs would occur; no fatalities are projected.

4.1.15.7 Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

This alternative identifies work requiring 455 million hours. It is anticipated that work under this alternative would generate approximately 4,550 TRCs. No fatalities are anticipated during any phase of the alternative.

4.1.15.8 Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

A total of 332 million labor hours are identified under this alternative. It is anticipated that about 3,320 TRCs would be generated by this alternative. No fatalities are expected during any phase of the alternative.

4.1.15.9 Alternative 6A: All Vitrification/No Separations; Clean Closure

Alternative 6A would impact occupational safety. Factors influencing the impact are total labor hours and the historical incident rate. There are two variations under Alternative 6A, Base Case and Option Case. Estimates of the impacts are addressed separately.

4.1.15.9.1 Base Case

Alternative 6A, Base Case, identifies 2,550 million labor hours to complete the tasks identified in this alternative. It is projected that there would be 25,300 TRCs and three fatalities during the work.

4.1.15.9.2 Option Case

Alternative 6A, Option Case, requires 2,620 million labor hours that would generate 26,200 TRCs. Three fatalities are anticipated.

4.1.15.10 Alternative 6B: All Vitrification with Separations; Clean Closure

Alternative 6B would impact occupational safety. Factors influencing the impact are total labor hours and the historical incident rate. There are two variations under Alternative 6B, Base Case and Option Case. Estimates of the impacts are addressed separately.

4.1.15.10.1 Base Case

A total of 519 million labor hours are required to accomplish all tasks under Alternative 6B, Base Case. Using the incident rate and total labor hours, it is projected there would be 5,190 TRCs and no fatalities.

4.1.15.10.2 Option Case

Alternative 6B, Option Case, would require 576 million labor hours to complete. Using the total labor hours and incident rates for illness, injury, and fatalities, it is anticipated there would be 5,760 TRCs and no fatalities.

4.1.15.11 Alternative 6C: All Vitrification with Separations; Landfill Closure

Alternative 6C would require 395 million labor hours to complete the tasks identified. Applying the incident rate to the total labor hours indicates that there would be approximately 3,950 TRCs and no fatalities.

4.2 FAST FLUX TEST FACILITY DECOMMISSIONING ALTERNATIVES

This section describes the potential short-term environmental and human health impacts associated with implementation of alternatives considered to decommission the FFTF and auxiliary facilities at Hanford, to manage waste from the decommissioning process, including waste designated as RH-special components (SCs), and to disposition the Hanford inventory of radioactively contaminated bulk sodium from FFTF as well as other facilities on site. Three FFTF Decommissioning alternatives are considered and analyzed, including (1) FFTF Decommissioning Alternative 1: No Action, in which only certain deactivation activities at FFTF would be conducted, consistent with previous DOE National Environmental Policy Act actions and two action alternatives; (2) FFTF Decommissioning Alternative 2: Entombment; and (3) FFTF Decommissioning Alternative 3: Removal. FFTF Decommissioning Alternative 2 would involve removing all aboveground structures within the 400 Area Property Protected Area (PPA), with minimal removal of below-grade structures, equipment, and materials as necessary to comply with regulatory standards. FFTF Decommissioning Alternative 3 would consist of removing all above-grade structures within the 400 Area PPA and the additional removal of contaminated below-grade structures, equipment, and materials. Associated construction, operations, deactivation, closure, and decommissioning activities are assessed, as applicable, for each alternative.

For each action alternative (i.e., Alternatives 2 and 3), two options (a Hanford and an Idaho option) are evaluated for disposition of RH-SCs and processing of bulk sodium. For RH-SCs, the Hanford Option would involve treating the waste in a new Remote Treatment Project (RTP) at Hanford's T Plant, followed by disposal of the treated components and residuals along with other Hanford waste in the 200 Areas. Under the Idaho Option, RH-SCs would be shipped to the proposed RTP at the Idaho National Laboratory (INL) Materials and Fuels Complex (MFC). Following treatment at the RTP, the FFTF components and residuals would be disposed of with other INL waste at the Nevada Test Site (NTS) or returned to Hanford for disposal in an IDF. For processing of bulk sodium under the Hanford Reuse Option, the bulk sodium would be stored in its current locations until it is shipped for processing to a new Sodium Reaction Facility (SRF) to be built in the 400 Area. The bulk sodium would be converted to a caustic sodium hydroxide solution for product reuse in processing tank waste at the WTP or for supporting Hanford tank corrosion controls. Under the Idaho Reuse Option, the bulk sodium would be

stored in its current locations until it is shipped to the INL MFC for processing in the existing Sodium Processing Facility (SPF). Following processing, the caustic solution would be returned to Hanford for product reuse. These alternatives and options are described further in Chapter 2, Section 2.5.3.

4.2.1 Land Resources

4.2.1.1 Alternative 1: No Action

4.2.1.1.1 Land Use

4.2.1.1.1.1 Facility Disposition

Under the No Action Alternative, the FFTF Reactor Containment Building (RCB), along with the rest of the buildings and structures within the 18-hectare (44.5-acre) FFTF PPA would remain in place (see Figure 4–26). Thus, the industrial nature of the 400 Area would not change and the presence of the FFTF RCB and associated facilities would preclude use of the area for other industrial purposes in the foreseeable future.

Any waste to be disposed of under this alternative would be placed in trenches 31 and 34 of LLBG 218-W-5 or in IDF-East (see Figure 4–2). Since the 200 Areas have been designated Industrial-Exclusive, disposal associated with this alternative would not affect Hanford land use. Additional geologic material would not be needed under this alternative; thus, there would be no need to excavate geologic material from Borrow Area C.

4.2.1.1.1.2 Disposition of Remote-Handled Special Components

Under this alternative, RH-SCs would be removed from the FFTF RCB. They would be packaged and stored within the 400 Area. Thus, there would be no change in land use within the 400 Area.

4.2.1.1.1.3 Disposition of Bulk Sodium

Under the No Action Alternative, the Hanford bulk sodium inventory would remain stored untreated in its current Hanford locations; FFTF bulk sodium would remain within the Sodium Storage Facility (SSF) within the 400 Area (see Figure 4–26). Since only existing facilities would be used, there would be no change in land use under this alternative.

4.2.1.1.2 Visual Resources

4.2.1.1.2.1 Facility Disposition

The FFTF RCB and associated buildings and structures would remain in place under the No Action Alternative. Thus, there would be no change in the appearance of the site or the current BLM Visual Resource Management Class IV rating for the 400 Area.

The minimal volume of waste to be disposed of under this alternative would be placed within trenches 31 and 34 of LLBG 218-W-5 or IDF-East. The use of either of these facilities would not change the overall visual appearance of the 200 Areas; thus, there would be no change in the BLM Visual Resource Management Class IV rating for the area.

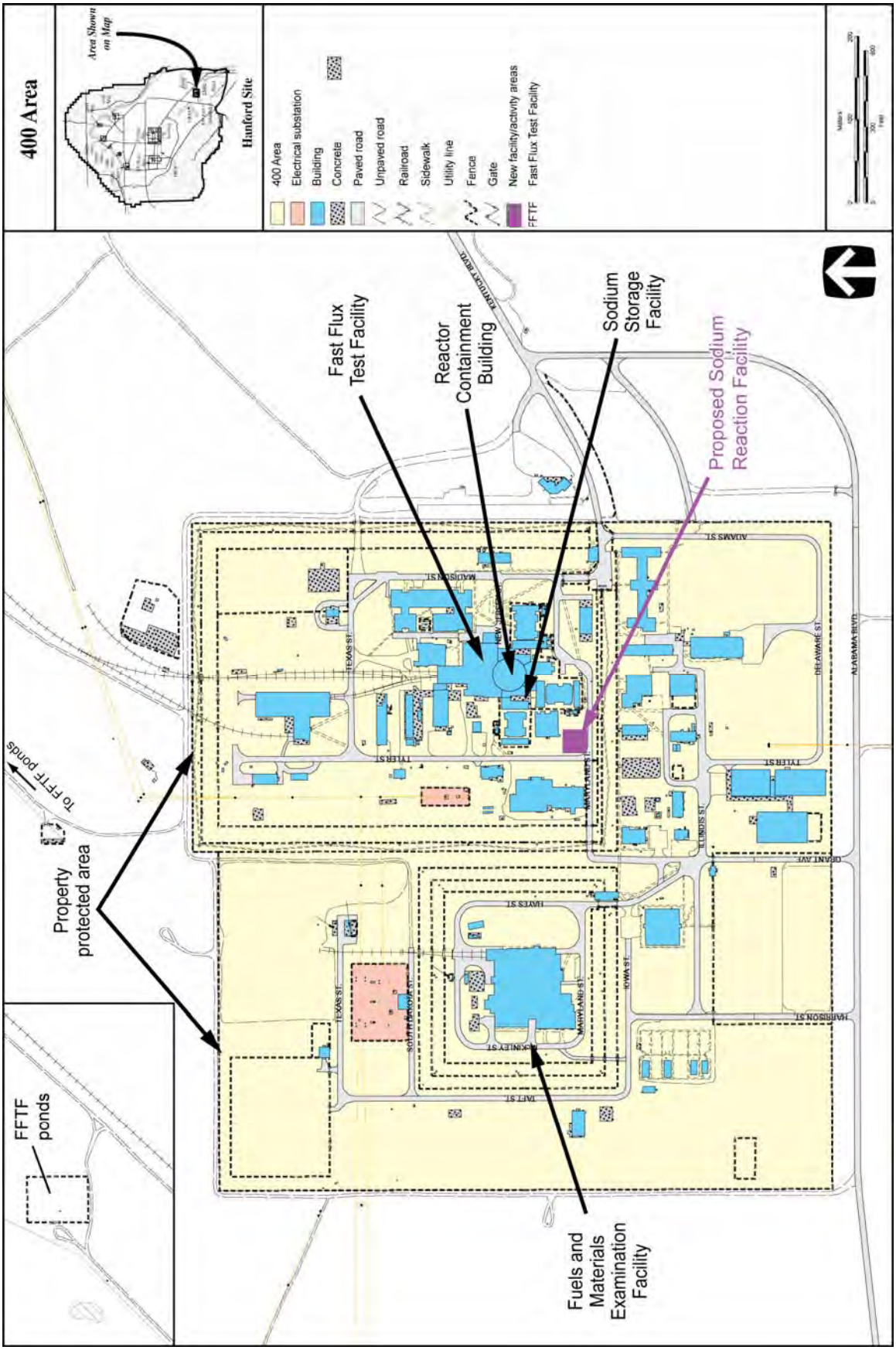


Figure 4–26. 400 Area Facility Locations

4.2.1.1.2.2 Disposition of Remote-Handled Special Components

Under the No Action Alternative, RH-SCs would be removed and packaged for storage in the 400 Area. Thus, there would be no impact on the visual environment of the 400 Area and, consequently, no change in the Visual Resource Management Class IV rating of the area.

4.2.1.1.2.3 Disposition of Bulk Sodium

Under the No Action Alternative, FFTF sodium would be stored in the SSF, which is located within the 400 Area, and other bulk sodium would remain in place in the 200 Areas. Thus, there would be no impact on visual resources and no change in the Visual Resource Management Class IV rating of either area.

4.2.1.2 Alternative 2: Entombment

4.2.1.2.1 Land Use

4.2.1.2.1.1 Facility Disposition

Under Alternative 2, the FFTF RCB and immediately adjacent support facilities would be dismantled to below grade, and a 0.7-hectare (1.7-acre) modified RCRA Subtitle C barrier would be placed over the site. Other facilities within the PPA would be dismantled to grade. After appropriate preparation, 2.1 hectares (5.3 acres) of the site, including the barrier, would be revegetated. Thus, under this alternative the PPA would be available for future development. Under this alternative, the Industrial designation of the 400 Area would not change.

Debris and other waste not placed in the RCB or used as backfill would be transported to trenches 31 and 34 of LLBG 218-W-5 or to IDF-East for disposal. Impacts on land use of constructing this IDF are addressed in Section 4.3.1.2.1.

Under this alternative, there would be a need to supply geologic material for grout and the modified RCRA Subtitle C barrier. This material would come from Borrow Area C, which is located to the south of State Route 240. The volume of material needed would necessitate the excavation of 2.8 hectares (7 acres), or 0.3 percent, of Borrow Area C. Since Borrow Area C has a land use designation of Conservation (Mining), the removal of this material would be consistent with current site land use plan.

4.2.1.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, RH-SCs would be stored, treated, and disposed of at Hanford. Since both storage and disposal facilities currently exist within the 200 Areas and are presently used for similar purposes, their use under this option would not affect land use. Treatment of RH-SCs would involve construction of a new RTP at the T Plant complex located in the 200-West Area. This facility would encompass 0.1 hectares (0.3 acres) of land. Since the 200-West Area has been designated as Industrial-Exclusive, the new facility would be in keeping with current land use.

IDAHO OPTION

Under this option, RH-SCs removed from the FFTF RCB would be stored at Hanford prior to shipment to INL, where they would be treated at a new RTP. The RTP, which would be located within developed portions of the MFC, is the only new facility to be built under this alternative. As is the case under the Hanford Option, once complete it would occupy 0.1 hectares (0.3 acre) of land. Since the proposed

location of the RTP is currently industrial in nature, there would be no change to the existing land use. Treated components would be returned to Hanford or sent to NTS for disposal, where they would be placed within existing disposal facilities. Thus, there would be no impact on land use at Hanford, INL, or NTS from this element of the Idaho Option.

4.2.1.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under the Hanford Reuse Option, sodium from FFTF would be sent to a new SRF to be built in the 400 Area. Construction of this new facility would require about 0.1 hectares (0.2 acres) of land near the SSF. Since it would be constructed within the already highly developed 400 Area, an area designated as Industrial, there would be no impact on land use. The treated sodium would be stored in an existing facility within the 200 Areas; thus, there also would be no impact on land use from this element of the Hanford Reuse Option.

IDAHO REUSE OPTION

Under this option, sodium from FFTF and other sodium would be transported to INL for treatment in the SPF. Although the SPF is an existing facility within the MFC, its use would require a minor, external modification to accommodate a sodium offload system. However, this modification would not alter land use within the MFC. Further, there would be no change in land use in the 400 Area and 200 Areas at Hanford from implementation of this option since only existing facilities would be used.

4.2.1.2.2 Visual Resources

4.2.1.2.2.1 Facility Disposition

Under the Entombment Alternative, a 0.7-hectare (1.7-acre) modified RCRA Subtitle C barrier would be placed over FFTF and adjacent support facilities following their dismantlement to below grade. Remaining structures within the PPA would also be dismantled, but a barrier would not be used. Disturbed areas within the PPA would be revegetated. Thus, under this alternative there would be an initial overall improvement in the visual character of the 400 Area. However, if the site were to accommodate industrial facilities in the future, its appearance could return to one similar to today's. Regardless, the overall BLM Visual Resource Management Class IV rating of the 400 Area would remain unchanged due to other development in the immediate area.

Some debris would be placed in the RCB or used as backfill. Remaining waste would be transported to trenches 31 and 34 of LLBG 218-W-5 or to IDF-East for disposal. Impacts on visual resources of constructing this IDF are addressed in Section 4.3.1.2.2.

Although only a limited area would be developed (2.8 hectares [7 acres]) within Borrow Area C to supply geologic material under this alternative, excavation activities would impact the view from State Route 240 and nearby higher elevations. Since Borrow Area C would be visible and would attract the attention of the viewer, the BLM visual resource management rating would be lowered from Class II to Class III.

4.2.1.2.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, RH-SCs would be stored, treated, and disposed of at Hanford. Since both storage and disposal facilities currently exist within the 200 Areas, their use under this option would not alter the

visual environment. Treatment of RH-SCs would involve construction of a new RTP, which, when complete, would require less than 0.1 hectares (0.3 acres) of land. This facility would be constructed within the T Plant complex in the 200-West Area. Since this area is presently industrial, the new facility would not meaningfully alter the visual environment. Thus, under this option the BLM Visual Resource Management Class IV rating of the 200-West Area would not change.

IDAHO OPTION

Under this option, RH-SCs removed from the FFTF RCB would be stored at Hanford prior to shipment to INL, where they would be treated at a new RTP. The RTP, which would be built within developed portions of the MFC and occupy 0.1 hectares (0.3 acre) when complete, is the only new facility to be built under this alternative. Since the MFC is currently industrial in nature, the RTP would be in keeping with the existing visual environment. Treated components would be returned to Hanford or sent to NTS for disposal, where they would be placed within existing disposal facilities. Thus, there would be no change in the BLM Visual Resource Management Class IV rating of involved areas at Hanford, INL, or NTS under this alternative.

4.2.1.2.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under this option, sodium from FFTF would be sent to a new SRF to be built in the 400 Area. This new facility, which would occupy 0.1 hectares (0.3 acre) of land, would be constructed near the SSF. Since the SRF would be constructed within the already highly developed 400 Area, there would be minimal impact on visual resources. Storage of the treated sodium would be within an existing facility within the 200 Areas; thus, there would be no impact on the visual environment from this element of the Hanford Reuse Option. The BLM Visual Resource Management Class IV rating for each involved area would not change under this option.

IDAHO REUSE OPTION

Under the Idaho Reuse Option, sodium from FFTF and other sodium would be transported to INL for treatment in the SPF. Since the SPF is an existing facility within the MFC that would require only a minor external modification to accommodate a sodium offload system, its use would not change the visual environment of the MFC. Also, there would be no change of visual impacts in the 400 Area and 200 Areas at Hanford from implementation of this option since only existing facilities would be used. Thus, the BLM Visual Resource Management Class IV rating for each involved area would not change.

4.2.1.3 Alternative 3: Removal

4.2.1.3.1 Land Use

4.2.1.3.1.1 Facility Disposition

Under this alternative, the FFTF RCB and adjacent support facilities would be removed to 0.9 meters (3 feet) below grade; however, an engineered barrier would not be needed since the reactor vessel and other radioactively contaminated equipment would be removed. A 1-meter (3.3-foot) thick layer of soil would be used over the site and would permit the growth of vegetation. In total, 2.4 hectares (6 acres) of the 400 Area would be revegetated under this alternative. Thus, as is the case under Alternative 2, the PPA would become available for future development. Under this alternative the Industrial designation of the 400 Area would not change.

Debris and other waste would be handled in the same manner as the Alternative 2 (see Section 4.2.1.2.1.1); thus, there would be no impact on land use at Hanford. Additionally, it would be necessary to develop 3.2 hectares (8 acres), or 0.3 percent, of Borrow Area C to supply the geologic material needed under this alternative. Since Borrow Area C has been designated Conservation (Mining), this action would be consistent with the current site land use plan.

4.2.1.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

The steps involved in the disposition of RH-SCs under the Hanford Option of this alternative are identical to those of the Entombment Alternative. Thus, impacts on land use from disposition-related activities would be the same as discussed under the Hanford Option in Section 4.2.1.2.1.2.

IDAHO OPTION

Similar to the Hanford Option, the actions taken at INL are the same under this alternative as under the Entombment Alternative. Thus, impacts on land use would be the same as discussed under the Idaho Option in Section 4.2.1.2.1.2.

4.2.1.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

The steps involved in the processing of bulk sodium under the Hanford Reuse Option of this alternative are identical to those of the Entombment Alternative. Thus, impacts on land use from processing activities would be the same as discussed under the Hanford Reuse Option in Section 4.2.1.2.1.3.

IDAHO REUSE OPTION

Similar to the Hanford Reuse Option, the steps involved in the processing of bulk sodium at INL are the same under this alternative as under the Entombment Alternative. Thus, impacts on land use would be the same as discussed under the Idaho Reuse Option in Section 4.2.1.2.1.3.

4.2.1.3.2 Visual Resources

4.2.1.3.2.1 Facility Disposition

The Removal Alternative would result in the dismantling and removal of the FFTF RCB and all associated structures within the PPA. Although an engineered barrier would not be used, the FFTF RCB site would be covered with a 1-meter (3.3-foot) thick layer of soil to permit the growth of vegetation. Overall, visual impacts of this alternative would be similar to those of the Entombment Alternative since disturbed areas would be recontoured and revegetated. As with the Entombment Alternative, any future development would return the site to an industrial appearance. Regardless of future development, due to other industrial nature of the 400 Area, there would be no change in the BLM Visual Resource Management Class IV rating of the area.

Placement of debris and other waste resulting from removal activities in trenches 31 and 34 of LLBG 218-W-5 or in IDF-East is not expected to alter the overall appearance of either facility or the BLM Visual Resource Management Class IV rating of the 200 Areas. Although slightly more land would be affected, the impact of developing 3.2 hectares (8 acres) of Borrow Area C would be minimal, as described in Section 4.2.1.2.2.1.

4.2.1.3.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

The steps involved in the disposition of RH-SCs under the Hanford Option of the Removal Alternative are identical to those of the Entombment Alternative. Thus, impacts on visual resources of disposition-related activities would be the same as discussed under the Hanford Option in Section 4.2.1.2.2.2.

IDAHO OPTION

Similar to the Hanford Option, the actions taken at INL are the same under this alternative as under the Entombment Alternative. Thus, impacts on visual resources would be the same as discussed under the Idaho Option in Section 4.2.1.2.2.2.

4.2.1.3.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

The steps involved in the processing of bulk sodium under the Hanford Reuse Option of the Removal Alternative are identical to those of the Entombment Alternative. Thus, impacts on visual resources of processing activities would be the same as discussed under the Hanford Reuse Option in Section 4.2.1.2.2.3.

IDAHO REUSE OPTION

Similar to the Hanford Reuse Option, the steps involved in the processing of bulk sodium at INL are the same under this alternative as under the Entombment Alternative. Thus, impacts on visual resources would be the same as discussed under the Idaho Reuse Option in Section 4.2.1.2.2.3.

4.2.2 Infrastructure

This subsection presents the potential impacts of FFTF Decommissioning alternatives and their associated options for disposition of RH-SCs and processing of bulk sodium on key utility infrastructure resources, including projected activity demands for electricity, fuel, and water. Total and peak annual utility infrastructure requirements are projected for each alternative and option, as well as for applicable component project phases (e.g., construction, operations, deactivation, closure, and decommissioning).

Key underlying assumptions used in projecting utility infrastructure demands for each of the FFTF Decommissioning alternatives and associated options are similar to those described in Section 4.1.2 for the Tank Closure alternatives. For example, it has been assumed for the purposes of analysis that liquid fuels are not capacity-limiting resources, as supplies would be replenished from offsite sources to support each alternative and provided at the point of use on an as-needed basis.

Hanford's site utility infrastructure is described in Chapter 3, Section 3.2.2, and INL's is described in Chapter 3, Section 3.3.2. Table 4–99 summarizes the projected utility infrastructure resource requirements for the FFTF Decommissioning alternatives and associated options. Projected demands for key utility infrastructure resources and impacts on the respective utility systems of implementation of each of the alternatives and options are further discussed in the following sections.

Table 4–99. FFTF Decommissioning Alternatives and Options – Summary of Utility Infrastructure Requirements

Alternatives and Options	Activity Phase	Electricity (M megawatt-hours)	Diesel Fuel[a] (M liters)	Gasoline (M liters)	Water (M liters)
Alternative 1: No Action	Deactivation	0.60	0.0	0.11	7,980
	Total[b]	0.60	0.0	0.11	7,980
	Peak (Year)	0.006 2008–2107)	N/A	0.0011 (2008–2107)	79.8 (2008–2107)
Alternative 2: Facility Disposition-Entombment	Decommissioning	0.0032	2.28	0.075	8.24
	Closure	0.0	1.74	0.29	11.4
	Total[b]	0.0032	4.02	0.36	19.6
	Peak (Year)	0.0032 (2017)	1.74 (2021)	0.098 (2021)	11.4 (2021)
Alternative 3: Facility Disposition-Removal	Decommissioning	0.0064	2.64	0.16	8.38
	Closure	0.0	1.11	0.21	10.5
	Total[b]	0.0064	3.76	0.37	18.9
	Peak (Year)	0.0032 (2013–2014)	1.11 (2021)	0.050 (2013–2014)	10.5 (2021)
Disposition of RH-SCs (Hanford Option for remote treatment)	Construction	0.0	0.24	0.090	7.50
	Operations	0.00000071	0.00012	0.0	0.69
	Deactivation	0.00000036	0.00006	0.0	0.35
	Total[b]	0.00000107	0.24	0.090	8.53
	Peak (Year)	0.00000071 (2017)	0.12 (2015–2016)	0.045 (2015–2016)	3.75 (2015–2016)
Disposition of RH-SCs (Idaho Option for remote treatment)	Construction	0.0	0.24	0.090	7.49
	Operations	0.00000071	0.0019	0.0	0.69
	Deactivation	0.00000036	0.00006	0.0	0.35
	Total[b]	0.00000107	0.24	0.090	8.53
	Peak (Year)	0.00000071 (2017)	0.12 (2015–2016)	0.045 (2015–2016)	3.74 (2015–2016)
Disposition of bulk sodium (Hanford Reuse Option)	Construction	0.0	0.95	0.36	0.17
	Operations	0.0013	0.011	0.0034	2.72
	Deactivation	0.0	0.13	0.051	0.032
	Total[b]	0.0013	1.09	0.42	2.92
	Peak (Year)	0.00069 (2017)	0.47 (2015–2016)	0.18 (2015–2016)	1.36 (2017–2018)
Disposition of bulk sodium (Idaho Reuse Option)	Construction	0.0	0.015	0.0088	0.0
	Operations	0.0013	0.11	0.0034	2.72
	Deactivation	0.0	0.0	0.0	0.0
	Total[b]	0.0013	0.12	0.012	2.72
	Peak (Year)	0.00068 (2015)	0.058 (2015)	0.0088 (2014)	1.36 (2015–2016)

[a] Assumed to be inclusive of all No. 2 diesel fuel, including road diesel and heating fuel oil.
[b] Totals may not equal the sum of the contributions due to rounding.
Note: To convert liters to gallons, multiply by 0.26417. Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Key: M=million; N/A=not applicable; RH-SCs=remote-handled special components.
Source: SAIC 2007b.

4.2.2.1 Alternative 1: No Action

Following the completion of deactivation activities for the FFTF complex and support buildings in the Hanford 400 Area under this alternative, utility infrastructure demands during the subsequent 100-year administrative control period would be very small and limited to usage levels necessary to maintain safety- and environmental protection-related systems, such as those for fire protection; heating, ventilating, and air conditioning; emergency lighting; and environmental monitoring; and to perform periodic facility inspections and system testing.

4.2.2.1.1 Electricity

Under Alternative 1, annual electrical energy demand to support FFTF complex surveillance activities over the 100-year administrative control period would remain relatively constant and would represent a small fraction (about 3.5 percent) of the 0.17 million megawatt-hours of electricity currently used annually at Hanford. The projected annual electricity demand of 0.006 million megawatt-hours during the administrative control period would be comparable to the 0.0051 million megawatt-hours used in fiscal year 2006 as deactivation was ongoing.

4.2.2.1.2 Fuel

Annualized liquid fuel consumption (diesel fuel and gasoline) during the 100-year administrative control period for the FFTF complex would be a very small fraction (less than 0.03 percent) of the 4.3 million liters (1.1 million gallons) of liquid fuels currently used annually at Hanford.

4.2.2.1.3 Water

Annualized water demands in the 400 Area over the 100-year administrative control period would also be a relatively small fraction (about 9.8 percent) of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford. The projected annual water demand of 79.8 million liters (21.1 million gallons) would be about 69 percent of the 116 million liters (30.6 million gallons) of groundwater used in the 400 Area in fiscal year 2006 during FFTF deactivation.

4.2.2.2 Alternative 2: Entombment

4.2.2.2.1 Electricity, Fuel, and Water

4.2.2.2.1.1 Facility Disposition

During the projected 8-year active decommissioning period under the Entombment Alternative, project planning calls for utility systems in the 400 Area PPA to be shut down as they are no longer needed. Deactivation of the office and maintenance buildings would be delayed until just prior to their scheduled demolition so they could be used to support overall entombment activities, with their utility infrastructure remaining operational. As decommissioning activities would proceed, all equipment, piping, ducting, and electrical components would be removed by demolition personnel from building interiors prior to final demolition. Remaining underground utilities, including electric, water, sewer, and communications, would be abandoned and capped at 3 feet (0.9 meters) below grade (BREI 2003:23, 29, 30, 31). Thus, existing utility infrastructure would be used to the extent possible and would then be supplemented or replaced by portable, temporary facilities as work progresses.

Electrical energy requirements under the Entombment Alternative would peak in 2017, associated with grout facility operations to grout the RCB and associated facilities. The peak electrical energy demand of 0.0032 million megawatt-hours (approximating an electric load of 0.37 megawatts) would be about 0.18 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system and about 0.54 percent of the 400 Area substation distribution capacity of 0.59 million megawatt-hours (67 megawatt load capacity).

Peak liquid fuel consumption under the Entombment Alternative would total about 1.84 million liters (0.49 million gallons) in 2021, primarily associated with surface barrier construction and related final site-closure activities.

Peak water demands would also occur in 2021, driven by water use for site regrading activities in conjunction with surface barrier construction. The projected peak water demand of 11.4 million liters

(3.0 million gallons) would be about 0.06 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 9.8 percent of the 116 million liters (30.6 million gallons) of groundwater used in the 400 Area in fiscal year 2006.

4.2.2.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Construction, operations, and deactivation of the RTP located near Hanford's T Plant, to treat RH-SCs, would be minimal compared with the FFTF facility disposition efforts. The new RTP would be located adjacent to the T Plant and would utilize existing utility tie-ins to the extent possible; operationally, the RTP would have a relatively short lifespan of one year. For facility construction, it is assumed that electric power requirements would be minimal; any required electricity would be produced via fuel-fired generators. The peak annual electrical energy demand of 0.00000071 million megawatt-hours (approximating an electric load of about 0.00008 megawatts) in 2017, associated with facility operations, would be about 0.00004 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system and about 0.00012 percent of the 400 Area substation distribution capacity of 0.59 million megawatt-hours (67 megawatt load capacity). Total liquid fuel demands of 0.33 million liters (0.087 million gallons) in 2015–2016 would primarily be limited to the amount necessary to operate construction equipment and transport RH-SCs by truck from the 400 Area to the T Plant. Water would be required to support both facility construction and operations with total estimated peak water requirements in the 2015–2016 timeframe of 3.75 million liters (0.99 million gallons), driven primarily by the need for dust control during facility construction.

IDAHO OPTION

Utility infrastructure demands for implementing this option would be very similar to those discussed above for the Hanford Option. The peak water demand of 3.74 million liters (0.99 million gallons) would occur in the 2015–2016 timeframe during facility construction. This requirement would be about 2.1 percent of the 182 million liters (48 million gallons) used annually at the MFC.

4.2.2.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Construction, operations, and deactivation of the SRF in the 400 Area to process Hanford bulk sodium would require relatively small quantities of utility resources as compared with the facility disposition efforts.

It has been assumed that a fuel-fired generator would be used to supply electric power during facility construction. The peak electrical energy demand of 0.00069 million megawatt-hours (approximating an electric load of 0.080 megawatts) in 2017 during the first year of facility operations would be about 0.04 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system and about 0.12 percent of the 400 Area substation distribution capacity of 0.59 million megawatt-hours (67 megawatt load capacity).

Peak liquid fuel consumption under this option would total about 0.65 million liters (0.17 million gallons) in 2015–2016, associated with facility construction. Water requirements would peak in 2017–2018 at 1.36 million liters (0.40 million gallons) annually, associated with sodium processing operations. This water demand would be a small fraction (about 1.2 percent) of the 116 million liters (30.6 million gallons) of groundwater used in the 400 Area in fiscal year 2006.

IDAHO REUSE OPTION

Construction impacts on utility infrastructure under this option would be negligible as compared with the Hanford Reuse Option because this option only involves modifications to the existing SPF at INL's MFC to receive and process Hanford sodium. Operational demands for utility resources would be very similar to those under the Hanford Reuse Option, except diesel fuel consumption for operations alone would be higher due to the need to transport Hanford sodium to and from INL. Total utility resource requirements would be less under this option, overall.

4.2.2.3 Alternative 3: Removal

4.2.2.3.1 Electricity, Fuel, and Water

4.2.2.3.1.1 Facility Disposition

Similar to the situation previously described (see Section 4.2.2.2.1.1), utility systems in the closure area would be shut down as they are no longer needed and would then be supplemented or replaced by portable, temporary facilities as site work progresses. Decommissioning activities involving the removal of major components, piping, and materials from the RCB under the Removal Alternative would drive overall utility resource demands under this alternative. Nevertheless, total utility infrastructure demands under this alternative would be similar to those projected above for the Entombment Alternative (see Table 4–99). This similarity is attributable to the fact that while decommissioning requirements to disposition the FFTF complex would be greater under this alternative, most utility resource needs to support final site closure would be markedly lower because no surface barriers would need to be constructed as under the Entombment Alternative.

Peak electrical energy requirements under the Removal Alternative would occur in 2013–2014, associated with grout facility operations as part of decommissioning. The peak electrical energy demand of 0.0032 million megawatt-hours (approximating an electric load of 0.37 megawatts) would be about 0.18 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system and about 0.54 percent of the 400 Area substation distribution capacity of 0.59 million megawatt-hours (67 megawatt load capacity).

Peak liquid fuel consumption under the Removal Alternative would total about 1.16 million liters (0.31 million gallons) in 2021, primarily associated with equipment operations in support of site regrading and revegetation activities. Similarly, peak water demands would also occur in 2021, driven by water use for final site activities including regrading and revegetation. The projected peak water demand of 10.5 million liters (2.77 million gallons) would be about 0.06 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 9.1 percent of the 116 million liters (30.6 million gallons) of groundwater used in the 400 Area in fiscal year 2006.

4.2.2.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Utility resource demands under this option would be the same as those discussed under Section 4.2.2.2.1.2 for the Hanford Option.

IDAHO OPTION

Utility resource demands under this option would be the same as those discussed under Section 4.2.2.2.1.2 for the Idaho Option.

4.2.2.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Utility resource demands under this option would be the same as those discussed under Section 4.2.2.2.1.3 for the Hanford Reuse Option.

IDAHO REUSE OPTION

Utility resource demands under this option would be the same as those discussed under Section 4.2.2.2.1.3 for the Idaho Reuse Option.

4.2.3 Noise and Vibration

Facility construction, operations, decommissioning, deactivation, and closure activities, as applicable to each alternative, would result in minor noise impacts from employee vehicles, trucks, construction equipment, generators, and other equipment. The offsite noise levels from activities in the 200 and 400 Areas would be negligible due to the distance to the Hanford boundary. Heavy diesel equipment used for construction under most of the alternatives is expected to cause the highest noise levels. For example, if 67 items of construction equipment were operating at FFTF during the regrading closure activity with a sound pressure level of 88 dBA at 15.2 meters (50 feet), the contribution to the sound level at the nearest site boundary would be 28 dBA (SAIC 2007b). If the equipment operates during a normal daytime shift, the estimated maximum sound level at the site boundary would be well below the Washington State standard daytime maximum noise level limitation of 60 dBA for industrial sources impacting residential receptors (WAC 173-60). Noise levels from decommissioning, operations, deactivation, and construction are expected to be less than those from this regrading closure activity.

Some disturbance of wildlife near the 200 and 400 Areas could occur as a result of noise from construction-type activities during decommissioning, construction, deactivation, and closure, as applicable to each alternative. Mitigation of impacts on threatened and endangered species is discussed in Section 4.2.7.

The number of employee vehicles and trucks moving materials for various phases of FFTF decommissioning activities will vary over the duration of the project and by FFTF Decommissioning alternative. The increase in the number of employee vehicle and truck trips is discussed below for each FFTF Decommissioning alternative.

Activities at Hanford associated with the FFTF Decommissioning alternatives that involve excavation, earthmoving, transporting fill material, and other vehicle traffic through Hanford could result in ground vibration that could affect operations of LIGO. Most of the activities that have been identified to have impacts on this facility are activities in which heavy vehicles or large construction equipment are used. It is expected that blasting would also have an impact on this facility if it is required for mining. Although DOE will coordinate vibration producing activities with LIGO, impacts of this type of activity associated with these FFTF Decommissioning alternatives are expected to result in some interference with the operations of this facility.

4.2.3.1 Alternative 1: No Action

The increase in the number of employee vehicle and truck trips under FFTF Decommissioning Alternative 1 is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. The increase in employee and truck traffic from the discussion of local traffic (see Section 4.2.9) was compared to the existing average traffic volume

(see Chapter 3, Sections 3.2.9.4 and 3.3.9.4). For the purpose of comparison among the alternatives, the increase in traffic noise level can be estimated from the ratio of the projected traffic volume to the existing traffic volume (see Appendix F, Section F.3).

4.2.3.2 Alternative 2: Entombment

4.2.3.2.1 Facility Disposition

The increase in the number of employee vehicle and truck trips under Alternative 2, facility disposition at Hanford, is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion is similar to that previously described for Alternative 1 (see Section 4.2.3.1).

4.2.3.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

The increase in the number of employee vehicle and truck trips under FFTF Decommissioning Alternative 2, disposition of RH-SCs, Hanford Option, is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion is similar to that previously described for Alternative 1 (see Section 4.2.3.1).

IDAHO OPTION

The increase in the number of employee vehicle and truck trips under FFTF Decommissioning Alternative 2, disposition of RH-SCs, Idaho Option, is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion are similar to that previously described for Alternative 1 (see Section 4.2.3.1).

4.2.3.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

The increase in the number of employee vehicle and truck trips under FFTF Decommissioning Alternative 2, disposition of bulk sodium, Hanford Reuse Option, is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion is similar to that previously described for Alternative 1 (see Section 4.2.3.1).

IDAHO REUSE OPTION

The increase in the number of employee vehicle and truck trips under FFTF Decommissioning Alternative 2, disposition of bulk sodium, Idaho Reuse Option, is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion is similar to that previously described for Alternative 1 (see Section 4.2.3.1).

4.2.3.3 Alternative 3: Removal

4.2.3.3.1 Facility Disposition

The increase in the number of employee vehicle and truck trips under FFTF Decommissioning Alternative 3, facility disposition at Hanford, is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion is similar to that previously described for Alternative 1 (see Section 4.2.3.1).

4.2.3.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

The impact on traffic noise levels under this option would be the same as discussed in Section 4.2.3.2.2 for the Hanford Option.

IDAHO OPTION

The impact on traffic noise levels under this option would be the same as discussed in Section 4.2.3.2.2 for the Idaho Option.

4.2.3.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

The impact on traffic noise levels under this option would be the same as discussed in Section 4.2.3.2.3 for the Hanford Reuse Option.

IDAHO REUSE OPTION

The impact on traffic noise levels under this option would be the same as discussed in Section 4.2.3.2.3 for the Idaho Reuse Option.

4.2.4 Air Quality

Activities under the various FFTF Decommissioning alternatives would result in some air quality impacts of air pollutant emissions from employee vehicles, trucks, and construction equipment and, as applicable under some FFTF Decommissioning alternatives, heating equipment, generators, and process equipment. Criteria pollutant concentrations for the activities associated with each FFTF Decommissioning alternative were modeled, and the year with peak concentrations for each alternative, pollutant, and averaging time was identified (see Appendix G). These concentrations are presented in Table 4–100 and compared with the ambient standards. The maximum concentrations that would result from these activities for each FFTF Decommissioning alternative would be below the ambient standards, except possibly for $PM_{2.5}$ under Alternatives 2 and 3. The peak period identified for each FFTF Decommissioning alternative and the primary contributing activities are discussed for each alternative below. Maximum air quality impacts are expected to occur along State Route 240 or along or near the Hanford boundary to the east, south, or west. The concentration estimates for PM are high as a result of the high estimated emissions. PM concentrations would be reduced by applying appropriate dust control measures (see Chapter 7, Section 7.1).

Table 4–100. Incremental Criteria Pollutant Concentrations by FFTF Decommissioning Alternative at Hanford

Pollutant and Averaging Period	Standard[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)						
		Alternative 1	Alternative 2			Alternative 3		
			Facility Disposition	Disposition of Remote-Handled Special Components	Disposition of Bulk Sodium	Facility Disposition	Disposition of Remote-Handled Special Components	Disposition of Bulk Sodium
Carbon monoxide								
8-hour	10,000[b]	4.35	60.6	5.47	719	53.0	5.47	719
1-hour	40,000[b]	31.3	435	39.3	5,160	381	39.3	5,160
Nitrogen dioxide								
Annual	100[b]	0.000644	2.84	c	c	2.04	c	c
PM_{10}[d]								
Annual	50[e]	0.0000395	0.454	0.608	0.326	1.04	0.608	0.326
24-hour	150[b]	0.00272	31.3	41.9	22.5	72	41.9	22.5
Sulfur dioxide								
Annual	50[e]	0.0000332	0.0243	0.0000491	0.00552	0.0399	c	c
24-hour	260[e]	0.00229	1.67	0.00339	0.381	2.75	c	c
3-hour	1,300[b]	0.014	10.2	0.0207	2.32	16.8	c	c
1-hour	660[e]	0.0419	30.6	0.062	6.97	50.4	c	c

[a] The more stringent of the Federal and Washington State standards is presented if both exist for the averaging period. The NAAQS (40 CFR 50), other than those for ozone, particulate matter, lead, and those based on annual averages, are not to be exceeded more than once per year. The 24-hour PM_{10} standard is attained when the expected number of days with a 24-hour average concentration above the standard is equal to or less than 1. The annual arithmetic mean PM_{10} standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard. The annual $PM_{2.5}$ standard is met when the 3-year average of the annual means is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 3-year average of the 98th percentile 24-hour averages is less than or equal to the standard.

[b] Federal and Washington State standard.

[c] There is no disposition of remote-handled special components or bulk sodium in the peak year.

[d] The Federal standards for $PM_{2.5}$ are 15 micrograms per cubic meter annual average and 35 micrograms per cubic meter 24-hour average. No specific data for $PM_{2.5}$ were available, but for the purposes of analysis, concentrations are assumed to be the same as PM_{10}.

[e] Washington State standard.

Note: NAAQS also includes standards for lead and ozone. No sources of lead emissions have been identified for the alternatives evaluated. Washington State also has ambient standards for fluorides.

Key: NAAQS=National Ambient Air Quality Standards; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: Appendix G, Section G.3.

Construction activities considered in estimating PM emissions include general construction equipment activity and windblown particulate from disturbed areas, resuspension of road dust, fuel combustion in construction equipment, and grout facility operations. For the Idaho options under Alternatives 2 and 3, the maximum concentrations would be below the ambient concentrations except possibly for $PM_{2.5}$ during construction of the RTP. As described in Section 4.1.4, the emissions calculations result in a substantial overestimate of PM_{10} and $PM_{2.5}$ emissions. A refined analysis of emissions, based on more detailed engineering of the construction activities and application of appropriate control technologies, is expected to result in substantially lower estimates of emissions and ambient concentrations from the major construction activities under any of the alternatives.

The sulfur dioxide emission factor used for fuel-burning sources was based on equipment burning a distillate fuel with a sulfur content of about 0.0015 percent (15 ppm), which is being phased in beginning in 2007. No adjustment was made for more restrictive emission standards for nitrogen dioxide and PM scheduled to be phased in beginning in 2007. In future years pollutant emissions and impacts are expected to be smaller than estimated in this analysis, as better fuels, combustion technologies, emission controls, and alternative energy sources are developed.

The contributions to the total ambient concentrations from sources in the region and existing and reasonably anticipated sources at Hanford that are unrelated to FFTF activities are expected to change over the period of the activities evaluated in this EIS and are addressed in the cumulative impacts section. The existing contributions of Hanford sources and regional monitored concentrations are discussed in Chapter 3, Section 3.2.4. Existing contributions of INL sources and monitored concentrations are discussed in Chapter 3, Section 3.3.4.

The Clean Air Act, as amended, requires that Federal actions conform to the host state's "state implementation plan" (see Appendix G, Section G.4). The final rule, "Determining Conformity of General Federal Actions to State or Federal Implementation Plans," requires a conformity determination for certain-sized projects in nonattainment areas. Hanford and INL are within areas currently designated as attainment for criteria air pollutants. Therefore, a conformity determination for these alternatives is not necessary to meet the requirements of the final rule (40 CFR 51.850–51.860).

Both carcinogenic and noncarcinogenic toxic pollutant concentrations were evaluated. The exposure of members of the public to airborne pollutants would be from process emissions released during operations and from equipment used during construction, operations, and decommissioning. Selected air toxics were modeled because they are representative of toxic constituents associated with emissions from operation of gasoline- and diesel-fueled equipment. Maximum concentrations for each alternative and the Washington State acceptable source impact levels are presented in Table 4–101. These concentrations were below the acceptable source impact levels for all alternatives. The acceptable source impact levels are used by the state in the permitting process and represent concentrations sufficiently low to protect human health and safety from potential carcinogenic and other toxic effects (WAC 173-460).

For noninvolved workers at nearby facilities, the highest annual concentration for each toxic chemical was used to estimate the Hazard Quotient for each chemical, as described in Appendix G. The Hazard Quotients were summed to give the Hazard Index from noncarcinogenic chemicals associated with the alternative. A Hazard Index of less than 1.0 indicates that adverse health effects of non-cancer-causing agents are not expected. Hazard indices for each alternative are summarized in Table 4–102. For carcinogens, the highest annual concentration was used to estimate the increased cancer risk from a chemical. Cancer risks from nonradiological toxic pollutant emissions for each alternative are summarized in Table 4–103.

Table 4–101. Incremental Toxic Chemical Concentrations by FFTF Decommissioning Alternative at Hanford

Pollutant	Averaging Period	Acceptable Source Impact Level[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)						
			Alternative 1	Alternative 2			Alternative 3		
				FD	Disposition of RH-SCs	DBS	FD	Disposition of RH-SCs	DBS
Ammonia	24-hour	100	0.000132	0.196	0.0157	14.0	0.0264	0.0157	14.0
Benzene	Annual	0.12	0.00000319	0.0106	b	b	0.0106	b	b
1,3-Butadiene	Annual	0.0036	0.0000000179	0.000223	b	b	0.000116	b	b
Formaldehyde	Annual	0.077	0.00000107	0.00358	b	b	0.00358	b	b
Mercury	24-hour	0.17	0	0	0	0	0	0	0
Toluene	24-hour	400	0.00338	11.3	b	b	11.3	b	b
Xylene	24-hour	1,500	0.000954	3.18	b	b	3.18	b	b

[a] WAC 173-460.

[b] There is no disposition of RH-SCs or bulk sodium in the peak year.

Key: DBS=Disposition of Bulk Sodium; FD=Facility Disposition; RH-SCs=remote-handled special components.

Source: Appendix G, Section G.3.

Table 4–102. Nonradiological Airborne Toxic Chemical Hazard Index for the Nearest Noninvolved Worker at Hanford by FFTF Decommissioning Alternative

Chemical	Hazard Quotient						
	Alternative 1	Alternative 2			Alternative 3		
		Facility Disposition	Disposition of Remote-Handled Special Components	Disposition of Bulk Sodium	Facility Disposition	Disposition of Remote-Handled Special Components	Disposition of Bulk Sodium
Ammonia	1.67×10^{-8}	1.35×10^{-4}	1.99×10^{-6}	1.78×10^{-3}	1.17×10^{-4}	1.99×10^{-6}	1.78×10^{-3}
Mercury	0	0	0	0	0	0	0
Toluene	8.57×10^{-9}	2.94×10^{-5}	2.34×10^{-9}	1.76×10^{-6}	2.92×10^{-5}	2.34×10^{-9}	1.76×10^{-6}
Xylene	1.21×10^{-7}	4.17×10^{-4}	8.16×10^{-8}	2.51×10^{-5}	4.13×10^{-4}	8.16×10^{-8}	2.51×10^{-5}
Hazard Index	1.46×10^{-7}	5.81×10^{-4}	2.07×10^{-6}	1.80×10^{-3}	5.59×10^{-4}	2.07×10^{-6}	1.80×10^{-3}

Source: Appendix G, Section G.3.

Table 4–103. Nonradiological Airborne Toxic Chemical Cancer Risk for the Nearest Noninvolved Worker by FFTF Decommissioning Alternative

Chemical	Cancer Risk						
	Alternative 1	Alternative 2			Alternative 3		
		Facility Disposition	Disposition of Remote-Handled Special Components	Disposition of Bulk Sodium	Facility Disposition	Disposition of Remote-Handled Special Components	Disposition of Bulk Sodium
Benzene	2.17×10^{-11}	8.16×10^{-8}	2.08×10^{-10}	5.83×10^{-9}	7.91×10^{-8}	2.08×10^{-10}	5.83×10^{-9}
1,3-Butadiene	4.69×10^{-13}	8.30×10^{-9}	3.35×10^{-11}	3.22×10^{-10}	5.21×10^{-9}	3.35×10^{-11}	3.22×10^{-10}
Formaldehyde	1.22×10^{-11}	5.43×10^{-8}	4.39×10^{-10}	5.45×10^{-9}	5.12×10^{-8}	4.39×10^{-10}	5.45×10^{-9}

Source: Appendix G, Section G.3.

4.2.4.1 Alternative 1: No Action

Criteria pollutant concentrations from activities under FFTF Decommissioning Alternative 1 are presented in Table 4–100. The peak concentrations occur from 2008–2107 for all criteria pollutants. The peak period concentration would result from administrative control activities.

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–101. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–102 and 4–103.

4.2.4.2 Alternative 2: Entombment

Criteria pollutant concentrations from facility disposition, disposition of RH-SCs, and disposition of bulk sodium activities under FFTF Decommissioning Alternative 2 at Hanford are presented in Table 4–100. The peak concentrations occur in 2016 for all pollutants except nitrogen dioxide, which peaks in 2021. The peak period concentration would result primarily from Hanford SRF construction for carbon monoxide; from Hanford SRF and RTP construction for PM; from grout facility construction for sulfur dioxide; and from modified RCRA Subtitle C barrier construction and site regrading for nitrogen dioxide. Figure 4–27 shows the 24-hour PM_{10} concentration over the project duration, including the Hanford options for disposition of RH-SCs and bulk sodium, and the contribution of major activities for these concentrations at Hanford.

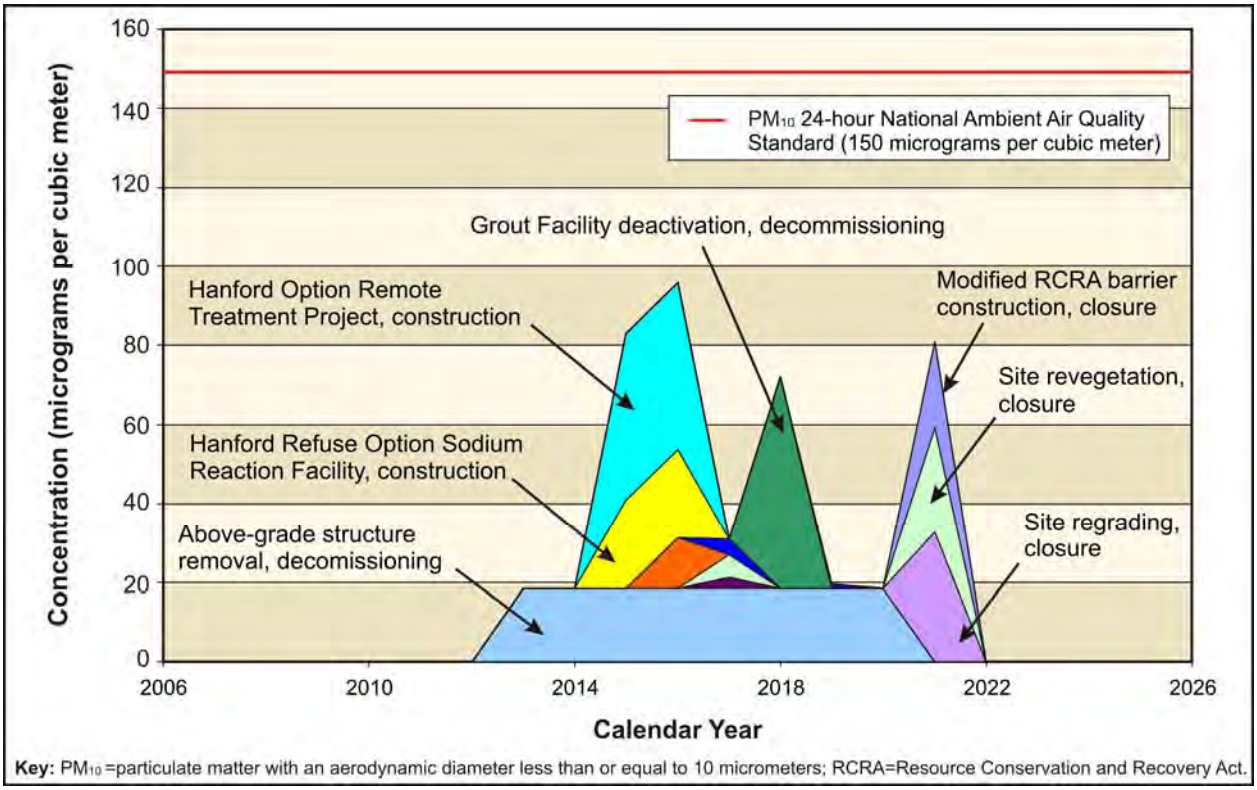


Figure 4–27. FFTF Decommissioning Alternative 2 PM_{10} Maximum 24-Hour Concentration at Hanford

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–101. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–102 and 4–103.

4.2.4.2.1 Facility Disposition

Decommissioning activities, especially above-grade structure and equipment removal and onsite grout facility construction and operations, would be the primary contributors to air pollutant impacts from facility disposition because of the amount of equipment used and earthmoving activity, as shown in Tables 4–100 and 4–101.

4.2.4.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Disposition of RH-SCs under the Hanford Option would result in air pollutant impacts of construction and operations of the RTP at Hanford, as shown in Tables 4–100 and 4–101.

IDAHO OPTION

Disposition of RH-SCs under the Idaho Option would result in air pollutant impacts of construction of the RTP at INL, as shown in Tables 4–104 and 4–105. Operation of the RTP would have no criteria or toxic air pollutants emissions.

4.2.4.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Processing bulk sodium under the Hanford Reuse Option would result in air pollutant impacts of construction and operations of an SRF in the 400 Area, as shown in Tables 4–100 and 4–101.

IDAHO REUSE OPTION

Processing bulk sodium under the Idaho Reuse Option would result in air pollutant impacts of modification and operations of the existing SPF at INL, as shown in Tables 4–104 and 4–105. Operation of the SPF would have no criteria or toxic air pollutant emissions.

Table 4–104. Incremental Criteria Pollutant Concentrations by FFTF Decommissioning Alternative at Idaho National Laboratory

Pollutant and Averaging Period	Standard[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)			
		Alternative 2		Alternative 3	
		Construction of INL Remote Treatment Project	Disposition of Bulk Sodium	Construction of INL Remote Treatment Project	Disposition of Bulk Sodium
Carbon monoxide					
8-hour	10,000[b]	7.56	46.6	7.56	46.6
1-hour	40,000[b]	10.8	66.6	10.8	66.6
Nitrogen dioxide					
Annual	100[b]	4	0.772	4	0.772
PM_{10}[c]					
Annual	50[d]	17.3	2.71	17.3	2.71
24-hour	150[b]	86.3	13.5	86.3	13.5
Sulfur dioxide					
Annual	80[b]	0.00136	0.00717	0.00136	0.00717
24-hour	365[b]	0.00681	0.0358	0.00681	0.0358
3-hour	1,300[b]	0.0153	0.0807	0.0153	0.0807

[a] The more stringent of the Federal and Idaho State standards is presented if both exist for the averaging period. The NAAQS (40 CFR 50), other than those for ozone, particulate matter, lead, and those based on annual averages, are not to be exceeded more than once per year. The 24-hour PM_{10} standard is attained when the expected number of days with a 24-hour average concentration above the standard is equal to or less than 1. The annual arithmetic mean PM_{10} standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard. The annual $PM_{2.5}$ standard is met when the 3-year average of the annual means is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 3-year average of the 98th percentile 24-hour averages is less than or equal to the standard.

[b] Federal and Idaho State standard.

[c] The Federal standards for $PM_{2.5}$ are 15 micrograms per cubic meter annual average and 35 micrograms per cubic meter 24-hour average. No specific data for $PM_{2.5}$ were available, but for the purposes of analysis, concentrations were assumed to be the same as PM_{10}.

[d] Idaho State standard.

Note: NAAQS also includes standards for lead and ozone. No sources of lead emissions have been identified for the alternatives evaluated. Concentrations in bold indicate potential exceedance of the standard.

Key: INL=Idaho National Laboratory; NAAQS=National Ambient Air Quality Standards; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: Appendix G, Section G.3.

Table 4–105. Incremental Toxic Chemical Concentrations by FFTF Decommissioning Alternative at Idaho National Laboratory

Pollutant	Averaging Period	Acceptable Ambient Concentration[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)			
			Alternative 2		Alternative 3	
			Construction of INL Remote Treatment Project	Disposition of Bulk Sodium	Construction of INL Remote Treatment Project	Disposition of Bulk Sodium
Ammonia	24-hour	0.3	0.0315	0.007	0.0315	0.007
Benzene	Annual	0.12	0.000848	0.000805	0.000848	0.000805
1,3-Butadiene	Annual	0.0036	0.0000353	0.00000936	0.0000353	0.00000936
Formaldehyde	Annual	0.077	0.00107	0.000395	0.00107	0.000395
Mercury	24-hour	2.5	0	0	0	0
Toluene	24-hour	18,800	0.00185	0.0517	0.00185	0.0517
Xylene	24-hour	21,800	0.00129	0.0147	0.00129	0.0147

[a] IDAPA 58.01.01.585 and 58.01.01.586.
Key: INL=Idaho National Laboratory.
Source: Appendix G, Section G.3.

4.2.4.3 Alternative 3: Removal

Criteria pollutant concentrations from facility disposition, disposition of RH-SCs, and disposition of bulk sodium activities under FFTF Decommissioning Alternative 3 are presented in Table 4–100. The peak concentrations occur in 2015 for carbon monoxide, PM, and nitrogen dioxide, and in 2012 for sulfur dioxide. The peak period concentration would result primarily from Hanford SRF construction and above-grade structure and equipment removal for carbon monoxide; from site regrading for nitrogen dioxide; from grout facility deactivation and Hanford RTP construction for PM; and grout facility construction for sulfur dioxide. Figure 4–28 shows the 24-hour PM_{10} concentration over the project duration, including the Hanford options for disposition of RH-SCs and bulk sodium, and the contribution of major activities to these concentrations at Hanford.

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–101. Impacts on the public due to nonradiological toxic pollutant emissions would be acceptable. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–102 and 4–103.

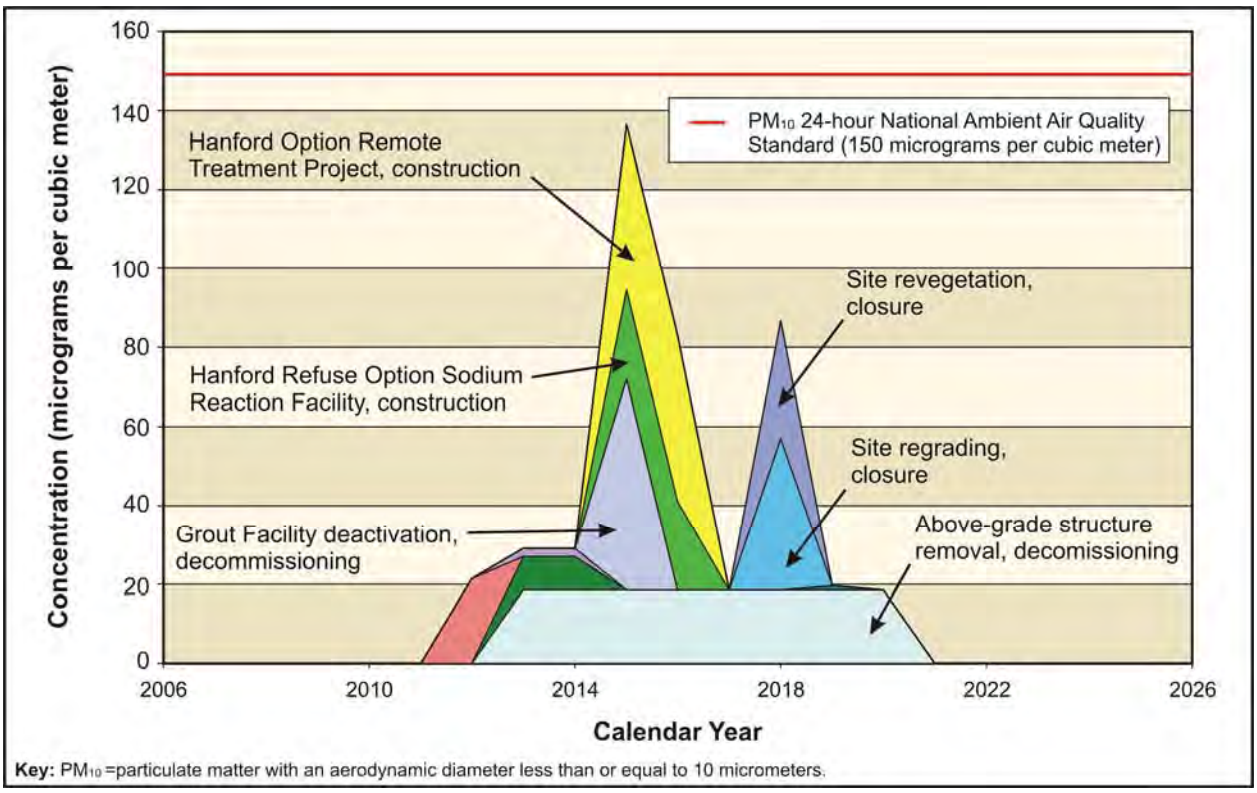


Figure 4–28. FFTF Decommissioning Alternative 3 PM_{10} Maximum 24-Hour Concentration at Hanford

4.2.4.3.1 Facility Disposition

Decommissioning activities, especially above-grade structure and equipment removal and onsite grout facility construction and deactivation, would be the primary contributors to air pollutant impacts of facility disposition because of the amount of equipment used and earthmoving activity, as shown in Tables 4–100 and 4–101.

4.2.4.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Disposition of RH-SCs under the Hanford Option would result in air pollutant impacts of construction and operations of the RTP at Hanford, as shown in Tables 4–100 and 4–101.

IDAHO OPTION

Disposition of RH-SCs under the Idaho Option would result in air pollutant impacts of construction of the RTP at INL, as shown in Tables 4–104 and 4–105. Operation of the RTP would have no criteria or toxic air pollutant emissions.

4.2.4.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Processing bulk sodium under the Hanford Reuse Option would result in air pollutant impacts of construction and operations of an SRF in the 400 Area, as shown in Tables 4–100 and 4–101.

IDAHO REUSE OPTION

Processing bulk sodium under the Idaho Reuse Option would result in air pollutant impacts of modification and operations of the existing SPF at INL, as shown in Tables 4–104 and 4–105. Operation of the SPF would have no criteria or toxic pollutant emissions.

4.2.5 Geology and Soils

Impacts on geology and soils would generally be directly proportional to the total area of land disturbed by facility decommissioning and demolition, site grading, excavation work, and construction of facilities to support facility disposition and related waste treatment options under the FFTF Decommissioning alternatives and options. Consumption of geologic resources, including rock, mineral, and soil resources, would constitute the major indirect impact on geologic and soil resources, as summarized in Table 4–106 for each of the alternatives and options. Key underlying assumptions regarding analysis of potential environmental impacts on geology and soils and the acquisition and use of geologic resources in support of the FFTF Decommissioning alternatives and options are similar to those described in Section 4.1.5 for the Tank Closure alternatives.

4.2.5.1 Alternative 1: No Action

4.2.5.1.1 Facility Disposition

No facility demolition or related ground-disturbing activities would be conducted during the 100-year administrative control period under the No Action Alternative. Also, no geologic resources would be consumed as part of related surveillance and monitoring activities at FFTF. Therefore, there would be no incremental impact on geologic and soil resources in the 400 Area of Hanford under the No Action Alternative, as the FFTF RCB and other structures within the FFTF PPA would remain in place.

Hazards from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions with the potential to affect Hanford facilities are summarized in Chapter 3, Section 3.2.5.1.4. Maximum considered earthquake ground motions for Hanford encompass those that may cause substantial structural damage to buildings (equivalent to an MMI of VII and up), thus presenting safety concerns for occupants. Ground shaking of MMI VII associated with postulated earthquakes is possible and supported by the historical record for the region. However, this level of ground motion is expected to primarily affect the integrity of inadequately designed or nonreinforced structures (see Appendix F, Table F–7). Little or no damage is expected in reinforced structures such as the FFTF RCB. DOE Order 420.1B requires that nuclear and nonnuclear facilities be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. The order stipulates natural phenomena hazards mitigation for DOE facilities and specifically provides for reevaluation and upgrade of existing DOE facilities when there is a significant degradation in the safety basis for the facility. DOE Standard 1020-2002 implements DOE Order 420.1B and provides criteria for the design of new structures, systems, and components and for the evaluation, modification, and upgrade of existing structures, systems, and components so that DOE facilities safely withstand the effects of natural phenomena hazards, such as earthquakes. An analysis of potential effects of a beyond-design-basis earthquake on human health and the environment is provided in Section 4.2.11.1.1.

Table 4–106. FFTF Decommissioning Alternatives – Summary of Major Geologic and Soil Resource Impact Indicators and Requirements

Parameter/ Resource	Alternatives and Options						
	Alternative 1: No Action	Alternative 2: Facility Disposition-Entombment	Alternative 3: Facility Disposition-Removal	Disposition of RH-SCs (Hanford Option for Remote Treatment)	Disposition of RH-SCs (Idaho Option for Remote Treatment)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
New, permanent land disturbance[a]	0.0	3.5	3.2	0.1	0.1	0.1	<0.1
Construction materials							
Concrete	0.0	0.0	0.0	2,900	2,920	79.9	31.7
Cement[b]	0.0	0.0	0.0	719	725	16.3	6.46
Sand[b]	0.0	0.0	0.0	1,410	1,420	38.8	15.4
Gravel[b]	0.0	0.0	0.0	1,840	1,850	50.6	20.1
Other borrow materials[c]							
Rock/basalt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gravel	0.0	0.0	0.0	1,390	1,280	112	0.0
Soil (specification backfill)	0.0	80,400	121,000	37.8	37.8	0.0	0.0
Decommissioning and closure-specific materials							
Grout[d]	0.0	24,900	24,900	0.0	0.0	0.0	0.0
Cement	0.0	188	188	0.0	0.0	0.0	0.0
Sand[e]	0.0	22,600	22,600	0.0	0.0	0.0	0.0
Landfill earthwork[f]	0.0	19,300	0.0	0.0	0.0	0.0	0.0
Total[g]	0.0	122,000	143,000	4,670	4,580	202	35.5

[a] Reflects land area assumed to be permanently disturbed for new facilities. The value also includes land area excavated in Borrow Area C or elsewhere to supply geologic materials listed in the table.

[b] Components of concrete.

[c] Resources for miscellaneous uses not exclusively tied to facility construction, operations, or closure, such as site grading and backfill for excavations.

[d] Grout comprises cement, sand, fly ash, and other materials.

[e] Principal component of grout that would be obtained from onsite deposits.

[f] Volume includes soil, sand, gravel, rock, and asphalt for construction of a modified Resource Conservation and Recovery Act Subtitle C barrier.

[g] Excludes concrete, cement, and grout. Totals may not equal the sum of the contributions due to rounding.

Note: All values are expressed in cubic meters except land disturbance, which is in hectares. Values presented in the table have been rounded to no more than three significant digits, where appropriate. To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, multiply by 2.471.

Key: RH-SCs=remote-handled special components.

Source: SAIC 2007b.

4.2.5.1.2 Disposition of Remote-Handled Special Components

Storage of removed RH-SCs within the 400 Area would have no incremental impact on geology and soils and would not entail any demand for geologic resources.

4.2.5.1.3 Disposition of Bulk Sodium

Storage of FFTF bulk sodium in the 400 Area SSF, as well as ongoing storage of the Hallam Reactor and Sodium Reactor Experiment (SRE) sodium in existing facilities within the 200-West Area, would have no incremental impact on geology and soils.

4.2.5.2 Alternative 2: Entombment

4.2.5.2.1 Facility Disposition

Under the Entombment Alternative, all above-grade (ground-level) structures associated with the FFTF RCB, two adjacent service buildings, and five other immediately adjacent facilities composing the FFTF complex would be dismantled and removed. Floors and walls, along with other demolition debris, would be collapsed into below-grade spaces to the extent possible, except that wood and large steel components would be removed. Waste not suitable to be consolidated into below-grade spaces would be categorized and removed for proper disposal. While contaminated structures, systems, and components would remain below grade in the RCB and two adjacent service buildings, hazardous and radioactive material would be removed from all other buildings. With the exception of the RCB and two adjacent service buildings, the building demolition sites and remaining below-grade void spaces would then be backfilled with soil. For the RCB and adjacent service buildings, an onsite grout facility would be constructed and operated to fill the below-grade spaces with grout to prevent subsidence and to immobilize remaining hazardous and radiological constituents. Subsequently, a modified RCRA Subtitle C barrier would be emplaced over the RCB and adjacent service buildings to entomb them and any residual hazardous and radiological constituents. The 2.7-meter-thick (9-foot-thick) engineered barrier would be composed of layers of topsoil in the upper part, which would support a mixed perennial grass ground cover, and underlain by layers of sand, gravel, asphalt, and/or riprap in the lower part, as previously described in Section 4.1.5 for the Tank Closure alternatives. In total, the entombment barrier would encompass an approximately 0.7-hectare (1.7-acre) area of the FFTF complex. In addition to the area encompassed by this barrier, an additional 2.8 hectares (6.9 acres) would also be excavated in Borrow Area C, for a total of 3.5 hectares (8.6 acres) of new, permanent land disturbance.

All other ancillary buildings within the 400 Area PPA would be demolished to grade as described above, except that all demolition debris and soils would first be excavated to a depth of 1 meter (3 feet) and removed for disposal prior to backfilling. Upon completion of all building demolition and barrier construction, the land surface of the entire 2.1-hectare (5.3-acre) site would regraded with topsoil, recontoured and then revegetated, including the modified RCRA Subtitle C barrier.

Because excavation work would be minimal and the 400 Area PPA is already disturbed, the direct impact of facility decommissioning activities on geology and soils would be minimal. As with any ground-disturbing activity, denuded surface soils and unconsolidated sediments in excavations and graded areas would be subject to wind and water erosion if left exposed over an extended period of time. Adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. During the 8-year facility decommissioning and demolition phase, prior to final regrading and revegetation of the site, temporary seeding, mulching, and the use of geotextile covers and similar best management practices would be employed to minimize soil erosion in disturbed areas.

FFTF decommissioning and closure activities would not preclude the use of rare or otherwise valuable geologic or soil resources. Geologic resources would be required to produce grout to stabilize below-grade structures, to backfill demolished facility sites, and to construct engineered barriers as part of final site closure. Total geologic resource requirements under Alternative 2 are projected to be 122,000 cubic meters (160,000 cubic yards), with little or no geologic resources expected to be required during the 100-year postclosure care period (see Table 4–106). It would be expected that this volume would be supplied by Borrow Area C, as further described in Section 4.1.5.

4.2.5.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Direct impacts on site geology and soils under this option would be limited to the construction of a new RTP to treat RH-SCs at a location adjacent to the existing T Plant in the 200-West Area (see Figure 4–2). Construction activities would permanently disturb about 0.1 hectares (0.3 acres) of land for the new facility. The proposed RTP would have a below-grade service level that would require excavation to a depth of approximately 6 meters (20 feet) (ANL-W 2004:27). The uppermost Hanford formation sediments across the 400 Area attain a thickness of up to 55 meters (180 feet), so the lateral and vertical extent of this unit would not be greatly impacted by facility construction and sublevel excavation.

Although the area has previously been disturbed and native soils may have been altered by fill placement, denuded surface soils and unconsolidated sediments in excavations would be subject to wind and water erosion if left exposed over an extended period of time. Adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. To reduce the risk of exposing contaminated soils, areas in which new facilities would be constructed under this alternative would be surveyed prior to any ground disturbance. Any contamination would be remediated as necessary. After construction, the previously disturbed areas would not be subject to long-term soil erosion.

Geologic resources would be required for new facility construction under this option, including aggregate (sand and gravel), cement, and soil for engineered backfill. Total geologic resource requirements under this option are projected to be 4,670 cubic meters (6,100 cubic yards) (see Table 4–106). It is expected that this volume would be supplied by Borrow Area C, as further described in Section 4.1.5.

As referenced and described in Section 4.2.5.1.1, hazards from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions with the potential to Hanford facilities have been evaluated. As stated in DOE Order 420.1B, DOE requires that nuclear and nonnuclear facilities be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. DOE Standard 1020-2002 implements DOE Order 420.1B and provides criteria for the design of new structures, systems, and components and for the evaluation, modification, are upgrade of existing structures, systems, and components so that DOE facilities safely withstand the effects of natural phenomena hazards, such as earthquakes. As the RTP would be a Performance Category 3 facility (ANL-W 2004:39), a probabilistic seismic hazard assessment would be required to determine the seismic design basis for RTP structures, systems, and components.

IDAHO OPTION

Under this option, RH-SCs stored at Hanford would be shipped to INL for treatment at the new RTP to be constructed within the MFC of INL. Direct and indirect impacts on site geology and soil under this option would be very similar in nature to those described above for the Hanford Option. As under the Hanford Option, construction activities would permanently disturb no more than about 0.1 hectares (0.3 acres) of land for the new facility. At INL, the RTP would be constructed within a developed portion

of the MFC. Across portions of INL, including the lava plain on which the MFC is situated, outcrops of basaltic bedrock are common and near-surface basalt is overlain by only a thin mantle of eolian silt usually less than 2 meters (6.6 feet) thick. Consequently, construction of the below-grade service level of the RTP at the MFC of INL may require blasting to excavate through the bedrock.

As described for the Hanford Option, adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss.

Total geologic resource requirements to support facility construction under this option are projected to be 4,580 cubic meters (5,990 cubic yards) (see Table 4–106). This volume would be supplied by one of a number of quarries at INL (see Chapter 3, Section 3.3.5.2).

As described in Chapter 3, Section 3.3.5.3, hazards from large-scale geologic conditions (such as earthquakes and volcanic activity) and site-specific geologic conditions with the potential to affect INL facilities have been extensively studied and evaluated. To be specific, the Eastern Snake River Plain, on which INL is situated, is a region of relatively low seismicity, although higher rates of seismic activity are indicated for regions in the surrounding Basin and Range Physiographic Province. Ground shaking of MMI VI has been reported on the site in the recent past, associated with a major earthquake epicenter in the Borah Peak Range northwest of INL. Otherwise, relatively few and minor earthquakes have occurred in the area surrounding INL. MMI VI shaking typically causes only slight damage to structures, while MMI VII activity is expected to affect primarily the integrity of inadequately designed or nonreinforced structures, but damage to properly or specially designed or upgraded facilities is not expected. As stated in DOE Order 420.1B, DOE requires that nuclear and nonnuclear facilities be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. DOE Standard 1020-2002 implements DOE Order 420.1B and provides criteria for the design of new structures, systems, and components and for the evaluation, modification, and upgrade of existing structures, systems, and components so that DOE facilities safely withstand the effects of natural phenomena hazards, such as earthquakes. As the RTP would be a Performance Category 3 facility (ANL-W 2004:39), a probabilistic seismic hazard assessment would be required to determine the seismic design basis for RTP structures, systems, and components.

4.2.5.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under the Hanford Reuse Option, direct impacts on site geology and soils would be limited to ground disturbance associated with construction of the new SRF in the Hanford 400 Area. Specifically, the facility would be constructed in a previously disturbed area near the existing SSF. The new SRF would permanently occupy about 0.1 hectares (0.2 acres) of land when completed. As the SRF would be constructed with a reinforced concrete slab floor and without a basement (ANL-W and Fluor Hanford 2002:19, 57), excavation work would be minimal, and the lateral and vertical extent of the Hanford formation sediments underlying the 400 Area would not be greatly impacted.

Although the area has previously been disturbed and native soils may have been altered by fill placement, denuded surface soils and unconsolidated sediments in excavations would be subject to wind and water erosion if left exposed over an extended period of time. Adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. To reduce the risk of exposing contaminated soils, areas in which new facilities would be constructed under this alternative would be surveyed prior to any ground disturbance. Any contamination would be remediated as necessary. After construction, the previously disturbed areas would not be subject to long-term soil erosion.

Geologic resources required for new facility construction under this option would be relatively small and limited to aggregate (sand and gravel) and cement for concrete and gravel for slab foundation construction. Total geologic resource requirements under this option are projected to be 202 cubic meters (264 cubic yards) (see Table 4–106). It is expected that this volume would be supplied by Borrow Area C, as further described in Section 4.1.5.

As referenced and described in Section 4.2.5.1.1, hazards from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions with the potential to affect Hanford facilities have been evaluated. As stated in DOE Order 420.1B, DOE requires that nuclear and nonnuclear facilities be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. DOE Standard 1020-2002 implements DOE Order 420.1B and provides criteria for the design of new structures, systems, and components and for the evaluation, modification, and upgrade of existing structures, systems, and components so that DOE facilities safely withstand the effects of natural phenomena hazards, such as earthquakes. As the SRF would presumably be a Performance Category 3 facility, a probabilistic seismic hazard assessment would be required to determine the seismic design basis for SRF structures, systems, and components.

IDAHO REUSE OPTION

The type and intensity of anticipated direct impacts on geology and soils under this option would be somewhat less than those described above for the Hanford Reuse Option. Under this option, ground disturbing activity would be limited to modifications to the existing SPF at INL's MFC in order to receive and process Hanford sodium. Facility modifications that could impact geologic strata would mainly be limited to constructing an enclosed concrete pad adjacent to the existing SPF (ANL-W and Fluor Hanford 2002:37).

Geologic resources required for SPF modifications at INL under this option would be relatively small and limited to aggregate (sand and gravel) and cement for concrete and gravel for slab foundation construction. Total geologic resource requirements under this option are projected to be about 36 cubic meters (47 cubic yards) (see Table 4–106). This volume would be supplied by one of a number of quarries at INL (see Chapter 3, Section 3.3.5.1.3).

As described in Chapter 3, Section 3.3.5.1.4, hazards from large-scale geologic conditions (such as earthquakes and volcanic activity) and site-specific geologic conditions with the potential to affect INL facilities have been extensively studied and evaluated. Design consideration of hazards to the modified SPF at INL from large-scale geologic conditions would be substantially the same as those described above for the Hanford Reuse Option.

4.2.5.3 Alternative 3: Removal

4.2.5.3.1 Facility Disposition

Decommissioning activities and associated impacts on geology and soils under the Removal Alternative would be somewhat greater than those described in Section 4.2.5.2.1 for the Entombment Alternative. All above-grade (ground-level) structures associated with the FFTF RCB, two adjacent service buildings, and five other immediately adjacent facilities would be dismantled and removed. Also, all other ancillary buildings within the 400 Area PPA would be demolished and removed to a depth of 1 meter (3 feet) below grade prior to backfilling the removed facilities with soil and restoring the site, as further described for the Entombment Alternative. However, under this alternative, the RCB reactor vessel, along with internal piping and equipment, would first be filled with grout, removed, and packaged for transport to an IDF for onsite disposal rather than being left in place. Identical to the Entombment Alternative, an onsite grout facility would be constructed and operated to grout and stabilize the reactor vessel prior to its

removal as well as to fill the below-grade spaces associated with the RCB and adjacent service buildings prior to backfilling them with soil. While no engineered barrier would be constructed under this alternative, decommissioning activities would have a higher demand for soil for use in backfilling than the Entombment Alternative. To support these activities about 3.2 hectares (7.9 acres) would be excavated in Borrow Area C. Upon completion of all building demolition, the entire 2.4-hectare (6.0-acre) site would be regraded with topsoil, recontoured, and then revegetated.

As described in Section 4.2.5.2.1, adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss during facility decommissioning and final site closure.

Total geologic resource requirements under Alternative 3 are projected to be 143,000 cubic meters (187,000 cubic yards), with little or no geologic resources expected to be required during the 100-year site institutional control period (see Table 4–106). It is expected that this volume would be supplied by Borrow Area C, as stated above and as further described in Section 4.1.5.

4.2.5.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Direct impacts on geology and soils and geologic resource demands under this option would be the same as those discussed under Section 4.2.5.2.2 for the Hanford Option.

IDAHO OPTION

Direct impacts on geology and soils and geologic resource demands under this option would be the same as those discussed under Section 4.2.5.2.2 for the Idaho Option.

4.2.5.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Direct impacts on geology and soils and geologic resource demands under this option would be the same as those discussed under Section 4.2.5.2.3 for the Hanford Reuse Option.

IDAHO REUSE OPTION

Direct impacts on geology and soils and geologic resource demands under this option would be the same as those discussed under Section 4.2.5.2.3 for the Idaho Reuse Option.

4.2.6 Water Resources

4.2.6.1 Alternative 1: No Action

4.2.6.1.1 Surface Water

No facility demolition would be conducted during the 100-year administrative control period under the No Action Alternative, so there would be no construction-related impacts on surface-water resources, including stormwater quality.

Utility systems necessary to maintain safety-related functions across the FFTF complex would be left operational following the completion of deactivation activities in the 400 Area. Water use and wastewater generation would likely be limited to levels necessary to maintain and test critical systems, such as fire protection, as part of surveillance and monitoring. Projected water use under FFTF

Decommissioning Alternative 1 and the impact on site utility infrastructure are discussed in Section 4.2.2.1.3. There would be no process wastewater discharges from the 400 Area following deactivation, and any sanitary wastewater generation would be a small fraction of the amount generated during standby operations and would be discharged to the existing treatment system that serves the 400 Area (see Chapter 3, Section 3.2.6.1.3).

4.2.6.1.2 Vadose Zone and Groundwater

Under FFTF Decommissioning Alternative 1, residual sodium would continue to be stored in the 400 Area SSF. Periodic facility inspections and necessary maintenance activities would be conducted to ensure the structural integrity of storage facilities. Adherence to appropriate spill prevention and emergency response plans and procedures would help to ensure that any spills, should they occur, do not reach soils or surfaces where they could be conveyed to surface water or groundwater.

Maintenance of the FFTF reactor vessel, related piping and equipment, RH-SCs, and tanks under an inert gas blanket through the 100-year administrative control period would ensure that there would be no direct impact on the vadose zone and groundwater in the short term. Emergency mitigative actions would be undertaken to address the failure of a system or component that could pose a threat to public health and safety or the environment. Following the administrative control period, remaining hazardous and radioactive materials including residual sodium would be available for potential release to the environment. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.2.1.1.

4.2.6.2 Alternative 2: Entombment

4.2.6.2.1 Surface Water, Vadose Zone, and Groundwater

4.2.6.2.1.1 Facility Disposition

Facility decommissioning activities associated with the Entombment Alternative would have little or no direct impact on surface-water features or surface-water quality, as there are no natural, perennial surface-water drainages in the 400 Area.

Demolition-related land disturbance, as well as barrier construction and site regrading work, would expose soils and sediments to possible erosion by infrequent, heavy rainfall or wind. Stormwater runoff from exposed areas could convey soil, sediments, and other pollutants (e.g., contaminated demolition debris and spilled materials, such as petroleum, oils, and lubricants from heavy equipment) from demolition and other work sites and staging areas. Any potential for this runoff to impact runoff quality beyond the confines of the 400 Area is low, and the Columbia River is located approximately 6.3 kilometers (3.9 miles) away. Nevertheless, appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulch) and spill prevention and waste management practices would be employed to minimize suspended sediment and other deleterious material transport and potential water-quality impacts. Further, all demolition and ground-disturbing activities would be conducted in accordance with current NPDES and appropriate state waste discharge general permits for stormwater discharges associated with construction and industrial activities, issued by Ecology. The NPDES permit specifically requires the development and implementation of a stormwater pollution prevention plan.

Nonhazardous sanitary wastewater (sewage) would be minimal during facility decommissioning and final site closure and would be managed via existing sanitary wastewater collection and treatment systems early on and via portable sanitary facilities as existing utility infrastructure is decommissioned and closed (see Section 4.2.2.2.1.1). Waste generation and management activities under this alternative are further discussed in Section 4.2.14.2.

Potable and raw water demand to support decommissioning and closure activities would primarily be driven by the need to provide dust control and mix concrete and grout during construction of the modified RCRA Subtitle C barrier. Potable and raw water would possibly be needed to aid soil compaction in backfilled areas and equipment washdown. Water to support demolition activities would be trucked to the point of use but could also be supplied via temporary utility service connections until the 400 Area's three water supply wells are closed and the support buildings demolished. Portable sanitary facilities would be provided to meet the workday potable and sanitary needs of decommissioning personnel, which would constitute a relatively small percentage of the total water demand. Projected water use under FFTF Decommissioning Alternative 1 and its impact on site utility infrastructure are discussed in Section 4.2.2.2.1.1.

Hazardous and radioactive material would be removed from many buildings within the 400 Area PPA under the Entombment Alternative as described above. Contaminated structures, systems, and components in the RCB and two adjacent service buildings would remain below grade but would be grouted. A modified RCRA Subtitle C barrier would be emplaced over the RCB and adjacent service buildings. The modified RCRA Subtitle C barrier is designed for a 500-year performance period. Nevertheless, this barrier would degrade over time, allowing infiltration and contaminant migration from the 400 Area. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.2.1.2.

4.2.6.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Construction of an RTP to treat RH-SCs would likely have little direct impact on surface-water features or surface-water quality because the facility would be constructed in a previously disturbed and developed part of the 200-West Area, where no surface-water features or surface-water drainages are located (see Figure 4–2). Any effects on stormwater runoff quality would likely be very localized and of short duration. Nevertheless, appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulch) and spill prevention and waste management practices would be employed to minimize suspended sediment and other deleterious material transport from the construction site, as well as potential water-quality impacts. Further, ground-disturbing activities would be conducted in accordance with current NPDES and state waste discharge general permits for stormwater discharges associated with construction activities, issued by Ecology. The NPDES permit specifically requires the development and implementation of a stormwater pollution prevention plan. The completed facility would incorporate appropriate stormwater management controls to collect, detain, and convey stormwater from the building and other impervious surfaces so as to minimize water-quality impacts during operations.

During RTP operations, there would be no direct discharge of effluents to either surface water or groundwater. Process wastewater generated from operation of the new facility, including any radioactive liquid effluents, would be discharged to existing treatment facilities that already service the 200 Areas, as described in Section 4.1.6.2.1. Nonhazardous sanitary wastewater (sewage) would be managed via appropriate sanitary wastewater collection and treatment systems.

Water would be required during construction for soil compaction, dust control, and other uses, including concrete production. Standard construction practices dictate that, at least initially, construction water would be trucked to construction locations on an as-needed basis for these uses until water supply and wastewater treatment utilities are in place. During operations, water would be required to support process makeup requirements and facility cooling, as well as the potable and sanitary needs of the operations workforce, among other uses. Some water would also be required during deactivation, such as for use in facility decontamination. Projected water use under the Hanford Option and its impact on site utility infrastructure are further discussed in Section 4.2.2.2.1.2.

No impact on the Hanford vadose zone or groundwater is expected from operation of the RTP in the Hanford 200-West Area. There would be no direct discharge of effluents to either surface water or the groundwater, as described above. Following completion of the facility's mission, the facility would be deactivated and all residual waste and any hazardous or radioactive materials would be removed for disposal. Waste generation and management activities under this alternative and option case are further discussed in Section 4.2.14.2.

IDAHO OPTION

Direct impacts on water resources associated with construction of the RTP within the MFC of INL would be very similar in nature to those described above for the Hanford Option. No natural surface-water features or surface-water drainages would be directly impacted because the facility would be constructed in a developed portion of the MFC. Appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulch) and spill prevention practices and waste management would be employed as previously discussed for the Hanford Option. Specifically, in accordance with INL's General Permit for Storm Water Discharges from Construction Sites, the INL Storm Water Pollution Prevention Plan for Construction Activities provides for measures and controls to prevent pollution of stormwater from construction activities at INL (see Chapter 3, Section 3.3.6.1.1).

During RTP operations, there would be no direct discharge of effluents to either surface water or groundwater at INL. Process wastewater generated from operation of the new facility, including any radioactive liquid effluents, would be discharged to existing treatment facilities that already service the MFC. Radioactive liquid waste would be conveyed to the Radioactive Liquid Waste Treatment Facility, while nonhazardous process wastewater would flow to the MFC Industrial Waste Pond. Nonhazardous sanitary wastewater (sewage) would be managed via the existing site sanitary sewer system (ANL-W 2004:66, 67).

Groundwater is the source of water at the MFC and across INL. Water would be required during construction, operations, and deactivation as previously described for the Hanford Option. Projected water use under the Idaho Option and its impact on INL's utility infrastructure are further discussed in Section 4.2.2.2.1.2.

No impact on the INL vadose zone or groundwater is expected from operation of the RTP at the INL MFC. There would be no direct discharge of effluents to either surface water or groundwater as previously described. Following completion of the facility's mission, the facility would be deactivated and all residual waste and any hazardous or radioactive materials would be removed for disposal. Waste generation and management activities under this alternative and option case are further discussed in Section 4.2.14.2.

4.2.6.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

There would be little direct impact on surface water from construction of the SRF adjacent to the SSF in the Hanford 400 Area because no surface-water features would be impacted and stormwater generation from the construction site would be minimal. Any effect on stormwater runoff quality would likely be very localized and of short duration. Nevertheless, appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulch) and spill prevention and waste management practices would be employed to minimize suspended sediment and other deleterious material transport from the construction site, as well as potential water-quality impacts. Further, ground-disturbing activities would be conducted in accordance with current NPDES and state waste discharge general permits for stormwater discharges associated with construction activities, issued by Ecology. The NPDES permit specifically requires the development and implementation of a stormwater pollution

prevention plan. The completed facility would incorporate appropriate stormwater management controls to collect, detain, and convey stormwater from the building and other impervious surfaces so as to minimize water-quality impacts during operations.

During RTP operations, there would be no direct discharge of effluents to surface water or groundwater. Process wastewater generation would be minimal, with any waste collected and transported for storage or disposal at appropriate onsite facilities. Nonhazardous sanitary wastewater (sewage) would be managed via the existing sanitary wastewater collection and treatment system that serves the 400 Area.

Water would be required during construction for soil compaction, dust control, and other uses, including concrete production. Construction water would be trucked to the point of use or supplied via temporary connection to existing nearby utilities. Most water use would occur during the operations period to process the bulk sodium into caustic solution for product reuse at Hanford. Some water would also be required during deactivation, such as for use in facility decontamination. Projected water use under the Hanford Reuse Option and its impact on site utility infrastructure are further discussed in Section 4.2.2.2.1.3.

No impact on the Hanford vadose zone or groundwater would be expected from operation of the SRF in the Hanford 400 Area. There would be no direct discharge of effluents to either surface water or groundwater, as described above. Following completion of the facility's mission, the facility would be deactivated and all residual waste and any hazardous or radioactive materials would be removed for disposal. Waste generation and management activities under this alternative and option case are further discussed in Section 4.2.14.2.

IDAHO REUSE OPTION

No direct impact on surface-water resources is expected from constructing modifications to the existing SPF at INL's MFC. Due to the relatively minor nature and duration of construction, the potential for stormwater runoff from construction areas to impact downstream surface-water quality is low. Surface-water drainages in the vicinity of the MFC are poorly defined and ephemeral, while infiltration to the subsurface is relatively rapid on unconsolidated sediment. Further, the closest major surface-water drainage is more than 20 kilometers (12 miles) west of the MFC. Any effect on runoff quality would likely be very localized and of short duration. Regardless, appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulch) and spill prevention practices and waste management would be employed as previously discussed for the Hanford Reuse Option. Specifically, in accordance with INL's General Permit for Storm Water Discharges from Construction Sites, the INL Storm Water Pollution Prevention Plan for Construction Activities provides for measures and controls to prevent pollution of stormwater from construction activities at INL (see Chapter 3, Section 3.3.6.1.1).

Operation of the modified Idaho SPF to process Hanford bulk sodium would result in no direct discharge of effluents to surface water or groundwater. Any wastewater generated from operation of the new facility would be discharged to existing treatment facilities that already service the MFC. Nonhazardous sanitary wastewater (sewage) would be managed via the existing site sanitary sewer system (ANL-W 2004:66, 67). Waste generation and management activities under this alternative and option case are further discussed in Section 4.2.14.2.

Overall water demands to implement this option would be less than those described for the Hanford Reuse Option. Projected water use under the Idaho Reuse Option and its impact on site utility infrastructure are further discussed in Section 4.2.2.2.1.3.

No impact on the INL vadose zone or groundwater is expected from operation of the modified SPF in the INL MFC. There would be no direct discharge of untreated effluents to surface water or groundwater as previously described. Waste generation and management activities under this alternative and option case are further discussed in Section 4.2.14.2.

4.2.6.3 Alternative 3: Removal

4.2.6.3.1 Surface Water, Vadose Zone, and Groundwater

4.2.6.3.1.1 Facility Disposition

Facility decommissioning activities under the Removal Alternative would have little or no impact on surface-water features or surface-water quality for the same reasons as previously described for the Entombment Alternative (see Section 4.2.6.2.1.1). Stormwater runoff and the potential for water-quality impacts would be somewhat greater under this alternative due to the greater area disturbed. Demolition-related land disturbance and stormwater runoff would also be similar to that described for the Entombment Alternative, except that the reactor vessel and other contaminated equipment would be removed for disposal at an IDF under this alternative rather than being left in place. While no engineered barrier would be constructed under this alternative, a slightly larger area (2.4 hectares [6.0 acres]) of the 400 Area would be regraded with topsoil, recontoured, and then revegetated. Nevertheless, application of the same soil erosion and sediment control measures and other practices described under the Entombment Alternative would apply under this alternative.

Any effluents generated during facility decommissioning would be managed as described for the Entombment Alternative (see Section 4.2.6.2.1.1). Waste generation and management activities under this alternative are further discussed in Section 4.2.14.3.

Potable and raw water demands to support decommissioning and closure activities would be very similar to those previously described for the Entombment Alternative. Projected water use under Alternative 3 and its impact on site utility infrastructure are discussed in Section 4.2.2.3.1.1.

Removal of the FFTF reactor vessel and other contaminated equipment from the RCB, along with other contaminated debris, is expected to have both short-term and long-term positive impacts on groundwater quality in the 400 Area because the major sources of residual contamination would not be available for release to the vadose zone and groundwater. Long-term impacts on water resources of this alternative, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.2.1.3.

4.2.6.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Impacts of this option on water resources would be the same as those discussed under Section 4.2.6.2.1.2 for the Hanford Option.

IDAHO OPTION

Impacts of this option on water resources would be the same as those discussed under Section 4.2.6.2.1.2 for the Idaho Option.

4.2.6.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Impacts of this option on water resources would be the same as those discussed under Section 4.2.6.2.1.3 for the Hanford Reuse Option.

IDAHO REUSE OPTION

Impacts of this option on water resources would be the same as those discussed under Section 4.2.6.2.1.3 for the Idaho Reuse Option.

4.2.7 Ecological Resources

4.2.7.1 Alternative 1: No Action

Under the No Action Alternative, the FFTF RCB (including RH-SCs), along with the rest of the buildings and structures within the 400 Area PPA, would remain in place. Sodium would be drained from FFTF and stored in the SSF within the 400 Area; other sodium would continue to be stored at current locations. Since FFTF would remain in place and existing facilities would be used for sodium storage, there would be no additional impact on terrestrial resources, wetlands, aquatic resources, or threatened and endangered species under this alternative.

Any waste to be disposed of under this alternative would be placed in trenches 31 and 34 of LLBG 218-W-5 or in IDF-East. Since there would be no need to excavate geologic material from Borrow Area C under this alternative, there would be no impact on ecological resources within the tract area.

4.2.7.2 Alternative 2: Entombment

4.2.7.2.1 Terrestrial Resources

4.2.7.2.1.1 Facility Disposition

Under the Entombment Alternative, FFTF and adjacent support facilities would be dismantled to below grade, and a 0.6-hectare (1.5-acre) engineered barrier would be placed over the site. Other facilities within the PPA would be dismantled to grade. After appropriate preparation, disturbed areas (including the barrier) would be revegetated. Vegetation placed over the barrier would include shallow-rooted species to prevent root penetration. The ultimate future use of the remaining portions of the PPA would determine how those areas would be revegetated. Since the site is located within an area designated Industrial, future development is a possibility. Thus, revegetation efforts under this alternative would likely seek to stabilize soil rather than recreate natural conditions. This stabilization approach would in turn limit wildlife use of the area. However, if future development is not planned, native plantings could be used, which would increase the ecological diversity of the area.

Debris and other waste not placed in the RCB or used as backfill would be transported to trenches 31 and 34 of LLBG 218-W-5 or to IDF-East. Similar to the No Action Alternative, impacts associated with construction and use of this IDF are addressed in Section 4.3.7.

The Entombment Alternative would require a limited amount of geologic material to be excavated from Borrow Area C. The amount of material required would necessitate the development of 2.8 hectares (7 acres) of Borrow Area C, which would have a minimal impact on terrestrial resources. Limited development should avoid the ecologically important needle-and-thread grass/Indian ricegrass community.

4.2.7.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, RH-SCs would be stored, treated, and disposed of at Hanford. Since storage facilities currently exist within the 200 Areas and are used for similar purposes, their use under this option would

not affect terrestrial resources. Treatment of RH-SCs would involve construction of a new RTP. This facility, which would be constructed in a disturbed portion of the 200-West Area at the T Plant complex, would occupy 0.1 hectares (0.3 acres) of land and would not impact terrestrial resources at Hanford. Treated components would be disposed of in IDF-East.

IDAHO OPTION

RH-SCs removed from the FFTF RCB would be stored at Hanford prior to shipment to INL, where they would be treated at a new RTP. The RTP would be built within a previously disturbed area of the MFC and would occupy 0.1 hectares (0.3 acres). Since this area is currently industrial in nature, the RTP would not impact terrestrial resources at the MFC or INL. Treated components would be returned to Hanford or sent to NTS for disposal. Since an existing waste site would be used at NTS there would be no impacts on terrestrial resources at the site. If returned to Hanford, waste would be placed in IDF-East.

4.2.7.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under the Hanford Reuse Option, sodium from FFTF would be sent to a new SRF to be built in the 400 Area. This facility would be constructed on less than 0.4 hectares (1 acre) of land within the already highly developed 400 Area near the SSF. Thus, there would be no impact on terrestrial resources within the 400 Area or at Hanford. Since treated sodium would be stored in an existing facility within the 200 Areas, again there would be no impact on terrestrial resources from this element of the Hanford Reuse Option.

IDAHO REUSE OPTION

Under this option, sodium from FFTF would be transported to INL for treatment in the SPF. The SPF is an existing facility within the MFC. Use of this facility would not alter existing terrestrial resources at the MFC or INL. There would also be no change in terrestrial resources at the 400 Area and 200 Areas at Hanford from implementation of this option since only existing facilities would be used.

4.2.7.2.2 Wetlands

4.2.7.2.2.1 Facility Disposition

Although the Entombment Alternative would involve removing aboveground portions of FFTF and dismantling associated buildings and structures, this alternative would not affect wetlands since these resources do not occur within either the 400 Area or 200 Areas. Neither disposal of waste at IDF-East nor excavation of 2.8 hectares (7 acres) of Borrow Area C would impact wetlands since none are present within these areas.

4.2.7.2.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

Actions involving the storage, treatment, and disposal of RH-SCs carried out under both options would not impact wetlands at either Hanford or INL since wetlands are not located within any of the areas affected by disposition activities.

4.2.7.2.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

Wetlands would not be affected by actions taken under either the Hanford or Idaho Reuse Options since none are located within any of the areas potentially impacted.

4.2.7.2.3 Aquatic Resources

4.2.7.2.3.1 Facility Disposition

Although the Entombment Alternative would involve removing aboveground portions of FFTF and dismantling associated buildings and structures, this alternative would not affect aquatic resources since these resources do not occur within either the 400 Area or 200 Areas. Neither disposal of waste at IDF-East nor excavation of 2.8 hectares (7 acres) of Borrow Area C would impact aquatic resources since none are present within these areas.

4.2.7.2.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

Actions involving the storage, treatment, and disposal of RH-SCs carried out under both options would not impact aquatic resources at Hanford or INL since aquatic resources are not located within any of the areas affected by disposition activities.

4.2.7.2.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

Aquatic resources would not be affected by actions taken under either the Hanford or Idaho Reuse Options since none are located within any of the areas potentially impacted.

4.2.7.2.4 Threatened and Endangered Species

4.2.7.2.4.1 Facility Disposition

Although the Entombment Alternative would involve removing aboveground portions of the FFTF RCB and dismantling associated buildings and structures, this alternative would not affect any special status species, including threatened and endangered species, since none have been recorded within the 400 Area.

Debris and other waste not placed in the RCB or used as backfill would be disposed of in IDF-East. Impacts associated with construction and operation of this IDF are addressed in Section 4.3.7.2.3.

As noted in Chapter 3, Section 3.2.7.4, surveys have identified Piper's daisy (state sensitive), stalked-pod milkvetch (state watch), crouching milkvetch (state watch), and the long-billed curlew (state monitor) within the boundaries of Borrow Area C. Although mitigation would not be required for the state watch or state monitor species, they should be considered during project planning. Impacts on state sensitive species, which are considered Level III resources under the *Hanford Site Biological Resources Management Plan*, would require mitigation. When avoidance and minimization are not possible or are insufficient, mitigation via rectification or compensation is recommended (DOE 2001b:4.9, 8.11). However, due to the limited land requirement under this alternative (i.e., 2.8 hectares [7 acres]), it is likely that impacts on listed species could be avoided. If impacts were likely to occur, a comprehensive mitigation action plan would be developed prior to construction (DOE 2003f:43).

4.2.7.2.4.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, RH-SCs would be stored, treated, and disposed of at Hanford. Since storage facilities currently exist within the 200 Areas and are used for similar purposes, their use under this option would not affect special status species. Treatment of RH-SCs would involve construction of a new RTP. Since this facility would be constructed in a disturbed portion of the 200-West Area at the T Plant complex, it would not impact any listed species. Treated components would be disposed of in IDF-East.

IDAHO OPTION

RH-SCs removed from the FFTF RCB would be stored at Hanford prior to shipment to INL, where they would be treated at a new RTP located within the MFC. Since this facility would be constructed in a disturbed portion of the MFC, its construction would not disturb any threatened or endangered species. Treated components would be returned to Hanford or sent to NTS for disposal. Since an existing waste site would be used at NTS, there would be no impact on threatened or endangered species at the site. If returned to Hanford, waste would be placed in IDF-East.

4.2.7.2.4.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under the Hanford Reuse Option, sodium from FFTF would be sent to a new SRF to be built in the 400 Area, and treated sodium would be stored in an existing facility within the 200 Areas. Since there are no special status species within either of these areas, there would be no impact under this option.

IDAHO REUSE OPTION

Under this option, sodium from FFTF would be transported to the MFC for treatment in the existing SPF. Use of this facility would not impact threatened and endangered species since none are found within the MFC. Also, there would be no impact on these species at Hanford since only existing facilities would be used.

4.2.7.3 Alternative 3: Removal

4.2.7.3.1 Terrestrial Resources

4.2.7.3.1.1 Facility Disposition

The Removal Alternative would result in the dismantlement and removal of the FFTF RCB and all associated buildings and structures within the PPA to or below grade. Since all contaminated equipment would be removed from the RCB, an engineered barrier would not be needed; instead, the area would be covered with soil, recontoured, and revegetated using native species. Overall, impacts on terrestrial resources from this alternative would be similar to those described for the Entombment Alternative (see Section 4.2.7.2.1.1); however, revegetation of the FFTF site would not be limited to shallow-rooted species since the facility would no longer be contaminated. Future industrial development would be the determining factor with regard to long-term restoration of the site.

Under this alternative, debris and other waste would be handled in the same manner as the Entombment Alternative (see Section 4.2.7.2.1.1). Impacts of the construction and use of IDF-East are addressed in Section 4.3.7.

The Removal Alternative would require a limited amount of geologic material to be excavated from Borrow Area C. The amount of material required would necessitate the development of 3.2 hectares (8 acres) of the area, which would have a minimal impact on terrestrial resources. Limited development should avoid the ecologically important needle-and-thread grass/Indian ricegrass community.

4.2.7.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

The steps involved in the disposition of RH-SCs under both the Hanford and Idaho Options for this alternative are identical to those of the Entombment Alternative. Thus, impacts on terrestrial resources from disposition-related activities would be the same as discussed under that alternative (see Section 4.2.7.2.1.2).

4.2.7.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

The steps involved in the processing of bulk sodium under both the Hanford Reuse and Idaho Reuse Options for this alternative are identical to those of the Entombment Alternative. Thus, impacts on terrestrial resources from processing activities would be the same as discussed under that alternative (see Section 4.2.7.2.1.3).

4.2.7.3.2 Wetlands

The steps involved in facility disposition, the disposition of RH-SCs, and the processing of bulk sodium under this alternative are identical to those of the Entombment Alternative. Further, there are no wetlands within any of the areas affected by these actions; thus, similar to the Entombment Alternative, there would be no impact on wetlands under this alternative or option cases.

4.2.7.3.2.1 Aquatic Resources

The steps involved in facility disposition, the disposition of RH-SCs, and the processing of bulk sodium under this alternative are identical to those of the Entombment Alternative. Further, there are no aquatic resources within any of the areas affected by these actions; thus, similar to the Entombment Alternative, there would be no impact on aquatic resources under this alternative or option cases.

4.2.7.3.3 Threatened and Endangered Species

4.2.7.3.3.1 Facility Disposition

This alternative would involve removing aboveground portions of the FFTF RCB and dismantling associated buildings and structures. Since no special status species, including threatened and endangered species, are found within the 400 Area, actions associated with facility disposition would not impact this group of organisms.

Debris and other waste not placed in the RCB or used as backfill would be disposed of in IDF-East. Impacts associated with construction and operation of this IDF are addressed in Section 4.3.7.2.3.

Potential impacts on sensitive species resulting from the removal of geologic material from Borrow Area C would be similar to those described in Section 4.2.7.2.4.1 since nearly the same land area would be affected.

4.2.7.3.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

The steps involved in the disposition of RH-SCs under both the Hanford and Idaho Options are identical to those of the Entombment Alternative. Further, since there are no threatened or endangered species within affected areas there would be no impact on this group of organisms from disposition-related activities (see Section 4.2.7.2.4.2).

4.2.7.3.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

The steps involved in processing bulk sodium under both the Hanford and Idaho Reuse Options are identical to those of the Entombment Alternative. Further, since there are no threatened or endangered species within affected areas, there would be no impact on this group of organisms from the sodium processing activities (see Section 4.2.7.2.4.3).

4.2.8 Cultural and Paleontological Resources

4.2.8.1 Alternative 1: No Action

Under the No Action Alternative, the FFTF RCB along with the other buildings in the FFTF PPA would remain in place. The current BLM Visual Resource Management Class IV rating for the 400 Area would not change, and there would be no change in appearance of the site. No geologic material would be excavated from Borrow Area C. Minimal volumes of waste to be disposed of would be placed within trenches 31 and 34 of LLBG 218-W-5 or in IDF-East. The use of these facilities would not change the overall visual appearance of the 200 Areas, as further described in Section 4.2.1.1.1.1.

4.2.8.1.1 Prehistoric Resources

As there would be no construction in areas not already in use, there would be no impact on prehistoric resources within this area.

4.2.8.1.1.1 Disposition of Remote-Handled Special Components

There are no known prehistoric resources in the 400 Area, which is considered an area of low archaeological sensitivity. Under the No Action Alternative, RH-SCs would remain in place within the FFTF RCB. Therefore, there would be no impact on prehistoric resources.

4.2.8.1.1.2 Disposition of Bulk Sodium

Under the No Action Alternative, FFTF sodium would be stored in the SSF, which is located in the 400 Area, and other bulk sodium would remain in place in the 200 Areas. There would be no impact on prehistoric resources.

4.2.8.1.2 Historic Resources

As there would be no construction in areas not already in use, there would be no impact on historic resources within this area.

4.2.8.1.2.1 Disposition of Remote-Handled Special Components

Under the No Action Alternative, RH-SCs would remain in place within the FFTF RCB. Therefore, there would be no impact on historic resources located in this area.

4.2.8.1.2.2 Disposition of Bulk Sodium

Under the No Action Alternative, FFTF sodium would be stored in the SSF, which is located in the 400 Area, and other bulk sodium would remain in place in the 200 Areas. There would be no impact on historic resources.

4.2.8.1.3 American Indian Interests

As there would be no construction in areas not already in use, and the overall visual appearance would not change, there would be no impact on American Indian interests within this area.

4.2.8.1.3.1 Disposition of Remote-Handled Special Components

The 400 Area is not known to contain any American Indian areas of interest. Under the No Action Alternative, RH-SCs would remain in place within the FFTF RCB. Therefore, there would be no impact on resources.

4.2.8.1.3.2 Disposition of Bulk Sodium

Under the No Action Alternative, FFTF sodium would be stored in the SSF, which is located in the 400 Area, and other bulk sodium would remain in place in the 200 Areas. There would be no impact on American Indian interests.

4.2.8.1.4 Paleontological Resources

As there would be no construction in areas not already in use, there would be no impact on paleontological resources within this area.

4.2.8.1.4.1 Disposition of Remote-Handled Special Components

No known paleontological resources have been reported in the 400 Area. Under the No Action Alternative, RH-SCs would remain in place within the FFTF RCB. Therefore, there would be no impact on paleontological resources.

4.2.8.1.4.2 Disposition of Bulk Sodium

Under the No Action Alternative, FFTF sodium would be stored in the SSF, which is located in the 400 Area, and other bulk sodium would remain in place in the 200 Areas. There would be no impact on paleontological resources.

4.2.8.2 Alternative 2: Entombment

4.2.8.2.1 Prehistoric Resources

4.2.8.2.1.1 Facility Disposition

Under this alternative, the FFTF RCB and adjacent support facilities would be dismantled, and a modified RCRA Subtitle C barrier would be placed over the site. The barrier would be revegetated, and the PPA

would become available for future development. The industrial designation of the 400 Area would not change. Facility disposition activities would not impact known prehistoric resources.

An estimated 2.8 hectares (7 acres) of Borrow Area C would be excavated for geologic material to support this alternative. Removal of this material would be consistent with the current site land use plan. If prehistoric resources were discovered during facility disposition in the 400 Area or excavation of geologic material from Borrow Area C, appropriate guidance set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g) would be implemented.

4.2.8.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Treatment of RH-SCs would involve construction of a new RTP adjacent to the T Plant complex in the 200-West Area. This facility would encompass 0.1 hectares (0.3 acres) of land. Prehistoric resources would not be disturbed by these activities. If prehistoric resources were discovered during construction of a new RTP, appropriate guidance set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g) would be implemented.

IDAHO OPTION

Under this option, RH-SCs would be stored at Hanford prior to shipment to INL, where they would be treated at a new RTP to be constructed in a developed portion of the MFC. Treated components would be returned to Hanford or sent to NTS for disposal where they would be placed in existing facilities. There would be no impact on prehistoric resources under this option. If prehistoric resources were discovered during construction of a new RTP, appropriate guidance set forth in the *Idaho National Laboratory Cultural Resource Management Plan* (DOE 2005) would be implemented.

4.2.8.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under this option, sodium from FFTF would be sent to a new SRF to be built in the already highly developed 400 Area. The treated sodium would be stored in an existing facility within the 200 Areas. There would be no impact on prehistoric resources under this option. If prehistoric resources were discovered during construction of a new SRF, appropriate guidance set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g) would be implemented.

IDAHO REUSE OPTION

Under this option, sodium from FFTF would be transported to INL for treatment in the SPF, an existing facility within the MFC. There would be no impact on prehistoric resources under this option.

4.2.8.2.2 Historic Resources

4.2.8.2.2.1 Facility Disposition

Facility disposition activities described in Section 4.2.8.2.1.1 are not expected to impact historic resources. Disturbed areas within the PPA would be revegetated, providing an overall improvement in the appearance of the 400 Area. The BLM Visual Resource Management Class IV rating of the 400 Area would remain unchanged due to other development in the immediate area.

Within Borrow Area C, excavation activities would impact the view from State Route 240 and nearby higher elevations. The BLM visual resource management rating would change from Class II to Class III.

4.2.8.2.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, both storage and disposal facilities exist within the 200 Areas. A new RTP would be constructed, requiring 0.1 hectares (0.3 acres) in a presently industrial area. If historic resources were discovered during construction, appropriate guidance set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g) would be implemented.

IDAHO OPTION

Under this option, RH-SCs removed from the FFTF RCB would be stored at Hanford prior to shipment to INL. A new RTP would be constructed in developed portions of the MFC. If historic resources were uncovered during construction, appropriate guidance set forth in the *Idaho National Laboratory Cultural Resource Management Plan* (DOE 2005) would be implemented.

4.2.8.2.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under this option, sodium from FFTF would be sent to a new SRF to be built in the already highly developed 400 Area. Sodium would be stored in an existing facility within the 200 Areas. If historic resources were uncovered during construction, appropriate guidance set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g) would be implemented.

IDAHO REUSE OPTION

Under this option, bulk sodium from FFTF and other sodium would be transported to INL for treatment in the existing SPF. There would be no impact on historic resources.

4.2.8.2.3 American Indian Interests

4.2.8.2.3.1 Facility Disposition

Under the Entombment Alternative, a limited area of 2.8 hectares (7 acres) would be excavated from Borrow Area C. Excavation activities would impact the view from State Route 240 and higher elevations, including Rattlesnake Mountain, an area of cultural significance to American Indians. The BLM visual resource management rating would change from Class II to Class III.

4.2.8.2.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, a new RTP in the 200-West Area would not affect American Indian interests. If artifacts of importance to American Indians were discovered during construction, procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g), which provides guidance for identifying, evaluating, recording, curating, and managing these resources, would be implemented.

IDAHO OPTION

Under this option, RH-SCs removed from the FFTF RCB would be stored at Hanford prior to shipment to INL. A new RTP would be constructed in developed portions of the MFC. There would be no impact on American Indian interests.

4.2.8.2.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under this option, a new SRF would be built in an already highly developed part of the 400 Area and therefore would have no visual impact. If artifacts of importance to American Indians were discovered during construction of the facility, appropriate guidance set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g) would be implemented.

IDAHO REUSE OPTION

As there would be no construction in areas not already in use at the MFC, there would be no impact on American Indian interests at INL.

4.2.8.2.4 Paleontological Resources

4.2.8.2.4.1 Facility Disposition

There would be no impact on paleontological resources under this alternative or options, as no such resources have been discovered within the affected areas. As is the case with other cultural resources, if any paleontological resources were discovered, procedures are in place to properly manage the discovery site.

4.2.8.2.4.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

There would be no impact on paleontological resources under this alternative or options, as no such resources have been discovered within the affected areas. As is the case with other cultural resources, if any paleontological resources were discovered, procedures are in place to properly manage the discovery site.

IDAHO OPTION

There would be no impact on paleontological resources under this alternative or options, as no such resources have been discovered within the affected areas. As is the case with other cultural resources, if any paleontological resources were discovered, procedures are in place to properly manage the discovery site.

4.2.8.2.4.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

There would be no impact on paleontological resources under this alternative or options, as no such resources have been discovered within the affected areas. As is the case with other cultural resources, if any paleontological resources were discovered, procedures are in place to properly manage the discovery site.

IDAHO REUSE OPTION

There would be no impact on paleontological resources under this alternative or options, as no such resources have been discovered within the affected areas. As is the case with other cultural resources, if any paleontological resources were discovered, procedures are in place to properly manage the discovery site.

4.2.8.3 Alternative 3: Removal

4.2.8.3.1 Prehistoric Resources

4.2.8.3.1.1 Facility Disposition

The Removal Alternative would result in the dismantlement and removal of the FFTF RCB and all associated buildings and structures within the PPA to or below grade. The area would be covered with soil, recontoured, and revegetated. The PPA would become available for future development. The Industrial designation of the 400 Area would not change.

An area of about 3.2 hectares (8 acres) would also be excavated from Borrow Area C to support activities under this alternative. Removal of this material would be consistent with the current site land use plan. If prehistoric resources were discovered during facility disposition in the 400 Area or excavation in Borrow Area C, appropriate guidance set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003g) would be implemented.

4.2.8.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

Activities under these options are identical to those of the Entombment Alternative. Therefore, there would be no impact on prehistoric resources.

4.2.8.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

Activities under these options are identical to those of the Entombment Alternative. Therefore, there would be no impact on prehistoric resources.

4.2.8.3.2 Historic Resources

4.2.8.3.2.1 Facility Disposition

Activities and potential impacts on historic resources would be similar to those described in Section 4.2.8.2.2.1 for the Entombment Alternative.

4.2.8.3.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

Disposition of RH-SCs under this option would not impact historic resources.

4.2.8.3.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

There are no known historic resources located within the areas that would be impacted by these options.

4.2.8.3.3 American Indian Interests

4.2.8.3.3.1 Facility Disposition

Activities and potential impacts on American Indian interests would be similar to those described in Section 4.2.8.2.2.1 for the Entombment Alternative.

4.2.8.3.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

There would be no impact on American Indian interests under these options for the same reasons as described in Section 4.1.8.2.3.2.

4.2.8.3.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

There would be no impact on American Indian interests under these options for the same reasons as described in Section 4.2.8.2.3.3.

4.2.8.3.4 Paleontological Resources

There would be no impact on known paleontological resources under this alternative or options as described in Section 4.2.8.2.4. No such resources have been discovered within the affected areas. As is the case with other cultural resources, if any paleontological resources were discovered, procedures are in place to properly manage the discovery site.

4.2.9 Socioeconomics

The primary or direct impacts of FFTF decommissioning and disposition on employment, regional demographics, housing and community services, and local transportation in both the Hanford and Idaho regions were analyzed for this section of the EIS. The potential primary impacts were set forth by analyzing projected changes in employment (in terms of FTEs) and truck activity related to the activities in each alternative (see Appendix I). The projected changes in employment and truck activity have the potential to generate economic impacts that may affect the need for housing units and public services and local transportation in both regions.

Key underlying assumptions used in projecting changes in employment for each of the FFTF Decommissioning alternatives and associated options are similar to those described in Section 4.1.9 for the Tank Closure alternatives. Impacts on local commuter traffic are determined by calculating the daily number of vehicles driving to and from work. The conservative assumption used for employees commuting to work in the Idaho region was that employees would commute in single-occupancy vehicles. As in the socioeconomics analysis for tank closure activities (see Section 4.1.9), it was assumed that Hanford employees would commute with an average of 1.25 passengers in each vehicle (Malley 2007). FFTF Decommissioning alternatives consist of three distinct activities: FFTF facility disposition, disposition of RH-SCs, and disposition of bulk sodium. Table 4–107 summarizes the indicators used to analyze the socioeconomic impacts under each activity.

Table 4–107. FFTF Decommissioning Alternatives and Options – Summary of Peak Estimated Socioeconomic Indicators

Alternatives and Options	Peak Annual Workforce[a] (Peak Year)	Peak Daily Commuter Traffic	Peak Daily Truck Loads (Peak Year)	
			Off Site	On Site
Alternative 1: No Action	1 (2008–2107)	1	Less than 1 (2008–2107)	0
Alternative 2: Facility disposition–Entombment	50 (2021)	40	3 (2017)	52 (2021)
Alternative 3: Facility disposition–Removal	85 (2013–2014)	68	2 (2013–2014)	63 (2021)
Disposition of RH-SCs (Hanford Option for remote treatment)	53 (2015–2016)	43	1 (2015–2016)	2 (2015–2016)
Disposition of RH-SCs (Idaho Option for remote treatment)	46 (2015–2016)	46	Less than 1 (2015–2016)	2 (2015–2016)
Disposition of bulk sodium (Hanford Reuse Option)	65 (2017)	52	Less than 1 (2015–2016)	Less than 1 (2015–2016)
Disposition of bulk sodium (Idaho Reuse Option)	55 (2015)	55	Less than 1 (2015)	Less than 1 (2014)

[a] Workforce is rounded into full-time equivalent quantities.

Note: Values presented in the table have been rounded to no more than two significant digits, where appropriate.

Key: RH-SCs=remote-handled special components.

Source: Appendix I; SAIC 2007b.

4.2.9.1 Alternative 1: No Action

Under Alternative 1, No Action, the total onsite employment of one FTE per year from 2008 through 2107 for the surveillance and maintenance period would have little or no impact on regional economic characteristics, the demographic characteristics, or housing and community services. In addition, the one truck trip per year along with a single commuter vehicle would have little or no impact on the local transportation in the Hanford ROI.

4.2.9.2 Alternative 2: Entombment

Under Alternative 2, employment activity for all three activities shown in Table 4–107 would be limited to the period from 2013 through 2021. No workforce estimate would be above 65 workers per year during the active years, followed by a single FTE needed for institutional controls through 2121. In addition to these direct employees associated with the closure and cleanup of FFTF, indirect positions would likely be created in the ROI. The impact on the region of both sources of jobs together would be small. The heaviest truck load activity would result from FFTF site regrading activities at Hanford.

4.2.9.2.1 Regional Economic Characteristics

4.2.9.2.1.1 Facility Disposition

The decommissioning and closure activities pertaining to facility disposition would require a peak workforce of 50 FTEs in 2021. By comparison, the labor force in the Hanford ROI is projected to be about 150,000 in 2021 (BEA 2007).

4.2.9.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Disposition of RH-SCs at Hanford under this option would require a peak workforce of 53 FTEs from 2015 through 2016. By comparison, the labor force in the Hanford ROI is projected to be about 138,000 in 2015 (BEA 2007).

IDAHO OPTION

Disposition of RH-SCs at INL under this option would require a peak workforce of 46 FTEs from 2015 through 2016. By comparison, the labor force in the Idaho ROI is projected to be about 178,000 in 2015 (BEA 2007).

4.2.9.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Processing bulk sodium at Hanford under this option would require a peak workforce of 65 FTEs in 2017. By comparison, the labor force in the Hanford ROI is projected to be about 142,000 in 2017 (BEA 2007).

IDAHO REUSE OPTION

Processing bulk sodium at INL under this option would require a peak workforce of 55 FTEs in 2015. By comparison, the labor force in the Idaho ROI is projected to be about 178,000 in 2015 (BEA 2007).

4.2.9.2.2 Demographic Characteristics

The majority of the peak decommissioning workforce would likely be drawn from the local labor force for each of the three activities, facility disposition, disposition of RH-SCs, and disposition of bulk sodium. There would likely be little in-migration of new workers and their families; thus, the demographic characteristics of the Hanford ROI and Idaho ROI would not be altered.

4.2.9.2.3 Housing and Community Services

For FFTF facility disposition, disposition of RH-SCs, and disposition of bulk sodium, the peak workforce required under this alternative would have little or no impact on the demand for housing, schools and other community services within the Hanford ROI or Idaho ROI.

4.2.9.2.4 Local Transportation

4.2.9.2.4.1 Facility Disposition

Under Alternative 2, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to 40 passenger vehicles per day are expected to commute to the site during the peak year of 2021. Based on predicted truck activity off site—up to 853 offsite truck trips per year (3 trips per day) in 2017—and predicted commuter traffic, the LOS on offsite roads in the Hanford area is not expected to change (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak in 2021, with up to 13,500 trips per year (52 trips per day) as a result of FFTF closure activities.

4.2.9.2.4.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under Alternative 2, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to 43 passenger vehicles per day are expected to commute to the site during the peak years of 2015 and 2016. Based on predicted truck activity off site—up to 272 offsite truck trips (1 truck trip per day) in 2015 and 2016—and predicted commuter traffic, the LOS on offsite roads in the Hanford area is not expected to change (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak in 2015 and 2016 with up to 545 trips per year (2 trips per day) as a result of the construction of the RTP.

IDAHO OPTION

Under Alternative 2, assuming an average of 1 person per passenger vehicle, up to 46 passenger vehicles per day are expected to commute to the site during the peak years of 2015 and 2016. Based on predicted truck activity off site—up to 125 offsite truck trips (less than 1 truck trip per day) in 2015 and 2016—and predicted commuter traffic, the LOS on U.S. Highway 20 in the INL area is not expected to change (see Chapter 3, Section 3.3.9.4). Onsite truck trips would peak in 2015 and 2016, with up to 540 trips per year (2 trips per day) as a result of the construction of the RTP.

4.2.9.2.4.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under Alternative 2, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to 55 passenger vehicles per day are expected to commute to the site during the peak year of 2017. Based on predicted truck activity off site—up to 35 offsite truck trips per year in 2015 and 2016—and predicted commuter traffic, the LOS on offsite roads in the Hanford area is not expected to change (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak in 2015 and 2016, with up to 23 trips per year as a result of the construction of the Hanford SRF.

IDAHO REUSE OPTION

Under Alternative 2, assuming an average of 1 person per passenger vehicle, up to 52 passenger vehicles per day are expected to commute to the site during the peak year of 2015. Based on predicted truck activity off site—up to 13 offsite truck trips per year in 2015—and predicted commuter traffic, the LOS on U.S. Highway 20 in the INL area is not expected to change (see Chapter 3, Section 3.3.9.4). Onsite truck trips would peak in 2014, with up to 13 trips per year as a result of the construction and operations of the INL SPF.

4.2.9.3 Alternative 3: Removal

Under Alternative 3, employment activity for all three activities shown in Table 4–107 would be limited to the period from 2012 through 2021. No workforce estimate would be above 85 workers per year during the active years, followed by a single FTE needed for institutional controls through 2121. In addition to these direct employees associated with the closure and cleanup of FFTF, indirect positions would likely be created in the ROI. The impact on the region of both sources of jobs together would be small. The heaviest truck load activity would result from FFTF site regrading activities at Hanford.

4.2.9.3.1 Regional Economic Characteristics

4.2.9.3.1.1 Facility Disposition

The decommissioning and closure activities pertaining to facility disposition would require a peak workforce of 85 FTEs from 2013 through 2014. By comparison, the labor force in the Hanford ROI is projected to be about 134,000 in 2013 (BEA 2007).

4.2.9.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Similar to the impacts under Alternative 2, disposition of RH-SCs at Hanford under this option would require a peak workforce of 53 FTEs from 2015 through 2016. By comparison, the labor force in the Hanford ROI is projected to be about 138,000 in 2015 (BEA 2007).

IDAHO OPTION

Similar to the impacts under Alternative 2, disposition of RH-SCs at INL under this option would require a peak workforce of 46 FTEs from 2015 through 2016. By comparison, the labor force in the Idaho ROI is projected to be about 178,000 in 2015 (BEA 2007).

4.2.9.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Similar to the impacts under Alternative 2, processing bulk sodium at Hanford under this option would require a peak workforce of 65 FTEs in 2017. By comparison, the labor force in the Hanford ROI is projected to be about 142,000 in 2017 (BEA 2007).

IDAHO REUSE OPTION

Similar to the impacts under Alternative 2, processing bulk sodium at INL under this option would require a peak workforce of 55 FTEs in 2015. By comparison, the labor force in the Idaho ROI is projected to be about 178,000 in 2015 (BEA 2007).

4.2.9.3.2 Demographic Characteristics

Similar to Alternative 2, this alternative would likely draw the majority of its peak workforce for each of the three activities, FFTF facility disposition, disposition of RH-SCs, and disposition of bulk sodium, from the local labor force. There would likely be little in-migration of new workers and their families; thus, the demographic characteristics of the Hanford ROI and Idaho ROI would not be altered.

4.2.9.3.3 Housing and Community Services

For each of the three activities, FFTF facility disposition, disposition of RH-SCs, and disposition of bulk sodium, the peak workforce required under this alternative would have little or no impact on the demand for housing, schools and other community services within the Hanford ROI or Idaho ROI.

4.2.9.3.4 Local Transportation

4.2.9.3.4.1 Facility Disposition

Under Alternative 3, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to 68 passenger vehicles per day are expected to commute to the site during the peak years of 2013 and 2014. Based on predicted truck activity off site—up to 448 offsite truck trips per year (2 trips per day)—and predicted commuter traffic, the LOS on offsite roads in the Hanford area is not expected to change (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak in 2021, with up to 16,400 trips per year (63 trips per day) as a result of FFTF closure activities.

4.2.9.3.4.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Similar to Alternative 2, assuming an average of 1.25 persons per passenger vehicle, up to 43 passenger vehicles per day are expected to commute to the site during the peak years of 2015 and 2016. Based on predicted truck activity off site—up to 272 offsite truck trips per year (1 truck trip per day) in 2015 and 2016—and predicted commuter traffic, the LOS on offsite roads in the Hanford area is not expected to change (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak in 2015 and 2016, with up to 545 trips per year (2 trips per day) as a result of the construction of the RTP.

IDAHO OPTION

Similar to Alternative 2, assuming an average of 1 person per passenger vehicle, up to 46 passenger vehicles per day are expected to commute to the site during the peak years of 2015 and 2016. Based on predicted truck activity off site—up to 125 offsite truck trips per year (less than 1 truck trip per day) in 2015 and 2016—and predicted commuter traffic, the LOS on U.S. Highway 20 in the INL area is not expected to change (see Chapter 3, Section 3.3.9.4). Onsite truck trips would peak in 2015 and 2016, with up to 540 trips per year (2 trips per day) as a result of the construction of the RTP.

4.2.9.3.4.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Similar to Alternative 2, assuming an average of 1.25 persons per passenger vehicle, up to 52 passenger vehicles per day are expected to commute to the site during the peak year of 2017. Based on predicted truck activity off site—up to 35 offsite truck trips per year in 2015 and 2016—and predicted commuter traffic, the LOS on offsite roads in the Hanford area is not expected to change (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak in 2015 and 2016, with up to 23 trips per year as a result of the construction of the Hanford SRF.

IDAHO REUSE OPTION

Similar to Alternative 2, assuming an average of 1 person per passenger vehicle, up to 55 passenger vehicles per day are expected to commute to the site during the peak year of 2015. Based on predicted truck activity off site—up to 13 offsite truck trips per year in 2015—and predicted commuter traffic, the LOS on U.S. Highway 20 in the INL area is not expected to change (see Chapter 3, Section 3.3.9.4). Onsite truck trips would peak in 2014, with up to 13 trips per year as a result of the construction and operations of the INL SPF.

4.2.10 Public and Occupational Health and Safety—Normal Operations

Details of the assessment methodology for determining radiation exposure to workers and members of the public are presented in Appendix K. Radiological impacts are presented for three public receptors: the general population living within 80 kilometers (50 miles) of the site (either Hanford or INL), an MEI living near the site boundary, and an onsite MEI. Impacts on the general population are evaluated for a residential scenario whereby people are exposed to radioactive materials emitted from project facilities. Radiation exposure occurs through inhalation, direct exposure to the radiological plume and material deposited on the ground, and ingestion of contaminated food products from animals raised locally and fruits and vegetables grown in a family garden (DOE 1995:A-7). Impacts on the MEI are evaluated for a scenario that includes the same exposure pathways assumed for the general population, but with an increased amount of time spent outdoors and a higher rate of contaminated food consumption. Impacts on the onsite MEI, a worker at the Columbia Generating Station or LIGO, are evaluated for inhalation and exposure to the radiological plume and material deposited on the ground. Doses are presented as the total effective dose equivalent.

In addition to members of the public, workers directly involved in the activities associated with each alternative and nearby noninvolved workers may receive radiological doses. Doses to an involved worker are calculated based on an FTE employee. It is assumed for purposes of this dose evaluation that an FTE worker has a 2,080-hour work year. In practice, the number of workers who receive a radiation dose may be larger than the number assumed in this analysis, resulting in a smaller average dose per worker. A noninvolved worker is a person working at the site who is incidentally exposed due to the radiological air emissions associated with the alternatives considered. The noninvolved worker is assumed to be about 100 meters (110 yards) away or at a nearby facility and is assumed to be there on a daily basis.

Impacts of FFTF deactivation were previously evaluated in the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington (FFTF Deactivation EA)* (DOE 2006b). Those impacts included negligible doses to the public and conservatively estimated (overestimated) worker doses from the removal and treatment of sodium-contaminated equipment from the facility. Impacts of FFTF deactivation are assumed to occur independent of the actions evaluated in this EIS and are not included in the impacts of FFTF Decommissioning alternatives. However, deactivation impacts are discussed in the following section for perspective.

Very small radiological impacts on the public would be expected from any of the FFTF Decommissioning alternatives. The options to disposition RH-SCs and bulk sodium at Hanford would have slightly higher offsite impacts than the options to perform these activities at INL. Implementing either the Entombment Alternative or the Removal Alternative would result in relatively small incremental worker doses over those estimated for deactivation activities, with the Removal Alternative having the higher dose. Worker doses from RH-SC and bulk sodium processing vary only slightly between the options of performing the work at Hanford or at INL.

4.2.10.1 Alternative 1: No Action

4.2.10.1.1 Radiological Impacts on the Public

As discussed in Section 4.2.10, the *FFTF Deactivation EA* evaluated impacts of removing equipment and piping and processing the residual sodium. The document conservatively assumed that all of the tritium contamination in the sodium was released to the environment, and the resulting dose to an MEI was estimated to be about 0.00026 millirem per year (DOE 2006b). Based on the extremely low dose to the MEI, doses to the offsite population would be very small and insubstantial. Completion of the FFTF deactivation activities is the assumed starting point of the alternatives evaluated in this EIS.

In contrast to the FFTF deactivation activities, under the No Action Alternative's 100 years of administrative control, no equipment- or building-disturbing activities would occur, so no substantive radiological air emissions would be expected. Therefore, no doses to the public would be expected.

4.2.10.1.2 Radiological Impacts on Workers

Worker doses would occur during the administrative control period. The worker population dose from deactivation activities was conservatively estimated to be about 576 person-rem (DOE 2006b). No additional LCFs would be expected in the worker population as a result of the deactivation activities.

Table 4–108 presents dose and risk estimates for a worker involved in the 100 years of administrative control. The average annual FTE radiation worker dose would be 50 millirem, less than the Administrative Control Level of 500 millirem. A radiation worker who received the average annual dose over his or her career (assumed to be 40 years) would receive a dose of 2,000 millirem, which corresponds to a risk of 1×10^{-3} (1 chance in 1,000) of developing an LCF.

Table 4–108. FFTF Decommissioning Alternative 1 Radiological Impacts on Workers

	Life-of-Project Worker Population		Average Annual Involved Full-Time Equivalent Worker		Annual Noninvolved Worker	
Activity	Dose (person-rem)	Latent Cancer Fatalities[a]	Dose (millirem per year)	Latent Cancer Fatality Risk[b]	Dose (millirem per year)	Latent Cancer Fatality Risk[b]
Administrative Control	1	0 (6×10^{-4})	50	3×10^{-5}	–	–

a The reported value is the projected number of latent cancer fatalities (LCFs) in the worker population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

b The lifetime risk that the worker would develop an LCF based on the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Appendix K, Section K.2.2.

Table 4–108 also shows the estimated collective worker dose for the 100-year administrative control period. The dose to the worker population would be about 1 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, no LCFs would be expected as a result of the dose associate with this activity.

The *FFTF Deactivation EA* estimated the dose to a noninvolved worker assumed to be 100 meters (110 yards) away during deactivation activities to be 0.16 millirem per year (DOE 2006b); a noninvolved worker beyond the vicinity of FFTF (for example, at the 300 Area) would receive a dose closer to that of the MEI—0.00026 millirem per year. There would be no potential dose to a noninvolved worker during the administrative control period because noninvolved workers would not be present in the area around FFTF and there would be no radiological air emissions related to maintaining FFTF that could affect workers in other areas of the site.

4.2.10.2 Alternative 2: Entombment

4.2.10.2.1 Radiological Impacts on the Public

Radiological impacts of deactivation activities, as discussed in Section 4.2.10.1, would occur independent of FFTF Decommissioning alternatives. Those activities are estimated to result in an MEI dose of 0.00026 millirem per year and no measurable increase in the collective offsite population dose. The following sections address the radiological doses and risks of the activities associated with this

alternative. Table 4–109 presents public dose and risk estimates from disposition of FFTF, RH-SCs, and bulk sodium. The population dose in the table is for the entire duration of the activity, whereas the MEI dose is for the year of maximum impact.

Table 4–109. FFTF Decommissioning Alternative 2 Radiological Impacts on the Public

Activity	Offsite Population		Maximally Exposed Individual	
	Life-of-Project Dose (person-rem)	Latent Cancer Fatalities[a]	Maximum Annual Dose (millirem per year)	Latent Cancer Fatality Risk[b]
Facility Disposition	0.000001	0 (6×10^{-10})	0.00000003	2×10^{-14}
Disposition of Remote-Handled Special Components				
Hanford Option	0.00014	0 (8×10^{-8})	0.0000016	1×10^{-12}
Idaho Option	0.000011	0 (7×10^{-9})	0.0000014	8×10^{-13}
Disposition of Bulk Sodium				
Hanford Reuse Option	0.0072	0 (4×10^{-6})	0.00012	7×10^{-11}
Idaho Reuse Option	0.00042	0 (3×10^{-7})	0.000045	3×10^{-11}

[a] The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[b] The lifetime risk that the maximally exposed individual would develop an LCF based on the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.2.

4.2.10.2.1.1 Facility Disposition

Grouting of belowground structures while preparing FFTF for entombment would result in small amounts of radiological air emissions. The population dose as a result of these emissions would be extremely small, 0.000001 person-rem. No excess LCFs would be expected to occur in the offsite population as a result of this small dose. The maximum annual MEI dose from facility disposition activities would be about 0.00000003 millirem, which would result in essentially no additional risk of an LCF (a risk of much less than 1 in a million). The dose and risk to an onsite MEI would be less than those estimated for the MEI; this is because the onsite MEI would be exposed for a shorter time (only during the workday) and through fewer pathways (e.g., no ingestion pathway).

4.2.10.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Processing of RH-SCs to remove the sodium and prepare them for disposal would result in radiological air emissions and a potential dose to the public, primarily from cesium-137. Under the option of performing this work in a new RTP located in the Hanford 200-West Area, the offsite population would receive a collective dose of 0.00014 person-rem. This dose would be received over the 2-year period in which the RTP is operated and decommissioned. No additional LCFs would be expected in the offsite population as a result of this activity. The maximum annual dose to an MEI of 0.0000016 millirem would occur during the year in which the RH-SCs are processed. There would be essentially no risk of developing an LCF from this dose (a risk of much less than 1 in a million). The dose and risk to an onsite MEI would be less than those estimated for the MEI; this is because the onsite MEI would be exposed for a shorter time (only during the workday) and through fewer pathways (e.g., no ingestion pathway).

IDAHO OPTION

Under the option of processing the RH-SCs at the INL RTP, the projected offsite population dose would be 0.000011 person-rem. The lower projected dose is due to a smaller exposed population and differences in population distribution and meteorology between Hanford and INL. No LCFs would be expected in the population as a result of this dose. The maximum annual dose to an MEI would be 0.0000014 millirem, which would result in essentially no additional risk of an LCF (a risk of much less than 1 in a million).

4.2.10.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Processing the bulk sodium at a new SRF near FFTF would result in airborne releases of tritium, cesium-137, and uranium isotopes that occur as contaminants in the sodium. Under this option, the offsite population would receive a collective dose of 0.0072 person-rem over the 3 years of processing the sodium and decommissioning the facility. No additional LCFs would be expected in the offsite population as a result of this activity. The maximum annual dose to an MEI of 0.00012 millirem would occur during the years in which the sodium is processed. There would be essentially no risk of developing an LCF from this dose (a risk of much less than 1 in a million). The dose and risk to an onsite MEI would be less than those estimated for the MEI.

IDAHO REUSE OPTION

Under the option of processing bulk sodium at INL, the offsite population and MEI doses would be lower than those under the Hanford Reuse Option. The lower population dose is due to differences in total population, population distribution, and meteorology. The dose to the population received over the 3-year course of the activity would be 0.00042 person-rem. No additional LCFs would be expected in the offsite population as a result of this activity. The maximum annual MEI dose would be 0.000045 millirem; there would be essentially no risk of developing an LCF from this dose (a risk of much less than 1 in a million).

4.2.10.2.2 Radiological Impacts on Workers

Radiological impacts on workers from facility deactivation (activities that would occur prior to implementing an FFTF Decommissioning alternative) would be the same as discussed in Section 4.2.10.1.2. The worker population dose from deactivation would be about 576 person-rem. No additional LCFs would be expected in the worker population as a result of this dose (DOE 2006b). Radiological doses and risks under Alternative 2 are presented in Table 4–110. Worker population impacts presented in Table 4–110 are for the duration of the project; average worker impacts are for the year of maximum impact.

4.2.10.2.2.1 Facility Disposition

Worker doses would result from facility disposition activities associated with stabilizing FFTF in preparation for entombment. The worker population would receive a dose of 0.37 person-rem during the preparation activities. No additional LCFs would be expected in the worker population as a result of this dose. The average annual worker dose would be 100 millirem; this dose corresponds to an increased risk of an LCF of 6×10^{-5}, or about 1 chance in 17,000.

The dose to a noninvolved worker assumed to be in the Hanford 300 Area would be 0.00000000066 millirem for this activity. There would be essentially no risk of an LCF from this exposure.

Table 4–110. FFTF Decommissioning Alternative 2 Radiological Impacts on Workers

Activity	Life-of-Project Worker Population		Average Annual Involved Full-time Equivalent Worker		Annual Noninvolved Worker	
	Dose (person-rem)	Latent Cancer Fatalities[a]	Dose (millirem per year)	Latent Cancer Fatality Risk[b]	Dose (millirem per year)	Latent Cancer Fatality Risk[b]
Facility Disposition	0.37	0 (2×10^{-4})	100	6×10^{-5}	0.00000000066	4×10^{-16}
Disposition of Remote-Handled Special Components						
Hanford Option	1.2	0 (7×10^{-4})	20	1×10^{-5}	0.00019	1×10^{-10}
Idaho Option	1.2	0 (7×10^{-4})	20	1×10^{-5}	0.0000011	7×10^{-13}
Disposition of Bulk Sodium						
Hanford Reuse Option	3.7	0 (2×10^{-3})	39	2×10^{-5}	0.0000037	2×10^{-12}
Idaho Reuse Option	3.6	0 (2×10^{-3})	39	2×10^{-5}	0.000055	3×10^{-11}

[a] The reported value is the projected number of latent cancer fatalities (LCFs) in the worker population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[b] The lifetime risk that the worker would develop an LCF based on the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Appendix K, Section K.2.2.

4.2.10.2.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Processing of RH-SCs to remove the sodium and prepare them for disposal would result in a worker dose, primarily from cesium-137 contaminants. Under the Hanford Option, the worker population would receive a collective dose of 1.2 person-rem. This dose would be received over the 2-year period in which the RTP is operated and decommissioned. No additional LCFs would be expected in the worker population as a result of this activity. The maximum annual worker dose would occur during the year in which the RH-SCs are processed. The average worker dose in that year would be 20 millirem; this dose corresponds to an increased risk of an LCF of 1×10^{-5}, or less than 1 chance in 100,000.

The annual dose to a noninvolved worker assumed to be 100 meters (110 yards) away in the 200-West Area would be 0.00019 millirem for this activity. There would be essentially no risk of an LCF from this exposure.

IDAHO OPTION

Under the Idaho Option, in which RH-SCs are processed at the INL RTP, the involved worker doses and risks would be the same as those estimated for Hanford.

The annual dose to a noninvolved worker assumed to be about 100 meters (110 yards) away from the RTP at another facility in the MFC would be 0.0000011 millirem for this activity. There would be essentially no risk of an LCF from this exposure.

4.2.10.2.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Processing of bulk sodium would result in a worker dose from contaminants in the sodium, primarily tritium, cesium-137, and uranium isotopes. Under the option of processing the sodium at a new SRF near FFTF, the worker population would receive a collective dose of 3.7 person-rem. This dose would be received over the 3-year period in which the SRF is operated and decommissioned. No additional LCFs would be expected in the worker population as a result of this activity. The maximum annual worker dose would occur during the 2 years in which the sodium is being processed. The average annual worker dose in those years would be 39 millirem; this dose corresponds to an increased risk of an LCF of 2×10^{-5}, or less than 1 chance in 50,000.

The annual dose to a noninvolved worker assumed to be in the Hanford 300 Area would be 0.0000037 millirem for this activity. There would be essentially no risk of an LCF from this exposure.

IDAHO REUSE OPTION

Under the option of processing the sodium at the INL SPF, the projected collective worker doses would be slightly less than that estimated for Hanford because the SPF would not be decommissioned under this project, but rather would remain available for processing sodium from other sources. The worker population would receive a collective dose of 3.6 person-rem over the 3-year duration of the activity, and the average worker would receive a maximum annual dose of 39 millirem. No additional LCFs would be expected among the workers as a result of the dose, and the risk of an LCF in the average worker would be 2×10^{-5} (1 in 50,000).

The annual dose to a noninvolved worker assumed to be about 100 meters (110 yards) away at another facility in the MFC would be 0.000055 millirem for this activity. There would be essentially no risk of an LCF from this exposure.

4.2.10.3 Alternative 3: Removal

4.2.10.3.1 Radiological Impacts on the Public

Radiological impacts of deactivation activities, as discussed in Section 4.2.10.1, occur independent of all FFTF Decommissioning alternatives. Those activities are estimated to result in an MEI dose of 0.00026 millirem per year and no measurable increase in the collective offsite population dose. The following sections address the radiological dose and risks for the activities associated with this alternative. Table 4–111 presents the public dose and risk estimates for this alternative. The population dose in the table is for the entire duration of the activity, whereas the MEI dose is for the year of maximum impact.

4.2.10.3.1.1 Facility Disposition

Facility disposition would result in minimal releases of radioactivity and therefore negligible doses to the offsite public and the MEI. No substantive increase in exposure beyond that from other site activities is expected.

4.2.10.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Doses and risks to members of the public from disposition of the RH-SCs at Hanford would be the same under this alternative as under Alternative 2, Entombment.

IDAHO OPTION

Doses and risks to members of the public from disposition of the RH-SCs at INL would be the same under this alternative as under Alternative 2, Entombment.

Table 4–111. FFTF Decommissioning Alternative 3 Radiological Impacts on the Public

Activity	Offsite Population		Maximally Exposed Individual	
	Life-of-Project Dose (person-rem)	Latent Cancer Fatalities[a]	Maximum Annual Dose (millirem per year)	Latent Cancer Fatality Risk[b]
Facility Disposition	Negligible	0	Negligible	0
Disposition of Remote-Handled Special Components				
Hanford Option	0.00014	0 (8×10^{-8})	0.0000016	1×10^{-12}
Idaho Option	0.000011	0 (7×10^{-9})	0.0000014	8×10^{-13}
Disposition of Bulk Sodium				
Hanford Reuse Option	0.0072	0 (4×10^{-6})	0.00012	7×10^{-11}
Idaho Reuse Option	0.00042	0 (3×10^{-7})	0.000045	3×10^{-11}

a The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

b The lifetime risk that the maximally exposed individual would develop an LCF based on the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.2.

4.2.10.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Doses and risks to members of the public from processing the bulk sodium at Hanford would be same under this alternative as under Alternative 2, Entombment.

IDAHO REUSE OPTION

Doses and risks to members of the public from processing the bulk sodium at INL would be same under this alternative as under Alternative 2, Entombment.

4.2.10.3.2 Radiological Impacts on Workers

Radiological doses and risks under Alternative 2 are presented in Table 4–112. Worker population impacts presented in Table 4–112 are for the duration of the project; average worker impacts are for the year of maximum impact.

4.2.10.3.2.1 Facility Disposition

Dismantling FFTF would result in a collective worker dose of 6.3 person-rem. No additional LCFs would be expected in the worker population as a result of this dose. The average annual dose to an individual worker would be about 100 millirem per year; this dose correlates to a risk of 6×10^{-5}, or about 1 chance in 17,000 of an LCF.

Table 4–112. FFTF Decommissioning Alternative 3 Radiological Impacts on Workers

Activity	Life-of-Project Worker Population		Average Annual Worker Dose		Annual Noninvolved Worker	
	Dose (person-rem)	Latent Cancer Fatalities[a]	Dose (millirem per year)	Latent Cancer Fatality Risk[b]	Dose (millirem per year)	Latent Cancer Fatality Risk[b]
Facility Disposition	6.3	0 (4×10^{-3})	100	6×10^{-5}	–	–
Disposition of Remote-Handled Special Components						
Hanford Option	1.2	0 (7×10^{-4})	20	1×10^{-5}	0.00019	1×10^{-10}
Idaho Option	1.2	0 (7×10^{-4})	20	1×10^{-5}	0.0000011	7×10^{-13}
Disposition of Bulk Sodium						
Hanford Reuse Option	3.7	0 (2×10^{-3})	39	2×10^{-5}	0.0000037	2×10^{-12}
Idaho Reuse Option	3.6	0 (2×10^{-3})	39	2×10^{-5}	0.000055	3×10^{-11}

[a] The reported value is the projected number of latent cancer fatalities (LCFs) in the worker population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[b] The lifetime risk that the worker would develop an LCF based on the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.2.

4.2.10.3.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Worker doses and risks associated with disposition of the RH-SCs at Hanford would be same under this alternative as under Alternative 2, Entombment.

IDAHO OPTION

Worker doses and risks associated with disposition of the RH-SCs at INL would be the same under this alternative as under Alternative 2, Entombment.

4.2.10.3.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Worker doses and risks associated with processing the bulk sodium at Hanford would be same under this alternative as under Alternative 2, Entombment.

IDAHO REUSE OPTION

Worker doses and risks associated with processing the bulk sodium at INL would be same under this alternative as under Alternative 2, Entombment.

4.2.11 Public and Occupational Health and Safety—Facility Accidents

This section addresses potential impacts on workers and the public associated with potential accidents under the FFTF Decommissioning alternatives and associated options for dispositioning RH-SCs and for processing Hanford bulk sodium. For each FFTF Decommissioning alternative and applicable option, radiological impacts of postulated accident scenarios are quantified for an MEI living near Hanford, the offsite population as a whole, and a noninvolved worker. Hazardous chemical impacts are also evaluated. For an involved worker, accident consequences have not been quantified because the number and location of personnel relative to a postulated accident are not known. In the event of an accident involving

chemicals or radioactive materials, workers near an accident could be at risk of serious injury or fatality. Safety procedures, safety equipment, and protective barriers are typical features that would prevent or minimize worker impacts. Additionally, following initiation of accident/site emergency alarms, workers in adjacent areas of the facility would evacuate in accordance with the technical area and facility emergency operating procedures and training. Therefore, involved worker impacts are not discussed further relative to the FFTF Decommissioning alternatives. The impacts of selected intentional destructive act scenarios are addressed in Appendix K, Section K.3.11.

There would be no radiological accidents associated with facility construction in support of decommissioning and closure activities under any action alternative. Further, any hazardous chemical accidents associated with facility construction would be typical of those normally associated with industrial construction materials, hazards, and practices. Projected accident consequences of each FFTF Decommissioning alternative and its options for treating RH-SCs and processing bulk sodium are presented in the following sections. Details of the methodology for assessing the potential impacts on workers and the public associated with postulated accidents are presented in Appendix K, Section K.3.

4.2.11.1 Alternative 1: No Action

4.2.11.1.1 Radiological Impacts of Airborne Releases

Under FFTF Decommissioning Alternative 1, reasonably foreseeable accidents that could occur include a fire in the FFTF SSF, failure of the SSF tanks, and fires involving the Hallam Reactor and SRE sodium stored in the 200-West Area. These accidents all involve sodium that is stored at Hanford and could occur under any of the FFTF Decommissioning alternatives.

Table 4–113 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. The accident that would have the highest consequences if it were to occur is the Hanford sodium storage tank failure (accident HSTF1). Table 4–114 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur. The accidents listed in these tables were selected from a spectrum of accidents described in Appendix K, Section K.3. The selection process ensures that the accidents chosen for evaluation in this EIS represent the full range of impacts of reasonably foreseeable accidents that could occur at the facilities. The scenarios are attributed to a variety of initiating events, including aircraft crash, material defect, human error, and high winds. Each one might also be initiated by a seismic event of sufficient magnitude to cause severe damage to structures in which the sodium is stored. Thus, if any other accident not evaluated in this EIS were to occur, its impacts on workers and the public should be within the range of the impacts evaluated.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–114) is the SRE sodium fire (accident SRE1). For this accident, no LCFs would be expected in the population; the risk to the offsite population would be an increase of 3×10^{-9} per year in the likelihood of an LCF (i.e., about 1 in 300 million per year of a single LCF occurring in the population). For the offsite MEI, the increase in the likelihood of an LCF would be 3×10^{-13} per year (i.e., about 1 in 3 trillion per year). For a noninvolved worker 100 meters (110 yards) from the accident, the increase in the likelihood of an LCF would be 7×10^{-13} per year (i.e., about 1 in 1.4 trillion per year). For any involved or noninvolved worker closer than 100 meters (110 yards) to the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher.

Table 4–113. FFTF Decommissioning Alternatives – Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatality[c]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatality[c]
Sodium Storage Facility fire (SSF1)	0.000001	6×10^{-10}	0.048	0 (3×10^{-5})	0.00000034	2×10^{-10}
Hanford sodium storage tank failure (HSTF1)	0.0000011	6×10^{-10}	0.048	0 (3×10^{-5})	0.00000087	5×10^{-10}
Hallam Reactor sodium fire (HSF1)	0.00000000046	3×10^{-13}	0.0000059	0 (4×10^{-9})	0.00000000025	2×10^{-13}
Sodium Reactor Experiment sodium fire (SRE1)	0.000000045	3×10^{-11}	0.00058	0 (3×10^{-7})	0.00000011	7×10^{-11}

a The alphanumeric code following the accident's title (e.g., SSF1) corresponds with the code in the accident's description in Appendix K, Section K.3.5.

b Based on populations of 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area (SSF1 and HSTF1) and 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area (HSF1 and SRE1).

c Increased likelihood of latent cancer fatality for an individual, assuming the accident occurs.

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Source: Appendix K, Section K.3.7.2.

Table 4–114. FFTF Decommissioning Alternatives – Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Sodium Storage Facility fire (SSF1)	1×10^{-6}	6×10^{-16}	0 (3×10^{-11})	2×10^{-16}
Hanford sodium storage tank failure (HSTF1)	1×10^{-5}	6×10^{-15}	0 (3×10^{-10})	5×10^{-15}
Hallam Reactor sodium fire (HSF1)	2×10^{-5}	5×10^{-18}	0 (7×10^{-14})	3×10^{-18}
Sodium Reactor Experiment sodium fire (SRE1)	1×10^{-2}	3×10^{-13}	0 (3×10^{-9})	7×10^{-13}

a The alphanumeric code following the accident's title (e.g., SSF1) corresponds with the code in the accident's description in Appendix K, Section K.3.5.

b Increased risk of a latent cancer fatality to the individual.

c Based on populations of 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area (SSF1 and HSTF1) and 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area (HSF1 and SRE1).

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Source: Appendix K, Section K.3.7.2.

Under FFTF Decommissioning Alternative 1, the possibility of an accident involving the stored sodium inventory would exist for the entire 100 year period of analysis. For the accident with the largest consequence (accident HSTF1), over the life of the project the risk of a single LCF occurring in the offsite population would be 3×10^{-8}, the risk of an LCF to the MEI would be 6×10^{-13}, and the risk of an LCF to the noninvolved worker would be 5×10^{-13}.

4.2.11.1.2 Hazardous Chemical Impacts

During FFTF decommissioning activities including activities under FFTF Decommissioning Alternative 1, No Action, the only chemical capable of creating a significant airborne hazard resulting from an accidental release is sodium formerly used as a reactor coolant. Three inventories of bulk sodium are addressed. These inventories include FFTF bulk sodium stored in the SSF, Hallam Reactor sodium stored in the 2727-W Building, and SRE sodium stored in the South Alkali Metal Storage Modules in the 200-West Area. Under FFTF Decommissioning Alternative 1, bulk sodium inventories would be stored for the foreseeable future. Accidents involving the stored sodium could occur under any of the FFTF Decommissioning alternatives.

Bulk sodium in its solid or molten form does not represent a significant airborne hazard. However, metallic sodium reacts violently with a broad range of materials, including water. On contact with water it will ignite and produce hydrogen. Metallic sodium is highly flammable and may ignite spontaneously on exposure to moisture in the air. If sodium is burned in air, the resulting combustion byproducts are mostly sodium oxide, with a small percentage of sodium carbonate and a very small percentage of sodium hydroxide. Because of the ability of sodium oxide to react with water in the air (or in the human respiratory tract) to form sodium hydroxide, all of the sodium released from a fire is assumed to come off as sodium hydroxide.

Because the sodium metal is contaminated with radioactive material, any airborne release caused by a fire would cause radiological as well as chemical impacts. For each sodium fire scenario analyzed as part of the radiological impacts of facility accidents, there is also a chemical impact. Therefore, the accident scenarios analyzed in this section of the EIS are the same as those analyzed and described in Section 4.2.11.1.1.

A sodium fire produces an opaque, white plume. Contact with the plume in high concentrations near the source of release is immediately irritating and can cause burns to the upper respiratory tract, exposed skin, and surface of the eyes. The recognizable and characteristic dense white plume, coupled with the immediate and severe health effects, create a self-evacuation effect for personnel in proximity to a release.

Table 4–115 shows the estimated concentrations of particulate sodium hydroxide for each accident scenario analyzed. Since AEGL values have not been developed for sodium hydroxide, the American Industrial Hygiene Association Emergency Response Planning Guideline (ERPG) levels 2 and 3 will be compared to the concentrations at specific distances as an indicator of human health impact. The guideline levels for sodium hydroxide are 5 milligrams per cubic meter for ERPG-2 and 50 milligrams per cubic meter for ERPG-3 (Fluor Hanford 2006). The results indicate that for the Hanford sodium storage tank failure scenario, the ERPG-2 value is slightly exceeded beyond the site boundary. For the remaining scenarios, the ERPG-2 and ERPG-3 thresholds are not exceeded beyond the nearest site boundary. For the noninvolved worker 100 meters (110 yards) from an accident, both the ERPG-2 and ERPG-3 thresholds would be exceeded for all scenarios analyzed.

4.2.11.2 Alternative 2: Entombment

4.2.11.2.1 Radiological Impacts of Airborne Releases

4.2.11.2.1.1 Facility Disposition

The accidents associated with facility disposition under FFTF Decommissioning Alternative 2 are the same as those addressed in Section 4.2.11.1 under Alternative 1. All scenarios involve sodium stored at Hanford and could occur under any of the FFTF Decommissioning alternatives.

Table 4–115. Chemical Impacts of Fast Flux Test Facility Accidents at Hanford

Accident	Distance to Site Boundary (meters)	Release Rate (kg/hr)	ERPG-2[a]		ERPG-3[b]		Concentration (mg/m^3)	
			Limit (mg/m^3)	Distance to Limit (meters)	Limit (mg/m^3)	Distance to Limit (meters)	Noninvolved Worker at 100 meters	Site Boundary
Sodium Storage Facility fire (SSF1)	6,800	5,320	5	3,700	50	850	2,400	2.2
Hanford sodium storage tank failure (HSTF1)	6,800	13,800	5	7,350	50	1,520	6,200	5.6
Hallam Reactor sodium fire (HSF1)	4,300	531	5	855	50	233	240	0.41
Sodium Reactor Experiment sodium fire (SRE1)	3,500	141	5	395	50	113	63	0.14

[a] ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their ability to take protective action.

[b] ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

Note: To convert meters to yards, multiply by 1.0936; pounds to kilograms, by 2.2046.

Key: ERPG=Emergency Response Planning Guideline; kg/hr=kilograms per hour; mg/m^3=milligrams per cubic meter.

Source: Appendix K, Section K.3.9.2.

4.2.11.2.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

A postulated breach and fire involving RH-SCs could occur at Hanford during the removal, transport, or treatment of the component for disposal. For purposes of this analysis, the accident is assumed to involve the RH-SC containing the largest inventory of radioactivity, and the location of the accident is the 400 Area. Table 4–116 shows the consequences of the postulated accident for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the 400 Area) and a noninvolved worker 100 meters (110 yards) from the accident. Table 4–117 shows the accident risks, obtained by multiplying the accident's consequences by the likelihood (frequency, per year) that the accident would occur.

Table 4–116. Radiological Consequences of Accidents Under the Hanford Option for Disposition of Remote-Handled Special Components

Accident[a]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatality[c]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatality[c]
Remote-handled special component fire (RHSC1) at Hanford	0.00011	7×10^{-8}	4.4	0 (3×10^{-3})	0.0009	5×10^{-7}

[a] The alphanumeric code following the accident's title (i.e., RHSC1), corresponds with the code in the accident's description in Appendix K, Section K.3.5.

[b] Based on a population of 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area.

[c] Increased likelihood of latent cancer fatality for an individual, assuming the accident occurs.

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: Hanford=Hanford Site.

Source: Appendix K, Section K.3.7.2.

Table 4–117. Annual Cancer Risks from Accidents Under the Hanford Option for Disposition of Remote-Handled Special Components

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Remote-handled special component fire (RHSC1) at Hanford	1×10^{-2}	7×10^{-10}	0 (3×10^{-5})	5×10^{-9}

a The alphanumeric code following the accident's title (i.e., RHSC1), corresponds with the code in the accident's description in Appendix K, Section K.3.5.

b Increased risk of a latent cancer fatality to the individual.

c Based on a population of 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area.

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: Hanford=Hanford Site.

Source: Appendix K, Section K.3.7.2.

For this accident, no LCFs would be expected in the population; the risk to the offsite population would be an increase of 3×10^{-5} per year in the likelihood of an LCF (i.e., about 1 in 33,000 per year of a single LCF occurring in the population). For the offsite MEI, the increase in the likelihood of an LCF would be 7×10^{-10} per year (i.e., about 1 in 1.4 billion per year). For a noninvolved worker 100 meters (110 yards) from the accident, the increase in the likelihood of an LCF would be 5×10^{-9} per year (i.e., about 1 in 200 million per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. The removal of the RH-SCs would be accomplished in less than one year, however the components might be stored on site for several additional years pending construction of a treatment facility. The public would be at risk of exposure to radioactivity from an accident during that time. If the period of time from removal to completion of the treatment is assumed to be 5 years, the risk to the offsite population and onsite workers during the project period would be no increase (1×10^{-4}) in the number of LCFs occurring in the offsite population, a 3×10^{-9} increase in the likelihood of an LCF for the MEI, and a 3×10^{-8} increase in the likelihood of an LCF for the noninvolved worker.

IDAHO OPTION

A postulated breach and fire involving RH-SCs could occur at INL during the transport or treatment of the component. For purposes of this EIS analysis, the accident is assumed to involve the RH-SC containing the largest inventory of radioactivity, and the location of the accident is the MFC at INL. Table 4–118 shows the consequences of the postulated accident for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the MFC) and a noninvolved worker 100 meters (110 yards) from the accident. Table 4–119 shows the accident risks, obtained by multiplying the accident's consequences by the likelihood (frequency per year) that the accident would occur.

Table 4–118. Radiological Consequences of Accidents Under the Idaho Option for Disposition of Remote-Handled Special Components

Accident[a]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatality[c]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatality[c]
Remote-handled special component fire (RHSC1) at Idaho National Laboratory	0.0001	6×10^{-8}	0.25	0 (2×10^{-4})	0.0036	2×10^{-6}

a The alphanumeric code following the accident's title (i.e., RHSC1), corresponds with the code in the accident's description in Appendix K, Section K.3.5.

b Based on a population of 205,962 persons residing within 80 kilometers (50 miles) of the Materials and Fuels Complex.

c Increased likelihood of latent cancer fatality for an individual, assuming the accident occurs.

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Source: Appendix K, Section K.3.7.2.

Table 4–119. Annual Cancer Risks from Accidents Under the Idaho Option for Disposition of Remote-Handled Special Components

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Remote-handled special component fire (RHSC1) at Idaho National Laboratory	1×10^{-2}	6×10^{-10}	0 (2×10^{-6})	2×10^{-8}

a The alphanumeric code following the accident's title (i.e., RHSC1), corresponds with the code in the accident's description in Appendix K, Section K.3.5.

b Increased risk of a latent cancer fatality to the individual.

c Based on a population of 205,962 persons residing within 80 kilometers (50 miles) of the Materials and Fuels Complex.

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Source: Appendix K, Section K.3.7.2.

For this accident, no LCFs would be expected in the population; the risk to the offsite population would be an increase of 2×10^{-6} per year in the likelihood of an LCF (i.e., about 1 in 500,000 per year of a single LCF occurring in the population). For the offsite MEI, the increase in the likelihood of an LCF would be 6×10^{-10} per year (i.e., about 1 in 1.6 billion per year). For a noninvolved worker 100 meters (110 yards) from the accident, the increase in the likelihood of an LCF would be 2×10^{-8} per year (i.e., about 1 in 50 million per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. The removal of the RH-SCs would be accomplished in less than one year, however the components might be stored on site at INL for several additional years pending construction of a treatment facility. The public would be at risk of exposure to radioactivity from an accident throughout that time. If the period of time from arrival of the component at INL to completion of the treatment is assumed to be 5 years, the risk to the offsite population and onsite workers during the project period would be an increase of 8×10^{-6} in the likelihood of a single LCF occurring in the offsite population, an increase of 3×10^{-9} in the likelihood of an LCF for the MEI, and an increase of 1×10^{-7} in the likelihood of an LCF for the noninvolved worker.

4.2.11.2.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Processing the FFTF bulk sodium and the Hallam Reactor and SRE sodium in the 400 Area could result in accidents involving spills and fires comparable to those discussed under FFTF Decommissioning Alternative 1. Table 4–113 shows the consequences of the postulated set of accidents for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–114 shows the accident risks, obtained by multiplying each accident's consequences by the likelihood (frequency per year) that the accident would occur.

Under this option, the possibility of an accident involving the stored sodium inventory would exist for 13 years until the sodium is processed. For the accident with the highest consequences (accident HSTF1), over the life of the project, the risk of a single LCF occurring in the offsite population would be 4×10^{-9}, the risk of an LCF to the MEI would be 8×10^{-14}, and the risk of an LCF to the noninvolved worker would be 7×10^{-14}.

IDAHO REUSE OPTION

A spill from the INL SPF storage tank was analyzed to represent a severe potential accident arising from the Idaho Reuse Option. Table 4–120 shows the consequences of the postulated accident for the public (offsite MEI and the general population living within 80 kilometers [50 miles] of the facility) and a noninvolved worker 100 meters (110 yards) from the facility. Table 4–121 shows the accident risk, obtained by multiplying its consequences by the likelihood (frequency per year) that the accident would occur.

Table 4–120. Radiological Consequences of Accidents Under the Idaho Reuse Option for Disposition of Bulk Sodium

Accident[a]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatality[c]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatality[c]
INL Sodium Processing Facility storage tank failure (INLSPF1)	0.000000055	3×10^{-11}	0.0002	0 (1×10^{-7})	0.00000034	2×10^{-10}

[a] The alphanumeric code following the accident's title (i.e., INLSPF1), corresponds with the code in the accident's description in Appendix K, Section K.3.5.
[b] Based on a population of 205,962 persons residing within 80 kilometers (50 miles) of the Materials and Fuels Complex.
[c] Increased likelihood of latent cancer fatality for an individual, assuming the accident occurs.
[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: INL=Idaho National Laboratory.
Source: Appendix K, Section K.3.7.2.

For this accident no LCFs would be expected in the population; the risk to the offsite population would be an increase of 1×10^{-12} per year in the likelihood of an LCF (i.e., about 1 in 1 trillion per year of a single LCF occurring in the population). For the offsite MEI, the increase in the likelihood of an LCF would be 3×10^{-16} per year (i.e., about 1 in 3,000 trillion per year). For a noninvolved worker 100 meters (110 yards) from the accident, the increase in the likelihood of an LCF would be 2×10^{-15} per year (i.e., about 1 in 500 trillion per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher.

Table 4–121. Annual Cancer Risks from Accidents Under the Idaho Reuse Option for Disposition of Bulk Sodium

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
INL Sodium Processing Facility storage tank failure (INLSPF1)	1×10^{-5}	3×10^{-16}	0 (1×10^{-12})	2×10^{-15}

[a] The alphanumeric code following the accident's title (i.e., INLSPF1), corresponds with the code in the accident's description in Appendix K, Section K.3.5.
[b] Increased risk of a latent cancer fatality to the individual.
[c] Based on a population of 205,962 persons residing within 80 kilometers (50 miles) of the Materials and Fuels Complex.
[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: INL=Idaho National Laboratory.
Source: Appendix K, Section K.3.7.2.

Under the Alternative 2, Idaho Reuse Option, the possibility of an accident involving the stored sodium inventory would exist for 9 years while the sodium is stored at Hanford and for 2 years while the sodium is being processed at INL. For the accident with the largest consequence (accident HSTF1), for the duration of time that the sodium was stored at Hanford, the risk of a single LCF occurring in the offsite population would be 3×10^{-9}, the risk of an LCF to the MEI would be 5×10^{-14}, and the risk of an LCF to the noninvolved worker would be 5×10^{-14}. Once the material was transferred to INL, over the 2 years of processing, the risk of a single LCF occurring in the offsite population would be 2×10^{-12}, the risk of an LCF to the MEI would be 6×10^{-16}, and the risk of an LCF to the noninvolved worker would be 4×10^{-15}.

4.2.11.2.2 Hazardous Chemical Impacts

4.2.11.2.2.1 Facility Disposition

As described in Section 4.2.11.1.2, accidents involving the three inventories of bulk sodium could occur under any of the FFTF Decommissioning alternatives. Chemical impacts of the analyzed accident scenarios are presented in Table 4–115.

4.2.11.2.2.2 Disposition of Remote-Handled Special Components

Potential hazardous chemical impacts associated with disposition of RH-SCs under the Hanford Option and Idaho Option would be encompassed by those analyzed in Section 4.2.11.1.2 for facility disposition.

4.2.11.2.2.3 Disposition of Bulk Sodium

Potential hazardous chemical impacts associated with disposition of bulk sodium under the Hanford Reuse Option would be encompassed by those analyzed in Section 4.2.11.1.2. Chemical impacts associated with disposition of bulk sodium under the Idaho Reuse Option are shown in Table 4–122.

Table 4–122. Chemical Impacts of Accidents Under the Idaho Reuse Option for Disposition of Bulk Sodium

Accident	Distance to Site Boundary (meters)	Release Rate (kg/hr)	ERPG-2[a]		ERPG-3[b]		Concentration (mg/m^3)	
			Limit (mg/m^3)	Distance to Limit (meters)	Limit (mg/m^3)	Distance to Limit (meters)	Noninvolved Worker at 100 Meters	Site Boundary
INL Sodium Processing Facility storage tank failure (INLSPF1)	5,500	1,380	5	1,530	50	390	620	0.75

[a] ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

[b] ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

Note: To convert meters to yards, by 1.0936; kilograms to pounds, by 2.2046.

Key: ERPG=Emergency Response Planning Guideline; INL=Idaho National Laboratory; kg/hr=kilograms per hour; mg/m^3=milligrams per cubic meter.

Source: Appendix K, Section K.3.9.2.

4.2.11.3 Alternative 3: Removal

4.2.11.3.1 Radiological Impacts of Airborne Releases

4.2.11.3.1.1 Facility Disposition

The accidents associated with facility disposition under FFTF Decommissioning Alternative 3 are the same as those addressed in Section 4.2.11.1 under Alternative 1. All scenarios involve sodium stored at Hanford and could occur under any of the FFTF Decommissioning alternatives.

4.2.11.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Potential human health impacts of postulated radiological accidents would be the same as those discussed in Section 4.2.11.2.1.2 under the Hanford Option of FFTF Decommissioning Alternative 2.

IDAHO OPTION

Potential human health impacts of postulated radiological accidents would be the same as those discussed in Section 4.2.11.2.1.2 under the Idaho Option of FFTF Decommissioning Alternative 2.

4.2.11.3.1.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Potential human health impacts of postulated radiological accidents would be the same as those discussed in Section 4.2.11.2.1.3 under the Hanford Reuse Option of FFTF Decommissioning Alternative 2.

IDAHO REUSE OPTION

Potential human health impacts of postulated radiological accidents would be the same as those discussed in Section 4.2.11.2.1.3 under the Idaho Reuse Option of FFTF Decommissioning Alternative 2.

4.2.11.3.2 Hazardous Chemical Impacts

Potential human health impacts of postulated chemical release scenarios under FFTF Decommissioning Alternative 3, Removal, are expected to be the same as those described in Section 4.2.11.1.2 under the No Action Alternative.

4.2.11.3.2.1 Disposition of Remote-Handled Special Components

HANFORD OPTION AND IDAHO OPTION

Potential hazardous chemical impacts associated with disposition of the RH-SCs under the Hanford Option and Idaho Option would be encompassed by those analyzed in Section 4.2.11.1.2 for facility disposition.

4.2.11.3.2.2 Disposition of Bulk Sodium

HANFORD REUSE OPTION AND IDAHO REUSE OPTION

Potential hazardous chemical impacts associated with disposition of bulk sodium under the Hanford Reuse Option and Idaho Reuse Option would be encompassed by those analyzed in Section 4.2.11.2.2.3 for FFTF Decommissioning Alternative 2.

4.2.11.4 Intentional Destructive Acts

This section addresses potential impacts of intentional destructive acts during FFTF decommissioning. Release scenarios and impacts resulting from intentional destructive acts may be similar to a number of the accident scenarios analyzed in this EIS. An additional intentional destructive act scenario was also considered. This scenario would apply to Alternatives 2 and 3, which include removal of RH-SCs.

Explosion in FFTF Primary Cold Trap. An intentional destructive act was postulated whereby the FFTF primary cold trap, containing 2,700 liters (710 gallons) of sodium, 470 curies of cesium-137, and 70 curies of cobalt-60, is destroyed by an explosive or incendiary device during removal or handling. All of the radioactive material was assumed to aerosolize and be released to the atmosphere. Analysis results indicate that the radiological impacts would be about three times those calculated for the accident scenario that involves the same inventory of radioactive material (RHSC1, remote-handled special component fire). The resulting offsite population dose was estimated to be 12 person-rem, with no (7×10^{-3}) additional LCFs. The MEI dose would be 0.00029 rem, which corresponds to an increased risk of an LCF of 2×10^{-7}. The noninvolved worker dose would be 0.0096 rem, which corresponds to an increased risk of an LCF of 6×10^{-6}.

Impacts and mitigation of intentional destructive acts are discussed in more detail in Appendix K, Section K.3.11.

4.2.12 Public and Occupational Health and Safety—Transportation

A number of factors affect the risk of transporting radioactive materials. These factors are predominantly categorized as radiological impacts or nonradiological impacts. Radiological impacts are those associated with the accidental release of radioactive materials and the effects of low levels of radiation emitted during normal, or incident-free, transportation. Nonradiological impacts are those associated with transportation, regardless of the nature of the cargo, such as accidents resulting in death or injury when there is no release of radioactive material.

The impacts of incident-free, or routine, transportation and transportation accidents comprise transportation impacts. The impacts of incident-free transportation and transportation accidents can be radiological and nonradiological. Incident-free transportation impacts include radiological impacts on the public and workers from the radiation field surrounding the transportation package. Nonradiological impacts of potential transportation accidents include traffic accident fatalities. The impact of a specific radiological accident is expressed in terms of probabilistic risk, which is defined as the accident probability (i.e., accident frequency) multiplied by the accident consequences. The overall risk is obtained by summing the individual risks from all accident severities, irrespective of their likelihood of occurrence. The analysis of accident risks takes into account a spectrum of accidents ranging from high-probability accidents of low severity (e.g., fender bender) to hypothetical high-severity accidents that have a low probability of occurrence. Additional information is provided in Section 4.1.12, and further details on modeling and parameter selections are provided in Appendix H.

Table 4–123 provides the estimated number of shipments of various wastes under each alternative by waste type. A shipment is defined as the amount of waste transported on a single truck or a single railcar. The values presented for offsite shipments in Table 4–123 are the estimated truck transports for the Idaho Option of treating RH-SCs at INL and the Idaho Reuse Option of treating bulk sodium at INL. If the Idaho options are selected for disposition of RH-SCs and bulk sodium, the treated RH-SCs would either be shipped to NTS or transported back to Hanford for disposal, and the treated sodium in the form of 50 percent caustic solution would be transported back to Hanford.

Table 4–123. FFTF Decommissioning Alternatives – Estimated Number of Shipments

Alternative	Number of Shipments							
	Offsite Shipments[a]			Onsite Shipments				
	Sodium Metal	Caustic Solution	RH-SCs	Sodium Metal	Caustic Solution	RH-SCs	Reactor Vessel	Other Wastes[b]
1: No Action	0	0	0	0	0	0	0	NA
2: Entombment	78	191	9	13	191	5	0	6,310
3: Removal	78	191	9	13	191	5	1	6,329

[a] These are estimates for truck transports. Rail transports would be one-half of the values given.

[b] Other wastes include components and decommissioning waste transported to an IDF and to sanitary and hazardous landfills.

Key: IDF=Integrated Disposal Facility; NA=not analyzed; RH-SCs=remote-handled special components.

Source: Appendix H, Section H.7.2.

The FFTF Decommissioning action alternatives consist of three distinct activities: facility disposition, disposition of RH-SCs, and disposition of bulk sodium. Table 4–124 summarizes the risks of transportation under each type of disposition. The health impacts associated with the shipment of radioactive materials were calculated assuming that all offsite shipments are transported using either truck or rail. The impacts of each alternative would include those of activities in facility disposition and the range of options for treatment and disposition of RH-SCs and sodium. The discussions for each alternative would include a range of impacts of treating these materials at either Hanford or INL.

Table 4–124. FFTF Decommissioning Alternatives – Risks of Transporting Radioactive Waste

Disposition Activity	Location (Transport Mode)	Number of Shipments	Incident-Free				Accident		
			Crew		Population				
			Dose (person-rem)	Risk[a]	Dose (person-rem)	Risk[a]	Radiological Risk[a, b]	Non-radiological Risk[a]	One-Way Offsite Travel (10^5 km)
Facility disposition	Hanford (2)	6,310	c	c	c	c	c	0.00417	N/A
	Hanford (3)	6,330	0.033	2.0×10^{-5}	0.0025	1.5×10^{-6}	7.6×10^{-11}	0.00418	N/A
Disposition of RH-SCs	INL (T)	9	0.839	5.0×10^{-4}	0.330	2.0×10^{-4}	4.5×10^{-8}	0.00019	0.096
	INL (R)	5	0.170	1.0×10^{-4}	0.074	4.4×10^{-5}	4.5×10^{-8}	0.00035	0.060
	Hanford	5	0.032	1.9×10^{-5}	0.0048	2.9×10^{-6}	1.3×10^{-10}	0.0000029	N/A
Disposition of bulk sodium	INL (T)	269	3.52	2.1×10^{-3}	0.945	5.7×10^{-4}	4.2×10^{-8}	0.0052	2.60
	INL (R)	135	0.157	9.4×10^{-5}	0.171	1.0×10^{-4}	3.5×10^{-8}	0.022	1.43
	Hanford	204	0.115	6.9×10^{-5}	0.0112	6.7×10^{-6}	4.2×10^{-12}	0.000084	N/A

[a] Risk is expressed in terms of latent cancer fatalities, except for the nonradiological, where it refers to the number of accident fatalities.

[b] To calculate accident population dose (person-rem), divide the values in this column by 0.0006. For additional insight on how this dose is calculated, see the text in Section 4.1.12.

[c] Not analyzed because all waste is sanitary or hazardous (not radioactive).

Note: To convert kilometers to miles, multiply by 0.6214. Values presented in the table have been rounded to no more than three significant digits, where appropriate.

Key: 2=Alternative 2; 3=Alternative 3; Hanford=Hanford Site; INL=Idaho National Laboratory; km=kilometers; N/A=not applicable; R=rail transport; RH-SCs=remote-handled special components; T=truck transport.

Source: Appendix H, Section H.7.2.

Table 4–124 shows that under all alternatives, the dose to the population along the routes (see column 6 of Table 4–124: INL rows) is expected to be between the lowest expected dose of 0.074 person-rem, which is associated with the transport of RH-SCs to INL for treatment and disposal at NTS[4] using rail transport, and the highest expected dose of about 0.945 person-rem, associated with the transport of sodium metals to INL for treatment and return transport of caustic solutions to Hanford using trucks. The additional LCFs that are expected from such exposures to the general population would be very small for all activities, ranging from 4.5×10^{-5} to 5.7×10^{-4}. Similarly, the range of expected doses to the workers (see column 4 of Table 4–124: INL rows) would be 0.170 person-rem to 3.52 person-rem. Overall, the risks of transporting various radioactive materials under all alternatives are expected to result in zero fatalities.

The risks to different receptors under incident-free transportation conditions were estimated on a per-trip or per-event basis. This basis was used because it is unlikely that the same person would be exposed to multiple events; for those that could have multiple exposures, the dose over the duration of transportation activities could be calculated by multiplying by the number of events or trips. The maximum annual dose to a transportation worker would be administratively controlled to 100 millirem per year unless the individual is a trained radiation worker, in which case the administrative limit would be 2 rem per year (DOE Standard 1098-99). The dose to a person stuck in traffic next to a shipment of RH-SCs for 30 minutes was calculated to be 19 millirem. For a receptor who is a member of the public residing along a transportation route, the dose over the duration of transportation activities would depend on the number of truck or rail shipments passing a particular point and would be independent of the actual route being considered. The maximum dose to this resident, if all the materials are shipped along this route, would be less than 0.2 millirem for all action alternatives. Refer to Appendix H, Table H–13, for additional results.

[4] These materials could also be returned to Hanford. Use of NTS would maximize the impact.

Table 4–125 summarizes the impacts of transporting nonradioactive support materials required to construct new facilities, as well as materials required to treat RH-SCs and sodium and to transport decommissioned equipment to storage or burial locations. The construction materials considered include concrete, cement, sand/gravel/dirt, asphalt, steel, and piping, among others. The table shows the impacts in terms of total number of kilometers, accidents, and fatalities for all alternatives. The results in Table 4–125 indicate that for the FFTF Decommissioning alternatives, the potential for traffic fatalities is largest under Alternative 3. The absolute risk, however, is very small considering that the duration of the alternative is about 10 years.

Table 4–125. FFTF Decommissioning Alternatives – Estimated Impacts of Construction and Operational Material Transport

Alternatives/Options	Total Distance Traveled (kilometers)	Number of Accidents	Number of Fatalities
1: No Action	0.031×10^6	0.0038	0.0003
2: Entombment			
Facility disposition	1.83×10^6	0.23	0.015
Options at Hanford	0.35×10^6	0.043	0.003
Disposition of bulk sodium	0.039×10^6	0.005	0.0003
Disposition of RH-SCs	0.31×10^6	0.04	0.0026
Options at INL	0.18×10^6	0.02	0.0015
Disposition of bulk sodium	0.018×10^6	0.002	0.0001
Disposition of RH-SCs	0.16×10^6	0.020	0.0013
3: Removal			
Facility disposition	2.06×10^6	0.25	0.017
Options at Hanford[a]	0.35×10^6	0.043	0.003
Options at INL[b]	0.18×10^6	0.022	0.0015

[a] Options include disposition of bulk sodium and RH-SCs at Hanford. These activities are common to Alternatives 2 and 3.

[b] Options include disposition of bulk sodium and RH-SCs at INL. These activities are common to Alternatives 2 and 3.

Note: To convert kilometers to miles, multiply by 0.6214. Values presented in the table have been rounded to no more than three significant digits, where appropriate.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; RH-SCs=remote-handled special components.

Source: Appendix H, Section H.8.

4.2.12.1 Alternative 1: No Action

Under Alternative 1, the transportation impacts would be limited to the transport of materials between Hanford and local or regional locations in support of administrative and deactivation activities. The transportation impacts of these activities would be 31,000 kilometers (about 20,000 miles) traveled, 0 (0.0038) traffic accidents, and 0 (0.0003) traffic fatalities (see Table 4–125).

4.2.12.2 Alternative 2: Entombment

Under this alternative, if the treatment of RH-SCs and bulk sodium were to be performed at INL, about 140 offsite rail shipments would occur (see Table 4–124, INL (R) rows 4 and 7). If these materials were to be transported using trucks, about 278 offsite shipments would be made (see Table 4–124, INL (T) rows). In addition, 6,310 truck shipments would be made to transport decommissioning waste to onsite storage and burial grounds. The total distance traveled on public roads or rail carrying radioactive materials would range from 150,000 kilometers (93,200 miles) by rail to 270,000 kilometers (168,000 miles) by truck.

No offsite shipments are expected under the Hanford Option of treating RH-SCs or the Hanford Reuse Option of treating bulk sodium at Hanford. The number of onsite transports would be 6,519 truck shipments (see Table 4–124: Hanford, rows 1, 5, and 8).

4.2.12.2.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities under this alternative (both offsite and onsite shipments if the treatment of RH-SCs and bulk sodium occurs at INL, and onsite shipments only if treatment occurs at Hanford) has been estimated to range from 0.33 to 4.36 person-rem for treatment at INL and 0.15 person-rem for treatment at Hanford (see column 4 of Table 4–124). The total dose to the exposed population would range from 0.25 to 1.28 person-rem for treatment at INL and 0.016 person-rem for treatment at Hanford. Accordingly, incident-free transportation of radioactive material would result in maximums of 0 (2.6×10^{-3}) LCFs among transportation workers and 0 (7.7×10^{-4}) LCFs in the total affected population over the duration of the alternative.

4.2.12.2.1.1 Facility Disposition

Under this alternative, the irradiated components, such as reactor vessels, test assemblies and hardware, and Interim Examination and Maintenance cells, would be entombed. Aboveground contaminated materials would be transported to an IDF, and hazardous materials would be transported to offsite locations for disposal. Facility disposition waste would need about 6,310 truck shipments from FFTF to an IDF and an offsite hazardous waste facility (see Table 4–124).

4.2.12.2.1.2 Disposition of Remote-Handled Special Components

Two options for disposition of these materials are considered: treatment at Hanford or treatment at INL with the option of returning the treated material to Hanford or shipping it to NTS for disposal.

HANFORD OPTION

Treatment of RH-SCs at Hanford would require transporting the treated components to an IDF for disposal, and the caustic solution for onsite product reuse. This option would entail five onsite truck shipments, with a potential exposure of 0.032 person-rem to transportation workers and 0.0048 person-rem to the population. Accordingly, this option would result in 0 (1.9×10^{-5}) LCFs among transportation workers and 0 (2.9×10^{-6}) LCFs in the affected population.

IDAHO OPTION

This option would require four trucks or two rail shipments to transport RH-SCs to INL for treatment, and four trucks or two rail shipments to transport the treated components to Hanford or NTS for disposal. Transport to NTS would result in higher transportation risks, and therefore was included in the values presented in Table 4–124. This option would also require one truck transport of caustic solution from treated sodium within the RH-SCs to Hanford for product reuse. Potential doses to transportation workers and the general population from rail shipments are estimated to be 0.17 and 0.074 person-rem, respectively. Potential doses to transportation workers and the general population from truck shipments are estimated to be 0.84 and 0.33 person-rem, respectively. Accordingly, this option would result in a maximum of 0 (5.0×10^{-4}) additional LCFs among workers and 0 (2.0×10^{-4}) additional LCFs among the exposed population.

4.2.12.2.1.3 Disposition of Bulk Sodium

Two options for disposition of bulk sodium are considered: treatment at Hanford or treatment at INL, with the return to Hanford of treated sodium in the form of caustic sodium hydroxide solution.

HANFORD REUSE OPTION

Under this option, the bulk sodium would be treated at Hanford and the caustic solution would be transported across Hanford for onsite reuse. This option would entail 204 onsite shipments of bulk sodium and caustic sodium hydroxide solution, with a potential exposure of about 0.12 person-rem to transportation workers and 0.011 person-rem to the population. Accordingly, this option would result in 0 (6.9×10^{-5}) LCFs among transportation workers and 0 (6.7×10^{-6}) LCFs in the affected population.

IDAHO REUSE OPTION

This option would require 269 truck shipments or 135 rail shipments to transport bulk sodium to INL and return the caustic product to Hanford for reuse. The potential exposure to transportation workers and the general population is estimated to be about 0.16 and 0.17 person-rem, respectively, using rail shipments and about 3.52 and 0.945 person-rem, respectively, using truck shipments. Accordingly, this option would result in a maximum of 0 (2.1×10^{-3}) additional LCFs among workers and 0 (5.7×10^{-4}) additional LCFs among the exposed population.

4.2.12.2.2 Impacts of Accidents During Transportation

As stated earlier, two sets of analyses were performed for the evaluation of transportation accident impacts: impacts of maximum reasonably foreseeable accidents and impacts of all accident (total transportation accidents) severities, irrespective of their likelihood of occurrence.

For treatment options at INL, the maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) is a severe impact, high-temperature fire involving a shipment of sodium metal. The consequences of such an accident in terms of population dose in the rural, suburban, and urban zones are 0.22, 1.20, and 5.60 person-rem, respectively. The likelihood of occurrence of such consequences per transport is less than 1.3×10^{-6}, 2.5×10^{-7}, and 2.8×10^{-8} in rural, suburban, and urban zones, respectively. This accident could result in a dose of 0.0015 rem to an individual hypothetically exposed to the accident plume for 2 hours at a distance of 100 meters (330 feet), with a corresponding LCF risk of 9.0×10^{-7}.

Estimates of the total transportation accident risks under this alternative are a maximum radiological dose risk to the population of 0.00014 person-rem, resulting in 8.7×10^{-8} LCFs (see Table 4–124, INL, rows 3 and 6), and maximum traffic fatalities of 0 (0.022) (see Table 4–124, INL, rows 4 and 7). Nearly all of the radiological risks would result from shipping caustic solution to Hanford. These results indicate that accident risks are very small.

For treatment options at Hanford, the consequences of the most severe accidents are enveloped by those of facility accidents. Estimates of the total transportation accidents from onsite shipments are very small (see Table 4–124); the population dose is estimated to be 2.2×10^{-7} person-rem, resulting in 1.3×10^{-10} LCFs, and traffic accidents resulting in 0 (0.000087) fatalities (see Table 4–124, rows 5 and 8).

4.2.12.2.2.1 Facility Disposition

It is estimated that the accident risks during transport of decommissioning waste would have the potential to result in 0 (0.0042) traffic fatalities.

4.2.12.2.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, estimates of the total transportation accident risks are a maximum radiological dose risk to the population of 2.2×10^{-7} person-rem, resulting in 1.3×10^{-10} LCFs, and traffic accidents resulting in 0 (0.0000029) fatalities. These results indicate that accident risks are very small.

IDAHO OPTION

Under this option, estimates of the total transportation accident risks are a maximum radiological dose risk to the population of 0.000075 person-rem, resulting in 4.5×10^{-8} LCFs, and traffic accidents resulting in 0 (0.00035) fatalities. Nearly all of the radiological risks would result from shipping caustic solution to Hanford. These results indicate that accident risks are very small.

4.2.12.2.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Under this option, estimates of the total transportation accident risks are a maximum radiological dose risk to the population of 7.0×10^{-9} person-rem, resulting in 4.2×10^{-12} LCFs, and traffic accidents resulting in 0 (0.000084) fatalities. These results indicate that accident risks are very small.

IDAHO REUSE OPTION

Under this option, estimates of the total transportation accident risks are a maximum radiological dose risk to the population of 0.00007 person-rem, resulting in 4.2×10^{-8} LCFs, and traffic accidents resulting in 0 (0.022) fatalities. Most of the radiological risks would result from shipping caustic solution to Hanford. These results indicate that accident risks are very small.

4.2.12.2.3 Impacts of Construction and Operational Material Transports

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and feed materials for the production and transport of waste (e.g., grout, fly ash, containers, boxes, and canisters) were evaluated. The range of transportation impacts under this alternative would be 2.01 to 2.18 million kilometers (1.25 to 1.36 million miles) traveled, 0 (0.25 to 0.27) accidents, and 0 (0.017 to 0.018) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–125).

4.2.12.2.3.1 Facility Disposition

The impacts of transporting construction and operational material in support of facility disposition would be 1.83 million kilometers (1.14 million miles) traveled, 0 (0.23) accidents, and 0 (0.015) fatalities over the entire period.

4.2.12.2.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

The impacts of transporting construction and operational material in support of treatment of RH-SCs would be about 310,000 kilometers (about 190,000 miles) traveled, 0 (0.04) accidents, and 0 (0.0026) fatalities.

IDAHO OPTION

The impacts of transporting construction and operational material in support of treatment of RH-SCs would be about 160,000 kilometers (about 100,000 miles) traveled, 0 (0.020) accidents, and 0 (0.0013) fatalities.

4.2.12.2.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

The impacts of transporting construction and operational material in support of bulk sodium disposition would be about 39,000 kilometers (about 24,000 miles) traveled, 0 (0.005) accidents, and 0 (0.0003) fatalities.

IDAHO REUSE OPTION

The impacts of transporting construction and operational material in support of bulk sodium disposition would be about 18,000 kilometers (about 11,000 miles) traveled, 0 (0.002) accidents, and 0 (0.0001) fatalities.

4.2.12.3 Alternative 3: Removal

The majority of activities under this alternative are similar to those discussed under Alternative 2. This alternative would entail an additional 20 shipments of irradiated components such as reactor vessels, test assemblies and hardware, and Interim Examination and Maintenance cells to an IDF under facility disposition. These shipments would add a very small impact to the overall risks presented under Alternative 2 (see Table 4–124, Hanford, row 2).

Overall, if the treatment of sodium metals and RH-SCs were to be performed at INL, about 140 offsite rail shipments would occur (see Table 4–124, INL (R) rows). If these materials were to be transported using trucks, about 278 offsite shipments would be made (see Table 4–124, INL (T) rows). In addition, 6,330 truck shipments would be made to transport decommissioning waste to onsite storage and burial grounds. The total distance traveled carrying radioactive materials would range from 150,000 kilometers (93,200 miles) by rail to 270,000 kilometers (168,000 miles) by truck.

No offsite shipments would be expected under the Hanford Option of treating RH-SCs or the Hanford Reuse Option of treating bulk sodium at Hanford. The number of onsite transports would be 6,539 truck shipments (see Table 4–124, Hanford, rows 2, 5, and 8).

4.2.12.3.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all transportation activities under this alternative (both offsite and onsite shipments if treatment of RH-SCs and bulk sodium occurs at INL, and onsite only if treatment occurs at Hanford) has been estimated to range from 0.36 to 4.39 person-rem for treatment at INL and the estimated dose would be 0.18 person-rem for treatment at Hanford (see column 4 of Table 4–124). The total dose to the exposed population would range from 0.25 to 1.28 person-rem for treatment at INL and would be 0.019 person-rem for treatment at Hanford. Accordingly, incident-free transportation of radioactive material would result in a maximum of 0 (2.6×10^{-3}) LCFs among transportation workers and 0 (7.7×10^{-4}) LCFs in the total affected population over the duration of the alternative.

4.2.12.3.1.1 Facility Disposition

Under this alternative, the irradiated components, such as reactor vessels, test assemblies and hardware, and Interim Examination and Maintenance cells, as well other aboveground decommissioning waste

would be transported to an IDF and offsite locations for disposal. Facility disposition waste would need about 6,330 truck shipments from FFTF to an IDF and an offsite hazardous waste facility (see Table 4–124).

4.2.12.3.1.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

IDAHO OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

4.2.12.3.1.3 Disposition of Bulk Sodium

Two options for disposition of bulk sodium are considered: treatment at Hanford or treatment at INL, with the return to Hanford of treated sodium in the form of caustic sodium hydroxide solution.

HANFORD REUSE OPTION

Transportation risks for activities under this option are the same those under Alternative 2.

IDAHO REUSE OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

4.2.12.3.2 Impacts of Accidents During Transportation

For treatment options at INL, the maximum reasonably foreseeable offsite transportation accident under this Alternative 3 (with a probability of occurrence of more than 1 in 10 million per year) is similar to that provided under Alternative 2.

Estimates of the total transportation accident risks under this alternative are also similar to those described under Alternative 2. These results indicate the accident risks are very small.

For treatment options at Hanford, the consequences of the most severe transportation accident are enveloped by those of facility accidents. Estimates of the total transportation accidents from onsite shipments are very small (see Table 4–124); the population dose is estimated to be 3.5×10^{-7} person-rem, resulting in 2.1×10^{-10} LCFs.

4.2.12.3.2.1 Facility Disposition

It is estimated that the transport of decommissioning and irradiated component wastes would have the potential to result in 0 (0.0042) traffic fatalities. The total population dose from accidents involving irradiated materials is estimated to be 1.27×10^{-7} person-rem, resulting in 7.6×10^{-11} LCFs (see Table 4–124).

4.2.12.3.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Transportation risks for activities under this option are the same as to those under Alternative 2.

IDAHO OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

4.2.12.3.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

IDAHO REUSE OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

4.2.12.3.3 Impacts of Construction and Operational Material Transports

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and feed materials for the production and transport of waste (e.g., grout, fly ash, containers, boxes, and canisters) were evaluated. The range of transportation impacts under this alternative would be 2.24 to 2.41 million kilometers (1.28 to 1.30 million miles) traveled, 0 (0.28 to 0.30) accidents, and 0 (0.019 to 0.020) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–125).

4.2.12.3.3.1 Facility Disposition

The impacts of transporting construction and operational material in support of facility disposition would be about 2.06 million kilometers (1.28 million miles) traveled, 0 (0.25) accidents, and 0 (0.017) fatalities over the entire period.

4.2.12.3.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

IDAHO OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

4.2.12.3.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

IDAHO REUSE OPTION

Transportation risks for activities under this option are the same as those under Alternative 2.

4.2.13 Environmental Justice

4.2.13.1 Alternative 1: No Action

This section addresses potential short-term impacts on minority, American Indian, Hispanic or Latino, and low-income populations under FFTF Decommissioning Alternative 1. Because access to Hanford is

restricted to the public, the majority of impacts under this alternative would be associated with onsite activities and would not affect populations residing off site; thus the potential for environmental justice concerns is small. Resource areas that could be impacted and that may affect populations residing off site include public and occupational health and safety due to normal operations and facility accidents, and air quality.

Section 4.2.10.1.1 discusses short-term impacts on the public resulting from normal operations under FFTF Decommissioning Alternative 1. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

Under this alternative, radiological impacts on the public from normal operations would be minimal. Deactivation activities are expected to result in an insubstantial dose to the offsite population. The dose to the MEI is estimated to be 0.00026 millirem per year. Similarly, any dose received by an MEI located at the Yakama Reservation boundary would essentially be zero. Since the impacts on the offsite population would be negligible, Alternative 1 would not pose disproportionately high and adverse impacts on minority and low-income populations due to normal operations. These impacts would be common to all FFTF Decommissioning alternatives.

Section 4.2.11.1.1 discusses the radiological impacts of airborne releases for facility accidents under Alternative 1. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Alternative 1 would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts of facility accidents.

Section 4.2.11.1.2 discusses the hazardous chemical impacts of facility accidents under FFTF Decommissioning Alternative 1. The Hanford sodium storage tank failure scenario could result in a hazardous plume slightly exceeding the site boundary to the east of the 400 Area, but it would not be expected to reach the far side of the Columbia River. The potentially affected area is located in Franklin County, census tract 206.01, block group 2. This block group does not contain minority or low-income populations. Therefore, Alternative 1 would not pose disproportionately high and adverse impacts on minority or low-income populations due to hazardous chemical impacts of facility accidents.

Air quality impacts are discussed in Section 4.2.4.1. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.2.12.1 discusses the potential human health risks of transporting construction and operational materials between local or regional locations and Hanford. The impacts of transporting construction and operational materials to Hanford under this alternative would be very small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.2.13.2 Alternative 2: Entombment

This section addresses potential short-term impacts on minority, American Indian, Hispanic or Latino, and low-income populations under Alternative 2. Because access to Hanford is restricted to the public, the majority of impacts under this alternative would be associated with onsite activities and would not affect populations residing off site; thus the potential for environmental justice concerns is small. Resource areas that could be impacted and that may affect populations residing off site include public and occupational health and safety due to normal operations and facility accidents, and air quality.

4.2.13.2.1 Facility Disposition

Section 4.2.10.2.1 discusses short-term radiological impacts on the public resulting from normal operations under Alternative 2. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

Under this alternative, radiological impacts on the public from normal operations would be minimal. Impacts from deactivation activities would be the same as those described under the No Action Alternative in Section 4.2.13.1. For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the average individual dose to a member of the minority, American Indian, Hispanic or Latino, and low-income populations over the life of the project is compared to the average individual dose to a member of the remainder of the population over the life of the project. These results are presented in Appendix J. There are no appreciable differences in cumulative average individual doses. Therefore, facility disposition under the Entombment Alternative would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Section 4.2.10.2.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations of facility disposition under the Entombment Alternative. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. The maximum annual dose received by the MEI from the general population as a result of facility disposition activities would be about 3.0×10^{-8} millirem, which equates to no additional risk of an LCF. The dose to an MEI located at the boundary of the Yakama Reservation would be approximately two orders of magnitude lower than that of the MEI from the general population. Therefore, facility disposition activities under the Entombment Alternative would not pose disproportionately high and adverse impacts on minority or low-income populations.

Section 4.2.11.2.1.1 discusses the radiological impacts of airborne releases for facility accidents associated with facility disposition under the Entombment Alternative. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, facility disposition under the Entombment Alternative would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts of facility accidents.

Section 4.2.11.2.2.1 discusses the hazardous chemical impacts of accidents associated with facility disposition under the Entombment Alternative. The Hanford sodium storage tank failure scenario could

result in a hazardous plume slightly exceeding the site boundary to the east of the 400 Area, but it would not be expected to reach the far side of the Columbia River. The potentially affected area is located in Franklin County, census tract 206.01, block group 2. This block group does not contain minority or low-income populations. Therefore, facility disposition under the Entombment Alternative would not pose disproportionately high and adverse impacts on minority or low-income populations due to hazardous chemical impacts of facility accidents.

Air quality impacts of facility disposition under Alternative 2 are discussed in Section 4.2.4.2.1. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.2.12.2.2.1 discusses the potential human health risks of transportation related to facility disposition under the Entombment Alternative. The impacts of transporting contaminated and hazardous materials to offsite locations for disposal under this alternative would not be expected to result in any additional LCFs in the offsite population. The impacts of transporting construction and operational materials would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.2.13.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Section 4.2.10.2.1.2 discusses short-term radiological impacts on the public from normal operations associated with disposition of RH-SCs at Hanford. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the average individual dose to a member of the minority, American Indian, Hispanic or Latino, and low-income populations over the life of the project is compared to the average individual dose to a member of the remainder of the population over the life of the project. There are no appreciable differences in cumulative average individual doses. Therefore, disposition of RH-SCs at Hanford would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Section 4.2.10.2.1.2 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations from disposition of RH-SCs at Hanford. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. The maximum annual dose to the offsite MEI from disposition of RH-SCs would be about 1.6×10^{-6} millirem, which equates to essentially no additional risk of an LCF. The dose to an MEI located at the boundary of the Yakama Reservation would be approximately one order of magnitude lower than that of the MEI from the general population. Therefore, disposition of RH-SCs at Hanford would not pose disproportionately high and adverse impacts on minority or low-income populations.

Section 4.2.11.2.1.2 discusses the radiological impacts of airborne releases for facility accidents associated with disposition of RH-SCs at Hanford under the Entombment Alternative. Examination of the risks shows that the chance of an LCF in the offsite population would be low (approximately 2.6×10^{-5} per year). This risk includes minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, disposition of RH-SCs at Hanford under the Entombment Alternative would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts of facility accidents.

Section 4.2.11.2.2.2 discusses the hazardous chemical impacts of accidents associated with disposition of RH-SCs at Hanford under the Entombment Alternative. Potential impacts under this option would be encompassed by those analyzed in Section 4.2.13.2.1 under facility disposition.

Air quality impacts from disposition of RH-SCs at Hanford under Alternative 2 are discussed in Section 4.2.4.2.2. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.2.12.2.1.2 discusses the potential human health risks of transportation related to disposition of RH-SCs at Hanford under the Entombment Alternative. This option would not require any offsite shipments. Onsite shipments of treated components and caustic sodium hydroxide solution would not be expected to result in any additional LCFs in the offsite population. The impacts of transporting construction and operational materials would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

IDAHO OPTION

Section 4.2.10.2.1.2 discusses short-term radiological impacts on the public from normal operations associated with disposition of RH-SCs at INL. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the average individual dose to a member of the minority, American Indian, Hispanic or Latino, and low-income populations over the life of the project is compared to the average individual dose to a member of the remainder of the population over the life of the project. There are no appreciable differences in cumulative average individual doses. Therefore, disposition of RH-SCs at INL would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Section 4.2.10.2.1.2 discusses impacts on the offsite MEI located south-southeast of the MFC as a result of normal operations from disposition of RH-SCs at INL. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Fort Hall Reservation and an individual subsisting on fish and wildlife were evaluated. The maximum annual dose to the offsite MEI from disposition of RH-SCs would be about 1.4×10^{-6} millirem, which equates to essentially no additional risk of an LCF. The dose to an MEI located at the boundary of the Fort Hall Reservation would be approximately two orders of magnitude

lower than that of the offsite MEI. Therefore, disposition of RH-SCs at INL would not pose disproportionately high and adverse impacts on minority or low-income populations.

Section 4.2.11.2.1.2 discusses the radiological impacts of airborne releases for facility accidents associated with disposition of RH-SCs at INL under the Entombment Alternative. Examination of the risks shows that the chance of an LCF in the offsite population would be low (approximately 1.5×10^{-6} per year). This risk includes minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, disposition of RH-SCs at INL under the Entombment Alternative would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts from facility accidents.

Section 4.2.11.2.2.2 discusses the hazardous chemical impacts of accidents associated with disposition of RH-SCs at INL under the Entombment Alternative. Potential impacts under this option would be encompassed by those analyzed in Section 4.2.13.2.1 under facility disposition.

Air quality impacts from disposition of RH-SCs at INL under Alternative 2 are discussed in Section 4.2.4.2.2. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.2.12.2.1.2 discusses the potential human health risks of transportation related to disposition of RH-SCs at INL under the Entombment Alternative. The impacts of transporting RH-SCs between Hanford, INL, and NTS, and caustic sodium hydroxide solution from INL to Hanford for product reuse under this option would not be expected to result in any additional LCFs in the offsite population. The impacts of transporting construction and operational materials would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.2.13.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Section 4.2.10.2.1.3 discusses short-term radiological impacts on the public from normal operations associated with disposition of bulk sodium at Hanford. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the average individual dose to a member of the minority, American Indian, Hispanic or Latino, and low-income populations over the life of the project is compared to the average individual dose to a member of the remainder of the population over the life of the project. There are no appreciable differences in cumulative average individual doses. Therefore, disposition of bulk sodium at Hanford would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Section 4.2.10.2.1.3 discusses impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations from disposition of bulk sodium at Hanford. To explore

potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. The maximum annual dose to the offsite MEI from disposition of bulk sodium would be about 1.2×10^{-4} millirem, which equates to essentially no additional risk of an LCF. The dose to an MEI located at the boundary of the Yakama Reservation would be approximately one order of magnitude lower than that of the MEI from the general population. Therefore, disposition of bulk sodium at Hanford would not pose disproportionately high and adverse impacts on minority or low-income populations.

Section 4.2.11.2.1.3 discusses the radiological impacts of airborne releases for facility accidents associated with disposition of bulk sodium at Hanford under the Entombment Alternative. Examination of the risks shows that the chance of an LCF in the offsite population would be low (approximately 3.5×10^{-9} per year). This risk includes minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, disposition of bulk sodium at Hanford under the Entombment Alternative would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts from facility accidents.

Section 4.2.11.2.2.3 discusses the hazardous chemical impacts of accidents associated with disposition of bulk sodium at Hanford under the Entombment Alternative. Potential impacts under this option would be encompassed by those analyzed in Section 4.2.13.2.1 under facility disposition.

Air quality impacts from disposition of bulk sodium at Hanford under Alternative 2 are discussed in Section 4.2.4.2.3. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.2.12.2.1.3 discusses the potential human health risks of transportation related to disposition of bulk sodium at Hanford under the Entombment Alternative. This option would not require any offsite shipments. Onsite shipments of bulk sodium and caustic solution would not be expected to result in any additional LCFs in the offsite population. The impacts of transporting construction and operational materials would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

IDAHO REUSE OPTION

Section 4.2.10.2.1.3 discusses short-term radiological impacts on the public from normal operations associated with disposition of bulk sodium at INL. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the average individual dose to a member of the minority, American Indian, Hispanic or Latino, and low-income populations over the life of the project is compared to the average individual dose to a member of the remainder of the population over the life of the project. The cumulative average individual dose to minority, American Indian, Hispanic or Latino, and low-income individuals slightly exceeds the cumulative average individual dose to the remainder of the population; however there are no appreciable differences in cumulative average individual doses.

Therefore, disposition of bulk sodium at INL would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Section 4.2.10.2.1.3 discusses impacts on the offsite MEI located south-southeast of the MFC as a result of normal operations from disposition of bulk sodium at INL. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Fort Hall Reservation and an individual subsisting on fish and wildlife were evaluated. The maximum annual dose to the offsite MEI from disposition of bulk sodium would be about 4.5×10^{-5} millirem, which equates to essentially no additional risk of an LCF. The dose to an MEI located at the boundary of the Fort Hall Reservation would be approximately one order of magnitude lower than that of the offsite MEI. Therefore, disposition of bulk sodium at INL would not pose disproportionately high and adverse impacts on minority or low-income populations.

Section 4.2.11.2.1.3 discusses the radiological impacts of airborne releases for facility accidents associated with disposition of bulk sodium at INL under the Entombment Alternative. Examination of the risks shows that the chance of an LCF in the offsite population would be low (approximately 1.2×10^{-12} per year). This risk includes minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, disposition of bulk sodium at INL under the Entombment Alternative would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts from facility accidents.

Section 4.2.11.2.2.3 discusses the hazardous chemical impacts of accidents associated with disposition of bulk sodium at INL under the Entombment Alternative. Potential impacts under this option would be encompassed by those analyzed in Section 4.2.13.2.1 under facility disposition.

Air quality impacts from disposition of bulk sodium at INL under Alternative 2 are discussed in Section 4.2.4.2.3. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.2.12.2.1.3 discusses the potential human health risks of transportation related to disposition of bulk sodium at INL under the Entombment Alternative. The impacts of transporting bulk sodium from Hanford to INL, and caustic sodium hydroxide solution from INL back to Hanford for product reuse under this option would not be expected to result in any additional LCFs in the offsite population. The impacts of transporting construction and operational materials would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.2.13.3 Alternative 3: Removal

This section addresses potential short-term impacts on minority, American Indian, Hispanic or Latino, and low-income populations under FFTF Decommissioning Alternative 3. Because access to Hanford is restricted to the public, the majority of impacts under this alternative would be associated with onsite activities and would not affect populations residing off site; thus the potential for environmental justice concerns is small. Resource areas that could be impacted and that may affect populations residing off site include public and occupational health and safety due to normal operations and facility accidents, and air quality.

4.2.13.3.1 Facility Disposition

Section 4.2.10.3.1.1 discusses short-term radiological impacts on the public from normal operations associated with facility disposition under the Removal Alternative. Facility disposition would result in minimal releases of radioactivity and, therefore, negligible doses to the offsite population and the MEI. Similarly, the doses to minority and low-income populations as well as the MEI at the boundary of the Yakama Reservation would also be negligible. Therefore, facility disposition under the Removal Alternative would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Section 4.2.11.3.1.1 discusses the radiological impacts of airborne releases for facility accidents associated with facility disposition under the Removal Alternative. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, facility disposition under the Removal Alternative would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts from facility accidents.

Section 4.2.11.3.2 discusses the hazardous chemical impacts associated with facility disposition under the Removal Alternative. Hazardous chemical impacts under this alternative would be the same as those described in Section 4.2.13.2.1 under the Entombment Alternative.

Air quality impacts of facility disposition under Alternative 3 are discussed in Section 4.2.4.3.1. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.2.12.3.1.1 discusses the potential human health risks of transportation related to facility disposition under the Removal Alternative. The impacts of transporting contaminated and hazardous materials to offsite locations for disposal under this alternative would not be expected to result in any additional LCFs in the offsite population. The impacts of transporting construction and operational materials would also be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.2.13.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Impacts of this option on aspects of environmental justice would be the same as those discussed in Section 4.2.13.2.2 under the Hanford Option.

IDAHO OPTION

Impacts of this option on aspects of environmental justice would be the same as those discussed in Section 4.2.13.2.2 under the Idaho Option.

4.2.13.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Impacts of this option on aspects of environmental justice would be the same as those discussed in Section 4.2.13.2.3 under the Hanford Reuse Option.

IDAHO REUSE OPTION

Impacts of this option on aspects of environmental justice would be the same as those discussed in Section 4.2.13.2.3 under the Idaho Reuse Option.

4.2.14 Waste Management

This section evaluates the impacts of waste generation associated with the various FFTF Decommissioning alternatives and options (see Section 4.2.1) on the waste management infrastructure at Hanford. As summarized in Section 4.3 and detailed in Chapter 2, Waste Management alternatives were developed to manage the various waste volumes projected to be generated under the alternatives for Tank Closure, FFTF Decommissioning, and Waste Management. Section 4.3.14 of this EIS evaluates the impacts of waste generation associated with the construction, operations, deactivation, and closure of the waste management facilities.

The following analysis is consistent with DOE policy and DOE Manual 435.1-1 that DOE radioactive waste shall be treated, stored, and, in the case of LLW, disposed of at the site where the waste is generated, if practical, or at another DOE facility. The analysis of these FFTF Decommissioning alternatives and options is based on disposal of LLW and MLLW at Hanford. However, if DOE determines that use of Hanford's or another DOE site's waste management facilities is not practical or cost-effective, DOE may approve the use of non-DOE (i.e., commercial) facilities to store, treat, and dispose of such waste.

Included in this section is a discussion of the waste inventories generated under each of the FFTF Decommissioning alternatives for facility disposition and options for disposition of RH-SCs and Hanford bulk sodium. The inventories include LLW, MLLW, hazardous waste, nonhazardous waste, liquid process waste, and 50 weight-percent sodium hydroxide.

LOW-LEVEL RADIOACTIVE WASTE

LLW and MLLW (e.g., personal protective equipment, tools, filters, empty containers) would be generated during routine operations, deactivation, decommissioning, and disposition of the SRF, the SPF, and the RTP associated with the action alternatives and options and during routine surveillance and maintenance under FFTF Decommissioning Alternative 1, No Action. LLW is typically not treated or only minimally treated (e.g., compacted) before disposal. Using a combination of on- and offsite capabilities, secondary MLLW would be treated to meet an RCRA land disposal restriction treatment standards prior to disposal. Therefore, this waste treatment would cause no or only minimal impacts on the Hanford waste management system. The LLW would be sent directly to disposal. The MLLW would be sent to disposal after treatment. All LLW and MLLW would be disposed of in an IDF.

HAZARDOUS WASTE

Hazardous waste is dangerous waste as defined in the *Washington Administrative Code* (WAC 173-303). Hazardous waste generated during operations, deactivation, or monitoring would be packaged in DOT-approved containers and shipped off site to permitted commercial recycling, treatment, and disposal facilities. Hanford shipped 182,177 kilograms (408,186 pounds) of hazardous waste off site in 2005 (Poston et al. 2006). Management of the additional waste generated under the FFTF Decommissioning alternatives and options would require little, if any, additional planning. The waste would be treated and disposed of at offsite commercial facilities.

NONHAZARDOUS WASTE

Any nonhazardous solid waste generated related to facility disposition activities or treatment facility construction, operations, or deactivation would be packaged and transported in conformance with standard industrial practice. Solid waste such as office paper, metal cans, and plastic and glass bottles that can be recycled would be sent off site for that purpose. The remaining nonhazardous solid waste would be sent for offsite disposal in a local landfill. This additional waste load would have only a minor impact on the handling and accumulation of nonhazardous solid waste at Hanford.

LIQUID PROCESS WASTE

Process waste would be generated by FFTF facility disposition activities and would possibly be generated in association with RH-SC treatment, bulk sodium disposition, and facility deactivation. Process liquids with substantial levels of radioactivity would be treated at the ETF or the TEDF or equivalent facilities at INL's MFC. Dilute process waste such as cooling waters or steam condensates would be routed to the Hanford or Idaho facilities, as applicable, whose mission it is to manage such wastes. It is assumed that the ETF and the TEDF, or their equivalents, would continue to be available to manage dilute process liquids generated under the FFTF Decommissioning alternatives. Wastewater management is further discussed in Section 4.2.6.

4.2.14.1 Alternative 1: No Action

FFTF Decommissioning Alternative 1, No Action, includes deactivation and 100 years of administrative controls of the FFTF complex.

Surveillance and maintenance activities associated with storage of bulk sodium in the 400 Area SSF and maintenance of the FFTF reactor vessel, related piping and equipment, RH-SCs, and tanks through the 100-year administrative control period would generate relatively small volumes of waste on an annualized basis. Table 4–126 presents the estimated waste volumes generated under FFTF Decommissioning Alternative 1.

4.2.14.2 Alternative 2: Entombment

4.2.14.2.1 Waste Inventories

4.2.14.2.2 Facility Disposition

FFTF Decommissioning Alternative 2, Entombment, provides for demolition of the FFTF RCB and immediately adjacent support facilities to below grade (other facilities within the PPA would be dismantled to grade), stabilization of below-grade spaces, and construction of a modified RCRA Subtitle C barrier to reduce infiltration, prevent intrusion, and isolate the below-grade portions of the reactor building. Accessible void spaces in the below-grade portions of the RCB would be grouted. These activities would produce a small quantity of secondary LLW and liquid LLW. Debris and other waste not placed in the RCB or used as backfill would be transported to trenches 31 and 34 of LLBG 218-W-5 or to IDF-East for disposal.

Table 4–126. FFTF Decommissioning Alternatives and Options – Summary of Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation	
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Annual Waste Volume
Alternative 1: No Action							
Low-level radioactive waste	N/A	N/A	1,699	N/A	1,699	2008–2017	17
Mixed low-level radioactive waste	N/A	N/A	57	N/A	57	2008–2017	1
Hazardous waste[a]	N/A	N/A	396	N/A	396	2008–2017	4
Nonradioactive/nonhazardous waste[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Liquid low-level radioactive waste (liters)	N/A	N/A	622,925	N/A	622,925	2008–2017	6,229
Alternative 2 Facility Disposition: Entombment							
Low-level radioactive waste	N/A	N/A	7	N/A	7	2017	7
Mixed low-level radioactive waste	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hazardous waste[a]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nonradioactive/nonhazardous waste[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Liquid low-level radioactive waste (liters)	N/A	N/A	181,699	N/A	181,699	2017	181,699
Alternative 3 Facility Disposition: Removal							
Low-level radioactive waste	N/A	N/A	692	N/A	692	2013–2014	346
Mixed low-level radioactive waste	N/A	N/A	8	N/A	8	2013–2014	4
Hazardous waste[a]	N/A	N/A	73	N/A	73	2013–2014	37
Nonradioactive/nonhazardous waste[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Liquid low-level radioactive waste (liters)	N/A	N/A	323,788	N/A	323,788	2013–2014	161,894
Disposition of RH-SCs: Hanford Option							
Low-level radioactive waste	N/A	8	60	N/A	68	2018	60
Mixed low-level radioactive waste	N/A	7	N/A	N/A	7	2017	7
Nonradioactive/nonhazardous waste[b]	N/A	N/A	4	N/A	4	2018	4
Liquid low-level radioactive waste (liters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Disposition of RH-SCs: Idaho Option							
Low-level radioactive waste	N/A	8	60	N/A	68	2018	60
Mixed low-level radioactive waste	N/A	7	N/A	N/A	7	2017	7
Nonradioactive/nonhazardous waste[b]	N/A	N/A	4	N/A	4	2018	4
Liquid low-level radioactive waste (liters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 4–126. FFTF Decommissioning Alternatives and Options – Summary of Waste Generation Volumes *(continued)*

Waste Type	Project Phase					Peak Annual Generation	
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Annual Waste Volume
Disposition of Bulk Sodium: Hanford Reuse Option							
Low-level radioactive waste	N/A	10	N/A	N/A	10	2017–2018	5
Mixed low-level radioactive waste	1	N/A	399	N/A	400	2019	399
Nonradioactive/nonhazardous waste[b]	N/A	N/A	454	N/A	454	2019	454
Liquid low-level radioactive waste (liters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Disposition of Bulk Sodium: Idaho Reuse Option							
Low-level radioactive waste	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mixed low-level radioactive waste	3	21	251	N/A	275	2016	262
Nonradioactive/nonhazardous waste[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Liquid low-level radioactive waste (liters)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[a] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

[b] Nonhazardous solid waste is shipped to offsite commercial facilities for recycling, treatment, and disposal.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Key: FFTF=Fast Flux Test Facility; N/A=not applicable; RH-SCs=remote-handled special components.

Source: SAIC 2007b, 2008.

4.2.14.2.3 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option RH-SCs would be stored, treated, and disposed of at Hanford. This option would use storage and disposal facilities currently existing within the 200 Areas, thereby minimizing any impact. Treatment of RH-SCs would involve construction of a new RTP within the T Plant complex located in the 200-West Area. This option would generate waste from operations and deactivation of this facility.

IDAHO OPTION

RH-SCs removed from the FFTF RCB would be stored at Hanford prior to shipment to INL, where they would be treated at a new RTP. Treated components would be returned to Hanford or sent to NTS for disposal, where they would be placed within existing disposal facilities. This option would generate waste from operations and deactivation of this facility.

4.2.14.2.4 Disposition of Bulk Sodium

The bulk sodium (approximately 300,000 gallons [1.14 million liters]) would be converted to a caustic sodium hydroxide solution for product reuse in processing tank waste at the WTP or for supporting Hanford tank corrosion controls. Two options are identified for conversion of the bulk sodium to liquid caustic.

HANFORD REUSE OPTION

Under the Hanford Reuse Option, sodium from FFTF would be sent to a new SRF to be built in the 400 Area. Construction, operations, and deactivation of this new facility would generate a small amount of waste.

IDAHO REUSE OPTION

Under this option, sodium from FFTF and other sodium would be transported to INL for treatment in the SPF. The SPF is an existing facility within the MFC. Modifications would have to made to the current facility. Construction, operations, and deactivation of the modifications would generate a small amount of waste.

Table 4–126 presents the estimated waste volumes generated under FFTF Decommissioning Alternative 2.

4.2.14.3 Alternative 3: Removal

4.2.14.3.1 Waste Inventories

4.2.14.3.2 Facility Disposition

FFTF Decommissioning Alternative 3, Removal, provides for demolition of above-grade structures and disposal of the contaminated debris in an IDF similar to Alternative 2, except that the reactor vessel would be stabilized with grout, removed, and disposed of at an IDF. Under this alternative, the FFTF RCB and adjacent support facilities would be removed to 0.9 meters (3 feet) below grade; however, an engineered barrier would not be needed since the reactor vessel and other radioactively contaminated equipment would also be removed.

Debris and other waste would be handled in the same manner as under the FFTF Decommissioning Entombment Alternative (see Section 4.2.14.2.2).

4.2.14.3.3 Disposition of Remote-Handled Special Components

HANFORD OPTION

The steps involved in disposition of RH-SCs under the Hanford Option of this alternative are identical to those of the Entombment Alternative, as discussed under the Hanford Option in Section 4.2.14.2.3.

IDAHO OPTION

Similar to the Hanford Option, the actions taken at INL are the same under this alternative as under the Entombment Alternative, as discussed under the Idaho Option in Section 4.2.14.2.3.

4.2.14.3.4 Disposition of Bulk Sodium

HANFORD REUSE OPTION

The steps involved in the disposition of bulk sodium under the Hanford Reuse Option of this alternative are identical to those of the Entombment Alternative, as discussed under the Hanford Reuse Option in Section 4.2.14.2.4.

IDAHO REUSE OPTION

Similar to the Hanford Reuse Option, the steps involved in disposition of bulk sodium at INL are the same under this alternative as under the Entombment Alternative, as discussed under the Idaho Reuse Option in Section 4.2.14.2.4.

Table 4–126 presents the estimated waste volumes generated under FFTF Decommissioning Alternative 3.

4.2.15 Industrial Safety

Illness, injury, and death are possible outcomes of any industrial accident. The accepted standard for measuring the outcome of an industrial accident is the TRC of illness, injury and death. This section addresses potential impacts of illness, injury, and death associated with implementation of each of the FFTF Decommissioning alternatives and options for disposition of RH-SCs and bulk sodium. Key underlying assumptions and industrial safety incident rates used in support of this analysis are the same as those described in Section 4.1.15 for the Tank Closure alternatives.

Using the referenced incidence rates and the projected labor hours for the FFTF Decommissioning alternatives and related options, occupational safety impacts associated with each of the alternatives and options were determined and are tabulated in Table 4–127. The number of cases associated with alternatives having less construction activities could be slightly overstated. Conversely, alternatives having a larger component of construction activity (e.g., Alternative 2, facility disposition, and disposition of RH-SCs, Idaho Option) could be slightly understated.

As shown in Figure 4–29, the greatest industrial safety impacts are associated with alternatives having the greatest number of labor hours.

Table 4–127. FFTF Decommissioning Alternatives – Industrial Safety Impacts

Alternative	Labor Category	Million Labor Hours	Total Recordable Case Rate per 100 Workers per Year	Projected Total Recordable Cases	Fatality Rate per 100,000 Workers per Year	Projected Fatalities
1: No Action	Construction	0.0	2.0	0.0	0.26	0.0
	Operations	0.0	2.0	0.0	0.26	0.0
	Deactivation	0.042	2.0	0.42	0.26	0.00005
	Closure	0.0	2.0	0.0	0.26	0.0
1 Total		0.042		0.42		0.00005
2: Facility disposition-Entombment	Construction	0.0	2.0	0.0	0.26	0.0
	Operations	0.0	2.0	0.0	0.26	0.0
	Deactivation	0.62	2.0	6.2	0.26	0.0008
	Closure	0.19	2.0	1.9	0.26	0.0002
2 Total		0.81		8.10		0.001
3: Facility disposition-Removal	Construction	0.0	2.0	0.00	0.26	0.0
	Operations	0.0	2.0	0.00	0.26	0.0
	Deactivation	0.80	2.0	8.0	0.26	0.001
	Closure	0.15	2.0	1.5	0.26	0.0002
3 Total		0.95		9.50		0.0012
Disposition of RH-SCs: Hanford Option	Construction	0.34	2.0	3.40	0.26	0.0004
	Operations	0.08	2.0	0.80	0.26	0.0001
	Deactivation	0.04	2.0	0.40	0.26	0.0001
	Closure	0.0	2.0	0.0	0.26	0.0
Hanford Option Total		0.47		4.70		0.0006
Disposition of RH-SCs: Idaho Option	Construction	0.30	1.5	2.25	0.26	0.0004
	Operations	0.08	1.5	0.6	0.26	0.0001
	Deactivation	0.04	1.5	0.3	0.26	0.00005
	Closure	0.0	1.5	0.0	0.26	0.0
Idaho Option Total		0.42		3.15		0.0005
Disposition of bulk sodium: Hanford Reuse Option	Construction	0.27	2.0	2.70	0.26	0.0004
	Operations	0.26	2.0	2.60	0.26	0.0003
	Deactivation	0.05	2.0	0.50	0.26	0.0001
	Closure	0.0	2.0	0.00	0.26	0.0
Hanford Reuse Option Total		0.58		5.80		0.0008
Disposition of bulk sodium: Idaho Reuse Option	Construction	0.05	1.5	0.38	0.26	0.00006
	Operations	0.22	1.5	1.65	0.26	0.0003
	Deactivation	0.001	1.5	0.01	0.26	0.000002
	Closure	0.0	1.5	0.00	0.26	0.0
Idaho Reuse Option Total		0.27		2.03		0.0003

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate. Totals may not equal the sum of the contributions due to rounding.

Key: RH-SCs=remote-handled special components.

Source: Labor hours compiled from Appendix I.

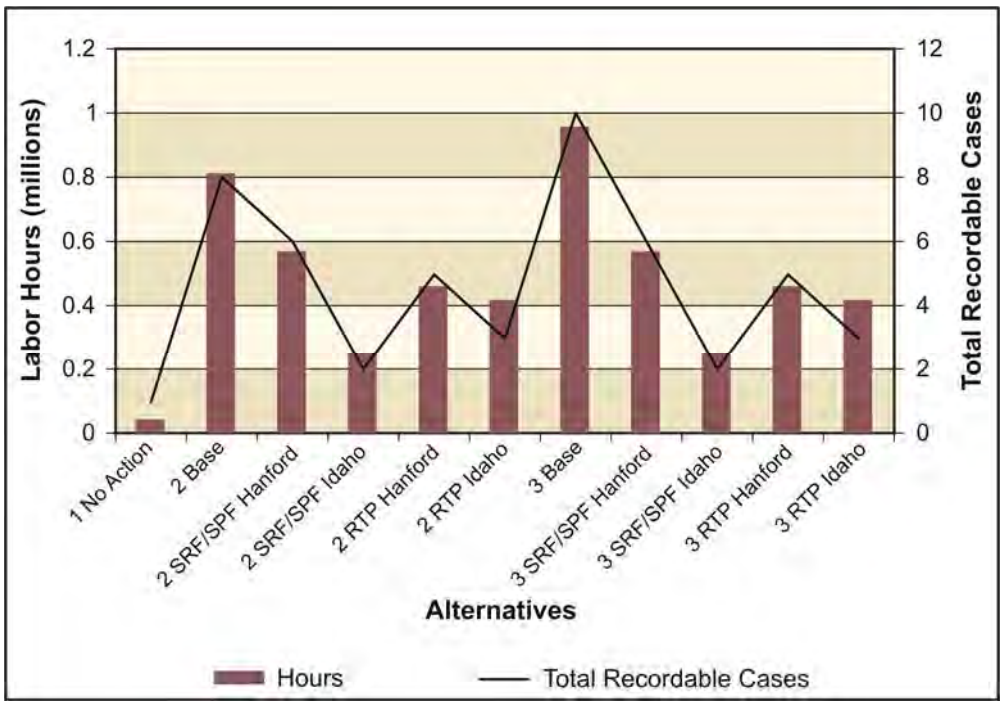


Figure 4–29. Total Recordable Cases and Labor Hours by Alternative

4.2.15.1 Alternative 1: No Action

Approximately one TRC and no fatalities are projected. Work under this alternative includes administrative controls for 100 years.

4.2.15.2 Alternative 2: Entombment

4.2.15.2.1 Facility Disposition

Completing the work identified in this alternative would require 810,000 labor hours, including the postclosure care period of 100 years. Approximately eight TRCs and no fatalities are projected.

4.2.15.2.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Under this option, a facility would be built to process the RH-SCs removed from FFTF. Construction, operations, and deactivation would require 470,000 total labor hours over 4 years. Approximately five TRCs are projected. No fatalities are projected.

IDAHO OPTION

Approximately three TRCs are projected over the period this work is conducted. No fatalities are anticipated during this time period.

4.2.15.2.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Construction, operations, and deactivation of the SRF in the 400 Area of Hanford would require a total of 580,000 labor hours. It is anticipated that approximately six TRCs will be generated during this alternative. No fatalities are projected during any phase of this alternative.

IDAHO REUSE OPTION

This option would require the shipment of the sodium to a new facility at the MFC at INL for conversion to a form acceptable for use in the WTP. This work would take place over a 4-year period and would require a total of 270,000 labor hours to complete. Approximately two TRCs and no fatalities are projected for this option. To calculate the number of potential TRCs, the rate for Idaho operations averaged from 2001 through 2006 (1.5 cases per 200,000 labor hours) was applied.

4.2.15.3 Alternative 3: Removal

4.2.15.3.1 Facility Disposition

It is anticipated there would be no more than 10 TRCs for work conducted under this alternative. No fatalities are projected for the same period.

4.2.15.3.2 Disposition of Remote-Handled Special Components

HANFORD OPTION

Industrial safety consequences from implementation of this option would be the same as those discussed under Section 4.2.15.2.2 for the Hanford Option.

IDAHO OPTION

Industrial safety consequences from implementation of this option would be the same as those discussed under Section 4.2.15.2.2 for the Idaho Option.

4.2.15.3.3 Disposition of Bulk Sodium

HANFORD REUSE OPTION

Industrial safety consequences from implementation of this option would be the same as those discussed under Section 4.2.15.2.3 for the Hanford Reuse Option.

IDAHO REUSE OPTION

Industrial safety consequences from implementation of this option would be the same as those discussed under Section 4.2.15.2.3 for the Idaho Reuse Option.

4.3 WASTE MANAGEMENT ALTERNATIVES

This section of Chapter 4 describes the potential short-term environmental and human health impacts associated with implementation of alternatives for administering ongoing solid waste management operations and proposed disposal of Hanford LLW and MLLW and a limited volume of offsite LLW and MLLW in an IDF to be located at Hanford. Specifically, some waste from tank closure activities as described in Section 4.1 as well as other LLW and MLLW from Hanford, including the waste resulting

from FFTF decommissioning described in Section 4.2, and waste from other DOE sites without appropriate facilities must be disposed of to facilitate cleanup of Hanford and other DOE sites. This section analyzes the impacts of expanding Hanford's waste disposal capacity to provide space for onsite and offsite wastes; this section also includes analysis of associated storage, disposal, and closure activities as well as facility-specific construction, operations, deactivation, and closure activities.

Three Waste Management alternatives are considered and analyzed, including (1) Waste Management Alternative 1: No Action Alternative, under which LLW, MLLW, and TRU waste would be stored and disposed of in existing Hanford facilities, no offsite waste would be received, construction/use of IDF-East would be discontinued, and IDF-East would be deactivated; (2) Waste Management Alternative 2: Disposal in IDF, 200-East Area only; and (3) Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas. Waste Management Alternative 2 would include storing LLW, MLLW, and TRU waste in the CWC prior to disposal in existing trenches 31 and 34, and conducting waste processing prior to disposal at new facilities or existing-facility expansions at the CWC, WRAP, and the T Plant. A total volume of 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW from other DOE sites would be received for disposal under this alternative. Waste from tank closure and treatment operations, onsite non-CERCLA waste, FFTF waste, waste management, and offsite waste from other DOE sites would be disposed of at IDF-East. A new RPPDF would be provided for disposal of equipment and soils that are not highly contaminated but result from tank farm clean closure activities.

Waste Management Alternative 3 would involve the same waste storage and processing provisions as under Waste Management Alternative 2 and the same volume of offsite waste accepted for disposal; a new RPPDF would also be provided. However, an additional IDF would be provided in the 200-West Area. Waste from tank closure and treatment operations would be disposed of at IDF-East, while onsite non-CERCLA waste, FFTF waste, waste management, and offsite waste from other DOE sites would be disposed of at IDF-West.

In addition, under each Waste Management action alternative (i.e., Alternatives 2 and 3), three disposal groupings are analyzed: Disposal Group 1, Disposal Group 2, and Disposal Group 3. These disposal groupings encompass the sizing requirements and associated construction, operations, and closure requirements for the IDF(s) and RPPDF necessary to accommodate the varying waste volumes considered under each disposal configuration. These alternatives and options are described further in Chapter 2, Section 2.5.4 of this EIS.

4.3.1 Land Resources

4.3.1.1 Alternative 1: No Action

4.3.1.1.1 Land Use

Under the No Action Alternative, new facility construction would not be initiated within the 200 Areas. Storage and treatment activities would continue to take place within the CWC, WRAP complex, and T Plant complex. Disposal would also continue in LLBG 218-W-5 trenches 31 and 34. Barriers would not be used upon closure of any of these facilities or trenches. Thus, there would be no change in land use within the 200 Areas under this alternative. Since this alternative would not require that geologic material be excavated from Borrow Area C, there would be no impact on land use within that area.

4.3.1.1.2 Visual Resources

As noted above, there would be no construction associated with the No Action Alternative within the 200 Areas, and barriers would not be used upon closure of facilities or trenches. Further, there would be

no need to excavate geologic material from Borrow Area C. Thus, this alternative would have no impact on the visual environment.

However, ongoing construction, consolidation, operations, maintenance, and deactivation of facilities on Rattlesnake and Gable Mountains would occur under this alternative. Rattlesnake and Gable Mountains are within the viewshed of Borrow Area C and the 200 Areas, respectively, and ongoing activities would result in short-term adverse impacts on land and visual resources, including the development or use of previously undisturbed land. Visual impacts from existing structures and maintenance activities on Rattlesnake and Gable Mountains and land use for construction of new facilities are considered a short-term impact because after a facility's mission has been completed, it would be deactivated and demolished, and vegetation and habitat would be allowed to naturally return over time. However, the eventual consolidation or removal of unnecessary facilities/infrastructure on Rattlesnake and Gable Mountains would tend to improve the visual profile of the features, allow restoration of natural habitat, and enhance tribal religious and cultural experiences.

4.3.1.2 Alternative 2: Disposal in IDF, 200-East Area Only

4.3.1.2.1 Land Use

Under this alternative, a number of new facilities or existing-facility expansions would be constructed. These include expansion at the T Plant, a new CWC storage facility, and two expansions of WRAP (both treating nontank waste): (1) a CH-Mixed TRU/TRU waste facility at the CWC and (2) an RH-Mixed TRU/TRU waste facility at WRAP (see Figure 4–2). These facilities would be constructed within the 200-West Area and would require a total of 2.7 hectares (6.6 acres) of land. Because all work would take place within the 200-West Area, which is within the area designated as Industrial-Exclusive, there would be no change in land use under this alternative from the construction and operations of new processing and storage facilities.

In addition to the facilities noted above, IDF-East and an RPPDF would be constructed between the 200-East and 200-West Areas (see Figure 4–1). Waste generated in connection with the Waste Management alternatives, as well as those associated with FFTF Decommissioning and Tank Closure alternatives would also be placed in these disposal facilities. Thus, the sizes of IDF-East and the RPPDF would vary depending upon the volume of waste generated under the various combinations of alternatives. Accordingly, waste volumes have been placed in three disposal groups, which are addressed separately below (see Appendix E, Section E.4.2, for a complete discussion of the waste groupings). Since IDF-East and the RPPDF would be located within the Industrial-Exclusive area, their construction would be consistent with the existing land use designation of the area.

Construction, operations, and closure of the various facilities associated with each of the disposal groups under this alternative would require the use of geologic material to produce grout, fill excavated areas, and cover waste sites. This material would come from Borrow Area C. The area needed to supply this material would vary depending on the volume required for each disposal group. The area of land needed within the borrow area, along with land requirements for IDF-East and the RPPDF, are addressed below. Since Borrow Area C has been designated Conservation (Mining), use of the area for this purpose would be inconsistent with the current site land use plan.

4.3.1.2.1.1 Disposal Group 1

Disposal Group 1 would require that IDF-East and the RPPDF be 32.8 hectares (81 acres) and 29.5 hectares (73 acres) in size, respectively. Further, in order to support activities under this disposal grouping, a total of 41.7 hectares (103 acres) within Borrow Area C would be required to supply geologic material. Thus, including the land requirement of the expanded and new facilities noted above, a total of 107 hectares (264 acres) would be developed under this disposal group. Closure of IDF-East and the

RPPDF would require an additional 1.6 hectares (4 acres) of land to accommodate the modified RCRA Subtitle C barrier, for a total land commitment of 108 hectares (268 acres).

4.3.1.2.1.2 Disposal Groups 2 and 3

Although the time required for construction and operations would vary, the land requirement for IDF-East and the RPPDF under Disposal Groups 2 and 3 would be the same. Under each disposal group, IDF-East would require 11.3 hectares (28 acres) of land, while the RPPDF would need 228 hectares (564 acres). The land requirement within Borrow Area C to supply geologic material would be 159 hectares (392 acres). Thus, including the new facilities noted above, the total land requirement at Hanford for each disposal group would be 401 hectares (991 acres). Placement of the modified RCRA Subtitle C barrier over IDF-East and the RPPDF would require an additional 7.7 hectares (19 acres) of land, for a total land commitment of approximately 409 hectares (1,010 acres).

4.3.1.2.2 Visual Resources

Since processing and storage facilities would be placed within the 200-West Area, an area that is already highly developed, and would occupy a relatively small area (2.7 hectares [6.6 acres]), impacts on visual resources from their construction and operations would be minimal. The BLM Visual Resource Management Class IV rating of the 200-West Area would not change under this alternative. The visual impacts of constructing the IDF-East and the RPPDF, as well as developing Borrow Area C, are addressed below for each disposal group.

Ongoing construction, consolidation, operations, maintenance, and deactivation of facilities on Rattlesnake and Gable Mountains would also occur under this alternative. Rattlesnake and Gable Mountains are within the viewshed of Borrow Area C and the 200 Areas, respectively, and ongoing activities would result in short-term adverse impacts on land and visual resources, including the development or use of previously undisturbed land. Visual impacts from existing structures and maintenance activities on Rattlesnake and Gable Mountains and land use for construction of new facilities are considered a short-term impact because after a facility's mission has been completed, it would be deactivated and demolished, and vegetation and habitat would be allowed to naturally return over time. However, the eventual consolidation or removal of unnecessary facilities/infrastructure on Rattlesnake and Gable Mountains would tend to improve the visual profile of the features, allow restoration of natural habitat, and enhance tribal religious and cultural experiences.

4.3.1.2.2.1 Disposal Group 1

As noted above (see Section 4.3.1.2.1.1), construction of the IDF and RPPDF would result in the conversion of 62.3 hectares (154 acres) to industrial use. During construction and operations these changes would add noticeably to the overall industrial nature of the 200 Areas and would be visible from Rattlesnake Mountain, Gable Mountain, and Gable Butte. The viewscape from these areas is important to American Indians with cultural ties to Hanford (see Chapter 3, Section 3.2.8). Although there would be an overall increase in the industrial appearance of the 200 Areas, the BLM Visual Resource Management Class IV rating would not change.

Closure of the disposal facilities would involve constructing a modified RCRA Subtitle C barrier over both IDF-East and the RPPDF. Their barriers would be slightly larger than the disposal sites and would be 2.7 meters (9 feet) high. The area would be revegetated with native grasses, thus improving its postclosure appearance.

To supply geologic material under this disposal group, 41.7 hectares (103 acres) within Borrow Area C would be excavated. This excavation would change the existing visual setting of Borrow Area C from a predominantly natural setting with limited disturbance to one in which mining activities dominate. This

impact would last for the duration of the project. It would also change the BLM visual resource management rating from Class II to Class IV. Excavation of the borrow area would change the viewscape from State Route 240 and Rattlesnake Mountain, an area important to American Indians with cultural ties to Hanford. Following closure, the area would be recontoured and revegetated with native plants to more closely resemble the pre-disturbance setting.

4.3.1.2.2.2 Disposal Groups 2 and 3

Disposal Groups 2 and 3 would require that 240 hectares (592 acres) of undeveloped land be used for construction of IDF-East and the RPPDF. These changes would noticeably add to the overall industrial nature of the 200 Areas and would be visible from Rattlesnake Mountain, Gable Mountain, and Gable Butte. This alteration in the viewscape would last for the operational period of the disposal sites. Although there would be an overall increase in the industrial appearance of the 200 Areas, the BLM Visual Resource Management Class IV rating would not change.

Closure of IDF-East and the RPPDF would involve constructing a modified RCRA Subtitle C barrier over both facilities. Their barriers would be slightly larger than the disposal sites and would be about 2.7 meters (9 feet) high. The area would be revegetated with native grasses, thus improving its postclosure appearance.

To supply geologic material under Disposal Groups 2 and 3, a total of 159 hectares (392 acres) within Borrow Area C would need to be excavated. This excavation would change the existing visual setting of Borrow Area C from a predominantly natural setting with limited disturbance to one in which mining activities would dominate for the duration of the project. It would also change the BLM visual resource management rating from Class I to Class IV. Excavation of the borrow area would be readily visible from State Route 240 and Rattlesnake Mountain, an area important to American Indians with cultural ties to Hanford. Following closure, the area would be recontoured and revegetated with native vegetation to more closely resemble the pre-disturbance setting.

4.3.1.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

4.3.1.3.1 Land Use

Under this Waste Management alternative, the same expanded or new facilities would be constructed as under Alternative 2 (see Section 4.3.1.2.1). These facilities would be built within the same locations in the 200-West Area and would require the same land (i.e., 2.7 hectares [6.6 acres]). Thus, since all work would take place within the area designated as Industrial-Exclusive, there would be no change in land use under this alternative.

Also, under this Waste Management alternative, the RPPDF would be constructed between the 200-East and 200-West Areas; however, separate IDFs would be constructed within each area. Land requirements for the IDFs, RPPDF, and Borrow Area C are addressed below. Use of the 200 Areas and Borrow Area C, which are designated as Industrial-Exclusive and Conservation (Mining), respectively, would not be in conformity with the current site land use plan.

4.3.1.3.1.1 Disposal Group 1

Disposal Group 1 would require construction of a 29.9-hectare (74-acre) IDF-East and a 2.4-hectare (6-acre) IDF-West. Additionally, a 29.5-hectare (73-acre) RPPDF would be built between the 200-East and 200-West Areas. To supply the required volume of geologic material needed under this alternative, it would be necessary to excavate 36.8 hectares (91 acres) within Borrow Area C. Thus, the total land requirement at Hanford for Disposal Group 1 under this alternative, including the processing and storage facilities noted above, would be about 102 hectares (251 acres). Final closure of the disposal facilities

with a modified RCRA Subtitle C barrier would require an additional 15 hectares (37 acres) of land, for a total land commitment of approximately 117 hectares (288 acres).

4.3.1.3.1.2 Disposal Groups 2 and 3

Although the operational periods would vary for Disposal Groups 2 and 3, the land requirement would be identical. Thus, 9.3 hectares (23 acres) would be needed for IDF-East, 2.4 hectares (6 acres) for IDF-West, and 228 hectares (564 acres) for the RPPDF. In addition, Borrow Area C would need to be 157 hectares (388 acres) to supply the required geologic material. Thus, including the land requirement of the expanded and new facilities noted above, a total of 400 hectares (988 acres) of land, would be required under either of these disposal groups. Final closure of the disposal facilities with a modified RCRA Subtitle C barrier would require an additional 12.5 hectares (31 acres) of land, for a total land commitment of approximately 413 hectares (1,020 acres).

4.3.1.3.2 Visual Resources

Impacts on the visual environment from construction and operations of the T Plant expansion, two WRAP expansions—a CH-Mixed TRU/TRU waste facility at the CWC and an RH-Mixed TRU/TRU waste facility at WRAP—and the new CWC storage facility would be similar to those described under Alternative 2 (see Section 4.3.1.2.2). As is the case under Alternative 2, the RPPDF would be constructed between the 200-East and 200-West Areas; however, separate IDFs would be constructed within these areas. The visual impacts of constructing the IDFs and RPPDF and of developing Borrow Area C under this alternative are addressed below for each disposal group.

Ongoing construction, consolidation, operations, maintenance, and deactivation of new or existing facilities on Rattlesnake and Gable Mountains would also occur under this alternative. These activities would have the same effects on visual resources as previously described in Section 4.3.1.2.2**.**

4.3.1.3.2.1 Disposal Group 1

Although this disposal group includes an IDF in both the 200-East Area and 200-West Area, the total land area disturbed is nearly identical to the area disturbed under Alternative 2. Additionally, the area required within Borrow Area C for geologic material would be similar to that required under Alternative 2. Thus, although the placement of IDF-West on 2.4 hectares (6 acres) of undeveloped land would minimally add to the total visual impact, overall impacts would be similar to those described for Disposal Group 1 under Alternative 2 (see Section 4.3.1.2.2.1).

4.3.1.3.2.2 Disposal Groups 2 and 3

Under Disposal Groups 2 and 3 of Waste Management Alternative 3, the land required for IDF-East, IDF-West, the RPPDF, and Borrow Area C would be nearly the same as the amount needed under Alternative 2. Thus, although the placement of the IDF-West on 2.4 hectares (6 acres) of undeveloped land would minimally add to the total visual impact, overall impacts would be similar to those described for Disposal Groups 2 and 3 under Alternative 2 (see Section 4.3.1.2.2.2).

4.3.2 Infrastructure

This subsection presents the potential impacts of Waste Management alternatives and associated disposal groupings on key utility infrastructure resources, including projected activity demands for electricity, fuel, and water. Total and peak annual utility infrastructure requirements are projected for each alternative and disposal group as well as for applicable component project phases (e.g., construction, operations, deactivation, and closure). In general, Hanford waste treatment and storage activities and commensurate utility requirements would be identical under Alternatives 2 and 3. For the three disposal groupings under

each action alternative, utility infrastructure demands would vary primarily in direct relation to the size, number, and required lifespan of disposal facilities (i.e., the IDF(s) and RPPDF) that would be constructed, operated, and ultimately closed under each disposal scenario.

Key underlying assumptions used in projecting utility infrastructure demands for each of the Waste Management alternatives and disposal groups are similar to those described in Section 4.1.2 for the Tank Closure alternatives. For example, it has been assumed for the purposes of analysis that liquid fuels are not capacity-limiting resources, as supplies would be replenished from offsite sources to support each alternative and provided at the point of use on an as-needed basis.

Hanford's site utility infrastructure is described in Chapter 3, Section 3.2.2, and INL's is described in Chapter 3, Section 3.3.2. Table 4–128 summarizes the projected utility infrastructure resource requirements for the Waste Management alternatives and associated disposal groups. Projected demands for key utility infrastructure resources and impacts on the respective utility systems from implementation of each of the alternatives and disposal groups are further discussed in the following sections.

4.3.2.1 Alternative 1: No Action

4.3.2.1.1 Electricity, Fuel, and Water

Ongoing waste storage, treatment, and disposal activities under Waste Management Alternative 1 would continue to represent a relatively small fraction of total Hanford utility infrastructure demands through 2035.

Under Waste Management Alternative 1, annual electrical energy demand to support ongoing waste management activities would remain relatively constant at 0.00019 million megawatt-hours through 2035 to specifically support ongoing waste disposal in trenches 31 and 34 in LLBG 218-W-5 (see Table 4–128). This demand is negligible compared to the 1.74 million megawatt-hour annual capacity (based on a peak load capacity of 199 megawatts) of the Hanford electric transmission system and would also be a very small fraction (about 0.1 percent) of the 0.17 million megawatt-hours of electricity currently used annually at Hanford.

Peak annual diesel fuel consumption of 3.46 million liters (0.91 million gallons) would occur in 2009 associated with ongoing operations of the LLBGs coinciding with deactivation of IDF-East. Gasoline consumption would not peak until 2036 and is projected to remain constant at 0.012 million liters (0.003 million gallons) annually, associated with mobile equipment operations during the 100-year postclosure care period for the LLBGs. This ongoing fuel demand would be a small fraction (about 0.3 percent) of the 4.3 million liters (1.1 million gallons) of liquid fuels currently used annually at Hanford. Water requirements would also peak in 2009 at 25.5 million liters (6.74 million gallons). This projected peak water demand would be about 0.1 percent of 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 3.1 percent of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford.

Table 4–128. Waste Management Alternatives – Summary of Utility Infrastructure Requirements

Alternatives	Activity Phase	Electricity (M megawatt-hours)	Diesel Fuel[a] (M liters)	Gasoline (M liters)	Water (M liters)
Alternative 1: No Action	Operations	0.0056	4.22	0.035	10.6
	Deactivation	0.0	9.65	1.20	25.1
	Total[b]	0.0056	13.9	1.23	35.7
	Peak (Year)	0.00019 (2007–2035)	3.46 (2009)	0.012 (2036–2135)	25.5 (2009)
Alternative 2 and 3: Treatment and Storage[c]	Construction	0.045	10.7	5.20	61.6
	Operations	0.50	31.1	3.24	364
	Deactivation	0.0068	0.28	0.044	4.98
	Total[b]	0.55	42.0	8.48	430
	Peak (Year)	0.018 (2011–2012)	2.60 (2011–2012)	1.01 (2011–2012)	23.9 (2011–2012)
Alternative 2: Disposal Group 1[d]	Construction	0.0	26.1	0.13	191
	Operations	0.0085	91.8	2.08	2,290
	Closure	0.0	97.5	11.0	134
	Total[b]	0.0085	215	13.2	2,620
	Peak (Year)	0.00019 (2007–2050)	39.0 (2051–2052)	3.68 (2051–2052)	67.0 (2051–2052)
Alternative 2: Disposal Group 2[d]	Construction	0.0	101	0.49	736
	Operations	0.0085	940	31.5	19,600
	Closure	0.0	377	42.6	517
	Total[b]	0.0085	1,420	74.6	20,800
	Peak (Year)	0.00019 (2007–2050)	151 (2101–2102)	14.2 (2101–2102)	259 (2101–2102)
Alternative 2: Disposal Group 3[d]	Construction	0.0	101	0.49	736
	Operations	0.0085	1,700	57.4	35,500
	Closure	0.0	377	42.6	517
	Total[b]	0.0085	2,180	100	36,800
	Peak (Year)	0.00019 (2007–2050)	151 (2166–2167)	14.2 (2166–2167)	259 (2166–2167)
Alternative 3: Disposal Group 1[d]	Construction	0.0	26.0	0.13	190
	Operations	0.0085	91.4	2.07	2,280
	Closure	0.0	97.1	11.0	133
	Total[b]	0.0085	215	13.2	2,610
	Peak (Year)	0.00019 (2007–2050)	38.9 (2051–2052)	3.66 (2051–2052)	66.7 (2051–2052)
Alternative 3: Disposal Group 2[d]	Construction	0.0	101	0.49	737
	Operations	0.0085	937	31.5	19,500
	Closure	0.0	377	42.6	518
	Total[b]	0.0085	1,410	74.6	20,700
	Peak (Year)	0.00019 (2007–2050)	149 (2101–2102)	14.1 (2101–2102)	256 (2101–2102)

Table 4–128. Waste Management Alternatives – Summary of Utility Infrastructure Requirements *(continued)*

Alternatives	Activity Phase	Electricity (M megawatt-hours)	Diesel Fuel[a] (M liters)	Gasoline (M liters)	Water (M liters)
Alternative 3: Disposal Group 3[d]	Construction	0.0	101	0.49	737
	Operations	0.0085	1,700	57.3	35,300
	Closure	0.0	377	42.6	518
	Total[b]	0.0085	2,170	100	36,500
	Peak (Year)	0.00019 (2007–2050)	149 (2166–2167)	14.1 (2166–2167)	256 (2166–2167)

a Assumed to be inclusive of all No. 2 diesel fuel, including road diesel and heating fuel oil.

b Totals may not equal the sum of the contributions due to rounding.

c The storage and treatment components of each alternative reflect the requirements to support ongoing storage and treatment of onsite- and offsite-generated waste through facility deactivation.

d Disposal Groupings 1 through 3 encompass waste disposal facility construction, operations, and closure activities in support of ongoing waste management activities in addition to those related to FFTF disposition and select Tank Closure alternatives as follows: (1) Disposal Group 1 supports Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C; (2) Disposal Group 2 supports Tank Closure Alternatives 2A and 6B; and (3) Disposal Group 3 supports Tank Closure Alternative 6A only.

Note: To convert liters to gallons, multiply by 0.26417. Values presented in the table have been rounded to no more than three significant digits, where appropriate.

Key: FFTF=Fast Flux Test Facility; M=million.

Source: SAIC 2007c.

4.3.2.2 Alternative 2: Disposal in IDF, 200-East Area Only

4.3.2.2.1 Electricity, Fuel, and Water

In support of ongoing Hanford waste treatment and storage activities under Waste Management Alternative 2, electrical energy requirements would peak in the 2011–2012 timeframe associated with construction of the T Plant expansion, two WRAP expansions—a CH-Mixed TRU/TRU waste facility at the CWC and an RH-Mixed TRU/TRU waste facility at WRAP—and the new CWC storage facility in the 200-West Area. It is assumed that construction of these facility additions would utilize existing utility tie-ins to the extent possible, although construction-related electricity demands could also be met via fuel-fired generators. Subsequent facility operations would extend to the year 2050 using existing utility systems. Nevertheless, the peak annual electrical energy demand in 2011–2012 of 0.018 million megawatt-hours (approximating an electric load of about 2.05 megawatts) would be about 1.0 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system (see Table 4–128).

Peak liquid fuel consumption under Alternative 2 would total about 3.61 million liters (0.95 million gallons) in the 2011–2012 timeframe to support expanded treatment and storage facility construction.

Peak water demands would also occur in the 2011–2012 timeframe driven by water use for facility construction. The projected peak water demand of 23.9 million liters (6.3 million gallons) would be about 0.1 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 2.9 percent of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford.

4.3.2.2.1.1 Disposal Group 1

Electrical energy requirements to support disposal facility construction, operations, and closure would be relatively minimal overall (see Table 4–128). For facility construction, it is assumed that any electric power required would be produced via fuel-fired generators. Under Waste Management Alternative 2, Disposal Group 1, activities, annual electrical energy demand is expected to remain relatively constant at

0.00019 million megawatt-hours through 2050 and limited to demands to support continued disposal operations in LLBG 218-W-5, as previously discussed under Alternative 1 (see Section 4.3.2.1.1). Neither operations nor eventual closure of IDF-East or the RPPDF between the 200-East and 200-West Areas is projected to require any electric power from the Hanford electric power distribution system, as any demands would be met via fuel-fired generators.

Peak annual liquid fuel consumption for Disposal Group 1 activities would total about 42.7 million liters (11.3 million gallons) in the 2051–2052 timeframe, primarily associated with mobile equipment operations to effect landfill closure of IDF-East and the RPPDF with a modified RCRA Subtitle C barrier. Similar to liquid fuel requirements, peak water demands would also occur in 2051–2052, driven by water use for dust control and soil compaction associated with IDF-East and RPPDF closure activities. The projected peak water demand of 67.0 million liters (17.7 million gallons) would be about 0.4 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 8.2 percent of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford.

4.3.2.2.1.2 Disposal Group 2

Under Disposal Group 2, total and peak electrical energy requirements would be the same as those discussed under Section 4.3.2.2.1.1 for Alternative 2, Disposal Group 1.

Total and peak liquid fuel consumption would be greater under this disposal group than under Disposal Group 1 due to the much larger RPPDF that would be constructed and the longer period of disposal operations (until 2100). Peak annual liquid fuel consumption for Disposal Group 2 activities would be about 165 million liters (43.6 million gallons) in the 2101–2102 timeframe, driven by IDF-East and RPPDF closure activities.

As for liquid fuels, peak water demands would also occur in the 2101–2102 timeframe associated with disposal facility closure activities. The projected peak annual water demand of 259 million liters (68.4 million gallons) would be about 1.4 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 32 percent of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford.

4.3.2.2.1.3 Disposal Group 3

Under Alternative 2, Disposal Group 3, total and peak electrical energy requirements would be the same as those discussed under Section 4.3.2.2.1.1. Otherwise, activities under this Alternative 2 disposal grouping would have the highest total utility resource requirements due to the longer operational timeframe (until 2165) associated with IDF-East and the RPPDF. Still, the magnitude of the peak annual demands for liquid fuels and water is projected to be the same as discussed under Alternative 2, Disposal Group 2 (see Section 4.3.2.2.1.2 and Table 4–128), but would occur later in time. Specifically, peak annual liquid fuel consumption for Disposal Group 3 activities would be about 165 million liters (43.6 million gallons) in the 2166–2167 timeframe, driven by IDF-East and RPPDF closure activities. The peak annual water demand of 259 million liters (68.4 million gallons) would also occur in the 2166–2167 timeframe associated with disposal facility closure activities.

4.3.2.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

4.3.2.3.1 Electricity, Fuel, and Water

Activities and associated utility infrastructure demands to support ongoing Hanford waste treatment and storage activities and proposed facility expansions under Waste Management Alternative 3 would be the same as those previously described in Section 4.3.2.2.1 under Alternative 2. While the Alternative 2

disposal groupings assume construction of a single IDF in the 200-East Area, two IDFs would be constructed (one in the 200-East Area and the other in the 200-West Area), operated, and ultimately closed under all Alternative 3 disposal groupings. Nevertheless, RPPDF considerations and related utility impacts would generally be identical to those under the Alternative 2 disposal scenarios.

4.3.2.3.1.1 Disposal Group 1

Electrical energy requirements to support disposal facility construction, operations, and closure would be relatively minimal overall (see Table 4–128) with total and peak electrical requirements under Alternative 3, Disposal Group 1, the same as previously described under Alternative 2, Disposal Group 1 (see Section 4.3.2.2.1.1).

Peak annual liquid fuel consumption under Alternative 3, Disposal Group 1, activities would total about 42.6 million liters (11.3 million gallons) in the 2051–2052 timeframe, primarily associated with mobile equipment operations to effect landfill closure of the two IDFs and the RPPDF with modified RCRA Subtitle C barriers. Peak water demands would also occur in 2051–2052, driven by water use for dust control and soil compaction associated with IDF and RPPDF closure activities. The projected peak water demand of 66.7 million liters (17.6 million gallons) would be about 0.4 percent of the 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 8.2 percent of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford.

4.3.2.3.1.2 Disposal Group 2

Electrical energy requirements to support disposal facility construction, operations, and closure would be relatively minimal overall (see Table 4–128) with total and peak electrical requirements under Alternative 3, Disposal Group 2, the same as previously described under Alternative 2, Disposal Group 1 (see Section 4.3.2.2.1.1).

Alternative 3, Disposal Group 2, would entail peak annual liquid fuel consumption of approximately 163 million liters (43.0 million gallons) in the 2101–2102 timeframe based on the projection that the larger of the two IDFs, IDF-East, and the RPPDF would be closed in that timeframe. Disposal facility closure is also projected to result in peak water demands in the same timeframe. The projected peak annual water demand of 256 million liters (67.6 million gallons) would be about 1.4 percent of 18,500-million-liter (4,890-million-gallon) annual capacity of the Hanford Export Water System and about 31 percent of the approximately 816.6 million liters (215.7 million gallons) of water used annually at Hanford.

4.3.2.3.1.3 Disposal Group 3

Electrical energy requirements to support disposal facility construction, operations, and closure would be relatively minimal overall (see Table 4–128), with total and peak electrical requirements under Alternative 3, Disposal Group 3, the same as previously described under Alternative 2, Disposal Group 1 (see Section 4.3.2.2.1.1). Nonetheless, activities under this Alternative 3 disposal grouping would have the highest total utility resource requirements due to the longer operational timeframe (until 2165) associated with the two IDFs and the RPPDF. However, the magnitude of the peak annual demands for liquid fuels and water are projected to be the same as discussed under Alternative 3, Disposal Group 2 (see Section 4.3.2.3.1.2), but peak demands would be shifted to the 2166–2167 timeframe (see Table 4–128).

4.3.3 Noise and Vibration

Facility construction, operations, decommissioning, deactivation, and closure activities, as applicable to each alternative, would result in minor noise impacts from employee vehicles, trucks, construction

equipment, generators, and other equipment as compared to the Tank Closure alternatives discussed in Section 4.1.3. The offsite noise levels from activities in the 200 and 400 Areas would be negligible due to the distance to the Hanford boundary. Heavy diesel equipment used for construction and closure under most of the alternatives is expected to cause the highest noise levels. For example, if 488 items of construction equipment were operating at the RPPDF during its construction with a sound pressure level of 88 dBA at 15.2 meters (50 feet), the contribution to the sound level at the nearest site boundary would be 21 dBA (SAIC 2007c). If the equipment operates during a normal daytime shift, the estimated maximum sound level at the site boundary would be well below the Washington State standard daytime maximum noise level limitation of 60 dBA for industrial sources impacting residential receptors (WAC 173-60). Noise levels from deactivation, construction, operations, and closure are expected to be less than those from this construction activity.

Some disturbance of wildlife near the 200 Areas could occur as a result of noise from construction-type activities during construction, operations, deactivation, and closure, as applicable to each alternative. Mitigation of impacts on threatened and endangered species is discussed in Section 4.3.7.

The number of employee vehicles and trucks moving materials for various phases of waste management activities will vary over the duration of the project and by alternative. The increase in the number of employee vehicle and truck trips is discussed below for each alternative.

Activities at Hanford associated with the Waste Management alternatives that involve excavation, earthmoving, transporting fill material, and other vehicle traffic through Hanford could result in ground vibration that could affect operations of LIGO. Most of the activities that have been identified to have impacts on this facility are activities in which heavy vehicles or large construction equipment are used. It is expected that blasting would also have an impact on this facility if it is required for mining. Although DOE would coordinate vibration-producing activities with LIGO, impacts of this type of activity associated with these alternatives are expected to result in some interference with the operations of this facility.

4.3.3.1 Alternative 1: No Action

The increase in the number of employee vehicle and truck trips under Waste Management Alternative 1 is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. The highest number of employee trips is expected to occur in year 2009 due to IDF-East deactivation (SAIC 2007c). The increase in employee and truck traffic from the discussion of local traffic (see Section 4.3.9) was compared to the existing average traffic volume (see Chapter 3, Section 3.2.9.4). For the purpose of comparison among the alternatives, the increase in traffic noise level can be estimated from the ratio of the projected traffic volume to the existing traffic volume (see Appendix F, Section F.3).

4.3.3.2 Alternative 2: Disposal in IDF, 200-East Area Only

The increase in the number of employee vehicle and truck trips under Waste Management Alternative 2 at Hanford is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. The highest number of employee trips is expected to occur during the period from 2019–2050 due to Solid Waste Operations Complex (SWOC) WRAP facility operations. Under Disposal Groups 1 through 3, activities would result in an increase of less than 1 dBA in traffic noise levels along routes to the site. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion is similar to that previously described for Alternative 1 (see Section 4.3.3.1). The highest number of employee trips is expected to occur in various years due to RPPDF and IDF-East closure.

4.3.3.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

The increase in the number of employee vehicle and truck trips under Waste Management Alternative 3 at Hanford is expected to result in an increase of less than 1 dBA in traffic noise levels along routes to the site. This increase would occur primarily during the peak traffic hours. The highest number of employee trips is expected to occur from 2019–2050 from SWOC WRAP (SAIC 2007c). Under Disposal Groups 1 through 3, activities would result in an increase of less than 2 dBA in traffic noise levels along routes to the site. An increase of less than 2 or 3 dBA would be barely discernible to many listeners. This assessment and conclusion is similar to that previously described for Alternative 1 (see Section 4.3.3.1). The highest number of employee trips is expected to occur in various years due to RPPDF closure under Disposal Groups 2 and 3 due to closure of IDF-East and the RPPDF under Disposal Group 1.

4.3.4 Air Quality

Activities under the various Waste Management alternatives would result in some air quality impacts of air pollutant emissions from employee vehicles, trucks, and construction equipment and, as applicable under some alternatives, heating equipment, generators, and process equipment. Criteria pollutant concentrations for the activities associated with each alternative were modeled, and the year with peak concentrations for each alternative, pollutant, and averaging time was identified (see Appendix G). These concentrations are presented in Table 4–129 and compared with the ambient standards. The maximum concentrations that would result from these activities for each alternative would be below the ambient standards except the annual standard for concentrations of PM under Disposal Groups 1, 2, and 3 and the 24-hour standard under all alternatives and disposal groups. The peak period identified for each alternative and the primary contributing activities are discussed for each alternative below. Maximum air quality impacts are expected to occur along State Route 240 or along or near the Hanford boundary. The concentration estimates for PM are high as a result of the high estimated emissions. PM concentrations would be reduced by applying appropriate dust control measures (see Chapter 7, Section 7.1).

Construction activities considered in estimating PM emissions include general construction equipment activity and windblown particulate from disturbed areas, resuspension of road dust, and fuel combustion in construction equipment.

As described in Section 4.1.4, the emissions calculations result in a substantial overestimate of PM_{10} and $PM_{2.5}$ emissions. A refined analysis of emissions, based on more detailed engineering of the construction activities and application of appropriate control technologies, is expected to result in substantially lower estimates of emissions and ambient concentrations from the major construction activities under any of the alternatives.

Table 4–129. Incremental Criteria Pollutant Concentrations by Waste Management Alternative at Hanford

Pollutant and Averaging Period	Standard[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)								
			Alternative 2				Alternative 3			
		Alternative 1	T&S	DG1	DG2	DG3	T&S	DG1	DG2	DG3
Carbon Monoxide										
8-hour	10,000[b]	70.6	2,240	7,880	**41,200**	**41,200**	2,240	8,190	**41,000**	**41,000**
1-hour	40,000[b]	451	12,200	**49,800**	**257,000**	**257,000**	12,200	**51,200**	**256,000**	**256,000**
Nitrogen Dioxide										
Annual	100[b]	1.24	3.47	19.2	92.1	92.1	3.47	20.1	92.0	92.0
PM_{10}[c]										
Annual	50[d]	4.54	3.93	27.1	**128**	**128**	4.59	27.2	**128**	**128**
24-hour	150[b]	**507**	**717**	**3,360**	**17,200**	**17,200**	**717**	**3,420**	**17,300**	**17,300**
Sulfur Dioxide										
Annual	50[d]	0.000442	0.00826	0.0380	0.182	0.182	0.00826	0.0388	0.181	0.181
24-hour	260[d]	0.048	1.29	4.70	24.5	24.5	1.29	4.88	24.4	24.4
3-hour	1,300[b]	0.254	6.36	23.7	120	120	6.36	24.5	120	120
1-hour	660[d]	0.705	16.5	68.4	353	353	16.5	70.5	352	352

a The more stringent of the Federal and Washington State standards is presented if both exist for the averaging period. The NAAQS (40 CFR 50), other than those for ozone, particulate matter, lead, and those based on annual averages, are not to be exceeded more than once per year. The 24-hour PM_{10} standard is attained when the expected number of days with a 24-hour average concentration above the standard is equal to or less than 1. The annual arithmetic mean PM_{10} standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard. The annual $PM_{2.5}$ standard is met when the 3-year average of the annual means is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 3-year average of the 98th percentile 24-hour averages is less than or equal to the standard.

b Federal and Washington State standard.

c The Federal standards for $PM_{2.5}$ are 15 micrograms per cubic meter annual average and 35 micrograms per cubic meter 24-hour average. No specific data for $PM_{2.5}$ were available, but for the purposes of analysis, concentrations are assumed to be the same as PM_{10}.

d Washington State standard.

Note: NAAQS also includes standards for lead and ozone. No sources of lead emissions have been identified for the alternatives evaluated. Washington State also has ambient standards for fluorides. Concentrations in **bold** text indicate potential exceedance of the standard.

Key: DG=Disposal Group; Hanford=Hanford Site; NAAQS=National Ambient Air Quality Standards; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; T&S=treatment and storage.

Source: Appendix G, Section G.3.

The sulfur dioxide emission factor used for fuel-burning sources was based on equipment burning a distillate fuel with a sulfur content of about 0.0015 percent (15 ppm), which is being phased in beginning in 2007. No adjustment was made for more restrictive emission standards for nitrogen dioxide and PM scheduled to be phased in beginning in 2007. In future years, pollutant emissions and impacts are expected to be smaller than estimated in this analysis, as better fuels, combustion technologies, emission controls, and alternative energy sources are developed.

The contributions to the total ambient concentrations from sources in the region and existing and reasonably anticipated sources at Hanford that are unrelated to waste management activities are expected to change over the period of the activities evaluated in this EIS and are addressed in the cumulative impacts section. The existing contributions of Hanford sources and regional monitored concentrations are discussed in Chapter 3, Section 3.2.4.

The Clean Air Act, as amended, requires that Federal actions conform to the host state's "state implementation plan" (see Appendix G, Section G.4). The final rule, "Determining Conformity of General Federal Actions to State or Federal Implementation Plans," requires a conformity determination for certain-sized projects in nonattainment areas. Hanford is within an area currently designated as attainment for criteria air pollutants. Therefore, a conformity determination for these alternatives is not necessary to meet the requirements of the final rule (40 CFR 51.850–51.860).

Both carcinogenic and noncarcinogenic toxic pollutant concentrations were evaluated. The exposure of members of the public to airborne pollutants would be from process emissions released during operations and from equipment used during construction and operations. Selected air toxics were modeled because they are representative of toxic constituents associated with emissions from operation of gasoline- and diesel-fueled equipment. Maximum concentrations for each alternative and the Washington State acceptable source impact levels are presented in Table 4–130. These concentrations were below the acceptable source impact levels for all alternatives. The acceptable source impact levels are used by the state in the permitting process and represent concentrations sufficiently low to protect human health and safety from potential carcinogenic and other toxic effects (WAC 173-460).

For noninvolved workers at nearby facilities, the highest annual concentration of each toxic chemical was used to estimate the Hazard Quotient for each chemical, as described in Appendix G. The Hazard Quotients were summed to give the Hazard Index from noncarcinogenic chemicals associated with the alternative. A Hazard Index of less than 1.0 indicates that adverse health effects of non-cancer-causing agents are not expected. Hazard Indices for each alternative are summarized in Table 4–131. For carcinogens, the highest annual concentration was used to estimate the increased cancer risk from a chemical. Cancer risks from nonradiological toxic pollutant emissions for each alternative are summarized in Table 4–132.

Table 4–130. Incremental Toxic Chemical Concentrations by Waste Management Alternative at Hanford

Pollutant	Averaging Period	Acceptable Source Impact Level[a] (micrograms per cubic meter)	Maximum Modeled Increment (micrograms per cubic meter)								
				Alternative 2				Alternative 3			
			Alternative 1	T&S	DG1	DG2	DG3	T&S	DG1	DG2	DG3
Ammonia	24-hour	100	0.210	0.874	3.84	20.0	20.0	0.874	4.09	20.0	20.0
Benzene	Annual	0.12	0.000264	0.00116	0.00698	0.0334	0.0334	0.00116	0.00721	0.0334	0.0334
1,3-Butadiene	Annual	0.0036	0.0000110	0.0000605	0.000182	0.000872	0.000872	0.0000605	0.000190	0.000871	0.000871
Formaldehyde	Annual	0.077	0.000332	0.00223	0.00600	0.0288	0.0288	0.00223	0.00625	0.0287	0.0287
Mercury	24-hour	0.17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Toluene	24-hour	400	0.0265	1.84	6.00	31.2	31.2	1.84	6.20	31.1	31.1
Xylene	24-hour	1,500	0.00973	0.526	1.78	9.27	9.27	0.526	1.84	9.25	9.25

[a] WAC 173-460.

Key: DG=Disposal Group; Hanford=Hanford Site; T&S=treatment and storage.
Source: Appendix G, Section G.3.

Table 4–131. Nonradiological Airborne Toxic Chemical Hazard Index for the Nearest Noninvolved Worker by Waste Management Alternative at Hanford

Chemical	Hazard Quotient								
	Alternative 1	Alternative 2				Alternative 3			
		T&S	DG1	DG2	DG3	T&S	DG1	DG2	DG3
Ammonia	1.19×10^{-3}	5.45×10^{-3}	2.00×10^{-2}	8.08×10^{-2}	8.08×10^{-2}	5.45×10^{-3}	2.34×10^{-2}	8.54×10^{-2}	8.53×10^{-2}
Mercury	0	0	0	0	0	0	0	0	0
Toluene	3.25×10^{-6}	1.07×10^{-4}	4.82×10^{-4}	1.94×10^{-3}	1.94×10^{-3}	1.07×10^{-4}	4.80×10^{-4}	1.95×10^{-3}	1.95×10^{-3}
Xylene	7.50×10^{-5}	1.63×10^{-3}	7.27×10^{-3}	2.93×10^{-2}	2.93×10^{-2}	1.63×10^{-3}	7.32×10^{-3}	2.95×10^{-2}	2.95×10^{-2}
Hazard Index	1.27×10^{-3}	7.18×10^{-3}	2.78×10^{-2}	1.12×10^{-1}	1.12×10^{-1}	7.18×10^{-3}	3.12×10^{-2}	1.17×10^{-1}	1.17×10^{-1}

Key: DG=Disposal Group; Hanford=Hanford Site; T&S=treatment and storage.
Source: Appendix G, Section G.3.

Table 4–132. Nonradiological Airborne Toxic Chemical Cancer Risk for the Nearest Noninvolved Worker by Waste Management Alternative at Hanford

Chemical	Cancer Risk								
	Alternative 1	Alternative 2				Alternative 3			
		T&S	DG1	DG2	DG3	T&S	DG1	DG2	DG3
Benzene	1.30×10^{-7}	7.63×10^{-7}	3.18×10^{-6}	1.28×10^{-5}	1.28×10^{-5}	7.63×10^{-7}	3.51×10^{-6}	1.33×10^{-5}	1.33×10^{-5}
1,3-Butadiene	2.02×10^{-8}	1.07×10^{-7}	3.49×10^{-7}	1.41×10^{-6}	1.41×10^{-6}	1.07×10^{-7}	4.06×10^{-7}	1.49×10^{-6}	1.48×10^{-6}
Formaldehyde	2.66×10^{-7}	1.58×10^{-6}	4.89×10^{-6}	1.97×10^{-5}	1.97×10^{-5}	1.58×10^{-6}	5.63×10^{-6}	2.07×10^{-5}	2.07×10^{-5}

Key: DG=Disposal Group; Hanford=Hanford Site; T&S=treatment and storage.
Source: Appendix G, Section G.3.

4.3.4.1 Alternative 1: No Action

Criteria pollutant concentrations from activities under Waste Management Alternative 1 are presented in Table 4–129. The peak concentrations occur in 2009 for all criteria pollutants. The peak period concentration would result primarily from IDF deactivation activities. The period of PM_{10} exceeding the 24-hour standard occurs in 2009. The periods of $PM_{2.5}$ exceeding the 24-hour standard extend from 2007 through 2035. Figure 4–30 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities.

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–130. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–131 and 4–132.

Criteria pollutant concentrations from activities under Waste Management Alternative 2 treatment and storage and activities related to the three disposal groups are presented in Table 4–129. The peak concentrations occur from 2011–2012 for carbon monoxide and sulfur dioxide, from 2013–2018 for nitrogen dioxide, and from 2019–2050 for PM under Alternative 2 (treatment and storage). The peak period concentration for Alternative 2 would result primarily from the WRAP CH-Mixed TRU/TRU waste facility at CWC and CWC storage facility construction for carbon monoxide and sulfur dioxide; from T Plant complex operations for nitrogen dioxide; and from CWC storage facility, WRAP CH-Mixed TRU/TRU waste facility, and WRAP RH-Mixed TRU/TRU waste facility operations for PM. The period during which PM_{10} exceeds the 24-hour standard would occur from 2011 through 2050. The period of $PM_{2.5}$ exceeding the 24-hour standard would occur from 2011 through 2051. Figure 4–31 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities.

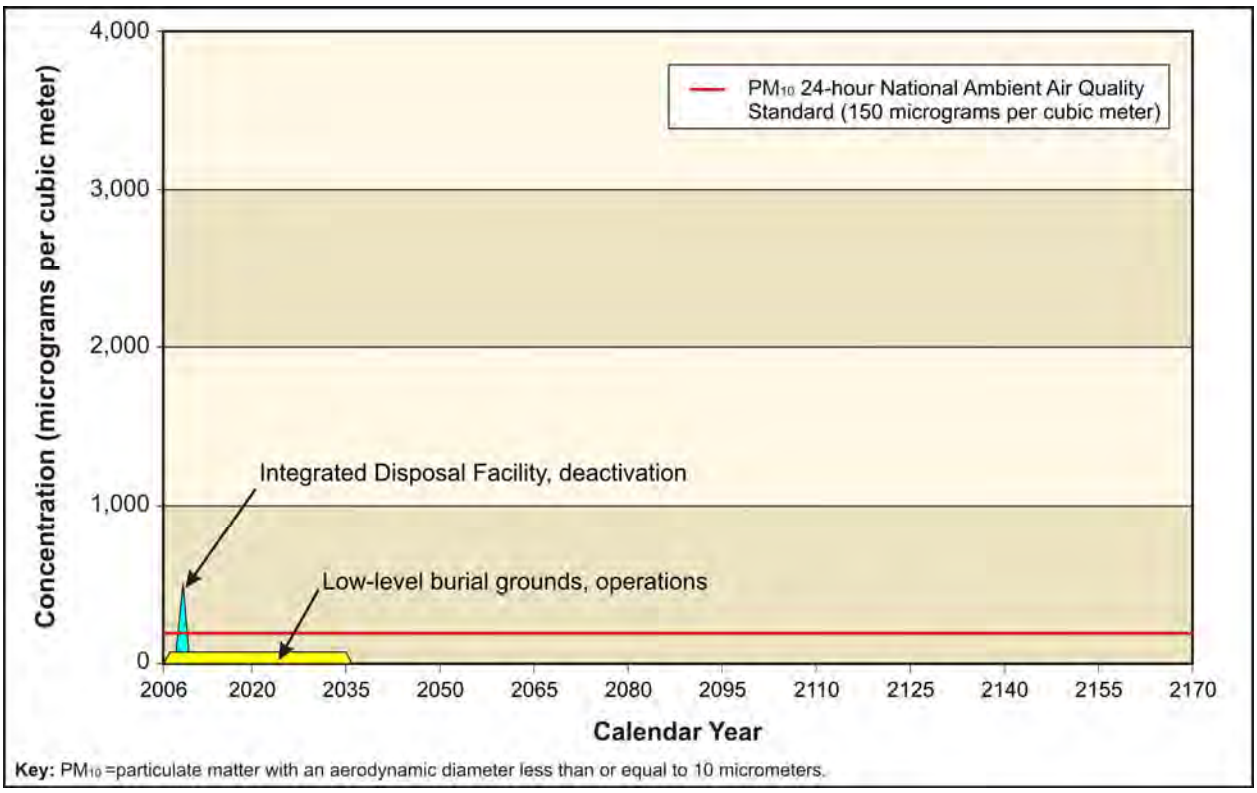


Figure 4–30. Waste Management Alternative 1 PM_{10} Maximum 24-hour Concentration

4.3.4.2 Alternative 2: Disposal in IDF, 200-East Area Only

For Disposal Group 1, the peak concentrations occur from 2051–2052 for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and from 2019–2021 for PM. The peak period concentration for Alternative 2, Disposal Group 1, would result primarily from IDF-East and RPPDF closure for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and from RPPDF construction and IDF-East operations for PM. The period during which PM_{10} and $PM_{2.5}$ exceed the 24-hour standard would occur from 2006 through 2052. Figure 4–32 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities.

For Disposal Group 2, the peak concentrations occur from 2101–2102 for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and from 2019–2021 for PM. The peak period concentrations would result primarily from RPPDF and IDF-East closure for carbon monoxide, nitrogen dioxide, and sulfur dioxide annual averages, and from RPPDF construction for PM. The period during which PM_{10} and $PM_{2.5}$ exceed the 24-hour standard would occur from 2006 through 2102. Figure 4–33 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities.

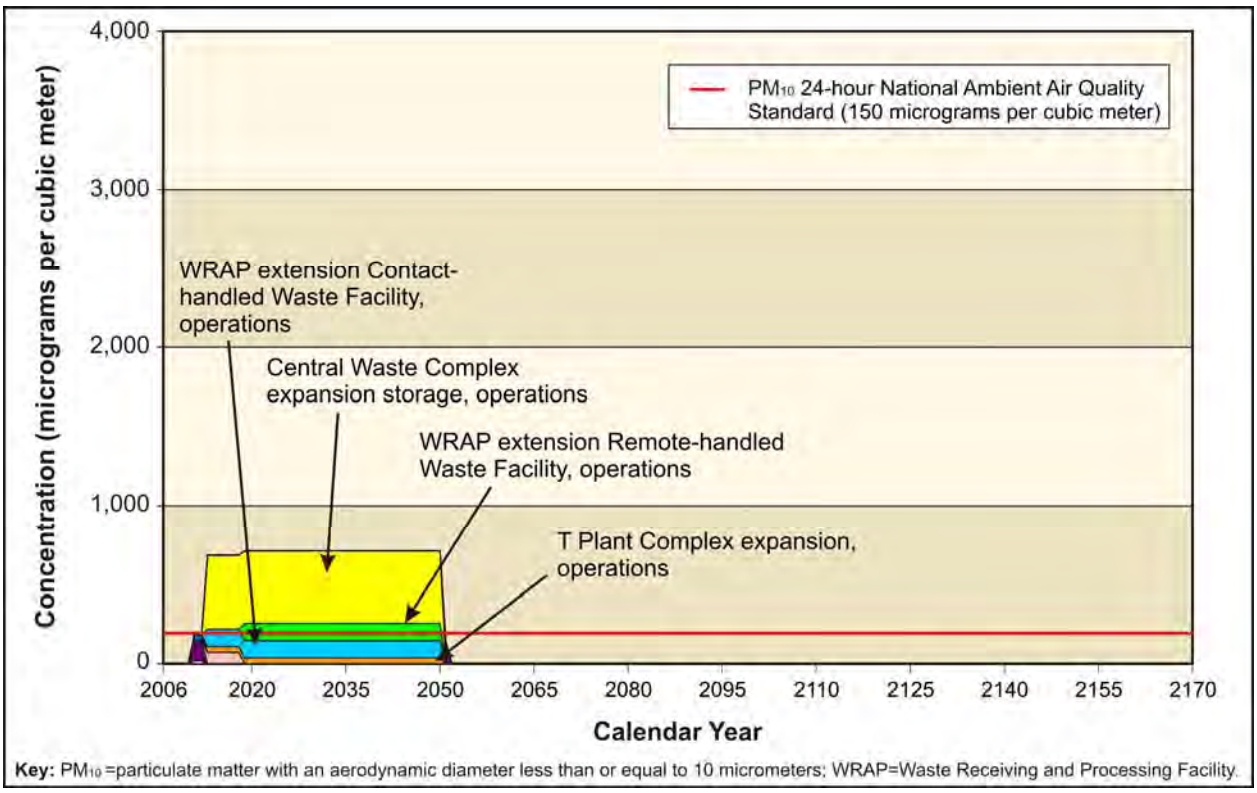


Figure 4–31. Waste Management Alternative 2 (Treatment and Storage) PM_{10} Maximum 24-hour Concentration

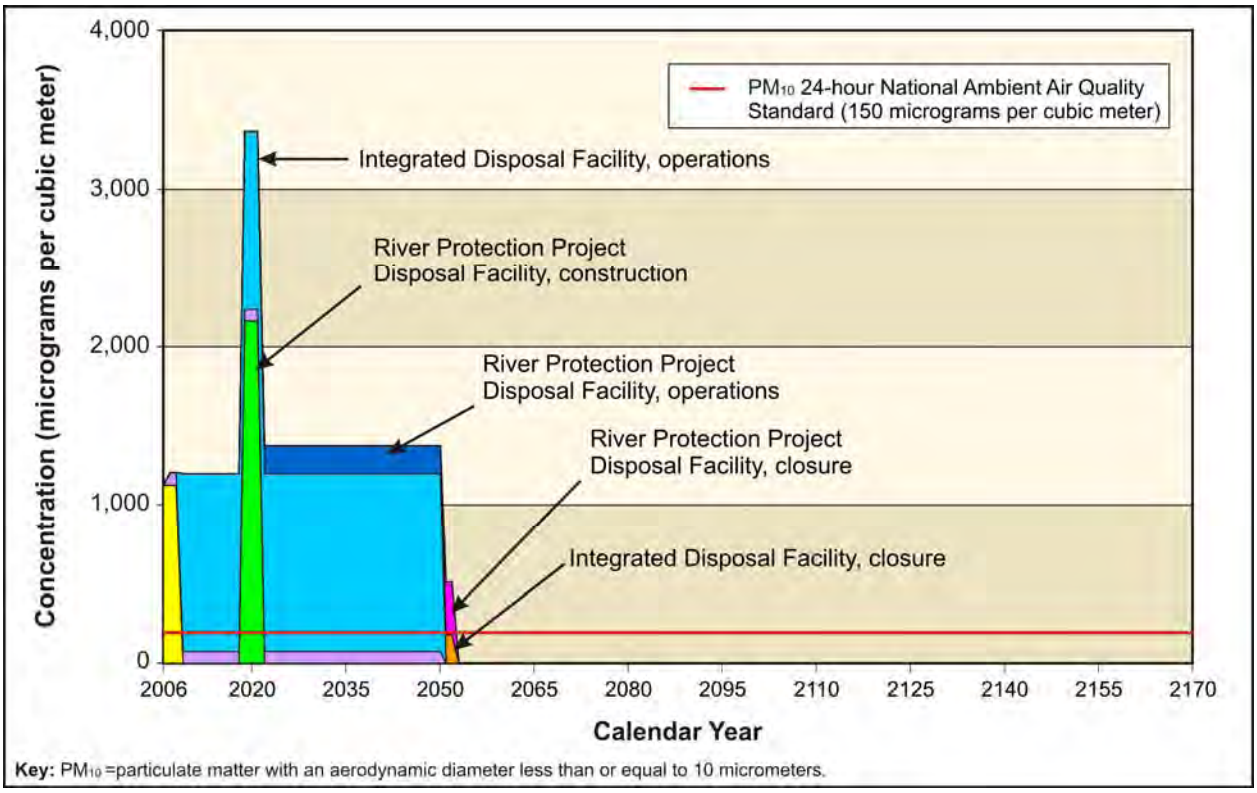


Figure 4–32. Waste Management Alternative 2, Disposal Group 1, PM_{10} Maximum 24-hour Concentration

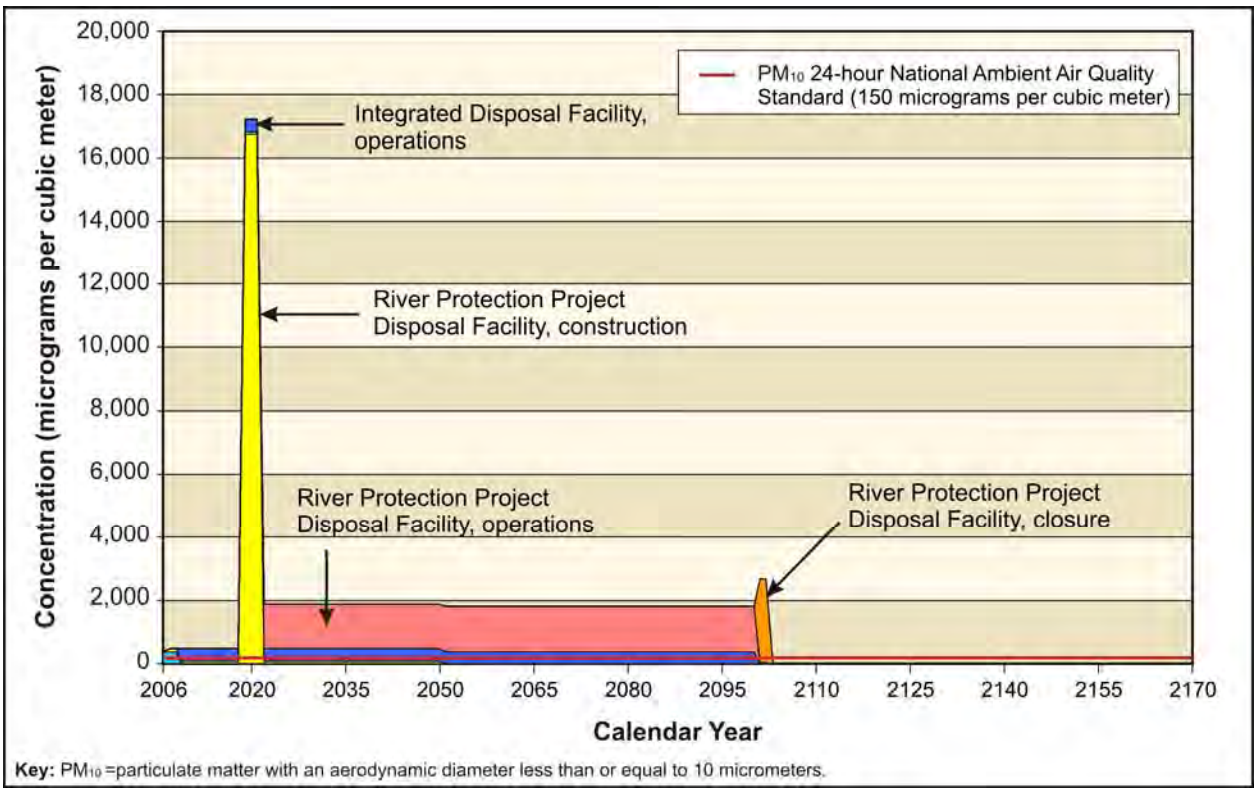


Figure 4–33. Waste Management Alternative 2, Disposal Group 2, PM_{10} Maximum 24-hour Concentration

For Disposal Group 3, the peak concentrations occur from 2166–2167 for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and from 2019–2021 for PM. The peak concentrations would result from the same activities as Disposal Group 2. The period during which PM_{10} and $PM_{2.5}$ exceed the 24-hour standard would occur from 2006 through 2167. Figure 4–34 shows the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities.

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–130. The guidelines would not be exceeded. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–131 and 4–132.

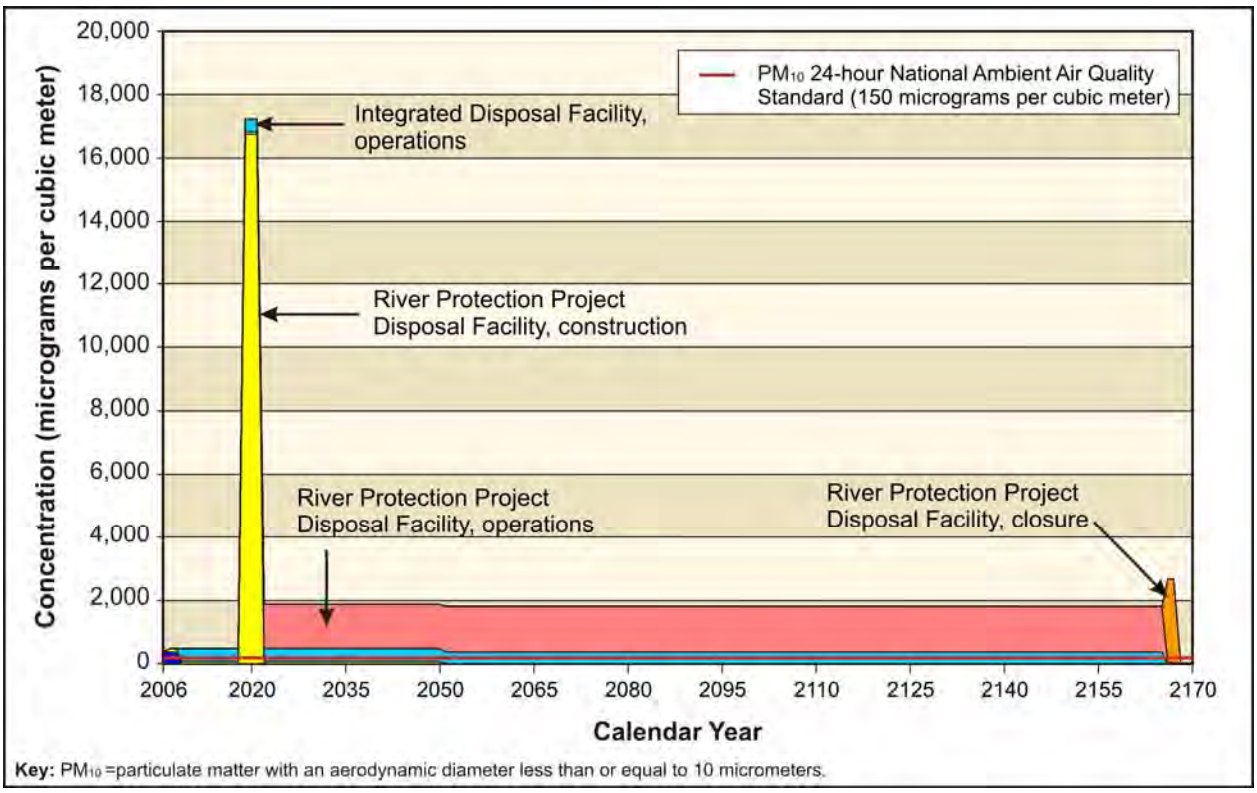


Figure 4–34. Waste Management Alternative 2, Disposal Group 3, PM_{10} Maximum 24-hour Concentration

4.3.4.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Criteria pollutant concentrations from activities under Waste Management Alternative 3 and activities related to the three disposal groups are presented in Table 4–129. The peak concentrations occur in the same years and arise from the same activities as Waste Management Alternative 2, treatment and storage and Disposal Groups 2 and 3. The period during which PM_{10} exceeds the 24-hour standard would occur for the same durations as Alternative 2 and the three disposal groups. Figures 4–35 through 4–38 show the 24-hour PM_{10} concentrations over the project duration and the contribution of major activities.

For Disposal Group 1, the peak concentrations occur from 2051–2052 for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and from 2019–2021 for PM. The peak period concentrations under Disposal Group 1 would result primarily from RPPDF, IDF-East, and IDF-West closure for carbon monoxide, nitrogen dioxide, and sulfur dioxide, and from RPPDF construction and IDF-East operations for PM.

Maximum concentrations of carcinogenic and noncarcinogenic toxic pollutants are presented in Table 4–130. The guidelines would not be exceeded. Hazardous chemical health effects on noninvolved workers are summarized in Tables 4–131 and 4–132.

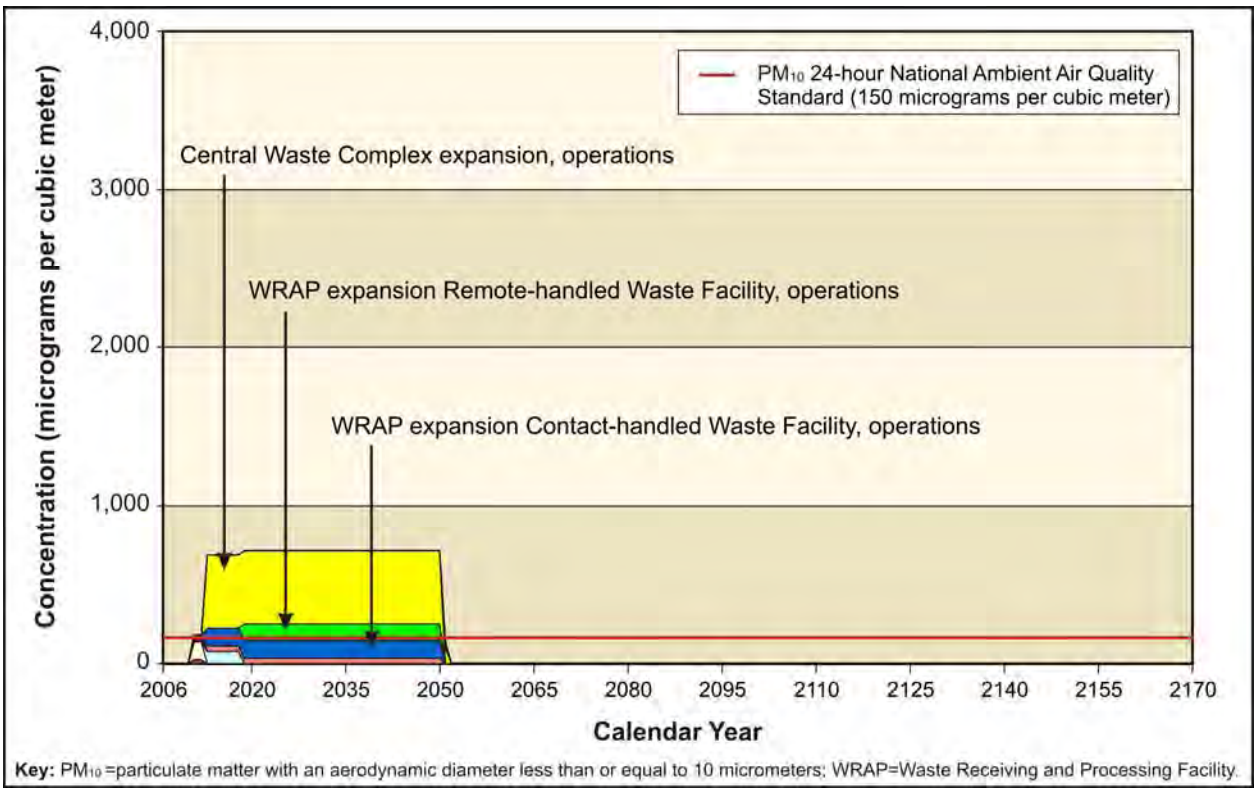


Figure 4–35. Waste Management Alternative 3 (Treatment and Storage) PM_{10} Maximum 24-hour Concentration

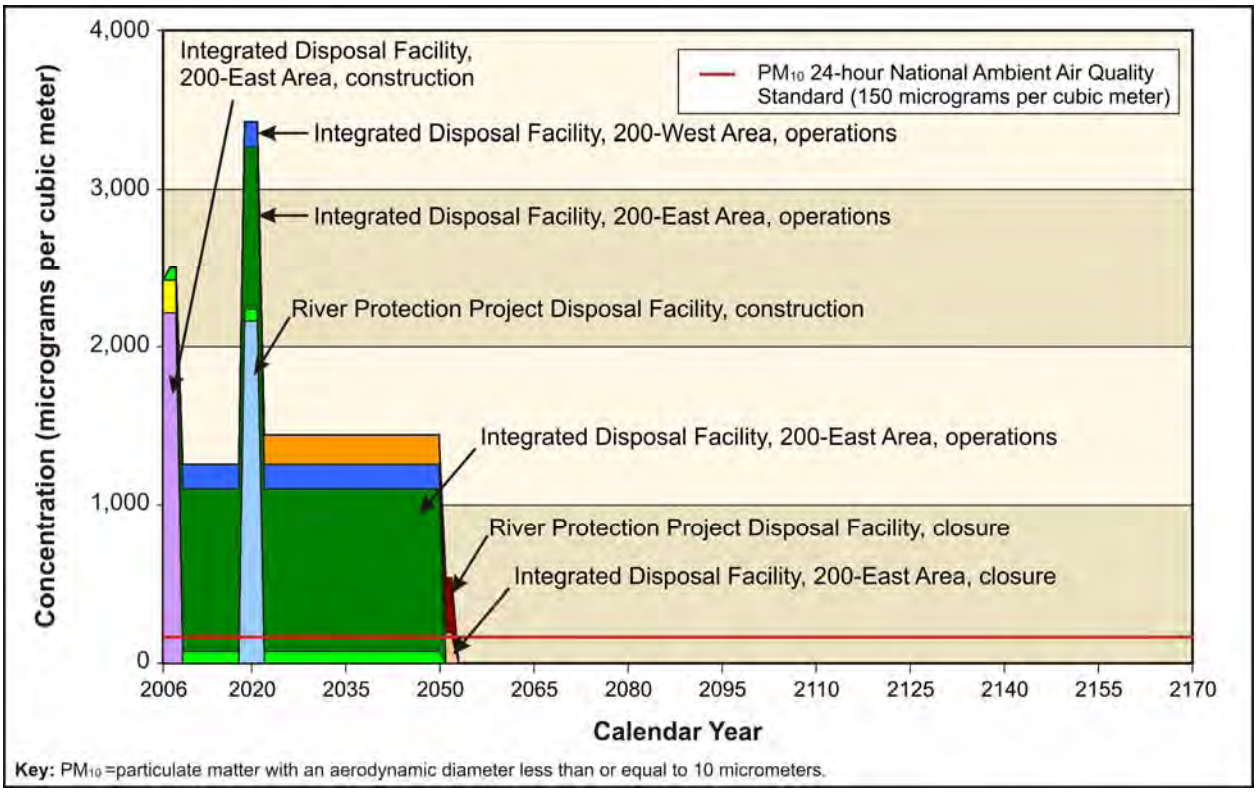


Figure 4–36. Waste Management Alternative 3, Disposal Group 1, PM_{10} Maximum 24-hour Concentration

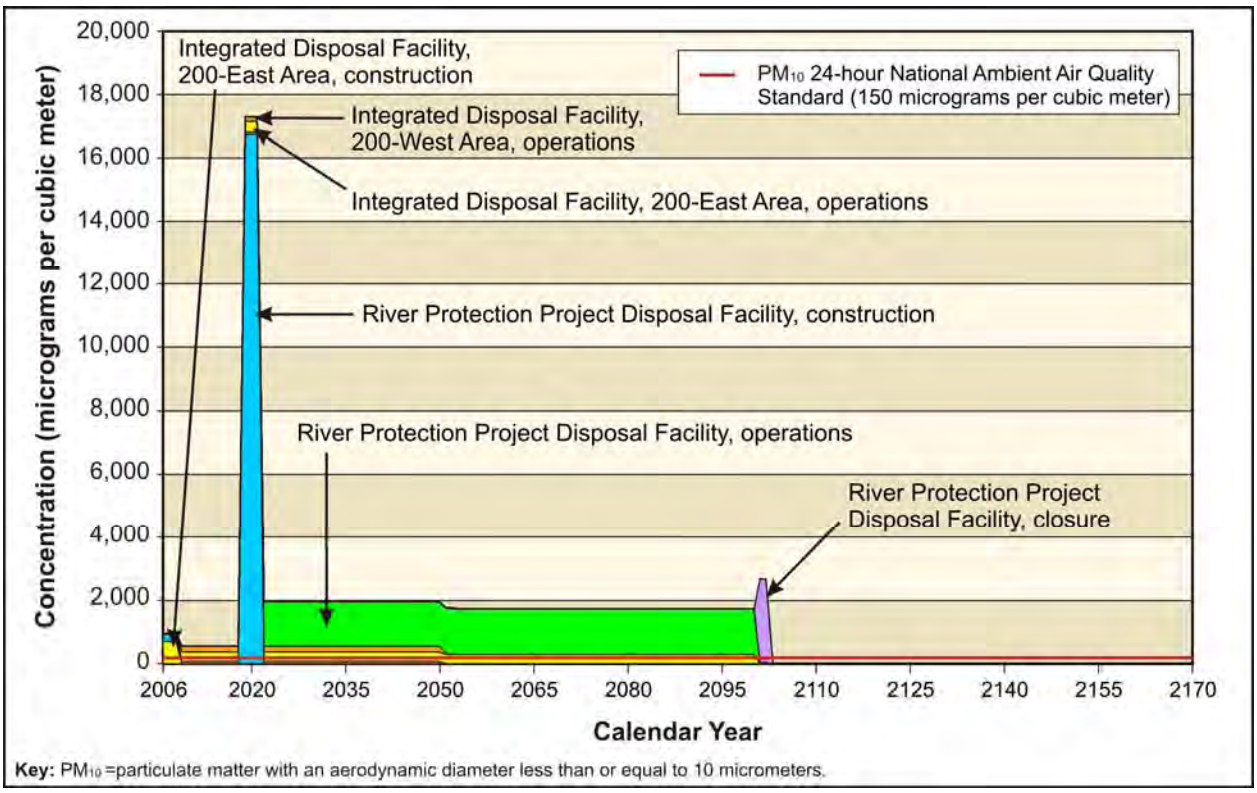


Figure 4–37. Waste Management Alternative 3, Disposal Group 2, PM_{10} Maximum 24-hour Concentration

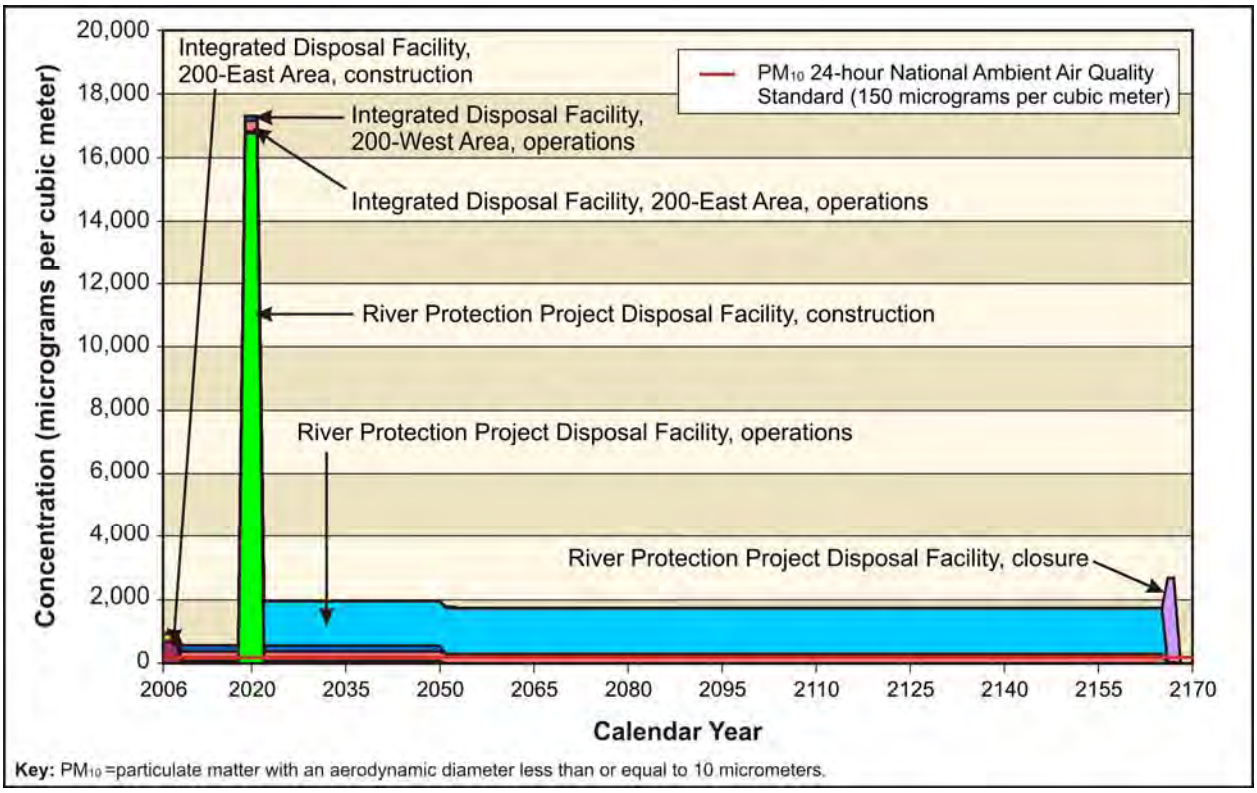


Figure 4–38. Waste Management Alternative 3, Disposal Group 3, PM_{10} Maximum 24-hour Concentration

4.3.5 Geology and Soils

Impacts on geology and soils would generally be directly proportional to the total area of land disturbed by facility construction, operations, deactivation, and closure associated with waste management treatment, storage, and waste disposal. Consumption of geologic resources, including rock, mineral, and soil resources, would constitute the major indirect impact on geologic and soil resources, as summarized in Table 4–133 for each of the Waste Management alternatives and disposal groupings. In general, Hanford waste treatment and storage activities and commensurate geologic resource requirements would be identical for Alternatives 2 and 3. For the three disposal groupings under each action alternative, direct impacts on geology and soils and associated demand for geologic resources would vary primarily in direct relation to the size, number, and required lifespan of disposal facilities (i.e., the IDF[s] and RPPDF) that would be constructed, operated, and ultimately closed under each disposal scenario. For disposal facility operations, it has been assumed that uncontaminated soils and sediments excavated during facility construction would typically be stockpiled on site for backfill or for other uses. Other key underlying assumptions regarding analysis of potential environmental impacts on geology and soils and the acquisition and use of geologic resources are similar to those described in Section 4.1.2 for the Tank Closure alternatives.

4.3.5.1 Alternative 1: No Action

Interim waste treatment, storage, and disposal activities under Alternative 1 would have little additional direct impact on geology and soils. No new facilities would be constructed or expanded under Alternative 1, although geologic resources would continue to be consumed in support of waste disposal operations in trenches 31 and 34 in LLBG 218-W-5 through 2035. Waste disposal operations there would consist partly of in-trench stabilization (encasement) of waste with concrete grout. Earthwork and ground disturbance would be required in association with deactivating IDF-East, which would occur in 2009 under the No Action Alternative. Entombment and ground disturbance would consist of backfilling the facility with previously excavated material. Following the cessation of waste disposal in LLBG 218-W-5 and filling it to grade with soil, the facility would be subject to a 100-year postclosure care period but would not undergo closure. In support of postclosure care, sodium bentonite clay or grout would be required for completion of groundwater monitoring wells. Total geologic resource requirements under Alternative 1 are projected to be 6,230 cubic meters (8,150 cubic yards) (see Table 4–133). It is expected that this volume would be supplied by Borrow Area C, as further described in Section 4.1.5.

Hazards from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions with the potential to affect Hanford facilities are summarized in Chapter 3, Section 3.2.5.1.4. Maximum considered earthquake ground motions for Hanford encompass those that may cause substantial structural damage to buildings (equivalent to an MMI of VII and up), thus presenting safety concerns for occupants. Ground shaking of MMI VII associated with postulated earthquakes is possible and supported by the historical record for the region. However, this level of ground motion is expected to primarily affect the integrity of inadequately designed or nonreinforced structures (see Appendix F, Table F–7). DOE Order 420.1B requires that nuclear and nonnuclear facilities be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. The order stipulates natural phenomena hazards mitigation for DOE facilities and specifically provides for reevaluation and upgrade of existing DOE facilities when there is a significant degradation in the safety basis for the facility. DOE Standard 1020-2002 implements DOE Order 420.1B and provides criteria for the design of new structures, systems, and components and for the evaluation, modification, and upgrade of existing structures, systems, and components so that DOE facilities safely withstand the effects of natural phenomena hazards, such as earthquakes. An analysis of potential effects of a beyond-design-basis earthquake on existing facilities and activities under this alternative and the potential consequences on human health and the environment is provided in Section 4.3.11.1.

Table 4–133. Waste Management Alternatives – Summary of Major Geologic and Soil Resource Impact Indicators and Requirements

Parameter/ Resource	Alternatives and Disposal Groupings							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
New, permanent land disturbance[a]	0.0	2.7	104	398	398	98.7	397	397
Construction and Operations Materials								
Concrete	5,540	9,840	8,410	8,410	8,410	8,410	8,410	8,410
Cement[b]	1,370	2,000	2,090	2,090	2,090	2,090	2,090	2,090
Sand[b]	2,690	4,480	4,080	4,080	4,080	4,080	4,080	4,080
Gravel[b]	3,510	6,150	5,320	5,320	5,320	5,320	5,320	5,320
Other Borrow Materials[c]								
Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gravel	34.4	0.0	209,000	808,000	808,000	208,000	809,000	809,000
Soil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Closure-Specific Materials								
Grout[d]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sand[e]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barrier materials[f]	0.0	0.0	1,760,000	6,800,000	6,800,000	1,540,000	6,730,000	6,730,000
Total[g]	6,230	10,600	1,980,000	7,610,000	7,610,000	1,760,000	7,550,000	7,550,000

a Reflects land area assumed to be permanently disturbed for new facilities. The value also includes land area excavated in Borrow Area C or elsewhere to supply geologic materials listed in the table.

b Component of concrete.

c Resources for miscellaneous uses not exclusively tied to facility construction, operations, or closure, such as site grading and backfill for excavations.

d Grout comprises cement, sand, fly ash, and other materials.

e Principal component of grout that would be obtained from onsite deposits.

f Volume includes soil, sand, gravel, rock, and asphalt for construction of modified Resource Conservation and Recovery Act Subtitle C barriers.

g Excludes concrete, cement, and grout. Totals may not equal the sum of the contributions due to rounding.

Note: All values are expressed in cubic meters except land disturbance, which is in hectares. To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471. Values presented in the table have been rounded to no more than three significant digits, where appropriate.

Source: SAIC 2007c.

4.3.5.2 Alternative 2: Disposal in IDF, 200-East Area Only

Under this Waste Management alternative, ongoing Hanford waste treatment and storage would have limited but direct impacts on site geology and soils. Impacts would primarily be associated with construction of new facilities or existing-facility expansions, including a T Plant expansion, storage facility, and two expansions of WRAP: (1) a CH-Mixed TRU/TRU waste facility at the CWC and (2) an RH-Mixed TRU/TRU waste facility at WRAP. Construction activities would permanently disturb about 2.7 hectares (6.6 acres) of land in the 200-West Area. In addition, a small area of Borrow Area C would be excavated to support this construction. Although the expanded facilities would generally be constructed at grade with concrete slab foundations, excavation to depths of up to 3 meters (10 feet) may be necessary, especially for reinforced concrete floor and wall construction for below-grade service areas. Nevertheless, the expansions would have little impact on the lateral and vertical extent of the Hanford formation, which composes the uppermost strata across the 200 Areas.

Although the 200-West Area has previously been disturbed and native soils may have been altered by fill placement, denuded surface soils and unconsolidated sediments in excavations would be subject to wind and water erosion if left exposed over an extended period of time. Adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. To reduce the risk of exposing contaminated soils, areas in which new facilities would be constructed under this alternative would be surveyed prior to any ground disturbance. Any contamination would be remediated as necessary. After construction, the previously disturbed areas would not be subject to long term soil erosion. Operations and eventual deactivation of the expanded treatment and storage facilities are not expected to have any direct impact on geology and soils.

Geologic resources, mainly consisting of aggregate (sand and gravel) and cement for concrete work, would be required for expanded treatment and storage facility construction. Total geologic resource requirements under Alternative 2 are projected to be 10,600 cubic meters (13,900 cubic yards) (see Table 4–133). It is expected that this volume would be supplied by Borrow Area C, as stated above and as further described in Section 4.1.5.

As described in Section 4.3.5.1, hazards from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions with the potential to affect Hanford facilities have been evaluated. As stated in DOE Order 420.1B, DOE requires that nuclear and nonnuclear facilities be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. DOE Standard 1020-2002 implements DOE Order 420.1B and provides criteria for the design of new structures, systems, and components and for the evaluation, modification, and upgrade of existing structures, systems, and components so that DOE facilities safely withstand the effects of natural phenomena hazards, such as earthquakes. An analysis of potential effects of a beyond-design-basis earthquake affecting the expanded facilities and related activities and the potential consequences on human health and the environment is provided in Section 4.3.11.2.1.

4.3.5.2.1 Disposal Group 1

Excavation work associated with constructing an expanding IDF-East and the RPPDF between the 200-East and 200-West Areas would constitute the major direct impact on geology and soils under this alternative. Construction of IDF-East and the RPPDF would require excavation to a depth of approximately 14 meters (45 feet) (see Appendix E, Sections E.3.4 and E.3.5). Blasting should not be required to support construction of these facilities as the gravel, sand, and silt deposits of the Hanford formation, which compose the uppermost strata across the 200 Areas, are up to 65 meters (213 feet) thick across the 200 Areas. Coarse aggregate (gravel) would be used in constructing drainage layers integral to each engineered disposal facility. Completed facilities would occupy about 62.3 hectares (154 acres) of

land. An additional 41.7 hectares (103 acres) would also be excavated in Borrow Area C, for a total of 104 hectares (257 acres) of new, permanent land disturbance. At the end of their life cycles, the facilities would be closed with an engineered barrier that would extend over an additional 1.6 hectares (4 acres) of previously disturbed land, as further described below. As with any ground-disturbing activity, denuded surface soils and unconsolidated sediments in excavations and graded areas would be subject to wind and water erosion if left exposed over an extended period of time. Adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. During the 3-year construction period for each of the facilities, temporary seeding, mulching, and the use of geotextile covers and similar best management practices would be employed to minimize soil erosion in disturbed areas. After construction, the previously disturbed areas would not be subject to long term soil erosion as the areas would either lie within the footprint of the completed structures or the temporarily disturbed areas would have been revegetated.

Disposal facility operations through 2050 under this disposal scenario, including the continued operation of LLBG 218-W-5, are not expected to have any additional direct impact on geology and soils. Operations of IDF-East and the RPPDF would require the use of soil to cover each layer of emplaced waste. However, the soil would be derived from stockpiles excavated during facility construction. Similarly, disposal operations in trenches 31 and 34 in LLBG 218-W-5 would require the consumption of cement and aggregate (sand and gravel) to produce concrete for in-trench stabilization (encasement) of waste, until filled. Previously excavated soil is also used as operational cover of emplaced waste, until filled. Once filled, the LLBG 218-W-5 trenches would be backfilled with soil to grade to complete deactivation.

Following completion of disposal activities in IDF-East and the RPPDF, these engineered facilities would be closed with a modified RCRA Subtitle C barrier. The 2.7 meter-thick (9 foot-thick) engineered barrier would be composed of layers of topsoil in the upper part, which would support a mixed perennial grass ground cover, and underlain by layers of sand, gravel, asphalt, and/or riprap in the lower part. Best management practices for soil erosion and sediment control would be employed during barrier construction, including watering to control fugitive dust. The final barriers would encompass approximately 64.5 hectares (159 acres), slightly larger than the footprints of disposal facilities (see Section 4.3.1.2.1.1). During the 100-year postclosure care period for IDF-East and the RPPDF, sodium bentonite clay or grout would be required for completion of groundwater monitoring wells.

Alternative 2, Disposal Group 1, activities would not preclude the use of rare or otherwise valuable geologic or soil resources. The surficial soils, unconsolidated strata, and underlying basaltic bedrock of the 200 Areas are present elsewhere in the region and at Hanford. However, relatively large quantities of geologic resources would be required, as described, to support facility construction and, most substantially, to construct engineered barriers to effect final landfill closure of IDF-East and the RPPDF. Total geologic resource requirements for Alternative 2, Disposal Group 1, are projected to be 1,980,000 cubic meters (2,590,000 cubic yards) (see Table 4–133). It is expected that this volume would be supplied by Borrow Area C, as stated above and as further described in Section 4.1.5.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative case from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.3.5.2. An analysis of potential effects of a beyond-design-basis earthquake affecting the disposal facilities and related activities and the potential consequences on human health and the environment is provided in Section 4.3.11.2.1.

4.3.5.2.2 Disposal Group 2

The type and intensity of anticipated direct impacts on geology and soils under Waste Management Alternative 2, Disposal Group 2, including factors that could lead to increased wind and water erosion,

would be somewhat greater than those described above in Section 4.3.5.2.1 for Alternative 2, Disposal Group 1. Under this alternative and disposal grouping, the RPPDF that would be constructed would be substantially larger (by about a factor of eight) than that required under Disposal Group 1. Nevertheless, the size of IDF-East required under this disposal grouping would only be about one-third of the size of that constructed under Alternative 2, Disposal Group 1. On the whole, the total scale of direct impacts associated with new facility disposal construction would be greater under this disposal grouping. In total, the completed facilities would occupy about 240 hectares (592 acres) of land (see Section 4.3.1.2.1.2).

Both IDF-East and the RPPDF would operate until 2100 under this alternative and disposal grouping. Disposal operations in LLBG 218-W-5 would be identical to those described in Section 4.3.5.2.1 for Alternative 2, Disposal Group 1. An additional 159 hectares (392 acres) would also be excavated in Borrow Area C, for a total of 398 hectares (984 acres) of new, permanent land disturbance.

Following completion of disposal activities in IDF-East and the RPPDF, each facility would be closed with a modified RCRA Subtitle C barrier, as described above in Section 4.3.5.2.1. The final barriers would encompass a total land area of about 247 hectares (611 acres) and would be subject to a 100-year postclosure care period.

Total geologic resource requirements for Alternative 2, Disposal Group 2, are projected to be 7,610,000 cubic meters (9,950,000 cubic yards), with the demand mainly driven by construction of the engineered barriers for landfill closure of IDF-East and the RPPDF (see Table 4–133). It is expected that this volume would be supplied by Borrow Area C, as stated above and as further described in **Section 4.1.5**.

4.3.5.2.3 Disposal Group 3

Direct impacts on geology and soils from disposal facility construction, operations, and closure and associated geologic resource demands under this disposal grouping would be identical to those described above for Alternative 2, Disposal Group 2 (see Section 4.3.5.2.2). Although IDF-East and the RPPDF would be operated through 2165 before being landfill-closed under this disposal group, the larger operational period is not expected to measurably change direct or indirect impacts.

4.3.5.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Direct impacts on geology and soils and geologic resource demands associated with construction, operations, and deactivation of expanded Hanford waste treatment and storage facilities would be the same as those discussed under **Section 4.3.5.2** for Waste Management Alternative 2.

4.3.5.3.1 Disposal Group 1

Direct impacts on geology and soils and associated geologic resource requirements to support Waste Management Alternative 3, Disposal Group 1, activities would be very similar to those described in Section 4.3.5.2.1 for Alternative 2, Disposal Group 1, despite the fact that two IDFs (in the 200-East and 200-West Areas) would be constructed under Alternative 3. The two IDFs together would be sized to provide approximately the same disposal capacity as the single IDF that would be constructed under Alternative 2, Disposal Group 1. IDF-East would be constructed in the same location as under Waste Management Alternative 2 and would receive only waste generated by the Tank Closure alternatives. IDF-West would be located north of WRAP and northwest of LLBG 218-W-5. It would be sized to receive the balance of the waste that would not be disposed of in IDF-East. Construction and operation of the two IDFs under this alternative and disposal group would be the same as that associated with the single IDF under Alternative 2, Disposal Group 1. Elements associated with construction and operation of the RPPDF under this alternative group and disposal operations in LLBG 218-W-5 would likewise be identical to Alternative 2, Disposal Group 1 (see Section 4.3.5.2.1). In total, the two IDFs and new

RPPDF would occupy about 61.8 hectares (153 acres) of land. Following completion of disposal activities in the IDF(s) and RPPDF, each facility would be closed with a modified RCRA Subtitle C barrier as described above in Section 4.3.5.2.1. An additional 36.8 hectares (91 acres) would also be excavated in Borrow Area C, for a total of about 98.7 hectares (244 acres) of new, permanent land disturbance. The final barriers would encompass a slightly larger land area than the footprints of the three disposal facilities and total approximately 76.9 hectares (190 acres).

Total geologic resource requirements for Waste Management Alternative 3, Disposal Group 1, are projected to be 1,760,000 cubic meters (2,302,000 cubic yards), with the demand mainly driven by construction of the engineered barriers for landfill closure of the two IDFs and RPPDF (see Table 4–133). It is expected that this volume would be supplied by Borrow Area C, as stated above and as further described in Section 4.1.5.

Design consideration of hazards with the potential to affect new and existing facilities under this alternative case from large-scale geologic conditions (such as earthquakes) and site-specific geologic conditions would be substantially the same as those described in Section 4.3.5.2. An analysis of potential effects of a beyond-design-basis earthquake affecting the disposal facilities and related activities and the potential consequences on human health and the environment is provided in Section 4.3.11.3.1.

4.3.5.3.2 Disposal Group 2

Under Waste Management Alternative 3, Disposal Group 2, direct and secondary impacts on geology and soils would be greater than those referenced above in Section 4.3.5.3.1 for Alternative 3, Disposal Group 1. Under this disposal group, the RPPDF that would be constructed would be substantially larger (by about a factor of eight) than that required under Disposal Group 1, although the combined size of IDF-East and IDF-West would only be about one-third of the size of those constructed under Alternative 3, Disposal Group 1. On the whole, the total scale of direct impacts associated with new facility disposal construction would be greater under this disposal grouping. In total, the completed facilities would occupy about 240 hectares (593 acres) of land.

IDF-East and the RPPDF would operate until 2100, while IDF-West would operate until 2050 under this alternative and disposal grouping. Disposal operations in LLBG 218-W-5 would be identical to those described in Section 4.3.5.2.1 and for Alternative 2, Disposal Group 1. An additional 157 hectares (388 acres) would also be excavated in Borrow Area C, for a total of 397 hectares (981 acres) of new, permanent land disturbance.

Following completion of disposal activities in IDF-East, IDF-West, and the RPPDF, each facility would be closed with a modified RCRA Subtitle C barrier as previously described above in Section 4.3.5.2.1. The final barriers would encompass a total land area of about 253 hectares (624 acres) and would be subject to a 100-year postclosure care period.

Total geologic resource requirements for Alternative 3, Disposal Group 2, are projected to be 7,550,000 cubic meters (9,880,000 cubic yards), with the demand largely driven by construction of the engineered barriers (see Table 4–133). It is expected that this volume would be supplied by Borrow Area C, as stated above and as further described in Section 4.1.5.

4.3.5.3.3 Disposal Group 3

Direct impacts on geology and soils from disposal facility construction, operations, and closure and associated geologic resource demands under this disposal grouping would be identical to those described above for Waste Management Alternative 3, Disposal Group 2 (see Section 4.3.5.3.2). Although IDF-East and the RPPDF would be operated through 2165 before being landfill-closed under this disposal

group, compared with landfill closure in 2100 under Disposal Group 2, the additional operational years are not expected to measurably change direct or indirect impacts.

4.3.6 Water Resources

4.3.6.1 Alternative 1: No Action

Interim waste storage, treatment, and disposal activities under Waste Management Alternative 1 are not expected to have any incremental impact on water resources over the short term. No facilities would be constructed or expanded under Alternative 1, although waste disposal operations in trenches 31 and 34 in LLBG 218-W-5 would continue through 2035. While the facility would not be closed with a barrier upon the cessation of waste disposal, it would be subject to a 100-year postclosure care period, to include groundwater monitoring.

Earthmoving would be involved in deactivating IDF-East in 2009, which would include backfilling the facility with previously excavated material. Stormwater runoff could convey soil, sediments, and other pollutants (e.g., site debris, petroleum, oils, and lubricants from heavy equipment) from the work sites and staging areas. However, any such potential for runoff to impact water quality beyond the confines of the 200 Areas is low. Nevertheless, appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulch) and spill prevention and waste management practices would be employed to minimize suspended sediment and other deleterious material transport and potential water-quality impacts. Projected water use under Alternative 1 and its impact on site utility infrastructure are discussed in Section 4.3.2.1.

Long-term impacts on water resources associated with ongoing waste management and disposal, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.1.

4.3.6.2 Alternative 2: Disposal in IDF, 200-East Area Only

Direct impacts on surface-water resources and quality associated with construction of expanded Hanford waste treatment and storage facilities would be negligible. The expanded facilities would be constructed in previously developed portions of the 200-West Area where no surface-water features or surface-water drainages are located and the depth to groundwater is generally greater than about 50 meters (164 feet). Any effect on stormwater runoff quality would likely be very localized and of short duration. Nevertheless, appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulch) and spill prevention and waste management practices would be employed to minimize suspended sediment and other deleterious material transport from the construction site and potential water quality impacts. Further, ground-disturbing activities would be conducted in accordance with current NPDES and state waste discharge general permits for stormwater discharges associated with construction activities, issued by Ecology. These permits specifically require the development and implementation of a stormwater pollution prevention plan. The expanded facilities would incorporate appropriate stormwater management controls to collect, detain, and convey stormwater from the building and other impervious surfaces so as to minimize water quality impacts during operations.

There would be no direct discharge of effluents to either surface water or groundwater from facility operations. Process wastewater, including any radioactive liquid effluents, generated from operation of the expanded facilities would be discharged to existing treatment facilities that already service the 200 Areas as described in Section 4.1.6.2.1. Nonhazardous sanitary wastewater (sewage) would be managed via appropriate sanitary wastewater collection and treatment systems.

Water would be required during construction for soil compaction, dust control, and other uses, including concrete production. Standard construction practices dictate that, at least initially, construction water

would be trucked to construction locations on an as needed basis for these uses until water supply and wastewater treatment utilities are in place. During operations, water would be required to support process makeup requirements and facility cooling, waste treatment processing, as well as the potable and sanitary needs of the operations workforce and other uses. Some water would also be required during deactivation, such as for use in facility decontamination. Projected water use under Waste Management Alternative 2 for these activities and its impact on site utility infrastructure are further discussed in Section 4.3.2.2.

No incremental impact on the Hanford vadose zone or groundwater is expected from operation of these facilities in the 200-West Area. There would be no direct discharge of effluents to either surface water or the ground, as described above. Following completion of their mission in 2050, the facilities would be deactivated, and all residual waste and any hazardous or radioactive materials would be removed for disposal. Waste generation and management activities under this alternative are further discussed in Section 4.3.14.2.

Long-term impacts on water resources associated with ongoing waste management and disposal, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.2.2.

4.3.6.2.1 Disposal Group 1

No direct impact on water resources is expected from constructing an expanded IDF-East and the RPPDF between the 200-East and 200-West Areas. No natural surface-water features would be impacted from construction of IDF-East in an area that has already been heavily disturbed. In the case of the relatively undeveloped area where the RPPDF would be constructed, natural drainage features across the area are very poorly defined or nonexistent, and flow is ephemeral, if it occurs at all.

Disposal facility construction is not expected to impact regional groundwater flow, as the depth of the completed disposal facilities would not exceed about 13.1 meters (43 feet) and the depth of the water table beneath the 200 Areas is generally greater than about 50 meters (164 feet).

Site clearing, grading, and facility excavation work would expose soils and sediments to possible erosion by infrequent, heavy rainfall or by wind. Stormwater runoff from exposed areas could convey soil, sediments, and other pollutants (e.g., contaminated debris and spilled materials, such as petroleum, oils, and lubricants from heavy equipment) from construction and staging areas. Any such potential for runoff to impact runoff quality beyond the confines of the work areas is low, and both disposal area locations are more than 11 kilometers (7 miles) from the Columbia River. Regardless, appropriate soil erosion and sediment control measures (e.g., sediment fences, stacked haybales, mulching and seeding temporarily disturbed areas) and spill prevention and waste management practices would be employed to minimize suspended sediment and other deleterious material transport and potential water quality impacts. Also, during facility construction, temporary covers would be used, as necessary, to limit precipitation run-on into the disposal facilities. Further, all excavation work and related ground-disturbing activities during construction would be conducted in accordance with a current NPDES and appropriate state waste discharge general permits for stormwater discharges associated with construction and industrial activities, issued by Ecology. These permits specifically require the development and implementation of a stormwater pollution prevention plan.

Normal disposal facility operations through 2050 under this disposal scenario, including the continued operation of trenches 31 and 34 in LLBG 218-W-5 until closed, in addition to IDF-East and the RPPDF, are not expected to have any additional direct impact on water resources. Trenches 31 and 34 are lined, an RCRA-compliant disposal facilities equipped with a leachate collection system (see Appendix E, Section E.3.3.2). There would be no direct discharge of effluents to either surface water or groundwater from facility operations. For continued operations of trenches 31 and 34 in LLBG 218-W-5, precipitation

and snowmelt captured by the trench liner systems would be drained to a sump, pumped to a holding tank, and removed by tanker truck for treatment at the ETF.

The completed IDF-East and RPPDF would incorporate appropriate stormwater management engineering and operational controls to collect, detain, and convey stormwater away from disposal, so as to minimize water-quality impacts during operations including run-on of stormwater and precipitation that could otherwise infiltrate emplaced waste. To be specific, the new engineered facilities would include a redundant (double) liner system, a leachate collection and removal system, and a leak detection system to protect subsurface water quality (see Appendix E, Section E.3.4.1). As discussed for LLBG 218-W-5, leachate collected by the IDF-East and RPPDF systems would similarly be detained and trucked to the ETF for treatment and disposal. Additional operational controls could include the use of temporary roll-on/roll-off geomembrane covers to further limit infiltration and leachate generation during waste disposal.

Following completion of disposal activities in IDF-East and the RPPDF, each facility would be closed with a modified RCRA Subtitle C barrier, as previously described in Section 4.3.5.2.1. Similarly, the LLBG would also be backfilled to grade and ultimately closed. The modified RCRA Subtitle C barrier is designed for a 500-year performance period. During the DOE-administered 100-year postclosure care period for IDF-East and the RPPDF, proper operation and maintenance of the barrier, including installed groundwater monitoring systems and barrier erosion control features, would ensure that postclosure impacts on surface-water hydrology and quality and on the Hanford vadose zone and groundwater are minimal. Nevertheless, this barrier would degrade over time, allowing infiltration and contaminant migration from disposal facilities and across the 200 Areas. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.2.1. Waste generation and management activities under this alternative are further discussed in Section 4.3.14.2.

Potable and raw water demand to support waste management disposal activities would primarily be driven by the need to provide dust control during disposal facility construction, operations, and closure via construction of the modified RCRA Subtitle C barriers, water might also be needed to aid soil compaction. Portable sanitary facilities would be provided to meet the workday potable and sanitary needs of decommissioning personnel, which would constitute a relatively small percentage of the total water demand. Projected water use under Alternative 2, Disposal Group 1, and its impact on site utility infrastructure are discussed in Section 4.3.2.2.1.1.

4.3.6.2.2 Disposal Group 2

The potential for direct and secondary impacts on water resources under Alternative 2 Disposal Group 2, would be somewhat greater than those described above in Section 4.3.6.2.1 for Alternative 2, Disposal Group 1. While the construction, operation, and closure activities and associated impacts would be very similar, a substantially larger RPPDF would be constructed under this alternative and disposal group (see Section 4.3.5.2.2), and both IDF-East and the RPPDF would operate until 2100 instead of 2050. Disposal operations in LLBG 218-W-5 would be identical to those described in Section 4.3.6.2.1 for Alternative 2, Disposal Group 1. Following completion of disposal activities in IDF-East and the RPPDF, each facility would be closed with a modified RCRA Subtitle C barrier, as for Disposal Group 1. Overall, it is expected that the potential for direct and secondary impacts on water resources, including groundwater, over the short term would be small for the same reasons previously described in Section 4.3.6.2.1. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.2.2. Total water use would be greater under this disposal group due to the demand for construction, operations, and closure of a larger RPPDF and the extension of disposal operations over a longer timeframe. Projected water use

under Alternative 2, Disposal Group 2, and its impact on site utility infrastructure are further discussed in Section 4.3.2.2.1.2.

4.3.6.2.3 Disposal Group 3

Activities under this alternative would bound any potential impacts on water resources from disposal facility construction, operations, and closure over the short term, but would generally be similar in nature to those described in Section 4.3.6.2.1 for Alternative 2, Disposal Group 1. The size of IDF-East and the RPPDF constructed under this alternative and associated impact considerations would be identical to those considered under Alternative 2, Disposal Group 2 (see Section 4.3.5.2.2). However, IDF-East and the RPPDF would operate until 2165 instead of 2100, and disposal facility closure would occur much later as a consequence under this alternative and disposal grouping. Nonetheless, any potential for direct and secondary impacts on water resources is still expected to be relatively small. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.2.3. Projected water use under Alternative 2, Disposal Group 3, and its impact on site utility infrastructure are discussed in Section 4.3.2.2.1.3.

4.3.6.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Direct impacts on water resources associated with construction, operations, and deactivation of expanded Hanford waste treatment and storage facilities would be the same as those discussed under Section 4.3.6.2 for Waste Management Alternative 2.

4.3.6.3.1 Disposal Group 1

No direct impact on water resources is expected from constructing an expanded IDF-East, a new IDF-West, and the RPPDF between the 200-East and 200-West Areas. No natural surface-water features would be impacted from construction of IDF-East, as the area has already been heavily disturbed. In the case of the relatively undeveloped areas where IDF-West and the RPPDF would be constructed, natural drainage features across the affected areas are very poorly defined or nonexistent, and flow is ephemeral, if it occurs at all. In general, the nature and intensity of ground-disturbing activities, effects on water resources, and application of soil erosion, sediment control, and stormwater management provisions would generally be the same as described for Alternative 2, Disposal Group 1 (see Section 4.3.6.2.1).

As further described in Section 4.3.5.3.1, IDF-East would receive only waste generated by the Tank Closure alternatives. IDF-West would receive the balance of the waste. Segregation of the waste in this manner may have implications for long-term facility performance and contamination transport, but is not expected to have any differing operating impacts on water resources in the short term.

All other design considerations, operating parameters, closure considerations, and potential effects on water resources would be the same as described for Alternative 2, Disposal Group 1 (see Section 4.3.6.2.1) as both 200-East and 200-West IDFs and the RPPDF would operate through 2050 under this alternative and disposal grouping before being landfill-closed. Disposal operations in LLBG 218-W-5 would also be identical to those described under Alternative 2, Disposal Group 1. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.3.1. Projected water use under Alternative 2, Disposal Group 3, and its impact on site utility infrastructure are discussed in Section 4.3.2.3.1.1.

4.3.6.3.2 Disposal Group 2

The potential for direct and secondary impacts on water resources under Waste Management Alternative 3, Disposal Group 2, would be somewhat greater than those described above for Alternative 3,

Disposal Group 1. While the construction, operations, and closure activities and associated impacts would be very similar, a substantially larger RPPDF would be constructed under this alternative and group (see Section 4.3.5.3.2). Also, IDF-East and the RPPDF would operate until 2100 instead of 2050 under this alternative and disposal grouping. Disposal operations in LLBG 218-W-5 would be identical to those previously described. Following completion of disposal activities in IDF-East and the RPPDF, each facility would be closed with a modified RCRA Subtitle C barrier, as for Disposal Group 1. Construction, extended operations, and eventual closure of relatively larger disposal facilities would increase the potential for water-quality impacts in the short term. Still, it is expected that the potential for direct and secondary impacts on water resources, including groundwater, over the short term would be small for the same reasons previously described in Section 4.3.6.3.1. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.3.2. Total water use would be greater under this disposal group due to the demand for construction, operations, and closure of a larger RPPDF and the extension of disposal operations over a longer timeframe. Projected water use under Alternative 3, Disposal Group 2, and its impact on site utility infrastructure are further discussed in Section 4.3.2.3.1.2.

4.3.6.3.3 Disposal Group 3

Potential direct and secondary impacts on water resources associated with disposal facility construction, operations, and closure activities would be somewhat greater than those for Alternative 3, Disposal Group 2 (see Section 4.3.6.3.2). Although the sizes of the two IDFs and RPPDF constructed would be identical to the sizes described under Alternative 3, Disposal Group 2, IDF-East and the RPPDF would operate until 2165 instead of 2100, and disposal facility closure would occur much later as a consequence. Nonetheless, any potential for direct and secondary impacts on water resources is still expected to be relatively small based on the rationale summarized in Section 4.3.6.3.1. Long-term impacts on water resources, including contaminant release to and transport through the Hanford groundwater system, are evaluated in Chapter 5, Section 5.3.1.3.3. This alternative would have the highest total water use under Alternative 3 due to the extended operations period for IDF-East and the RPPDF. Projected water use under Alternative 3, Disposal Group 3, and its impact on site utility infrastructure are further discussed in Section 4.3.2.3.1.3.

4.3.7 Ecological Resources

4.3.7.1 Alternative 1: No Action

Under the No Action Alternative, no new facility construction would be initiated within the 200 Areas. Storage and treatment activities would continue to take place within the CWC, WRAP, and T Plant complex. Disposal would also continue in LLBG 218-W-5 trenches 31 and 34, and no barriers would be used upon closure of any of the facilities or trenches. Thus, there would be no additional impact on ecological resources within the 200 Areas under this alternative. Since this alternative would not require that geologic material be excavated from Borrow Area C there would be no impact on ecological resources within that area.

4.3.7.2 Alternative 2: Disposal in IDF, 200-East Area Only

4.3.7.2.1 Terrestrial Resources

Under this alternative, a number of new facilities or existing-facility expansions would be constructed in the 200-West Area. These include expansion at the T Plant, two expansions of WRAP: (1) a CH-Mixed TRU/TRU waste facility at the CWC and (2) an RH-Mixed TRU/TRU waste facility at WRAP, and a new CWC storage facility (see Figure 4–2). These facilities would require a total of 2.7 hectares (6.6 acres) of land. Of this total, up to 0.4 hectares (1 acre) of sagebrush habitat (and associated microbiotic crusts) could be disturbed by construction of the RH-Mixed TRU/TRU waste facility at

WRAP. Hanford guidance would not require the replacement of this sagebrush habitat (DOE 2003f:21). Other facilities would be built on previously disturbed land. Operations are not be expected to impact terrestrial resources.

4.3.7.2.1.1 Disposal Group 1

Disposal Group 1 would involve construction of IDF-East and the RPPDF between the 200-East and 200-West Areas (see Figures 4–1 and 4–2. The former would require 32.8 hectares (81 acres), while the latter would disturb 29.5 hectares (73 acres). Nearly all the land that would be disturbed by these facilities is sagebrush habitat. Hanford guidance may require the replacement of sagebrush habitat within IDF-East at a ratio of 1:1 and the RPPDF at a ratio of 3:1. Specific measures to be taken in connection with mitigating the loss of sagebrush habitat would be set forth in a mitigation action plan prior to initiation of construction (DOE 2003f:21, 43). Operations are not expected to impact terrestrial resources. Closure of IDF-East and the RPPDF would involve placement of barriers, which would encompass slightly more land (1.6 hectares [4 acres]) than the waste disposal facilities, resulting in sagebrush habitat disturbance totaling 63.9 hectares (158 acres).

Under this disposal group, 41.7 hectares (103 acres) of Borrow Area C would be excavated to supply needed geologic material. As noted in Chapter 3, Section 3.2.7.1, the two major plant communities present within the area are Sandberg's bluegrass/cheatgrass (782.3 hectares [1,933 acres]) and needle-and-thread grass/Indian ricegrass (107 hectares [265 acres]). The latter represents an unusual and relatively pristine community type at Hanford and thus is considered a more highly valued community than the former. It is not possible to determine specific impacts on ecological resources of developing Borrow Area C since the particular portion of the site from which geologic material would be excavated is not known. However, most of Borrow Area C can be developed without significant adverse impacts on species or habitats (Sackschewsky and Downs 2007:8). To the extent that it is possible, the needle-and-thread grass/Indian ricegrass community should be avoided.

4.3.7.2.1.2 Disposal Groups 2 and 3

Since construction of IDF-East and the RPPDF under Disposal Groups 2 and 3 would disturb the same area (11.3 hectares [28 acres] and 228 hectares [564 acres], respectively) they are grouped together. Construction of both facilities could disturb up to their total area in sagebrush habitat depending upon the exact placement of each. Disturbance of sagebrush habitat would destroy microbiotic crusts. Hanford guidance may require the replacement of sagebrush habitat within IDF-East at a ratio of 1:1 and the RPPDF at a ratio of 3:1. Specific measures to be taken in connection with mitigating the loss of sagebrush habitat would be set forth in a mitigation action plan prior to construction (DOE 2003f:21, 43). Operations are not expected to impact terrestrial resources. Closure of IDF-East and the RPPDF would involve placement of barriers which would encompass slightly more land (7.7 hectares [19 acres]) than the waste disposal facilities. Sagebrush habitat disturbance could total 247 hectares (611 acres). The loss of any sagebrush habitat would be mitigated.

Under Disposal Groups 2 and 3, 159 hectares (392 acres) of Borrow Area C would be developed to supply needed geologic material. Impacts on terrestrial resources from the excavation of geologic material from the area would be somewhat greater than those described above for Disposal Group 1.

4.3.7.2.2 Wetlands and Aquatic Resources

There are no wetlands or aquatic resources within any of the areas where expanded or new facilities would be constructed in the 200-East Area, 200-West Area, or between these two areas. Additionally, these resources are not found within Borrow Area C. Thus, there would be no impact on wetlands or aquatic resources under this alternative.

4.3.7.2.3 Threatened and Endangered Species

Construction and operations of the CWC, WRAP, and T Plant complex within the 200-West Area would not adversely affect any special status species since none have been recorded within the areas where these facilities would be built (Sackschewsky and Downs 2007:3).

4.3.7.2.3.1 Disposal Group 1

Under this disposal group, construction of IDF-East and the RPPDF would disturb a total of 62.3 hectares (154 acres) of sagebrush habitat. While no Federal or state threatened or endangered species were observed within either of the potential sites for these facilities, the sage sparrow (state candidate) was observed within IDF-East (see Chapter 3, Section 3.2.7.4). Surveys within the area to be occupied by the RPPDF identified the black-tailed jackrabbit, sage sparrow, and loggerhead shrike (all state candidates; the loggerhead shrike is also a Federal species of concern); one special status plant species, crouching milkvetch (state watch), was also observed. Operations of new facilities within the 200 Areas is not expected to impact any federally or state-listed species.

State watch species should be considered during project planning, though mitigation would not be required. Impacts on state candidate species, which are considered Level III resources under the *Hanford Site Biological Resources Management Plan*, require mitigation where impacts would occur. When avoidance and minimization are not possible or are insufficient, mitigation via rectification or compensation is recommended (DOE 2001b:4.9, 8.11). A comprehensive mitigation action plan, which would deal with impacts on listed species (as well as sagebrush habitat), would be developed prior to construction.

As noted in Chapter 3, Section 3.2.7.4, surveys have identified Piper's daisy, stalked-pod milkvetch (state watch), crouching milkvetch, and the long-billed curlew (state monitor) within the boundaries of Borrow Area C. Mitigation requirements for Piper's daisy and the two species of milkvetch are addressed above. Although avoidance and minimization of impacts on state monitor species is recommended, mitigation is not required (DOE 2001b:4.11). A mitigation action plan would be developed prior to excavation.

4.3.7.2.3.2 Disposal Groups 2 and 3

Under both Disposal Groups 2 and 3, IDF-East and the RPPDF would disturb a total of 240 hectares (592 acres) of sagebrush habitat. Since the same areas would be used for these facilities under these disposal groups as noted above for Disposal Group 1, the same species could be affected. However, because more habitat would be disturbed, the potential to impact these species would be greater. Mitigation requirements would be similar to those noted above, including the need to prepare a mitigation action plan prior to the start of construction.

4.3.7.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

4.3.7.3.1 Terrestrial Resources

Under this Waste Management alternative, the same expanded and new facilities would be constructed in the same locations within the 200-West Area as under Alternative 2. Further, they would occupy the same area. Thus, the impacts on terrestrial resources under Alternative 3 would be the same as those discussed in Section 4.3.7.2.1.

4.3.7.3.1.1 Disposal Group 1

Although the RPPDF would be located in the same area and be the same size (29.5 hectares [73 acres]) as under Alternative 2, two IDFs would be constructed under this alternative. IDF-East would be situated in

the same location as under Alternative 2, but would be 29.9 hectares (74 acres) in size. IDF-West would be 2.4 hectares (6 acres) in size (see Figures 4–1 and 4–2. Due to the general similarity in size, impacts on the 200-East Area under this alternative would be essentially the same as described above under Alternative 2 (see Section 4.3.7.2.1). The area where IDF-West would be located has been burned in the past and is presently considered recovering shrub-steppe habitat, with sagebrush having been replanted in the western portion of the site. However, its loss would not be mitigable according to the *Hanford Site Biological Resources Management Plan* (DOE 2001b; Sackschewsky and Downs 2007:4). Operations are not expected to impact terrestrial resources. Closure of IDF-East, IDF-West, and the RPDDF would encompass slightly more land (15 hectares [37 acres]) than the waste disposal facilities. Sagebrush habitat disturbance could total 76.9 hectares (190 acres). The loss of any additional sagebrush habitat would be mitigated.

To support activities under this disposal grouping, a total of 36.8 hectares (91 acres) within Borrow Area C would be required to supply geologic material. Although 4.9 hectares (12 acres) less land would be required under this alternative than under Alternative 2, impacts on terrestrial resources of developing the site would be similar to those described in Section 4.3.7.2.1.1.

4.3.7.3.1.2 Disposal Groups 2 and 3

Under Waste Management Alternative 3, the RPPDF would be located and sized (228 hectares [564 acres]) as noted under Alternative 2; thus, impacts related to Disposal Groups 2 and 3 would be the same (see Section 4.3.7.2.1.2). As is the case for Disposal Group 1, two IDFs would be constructed under Disposal Groups 2 and 3. IDF-West would be located in the same area and be the same size as is the case for Disposal Group 1. However, IDF-East would be smaller (i.e., 9.3 hectares [23 acres] versus 29.9 hectares [74 acres]). Thus, impacts of construction and operations of IDF-East under Disposal Groups 2 and 3 would be somewhat less than those described for Disposal Group 1. Closure of IDF-East, IDF-West, and the RPPDF would encompass slightly more land (12.5 hectares [31 acres]) than the waste disposal facilities. Sagebrush habitat disturbance could total 253 hectares (624 acres). The loss of any additional sagebrush habitat would be mitigated.

Since the requirement for geologic material would be about the same under this alternative as under Alternative 2, nearly the same land area (i.e., 157 hectares [388 acres] for Alternative 3 versus 159 hectares [392 acres] for Alternative 2) would need to be excavated within Borrow Area C. Thus, the impacts on terrestrial resources of developing the site would be as described in Section 4.3.7.2.1.2.

4.3.7.3.2 Wetlands and Aquatic Resources

There are no wetlands or aquatic resources within any of the areas where expanded or new facilities would be constructed in the 200-East Area, the 200-West Area, or between these two areas. Additionally, these resources are not found within Borrow Area C. Thus, there would be no impact on wetlands or aquatic resources under this alternative.

4.3.7.3.3 Threatened and Endangered Species

As noted under "Terrestrial Resources," there would be no difference in the number and size of expanded or new facilities required under Waste Management Alternative 3 as compared to Alternative 2 (see Section 4.3.7.2.3). Since special status species have not been recorded within the areas where new facilities or existing-facility expansions of the CWC, WRAP, and T Plant complex would be built, there would be no adverse impacts on this group of organisms.

4.3.7.3.3.1 Disposal Group 1

Impacts resulting from construction of the RPPDF on threatened and endangered species would be the same as described above under Waste Management Alternative 2 since the facility would be located in the same area and be the same size. Also, impacts resulting from construction of IDF-East would be similar to Alternative 2 since the area to be disturbed would be only slightly smaller (2.8 hectares [7 acres]) (see Section 4.3.7.2.3). However, under this alternative, IDF-West would encompass 2.4 hectares (6 acres) within the 200-West Area. Surveys of the proposed site of IDF-West identified one listed species, the stalked-pod milkvetch (see Chapter 3, Section 3.2.7.4). Although mitigation would not be required for this species, it should be considered during project planning.

Since the requirement for geologic material would be about the same under this alternative as under Alternative 2, nearly the same land area would need to be excavated within Borrow Area C. Thus, the impacts on threatened and endangered species of developing the site would be as described in Section 4.3.7.2.3.1.

4.3.7.3.3.2 Disposal Groups 2 and 3

Impacts resulting from construction of the RPPDF on threatened and endangered species would be the same as described above under Waste Management Alternative 2 since the facility would be located in the same area and be the same size. Also, impacts resulting from construction of IDF-East would be similar to Alternative 2 since the area to be disturbed would be only slightly smaller. Similar to Disposal Group 1, under this alternative, IDF-West would encompass 2.4 hectares (6 acres) within the 200-West Area with the possibility that the stalked-pod milkvetch could be disturbed. While this species should be considered during project planning, mitigation would not be required.

Since the requirement for geologic material would be about the same under this alternative as under Alternative 2, nearly the same land area would need to be excavated within Borrow Area C. Thus, the impacts on threatened and endangered species of developing the site would be as described in Section 4.3.7.2.3.2.

4.3.8 Cultural and Paleontological Resources

4.3.8.1 Alternative 1: No Action

Under the No Action Alternative, there would be no new construction within the 200 Areas. Treatment activities and storage would resume within the CWC, WRAP complex, and T Plant complex with disposal continuing in LLBG 218-W-5 trenches 31 and 34. In addition, there would be no need to excavate geologic material from Borrow Area C. Therefore, there would be no changes to the 200 Areas and no known cultural or paleontological resources would be impacted.

4.3.8.1.1 Prehistoric Resources

Prehistoric resources located in the 200-East and 200-West Areas, as discussed above in Section 4.3.8.1, would not be disturbed under this alternative.

4.3.8.1.2 Historic Resources

Historic resources located in the 200-East and 200-West Areas would not be disturbed under this alternative, as discussed above in Section 4.3.8.1.

4.3.8.1.3 American Indian Interests

Under this Waste Management alternative, there would be no impact on American Indian interests.

4.3.8.1.4 Paleontological Resources

There would be no impacts on known paleontological resources under this Waste Management alternative, as discussed above in Section 4.3.8.1.

4.3.8.2 Alternative 2: Disposal in IDF, 200-East Area Only

4.3.8.2.1 Prehistoric Resources

Prehistoric resources located in the 200-East and 200-West Areas would not be disturbed under this Waste Management alternative, as no known resources are located in the vicinity of the expanded storage and treatment and disposal facilities that would be constructed. If prehistoric resources were discovered during construction or excavation of geologic material, procedures are in place to properly manage the discovery site. This condition applies to all disposal groups.

4.3.8.2.1.1 Disposal Groups 1, 2, and 3

Potential impacts on prehistoric resources are described in Section 4.2.8.2.1, and would be similar under all disposal groups.

4.3.8.2.2 Historic Resources

Historic resources located in the 200-East and 200-West Areas would not be disturbed under this Waste Management alternative, as no known resources are located in the vicinity of the expanded storage and treatment and disposal facilities that would be constructed. If historic resources were discovered during construction or excavation of geologic material, procedures are in place to properly manage the discovery site. This condition applies to all disposal groups.

4.3.8.2.2.1 Disposal Groups 1, 2, and 3

Potential impacts on prehistoric resources are described in Section 4.2.8.2.2, and would be similar under all disposal groups.

4.3.8.2.3 American Indian Interests

Under this Waste Management alternative, there would be visual impacts on the viewscape from higher elevations such as Rattlesnake Mountain. If there were visual impacts on areas of interest, appropriate mitigation measures would be developed in consultation with area tribes.

4.3.8.2.3.1 Disposal Group 1

Under Waste Management Alternative 2, Disposal Group 1, expansion of the IDF and construction of the RPPDF would affect 62.3 hectares (154 acres) of land in the 200 Areas. The BLM visual resource management rating would not change. In addition, a modified RCRA Subtitle C barrier would be constructed over both IDF-East and the RPPDF, increasing the area of the viewscape. Construction and operations would be visible from Rattlesnake Mountain, Gable Mountain, and Gable Butte, all having cultural importance to American Indians. An additional 41.7 hectares (103 acres) of Borrow Area C would be excavated for geologic material. The rating for this area would change from Class II to Class IV. Excavation would change the viewscape from State Route 240 and Rattlesnake Mountain. Following closure, the area would be recontoured and revegetated.

4.3.8.2.3.2 Disposal Groups 2 and 3

Waste Management Alternative 2, Disposal Group 2 or 3, would require 240 hectares (592 acres) of undeveloped land for construction of IDF-East and the RPPDF. This construction would noticeably change the area and be visible from Rattlesnake Mountain, Gable Mountain, and Gable Butte. This viewscape would last for the operational period of the sites.

Construction of modified RCRA Subtitle C barriers over other facilities during closure would increase the area of the viewscape. In addition, 159 hectares (392 acres) of land would be excavated in Borrow Area C. Excavated areas would be visible from Rattlesnake Mountain. Excavations in Borrow Area C would be recontoured and revegetated.

4.3.8.2.4 Paleontological Resources

There would be no impacts on paleontological resources under this alternative, as no such resources have been discovered in the 200 Areas. As is the case with other cultural resources, if any paleontological resources were discovered during construction or excavation of geologic material, procedures are in place to properly manage the discovery site.

4.3.8.2.4.1 Disposal Groups 1, 2, and 3

Potential impacts on paleontological resources are described in Section 4.2.8.2.3, and would be similar under all disposal groups.

4.3.8.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

4.3.8.3.1 Prehistoric Resources

Prehistoric resources located in the 200-East and 200-West Areas would not be disturbed under this Waste Management alternative, as no known resources are located in the vicinity of the expanded storage and treatment and disposal facilities that would be constructed. If prehistoric resources were discovered during construction or excavation of geologic material, procedures are in place to properly manage the discovery site. This construction applies to all disposal groups.

4.3.8.3.1.1 Disposal Groups 1, 2, and 3

Potential impacts on prehistoric resources are described in Section 4.2.8.3.1, and would be similar under all disposal groups.

4.3.8.3.2 Historic Resources

Historic resources located in the 200-East and 200-West Areas would not be disturbed under this Waste Management alternative, as no known resources are located in the vicinity of the expanded storage and treatment and disposal facilities that would be constructed. If historic resources were discovered during construction or excavation of geologic material, procedures are in place to properly manage the discovery site.

4.3.8.3.2.1 Disposal Groups 1, 2, and 3

Potential impacts on historic resources are described in Section 4.2.8.3.1, and would be similar under all disposal groups.

4.3.8.3.3 American Indian Interests

Under this Waste Management alternative, impacts on the viewscape from construction and operations of the T Plant expansion, two WRAP expansions, and the new CWC storage facility would be similar to those described under Alternative 2. There would be visual impacts on the viewscape from higher elevations such as Rattlesnake Mountain.

4.3.8.3.3.1 Disposal Group 1

This disposal group includes an IDF in both the 200-East and 200-West Areas. The total land area disturbed and the land required within Borrow Area C for geologic material would be nearly the same as under Alternative 2. Therefore, the visual impact on Rattlesnake Mountain would be the same as those described under Alternative 2, Disposal Group 1 (see Section 4.3.8.2.3.1). The placement of IDF-West on 2.4 hectares (6 acres) of undeveloped land would add minimally to the visual impact.

4.3.8.3.3.2 Disposal Groups 2 and 3

Under Waste Management Alternative 3, Disposal Group 2 or 3, the land required for IDF-East, IDF-West, the RPPDF, and Borrow Area C would be nearly the same as that required under Alternative 2. Therefore, visual impacts on American Indian interests would be the same as those under Alternative 2 (see Section 4.3.8.2.3.2).

4.3.8.3.4 Paleontological Resources

There would be no impacts on paleontological resources under this Waste Management alternative, as no such resources have been discovered in the 200 Areas. As is the case with other cultural resources, if any paleontological resources were discovered during construction or excavation of geologic material, procedures are in place to properly manage the discovery site. This condition applies to all disposal groups.

4.3.8.3.4.1 Disposal Groups 1, 2, and 3

Potential impacts on paleontological resources are described in Section 4.2.8.3.4, and would be similar under all disposal groups.

4.3.9 Socioeconomics

The primary (direct) and secondary (indirect) impacts of waste disposal management on employment, regional demographics, housing and community services, and local transportation were analyzed for this section of the EIS. The potential primary impacts were set forth by analyzing projected changes in employment (in terms of FTEs) and truck activity related to the activities in each alternative (see Appendix I). The projected changes in employment and truck activity have the potential to generate economic impacts that may affect the need for housing units, public services, and local transportation in the region.

Key underlying assumptions used in projecting changes in employment for each of the Waste Management alternatives and associated options are similar to those described in Section 4.1.9 for the Tank Closure alternatives. Waste Management alternatives consist of the storage and treatment of both onsite and offsite waste, along with three disposal options located in the 200-East Area (Waste Management Alternative 2) and three disposal options located in both the 200-East and 200-West Areas (Waste Management Alternative 3) in addition to the No Action Alternative. Table 4–134 summarizes the indicators used to analyze the socioeconomic impacts under each alternative.

Table 4–134. Waste Management Alternatives and Options – Summary of Peak Estimated Socioeconomic Indicators

Alternatives and Options	Peak Annual Workforce[a] (Peak Year)	Peak Daily Commuter Traffic	Peak Daily Truck Loads (Peak Year)	
			Off Site	On Site
Alternative 1: No Action	109 (2009)	88	Less than 1 (2009)	6 (2009)
Alternatives 2 and 3: Waste Treatment and Storage	449 (2019–2050)	360	2 (2011–2012)	7 (2011–2012)
Alternative 2 – Disposal in IDF, 200-East Area Only				
Disposal Group 1	1,180 (2051–2052)	943	28 (2051–2052)	428 (2051–2052)
Disposal Group 2	4,540 (2101–2102)	3,640	34 (2101–2102)	1,500 (2101–2102)
Disposal Group 3	4,540 (2166–2167)	3,640	34 (2166–2167)	1,500 (2166–2167)
Alternative 3 – Disposal in IDF, 200-East and 200-West Areas				
Disposal Group 1	1,170 (2051–2052)	940	28 (2051–2052)	372 (2051–2052)
Disposal Group 2	4,500 (2101–2102)	3,600	33 (2101–2102)	1,480 (2101–2102)
Disposal Group 3	4,500 (2166–2167)	3,600	33 (2166–2167)	1,480 (2166–2167)

[a] Workforce is rounded into full-time equivalent quantities.

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.

Key: IDF=Integrated Disposal Facility.

Source: Appendix I; SAIC 2007c.

4.3.9.1 Alternative 1: No Action

Because construction activities would be minimal under Alternative 1, the No Action Alternative, the peak workforce is estimated to reach only 109 FTEs in 2009. This workforce, along with an additional 81 indirect jobs created as a secondary impact, would have little impact on regional economic characteristics, demographic characteristics, or housing and community services. In addition, the 114 offsite truck trips (less than 1 trip per day) and 1,460 onsite trips per year (approximately 6 trips per day), along with additional commuters (up to 88 vehicles per day in the peak year), would have little impact on the local transportation in the ROI.

4.3.9.2 Alternative 2: Disposal in IDF, 200-East Area Only

Under Alternative 2, employment activity, at a peak of 449 FTEs from 2019 through 2050 (see Table 4–134), would be dominated by the workforce required to operate WRAP. The existence of these direct jobs would be expected to result in the creation of another 336 indirect jobs in the ROI during the peak years. During the same time period, there could be up to 360 additional vehicles per day during the commute times. Local offsite truck traffic could run as high as 504 trucks (2 trips per day) during the peak years 2011 and 2012. Construction of the expanded facilities at WRAP would account for the major portion of this offsite and the onsite truck traffic (1,880 truck loads, or approximately 7 trips per day). The socioeconomic impacts below would be affected by this workforce and local vehicles in addition to any workers and vehicles needed for each of the disposal group options below.

4.3.9.2.1 Regional Economic Characteristics

4.3.9.2.1.1 Disposal Group 1

The projected workforce that would be needed for construction of the barriers over IDF-East and the RPPDF would dominate the total workforce in 2051 and 2052. The peak estimate of 1,180 FTEs is less than 1 percent of the projected labor force of about 211,000 (in 2051) in the ROI (BEA 2007). In addition to the direct employees associated with constructing barriers for Disposal Group 1, approximately 880 indirect positions would likely be created as a secondary impact on the ROI.

4.3.9.2.1.2 Disposal Group 2

The projected workforce needed for construction of the barriers over IDF-East and the RPPDF would peak in 2101 and 2102. The peak estimate of 4,540 FTEs would be approximately 1.4 percent of the projected labor force of about 314,000 (in 2101), compared with approximately 10 percent in 2006 in the ROI (BEA 2007). An additional 3,400 indirect jobs would be created in the ROI during those peak years.

4.3.9.2.1.3 Disposal Group 3

The projected workforce needed for construction of the barriers over IDF-East and the RPPDF would peak much later than under Disposal Group 2, beginning in 2166. The estimate of 4,540 FTEs would be approximately 1 percent of the projected labor force of about 447,000 (in 2166), compared with approximately 10 percent in 2006 in the ROI (BEA 2007). The creation of an additional 3,400 indirect jobs in the ROI would also occur in 2166 and 2167.

4.3.9.2.2 Demographic Characteristics

4.3.9.2.2.1 Disposal Group 1

The vast majority of workers under Disposal Group 1 would come from the local workforce in the ROI. There would be little in-migration of new workers and their families; therefore, any changes in demographic characteristics of the Tri-Cities area and the ROI would be minimal.

4.3.9.2.2.2 Disposal Groups 2 and 3

The near-term impacts (less than 100 years) from the workforces under Disposal Groups 2 and 3 would have little impact on the local workforce in the ROI. There would be little in-migration of new workers and their families; therefore, any changes in demographic characteristics of the Tri-Cities area and the ROI would be minimal.

4.3.9.2.3 Housing and Community Services

4.3.9.2.3.1 Disposal Groups 1, 2, and 3

For each of the three disposal groups, the peak workforce required would be relatively small compared to the local population and would have little or no impact on the demand for housing, schools and other community services within the ROI.

4.3.9.2.4 Local Transportation

4.3.9.2.4.1 Disposal Group 1

Under Alternative 2, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to 943 passenger vehicles per day are expected to commute to the site during the peak years of 2051 and

2052. Based on predicted offsite truck activity, up to 7,210 truck trips per year (28 trips per day) in 2051 and 2052, and predicted commuter traffic, the LOS on offsite roads in the Hanford area is expected to be impacted (see Chapter 3, Section 3.2.9.4). Onsite truck trips would also peak in 2051 and 2052, with up to 111,000 truck trips per year (approximately 428 trips per day) moving concrete aggregate materials and other borrow materials on site to construct the barriers over IDF-East and the RPPDF.

4.3.9.2.4.2 Disposal Groups 2 and 3

Under Alternative 2, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to 3,640 passenger vehicles per day are expected to commute to the site during the peak years (2101 through 2102 for Disposal Group 2, and 2166 through 2167 for Disposal Group 3). Based on predicted offsite truck activity, up to 8,840 truck trips (34 trips per day) in the peak years, and predicted commuter traffic, the LOS on offsite roads in the Hanford area is expected to be impacted (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak at 392,000 truck trips per year (approximately 1,500 trips per day) moving concrete aggregate materials and other borrow materials on site to construct the barriers over IDF-East and the RPPDF.

4.3.9.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

As under Waste Management Alternative 2, the socioeconomic impacts for Alternative 3 would be affected by the workforce and local vehicles needed for the treatment and storage of the waste, in addition to any workers and vehicles needed for each of the disposal group options below (see Table 4–134).

4.3.9.3.1 Regional Economic Characteristics

4.3.9.3.1.1 Disposal Group 1

Similar to Waste Management Alternative 2, the projected workforce that would be needed for construction of the barriers over IDF-East and the RPPDF would dominate the total workforce for two years, beginning in 2051. The peak estimate of 1,170 FTEs is less than 1 percent of the projected labor force of about 211,000 (in 2051) in the ROI (BEA 2007). In addition to these direct employees, approximately 880 indirect positions would likely be created as a secondary impact on the ROI during the peak years.

4.3.9.3.1.2 Disposal Group 2

Similar to Waste Management Alternative 2, the projected workforce needed for construction of the barriers over IDF-East and the RPPDF would peak in 2101 and 2102. The peak estimate of 4,500 FTEs would be approximately 1.4 percent of the projected labor force of about 314,000 (in 2101), compared with approximately 10 percent in 2006 in the ROI (BEA 2007). Approximately 3,400 indirect jobs in 2101 and 2102 would likely be created in the ROI in addition to these direct employees.

4.3.9.3.1.3 Disposal Group 3

Similar to Waste Management Alternative 2, the projected closure workforce needed for construction of the barriers over IDF-East and the RPPDF would peak much later than under Disposal Group 2, beginning in 2166. The estimate of 4,500 FTEs would be approximately 1 percent of the projected labor force of about 447,000 (in 2166), compared with approximately 10 percent in 2006 in the ROI (BEA 2007). The existence of these jobs would be expected to result in the creation of another 3,400 indirect jobs in the ROI.

4.3.9.3.2 Demographic Characteristics

4.3.9.3.2.1 Disposal Group 1

Similar to Waste Management Alternative 2, the vast majority of workers under Disposal Group 1 would come from the local workforce in the ROI. There would be little in-migration of new workers and their families; therefore, any changes in demographic characteristics of the Tri-Cities area and the ROI would be minimal.

4.3.9.3.2.2 Disposal Groups 2 and 3

Similar to Waste Management Alternative 2, the near-term impacts (less than 100 years) from the workforces under Disposal Groups 2 and 3 would have little impact on the local workforce in the ROI. There would be little in-migration of new workers and their families; therefore, any changes in demographic characteristics of the Tri-Cities area and the ROI would be minimal.

4.3.9.3.3 Housing and Community Service

4.3.9.3.3.1 Disposal Groups 1, 2, and 3

For each of the three disposal groups, the peak workforce required would be relatively small compared to the local population and would have little or no impact on the demand for housing, schools and other community services within the ROI.

4.3.9.3.4 Local Transportation

4.3.9.3.4.1 Disposal Group 1

Similar to Waste Management Alternative 2, under Alternative 3, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to 940 passenger vehicles per day are expected to commute to the site during the peak years of 2051 and 2052. Based on predicted offsite truck activity, up to 7,180 truck trips per year (28 trips per day) in 2051 and 2052, and predicted commuter traffic, the LOS on offsite roads in the Hanford area is expected to be impacted (see Chapter 3, Section 3.2.9.4). Onsite truck trips would also peak in 2051 and 2052, with up to 97,000 truck trips per year (approximately 372 trips per day) moving concrete aggregate materials and other borrow materials on site to construct the barriers over IDF-East, IDF-West, and the RPPDF.

4.3.9.3.4.2 Disposal Groups 2 and 3

Under Waste Management Alternative 3, assuming an average of 1.25 persons per passenger vehicle (Malley 2007), up to about 3,600 passenger vehicles per day are expected to commute to the site during the peak years (2101 through 2102 for Disposal Group 2, and 2166 through 2167 for Disposal Group 3). Based on predicted offsite truck activity, up to 8,570 truck trips (33 trips per day) in peak years, and predicted commuter traffic, the LOS on offsite roads in the Hanford area is expected to be impacted (see Chapter 3, Section 3.2.9.4). Onsite truck trips would peak at 384,000 truck trips per year (approximately 1,480 trips per day) moving concrete aggregate materials and other borrow materials on site to construct the barriers over IDF-East, IDF-West, and the RPPDF.

4.3.10 Public and Occupational Health and Safety—Normal Operations

Details of the assessment methodology for determining radiation exposure to workers and members of the public are presented in Appendix K. Radiological impacts are presented for three public receptors: the general population living within 80 kilometers (50 miles) of Hanford, an MEI living near the site

boundary, and an onsite member of the public who works at the Columbia Generating Station or LIGO. Impacts on the general population are evaluated for a residential scenario whereby people are exposed to radioactive materials emitted from project facilities. Radiation exposure occurs through inhalation, direct exposure to the radiological plume and material deposited on the ground, and ingestion of contaminated food products from animals raised locally and fruits and vegetables grown in a family garden (DOE 1995:A-7). Impacts on the offsite MEI are evaluated for a scenario that includes the same exposure pathways assumed for the general population, but with an increased amount of time spent outdoors and a higher rate of contaminated food consumption. Impacts on an individual who works at the Columbia Generating Station or LIGO would be from inhalation and exposure to the plume and material deposited on the ground. Doses are presented as the total effective dose equivalent.

In addition to members of the public, workers directly involved in the activities associated with Waste Management alternatives and nearby noninvolved workers may receive radiological doses. Doses to an involved worker are calculated based on an FTE worker. It is assumed for purposes of this dose evaluation that an FTE worker has a 2,080-hour work year. In practice, the number of workers who receive a radiation dose may be larger than the number assumed in this analysis, resulting in a smaller average dose per worker. A noninvolved worker is a person working at the site who is incidentally exposed due to the radiological air emissions associated with the alternatives considered. The noninvolved worker is assumed to be about 100 meters (110 yards) away or at a nearby facility on a daily basis.

Small operational impacts on members of the public would be expected from all of the Waste Management alternatives. Routine radiological air emissions as a result of LLBG operations would be expected to be negligible; the more likely source of emissions from waste management operations would be from waste processing facilities, where waste containers are opened and waste is sorted, reduced in size or otherwise treated, and repackaged. Consequently, impacts analysis on the public are based on radiological air emissions projected to occur from waste processing facilities such as a new facility at the T Plant or expansion of WRAP.

4.3.10.1 Alternative 1: No Action

4.3.10.1.1 Radiological Impacts on the Public

Under the Waste Management No Action Alternative, there would be no incremental radiological impacts on the public due to operations. WRAP and T Plant emissions from current waste processing activities contribute to offsite radiological air emissions that make up the current affected environment. Therefore, they are accounted for in the offsite doses discussed in Chapter 3.

4.3.10.1.2 Radiological Impacts on Workers

Table 4–135 presents dose and risk estimates for an involved FTE worker receiving an average exposure. The average annual radiation worker dose would be 200 millirem, less than the Administrative Control Level of 500 millirem (DOE 2006a:2; Fluor Hanford 2006:2-1). A worker who received the average annual radiation dose over the 29 years of this activity would receive a dose of 5,800 millirem, which corresponds to a risk of about 3×10^{-3} (1 chance in 300) of developing an LCF.

The total effective dose equivalent to the worker population from the 29 years of occupational exposure under this alternative is estimated to be 37 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, no LCFs due to occupational radiation exposure would be expected in the worker population.

Table 4–135. Waste Management Alternative 1 Radiological Impacts on Workers

	Years[a]	Dose	Latent Cancer Fatality Risk[b]
Average Involved Full-Time Equivalent Worker			
Average annual impact	2007–2035	200 millirem	1×10^{-4}
Impact over life of project[c]	2007–2035	5,800 millirem	3×10^{-3}
Life-of-Project Worker Population	2007–2035	37 person-rem	0 (2×10^{-2})

a Years indicate the portion of the project during which a worker dose is expected under this alternative.

b For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Impact over the life of the project is the average impact a full-time equivalent radiation worker would receive while working on this project. It is determined by multiplying the average annual impact by the smaller of the project duration (29 years) or 40 years (assuming a worker spends a 40-year career supporting this project).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.3.

4.3.10.2 Alternative 2: Disposal in IDF, 200-East Area Only

Under this Waste Management alternative, doses to the public would result from radiological air emissions associated with waste processing in new or expanded facilities constructed at the T Plant and the CWC. Worker doses would result from waste processing facility and waste disposal operations.

4.3.10.2.1 Radiological Impacts on the Public

Table 4–136 presents estimated doses to the general population and the MEI under Alternative 2. Activities resulting in radiological air emissions would occur from 2013 to 2051. Over the operational life of the project, the population within 80 kilometers (50 miles) of the 200 Areas would receive a dose of 0.00067 person-rem and the MEI would receive a dose of 0.0000082 millirem. Using the risk factor of 0.0006 LCFs per person-rem (DOE 2003h:9), no LCFs would be expected in the general population as a result of this alternative. The probability of the MEI developing an LCF would be essentially zero (less than 1 chance in 300 billion). The MEI would be located across the river from the 300 Area. Radiological air emissions would remain fairly constant over the duration of the alternative, with an annual population dose of 0.000018 person-rem and an annual MEI dose of 0.00000021 millirem.

Table 4–136. Waste Management Alternative 2 Radiological Impacts on the Public

Receptor	Impacts over Life of Project[a]		Peak Annual Impacts	
	Dose (person-rem)	Latent Cancer Fatalities[b]	Dose (person-rem per year)	Latent Cancer Fatalities[b]
General population	0.00067	0 (4×10^{-7})	0.000018	0 (1×10^{-8})
	Dose (millirem)	Lifetime Risk of a Latent Cancer Fatality[c]	Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality[c]
Maximally exposed individual	0.0000082	5×10^{-12}	0.00000021	1×10^{-13}
Maximally exposed onsite individual	0.0000022	1×10^{-12}	0.000000057	3×10^{-14}

a Impacts accrued over the operational life of the project analyzed in this alternative, 2013 through 2051.

b The reported value is the projected number of latent cancer fatalities (LCFs) in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c The lifetime risk of developing an LCF is based on the risk factor of 0.0006 LCFs per rem.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.3.

Radiological air emissions from the 200 Area solid waste management facilities could also impact a member of the public who works on the Hanford Site. The annual radiological dose to an individual at LIGO exposed while at work would be 0.000000057 millirem. Over the 39-year period during which there would be radiological emissions from waste management activities, a worker at LIGO would receive a dose of 0.0000022 millirem, with a corresponding risk of developing an LCF of essentially zero (about 1 chance in a trillion).

4.3.10.2.2 Radiological Impacts on Workers

Radiological exposure of workers would occur from activities at the waste processing facilities and from LLBG operations. Table 4–137 presents dose and risk estimates for an involved and a noninvolved worker receiving an average exposure from activities at the waste processing facilities. Radiological doses to workers from LLBG operations of different durations are addressed in the following sections. The three different durations reflect the time disposal capabilities would be needed to support various Tank Closure alternatives. Doses resulting from waste processing facility operations would be the same regardless of the disposal group selected.

Table 4–137. Waste Management Alternative 2 Radiological Impacts on Workers

	Years[a]	Dose	Latent Cancer Fatality Risk[b]
Average Involved Full-Time Equivalent Worker			
Average annual impact	2013–2051	200 millirem	1×10^{-4}
Impact over life of project[c]	2013–2051	7,800 millirem	5×10^{-3}
Life-of-Project Worker Population	2013–2051	3,000 person-rem	2
Noninvolved Worker–Year of Maximum Impact			
100-meter distance	2013–2051	0.00023 millirem	1×10^{-10}

a Years indicate the portion of the project during which a worker dose is expected under this alternative.

b For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

c Impact over the life of the project is the average impact a full-time equivalent radiation worker would receive while working on this project. It is determined by multiplying the average annual impact by the smaller of the project duration (39 years) or 40 years (assuming a worker spends a 40-year career supporting this project).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Appendix K, Section K.2.3.

The average annual radiation worker dose would be 200 millirem, less than the Administrative Control Level of 500 millirem. A worker who received the average annual radiation dose over the 39 years of this activity would receive a dose of 7,800 millirem, which corresponds to a risk of 5×10^{-3} (1 chance in 200) of developing an LCF.

The total effective dose equivalent to the worker population from 39 years of occupational exposure under this alternative is estimated to be 3,000 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, 2 LCFs could be expected in the worker population. This number should be viewed in the context of the duration of the project and the DOE administrative controls that limit worker dose. Due to the duration of this activity, the total dose would be distributed over a few generations of workers. Even though the worker population dose implies a number of LCFs, the operational controls used by DOE and its contractors would limit the dose that individual workers would receive and, therefore, the risk of developing an LCF. A majority of the worker population dose under this alternative (2,800 person-rem, or 94 percent) is associated with operation of WRAP.

The potential dose to a noninvolved worker would result from exposure to, and inhalation of, radiological contaminants released to the atmosphere from waste processing activities. The potential dose to a noninvolved worker would be 2.3×10^{-4} millirem per year, well less than the DOE recommended

Administrative Control Level of 500 millirem per year (DOE 2006a:2; Fluor Hanford 2006:2-1). The annual risk of an LCF as a result of this exposure would be essentially zero (less than 1 in 7 billion).

4.3.10.2.2.1 Disposal Group 1

Table 4–138 presents dose and risk estimates for a radiation worker involved in LLBG operations who would receive an average radiation exposure. LLBG operations would be conducted for 44 years under Disposal Group 1. The average annual dose would be 200 millirem, less than the Administrative Control Level of 500 millirem. A worker who received the average annual radiation dose over a 40-year career would receive a dose of 8,000 millirem, which corresponds to a risk of 5×10^{-3} (1 chance in 200) of developing an LCF.

Table 4–138. Waste Management Alternative 2, Disposal Group 1, Radiological Impacts on Workers

	Years[a]	Dose	Latent Cancer Fatality Risk[b]
Average Involved Full-Time Equivalent Worker			
Average annual impact	2007–2050	200 millirem	1×10^{-4}
Impact over life of project[c]	2007–2050	8,000 millirem	5×10^{-3}
Life-of-Project Worker Population	2007–2050	360 person-rem	0 (2×10^{-1})

a Years indicate the portion of the project during which a worker dose is expected under this alternative and disposal group.

b For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

c Impact over the life of the project is the average impact a full-time equivalent radiation worker would receive while working on this project. It is determined by multiplying the average annual impact by the smaller of the project duration or 40 years (assuming a worker spends a 40-year career supporting this project).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Appendix K, Section K.2.3.

The total effective dose equivalent to the worker population from 44 years of occupational exposure during disposal operations is estimated to be 360 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, no LCFs due to occupational radiation exposure would be expected in the worker population.

The total radiological impact on the worker population would be 3,360 person-rem, the combination of the doses from disposal operations (360 person-rem) and waste processing facility operations (3,000 person-rem) (see Section 4.3.10.2.2). Applying the risk factor of 0.0006 LCFs per person-rem, 2 LCFs could be expected in the worker population. This number should be viewed in the context of the duration of the project and the DOE administrative controls that limit worker dose. Due to the duration of this activity, the total dose would be distributed over a few generations of workers. Even though the worker population dose implies a number of LCFs, the operational controls used by DOE and its contractors would limit the dose that individual workers would receive and, therefore, the risk of developing an LCF.

4.3.10.2.2.2 Disposal Group 2

Table 4–139 presents dose and risk estimates for a radiation worker involved in LLBG operations who would receive an average radiation exposure. LLBG operations would be conducted for 94 years under Disposal Group 2. The average annual dose would be 200 millirem, less than the Administrative Control Level of 500 millirem. A worker who received the average annual radiation dose over a 40-year career would receive a dose of 8,000 millirem, which corresponds to a risk of 5×10^{-3} (1 chance in 200) of developing an LCF.

Table 4–139. Waste Management Alternative 2, Disposal Group 2, Radiological Impacts on Workers

	Years[a]	Dose	Latent Cancer Fatality Risk[b]
Average Involved Full-Time Equivalent Worker			
Average annual impact	2007–2100	200 millirem	1×10^{-4}
Impact over the life of project[c]	2007–2100	8,000 millirem	5×10^{-3}
Life-of-Project Worker Population	2007–2100	3,600 person-rem	2

a Years indicate the portion of the project during which a worker dose is expected under this alternative.

b For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

c Impact over the life of the project is the average impact a full-time equivalent radiation worker would receive while working on this project. It is determined by multiplying the average annual impact by the smaller of the project duration or 40 years (assuming a worker spends a 40-year career supporting this project).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.
Source: Appendix K, Section K.2.3.

The total effective dose equivalent to the worker population from 94 years of occupational exposure during disposal operations is estimated to be 3,600 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, 2 LCFs due to occupational radiation exposure could be expected in the worker population. A majority of the worker population dose under this alternative (3,400 person-rem, or 94 percent) is associated with operation of the RPPDF.

The total radiological impact on the worker population would be 6,600 person-rem, the combination of the doses from disposal operations (3,600 person-rem) and waste processing facility operations (3,000 person-rem) (see Section 4.3.10.2.2). Applying the risk factor of 0.0006 LCFs per person-rem, 4 LCFs could be expected in the worker population. This number should be viewed in the context of the duration of the project and the DOE administrative controls that limit worker dose. Due to the duration of this activity, the total dose would be distributed over several generations of workers. Even though the worker population dose implies a number of LCFs, the operational controls used by DOE and its contractors would limit the dose that individual workers would receive and, therefore, the risk of developing an LCF.

4.3.10.2.2.3 Disposal Group 3

Table 4–140 presents dose and risk estimates for a radiation worker involved in LLBG operations who would receive an average radiation exposure. LLBG operations would be conducted for 159 years under Disposal Group 3. The radiological impact on an individual worker would be the same as under Disposal Group 2—an average annual dose of 200 millirem and a project dose from 40 years of exposure of 8,000 millirem. The risk of developing an LCF associated with a dose of 8,000 millirem would be 5×10^{-3} (1 chance in 200).

The total effective dose equivalent to the worker population from 159 years of occupational exposure during Disposal Group 3 operations is estimated to be 6,400 person-rem. Applying the risk factor of 0.0006 LCFs per person-rem, 4 LCFs due to occupational radiation exposure could be expected in the worker population. A majority of the worker population dose under this alternative (6,200 person-rem, or 97 percent) is associated with operation of the RPPDF.

Table 4–140. Waste Management Alternative 2, Disposal Group 3, Radiological Impacts on Workers

	Years[a]	Dose	Latent Cancer Fatality Risk[b]
Average Involved Full-Time Equivalent Worker			
Average annual impact	2007–2165	200 millirem	1×10^{-4}
Impact over life of project[c]	2007–2165	8,000 millirem	5×10^{-3}
Life-of-Project Worker Population	2007–2165	6,400 person-rem	4

a Years indicate the portion of the project during which a worker dose is expected under this alternative.

b For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number (see Appendix K, Section K.1.1.3).

c Impact over the life of the project is the average impact a full-time equivalent radiation worker would receive while working on this project. It is determined by multiplying the average annual impact by the smaller of the project duration or 40 years (assuming a worker spends a 40-year career supporting this project).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Appendix K, Section K.2.3.

The total radiological impact on the worker population would be 9,400 person-rem, the combination of the doses from disposal operations (6,400 person-rem) and waste processing facility operations (3,000 person-rem) (see Section 4.3.10.2.2). Applying the risk factor of 0.0006 LCFs per person-rem, 6 LCFs could be expected in the worker population. This number should be viewed in the context of the duration of the project and the DOE administrative controls employed that limit worker dose. Due to the duration of this activity, the total dose would be distributed over several generations of workers. Even though the worker population dose implies a number of LCFs, the operational controls used by DOE and its contractors would limit the dose that individual workers would receive and, therefore, the risk of developing an LCF.

4.3.10.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Radiological impacts under this alternative would be the same as under Alternative 2. Doses to the public would result from radiological air emissions associated with waste processing in new or expanded facilities constructed at the T Plant and the CWC. Worker doses would result from waste processing facility and waste disposal operations.

4.3.10.3.1 Radiological Impacts on the Public

Radiological impacts on the public would be the same as under Alternative 2, discussed in Section 4.3.10.2.1.

4.3.10.3.2 Radiological Impacts on Workers

Radiological impacts on workers would be the same as under Waste Management Alternative 2, discussed in Section 4.3.10.2.2. Radiological exposure to workers would occur from waste processing facility activities and LLBG operations. Doses resulting from waste processing facility operations would be the same regardless of the disposal group selected.

4.3.10.3.2.1 Disposal Group 1

Radiological impacts on workers from disposal operations under Waste Management Alternative 3, Disposal Group 1, would be the same as those under Alternative 2, Disposal Group 1 (see Section 4.3.10.2.2.1).

4.3.10.3.2.2 Disposal Group 2

Radiological impacts on the worker population from disposal operations for the duration of the project under Waste Management Alternative 3, Disposal Group 2, are estimated to be slightly smaller than those under Alternative 2. The collective worker population dose from 94 years of disposal operations would be about 3,500 person-rem. This small reduction in worker population dose would not change the estimated 2 LCFs that could occur in the worker population. The average annual worker dose would be the same as that under Alternative 2, Disposal Group 2 (see Section 4.3.10.2.2.2).

4.3.10.3.2.3 Disposal Group 3

Radiological impacts on workers from disposal operations under Waste Management Alternative 3, Disposal Group 3, would be the same as those under Alternative 2, Disposal Group 3 (see Section 4.3.10.2.2.3).

4.3.11 Public and Occupational Health and Safety—Facility Accidents

This section addresses potential impacts on workers and the public associated with potential accidents under the Waste Management alternatives and associated disposal groupings. For each Waste Management alternative, radiological impacts of postulated accident scenarios are quantified for an MEI living near Hanford, the offsite population as a whole, and a noninvolved worker. Hazardous chemical impacts are also evaluated. For an involved worker, accident consequences have not been quantified. While involved workers are expected to be in or near waste treatment, storage, and disposal facilities analyzed under the Waste Management alternatives, the number and location of personnel relative to a postulated accident are not known. In the event of an accident involving chemicals or radioactive materials, workers near an accident could be at risk of serious injury or fatality. Safety procedures, safety equipment, and protective barriers are typical features that would prevent or minimize worker impacts. Additionally, following initiation of accident/site emergency alarms, workers in adjacent areas of the facility would evacuate in accordance with the technical area and facility emergency operating procedures and training. Therefore, involved worker impacts are not discussed further relative to the Waste Management alternatives. The impacts of intentional destructive act scenarios would be comparable to those of scenarios SWOC FIR-4 (large fire of waste containers outside facility) and SWOC EE-2 (aircraft crash).

There would be no radiological accidents associated with facility construction in support of Hanford waste treatment and storage activities or new disposal facility construction under the various disposal groups evaluated as part of Waste Management Alternatives 2 and 3. Any hazardous chemical accidents associated with facility construction (e.g., fuel spills) would be typical of those normally associated with industrial construction materials, hazards, and practices. The projected accident consequences under each Waste Management alternative are presented in the following sections. Details of the methodology for assessing the potential impacts on workers and the public associated with postulated accidents are presented in Appendix K, Section K.3.

4.3.11.1 Alternative 1: No Action

4.3.11.1.1 Radiological Impacts of Airborne Releases

Under Waste Management Alternative 1, reasonably foreseeable accidents include fires involving stored waste, spills of waste containers, external events, and natural phenomena. Table 4–141 shows the consequences of the accidents associated with the No Action Alternative. Table 4–142 shows the annual cancer risks for the accidents.

Table 4–141. Waste Management Alternative 1 Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatality[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatality[b]
Single-drum deflagration (SWOC FIR-1)	0.00079	5×10^{-7}	3.6	0 (2×10^{-3})	0.84	5×10^{-4}
Medium fire inside facility (SWOC FIR-6)	0.015	9×10^{-6}	66	0 (4×10^{-2})	16	9×10^{-3}
Glovebox or greenhouse fire (SWOC FIR-8)	0.028	2×10^{-5}	130	0 (8×10^{-2})	30	4×10^{-2}
Large fire of waste containers outside facility (SWOC FIR-4)	0.25	2×10^{-4}	1,100	1	260	3×10^{-1}
Handling spill of single waste container (SWOC SP-2)	0.00015	9×10^{-8}	0.66	0 (4×10^{-4})	0.16	9×10^{-5}
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	0.00072	4×10^{-7}	3.3	0 (2×10^{-3})	0.77	5×10^{-4}
Spill of single large-diameter container (SWOC SP-4)	0.007	4×10^{-6}	32	0 (2×10^{-2})	7.5	4×10^{-3}
Design-basis seismic event (SWOC NPH-1)	0.0068	4×10^{-6}	31	0 (2×10^{-2})	7.3	4×10^{-3}
Beyond-design-basis accident (SWOC NPH-2)	0.026	2×10^{-5}	120	0 (7×10^{-2})	28	3×10^{-2}
Range fire (SWOC EE-1)	0.12	7×10^{-5}	560	0 (3×10^{-1})	130	2×10^{-1}
Aircraft crash (SWOC EE-2)	0.28	2×10^{-4}	1,300	1	300	4×10^{-1}

[a] The alphanumeric code following the accident's title (e.g., SWOC FIR-1), corresponds with the code in the accident's description in Appendix K, Section K.3.6.
[b] Increased likelihood of latent cancer fatality for an individual, assuming the accident occurs.
[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.
[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: SWOC=Solid Waste Operations Complex.
Source: Appendix K, Section K.3.7.3.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–142) is the large fire of waste containers outside a facility (SWOC FIR-4). For this accident, no LCFs would be expected in the offsite population; there would be an increased risk of an LCF of 7×10^{-3} per year (i.e., about 1 in 140 per year of a single LCF occurring in the population). For the MEI, the increase in the likelihood of an LCF would be 2×10^{-6} per year (i.e., about 1 in 500,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the increase in the likelihood of an LCF would be 3×10^{-3} per year (i.e., about 1 in 330 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. The accident that would have the highest consequences were it to occur would be the aircraft crash (SWOC EE-2). The consequences would be about 1.2 times those shown for the large fire of waste containers outside facility (SWOC FIR-4).

Under Waste Management Alternative 1, operations would continue for a project period of 29 years; during this time period, workers and the public would be at risk of exposure to radioactivity from an accident. For the highest-risk accident (accident SWOC FIR-4) in Table 4–142, the risk to the offsite population and onsite workers during this 29-year project period would be no (2×10^{-1}) increase in the number of LCFs in the offsite population, a 4×10^{-5} increased likelihood of an LCF for the MEI, and a 9×10^{-2} increased likelihood of an LCF for the noninvolved worker.

Table 4–142. Waste Management Alternative 1 Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Single-drum deflagration (SWOC FIR-1)	1×10^{-2}	5×10^{-9}	0 (2×10^{-5})	5×10^{-6}
Medium fire inside facility (SWOC FIR-6)	1×10^{-2}	9×10^{-8}	0 (4×10^{-4})	9×10^{-5}
Glovebox or greenhouse fire (SWOC FIR-8)	1×10^{-2}	2×10^{-7}	0 (8×10^{-4})	4×10^{-4}
Large fire of waste containers outside facility (SWOC FIR-4)	1×10^{-2}	2×10^{-6}	0 (7×10^{-3})	3×10^{-3}
Handling spill of single waste container (SWOC SP-2)	1×10^{-2}	9×10^{-10}	0 (4×10^{-6})	9×10^{-7}
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	1×10^{-2}	4×10^{-9}	0 (2×10^{-5})	5×10^{-6}
Spill of single large-diameter container (SWOC SP-4)	1×10^{-2}	4×10^{-8}	0 (2×10^{-4})	4×10^{-5}
Design-basis seismic event (SWOC NPH-1)	1×10^{-3}	4×10^{-9}	0 (2×10^{-5})	4×10^{-6}
Beyond-design-basis accident (SWOC NPH-2)	1×10^{-3}	2×10^{-8}	0 (7×10^{-5})	3×10^{-5}
Range fire (SWOC EE-1)	1×10^{-2}	7×10^{-7}	0 (3×10^{-3})	2×10^{-3}
Aircraft crash (SWOC EE-2)	3×10^{-5}	5×10^{-9}	0 (2×10^{-5})	1×10^{-5}

a The alphanumeric code following the accident's title (e.g., SWOC FIR-1), corresponds with the code in the accident's description in Appendix K, Section K.3.6.
b Increased risk of a latent cancer fatality to the individual.
c Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.
d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: SWOC=Solid Waste Operations Complex.
Source: Appendix K, Section K.3.7.3.

4.3.11.1.2 Hazardous Chemical Impacts

Hazardous waste exists in two major areas in the SWOC. The first is the toxic chemical contents of waste containers encountered during retrieval and handling of TRU waste containers and suspect TRU waste containers. The second significant toxic chemical within the SWOC is the sodium in storage modules at the CWC facility. The future disposition of the bulk sodium stored at the CWC is addressed in Section 4.2. The consequences of accidents involving the bulk sodium have been addressed in Section 4.2.11.1.2.

To estimate the hazard significance and potential impacts of an accidental release of the hazardous chemicals within the SWOC waste containers, the containers were evaluated using the methodologies for identifying hazardous chemicals that should be subjected to quantitative analyses in both the DOE safety analysis and emergency management programs. The results of this evaluation are discussed in Appendix K and indicate that, with the exception of sodium metal mentioned above, none of the chemicals listed were found to exist in a form or quantity that represents a sufficiently high health hazard

that would require analysis and inclusion in a documented facility safety analysis or an emergency preparedness hazards assessment.

The chemical hazards in the waste management containers are generally mixed together with the radiological hazards. Radiological accident scenarios are expected to release both radioactive materials and toxic chemicals. The scenario most likely to release a significant quantity of hazardous chemicals is a fire event involving multiple waste containers. From the results reported in Appendix K for this type of event, the dose consequence to the noninvolved worker (at 100 meters [110 yards]) would be 210 rem; doses from other fire scenarios analyzed range from approximately 1 rem to a maximum of 300 rem.

The evaluation of chemical exposures shows that exposures to the noninvolved worker do not exceed the AEGLs (i.e., 60-minute AEGL-2 value), which were established by the U.S. Environmental Protection Agency (EPA) and implemented by DOE as the trigger point for planning protective measures for the public in the event of a large release of hazardous chemicals. The equivalent radiological threshold established by the EPA for planning protective measures in the event of a large release of radioactive material is 1 rem. From the results of the radiological analysis and the chemical evaluations, it is clear that the potential health impacts of the radioactive components of the waste far outweigh those of the chemical components. Therefore, further quantitative analysis to determine potential human health impacts of an accidental release of hazardous chemicals from within the mixed waste is not necessary.

4.3.11.2 Alternative 2: Disposal in IDF, 200-East Area Only

4.3.11.2.1 Radiological Impacts of Airborne Releases

Table 4–143 shows the consequences of the accidents associated with Alternative 2. Table 4–144 shows the annual cancer risks for the accidents. Two accident scenarios in addition to those evaluated under Alternative 1 are possible under Alternative 2. The new scenarios involve ILAW containers disposed of in IDF-East.

The accident with the highest radiological risk to the offsite population and onsite workers (see Table 4–144) is the large fire of waste containers outside facility (SWOC FIR-4). For this accident, no LCFs would be expected in the offsite population; there would be an increased risk of an LCF of 7×10^{-3} per year (i.e., about 1 in 140 per year of a single LCF occurring in the population). For the MEI, the increase in the likelihood of an LCF would be 2×10^{-6} per year (i.e., about 1 in 500,000 per year). For a noninvolved worker 100 meters (110 yards) from the accident, the increase in the likelihood of an LCF would be 3×10^{-3} per year (i.e., about 1 in 330 per year). For any involved or noninvolved worker closer than 100 meters (110 yards) from the accident's location, the risk of exposure to radioactivity and an LCF would depend on the distance and other factors, but would generally be higher. The accident that would have the highest consequences were it to occur would be the aircraft crash (SWOC EE-2). The consequences would be about 1.2 times those shown for the large fire of waste containers outside facility.

Table 4–143. Waste Management Alternative 2 Radiological Consequences of Accidents

Accident[a]	Maximally Exposed Individual		Offsite Population[c]		Noninvolved Worker	
	Dose (rem)	Latent Cancer Fatality[b]	Dose (person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatality[b]
Single-drum deflagration (SWOC FIR-1)	0.00079	5×10^{-7}	3.6	0 (2×10^{-3})	0.84	5×10^{-4}
Medium fire inside facility (SWOC FIR-6)	0.015	9×10^{-6}	66	0 (4×10^{-2})	16	9×10^{-3}
Glovebox or greenhouse fire (SWOC FIR-8)	0.028	2×10^{-5}	130	0 (8×10^{-2})	30	4×10^{-2}
Large fire of waste containers outside facility (SWOC FIR-4)	0.25	2×10^{-4}	1,110	1	260	3×10^{-1}
Handling spill of single waste container (SWOC SP-2)	0.00015	9×10^{-8}	0.66	0 (4×10^{-4})	0.16	9×10^{-5}
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	0.00072	4×10^{-7}	3.3	0 (2×10^{-3})	0.77	5×10^{-4}
Spill of single large-diameter container (SWOC SP-4)	0.007	4×10^{-6}	32	0 (2×10^{-2})	7.5	4×10^{-3}
Design-basis seismic event (SWOC NPH-1)	0.0068	4×10^{-6}	31	0 (2×10^{-2})	7.3	4×10^{-3}
Beyond-design-basis accident (SWOC NPH-2)	0.026	2×10^{-5}	120	0 (7×10^{-2})	28	3×10^{-2}
Range fire (SWOC EE-1)	0.12	7×10^{-5}	560	0 (3×10^{-1})	130	2×10^{-1}
Aircraft crash (SWOC EE-2)	0.28	2×10^{-4}	1,300	1	300	4×10^{-1}
Earthmover shears tops off six ILAW containers (ILAW1)	0.0000034	2×10^{-9}	0.016	0 (9×10^{-6})	0.0036	2×10^{-6}
Crushing of ILAW containers by falling crane boom (ILAW2)	0.000031	2×10^{-8}	0.14	0 (8×10^{-5})	0.033	2×10^{-5}

[a] The alphanumeric code following the accident's title (e.g., SWOC FIR-1), corresponds with the code in the accident's description in Appendix K, Section K.3.6.

[b] Increased likelihood of latent cancer fatality for an individual, assuming the accident occurs.

[c] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively (see Appendix K, Section K.2.1.3.1.2).

[d] The reported value is the projected number of latent cancer fatalities (LCFs) in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: ILAW=immobilized low-activity waste; SWOC=Solid Waste Operations Complex.
Source: Appendix K, Section K.3.7.3.

4.3.11.2.1.1 Disposal Group 1

Under Disposal Group 1, disposal operations would continue for 44 years. For the highest risk accident shown in Table 4–144 (SWOC FIR-4), there would be no (3×10^{-1}) additional LCFs in the offsite population as a consequence of the 44-year project period. As a result of the 44-year duration of the project, there would be an increased risk of an LCF for an MEI of 6×10^{-5} (1 in 11,000) and an increased risk of an LCF for the noninvolved worker of 1×10^{-1} (1 in 10).

Table 4–144. Waste Management Alternative 2 Annual Cancer Risks from Accidents

Accident[a]	Frequency (per year)	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[b]	Offsite Population[c, d]	Noninvolved Worker[b]
Single-drum deflagration (SWOC FIR-1)	1×10^{-2}	5×10^{-9}	0 (2×10^{-5})	5×10^{-6}
Medium fire inside facility (SWOC FIR-6)	1×10^{-2}	9×10^{-8}	0 (4×10^{-4})	9×10^{-5}
Glovebox or greenhouse fire (SWOC FIR-8)	1×10^{-2}	2×10^{-7}	0 (8×10^{-4})	4×10^{-4}
Large fire of waste containers outside facility (SWOC FIR-4)	1×10^{-2}	2×10^{-6}	0 (7×10^{-3})	3×10^{-3}
Handling spill of single waste container (SWOC SP-2)	1×10^{-2}	9×10^{-10}	0 (4×10^{-6})	9×10^{-7}
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	1×10^{-2}	4×10^{-9}	0 (2×10^{-5})	5×10^{-6}
Spill of single large-diameter container (SWOC SP-4)	1×10^{-2}	4×10^{-8}	0 (2×10^{-4})	4×10^{-5}
Design-basis seismic event (SWOC NPH-1)	1×10^{-3}	4×10^{-9}	0 (2×10^{-5})	4×10^{-6}
Beyond-design-basis accident (SWOC NPH-2)	1×10^{-3}	2×10^{-8}	0 (7×10^{-5})	3×10^{-5}
Range fire (SWOC EE-1)	1×10^{-2}	7×10^{-7}	0 (3×10^{-3})	2×10^{-3}
Aircraft crash (SWOC EE-2)	3×10^{-5}	5×10^{-9}	0 (2×10^{-5})	1×10^{-5}
Earthmover shears tops off six ILAW containers (ILAW1)	1×10^{-1}	2×10^{-10}	0 (9×10^{-7})	2×10^{-7}
Crushing of ILAW containers by falling crane boom (ILAW2)	1×10^{-1}	2×10^{-9}	0 (8×10^{-6})	2×10^{-6}

a The alphanumeric code following the accident's title (e.g., SWOC FIR-1), corresponds with the code in the accident's description in Appendix K, Section K.3.6.

b Increased risk of a latent cancer fatality to the individual.

c Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively (see Appendix K, Section K.2.1.3.1.2).

d The reported value is the projected number of latent cancer fatalities (LCFs) in the population, based on the probability (frequency) of the accident occurring, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

Key: ILAW=immobilized low-activity waste; SWOC=Solid Waste Operations Complex.

Source: Appendix K, Section K.3.7.3.

4.3.11.2.1.2 Disposal Group 2

Under Disposal Group 2, disposal operations would continue for 94 years. For the highest-risk accident shown in Table 4–144 (SWOC FIR-4), there would be a risk of about 1 (6.3×10^{-1}) additional LCF in the offsite population as a consequence of the 94-year project period. As a result of the 94-year duration of the project, there would be an increased risk of an LCF for an MEI of 1×10^{-4} (1 in 10,000) and an increased risk of an LCF for the noninvolved worker of 3×10^{-1} (1 in 3). This risk to an MEI or noninvolved worker is theoretical because the same individual would not be present for the duration of the project.

4.3.11.2.1.3 Disposal Group 3

Under Disposal Group 3, disposal operations would continue for 159 years. For the highest-risk accident shown in Table 4–144 (SWOC FIR-4), there would be a risk of 1 (1.1) additional LCF in the offsite population as a consequence of the 159-year project period. As a result of the 159-year duration of the project, there would be an increased risk of an LCF for an MEI of 2×10^{-4} (1 in 5,000) and an increased risk of an LCF for the noninvolved worker of 5×10^{-1} (1 in 2). This risk to an MEI or noninvolved worker is theoretical because the same individual would not be present for the duration of the project.

4.3.11.2.2 Hazardous Chemical Impacts

The hazardous chemical impacts of accidents under Alternative 2 (including Disposal Groups 1, 2, and 3) would be the same as those addressed under Alternative 1 (see Section 4.3.11.1.2).

4.3.11.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

4.3.11.3.1 Radiological Impacts of Airborne Releases

The accident scenarios under Alternative 3 are the same as those under Alternative 2. The consequences and annual risks of the accidents are presented in Tables K–143 and K–144.

4.3.11.3.1.1 Disposal Groups 1, 2, and 3

The radiological impacts of reasonably anticipated accidents under Alternative 3, Disposal Groups 1, 2, and 3, would be the same as those addressed under Alternative 2 (see Sections 4.3.11.2.1.1, 4.3.11.2.1.2, and 4.3.11.2.1.3).

4.3.11.3.2 Hazardous Chemical Impacts

The hazardous chemical impacts of accidents under Alternative 3 (including Disposal Groups 1, 2, and 3) would be the same as those addressed under Alternative 1 (see Section 4.3.11.1.2).

4.3.11.4 Intentional Destructive Acts

This section addresses potential impacts of intentional destructive acts at waste management facilities. Release scenarios and impacts resulting from intentional destructive acts may be similar to a number of the accidents scenarios analyzed in this EIS. An additional intentional destructive act scenario was also considered. This scenario would apply to all Waste Management alternatives.

Large Aircraft Crash at Solid Waste Operations Complex Storage Building. Impacts of the aircraft crash accident scenario (SWOC EE-2) were extrapolated to reflect the potential impacts of an intentional destructive act that could involve a larger aircraft, more fuel, and damage to a larger number of containers in a SWOC storage building. The radiological impacts would be about 18 times greater than those calculated for the accident scenario. The offsite population dose was estimated to be 24,000 person-rem, which would result in 14 additional LCFs. The MEI dose would be 5.1 rem, which corresponds to an increased risk of an LCF of 3×10^{-3}. The noninvolved worker dose would be 5,400 rem, which could result in a near-term fatality.

The impacts and mitigation of intentional destructive acts are discussed in more detail in Appendix K, Section K.3.11.

4.3.12 Public and Occupational Health and Safety—Transportation

A number of factors affect the risk of transporting radioactive materials. These factors are predominantly categorized as radiological impacts or nonradiological impacts. Radiological impacts are those associated with the accidental release of radioactive materials and the effects of low levels of radiation emitted during normal, or incident-free, transportation. Nonradiological impacts are those associated with transportation, regardless of the nature of the cargo, such as accidents resulting in death or injury when there is no release of radioactive material.

The impacts of incident-free, or routine, transportation and transportation accidents comprise transportation impacts. The impacts of incident-free transportation and transportation accidents can be radiological and nonradiological. Incident-free transportation impacts include radiological impacts on the

public and workers from the radiation field surrounding the transportation package. Nonradiological impacts of potential transportation accidents include traffic accident fatalities. The impact of a specific radiological accident is expressed in terms of probabilistic risk, which is defined as the accident probability (i.e., accident frequency) multiplied by the accident consequences. The overall risk is obtained by summing the individual risks from all accident severities, irrespective of their likelihood of occurrence. The analysis of accident risks takes into account a spectrum of accidents ranging from high-probability accidents of low severity (e.g., fender bender) to hypothetical high-severity accidents that have a low probability of occurrence. Additional information is provided in Section 4.1.12, and further details on modeling and parameter selections are provided in Appendix H.

Table 4–145 provides the estimated number of shipments of various wastes under each alternative by waste type. A shipment is defined as the amount of waste transported on a single truck or a single railcar. The values presented for offsite shipments in Table 4–145 are the estimated number of shipments for transporting about 82,000 cubic meters (107,000 cubic yards) of LLW and MLLWs from DOE facilities. This activity is common to both Alternatives 2 and 3. The values presented for the offsite waste shipments in Table 4–145 are estimated truck transports. Offsite rail shipments were assumed to be one-half of the values given.

Table 4–145. Waste Management Alternatives – Estimated Number of Shipments

Alternative	Number of Shipments			
	Offsite Shipments[a]		Onsite Shipments	
	LLW[b]	MLLW[b]	LLW[b]	MLLW[b]
1	0	0	807	196
2	15,300	1,320	807	196
3	15,300	1,320	807	196

a These are estimates for truck transports. Rail transports would be one-half of the values given.

b These include both the contact-handled and remote-handled wastes.

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate.

Key: LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste.

Source: Appendix H, Section H.7.3.

Table 4–146 summarizes the risks of transportation under each alternative. This table shows that the dose to the population along the routes (see column 6 of Table 4–146: off site) is expected to be between the lowest expected dose of about 135 person-rem, which is associated with the rail transport of offsite waste to Hanford, and the highest expected dose of about 352 person-rem, associated with the truck transport of offsite waste to Hanford. The additional LCFs expected from such exposures to the general population would be less than 1 for all alternatives, ranging from 8.1×10^{-2} to 2.1×10^{-1}. Rail transport would lead to lower doses to the general population, due to the smaller number of transports and lower exposure to the people in the vicinity of stations where the reclassification and inspections would take place. Almost half of the doses to the general population resulting from truck transports are from exposures at rest areas, gas stations, and stops along the route.

The lowest expected dose to the workers transporting wastes (see column 4 of Table 4–146: off site) would be about 53 person-rem for offsite rail shipments, and the highest would be 2,620 person-rem for offsite truck shipments. The additional LCF among the exposed crew would range from 0 to 2 (1.57). Rail transport results in lower doses to rail crews because they are farther away from the waste packages than truck crews. Note that the maximum annual dose to a transportation crew member would be 100 millirem per year, unless the individual is a trained radiation worker, in which case the maximum annual dose would be 2 rem (DOE Standard-1098-99). The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure of 2 rem is 0.0012. Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

Table 4–146. Waste Management Alternatives – Risks of Transporting Radioactive Waste

Alternative	Location (transport mode)	Number of Shipments	Incident-Free				Accident		
			Crew		Population				
			Dose (person-rem)	Risk[a]	Dose (person-rem)	Risk[a]	Radiological Risk[a, b]	Non-Radiological Risk[a]	One-Way Offsite Travel (10^6 km)
1	Off site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	On site	1,000	2.6	1.6×10^{-3}	0.083	5.0×10^{-5}	2.1×10^{-9}	0.00026	N/A
2	Off site (T)	16,600	2,620	1.57	352	2.1×10^{-1}	6.0×10^{-5}	1.10	53.8
	Off site (R)	8,290	52.7	3.2×10^{-2}	135	8.1×10^{-2}	2.9×10^{-5}	4.28	27.4
	On site	1,000	4.3	2.6×10^{-3}	0.138	8.0×10^{-5}	3.6×10^{-9}	0.00041	N/A
3	Off site (T)	16,600	2,620	1.57	352	2.1×10^{-1}	6.0×10^{-5}	1.10	53.8
	Off site (R)	8,290	52.7	3.2×10^{-2}	135	8.1×10^{-1}	2.9×10^{-5}	4.28	27.4
	On site	1,000	2.6	1.6×10^{-3}	0.083	5.0×10^{-5}	2.1×10^{-9}	0.00026	N/A

[a] Risk is expressed in terms of latent cancer fatalities, except for the nonradiological, where it refers to the number of accident fatalities.

[b] To calculate population dose (person-rem), divide the values in this column by 0.0006. For additional insight on how this dose is calculated, see the text in Section 4.1.12.

Note: To convert kilometers to miles, multiply by 0.6214. Values presented in the table have been rounded to no more than three significant digits, where appropriate.

Key: km=kilometers; N/A=not applicable—no offsite waste would be accepted at Hanford; R=rail transport; T=truck transport.

Source: Appendix H, Section H.7.3.

The risks to different receptors under incident-free transportation conditions were estimated on a per-trip or per-event basis. This basis was used because it is unlikely that the same person would be exposed to multiple events; for those that could have multiple exposures, the dose over the duration of transportation activities could be calculated by multiplying by the number of events or trips. The dose to a person stuck in traffic next to a shipment of RH-waste in a Type B cask for 30 minutes was calculated to be 10 millirem. For a receptor who is a member of the public residing along a transportation route, the dose over the duration of transportation activities would depend on the number of truck or rail shipments passing a particular point and would be independent of the actual route being considered. The maximum dose to this resident, if all the materials are shipped along this route, would be less than 5 millirem for all action alternatives. Refer to Appendix H, Table H–17, for additional results.

The expected number of traffic fatalities from accidents involving radioactive material transport would range from 1, for truck shipments, and 4, for rail shipments. Considering that the duration of accepting offsite waste is about 30 years and the average number of traffic fatalities in the U.S. is about 40,000 per year, the expected risk of traffic fatality under all alternatives is small.

Table 4–147 summarizes the impacts of transporting nonradioactive support materials required to construct new facilities, materials required to support operational activities, and waste en route to storage or burial locations. The construction materials considered include concrete, cement, sand/gravel/dirt, asphalt, steel, and piping, among others. The table shows the impacts in terms of total number of kilometers, accidents, and fatalities for all alternatives. The results in Table 4–147 indicate that for the Waste Management alternatives, potential for traffic fatalities are the largest under Disposal Group 3. However, the absolute risk is small, considering that the operational period for this disposal group is over 120 years.

Table 4–147. Waste Management Alternatives – Estimated Impacts of Construction and Operational Material Transport

Alternatives/Disposal Groups	Total Distance Traveled (kilometers)	Number of Accidents	Number of Fatalities
1	0.40×10^6	0.05	0.003
2	4.15×10^6	0.51	0.03
Disposal Group 1	8.40×10^6	1.03	0.07
Disposal Group 2	29.7×10^6	3.66	0.25
Disposal Group 3	38.0×10^6	4.67	0.32
3	4.15×10^6	0.51	0.03
Disposal Group 1	7.65×10^6	0.94	0.06
Disposal Group 2	29.9×10^6	3.68	0.25
Disposal Group 3	38.1×10^6	4.68	0.32

Note: To convert kilometers to miles, multiply by 0.6214. Values presented in the table have been rounded to no more than three significant digits, where appropriate.
Source: Appendix H, Section H.8.

4.3.12.1 Alternative 1: No Action

Under this alternative, transportation activities would be limited to shipments of onsite-generated waste to the active burial grounds in the 200-West Area. About 1,000 shipments would be transported from various facilities at Hanford to the 200-West Area of Hanford for disposal (see Table 4–145). These transports would mostly occur using onsite roads.

4.3.12.1.1 Impacts of Incident-Free Transportation

The dose to transportation workers from all onsite transportation activities would be 2.6 person-rem, and the dose to the exposed population would be 0.083 person-rem. Accordingly, incident-free transportation of radioactive material would result in 0 (1.6×10^{-3}) LCFs among transportation workers and 0 (5.0×10^{-5}) LCFs among the exposed population (see Table 4–146).

4.3.12.1.2 Impacts of Accidents During Transportation

As stated earlier, two sets of analyses were performed for the evaluation of transportation accident impacts: impacts of maximum reasonably foreseeable accidents and impacts of all accident (total transportation accidents) severities, irrespective of their likelihood of occurrence.

The maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) would not lead to a release. The consequences of the most severe onsite accident that could release the content of the waste were estimated to have a likelihood of less than 1 in 1 billion per year.

Estimates of the total transportation accident risks under this alternative are a radiological dose risk to the population of 3.5×10^{-6} person-rem, resulting in 2.1×10^{-9} LCFs, and traffic accidents resulting in 0 (0.00026) fatalities (see Table 4–146).

4.3.12.1.3 Impacts of Construction and Operational Material Transports

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and feed materials for the production and transport of waste (e.g., grout, fly ash, containers, boxes, and canisters) were evaluated. The impacts of transport activities under this alternative would be

400,000 kilometers (250,000 miles) traveled, 0 (0.05) accidents, and 0 (0.003) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–147). No disposal groups are analyzed under this alternative.

4.3.12.2 Alternative 2: Disposal in IDF, 200-East Area Only

Under this alternative, limited offsite waste would be accepted for disposal. This waste would require about 8,290 rail shipments or about 16,600 truck shipments. In addition, about 1,000 truck shipments would be made to transport onsite-generated waste to storage locations and burial grounds. The total distance traveled carrying radioactive materials would be 27.4 million kilometers (17 million miles) on public rail or 53.8 million kilometers (33.4 million miles) on public roads.

4.3.12.2.1 Impacts of Incident-Free Transportation

The dose to transportation workers from offsite transportation activities has been estimated to be about 53 person-rem for rail shipments and 2,620 person-rem for truck shipments. The additional LCF among the transportation workers would range from 0 (3.2×10^{-2}) to 2 (1.57). The dose to transportation workers from onsite transport activity has been estimated to be 4.3 person-rem, resulting in 0 (2.6×10^{-3}) additional LCFs (see Table 4–146). As stated under Alternative 2, the maximum annual dose to a transportation worker would be 100 millirem, unless the individual is a trained radiation worker, in which case the maximum annual dose would be 2 rem (DOE Standard 1098-99). Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

The expected cumulative dose to the general population during offsite transportation of waste by truck would be about 352 person-rem, resulting in 0 (2.1×10^{-1}) additional LCFs. The expected doses to the general population during offsite transportation of waste by rail would be about 135 person-rem, resulting in 0 (8.1×10^{-2}) additional LCFs. Rail transport would lead to lower doses to the general population, due to the smaller number of transports and lower exposure to the people in the vicinity of stations where the reclassification and inspections would take place. Almost half of the doses to the general population resulting from truck transports are from exposures at rest areas, gas stations, and stops along the route.

4.3.12.2.1.1 Disposal Group 1

The estimates of incident-free operational risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.2.1 of this chapter.

4.3.12.2.1.2 Disposal Group 2

The estimates of incident-free operational risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.2.1 of this chapter.

4.3.12.2.1.3 Disposal Group 3

The estimates of incident-free operational risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.2.1 of this chapter.

4.3.12.2.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident under this alternative (with a probability of occurrence of more than 1 in 10 million per year) is a severe impact high-temperature fire rail accident involving a shipment of RH-LLW. The consequences of such an accident in terms of population dose in the rural, suburban, and urban zones are 1.62, 25.24, and 120.9 person-rem,

respectively. The likelihood of occurrence of such consequences per shipment is less than 2.5×10^{-7}, 2.8×10^{-8}, and 5.3×10^{-9} in rural, suburban, and urban zones, respectively. This accident could result in a dose of 0.00031 rem to an individual hypothetically exposed to the accident plume for 2 hours at a distance of 100 meters (330 feet), with a corresponding LCF risk of 1.9×10^{-7}.

Estimates of the total transportation accident risks (both off site and on site) under this alternative are a radiological dose risk to the population ranging from 0.048 to 0.1 person-rem, resulting in 2.9×10^{-5} to 6.0×10^{-5} LCFs, and traffic accidents resulting in 1 (1.10) to 4 (4.28) fatalities, for rail or truck shipments, respectively (see Table 4–146). All of the risks would result from offsite shipment of wastes to Hanford. These results indicate that the annual accident risks are small, considering that the duration of these activities is 35 years.

4.3.12.2.2.1 Disposal Group 1

The estimates of accident risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.2.1 of this chapter.

4.3.12.2.2.2 Disposal Group 2

The estimates of accident risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.2.1 of this chapter.

4.3.12.2.2.3 Disposal Group 3

The estimates of accident risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.2.1 of this chapter.

4.3.12.2.3 Impacts of Construction and Operational Material Transports

The impacts of transporting construction materials (e.g., concrete, gravel/sand/soil, asphalt, steel, and piping) and feed materials for the production and transport of waste (e.g., grout, fly ash, containers, boxes, and canisters) were evaluated. In addition, under this alternative, three different combinations of waste capacities allocated to IDF-East and the RPPDF over varying operational timeframes to accommodate the waste generated under the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives—disposal groups—are evaluated. The transportation impacts under this alternative would consist of two parts: (1) transports in support of construction and operation of the disposal group IDF and (2) transports in support of activities within the alternative (see Table 4–147). The impacts of transport activities for the disposal groups would range from 8.40 to 38.0 million kilometers (5.22 to 23.6 million miles) traveled, from 1 (1.03) to 5 (4.67) accidents and would result in 0 (0.07 to 0.32) fatalities over the entire duration, from construction through deactivation and closure. The impacts of transport activities within the alternative would be 4.15 million kilometers (2.58 million miles) traveled, 1 (0.51) accident, and 0 (0.03) fatalities over the entire duration, from construction through deactivation and closure (see Table 4–147).

4.3.12.2.3.1 Disposal Group 1

The impacts of transport activities for this disposal group would be 8.40 million kilometers (5.22 million miles) traveled, 1 (1.03) accident, and 0 (0.07) fatalities over the entire duration, from construction through deactivation and closure.

4.3.12.2.3.2 Disposal Group 2

The impacts of transport activities for this disposal group would be 29.7 million kilometers (18.5 million miles) traveled, 4 (3.66) accidents, and 0 (0.25) fatalities over the entire duration, from construction through deactivation and closure.

4.3.12.2.3.3 Disposal Group 3

The impacts of transport activities for this disposal group would be 38.0 million kilometers (23.6 million miles) traveled, 5 (4.67) accidents, and 0 (0.32) fatalities over the entire duration, from construction through deactivation and closure.

4.3.12.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Under this alternative, as explained under Alternative 2, limited offsite waste would be accepted for disposal. This waste would require about 8,290 rail shipments or 16,600 truck shipments. In addition, 1,000 truck shipments would be made to transport onsite-generated waste to storage locations and burial grounds (see Table 4–146). The total distance traveled carrying radioactive materials would be 27.4 million kilometers (17 million miles) on public rail or 53.8 million kilometers (33.4 million miles) on public roads.

4.3.12.3.1 Impacts of Incident-Free Transportation

The dose to transportation workers and the population from offsite transportation activities would be similar to those described under Alternative 2. The dose to transportation workers from onsite transport activity has been estimated to be 2.6 person-rem, resulting in 0 (1.6×10^{-3}) additional LCFs. This dose is slightly lower because of the shorter distance between the generator and disposal location.

4.3.12.3.1.1 Disposal Group 1

The estimates of incident-free operational risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.3.1 of this chapter.

4.3.12.3.1.2 Disposal Group 2

The estimates of incident-free operational risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.3.1 of this chapter.

4.3.12.3.1.3 Disposal Group 3

The estimates of incident-free operational risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.3.1 of this chapter.

4.3.12.3.2 Impacts of Accidents During Transportation

The maximum reasonably foreseeable offsite transportation accident and the corresponding consequences under this alternative are similar to those described under Alternative 2.

Estimates of the total transportation accident risks (both off site and on site) under this alternative are similar to those described under Alternative 2.

4.3.12.3.2.1 Disposal Group 1

The estimates of accident risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.3.1 of this chapter.

4.3.12.3.2.2 Disposal Group 2

The estimates of accident risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.3.1 of this chapter.

4.3.12.3.2.3 Disposal Group 3

The estimates of accident risks during transport of waste materials for this disposal group have already been accounted for, as analyzed in Sections 4.1.12, 4.2.12, and 4.3.12.3.1 of this chapter.

4.3.12.3.3 Impacts of Construction and Operational Material Transports

The impacts of transporting construction and operational materials under this alternative are similar to those described under Alternative 2 (see Table 4–147). Also similar to Alternative 2, under this alternative, three different combinations of waste capacities allocated to IDF-East, IDF-West, and the RPPDF over varying operational timeframes to accommodate the waste generated under the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives—disposal groups—are evaluated. The impacts of transport activities for the disposal groups would range from 7.65 to 38.1 million kilometers (4.75 to 23.7 million miles) traveled, from 1 (0.94) to 5 (4.68) accidents, and would result in 0 (0.06 to 0.32) fatalities over the entire duration, from construction through deactivation and closure.

4.3.12.3.3.1 Disposal Group 1

The impacts of transport activities for this disposal group would be 7.65 million kilometers (4.75 million miles) traveled, 1 (0.94) accident, and 0 (0.06) fatalities over the entire duration, from construction through deactivation and closure.

4.3.12.3.3.2 Disposal Group 2

The impacts of transport activities for this disposal group would be 29.9 million kilometers (18.6 million miles) traveled, 4 (3.68) accidents, and 0 (0.15) fatalities over the entire duration, from construction through deactivation and closure.

4.3.12.3.3.3 Disposal Group 3

The impacts of transport activities for this disposal group would be 38.1 million kilometers (23.7 million miles) traveled, 5 (4.68) accidents, and 0 (0.32) fatalities over the entire duration, from construction through deactivation and closure.

4.3.13 Environmental Justice

4.3.13.1 Alternative 1: No Action

This section addresses potential short-term impacts on minority, American Indian, Hispanic or Latino, and low-income populations under Waste Management Alternative 1. Because access to Hanford is restricted to the public, the majority of impacts under this Waste Management alternative would be associated with onsite activities and would not affect populations residing off site; thus the potential for environmental justice concerns is small. Resource areas that could be impacted and that may affect

populations residing off site include public and occupational health and safety due to normal operations and facility accidents, and air quality.

Section 4.3.10.1.1 discusses short-term impacts on the public resulting from normal operations under Waste Management Alternative 1. Radiological impacts of normal operations on minority, American Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

Under this alternative, there would be no incremental radiological impacts on the public or the offsite MEI due to normal operations. Therefore, Waste Management Alternative 1 would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations.

Section 4.3.11.1.1 discusses the radiological impacts of airborne releases for facility accidents under Waste Management Alternative 1. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, activities under the No Action Alternative would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts of facility accidents.

Section 4.3.11.1.2 discusses hazardous chemical impacts of facility accidents under Waste Management Alternative 1. The potential risks of hazardous chemical impacts from reasonably foreseeable accidents would be encompassed by those discussed in Section 4.2.11.1.2 under the FFTF Decommissioning No Action Alternative.

Air quality impacts are discussed in Section 4.3.4.1. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.3.12.1.3 discusses the potential human health risks of transporting construction materials from onsite, local, or regional locations to Hanford. The impact of transporting construction materials to Hanford under this Waste Management alternative would be very small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.3.13.2 Alternative 2: Disposal in IDF, 200-East Area Only

This section addresses potential short-term impacts on minority, American Indian, Hispanic or Latino, and low-income populations under Waste Management Alternative 2. Because access to Hanford is restricted to the public, the majority of impacts under this Waste Management alternative would be associated with onsite activities and would not affect populations residing off site; thus the potential for environmental justice concerns is small. Resource areas that could be impacted and that may affect populations residing off site include public and occupational health and safety due to normal operations and facility accidents, and air quality.

Section 4.3.10.2.1 discusses short-term impacts on the public resulting from normal operations under Waste Management Alternative 2. Radiological impacts of normal operations on minority, American

Indian, Hispanic or Latino, and low-income populations were determined by applying the same methodology used to determine public (total population) impacts of normal operations. The exposure scenario used to model minority, American Indian, Hispanic or Latino, and low-income population exposures assumes that these groups would be exposed in the same manner as the general population—by external exposure to radioactive materials and by internal exposure from inhalation and ingestion of radiologically contaminated produce and animal products.

For purposes of evaluating the potential for disproportionately high and adverse impacts caused by radiological emissions from normal operations, the total dose to an average individual of the minority, American Indian, Hispanic or Latino, and low-income populations is compared to the total dose to an average individual of the remainder of the population. These results are presented in Appendix J. Table 4–148 summarizes the average individual total doses over the life of the project under this Waste Management alternative. There are no appreciable differences between average individual total doses. Therefore, Waste Management Alternative 2 would not pose disproportionately high and adverse impacts on minority or low-income populations due to normal operations. The radiological impacts on the offsite population would be the same regardless of the disposal group.

Table 4–148. Waste Management Alternative 2 Average Individual Total Dose from Radioactive Air Emissions over the Life of the Project

Subset Population	Individual Average Dose (millirem)	
	Subset Population	Remainder of Population
Minority	1.2×10^{-6}	1.5×10^{-6}
American Indian	8.0×10^{-7}	1.4×10^{-6}
Hispanic or Latino	1.2×10^{-6}	1.5×10^{-6}
Low-income	1.1×10^{-6}	1.4×10^{-6}

Source: Appendix J, Section J.5.6.1.3.

Section 4.3.10.2.1 discusses radiological impacts on the offsite MEI at the far side of the Columbia River opposite Hanford as a result of normal operations under Alternative 2. To explore potential American Indian environmental justice concerns associated with normal operations, impacts on a hypothetical individual residing at the boundary of the Yakama Reservation and an individual subsisting on fish and wildlife were evaluated. These results are tabulated in Appendix J. Under Waste Management Alternative 2, the total dose received by an individual residing at the point of greatest impact along the reservation boundary would be approximately one order of magnitude less than the total dose received by the MEI from the general population. Therefore, Alternative 2 would not pose disproportionately high and adverse impacts on the American Indian population due to normal operations. These impacts would be the same regardless of the disposal group.

Section 4.3.11.2.1 discusses the radiological impacts of airborne releases for facility accidents under Waste Management Alternative 2. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, facility disposition under Waste Management Alternative 2 would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts of facility accidents. The accident scenarios analyzed in Section 4.3.11.2.1 encompass the range of waste management storage and disposal activities. The radiological impacts of accidents would be the same regardless of the disposal group.

Section 4.3.11.2.2 discusses hazardous chemical impacts of facility accidents under Waste Management Alternative 2. The potential risks of hazardous chemical impacts from reasonably foreseeable accidents would be encompassed by those discussed in Section 4.2.11.2.2 under FFTF Decommissioning

Alternative 2. The hazardous chemical impacts of accidents would be the same regardless of the disposal group.

Air quality impacts are discussed in Section 4.3.4.2. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.3.12.2 discusses the potential human health risks of transporting offsite waste for disposal at Hanford and transporting construction materials from onsite, local, and regional locations to Hanford. Examination of the risks shows that there would be essentially no LCFs for the offsite population (which includes minority, American Indian, Hispanic or Latino, and low-income individuals) residing along the transportation routes. The radiological impacts of transportation would be the same regardless of the disposal group. The impact of transporting construction materials to Hanford under all disposal groups would be small. Therefore, this alternative would not pose disproportionately high and adverse impacts on minority or low-income populations residing along the transportation routes.

4.3.13.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

This section addresses potential short-term impacts on minority, American Indian, Hispanic or Latino, and low-income populations under Waste Management Alternative 3. Because access to Hanford is restricted to the public, the majority of impacts under this alternative would be associated with onsite activities and would not affect populations residing off site; thus the potential for environmental justice concerns is small. Resource areas that could be impacted and that may affect populations residing off site include public and occupational health and safety due to normal operations and facility accidents, and air quality.

Section 4.3.10.3 discusses short-term radiological impacts on the public resulting from normal operations under Waste Management Alternative 3. Under this alternative, radiological impacts on the general public, minority and low-income populations, the offsite MEI, and an MEI residing at the boundary of the Yakama Reservation would be the same as those described in Section 4.3.13.2 under Waste Management Alternative 2, regardless of the disposal group (see Table 4–148).

Section 4.3.11.3.1 discusses the radiological impacts of airborne releases for facility accidents under Waste Management Alternative 3. Examination of the risks shows that there would be essentially no LCFs per year for the offsite population, including minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, Waste Management Alternative 3 would not pose disproportionately high and adverse impacts on the minority, American Indian, Hispanic or Latino, or low-income populations due to radiological impacts of facility accidents. The accident scenarios analyzed in Section 4.3.11.3.1 encompass the range of waste management storage and disposal activities. The radiological impacts of accidents would be the same regardless of the disposal group.

Section 4.3.11.3.2 discusses hazardous chemical impacts of facility accidents under Waste Management Alternative 3. The potential risks of hazardous chemical impacts from reasonably foreseeable accidents would be encompassed by those discussed in Section 4.2.11.2.2 under FFTF Decommissioning Alternative 2. The hazardous chemical impacts of accidents would be the same regardless of the disposal group.

Air quality impacts are discussed in Section 4.3.4.3. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high and adverse health or environmental impacts on minority,

American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.3.12.3 discusses potential human health risks of transporting offsite waste for disposal at Hanford and transporting construction materials from onsite, local, and regional locations to Hanford. The radiological risks would be the same as those described under Waste Management Alternative 2. Similar to Waste Management Alternative 2, the risks of transporting construction and operational materials to Hanford under all disposal groups would be small. Therefore, this Waste Management alternative would not pose disproportionately high and adverse impacts on minority, American Indian, Hispanic or Latino, and low-income populations residing along the transportation routes.

4.3.14 Waste Management

This section evaluates the impacts of waste generation associated with implementation of each of the various Waste Management alternatives and disposal groups, as applicable, on the waste management infrastructure at Hanford. As summarized in Section 4.3 and detailed in Chapter 2, these Waste Management alternatives and disposal groups were developed to manage the various waste volumes projected to be generated under the alternatives for Tank Closure, FFTF Decommissioning, and Waste Management. In general, the disposal groupings vary primarily in direct relation to the required size, number, and lifespan of disposal facilities (i.e., IDF-East, IDF-West, and the RPPDF) that would be constructed, operated, and ultimately closed under each disposal scenario. This subsection evaluates the impacts of waste generation associated with the construction, operations, deactivation, and closure of expanded waste treatment and storage facilities and new waste disposal, in addition to existing waste management activities analyzed under Waste Management Alternative 1, No Action. Common to Waste Management Alternatives 2 and 3 is that Hanford waste treatment and storage activities would be expanded at the CWC, T Plant, and WRAP to provide greater capacity and throughput. Also common to all three Waste Management alternatives is the continued operation of trenches 31 and 34 for disposal of LLW/MLLW until filled. The remaining space in the two trenches is 17,215 cubic meters (approximately 22,517 cubic yards) and the fiscal year 2007 projected emplacement rate is approximately 476 cubic meters (approximately 623 cubic yards) in the two trenches. Using this emplacement rate, the remaining time the trenches will operate is approximately 36 years, or through 2043. For analysis purposes, this EIS assumes the trenches will operate through 2050.

The following analysis is consistent with DOE policy and DOE Manual 435.1-1 that DOE radioactive waste shall be treated, stored, and, in the case of LLW, disposed of at the site where the waste is generated, if practical, or at another DOE facility. The analysis of these FFTF Decommissioning alternatives and options is based on disposal of LLW and MLLW of at Hanford. However, if DOE determines that use of Hanford's or another DOE site's waste management facilities is not practical or cost-effective, DOE may approve the use of non-DOE (i.e., commercial) facilities to store, treat, and dispose of such waste.

Included in this section is a discussion of the waste inventories projected to be generated under each of the Waste Management alternatives as summarized in Table 4–149 for each of the Waste Management alternatives and disposal groupings. The inventories include secondary LLW, MLLW, and hazardous waste. Operations of the WRAP and T Plant will produce small amounts of LLW and MLLW. No TRU waste or liquid LLW is expected to be generated by facility construction, operations, deactivation, or closure.

LOW-LEVEL RADIOACTIVE WASTE

LLW would be generated during routine operations at the two MLLW trenches (trenches 31 and 34) in LLBG 218 W-5 and during operations of WRAP and the T Plant. LLW is typically not treated or only minimally treated (e.g., compaction) before disposal. Therefore, this waste treatment would cause no impacts on the Hanford waste management system. The LLW would be sent directly to disposal. Therefore, long-term storage facilities would not be required. All LLW would be disposed of in an IDF.

MIXED LOW-LEVEL RADIOACTIVE WASTE

MLLW would be generated during routine operations at WRAP and the T Plant. Using a combination of on and offsite capabilities, MLLW would be treated to meet an RCRA land disposal restriction treatment standards prior to disposal. All MLLW would be disposed of in an IDF.

HAZARDOUS WASTE

Hazardous waste is dangerous waste as defined in the *Washington Administrative Code* (WAC 173-303). Hazardous waste generated during operations at the two MLLW trenches (trenches 31 and 34) in LLBG 218-W-5 and for postclosure care of the IDF(s) would be packaged in DOT-approved containers and shipped off site to permitted commercial recycling, treatment, and disposal facilities. Hanford shipped 182,177 kilograms (408,186 pounds) of hazardous waste off site in 2005 (Poston et al. 2006) Management of the additional waste generated under the Waste Management alternatives would require little, if any, additional planning. The waste would be treated and disposed of at offsite commercial facilities.

4.3.14.1 Alternative 1: No Action

4.3.14.1.1 Waste Inventories

Under Waste Management Alternative 1, No Action, no new facility construction would be initiated. Storage and treatment of LLW, MLLW, and TRU waste at the CWC, WRAP, and T Plant complex would continue. Disposal actions would continue at the lined disposal trenches, trenches 31 and 34, in LLBG 218-W-5 through 2035. No offsite shipments of TRU waste or LLW/MLLW would be received. Administrative controls would be implemented for a period of 100 years following disposal operations (2036 through 2135). Table 4–149 presents the estimated waste volumes generated under Waste Management Alternative 1.

Table 4–149. Waste Management Alternatives – Summary of Waste Generation Volumes

Waste Type	Project Phase					Peak Annual Generation	
	Construction	Operations	Deactivation	Closure	Total	Year(s) of Peak	Annual Waste Volume
Alternative 1: No Action							
Low-level radioactive waste	NA	38	NA	NA	38	2007–2035	1
Hazardous waste[a]	NA	38	NA	NA	38	2007–2035	1
Alternatives 2 and 3: Treatment and Storage							
Low-level radioactive waste	NA	1,457	NA	NA	1,457	2019–2050	40
Hazardous waste[a]	NA	98	NA	NA	98	2019–2050	3
Alternative 2: Disposal Group 1							
Low-level radioactive waste	NA	58	NA	NA	58	2007–2050	1
Hazardous waste[a]	NA	58	NA	NA	58	2007–2050	1
Alternative 2: Disposal Group 2							
Low-level radioactive waste	NA	58	NA	NA	58	2007–2050	1
Hazardous waste[a]	NA	58	NA	NA	58	2103–2202	3
Alternative 2: Disposal Group 3							
Low-level radioactive waste	NA	58	NA	NA	58	2007–2050	1
Hazardous waste[a]	NA	58	NA	NA	58	2168–2267	3
Alternative 3: Disposal Group 1							
Low-level radioactive waste	NA	58	NA	NA	58	2007–2050	1
Hazardous waste[a]	NA	58	NA	NA	58	2007–2050	1
Alternative 3: Disposal Group 2							
Low-level radioactive waste	NA	58	NA	NA	58	2007–2050	1
Hazardous waste[a]	NA	58	NA	NA	58	2103–2152	3
Alternative 3: Disposal Group 3							
Low-level radioactive waste	NA	58	NA	NA	58	2007–2050	1
Hazardous waste[a]	NA	58	NA	NA	58	2168–2267	3

[a] Hazardous waste is accumulated on site for less than 90 days and then shipped to offsite commercial facilities for treatment and/or disposal.

Note: All values are in cubic meters. To convert cubic meters to cubic yards, multiply by 1.308.

Key: NA=not available.

Source: SAIC 2007c, 2008.

4.3.14.2 Alternative 2: Disposal in IDF, 200-East Area Only

Waste Management Alternative 2 includes continued storage and treatment of LLW, MLLW, and TRU waste. Existing waste management facilities at the CWC, T Plant, and WRAP would be expanded as summarized above. Waste management operations at the expanded facilities would produce a small amount of waste, as shown in Table 4–149.

Under this alternative, no additional offsite TRU waste would be received. Offsite shipments of waste to Hanford would be limited to 82,000 cubic meters (107,256 cubic yards) of LLW and MLLW. Construction, operations, deactivation, and closure of two disposal facilities would provide for disposal of tank waste, onsite-generated non-CERCLA waste, FFTF waste, waste management waste streams, and offsite-received LLW/MLLW. Disposal facilities would include a single IDF in the 200-East Area and an RPPDF. The RPPDF would be used for disposing of equipment and soils that are not highly contaminated but result from clean closure of the tank farms. The IDF would be used for disposal of all other waste streams.

As mentioned in Section 4.3.14 and under Alternative 2, three disposal groups were developed to accommodate the different waste volumes generated by Tank Closure, FFTF Decommissioning, and Waste Management alternative activities. Within each disposal group, the largest waste volume was utilized to size the disposal facilities (IDF and RPPDF). These three disposal groups are described further in Chapter 2, Section 2.5, of this EIS.

Closure actions would include construction of a modified RCRA Subtitle C barrier over IDF-East and the RPPDF. Closure actions at the CWC, WRAP, T Plant, and LLBG (trenches 31 and 34) are not included in the alternative.

4.3.14.2.1 Waste Inventories

Table 4–149 presents the estimated waste volumes generated under Waste Management Alternative 2.

4.3.14.2.2 Disposal Groups 1, 2, and 3

Under all disposal groups, MLLW and LLW would be generated from operations of WRAP and the T Plant, and LLW would be generated from operations of the LLBG. All waste would be disposed of in IDF-East.

4.3.14.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Waste Management Alternative 3 includes continued storage and treatment of LLW, MLLW, and TRU waste. Existing waste management facilities at the CWC, WRAP, and T Plant would be expanded as under Alternative 2. Waste management operations at the expanded facilities would produce a small amount of waste, as shown in Table 4–149.

Under this alternative, no additional offsite TRU waste would be received. Offsite shipments of waste to Hanford would be limited to 82,000 cubic meters (107,256 cubic yards) of LLW and MLLW. Construction, operations, deactivation, and closure of two IDFs and one RPPDF would provide for disposal of tank waste, onsite-generated non-CERCLA waste, FFTF waste, waste management waste streams, and offsite-received LLW/MLLW. Disposal facilities would consist of one IDF in the 200-East Area, which would be used for tank waste only; one IDF in the 200-West Area, which would be used for onsite-generated non-CERCLA, offsite-received LLW/MLLW, FFTF waste, and waste management waste streams; and an RPPDF. The RPPDF would be used for disposing of equipment and soils associated with clean closure of the tank farms as under Waste Management Alternative 2. The IDFs would be used for disposal of all other waste streams. As mentioned in Section 4.3.14 and under

Alternative 2, three disposal groups were developed to accommodate the different waste volumes generated by Tank Closure, FFTF Decommissioning, and Waste Management alternative activities. Within each disposal group, the largest waste volume was utilized to size the disposal facilities (IDF-East, IDF-West, and the RPPDF). These three disposal groups are described further in Chapter 2, Section 2.5, of this EIS.

Closure actions would include construction of a modified RCRA Subtitle C barrier over each IDF and RPPDF. Closure actions at the CWC, WRAP, T Plant, and LLBG (trenches 31 and 34) are not included in the alternative.

4.3.14.3.1 Waste Inventories

Table 4–149 presents the estimated waste volume generated under Waste Management Alternative 3.

4.3.14.3.2 Disposal Groups 1, 2, and 3

Under all disposal groups, MLLW, and LLW would be generated from operations of WRAP and the T Plant, and LLW would be generated from operations of the LLBG. All waste would be disposed of in an IDF.

4.3.15 Industrial Safety

Illness, injury, and death are possible outcomes of any industrial accident. The accepted standard for measuring the outcome of an industrial accident is the TRC of illness, injury, and death. This section addresses potential impacts on the worker associated with implementation of each of the Waste Management alternatives and disposal groupings. Key underlying assumptions and industrial safety incident rates used in support of this analysis are the same as those described in Section 4.1.15 for the Tank Closure alternatives.

Using the referenced incidence rates and the projected labor hours, occupational safety impacts associated with each of the alternatives were determined (see Table 4–150). The number of cases associated with alternatives having less construction activities could be slightly overstated. Conversely, alternatives having a larger component of construction activity could be slightly understated.

As shown in Figure 4–39, the greatest industrial safety impacts are associated with alternatives having the greatest number of labor hours.

4.3.15.1 Alternative 1: No Action

There are one million total labor hours identified under this alternative. Using the selected TRC rate of 2.0 and total labor hours, it is anticipated that there will be 10 reportable cases and no fatalities.

4.3.15.2 Alternative 2: Disposal in IDF, 200-East Area Only

This Waste Management alternative examines the construction, operations, deactivation, and closure of IDF-East and the RPPDF in addition to ongoing LLBG 218-W-5 activities. This alternative also involves the construction, operations, and deactivation of several new and expanded facilities to support ongoing Hanford waste treatment and storage activities. In summary, using the total labor hours (37.9 million) and the incidence rate (2.0), it is anticipated that approximately 379 TRCs would occur. Fatalities are not expected based on the number of workers and total labor hours. Under Alternative 2 there are three separate disposal groups associated with disposal activities.

Table 4–150. Waste Management Alternatives – Industrial Safety Impacts

Alternative	Labor Category	Million Labor Hours	Total Recordable Case Rate per 100 Workers per Year	Projected Total Recordable Cases	Fatality Rate per 100,000 Workers per Year	Projected Fatalities
1: No Action	Construction	0.0	2.0	0.0	0.26	0.0
	Operations	0.69	2.0	6.9	0.26	0.0009
	Deactivation	0.31	2.0	3.1	0.26	0.0004
	Closure	0.0	2.0	0.0	0.26	0.0
1 Total		1.00		10.0		0.001
2 and 3: Treatment and Storage	Construction	3.52	2.0	35.2	0.26	0.005
	Operations	33.9	2.0	339	0.26	0.04
	Deactivation	0.47	2.0	4.70	0.26	0.0006
	Closure	0.0	2.0	0.0	0.26	0.0
2 and 3 Treatment and Storage Total		37.9		379		0.05
2: Disposal Group 1	Construction	2.05	2.0	20.5	0.26	0.003
	Operations	11.7	2.0	117	0.26	0.015
	Deactivation	0.0	2.0	0.0	0.26	0.0
	Closure	6.13	2.0	61.3	0.26	0.008
2 Disposal Group 1 Total		19.9		199		0.026
2: Disposal Group 2	Construction	8.89	2.0	88.9	0.26	0.012
	Operations	95.2	2.0	952	0.26	0.12
	Deactivation	0.0	2.0	0.00	0.26	0.0
	Closure	23.7	2.0	237	0.26	0.03
2 Disposal Group 2 Total		128		1,280		0.16
2: Disposal Group 3	Construction	8.89	2.0	88.9	0.26	0.012
	Operations	172	2.0	1,720	0.26	0.22
	Deactivation	0.0	2.0	0.00	0.26	0.0
	Closure	23.7	2.0	237	0.26	0.03
2 Disposal Group 3 Total		205		2,050		0.26
3: Disposal Group 1	Construction	3.67	2.0	36.7	0.26	0.005
	Operations	11.6	2.0	116	0.26	0.015
	Deactivation	0.0	2.0	0.0	0.26	0.0
	Closure	6.11	2.0	61.1	0.26	0.008
3 Disposal Group 1 Total		21.4		214		0.03
3: Disposal Group 2	Construction	10.5	2.0	105	0.26	0.014
	Operations	94.8	2.0	948	0.26	0.123
	Deactivation	0.0	2.0	0.00	0.26	0.0
	Closure	23.7	2.0	237	0.26	0.03
3 Disposal Group 2 Total		129		1,290		0.17
3: Disposal Group 3	Construction	10.5	2.0	105	0.26	0.01
	Operations	171	2.0	1,710	0.26	0.22
	Deactivation	0.0	2.0	0.0	0.26	0.0
	Closure	23.7	2.0	237	0.26	0.03
3 Disposal Group 3 Total		205		2,050		0.26

Note: Values presented in the table have been rounded to no more than three significant digits, where appropriate. Totals may not equal the sum of the contributions due to rounding.
Source: Labor hours compiled from Appendix I.

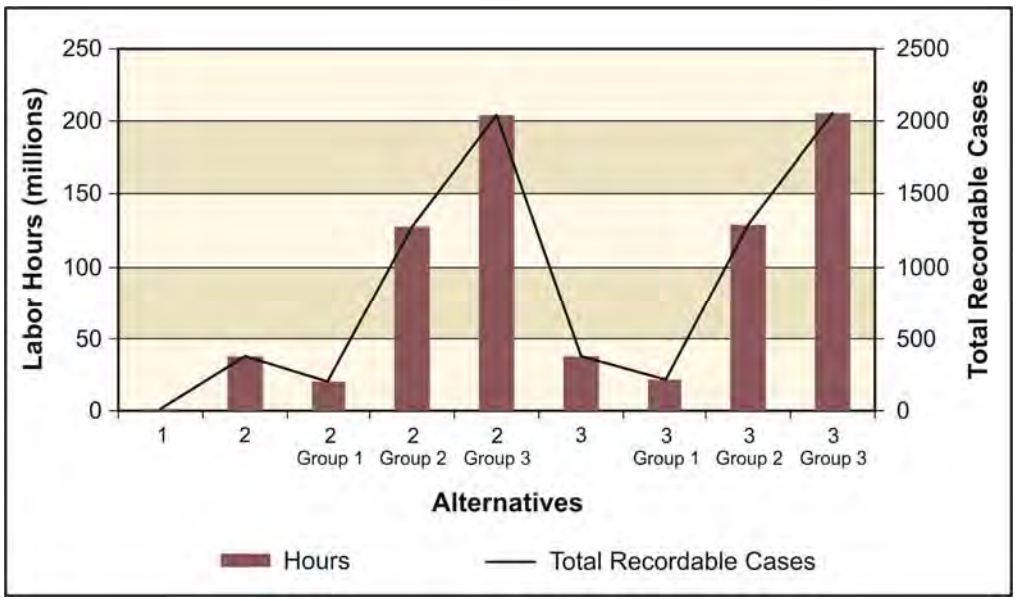


Figure 4–39. Total Recordable Cases and Labor Hours by Alternative

4.3.15.2.1 Disposal Group 1

The work specified in this group would require 19.9 million labor hours to complete. Applying the TRC rate of 2.0, 199 TRCs can be expected. No fatalities are anticipated.

4.3.15.2.2 Disposal Group 2

Work under this disposal group would require approximately 128 million total labor hours, generating 1,280 TRCs. Based on the projected labor hours and incident rate, no fatalities are anticipated.

4.3.15.2.3 Disposal Group 3

Under this disposal group, total labor hours equal about 205 million hours, and it is anticipated that there would be 2,050 TRCs. No deaths are projected.

4.3.15.3 Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Waste Management Alternative 3 includes the construction of IDFs in the 200-East and 200-West Areas of Hanford, in addition to the RPPDF and continued LLBG 218-W-5 activities. As under Alternative 2, several Hanford waste treatment and storage facilities would also be expanded. The construction, operations, and deactivation of waste treatment and storage facilities would require roughly 38 million labor hours. Applying the 2.0 TRC rate per 200,000 labor hours results in 379 TRCs over the life of the project. Applying the fatality (0.26) rate per 100,000 workers returns a value of 0.05. A fatality is not projected to occur over the period of the project. The following paragraphs evaluate the impact of three disposal groups associated with the closure of waste tanks and decommissioning of FFTF.

4.3.15.3.1 Disposal Group 1

This disposal group requires about 21 million hours to complete. It would generate 214 TRCs; no fatalities are expected.

4.3.15.3.2 Disposal Group 2

This disposal group requires a total of about 129 million labor hours. Approximately 1,290 TRCs are anticipated, and no fatalities are expected for this alternative.

4.3.15.3.3 Disposal Group 3

To complete the work under this disposal group would require about 205 million hours. This alternative is expected to generate 2,050 TRCs; fatalities are not anticipated.

4.4 COMBINATION OF ALTERNATIVES

The potential short-term environmental and human health impacts associated with implementation of alternatives and options for (1) Hanford SST system closure (i.e., tank closure), (2) decommissioning of the FFTF and auxiliary facilities (i.e., FFTF decommissioning), and (3) management of waste resulting from other Hanford activities and limited volumes from other DOE sites (i.e., waste management) are presented separately in Sections 4.1, 4.2, and 4.3, respectively, of this chapter. The individual Tank Closure, FFTF Decommissioning, and Waste Management alternatives and options, as applicable, are described in detail in Chapter 2 and Appendix E. This section presents the potential short-term, combined impacts on key resource indicators of implementing selected alternatives and options associated with the three sets of proposed actions.

Key resource indicators have been selected from the total range of impacts measures presented for each resource area or discipline analyzed elsewhere in this chapter to focus on those measures that provide the most meaningful and useful assessment of potential impact. Combined impacts analyses have not been performed for the following resource areas or disciplines: noise and the facility accidents component of public and occupational health and safety. As presented in this section, the combined impacts analyses provide a basis for determining the potential peak and/or total impact on an environmental resource area or human health indicator associated with implementation of alternatives and options from each of the sets of proposed actions analyzed in this EIS. For the purposes of this combined impacts analysis, the impacts from disposition of RH-SCs at INL are counted in the combination total for Hanford even though the work would not occur at Hanford.

Several hundred impacts scenarios could result from the potential combinations of the 11 Tank Closure, 3 FFTF Decommissioning, and 3 Waste Management alternatives when factored with their associated option cases and waste disposal groups. For purposes of analysis, the following combinations of alternatives were chosen to represent key points along the range of actions and associated overall impacts that could result from full implementation of the three sets of proposed actions:

- **Combination 1:** all No Action Alternatives
- **Combination 2:** Tank Closure Alternative 2B (Expanded WTP Vitrification; Landfill Closure), FFTF Decommissioning Alternative 2 (Entombment) with the Idaho Option for disposition of RH-SCs and the Hanford Reuse Option for disposition of bulk sodium, and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 1
- **Combination 3:** Tank Closure Alternative 6B, Base Case (All Vitrification with Separations; Clean Closure); FFTF Decommissioning Alternative 3 (Removal) with the Idaho Option for disposition of RH-SCs and the Hanford Reuse Option for disposition of bulk sodium, and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 2

Alternative Combination 1 represents the potential short-term impacts resulting from minimal DOE action and the greatest long-term impact with respect to groundwater. Alternative Combination 2 is a midrange case representative of DOE's Preferred Alternative(s), as addressed in Chapter 2, Section 2.12. Alternative Combination 3 reflects the most conservative estimate of impacts for most resource areas in terms of the intensity of the potential impact and therefore represents, on the whole, a combination that would result in maximum potential short-term impacts, but would likely have the lowest long-term impacts on groundwater. For some resource areas, a combination that includes Alternative 6A, Option Case, would result in maximum short-term impacts. Selection of these three alternative combinations for detailed analysis in this EIS is done only to establish overall impact-level reference cases for stakeholders and decisionmakers to consider, and does not preclude the selection and implementation of different combinations of the various alternatives in support of final agency decisions.

4.4.1 Land Resources

4.4.1.1 Land Use

The land use impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.1, 4.2.1, and 4.3.1. Those analyses evaluated the land requirements of each alternative and whether proposed facilities and actions would be compatible with guidelines established by the *Hanford Comprehensive Land-Use Plan EIS* and recent supplement analysis (DOE 1999, 2008) and RODs (64 FR 61615, 73 FR 55824). Although in some cases previously undisturbed land would be developed, the analyses established that all proposed facilities and actions would be compatible with site land-use guidelines; thus, this issue is not addressed further in this section. However, since the land needed for facility construction is additive, the total land requirement for each of the three combinations is addressed below.

To determine the combined land requirement at Hanford, the area needed for each component within each combination was added together (see Table 4–151). Since not all facilities would be constructed and not all activities would occur within previously disturbed areas, the table also presents the area of undeveloped land that would be required. The land requirement at INL is minimal under all combinations (none under Combination 1 and 0.1 hectares [0.3 acres] of disturbed land under Combinations 1 and 2); therefore, it is not addressed further.

As noted in Table 4–151, Combination 1 requires the least amount of land (i.e., 2 hectares [5 acres]), all of which would be undisturbed land within Borrow Area C. Combination 2 has a total land requirement of 307 hectares (759 acres), 67 percent of which is undeveloped. The total land area needed under Combination 3 would be 793 hectares (1,960 acres), 94 percent of which is undeveloped. Under Combinations 2 and 3, approximately two-thirds of the undeveloped land would be within Borrow Area C.

Although not addressed in the table, the greatest land area would be required under an alternative combination that included Tank Closure Alternative 6A, Base Case; FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford); and Waste Management Alternative 3 (with waste Disposal Group 2 or 3). Under this combination, a total of 1,150 hectares (2,830 acres) would be needed, 95 percent of which is currently undeveloped.

Table 4–151. Combined Hanford Land Use Requirements

Combination and Component	Alternative	Land Area Required (hectares)	
		Hanford	
		Total Land	Undeveloped Land
Combination 1			
Tank Closure	No Action	2.0	2.0
FFTF Decommissioning	No Action	0	0
Waste Management	No Action	0	0
Total		2.0	2.0
Combination 2			
Tank Closure	2B	195	97.9
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	3.6	2.8
Waste Management	2, DG 1	108	106
Total		307	207
Combination 3			
Tank Closure	6B, Base Case	381	340
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	3.3	3.2
Waste Management	2, DG 2	409	406
Total		793	749

Note: To convert hectares to acres, multiply by 2.471. Totals may not equal the sum of the contributions due to rounding.
Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; Hanford=Hanford Site.
Source: Compiled from Sections 4.1.1.2.1–4.1.1.12.1, 4.2.1.1.1–4.2.1.3.1, 4.3.1.1.1–4.3.1.3.1.

4.4.1.2 Visual Resources

The impact on visual resources under these *TC & WM EIS* combinations is related to a number of factors. Among these is the area of undeveloped land that would be disturbed by new facilities, as analyzed in Section 4.4.1.1 above. Thus, the values for undeveloped land found in Table 4–151 provide a guide to the range of visual impacts that could be expected from the various alternative combinations. Additionally, the size of the area to be disturbed, the location of new facilities relative to public points of observation (i.e., public roadways or nearby higher elevations), and the proximity of new development to present industrial development must also be considered when evaluating combined visual impacts.

The least amount of undeveloped land (i.e., 2 hectares [5 acres]) would be required under Combination 1. In this case, all development would be within Borrow Area C, an area that, with the exception of an access road, is undisturbed grassland at present. This combination would disturb about 0.2 percent of Borrow Area C. Combination 2 would require 207 hectares (511 acres) of undeveloped land, and Combination 3 would require 793 hectares (1,960 acres) of undeveloped land. In both cases, about two-thirds of this land would be within Borrow Area C.

Facilities and actions likely to have the greatest overall impact on visual resources are those that would require large areas (e.g., over 20 hectares [50 acres]). Facilities needing less land would generally be located within built-up areas and, thus, would tend to blend in with existing development. No facilities that would be constructed under Combination 1 would require more than 20 hectares (50 acres) of land. Under Combination 2, expansion of IDF-East, construction of the RPPDF, and mining activities within Borrow Area C would each require over 20 hectares (50 acres). While IDF-East and the RPPDF could be visible from nearby higher elevations, they would be minimally visible or not at all visible from Route 240. The disturbance to Borrow Area C would be readily visible from State Route 240, as well as Rattlesnake Mountain, an area important to American Indians (see Chapter 3, Section 3.2.8.3). In addition to the facilities noted for Combination 2, Combination 3 would require construction of the ILAW Interim Storage Facilities and the HLW Debris Storage Facilities. Combination 3 would require

401 hectares (991 acres) within Borrow Area C, nearly triple the land requirement of Combination 2 (139 hectares [344 acres]).

As is the case for land use (see Section 4.4.1.1), the greatest impact on visual resources would result from a combination of *TC & WM EIS* alternatives that is not represented in Table 4–151—Tank Closure Alternative 6A, Base Case; FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford); and Waste Management Alternative 3 (with waste Disposal Group 2 or 3)—requiring a total of 1,090 hectares (2,700 acres) of undeveloped land. This would include 656 hectares (1,620 acres) within Borrow Area C, as well as large areas between the 200-East and 200-West Areas and adjacent to the 200-East Area.

Regardless of the alternative combination being evaluated, construction within the 200 Areas would not change the BLM Visual Resource Management Class IV rating. However, the BLM rating for Borrow Area C would be lowered to Class III under Combination 1 and Class IV under Combinations 2 and 3.

4.4.2 Infrastructure

The utility infrastructure impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.2, 4.2.2, and 4.3.2. This section summarizes the overall demands on utility infrastructure and resource requirements of the three alternative combinations. Table 4–152 presents the projected peak annual and total demands for electricity, liquid fuels, and water under each alternative combination. Under each combination, the peaks for each component could potentially occur during different time periods and not overlap. To determine the potential maximum impact of each alternative combination, the peaks of each component were totaled together even when peak impacts are projected to occur in different timeframes. The resulting total projections are overly conservative and represent the upper limit for utility resource requirements.

As shown in Table 4–152, the tank closure component is the most significant contributor to combined peak and combined total utility demands under all combinations, except that surveillance and monitoring activities during the 100-year administrative control period associated with the FFTF Decommissioning No Action Alternative have greater total demands for electricity and water than those associated with the Tank Closure No Action Alternative. For electricity, gasoline, and water, both the highest combined peak and combined total demands occur under Combination 3 due to the requirements associated with Tank Closure Alternative 6B, Base Case, combined with those of Waste Management Alternative 2, Disposal Group 2. Combined peak demands are highest under Combination 3 despite the fact that Tank Closure Alternative 2B under Combination 2 has higher peak annual demands for diesel fuel, gasoline, and water than Alternative 6B, Base Case. The combined peak diesel fuel demand is highest under Combination 2, although the combined total diesel fuel demand is highest under Combination 3.

Overall, combined peak annual electrical energy demands could range from 0.04 million megawatt-hours under Combination 1 to as high as 1.26 million megawatt-hours under Combination 3, with the total combined energy requirements ranging from 0.73 to 21.7 million megawatt-hours over the entire duration of alternatives. The peak electrical energy demand of 1.26 million megawatt-hours (approximating an electric load of 144 megawatts) under Combination 3 would be about 72 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system.

Table 4–152. Combined Utility Infrastructure Requirements

Combination and Component	Alternative	Electricity Peak Year(s)[a] and Total (M megawatt-hours)	Diesel Fuel Peak Year(s)[a] and Total (M liters)	Gasoline Peak Year(s)[a] and Total (M liters)	Water Peak Year(s)[a] and Total (M liters)
Combination 1					
Tank Closure	No Action	0.035 (2008)	11.8 (2008)	1.0 (2008)	1,090 (2008)
		0.12	35.9	4.61	3,300
FFTF Decommissioning	No Action	0.006 (2008–2107)	0	0.0011 (2008–2107)	79.8 (2008–2107)
		0.60	0	0.11	7,980
Waste Management	No Action	0.00019 (2007–2035)	3.46 (2009)	0.012 (2036–2135)	25.5 (2009)
		0.0056	13.9	1.23	35.7
Combined Peak[b]		0.04	15.3	1.01	1,200
Combined Total[b]		0.73	49.8	5.95	11,300
Combination 2					
Tank Closure	2B	1.16 (2040)	271 (2040)	8.18 (2040)	3,560 (2040)
		17.9	4,040	156	86,300
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	0.0039 (2017)	2.33 (2015–2021)	0.32 (2015–2021)	16.5 (2015–2021)
		0.0045	5.35	0.87	31.1
Waste Management	2, DG 1	0.018 (2007–2050)	41.6 (2011–2052)	4.69 (2011–2052)	90.9 (2011–2052)
		0.56	257	21.7	3,050
Combined Peak[b]		1.18	315	13.2	3,670
Combined Total[b]		18.5	4,300	179	89,400
Combination 3					
Tank Closure	6B, Base Case	1.24 (2040)	255 (2040)	6.56 (2040)	3,500 (2040)
		21.1	4,360	216	92,600
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	0.0039 (2013–2017)	1.70 (2015–2021)	0.28 (2013–2016)	15.6 (2015–2021)
		0.0077	5.09	0.88	30.4
Waste Management	2, DG 2	0.018 (2007–2050)	154 (2011–2102)	15.2 (2011–2102)	283 (2011–2102)
		0.56	1,460	83.1	21,200
Combined Peak[b]		1.26	258	22.0	3,800
Combined Total[b]		21.7	5,830	300	114,000

[a] Year(s) in parentheses denotes the timeframe over which the listed peak value could theoretically occur based on projected timeframes for contributing activities associated with each component.

[b] The combined peaks and combined totals may not equal the sum of the contributions due to rounding.

Note: To convert liters to gallons, multiply by 0.26417.

Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; Hanford=Hanford Site; M=million.

Source: Compiled from Tables 4–2, 4–99, and 4–128.

For liquid fuels (diesel fuel and gasoline), combined peak annual requirements could range from about 16.3 million liters (4.3 million gallons) under Combination 1 to as high as 328 million liters (86.6 million gallons) under Combination 2, with the total combined liquid fuel requirements ranging from 55.7 million liters (14.7 million gallons) to 6,130 million liters (1,619 million gallons) over the entire duration of alternatives. It has been assumed for the purposes of analysis that liquid fuels are not capacity-limiting

resources, as supplies would be replenished from offsite sources to support each alternative and provided at the point of use on an as-needed basis.

Water requirements could entail a combined peak annual demand ranging from about 1,200 million liters (317 million gallons) under Combination 1 to 3,800 million liters (1,000 million gallons) under Combination 3, with total combined water requirements ranging from 11,300 million liters (2,985 million gallons) to 114,000 million liters (30,115 million gallons) over the duration of the alternatives. The projected peak annual water demand of 3,800 million liters (1,000 million gallons) under Combination 3 would be about 21 percent of the 18,500 million liter (4,890 million gallon) annual capacity of the Hanford Export Water System and about 17 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

As discussed above, none of the three combinations of alternatives would exceed the capacity of a Hanford utility system. While Combination 3 reflects the upper end of the three combinations, it does not bound infrastructure resource demands. A combination that would include Tank Closure Alternative 6A, Option Case, instead of Alternative 6B, Base Case, along with FFTF Decommissioning Alternative 2 (with all facilities to be built at Hanford) and Waste Management Alternative 2 (with waste Disposal Group 3), would have the greatest combined impact on utility infrastructure.

Under such a combination, the combined peak annual electrical energy demand could be 1.99 million megawatt-hours with a total combined energy requirement of 189 million megawatt-hours over the entire duration of the alternatives. The peak electrical energy demand of 1.99 million megawatt-hours (approximating an electric load of 227 megawatts) would be about 114 percent of the 1.74 million megawatt-hour annual capacity (199 megawatt load capacity) of the Hanford electric power distribution system, exceeding its capacity. For water, the combined peak annual water demand could be about 6,880 million liters (1,817 million gallons) with a total combined water requirement of approximately 681,000 million liters (180,000 million gallons). The projected peak annual water demand of 6,880 million liters (1,817 million gallons) under all alternatives under this combination would be about 37 percent of the 18,500 million liter (4,890 million gallon) annual capacity of the Hanford Export Water System and about 30 percent of the 200 Areas' historical average annual water use of more than 22,700 million liters (6,000 million gallons).

4.4.3 Air Quality

The nonradiological air pollutant impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.4, 4.2.4, and 4.3.4. This section summarizes the overall impacts of the three alternative combinations. Table 4–153 provides the peak incremental concentrations for selected pollutants and averaging periods under the three combinations of alternatives.

Under each combination, the peaks for each pollutant and component could potentially occur during different time periods. For the purposes of analysis, the incremental concentrations during the peak year for each component and averaging period were totaled together. The resulting conservative total estimates represent the upper limit of the concentrations that could be realized.

Under Combination 1, the projected air pollutant concentrations would be dominated by the Tank Closure alternative. Under Combination 2, the Tank Closure alternative dominates for carbon monoxide, and the Tank Closure and Waste Management alternatives have similar contributions for the other pollutants. Under Combination 3, the Waste Management alternative dominates for all pollutants.

Table 4–153. Combined Criteria Air Pollutant Concentrations

Combination and Component	Alternative	Maximum Average Concentration (micrograms per cubic meter)			
		Carbon Monoxide (8 hours)	Nitrogen Dioxide (annual)	Particulate Matter, PM_{10} (24 hours)	Sulfur Dioxide (1 hour)
Combination 1					
Tank Closure	No Action	3,410	8.56	**546**	24.0
FFTF Decommissioning	No Action	4.35	0.000644	0.00272	0.0419
Waste Management	No Action	70.6	1.24	**507**	0.705
Total		3,480	9.8	1,050	24.7
Combination 2					
Tank Closure	2B	5,840	20.4	**4,510**	99.4
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	780	2.84	53.8	37.6
Waste Management	2, DG 1	**10,100**	22.7	**4,080**	84.9
Total		16,700	45.9	8,650	222
Combination 3					
Tank Closure	6B, Base Case	5,290	14.2	**5,110**	65.4
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	772	2.04	94.5	50.4
Waste Management	2, DG 2	**43,400**	95.5	**18,000**	370
Total		49,500	112	23,200	486
Most Stringent Standard or Guideline		10,000	100	150	660

Note: Exceedances are shown in **bold** text. Totals may not equal the sum of the contributions due to rounding.
Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers.
Source: Compiled from Tables 4–3, 4–100, and 4–129.

When added this way, the total incremental concentrations do not exceed the ambient standards, except for PM, which exceeds ambient standards under all three combinations; carbon monoxide, which exceeds ambient standards under Combinations 2 and 3; and nitrogen dioxide, which exceeds ambient standards under Combination 3. As discussed previously, the PM emissions for all activities are conservatively estimated and no controls are assumed in the estimates, but the methodology is consistently applied so that alternatives can be compared. Actual concentrations from tank closure, FFTF decommissioning, and waste management activities would be appropriately controlled such that the ambient standards would not be exceeded.

4.4.4 Geology and Soils

The geologic and soil resource requirements for implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.5, 4.2.5, and 4.3.5. This section summarizes the overall demands for and projected consumption of geologic and soil resources of the three alternative combinations. Table 4–154 provides the volumes of selected geologic and soil materials and total material requirements under the three combinations of alternatives. Representative geologic resources were selected from certain categories (e.g., construction, borrow/backfill, and closure) to facilitate meaningful comparison of demands for alternative components within each combination. As previously described in Section 4.1.5 and elsewhere, it is expected that these materials would be excavated from Borrow Area C and so conservatively reflect the combined impact of obtaining required materials from onsite reserves.

Table 4–154. Combined Geologic and Soil Resource Requirements

Combination and Component	Alternative	Representative Resource Demands (cubic meters)			Total Requirements[a] (cubic meters)
		Construction Gravel	Borrow-Soil	Closure-Barrier Materials	
Combination 1					
Tank Closure	No Action	21,100	55,100	0	92,800
FFTF Decommissioning	No Action	0	0	0	0
Waste Management	No Action	3,510	0	0	6,230
Total		24,600	55,100	0	99,000
Combination 2					
Tank Closure	2B	255,000	782,000	2,300,000[b]	4,330,000
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	1,900	80,400	19,300	127,000
Waste Management	2, DG 1	11,500	0	1,760,000[c]	1,990,000
Total		268,000	863,000	4,080,000	6,450,000
Combination 3					
Tank Closure	6B, Base Case	880,000	8,550,000	689,000[d]	10,900,000
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	1,900	121,000	0	148,000
Waste Management	2, DG 2	11,500	0	6,800,000[c]	7,630,000
Total		893,000	8,670,000	7,490,000	18,700,000

[a] Reflects total requirements for all resources for all component activities in addition to and including the representative resources included in the table.

[b] Volume includes soil, sand, gravel, rock, and asphalt for construction of modified Resource Conservation and Recovery Act Subtitle C barriers for landfill closure of all tank farms and six sets of cribs and trenches (ditches).

[c] Volume includes soil, sand, gravel, rock, and asphalt for construction of modified Resource Conservation and Recovery Act Subtitle C barriers for landfill closure of IDF-East and the RPPDF.

[d] Volume includes soil, sand, gravel, rock, and asphalt for construction of modified Resource Conservation and Recovery Act Subtitle C barriers for landfill closure of the six sets of cribs and trenches (ditches) in the B and T Areas.

Note: To convert cubic meters to cubic yards, multiply by 1.308. Totals may not equal the sum of the contributions due to rounding.

Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; Hanford=Hanford Site; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Source: Compiled from Tables 4–7, 4–106, and 4–133.

Total geologic resource requirements could range from approximately 99,000 cubic meters (129,000 cubic yards) of material under Combination 1 to as much as 18,700,000 cubic meters (24,600,000 cubic yards) under Combination 3 (see Table 4–154). While the tank closure component generally has the highest geologic resource demands and associated potential for indirect impacts on geology and soils, the waste management component has roughly comparable total demands, driven by the requirements for disposal facility construction, operations, and closure. In contrast to tank closure and waste management activities, FFTF decommissioning activities have relatively insignificant geologic resource requirements under any of the alternative combinations.

As discussed above, it is expected that required materials would be excavated from Borrow Area C at Hanford. Further, it is estimated that Borrow Area C could yield 42.6 million cubic meters (55.7 million cubic yards) of borrow material. In addition, gravel pit No. 30, located between the 200-East and 200-West Areas, is an approximately 54-hectare (134-acre) borrow site that is currently in operation. Aggregate reserves at pit No. 30 are estimated at 15.3 million cubic meters (20 million cubic yards) of material (see Section 4.1.5).

Based on the estimates above, the geologic resources demands associated with all of the alternative combinations considered could be supplied via Hanford's onsite resource reserves; gravel pit No. 30 alone would be able to supply the demands of Combinations 1 and 2 without the need to develop Borrow Area C to a significant degree.

However, a more conservative case combination that would include Tank Closure Alternative 6A, Option Case, instead of Alternative 6B, Base Case, along with FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford) and Waste Management Alternative 2 or 3 (with waste Disposal Group 3), would have the greatest combined geologic resource requirements. In this case, the combined geologic resource requirements could be as high as 33.8 million cubic meters (44.2 million cubic yards). Assuming that this material would be exclusively obtained from Borrow Area C, the demand to support such a combination would require excavation of approximately 79 percent, on a volumetric basis, of Borrow Area C.

4.4.5 Water Resources

The water resource impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.6, 4.2.6, and 4.3.6. The analysis of water resources in the aforementioned sections focuses on direct, short-term impacts on surface water, the vadose zone, and groundwater from activities such as new facility construction and closure, which could impact stormwater runoff, surface water, or groundwater hydrology or quality. This section summarizes the combined impacts on water resources of the three alternative combinations. In general, potential impacts are expected to vary proportionally to the total amount of land that would be disturbed and, more importantly, in relation to the land that would be disturbed in the same general timeframe.

Overall, component activities under the three combinations are not expected to have any direct impact on major surface-water features, including the Columbia River, as there are no natural, perennial surface-water drainages on the Central Plateau of Hanford. All construction- and closure-related land disturbance, especially for new facility construction, would expose soils and sediments to possible erosion by infrequent, heavy rainfall or by wind. While unlikely to reach surface-water features as discussed above, which would be controlled via application of best management practices and other measures, stormwater runoff from exposed areas could convey soil, sediments, and other pollutants (e.g., construction waste materials and spilled materials, such as petroleum, oils, and lubricants from construction equipment) from construction footprint and laydown areas. As described in Section 4.4.1.1, Combination 2 has a total land requirement of about 307 hectares (758 acres). The total land area needed under Combination 3 would be about 793 hectares (1,960 acres). Under Combinations 2 and 3, about two-thirds of the undeveloped land would be within Borrow Area C. Further, the only component activity with the potential to directly impact surface-water hydrology is excavation work in Borrow Area C, which could impact the areas surrounding Cold Creek but which would be conducted so as to minimize any direct impacts. Excavation activities and thus, potential impacts on this surface-water feature, would be greatest under Combination 3 as indicated above, with the relative intensity of the excavation impacts to meet geologic resources demands further described in Section 4.4.4.

Any component activity that would contribute to the disturbance of a larger land area would have a greater potential for short-term impacts on water resources than the three combinations discussed herein.

4.4.6 Ecological Resources

4.4.6.1 Terrestrial Resources

The ecological resource impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.7, 4.2.7, and 4.3.7. The analysis of

terrestrial resources focused on those projects and activities that would result in the loss of habitat within undeveloped areas of Hanford, with special attention to the loss of sagebrush habitat. To determine the area of terrestrial habitat that would be affected under each alternative combination, the total area of undeveloped land for each component was added together. Similarly, the area of sagebrush habitat affected was also summed. The results are presented in Table 4–155. Since no new facilities would be built at INL under Combination 1 and only minimal disturbance (0.1 hectares [0.3 acres]) would take place within the MFC under Combinations 2 and 3, terrestrial habitat would not be impacted at the site.

Table 4–155. Combined Hanford Ecological Resource Disturbance

Combination and Component	Alternative	Land Area (hectares)	
		Terrestrial Habitat	Sagebrush Habitat
Combination 1			
Tank Closure	No Action	2.0	0
FFTF Decommissioning	No Action	0	0
Waste Management	No Action	0	0
Total		2.0	0
Combination 2			
Tank Closure	2B	97.9	1.2
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	2.8	0
Waste Management	2, DG 1	106	64.3
Total		207	65.6
Combination 3			
Tank Closure	6B, Base Case	340	98.3
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	3.2	0
Waste Management	2, DG 2	406	248
Total		749	346

Note: To convert hectares to acres, multiply by 2.471. Totals may not equal the sum of the contributions due to rounding.
Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; Hanford=Hanford Site.
Source: Compiled from Sections 4.1.7.3.1, 4.1.7.10.1, 4.2.7.1, 4.2.7.2.1, 4.2.7.3.1, 4.3.7.1, 4.3.7.2.1, and 4.3.7.3.1.

Under Combination 1, a total of 2 hectares (5 acres) of terrestrial habitat would be disturbed. All of this habitat is classified as grassland and is found within Borrow Area C; no sagebrush habitat would be affected under this combination. Combination 2 would involve disturbance of 207 hectares (511 acres), 32 percent of which is sagebrush habitat. In the case of Combination 3, a total of 749 hectares (1,850 acres) of terrestrial habitat would be impacted by project facilities and activities. Of this total, 46 percent would be sagebrush habitat. Mitigation measures relative to the disturbance of sagebrush habitat are addressed earlier in this chapter under each alternative.

Although not addressed in Table 4–155, the greatest impact on terrestrial habitat would occur under an alternative combination that included Tank Closure Alternative 6A, Base Case; FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford); and Waste Management Alternative 3 (with waste Disposal Group 2 or 3). Such a combination would disturb a total of up to 1,090 hectares (2,700 acres) of terrestrial habitat, 40 percent of which would be sagebrush.

4.4.6.2 Wetlands and Aquatic Resources

Since there are no wetlands or aquatic resources within any of the areas potentially disturbed by alternatives proposed under any of the three *TC & WM EIS* components, there would be no impact on these resources from any of the alternative combinations.

4.4.6.3 Threatened and Endangered Species

Impacts of individual components of this EIS on threatened and endangered species, including other Federally or state-listed special status species, have been evaluated earlier in this chapter under "Ecological Resources" (see Sections 4.1.7, 4.2.7, and 4.3.7). That analysis focused on listed species that would be potentially affected by proposed projects and actions and was based on their observed presence, as well as the amount of undeveloped land, especially sagebrush habitat, that potentially would be disturbed.

For the combined impacts analysis, the number of special status species observed or potentially present within areas affected by the three *TC & WM EIS* alternative combinations was determined. While none of the combinations would impact Federally or state-listed threatened or endangered species, a number of state-listed species with other special status designations could be affected. Under Combination 1, three state-listed species (all of which occur within Borrow Area C) could be impacted. These include Piper's daisy (state sensitive), stalked-pod milkvetch (state watch), and long-billed curlew (state monitor). In addition to the three special status species, black-tailed jackrabbit (state candidate) could also be affected under Combination 2. Under Combination 3, as many as seven special status species could be impacted. These include the loggerhead shrike (Federal species of concern and state candidate), sage sparrow (state candidate), black-tailed jackrabbit, long-billed curlew, Piper's daisy, stalked-pod milkvetch, and crouching milkvetch (state watch). Since the potential to cause disturbance to these species would be greater as habitat disturbance increases, especially sagebrush habitat, the overall potential to impact special status species increases from Combination 1 to Combination 3.

Although not one of the identified alternative combinations, a combination that would include Tank Closure Alternative 6A, Option Case, FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford), and Waste Management Alternative 2 or 3 (with waste Disposal Group 2 or 3), has the greatest potential to impact special status species. This combination could affect the same seven species affected under Combination 3. However, the overall potential to impact these species would be greater under this combination due to the greater area of terrestrial habitat, including sagebrush habitat that would be impacted (see Section 4.4.6.1).

4.4.7 Cultural and Paleontological Resources

4.4.7.1 Prehistoric Resources

The cultural and paleontological resource impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.8, 4.2.8, and 4.3.8. This section summarizes the overall impacts on cultural and paleontological resources of the three alternative combinations. Potential impacts on cultural and paleontological resources are directly related to the acreage and location of land disturbed (see Table 4–149) and the visual impacts expected from these combinations.

Combination 1 would require the least acreage of undeveloped land and would involve the least disturbance of this land. Geologic material would be excavated from Borrow Area C to support construction, operations, deactivation, decommissioning, and closure activities for tank closure, FFTF decommissioning, and waste management components. Combination 1 would disturb about 2 hectares (5 acres) of Borrow Area C. Cultural deposits have no to low potential of being present in Borrow Area C. Prehistoric resources located in the 200-East and 200-West Areas would not be disturbed under this combination.

Combination 2 would require 207 hectares (511 acres), and Combination 3 would require 793 hectares (1,960 acres) of previously undisturbed land. Although a larger area of land would be disturbed compared with Combination 1, cultural deposits have no to low potential of being present in the areas that would be impacted under these combinations. Known prehistoric resources located in the 200-East and 200-West Areas would not be disturbed.

4.4.7.2 Historic Resources

The acreage of undeveloped land required under Combination 1 would have no impact on historic resources including buildings associated with the Manhattan Project and Cold War era, located within the 200-East and 200-West Areas.

Combinations 2 and 3, which would disturb more land than Combination 1, also would not affect historic resources in the area. Historic resources located in the northwest portion of the 200-West Area would not be affected by construction or excavation.

4.4.7.3 American Indian Interests

Impacts of individual components of this EIS on American Indian areas of interest have been evaluated earlier in this chapter under "Cultural and Paleontological Resources" (see Sections 4.1.8, 4.2.8, and 4.3.8).

Construction of new facilities and disturbance of previously undeveloped land are actions that would have the greatest impact. The size of the area to be disturbed and the location of new facilities need to be considered in evaluating the impacts. The view from State Route 240 and Rattlesnake Mountain, an area of noted cultural and religious significance to the American Indians, would be impacted. Under Combination 1, the industrial appearance of the 200-East and 200-West Areas would remain largely unchanged. Combination 2 would entail expansion of IDF-East and construction of the RPPDF. Disposal facility expansion/construction, along with mining activities in Borrow Area C, would require over 20 hectares (50 acres) of land. Expansion of IDF-East and construction of the RPPDF would be minimally visible. The disturbance to Borrow Area C would be readily visible from Rattlesnake Mountain. Combination 3 would require construction of the ILAW Interim Storage Facilities and HLW Debris Storage Facilities in addition to other facilities in relation to Combination 2. The land requirement within Borrow Area C would increase to 401 hectares (991 acres), nearly triple the land requirement for Combination 2 (139 hectares [344 acres]), causing the greatest visual impact on Rattlesnake Mountain.

4.4.8 Paleontological Resources

Impacts of individual components of this EIS on paleontological resources have been evaluated earlier in this chapter under "Cultural and Paleontological Resources" (see Sections 4.1.8, 4.2.8, and 4.3.8). Since no paleontological resources have been discovered within any of the areas that would potentially be disturbed by the alternatives proposed under any of the combinations, there would be no impact on these resources from any of the alternative combinations.

4.4.9 Socioeconomics

The socioeconomic impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.9, 4.2.9, and 4.3.9. This section summarizes the overall socioeconomic effects of the three alternative combinations. Table 4–156 provides the projected peak workforce, commuter traffic, and truck activity under the three combinations.

Table 4–156. Combined Socioeconomic Impact Measures

Combination and Component	Alternative	Peak Annual Workforce[a] (Peak Year)	Peak Daily Commuter Traffic	Peak Daily Truck Loads (Peak Year)	
				Off Site	On Site
Combination 1					
Tank Closure	No Action	1,730 (2008)		4 (2008)	23 (2006–2008)
FFTF Decommissioning	No Action	1 (2008–2107)		Less than 1 (2008–2107)	0
Waste Management	No Action	109 (2009)		Less than 1 (2009)	6 (2009)
Total		1,840	1,470	4	29
Combination 2					
Tank Closure	2B	6,860 (2040)		48 (2040)	217 (2039–2043)
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	151 (2017)		3 (2017)	52 (2021)
Waste Management	2, DG 1	1,180 (2051–2052)		28 (2051–2052)	428 (2051–2052)
Total		8,190	6,550	79	697
Combination 3					
Tank Closure	6B, Base Case	7,870 (2021–2022)		66 (2040)	188 (2100)
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	139 (2017)		2 (2013–2014)	63 (2021)
Waste Management	2, DG 2	4,540 (2101–2102)		34 (2101–2102)	1,500 (2101–2102)
Total		12,500	10,000	102	1,750

[a] The workforce is rounded into full-time equivalent quantities.
Note: Totals may not equal the sum of the contributions due to rounding.
Key: DG=Disposal Group; FFTF=Fast Flux Test Facility.
Source: Compiled from Sections 4.1.9.1–4.1.9.11, 4.2.9.1–4.2.9.3, and 4.3.9.1–4.3.9.3.

Under each combination, the peaks for each component could potentially occur during different timespans. To determine the potential impact of each alternative combination, the peak amounts of each component were totaled together. The resulting conservative total estimates represent the upper limit of workforce requirements. As shown in Table 4–156, the projected total workforce in all three combinations would be dominated by the requirements of the tank closure component. The total workforce requirements would range from 1,840 to 12,500 FTEs over the entire duration of activities. The lower end of the range would represent approximately 1.5 percent of the projected labor force (123,317 in 2008) in the ROI. The higher workforce ranges from approximately 8.4 percent (149,947 in 2021) to 4 percent (313,824 in 2101) of the projected labor force in the ROI. For comparison, in 2006, the employment of approximately 10,000 people at Hanford was about 10 percent of those employed in the ROI.

The number of daily commuter vehicles would correlate with the number of employees. Assuming that employees would commute to work at a rate averaging 1.25 people per vehicle (Malley 2007), up to 10,000 vehicles per day could impact the commuter traffic under Combination 3. In addition to the commuter traffic, trucks moving equipment and resources off site would peak around 26,500 trips per year (102 trips per day) under Combination 2. Combination 3 would require the larger number of trucks

(approximately 457,000 trips per year) moving material on site. Based on this predicted truck activity and commuter traffic, the LOS on offsite roads in the Hanford area is expected to be impacted.

4.4.10 Public and Occupational Health and Safety—Normal Operations

Public and worker health impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.10, 4.2.10, and 4.3.10. This section summarizes the health impacts of selected combinations of alternatives on the public and workers. Table 4–157 presents the projected peak annual and total impacts on the general population and an MEI under each component (alternative) and combination. Combined impacts on the general population are estimated by adding the impacts on the population living within 80 kilometers (50 miles) of the site (Hanford or INL) under each alternative. Under each combination, the peaks for each component could potentially occur during different time periods and not overlap. To determine the potential maximum impact of each alternative combination, the peaks of each component were totaled even when peak impacts are projected to occur in different timeframes. Similarly, impacts on an MEI are added although the MEI may be in different locations along the perimeter of Hanford or INL. This approach provides a conservative estimate of potential impacts.

Table 4–158 presents the combined impacts of normal operations on the worker population. The total impact on the worker population is calculated as the sum of the impacts of each alternative regardless of the duration or the time of occurrence. In some cases the periods in which doses occur would overlap, but because of the varying durations of activities, there would be times when only one or two of the activities would be under way. Average annual impacts on an FTE are not additive. The average dose across all three alternatives would be lower than the highest dose of any single alternative.

Under each of the three combinations, the selected Tank Closure alternative dominates the impacts on the public and workers. The Tank Closure alternative accounts for an especially high proportion of impacts on the public to more than 99 percent of the dose to the general population and the MEI. The dose from the operational life of the project under Combination 1, about 600 person-rem, would result from a comparatively low annual offsite impact occurring at a fairly constant rate for approximately 100 years. Although the dose from the life of the project in the general population would be of the same order of magnitude under Combinations 2 and 3 (460 person-rem and 600 person-rem, respectively), the peak annual dose under the Tank Closure Alternative 6B is substantially higher. This means that most of the public dose occurs over a shorter period of time—during waste treatment, tank and soil excavation activities, or both.

Table 4–158 shows that the cumulative worker dose increases as the level of activity increases among the combinations. Combination 1, comprising the No Action Alternatives, would have worker doses from continued operations and maintenance activities under each alternative. Combination 2 would have higher cumulative worker doses: the Tank Closure alternative worker dose would increase as a result of retrieving and processing tank waste; the FFTF Decommissioning alternative dose would increase due to processing sodium and RH-SCs and entombing the buildings; and the Waste Management alternative dose would increase due to a longer period of disposal operations and an increase in waste processing activities. Combination 3 would have the largest cumulative worker doses: the Tank Closure alternative worker dose would increase as a result of tank and soil removal and processing; the FFTF Decommissioning alternative dose would increase as a result of the removal of the RCB vessels, piping, and components for disposal at IDF-East; and the Waste Management alternative dose would increase due to the receipt of offsite waste and a longer period of disposal operations.

Table 4–157. Combined Public Health Impacts—Normal Operations

Combination and Component	Alternative	Time Period	General Population[a]		Maximally Exposed Individual[b]	
			Dose (person-rem)	Risk (LCFs)	Dose (millirem)	Risk (LCFs)
Combination 1						
Tank Closure	No Action	Peak annual	6.3	0 (4×10^{-3})	0.13	8×10^{-8}
		Project total	600	0 (4×10^{-1})	12	7×10^{-6}
FFTF Decommissioning	No Action	Peak annual	0	0	0	0
		Project total	0	0	0	0
Waste Management	No Action	Peak annual	0	0	0	0
		Project total	0	0	0	0
Combined Impacts		Peak annual	6.3	0 (4×10^{-3})	0.13	8×10^{-8}
		Project total	600	0 (4×10^{-1})	12	7×10^{-6}
Combination 2						
Tank Closure	2B	Peak annual	76	0 (5×10^{-2})	1.7	1×10^{-6}
		Project total	460	0 (3×10^{-1})	9.2	5×10^{-6}
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	Peak annual	0.0033	0 (2×10^{-6})	0.00012	7×10^{-11}
		Project total	0.0072	0 (4×10^{-6})	0.00026	2×10^{-10}
Waste Management	2, DG 1	Peak annual	0.000018	0 (1×10^{-8})	0.00000021	1×10^{-13}
		Project total	0.00067	0 (4×10^{-7})	0.0000082	5×10^{-12}
Combined Impacts		Peak annual	76	0 (5×10^{-2})	1.7	1×10^{-6}
		Project total	460	0 (3×10^{-1})	9.2	5×10^{-6}
Combination 3						
Tank Closure	6B, Base Case	Peak annual	76	0 (5×10^{-2})	1.7	1×10^{-6}
		Project total	600	0 (4×10^{-1})	12	7×10^{-6}
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	Peak annual	0.0033	0 (2×10^{-6})	0.00012	7×10^{-11}
		Project total	0.0072	0 (4×10^{-6})	0.00026	2×10^{-10}
Waste Management	2, DG 2	Peak annual	0.000018	0 (1×10^{-8})	0.00000021	1×10^{-13}
		Project total	0.00067	0 (4×10^{-7})	0.0000082	5×10^{-12}
Combined Impacts		Peak annual	76	0 (5×10^{-2})	1.7	1×10^{-6}
		Project total	600	0 (4×10^{-1})	12	7×10^{-6}

[a] The reported value is the projected number of LCFs in the population and is therefore presented as a whole number. When the reported whole value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3).

[b] Probability of an LCF in the maximally exposed individual is calculated by converting the dose in millirem to rem (divide by 1,000), then multiplying the dose by the risk factor of 0.0006 LCFs per rem.

Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; LCFs=latent cancer fatalities.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Compiled from Tables 4–19, 4–23, 4–39, 4–109, 4–111, and 4–136.

Table 4–158. Combined Worker Health Impacts—Normal Operations

Combination and Component	Alternative	Project Total Impact–Worker Population		Duration of Radiological Work (years)	Average Annual Impact–Full-Time Equivalent Worker[b]	
		Dose (person-rem)	Risk (LCFs)[a]		Dose (millirem/year)	Risk (LCFs)[a]
Combination 1						
Tank Closure	No Action	280	0 (2×10^{-1})	102	140	9×10^{-5}
FFTF Decommissioning	No Action	1	0 (6×10^{-4})	100	50	3×10^{-5}
Waste Management	No Action	37	0 (2×10^{-2})	29	200	1×10^{-4}
Combined Impacts		320	0 (2×10^{-1})		<200	$<1\times10^{-4}$
Combination 2						
Tank Closure	2B	11,000	7	61	160	1×10^{-4}
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	5.2	0 (3×10^{-3})	3	33	2×10^{-5}
Waste Management	2, DG 1	3,400	2	45	200	1×10^{-4}
Combined Impacts		14,000	9		<200	$<1\times10^{-4}$
Combination 3						
Tank Closure	6B, Base Case	82,000	49	96	870	5×10^{-4}
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	11	0 (7×10^{-3})	3	51	3×10^{-5}
Waste Management	2, DG 2	6,600	4	94	200	1×10^{-4}
Combined Impacts		89,000	50		<870	$<5\times10^{-4}$

[a] For an individual, the lifetime risk of developing a latent cancer fatality (LCF) is based on the risk factor of 0.0006 LCFs per rem. For the worker population, the reported value is the projected number of LCFs and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses (see Appendix K, Section K.1.1.3). The LCF risk in the worker population should be viewed in light of the number of years in which the worker dose occurs (spanning multiple generations of workers) and the controls implemented by the Department of Energy and its contractors to limit individual worker dose.

[b] Average annual dose and risk are not additive. On average, the dose or risk would be lower than the highest dose or risk of any single alternative.

Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; LCFs=latent cancer fatalities.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Source: Compiled from Tables 4–20, 4–24, 4–41, 4–108, 4–110, 4–112, 4–135, 4–137, 4–138, and 4–139.

Worker risks shown in Table 4–158 should be viewed in the context of the duration of the alternatives and the DOE administrative controls employed that limit worker dose, as discussed in Section 4.1.10. Some of the alternatives would occur over multiple generations of workers (e.g., Combinations 2 and 3, Tank Closure and Waste Management alternatives), so a large number of workers would be exposed. Individual worker exposure would be controlled in accordance with DOE requirements and contractor procedures. Individual annual doses must be less than 2 rem (2,000 millirem) per year unless a higher dose is explicitly approved. An Administrative Control Level of 500 millirem per year is applied to projects to ensure that the dose limit is not exceeded (DOE 2006a:2, Fluor Hanford 2006:2-1). The number of LCFs is calculated by multiplying individual FTE doses that are less than the regulatory limit by a large number of FTEs. For example, Combination 3 would require about 112,000 FTE radiation worker years; however, the actual number of worker years could be greater than 112,000 to comply with the administrative control level.

Note that the FTE worker average annual dose, shown in Table 4–158, would not occur in practice. Work would be divided among a larger number of workers so that the dose received by each individual was maintained within the Administrative Control Level of 500 millirem per year.

4.4.11 Public and Occupational Health and Safety—Transportation

The risks from the transportation of radioactive and nonradioactive materials resulting from implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.12, 4.2.12, and 4.3.12. This section summarizes the overall transportation risks of the three alternative combinations. Table 4–159 provides the impacts on transportation workers and on the general population from transportation activities under the three selected alternative combinations.

Table 4–159. Combined Transportation Risks

Combination and Component	Alternative	Worker		General Population		Nonradiological Traffic Fatalities[a]
		Collective Dose (person-rem)	Risk (Latent Cancer Fatalities)	Collective Dose (person-rem)	Risk (Latent Cancer Fatalities)	
Combination 1						
Tank Closure	No Action	0	0	0	0	0
FFTF Decommissioning	No Action	0	0	0	0	0
Waste Management	No Action[b]	2.62	0.00	0.08	0.00	0.00
Total		2.62	0 (0.0)	0.08	0 (0.0)	0 (0.0)
Combination 2						
Tank Closure	2B	262	1.6×10^{-1}	73	4.4×10^{-2}	0.57
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option[c]	0.95	0.00	0.34	0.00	0.021
Waste Management	2, DG 1[d]	2,620	1.57	352	2.1×10^{-1}	1.20
Total		2,880	2 (1.7)	425	0 (2.5×10^{-1})	2 (1.8)
Combination 3						
Tank Closure	6B, Base Case	560	3.4×10^{-1}	89	5.3×10^{-2}	1.3
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option[b]	0.99	0.00	0.34	0.00	0.024
Waste Management	2, DG 2[e]	2,620	1.57	352	2.1×10^{-1}	1.4
Total		3,180	2 (1.9)	441	0 (2.6×10^{-1})	3 (2.7)

[a] Traffic fatalities include those associated with the transport of both radioactive and nonradioactive materials.

[b] The values provided are for onsite transport of waste to a disposal site in the 200-East Area.

[c] This includes disposition of remote-handled special components at Idaho National Laboratory and disposition of bulk sodium at Hanford.

[d] The values presented are for truck transport of radioactive materials as well as construction and operational materials under Disposal Group 1. Note that Disposal Group 1 material transport needs are based on the disposal area that meets the needs of Tank Closure Alternative 4; no attempt was made to adjust the burial size for Alternative 2B. Also, traffic fatalities using rail would be higher by a factor of 3 than the value presented here (see Section 4.3.12).

[e] The values presented are for truck transport of radioactive materials as well as construction and operational materials under Disposal Group 2. Note that Disposal Group 2 material transport needs are based on the disposal area that meets the needs of Tank Closure Alternative 6B, Option Case; no attempt was made to adjust the burial size for Alternative 6B, Base Case. Also, traffic fatalities using rail would be higher by a factor of 3 than the value presented here (see Section 4.3.12).

Note: Totals may not equal the sum of the contributions due to rounding.

Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; Hanford=Hanford Site.

Source: Compiled from Tables 4–69, 4–70, 4–124, 4–125, 4–146, and 4–147.

As indicated in Table 4–159, no combination of transports would be expected to result in an LCF among the exposed population. There could be two additional fatalities among the exposed workers under Combinations 2 and 3. The maximum annual dose to a transportation crew would be limited to 100 millirem per year, unless the individual is a trained radiation worker, which would administratively limit the annual dose to 2 rem (DOE Standard 1098-99). The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure of 2 rem is 0.0012 per year. Therefore, an individual transportation worker is not expected to develop a latent fatal cancer from exposures during these activities during his or her lifetime.

The expected traffic fatalities range from 0 to 3 over the entire duration of activities. Considering that the duration of activities ranges from 30 to over 100 years and the average traffic fatalities in the U.S. is about 40,000 per year, the expected risk of traffic fatalities is small.

4.4.12 Environmental Justice

The potential for high and adverse impacts on minority and low-income populations that would result from implementing the Tank Closure, FFTF Decommissioning, and Waste Management alternatives is discussed in Sections 4.1.13, 4.2.13, and 4.3.13. This section presents the impacts that would result under selected combinations of alternatives. Resource areas that could impact the general population, and therefore could potentially impact minority and low-income populations, include public and occupational health and safety due to normal operations, accidents, and transportation; and air quality.

Section 4.4.9 discusses the short-term radiological impacts on the public resulting from normal operations. As shown in Table 4–158, the majority of the dose received by the public and the MEI under all combinations is dominated by the Tank Closure alternatives. As presented in Appendix J and Section 4.1.13, there is no appreciable difference between the average total dose to an individual of the minority, American Indian, Hispanic or Latino, or low-income populations, and an individual of the remainder of the population in both the peak year of exposure and across the lifetime of the project for all Tank Closure alternatives. Similarly, the dose to the Yakama Reservation MEI is approximately one order of magnitude lower than the dose to the offsite MEI for both the peak year of exposure and across the lifetime of the project for all Tank Closure alternatives. Therefore, none of the selected combinations of alternatives would pose disproportionately high and adverse impacts on minority or low-income populations.

Radiological and chemical impacts of facility accidents under the selected alternative combinations would be the same as those identified in Sections 4.1.11, 4.2.11, and 4.3.11. Potential impacts on minority and low-income populations due to facility accidents would be the same as those described in Sections 4.1.13, 4.2.13, and 4.3.13. Since no disproportionately high and adverse impacts were identified under the individual alternatives, none of the combined alternatives would pose disproportionately high and adverse impacts on minority or low-income populations due to facility accidents.

Air quality impacts under the combination alternatives are discussed in Section 4.4.3. Air quality impacts were not analyzed separately for each minority population because the results would be similar to those for radiological impacts; because there would be no disproportionately high or adverse health or environmental impacts on minority, American Indian, Hispanic or Latino, or low-income populations due to normal operations, the same would be true for nonradioactive air emissions.

Section 4.4.10 discusses the risks to the general population of transporting radioactive and nonradioactive materials to implement the three selected combination alternatives. None of the selected combinations would be expected to result in an LCF to the exposed population, which includes minority, American Indian, Hispanic or Latino, and low-income populations. Therefore, none of the alternative combinations would pose disproportionately high and adverse impacts on minority or low-income populations residing along transportation routes.

4.4.13 Waste Management

Waste management generation and facility utilization impacts of implementing the various tank closure, FFTF decommissioning, and waste management component activities are presented in Sections 4.1.14, 4.2.14, and 4.3.14. The various alternatives would generate several types of waste: HLW, mixed TRU waste, LLW, MLLW, hazardous waste, and nonhazardous waste. In all cases, the waste management capacity is either sufficient or the new infrastructure will be constructed as part of the alternative. This section describes the combined impacts of managing these wastes. Projected waste generation rates for the proposed activities were compared with Hanford's capacity to manage the waste, including the additional waste disposal capacity that is proposed to be constructed—specifically, projected waste generation rates were compared with site processing rates and capacities of treatment, storage, and disposal facilities likely to be involved in managing the additional waste. Potential impacts of waste generated as a result of site environmental restoration activities unrelated to tank closure, FFTF decommissioning, or waste management are not within the scope of this analysis.

Table 4–160 presents the projected waste generation for the three alternative combinations considered. The three combinations include onsite, non-CERCLA waste. Combinations 2 and 3 also include the projected receipt of offsite waste shipments. Under Combination 1, no offsite waste would be received. The estimated volume of the onsite, non-CERCLA waste that would be generated at Hanford would not be regulated as CERCLA waste and would be generated in facilities and during operations that are not related to tank waste. Examples of facilities and operations that are expected to generate such non-CERCLA waste include the Plutonium Finishing Plant, T Plant complex, WESF, WRAP, Waste Sampling and Characterization Facility, groundwater sampling activities, Pacific Northwest National Laboratory, Cold Vacuum Drying Facility, Canister Storage Building, and the Liquid Waste Processing Facilities, which include the LERF, ETF, SALDS, and TEDF. Estimates of these volumes were developed from the Hanford Site Solid Waste Integrated Forecast Technical (SWIFT) database (Barcot 2005) for LLW, MLLW, and TRU waste and from the SWIFT 2007.0 database (Barcot 2006) for hazardous waste. From this source, the volume of LLW and MLLW for the period from 2006 through 2035 is estimated to be approximately 5,300 cubic meters (187,200 cubic yards). For TRU waste, the estimated volume is 22,526 cubic meters (29,500 cubic yards) and for hazardous waste, the estimated volume is 870 cubic meters (1,140 cubic yards). However, since hazardous waste is often shipped directly off site for disposal, estimates are often not provided. Therefore, it is expected that this is only a subset of the total hazardous waste that will be generated at Hanford. Likewise, because nonhazardous waste is also shipped directly off site for disposal, no estimates are provided other than those projected from the tank closure activities.

Table 4–160. Combined Waste Generation Volumes

Component	Alternative	Waste Type						
		HLW[a]	Mixed TRU Waste	LLW	MLLW	Hazardous Waste[b]	Nonradioactive/ Nonhazardous Waste[b]	Liquid LLW (liters)
Combination 1								
Tank Closure	No Action	N/A	N/A	35	21	12	307	N/A
FFTF Decommissioning	No Action	N/A	N/A	1,699	57	396	NR	622,925
Waste Management	No Action	N/A	N/A	38	N/A	38	NR	N/A
Onsite, non-CERCLA waste[c]		N/A	22,526	3,735	1,516	870	NR	N/A
Offsite waste[d]		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total		N/A	22,526	5,507	1,594	1,316	307	622,295
Combination 2								
Tank Closure	2B	15,968	206	38,374	725,811	79,262	2,273	9,691
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	N/A	N/A	153	690	NR	462	181,699
Waste Management	2, Disposal Group 1	N/A	N/A	1,515	98	58	NR	N/A
Onsite, non-CERCLA waste[c]		N/A	22,526	3,735	1,516	870	NR	N/A
Offsite waste		N/A	N/A	62,000	20,000	N/A	N/A	N/A
Total		15,968	22,732	105,777	748,115	80,190	2,735	191,390
Combination 3								
Tank Closure	6B, Base Case	790,459	412	103,852	2,518,334	80,880	2,480,402	9,691
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	N/A	N/A	828	708	73	10,180	323,788
Waste Management	2, Disposal Group 2	N/A	N/A	1,515	98	58	NR	N/A
Onsite, non-CERCLA waste[c]		N/A	22,526	3,735	1,516	870	NR	N/A
Offsite waste		N/A	N/A	62,000	20,000	N/A	N/A	N/A
Total		790,459	22,938	171,930	2,540,619	81,881	2,490,582	333,479

[a] Includes cesium and strontium canisters, HLW melters, and other HLW. Includes ILAW under Alternative 6B, Base Case.

[b] Hazardous and nonhazardous waste is directly shipped off site; therefore, it is generally not forecasted.

[c] Data for LLW, MLLW, and TRU waste are from the Hanford Site Solid Waste Integrated Forecast Technical database fiscal year (FY) 2006–2035 report, while data for hazardous waste are from the FY 2007–2035 report. The FY 2007 report was used for hazardous waste because the forecast, shows a 630-cubic-meter increase over the FY 2006 forecast due to changes in the site infrastructure forecast, based on historical generation rates and process knowledge regarding infrastructure support/operations.

[d] No offsite waste would be received under the Waste Management No Action Alternative.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308; to liters to gallons, by 0.26417.

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; FFTF=Fast Flux Test Facility; HLW=high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; NR=not reported; TRU=transuranic.

Source: Compiled from Tables 4–84, 4–86, 4–94, 4–126, and 4–149.

The estimates for the disposal of offsite-received LLW and MLLW from other DOE sites are provided and are consistent with the January 6, 2006, Settlement Agreement among DOE, Ecology, and the Washington State Attorney General's Office (*State of Washington v. Bodman*, Civil No. 2.03-cv-05018-AAM). The volumes of such offsite waste are limited to 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW; these volumes were established in existing stipulations that were agreed upon with the State of Washington and entered as orders of the court, and as recorded in the ROD for the solid waste program (69 FR 39449). Thus, this *TC & WM EIS* evaluated the upper limits of offsite wastes that may be disposed of at Hanford. These upper limit volumes were used for analysis purposes only.

Disposal and Capacity

For waste disposal, the range of actions includes onsite and offsite disposal. Waste disposed of on site is influenced by the volume of waste produced and the ability of the waste to meet onsite disposal criteria. The Waste Management alternatives analyze the use of current disposal facilities (e.g., lined trenches) and construction of new facilities (IDF and RPPDF). All three Waste Management alternatives include continued disposal of LLW and MLLW in lined trenches, with the timeframe of disposal completion varying from 2035 to 2050. Waste Management Alternatives 2 and 3 both include construction of the RPPDF for disposal of equipment and soils that are not highly contaminated but result from clean closure activities, and one or two IDFs for tank waste, onsite-generated non-CERCLA waste, FFTF waste, waste management waste streams, and, as applicable, LLW and MLLW received from offsite locations. The difference between the action alternatives is that Waste Management Alternative 2 includes one IDF, while Waste Management Alternative 3 includes two facilities, one in the 200-East Area (for tank waste only), IDF-East, and one in the 200-West Area, IDF-West. The Waste Management No Action Alternative discontinues the construction of IDF-East.

Both Waste Management action alternatives analyze three disposal group options. These options were developed based on the amount and types of waste generated under the various alternatives (within each of the three sets of alternatives that this *TC & WM EIS* analyzes, i.e., tank closure, FFTF decommissioning, and waste management). Facility operational timeframes also vary among the disposal group options. Disposal details for each of the Waste Management alternatives and disposal groupings are discussed in Chapter 2.

For HLW, combined generation rates range from 15,968 cubic meters (20,886 cubic yards) under Combination 2 to 790,459 cubic meters (1,034,000 cubic yards) under Combination 3 (see Table 4–160). All HLW would be treated, packaged, and stored on site. Under Tank Closure Alternative 1, the cesium and strontium capsules would be stored indefinitely in the WESF, in a manner similar to the present.

For mixed TRU waste, combined generation rates range from 22,526 cubic meters (29,500 cubic yards) under Combination 1 to 22,938 cubic meters (30,000 cubic yards) under Combination 3. It is anticipated that TRU waste would be disposed of at WIPP.

For LLW, combined generation rates range from 5,507 cubic meters (7,200 cubic yards) under Combination 1 to 171,930 cubic meters (225,000 cubic yards) under Combination 3. All LLW would be sent directly to disposal on site.

For MLLW, combined generation rates range from 1,594 cubic meters (2,080 cubic yards) under Combination 1 to 2,540,619 cubic meters (3,323,130 cubic yards) under Combination 3. Using a combination of on- and offsite capabilities, MLLW would be treated to meet an RCRA land disposal restriction treatment standards and then disposed of on site.

Hazardous waste volumes are often not forecasted, but for what has been forecasted, combined generation rates range from 1,316 cubic meters (1,720 cubic yards) under Combination 1 to 81,881 cubic meters

(107,000 cubic yards) under Combination 3. All hazardous waste generated at Hanford is shipped off site for disposal or recycling.

Nonhazardous waste volumes are also often not forecasted, but for what has been forecasted, combined generation rates range from 307 cubic meters (402 cubic yards) under Combination 1 to 2,480,402 cubic meters (3,240,000 cubic yards) under Combination 3. All nonhazardous waste generated at Hanford is shipped off site for disposal or recycling.

As discussed above, none of the three combinations of alternatives would exceed the capacity of the current or planned Hanford waste management infrastructure. While Combination 3 reflects the upper end of the three combinations, it does not bound waste management infrastructure demands. A combination that would include Tank Closure Alternative 6A (Base or Option Case) in substitution for Alternative 6B, Base Case, along with FFTF Decommissioning Alternative 2 (with all facilities to be built at Hanford), and Waste Management Alternative 2 or 3 (with Disposal Group 3) would have the greatest combined impact on the waste management infrastructure for HLW, MLLW, hazardous waste, and liquid LLW.

A combination that would include Tank Closure Alternative 6B (Option Case) in substitution for Alternative 6B, Base Case, along with FFTF Decommissioning Alternative 2 (with all facilities to be built at Hanford), and Waste Management Alternative 2 or 3 (with Disposal Group 3) would have the greatest combined impact on the waste management infrastructure for LLW.

A combination that would include Tank Closure Alternative 4 in substitution for Alternative 6B, Base Case, along with FFTF Decommissioning Alternative 2 (with all facilities to be built at Hanford), and Waste Management Alternative 2 or 3 (with Disposal Group 3) would have the greatest combined impact on the waste management infrastructure for mixed TRU waste.

However, the generation of these wastes would unlikely have major impacts on the waste management infrastructure at Hanford because sufficient capacity exists or would be constructed under the corresponding Waste Management alternatives.

4.4.14 Industrial Safety

The industrial safety risks and impacts of implementing the various Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Sections 4.1.15, 4.2.15, and 4.3.15. This section summarizes the overall industrial safety impacts of the three alternative combinations. For each alternative combination, the number of TRCs and fatalities is projected over the duration of the alternatives under each combination (see Table 4–161). The resulting total number of TRCs and fatalities represents the potential impacts on worker safety.

As indicated in the table, the number of projected TRCs and fatalities is greatly influenced by the requirements of the Tank Closure alternatives. The number of TRCs ranges from 173 under Combination 1 to 6,870 under Combination 3. The greater number of TRCs is directly related to the amount of work required and the length of time that work is performed.

Table 4–161. Industrial Safety Impacts for Selected Combinations of Alternatives

Combination and Component	Alternative	Number of Total Recordable Cases	Number of Fatalities
Combination 1			
Tank Closure	No Action	163	0.02
FFTF Decommissioning	No Action	0.42	0.00005
Waste Management	No Action	10.0	0.001
Total		173	0.02
Combination 2			
Tank Closure	2B	3,940	0.52
FFTF Decommissioning	2, Idaho Option, Hanford Reuse Option	17.1	0.002
Waste Management	2, DG 1	578	0.076
Total		4,540	0.60
Combination 3			
Tank Closure	6B, Base Case	5,190	0.67
FFTF Decommissioning	3, Idaho Option, Hanford Reuse Option	18.5	0.002
Waste Management	2, DG 2	1,660	0.21
Total		6,870	0.88

Note: Totals may not equal the sum of the contributions due to rounding.
Key: DG=Disposal Group; FFTF=Fast Flux Test Facility; Hanford=Hanford Site.
Source: Compiled from Tables 4–98, 4–127, and 4–150.

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CHAPTER 5
LONG-TERM ENVIRONMENTAL CONSEQUENCES

Chapter 5 presents the potential long-term impacts on the existing natural and human environment and on human health of implementation of reasonable alternatives for each of the following: (1) tank waste retrieval and treatment and single-shell tank system closure at the Hanford Site (Hanford); (2) decommissioning of the Fast Flux Test Facility and auxiliary facilities and disposition of Hanford's inventory of radioactively contaminated bulk sodium; and (3) management of waste resulting from the above and other Hanford activities and limited volumes from other U.S. Department of Energy sites. Impact analyses for the alternatives and options considered for each of the three sets of proposed actions are presented separately in Sections 5.1, 5.2, and 5.3, respectively. Impact analyses are grouped first by resource area or discipline (i.e., groundwater, human health, and ecological risks) and then by alternative so that impacts of releases to air and groundwater can be meaningfully compared across alternatives. All disciplines are analyzed in a manner commensurate with their importance and the expected level of impact on them under a specific alternative—the sliding-scale assessment approach. The combined impacts of implementing selected alternatives from each of the three sets of proposed actions are presented in Section 5.4. Cumulative impacts associated with the alternative combinations are presented in Chapter 6. Mitigation measures to reduce the potential for environmental impacts are summarized in Chapter 7, Section 7.1. Analyses of comparative impacts across the alternatives are presented in Chapter 7, Sections 7.2 through 7.4. A detailed discussion of each alternative is provided in Chapter 2, Section 2.5.

The long-term impact analysis results for groundwater, human health, and ecological risk through the 10,000-year period of analysis presented in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* are derived from modeling releases to air and groundwater, as appropriate. The air modeling process used for this *TC & WM EIS* is described in Appendix F and Appendix G. Figure 5–1 describes the groundwater modeling process used for this *TC & WM EIS*. The process begins with development of inventories of constituents of potential concern (COPCs) for the alternative and cumulative impact analyses described in Appendices D and S, respectively.

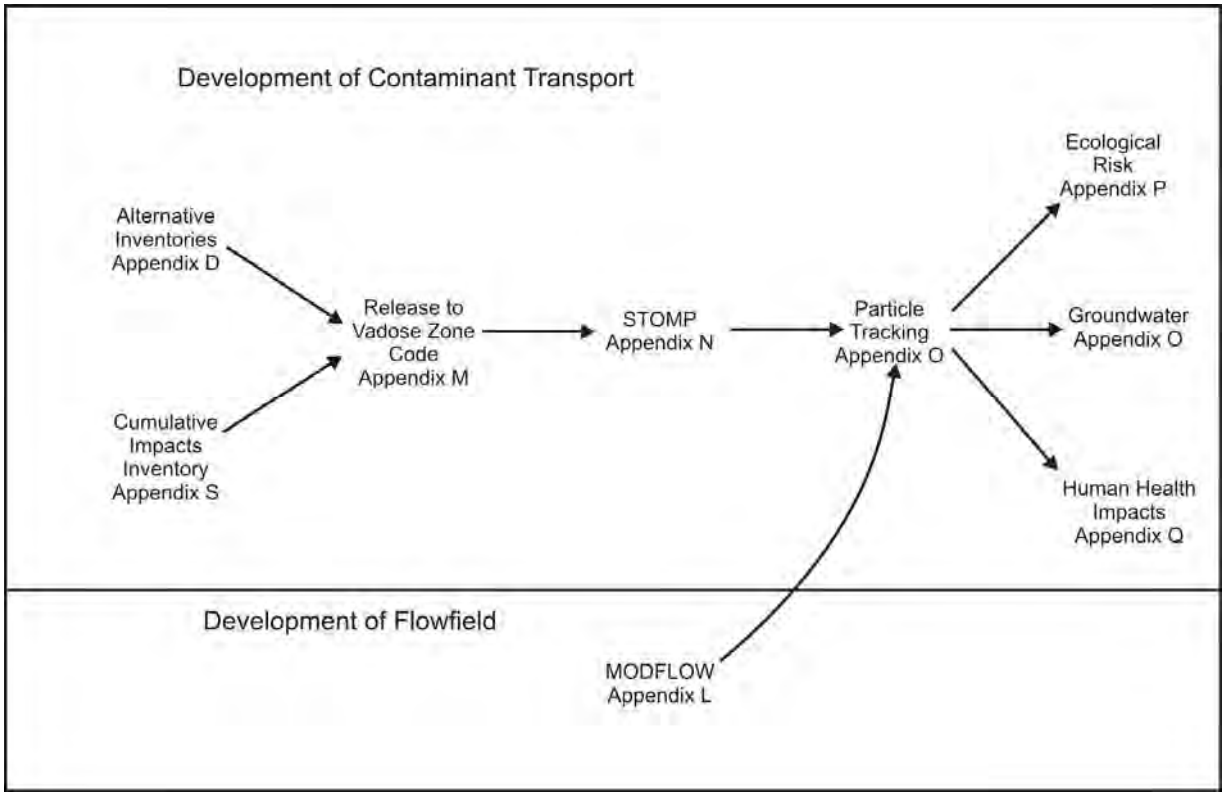


Figure 5–1. Groundwater Modeling Process

The Release to Vadose Zone code uses site-specific parameters to estimate release rates to the vadose zone for each source location analyzed in the alternative and cumulative impact analyses. Parameter examples include contaminant inventories, aqueous recharge, and subsurface geology. Appendix M includes further description of the Release to Vadose Zone code. The output of the Release to Vadose Zone code is an input file to the vadose zone model STOMP [Subsurface Transport Over Multiple Phases] computer code (White and Oostrom 2000, 2006). Appendix M also presents the releases from a number of assumed source forms, some of which are intact and leaching during the entire 10,000-year period of analysis.

The STOMP model uses an integrated-volume finite-difference approach to solve nonlinear water and solute transport balances for the vadose zone. The development and implementation of the vadose zone modeling are presented in Appendix N. The vadose zone modeling provides contaminant and aqueous releases to the aquifer over time, which are incorporated into the groundwater contaminant transport.

A groundwater flow field was developed to determine the direction and rate of water movement in the aquifer, that is, where contaminants entering the groundwater will go and how long it will take to move a given contaminant from the point where it enters the groundwater to any given point along its trajectory toward a location of interest. Groundwater flow through the unconfined aquifer is simulated using the U.S. Geological Survey MODFLOW [modular three-dimensional finite-difference groundwater flow model] 2000 Engine, Version 1.15.00 (USGS 2004). The commercial version used in this *TC & WM EIS* is Visual MODFLOW, Version 4.2 (WHI 2006). A description of the development of the groundwater flow field is provided in Appendix L.

The input for the groundwater contaminant transport runs was based on the output from the vadose zone flow and transport runs that were calculated using the STOMP code. The particle-tracking code (see Appendix O, Section O.2), in combination with the MODFLOW Base Case flow field (see Appendix L), was used to calculate a fully three-dimensional transient analysis of groundwater transport over a period of 10,000 years for each site. The particle-tracking model provides contaminant concentrations in the groundwater over time. A description of the particle-tracking model, along with the listing of benchmarks used to compare COPC concentrations, is provided in Appendix O. These concentrations were used to analyze ecological and human health risk. Detailed descriptions of these risk analyses are provided in Appendices P and Q, respectively. Appendix Q also provides the process to identify the COPCs used for long-term analysis. A map of the Core Zone and barrier boundaries used for the analysis is also provided in Chapter 2, Figure 2–80, and Appendix O, Figure O–1.

5.1 TANK CLOSURE ALTERNATIVES

This section describes the potential long-term environmental impacts associated with implementation of each of the 11 Tank Closure alternatives considered in this *TC & WM EIS* for retrieving and treating the tank waste inventory generated during the defense production years at the Hanford Site (Hanford). The impact analysis also considers different closure scenarios associated with the single-shell tank (SST) system.

Tank Closure Alternative 1, No Action, reflects the environmental baseline against which the impacts of the other action alternatives can be compared. Under Alternative 1, the U.S. Department of Energy (DOE) has assumed for purposes of analysis that construction of the River Protection Project Waste Treatment Plant (WTP) would be terminated in 2008. The tank waste in the SST and double-shell tank (DST) systems would remain in the tank farm indefinitely. DOE would maintain security and management of the site for a 100-year administrative control period (ending in calendar year [CY] 2107), after which the tank waste would be available for release to the environment.

In contrast, Tank Closure Alternatives 2 through 6 involve the construction, subsequent operations, and eventual deactivation of new facilities over varying timeframes (ranging from 34 to 161 years) in the 200-East and 200-West Areas of Hanford to support tank waste retrieval, treatment, and disposal. The waste in the SST and DST systems would be retrieved, treated, and disposed of. With the exception of Alternative 2A, each alternative also analyzes closure of the SST system by either landfill closure (i.e., construction of a surface barrier) or selective or full clean closure (i.e., removal) of the SST system and associated waste and contaminated soils. Each of the 11 Tank Closure alternatives (Alternatives 1 through 6C) are described in detail in Chapter 2, Section 2.5, of this environmental impact statement (EIS).

5.1.1 Groundwater

5.1.1.1 Tank Closure Alternative 1: No Action

This section describes the groundwater analysis results for Tank Closure Alternative 1, including long-term groundwater impacts of contaminant sources within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an Integrated Disposal Facility (IDF) and the River Protection Project Disposal Facility (RPPDF) are presented in Section 5.3, which discusses waste management impacts.

5.1.1.1.1 Actions and Timeframes Influencing Groundwater Impacts

Under Tank Closure Alternative 1, no sources would be removed from within the tank farm barriers. Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, three major periods were identified for Tank Closure Alternative 1, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 1 that are presented in this section would be common to all of the Tank Closure alternatives.

- The administrative control period was assumed to start in 2008 and end in CY 2107 (100-year duration). It was assumed that during this administrative control period, corrective action or emergency response measures would preclude further releases from the SST and DST systems, but that releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system.

- The post–administrative control period was assumed to start in CY 2108 and continue through the 10,000-year period of analysis until CY 11,940. During this post–administrative control period, releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system. In addition, all stored waste at the SST and DST farms (referred to as “other tank farm sources” in this chapter) would be released to the vadose zone at the start of the post–administrative control period.

5.1.1.1.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 1. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Tank Closure Alternative 1 is focused on the following COPC drivers:

- Radiological risk drivers: hydrogen-3 (tritium), iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 1 were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-11}, which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 1.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed are the radionuclides carbon-14, cesium-137, neptunium-237, plutonium-239, and strontium-90 and the chemicals acetonitrile, benzene, 1-butanol, lead, mercury, polychlorinated biphenyls, and 2,4,6-trichlorophenol. These constituents do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.1.3 Analysis of Release and Mass Balance[1]

This section presents the impacts of Tank Closure Alternative 1 in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of

[1] A "mass balance" (also called a material balance) is an application of conservation of mass to the analysis of a physical system, i.e., the mass of a chemical or radionuclide that enters a system must, by conservation of mass, either leave the system, accumulate within the system, or decay/react to a different chemical or radionuclide (input = output + accumulation + decay/reaction). By accounting for material entering and leaving a system, mass flows can be identified that might have been unknown, or difficult to measure without this technique.

Applied to this EIS, mass balance refers to accounting for the total amount of COPCs released from key sources to the vadose zone, groundwater, and Columbia River during the 10,000-year period of analysis at various locations and points in time, taking into consideration retardation factors (retention in the vadose zone and aquifer) and radioactive decay. This accounting allows tracking of the mass flows, accumulations, and decays at each stage through transit from source to arrival at the Columbia River.

analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms (see Figures 5–2 through 5–7). Three subtotals are plotted representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–2 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–3, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant sources for tritium are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers the predominant sources are other tank farm sources. This suggests that other tank farm sources, which are released in the analysis during the post–administrative control period, are an important impact driver under Tank Closure Alternative 1.

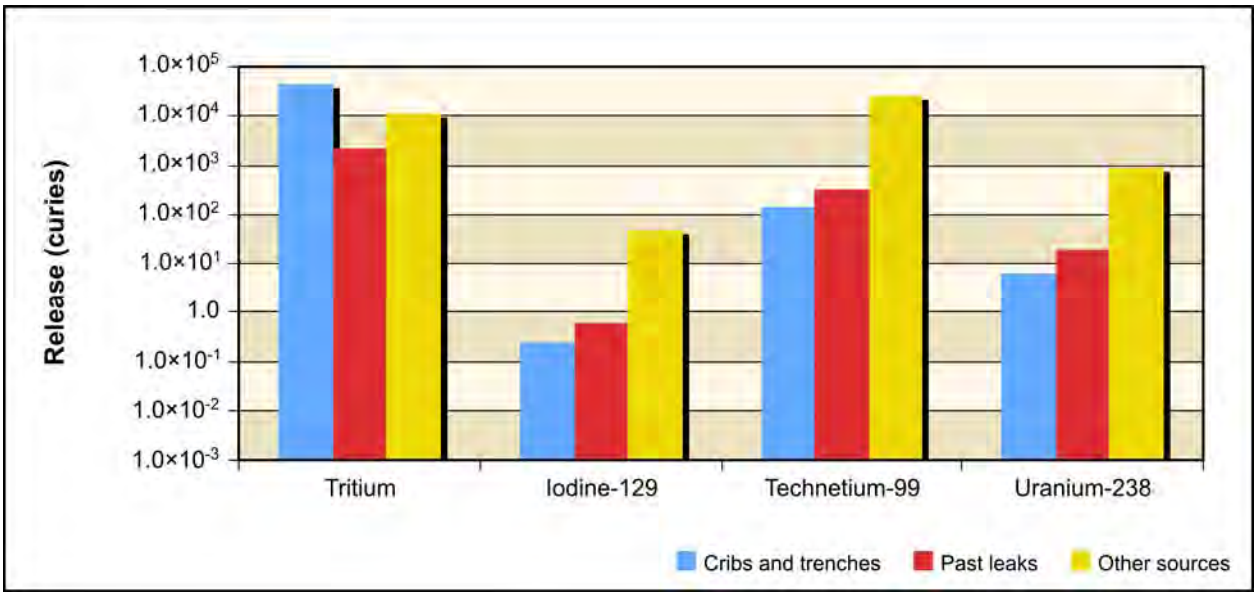


Figure 5–2. Tank Closure Alternative 1 Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

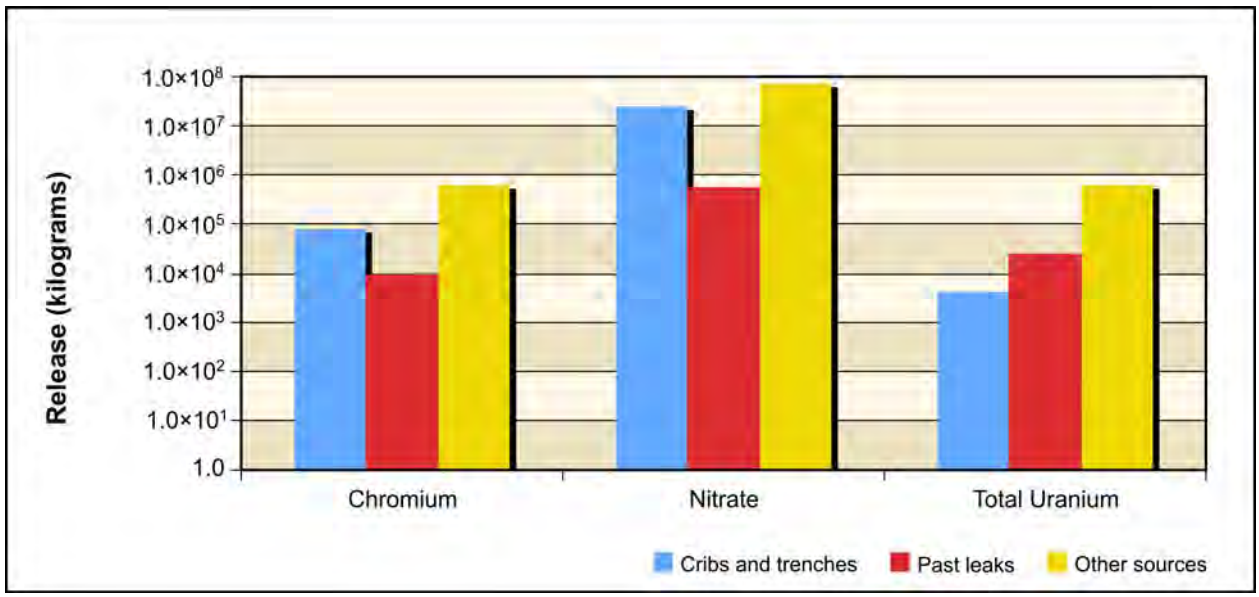


Figure 5–3. Tank Closure Alternative 1 Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–4 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–5, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

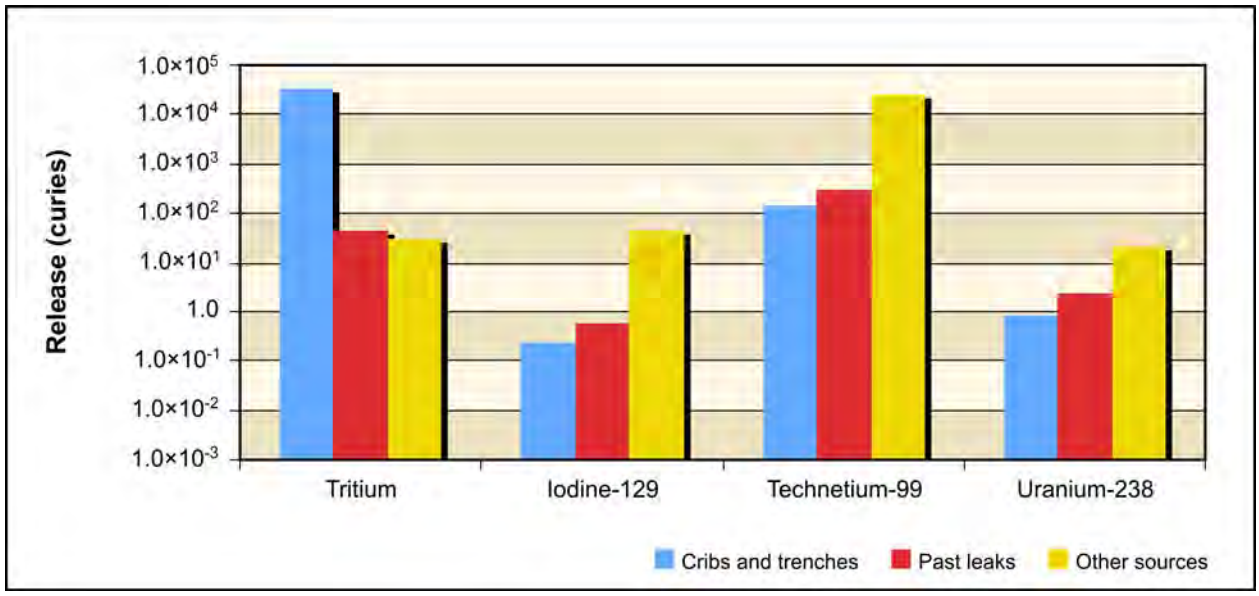


Figure 5–4. Tank Closure Alternative 1 Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

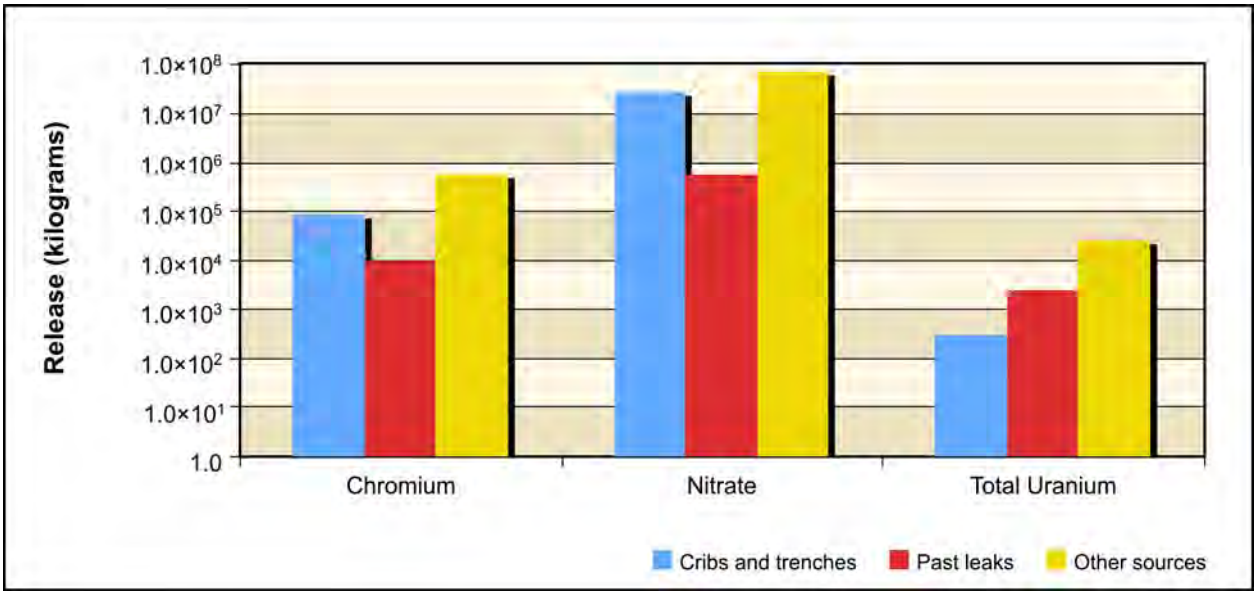


Figure 5–5. Tank Closure Alternative 1 Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For tritium, the amount released to groundwater is attenuated by radioactive decay in the vadose zone. For cribs and trenches (ditches), about 70 percent of the total inventory of tritium reached groundwater in the analysis; for past leaks, only 2 percent; and for other tank farm sources, less than 1 percent reached the water table. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process.

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture addition and movement through the vadose zone. For cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 14 percent of uranium-238 and 8 percent of total uranium inventory reached groundwater during the period of analysis. For past leaks, about 18 percent of uranium-238 and 14 percent of total uranium of the total inventory reached groundwater during the period of analysis. For other tank farm sources, about 4 percent of uranium-238 and 7 percent of total uranium of the total inventory reached groundwater during the period of analysis. These results also suggest that uranium-238 and total uranium impacts would occur later in the post–administrative control period because of the long travel times for these COPCs in the vadose zone.

Figure 5–6 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–7, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

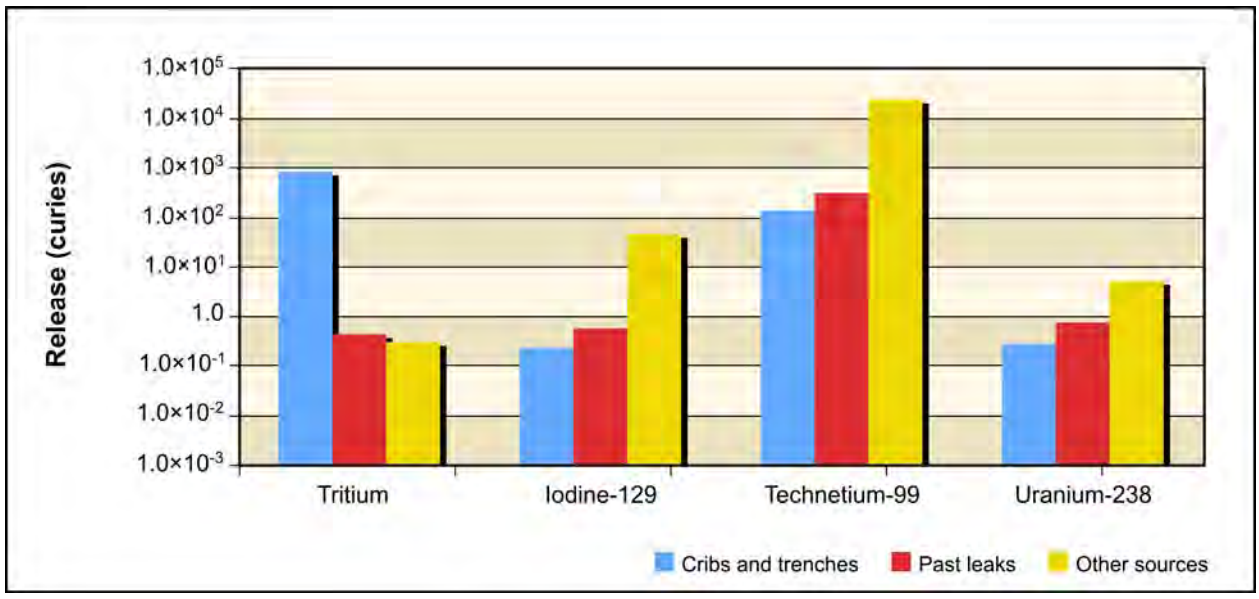


Figure 5–6. Tank Closure Alternative 1 Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

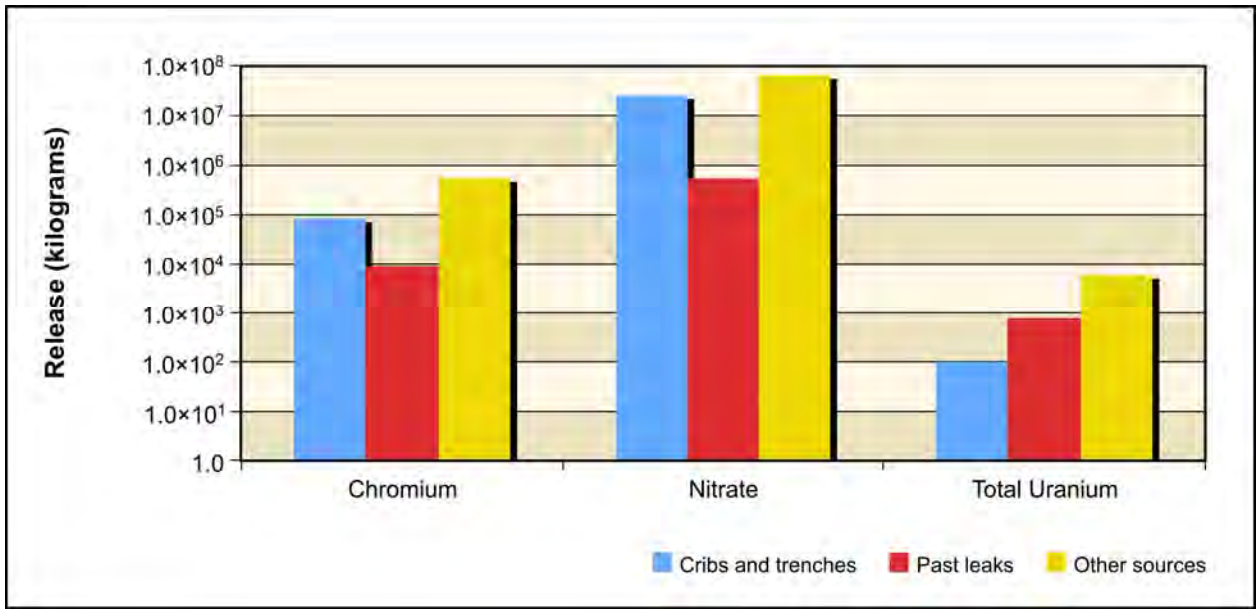


Figure 5–7. Tank Closure Alternative 1 Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to the Columbia River is less than that of the release to groundwater because of retardation. Overall, about 25 percent of the amount released to groundwater during the period of analysis reached the Columbia River.

For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reached the Columbia River during the period of analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post–administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

5.1.1.1.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 1 impacts in terms of groundwater concentration versus time at the tank farm barriers, Core Zone Boundary, and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Table 5–1 and Figures 5–8 through 5–14). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Although the concentration-versus-time plots presented in this section (as well as in the following sections and throughout this *TC & WM EIS*) appear similar in structure to the classic advection-dispersion breakthrough curves, the reader is cautioned that the curves presented in these sections are not amenable to the classic analysis. The classic presentation is a time-series plot of concentration from a single source at a fixed location. In this *TC & WM EIS*, each concentration-versus-time plot is from a multiple number of sources (typically on the order of 30) at a variable location (the location of the highest peak concentration along the line of analysis). Therefore, attempts to apply classic transport theory to these results can, in general, result in misleading conclusions. Table 5–1 lists the maximum concentrations of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore.

Table 5–1. Tank Closure Alternative 1 Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	4,190	2,690	2,460	5,570	12	3,790	180	20,000
	(2112)	(2052)	(2117)	(2052)	(2051)	(2102)	(2054)	
Technetium-99	**70,100**	**175,000**	**38,700**	**15,000**	**14,800**	**350,000**	**5,230**	900
	(2114)	(3837)	(3238)	(2051)	(3536)	(3837)	(4032)	
Iodine-129	**71**	**398**	**67**	**71**	**29**	**682**	**13**	1
	(2114)	(3801)	(3312)	(3756)	(3536)	(3801)	(4411)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	**23**	**490**	**259**	**102**	**40**	**1,070**	6	15
	(11,789)	(11,749)	(11,730)	(11,820)	(11,758)	(11,683)	(11,918)	
Chemical in micrograms per liter								
Chromium	**284**	**5,050**	**1,650**	**911**	**308**	**12,200**	**165**	100
	(2114)	(3628)	(3172)	(2050)	(3587)	(3524)	(4019)	
Nitrate	**69,600**	**1,740,000**	**107,000**	**201,000**	34,900	**1,130,000**	23,500	45,000
	(2119)	(2087)	(3138)	(2088)	(3654)	(2059)	(3911)	
Total uranium	5	**695**	**281**	**96**	**51**	**1,220**	8	30
	(11,769)	(11,762)	(11,762)	(11,836)	(11,739)	(11,648)	(11,591)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

Figure 5–8 shows concentration versus time for tritium. Note that for visual clarity, the time period shown in this figure is from CYs 1940 through 2440 (500 years), rather than the full 10,000-year period of analysis. Releases from cribs and trenches (ditches) cause groundwater concentrations to exceed benchmark concentrations by about three orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore approach the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

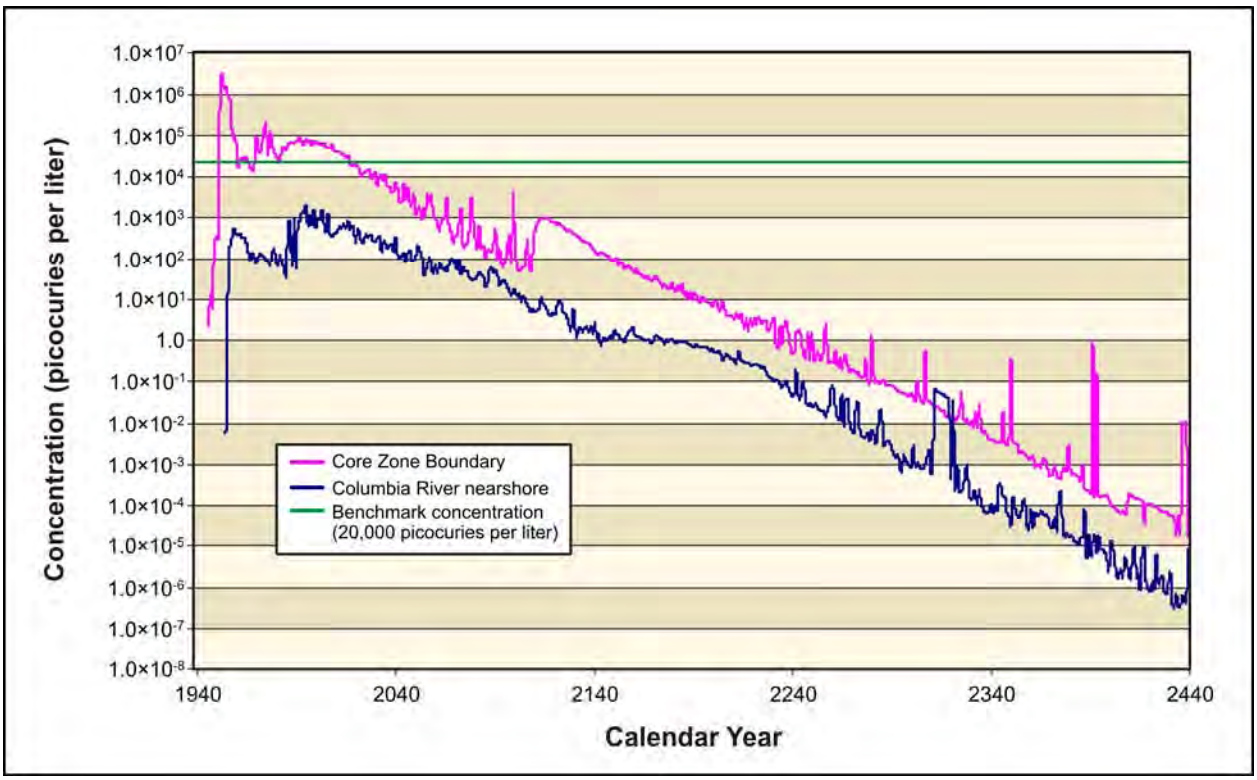


Figure 5–8. Tank Closure Alternative 1 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–9 through 5–12 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from cribs and trenches (ditches) cause groundwater concentrations of iodine-129 to exceed benchmark concentrations by about two to three orders of magnitude during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore approach or exceed the benchmark concentration. Releases from other tank farm sources cause groundwater concentrations to exceed benchmark concentrations by about three orders of magnitude during the middle and latter parts of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore exceed the benchmark concentration by about an order of magnitude, tapering off to near the benchmark concentration at the end of the period of analysis. Technetium-99, chromium, and nitrate concentrations show a similar curve, with chromium and nitrate concentrations at the Columbia River nearshore dropping below the benchmark concentrations.

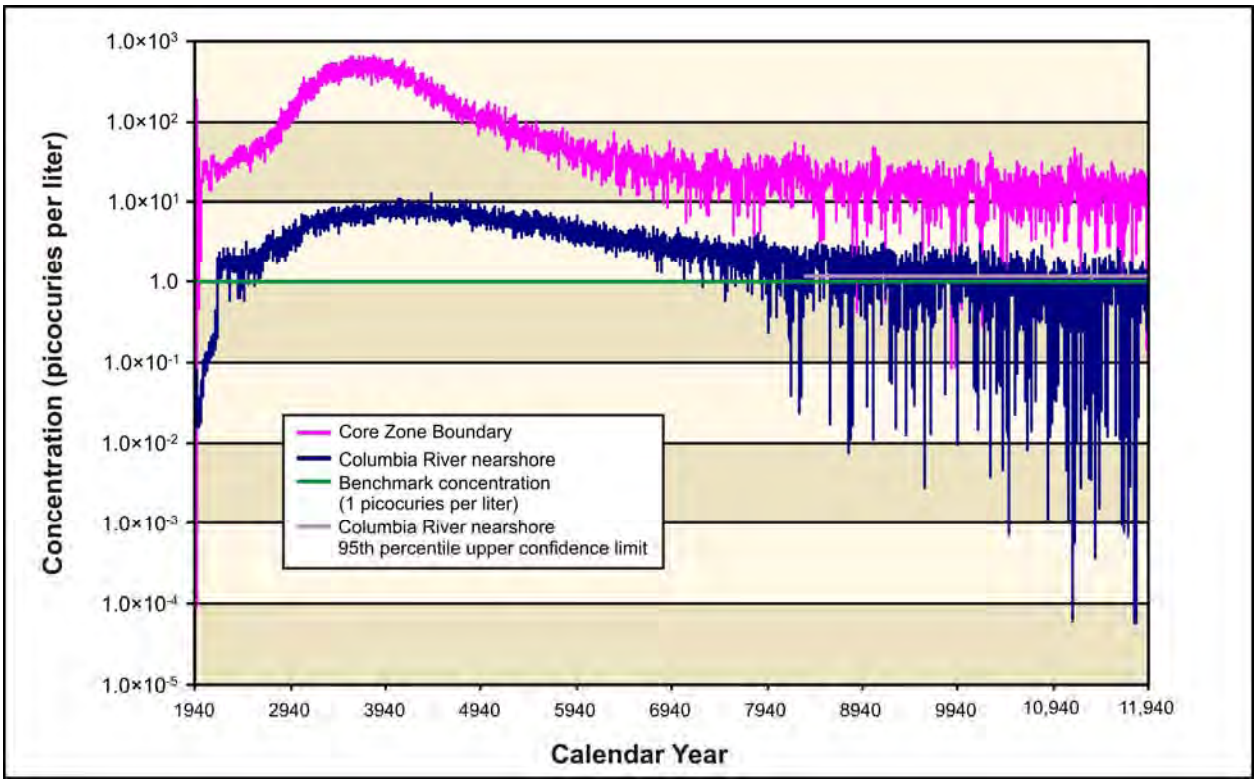


Figure 5–9. Tank Closure Alternative 1 Iodine-129 Concentration Versus Time

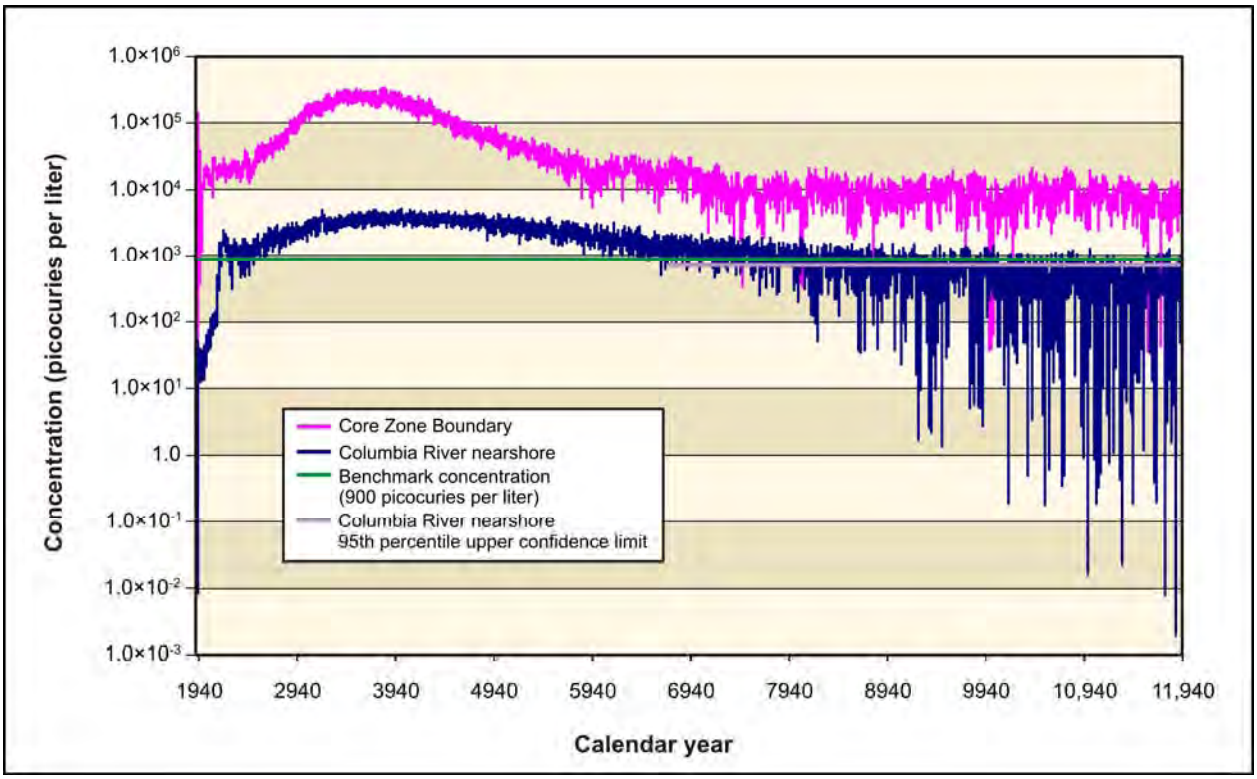


Figure 5–10. Tank Closure Alternative 1 Technetium-99 Concentration Versus Time

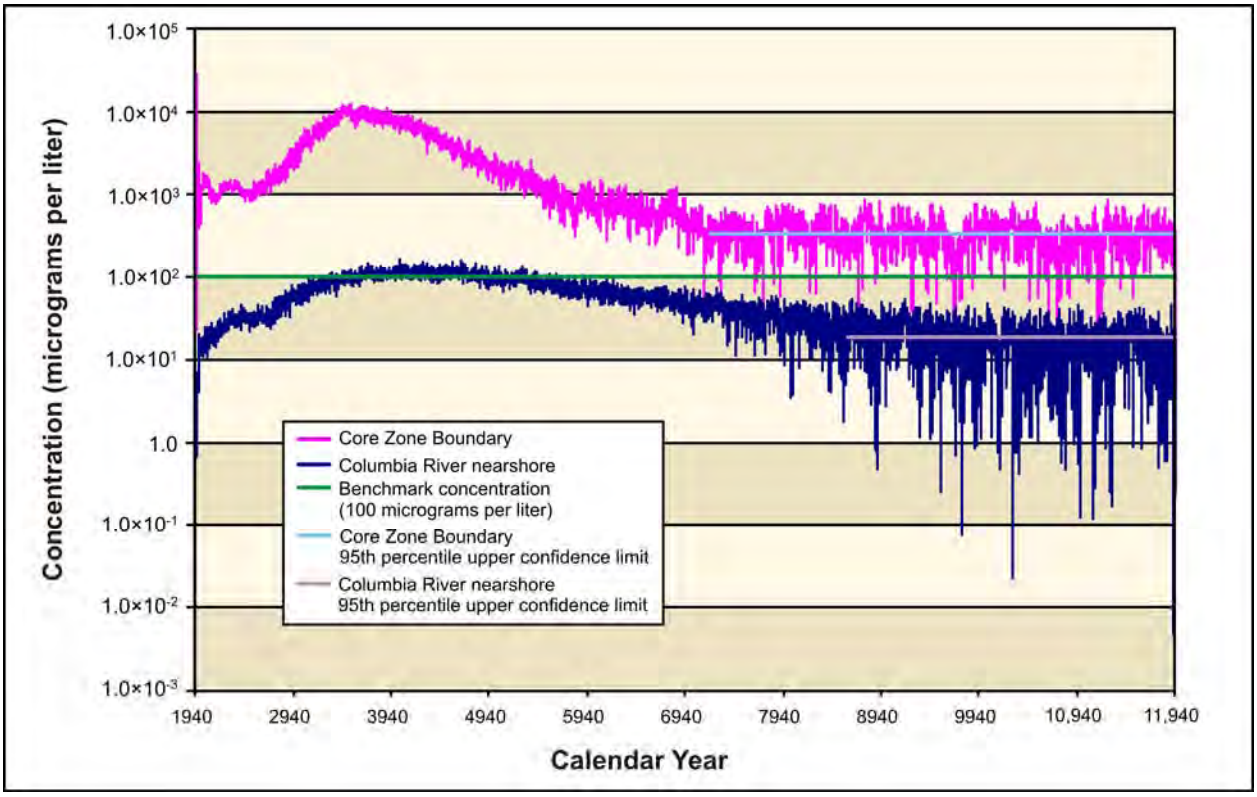


Figure 5–11. Tank Closure Alternative 1 Chromium Concentration Versus Time

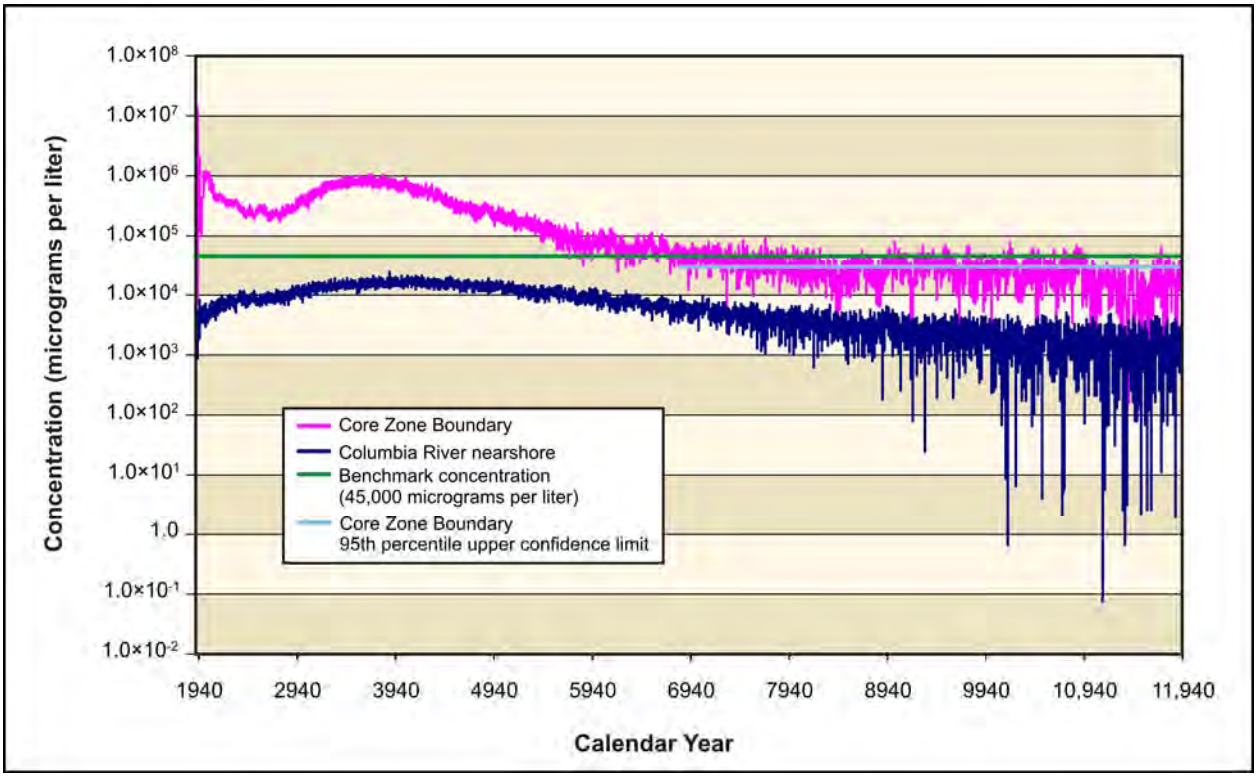


Figure 5–12. Tank Closure Alternative 1 Nitrate Concentration Versus Time

Figures 5–13 and 5–14 show concentration versus time for uranium-238 and total uranium. Early releases from cribs and trenches (ditches) result in groundwater concentrations that are one to two orders of magnitude lower than benchmark concentrations. Releases from other tank farm sources cause groundwater concentrations to rise, nearing benchmark concentrations by CY 6000. Concentrations continue to rise throughout the duration of the period of analysis, exceeding benchmark concentrations by about two orders of magnitude at the end of the period of analysis. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, nearing the benchmark concentration by CY 11,940.

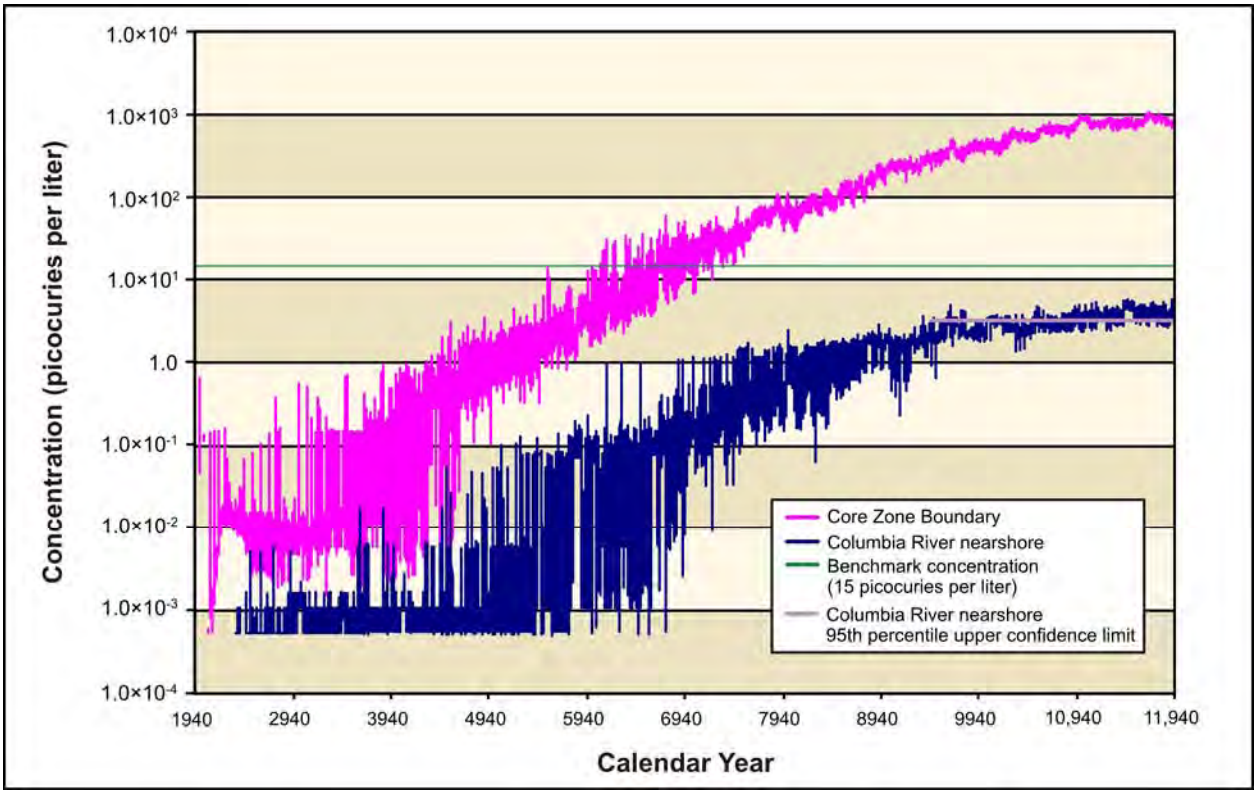


Figure 5–13. Tank Closure Alternative 1 Uranium-238 Concentration Versus Time

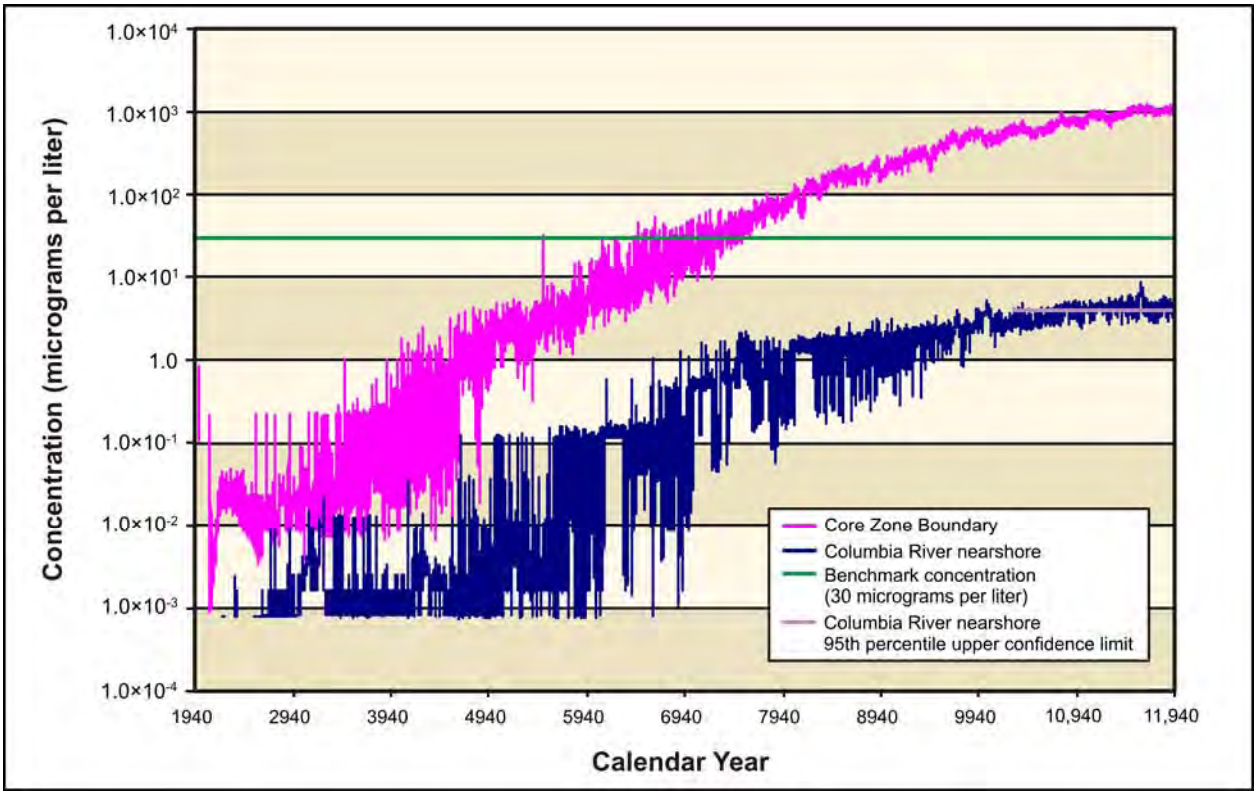


Figure 5–14. Tank Closure Alternative 1 Total Uranium Concentration Versus Time

5.1.1.1.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 1 in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Figures 5–15 through 5–36). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Note that, in this section and in subsequent sections, the benchmark concentration is identified as "maximum contaminant level" in the legend of the spatial distribution figures. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–15 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward the Gable Mountain–Gable Butte Gap (Gable Gap). Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135, as shown in Figure 5–8.

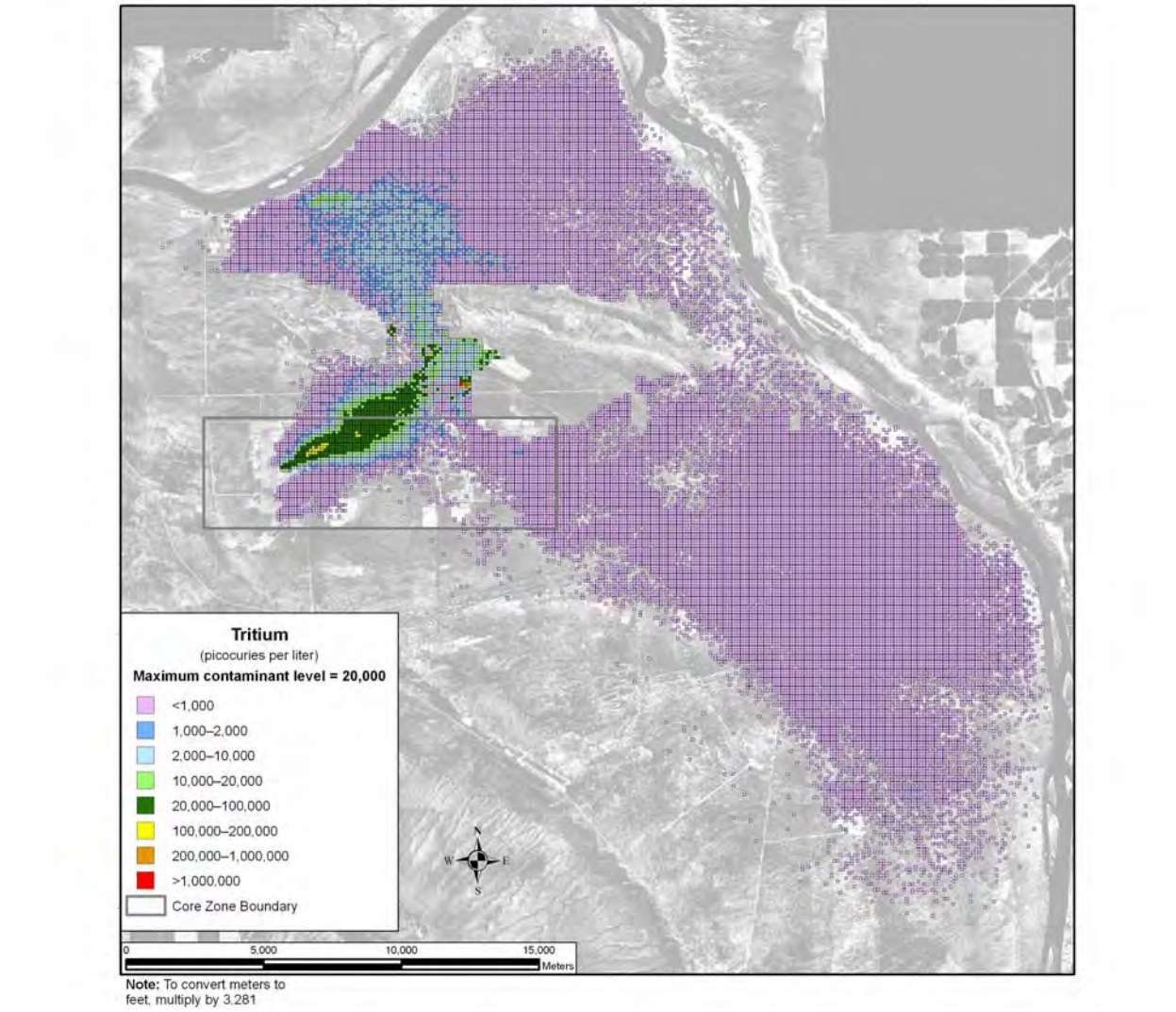


Figure 5–15. Tank Closure Alternative 1 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

Figure 5–16 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Around CY 3890, releases from other tank farm sources create a large plume exceeding the benchmark, extending from the A Barrier to the Columbia River (see Figure 5–17). By CY 7140, most of the mass in the plume has reached the Columbia River, with only isolated pockets of high-concentration areas where the groundwater flow velocities are extremely small (see Figure 5–18). Figure 5–19 shows the total area in which groundwater concentrations of iodine-129 exceed the benchmark concentration in the analysis as a function of time. The area of exceedance peaks between CY 3240 and CY 4540 as a result of releases from other tank farm sources. Figures 5–20 through 5–23 show the spatial distribution at the same three times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 is similar to that of iodine-129. The other conservative tracers, chromium (see Figures 5–24 through 5–26) and nitrate (see Figures 5–27 through 5–29), show similar spatial distributions at selected times.

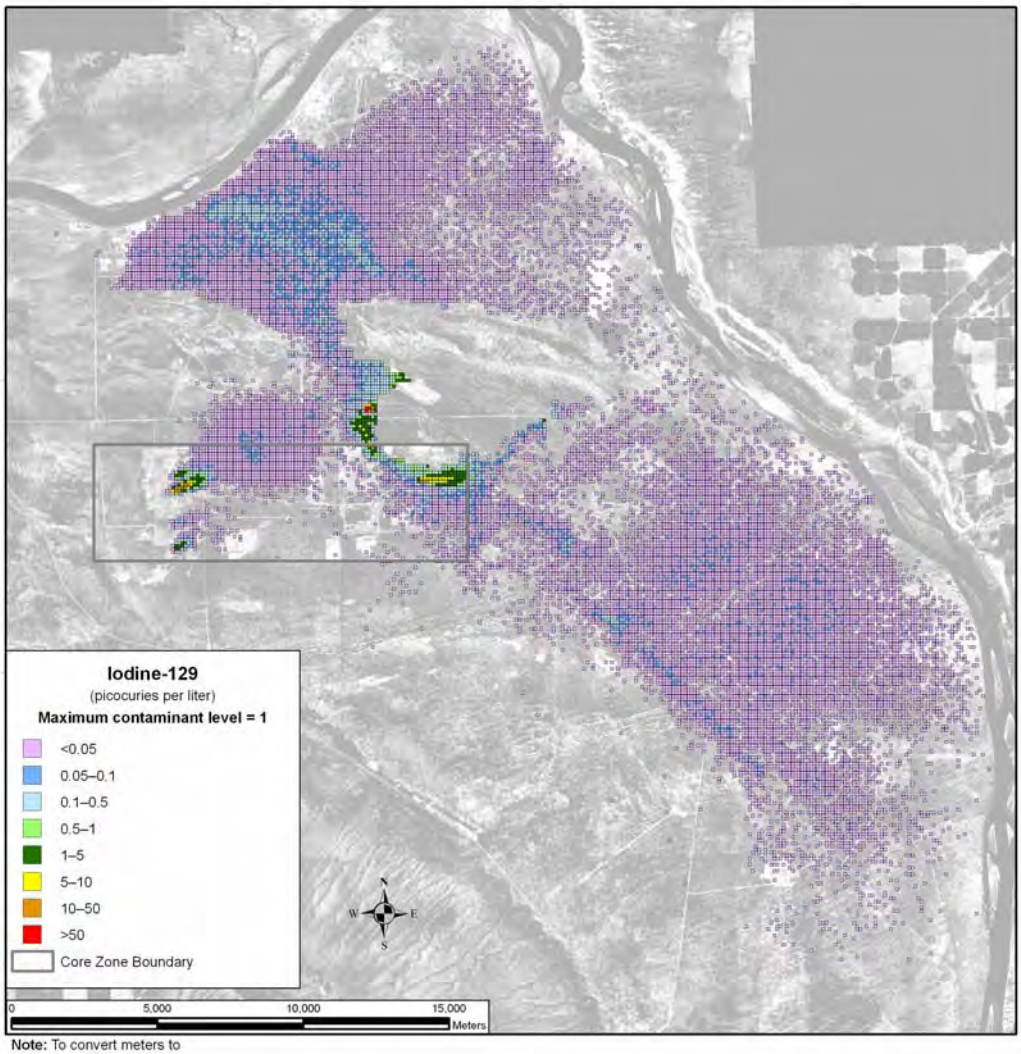


Figure 5–16. Tank Closure Alternative 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

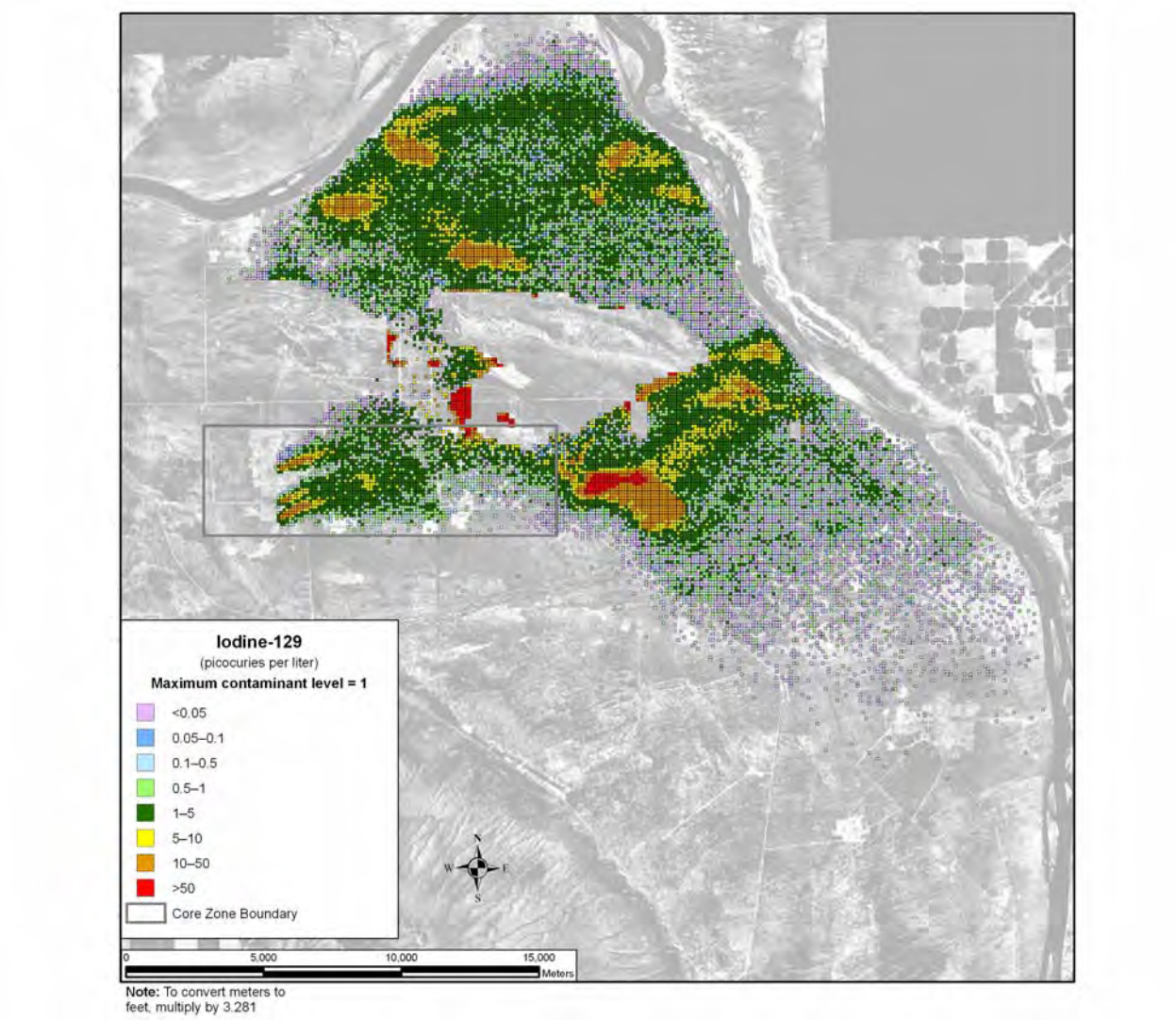


Figure 5–17. Tank Closure Alternative 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

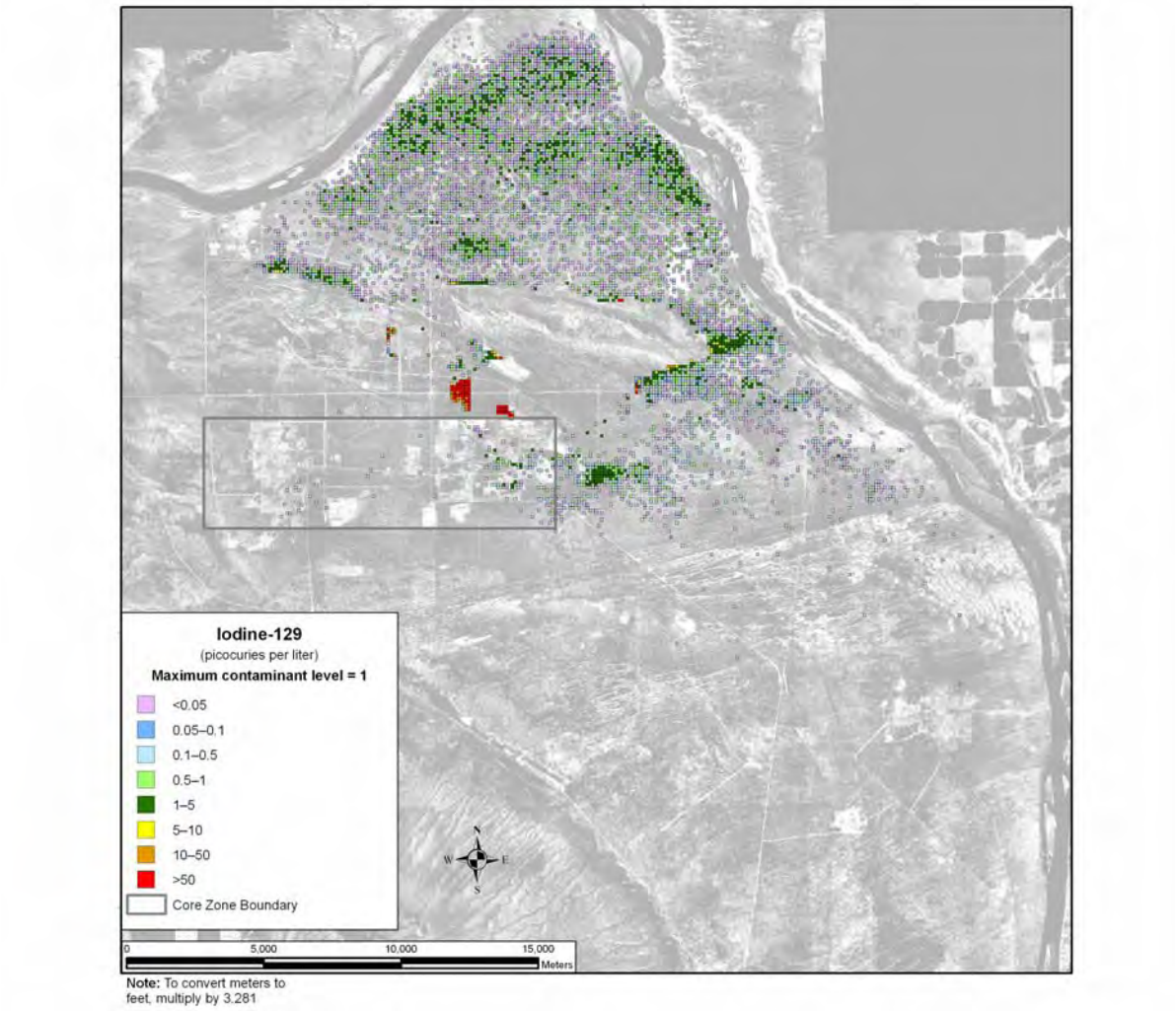


Figure 5–18. Tank Closure Alternative 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

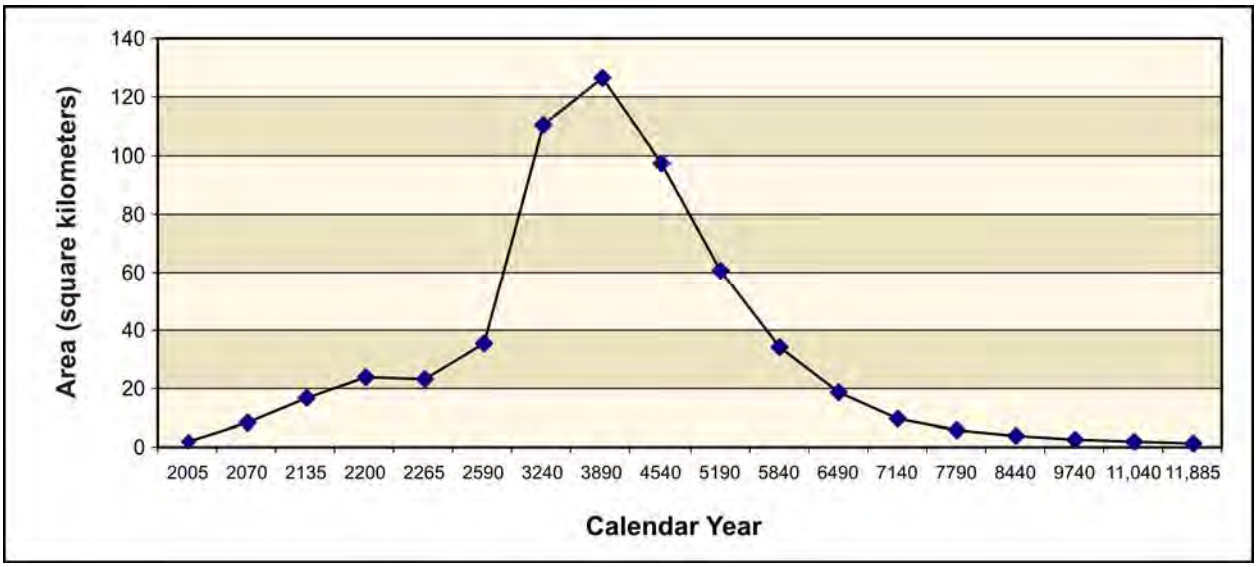


Figure 5–19. Tank Closure Alternative 1 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

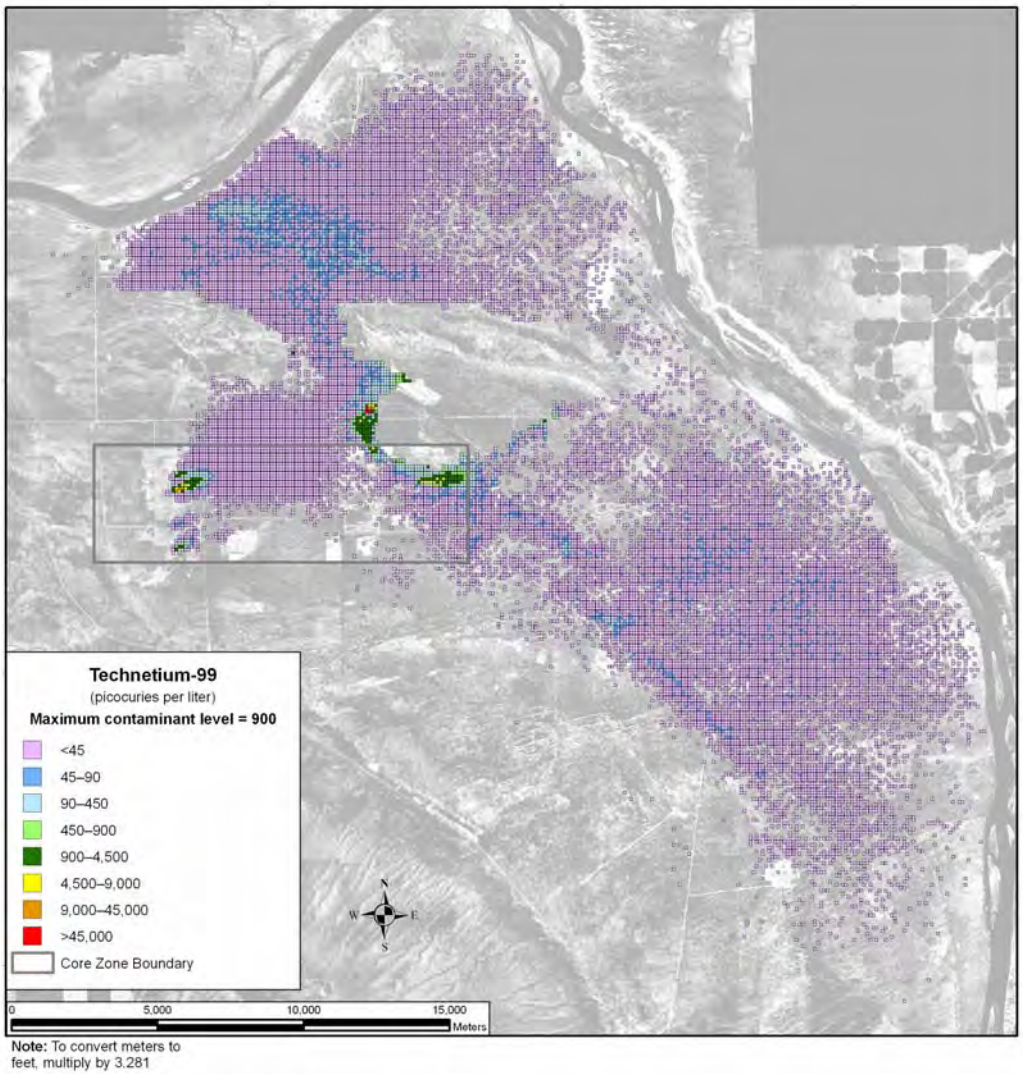


Figure 5–20. Tank Closure Alternative 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

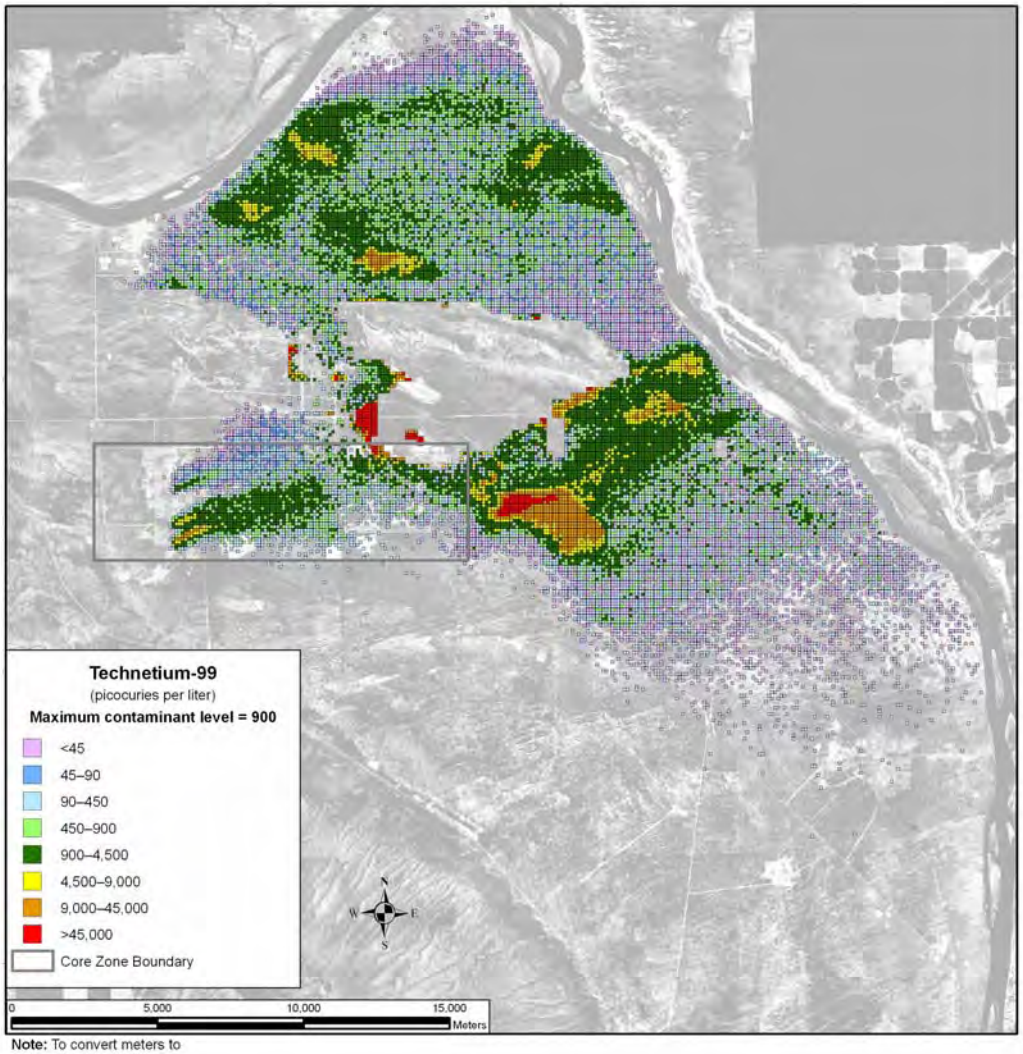


Figure 5–21. Tank Closure Alternative 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

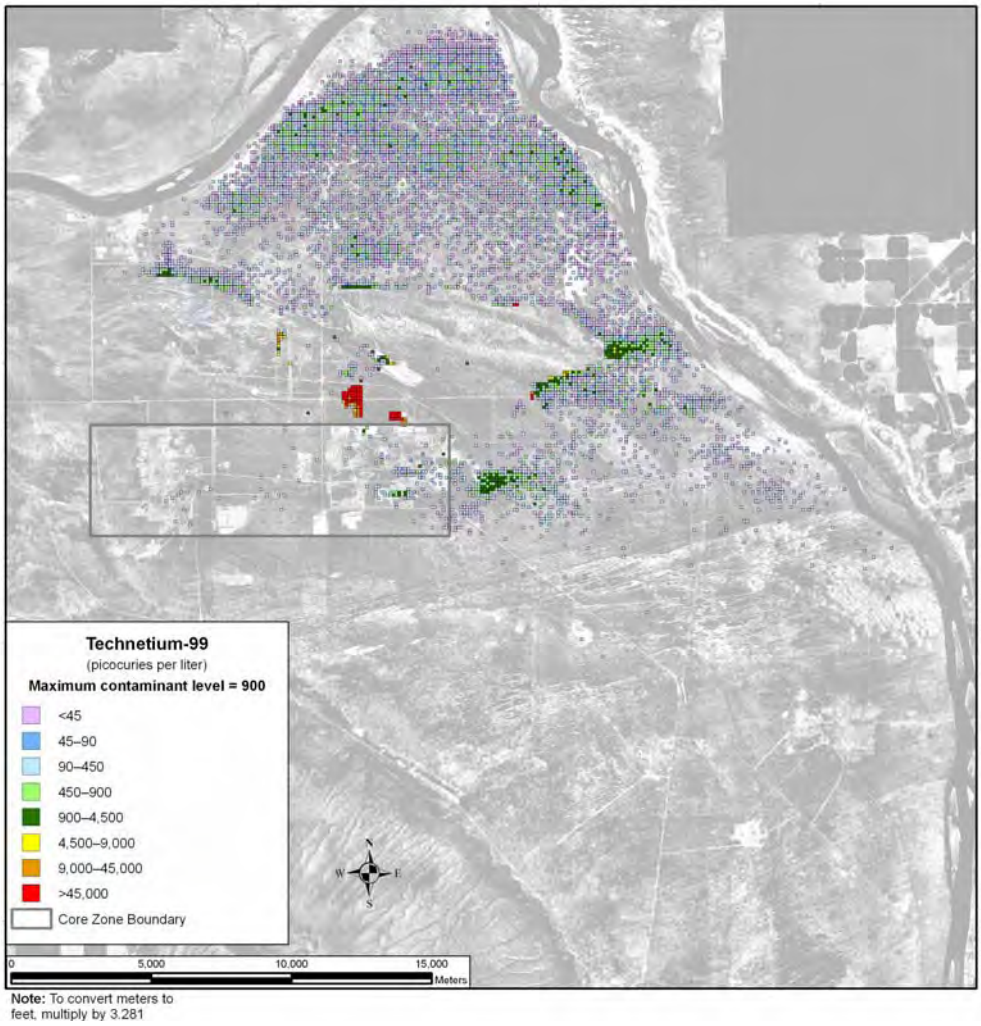


Figure 5–22. Tank Closure Alternative 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

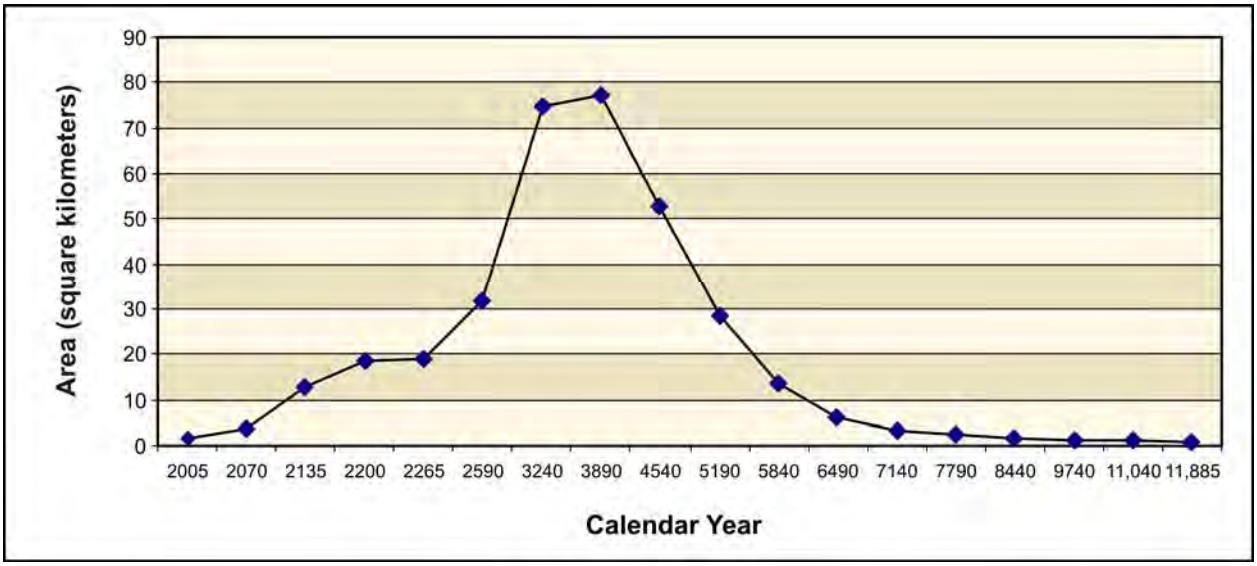


Figure 5–23. Tank Closure Alternative 1 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

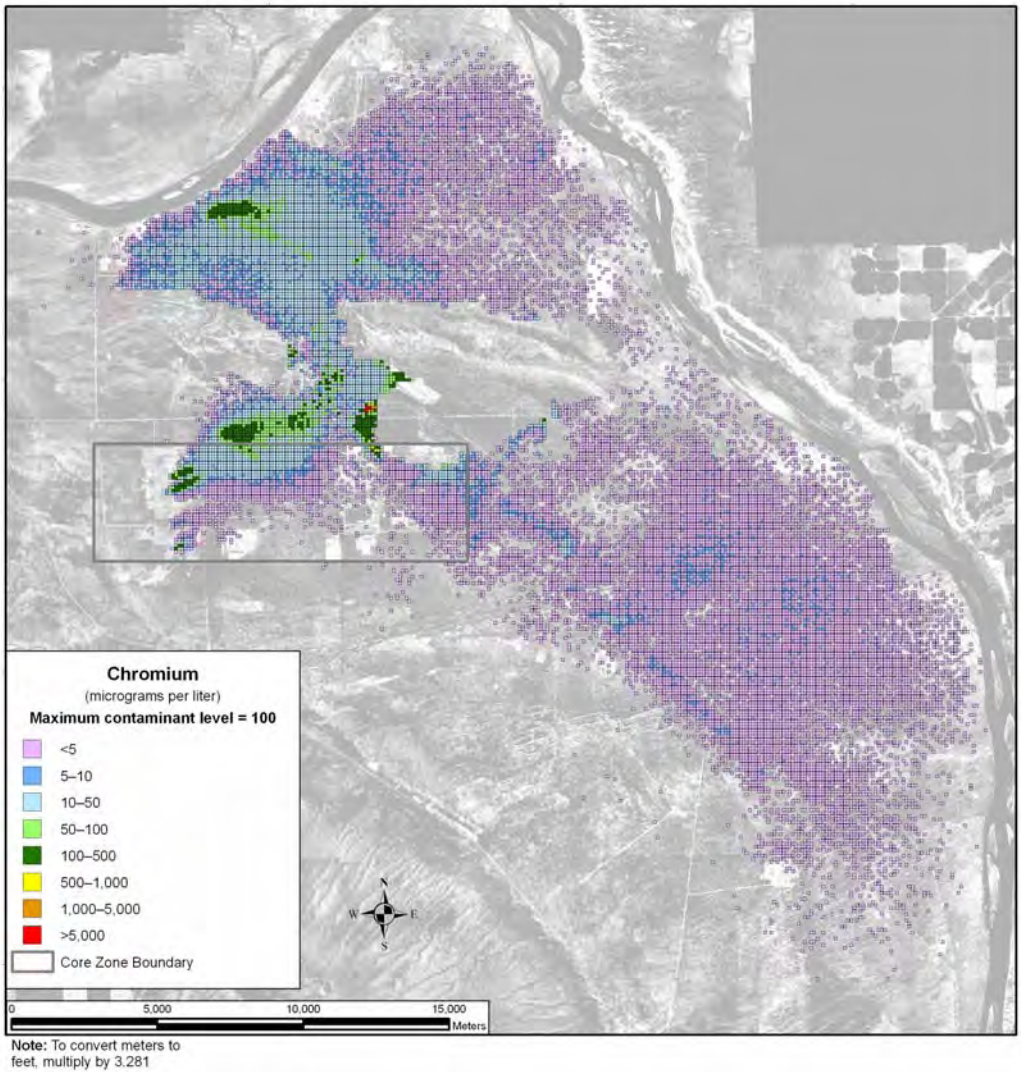


Figure 5–24. Tank Closure Alternative 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

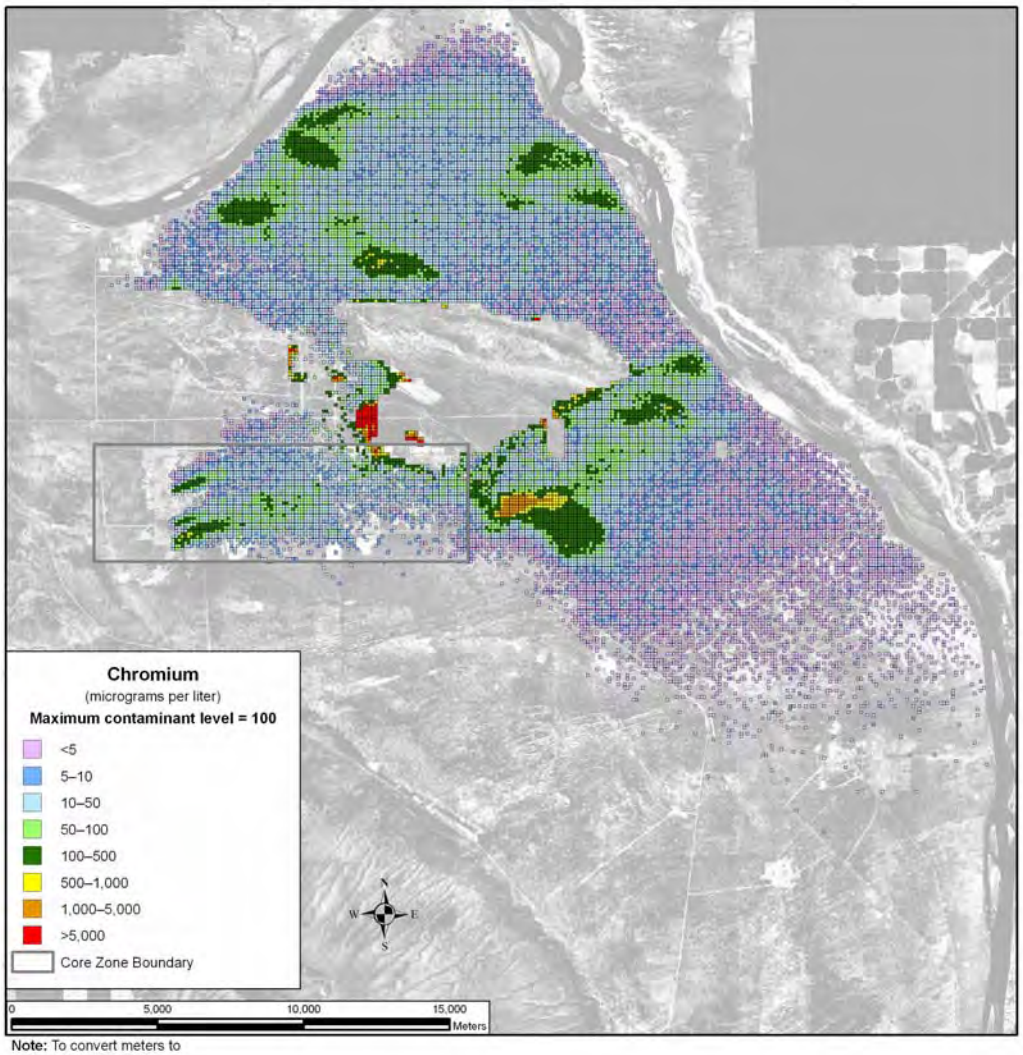


Figure 5–25. Tank Closure Alternative 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

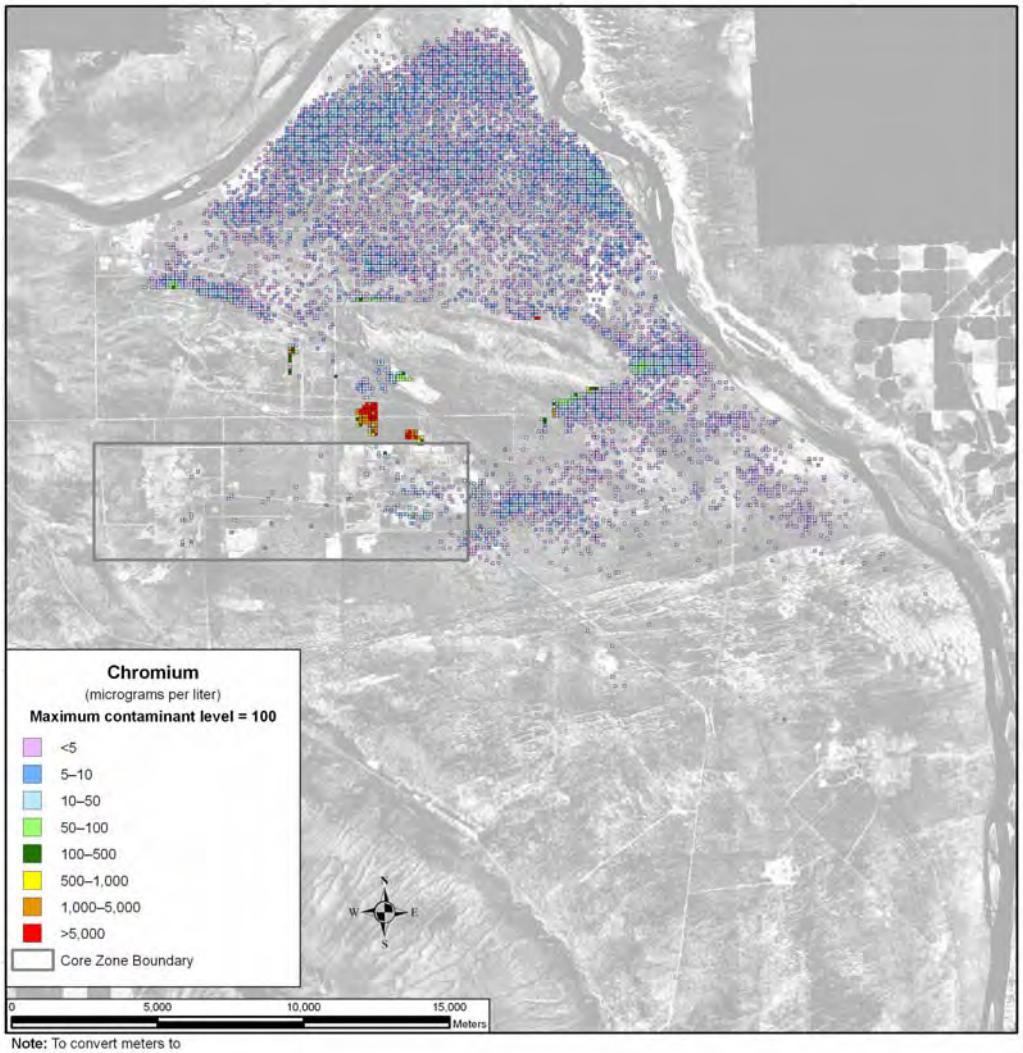


Figure 5–26. Tank Closure Alternative 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

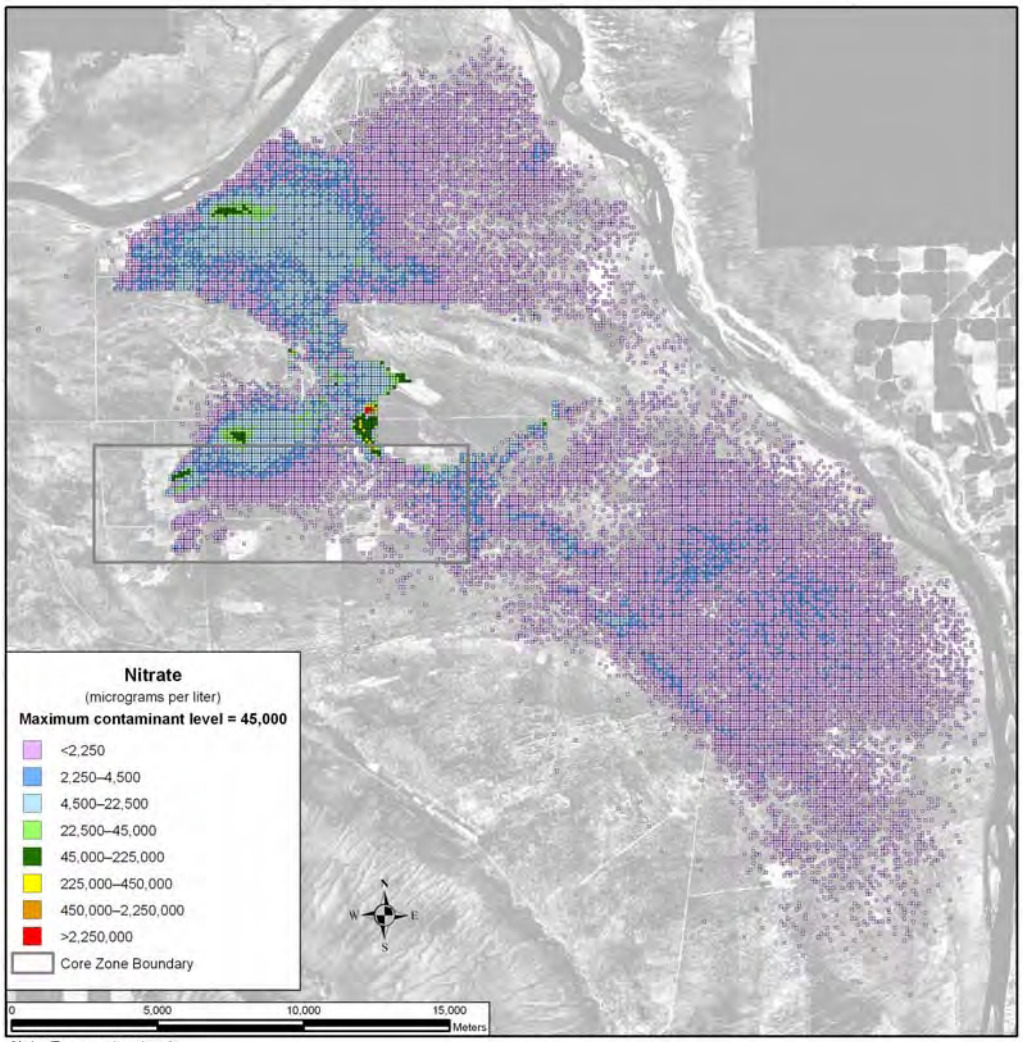


Figure 5–27. Tank Closure Alternative 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

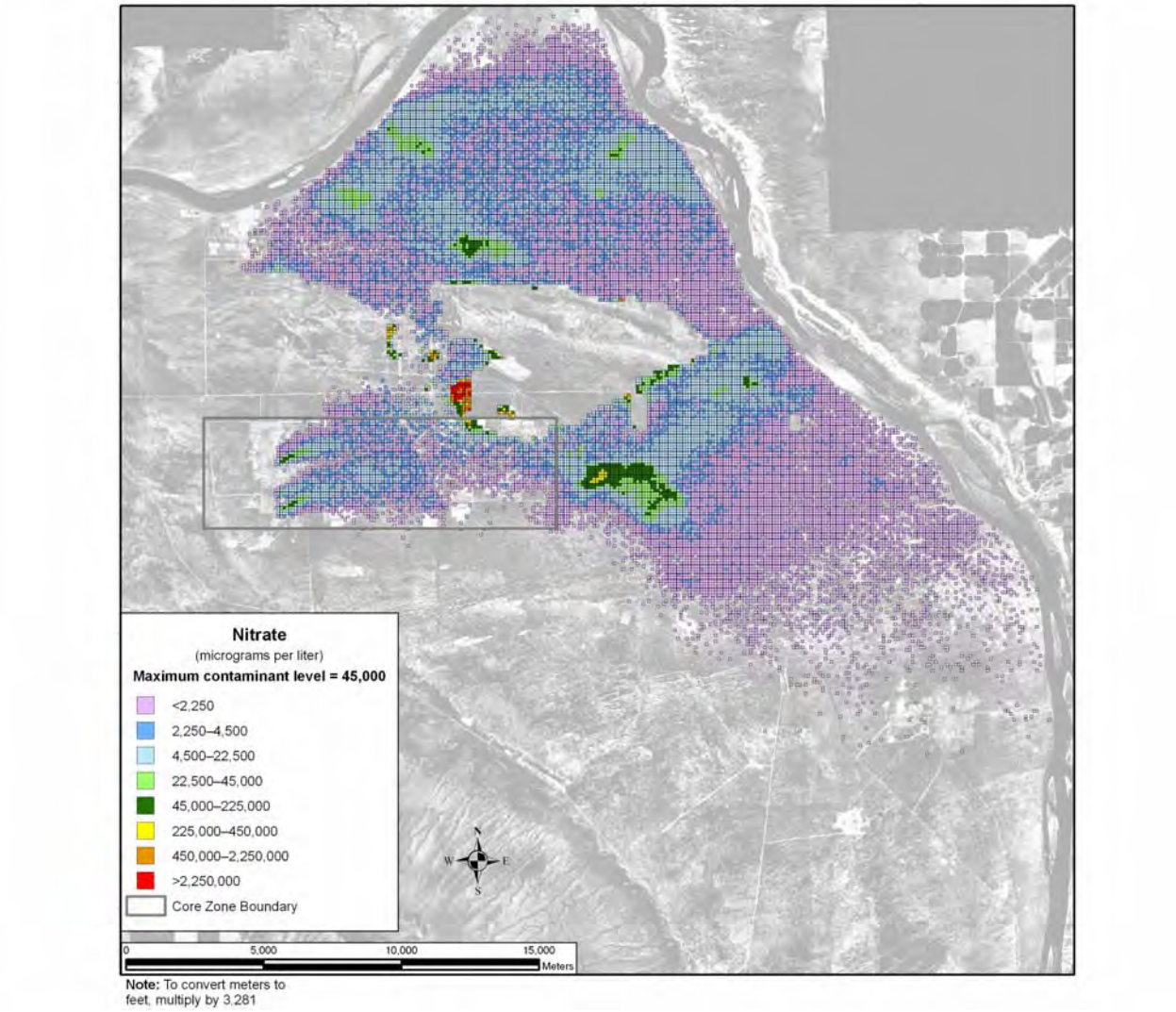


Figure 5–28. Tank Closure Alternative 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

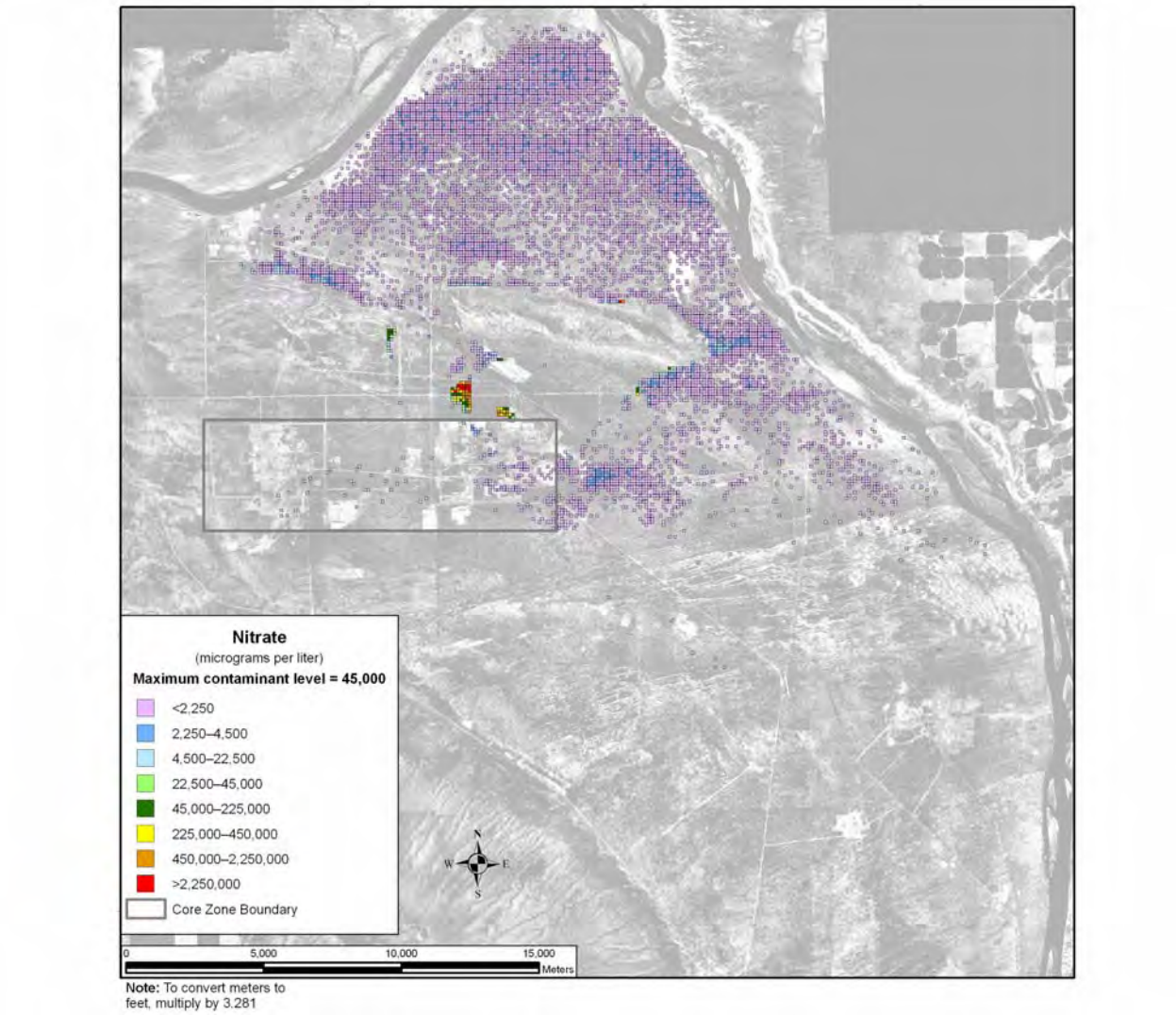


Figure 5–29. Tank Closure Alternative 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium show a different spatial distribution in the analysis over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–30 shows the distribution of uranium-238 during CY 2135. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration that is predominantly contained within the Core Zone Boundary. By CY 3890 (see Figure 5–31), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–32), the greatest development of the plume during the analysis period is seen, resulting primarily from the release of other tank farm sources at the A and B Barriers. Figure 5–33 shows the total area in which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest near the end of the period of analysis. Figures 5–34 through 5–36 show the corresponding spatial distribution for total uranium.

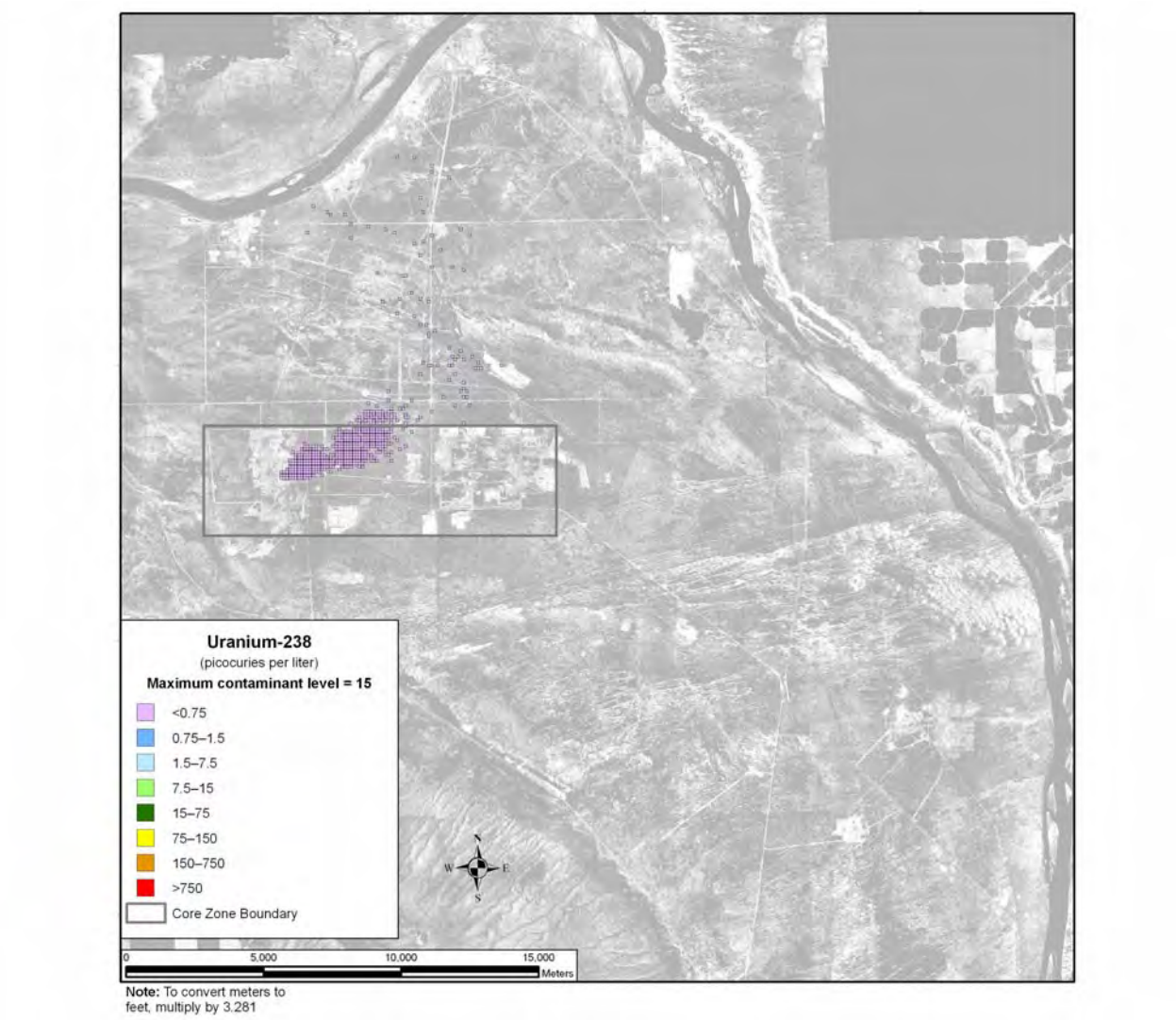


Figure 5–30. Tank Closure Alternative 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135

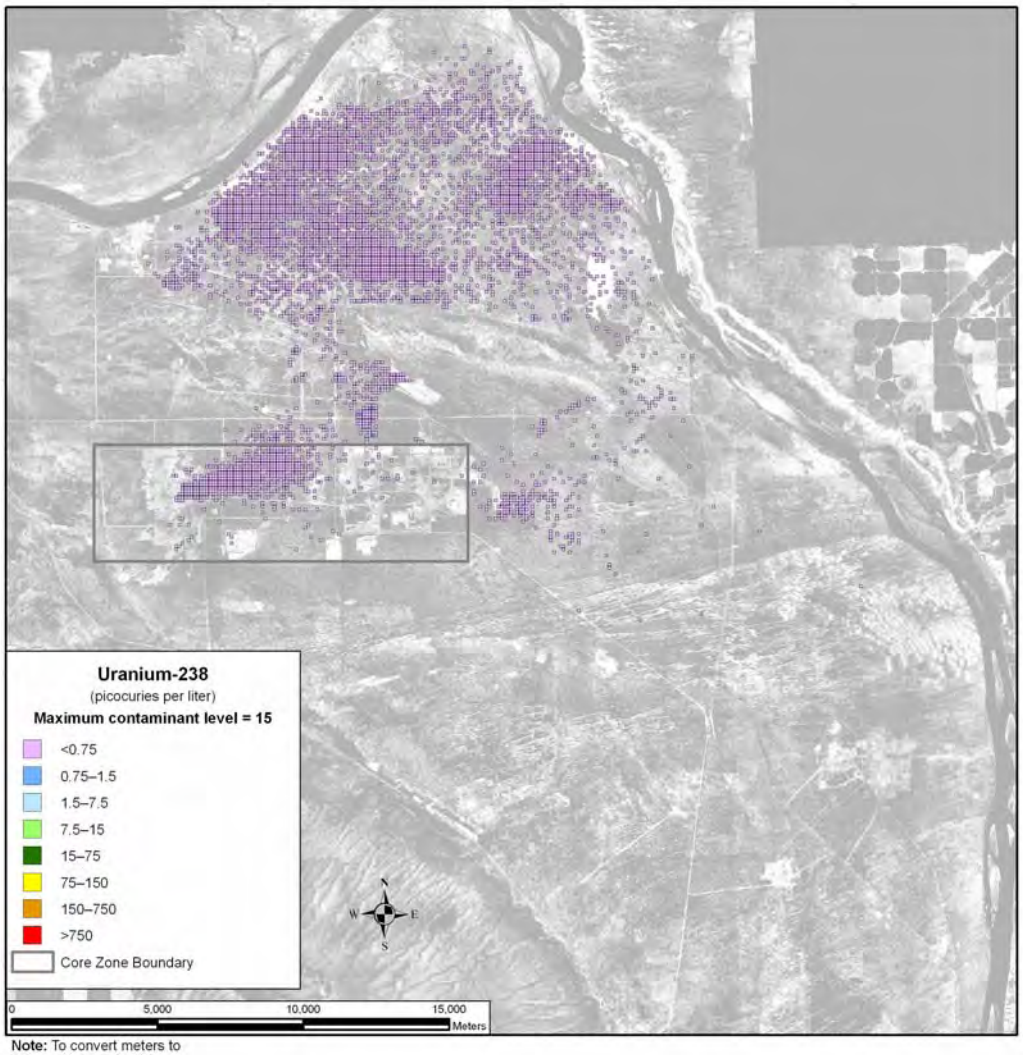


Figure 5–31. Tank Closure Alternative 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890

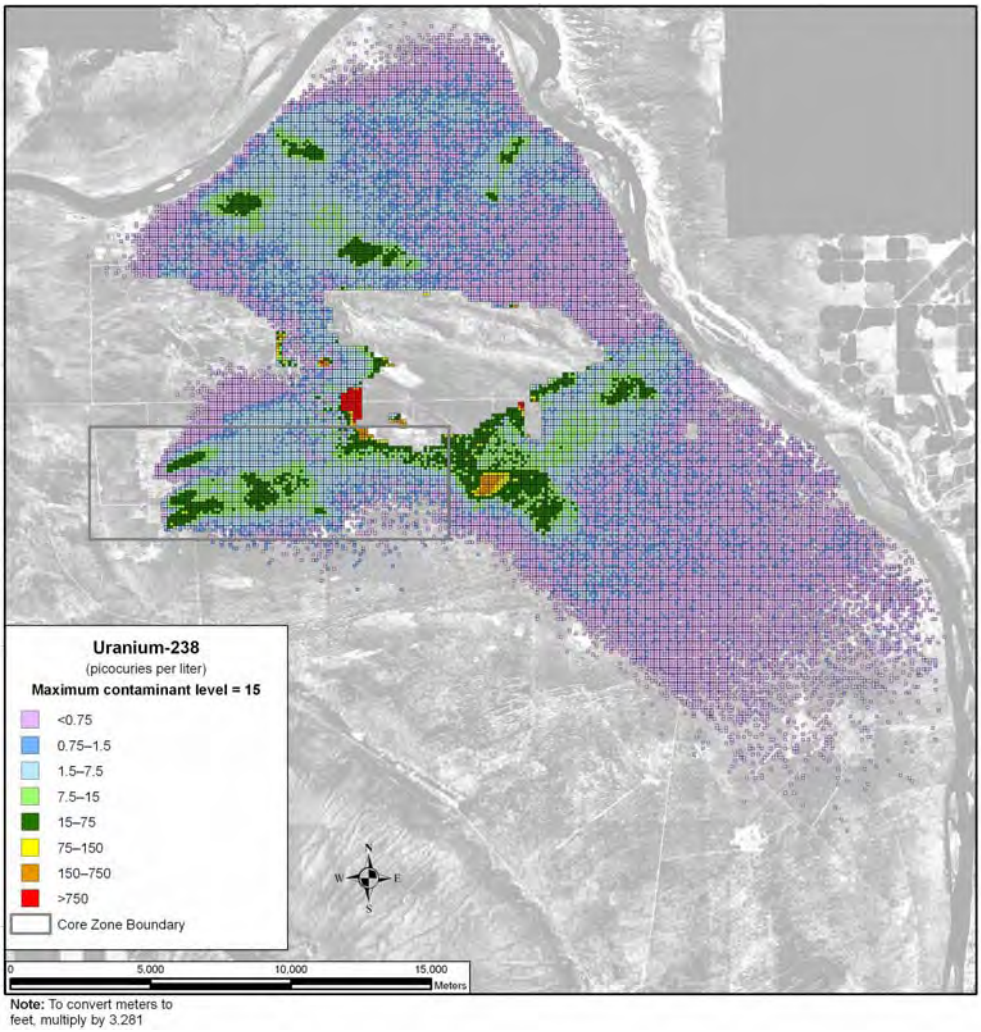


Figure 5–32. Tank Closure Alternative 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

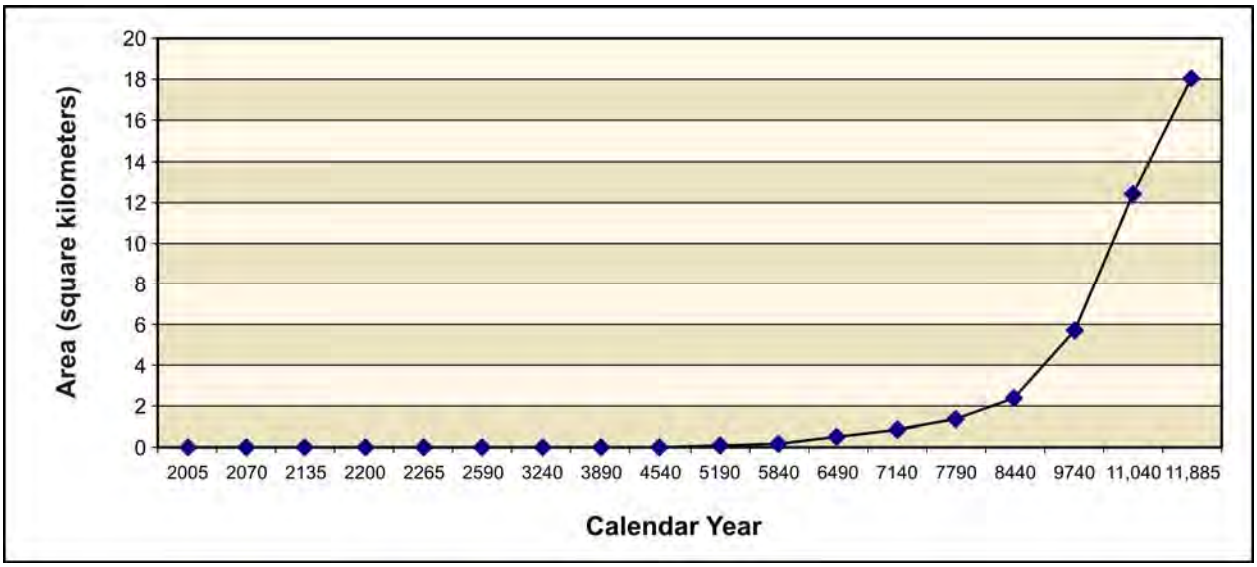


Figure 5–33. Tank Closure Alternative 1 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

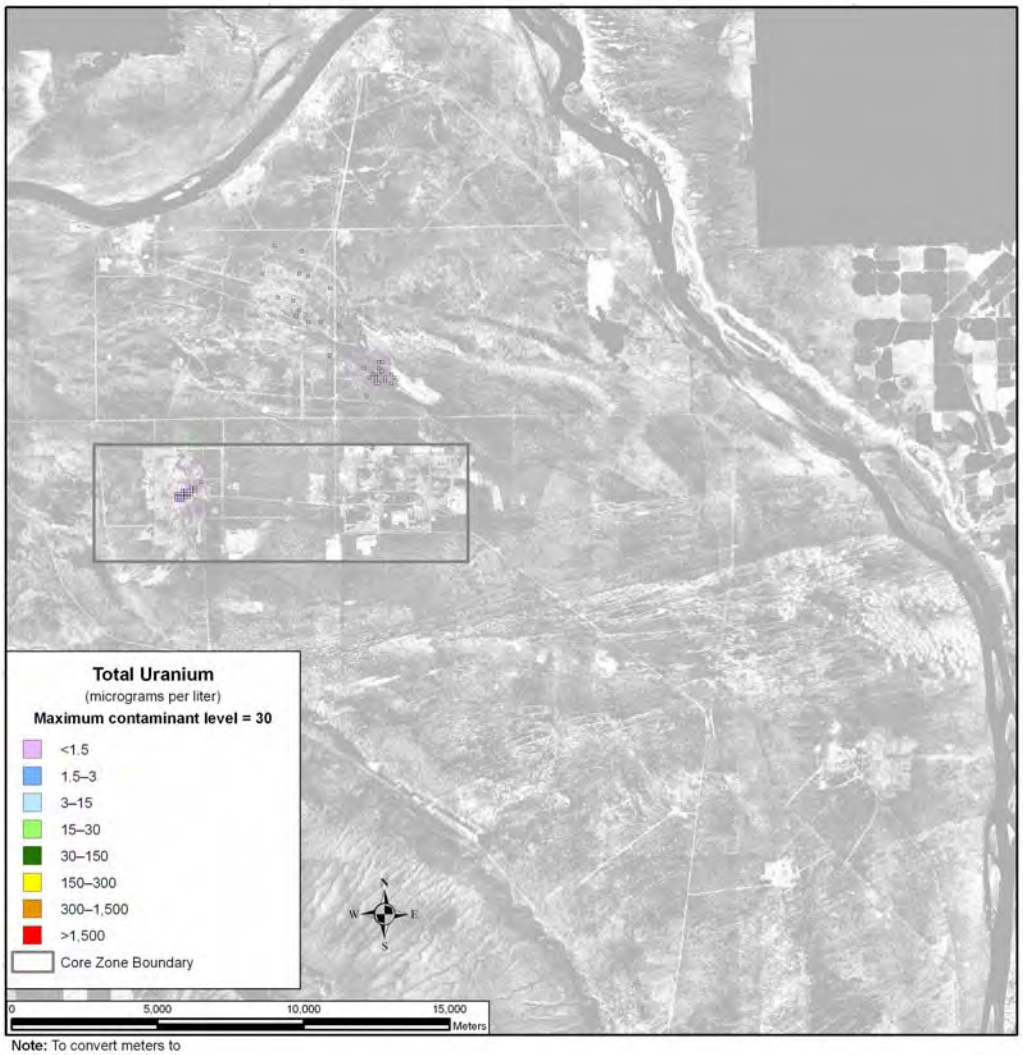


Figure 5–34. Tank Closure Alternative 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

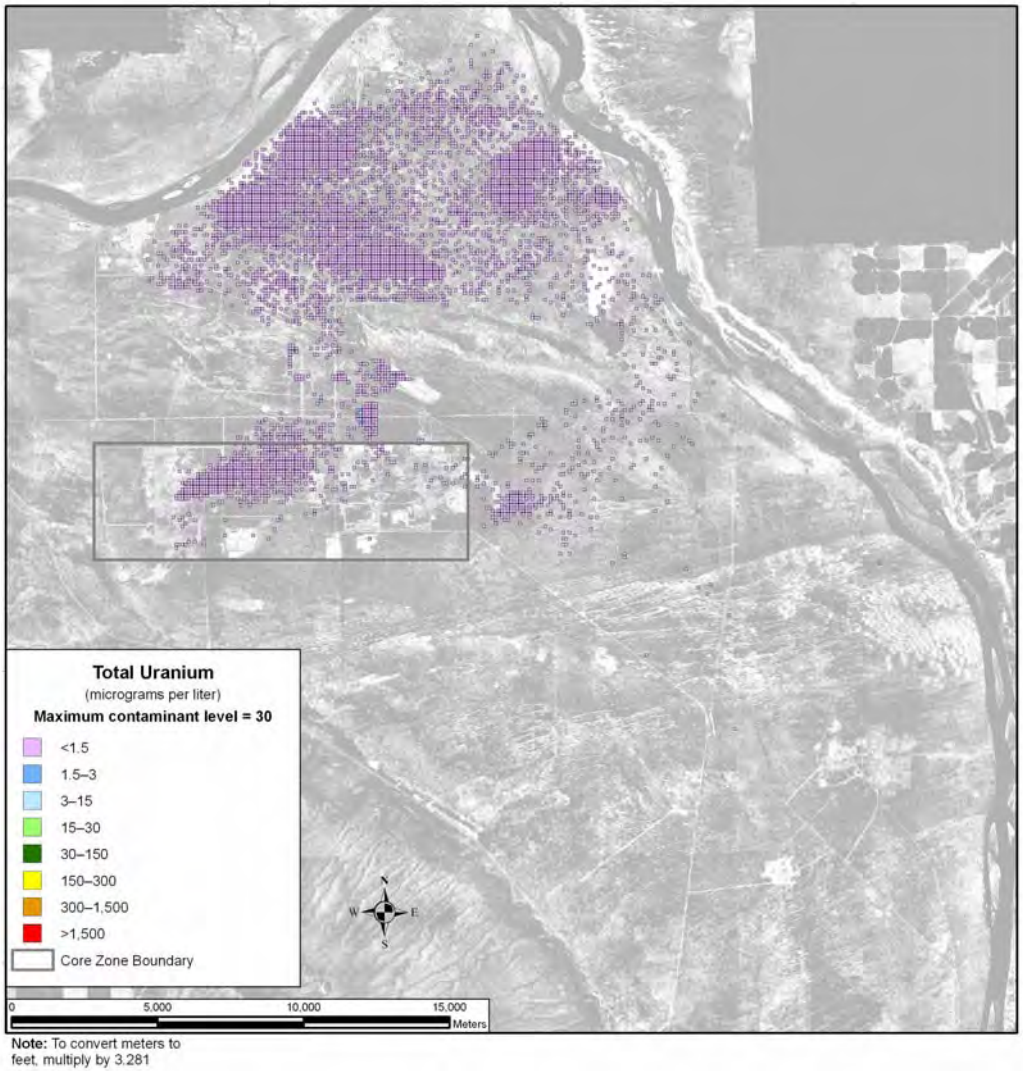


Figure 5–35. Tank Closure Alternative 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890

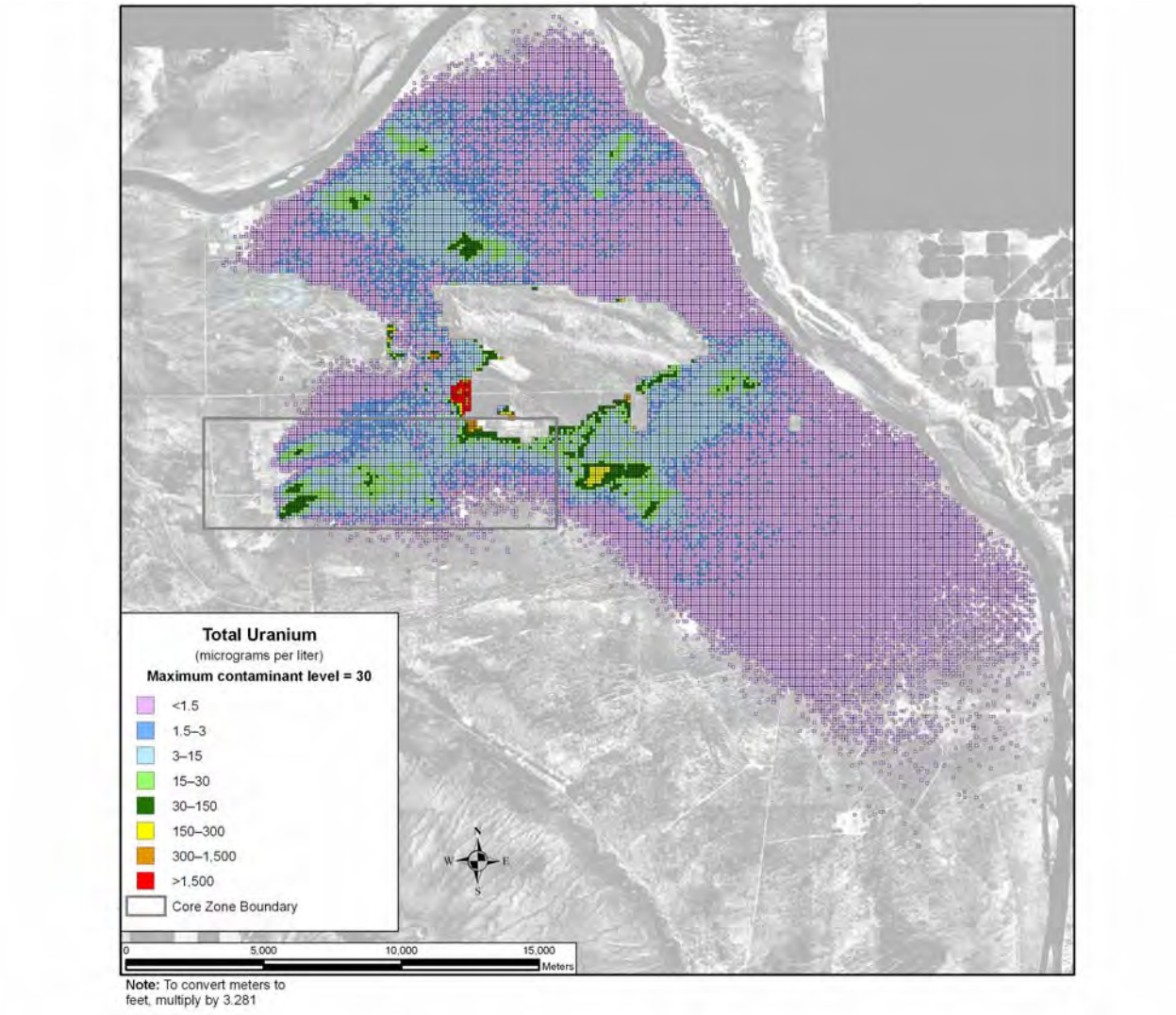


Figure 5–36. Tank Closure Alternative 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

5.1.1.1.6 Summary of Impacts

In general, the inventory remaining in the tank farms, available for release to the environment at the start of the post–administrative control period, is the predominant contributor in the analysis. Discharges to cribs and trenches (ditches) and past leaks during the past-practice period are a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by two to three orders of magnitude during most of the period of analysis. Concentrations at the Columbia River are about two orders of magnitude smaller. The intensities and areas of these groundwater plumes peak between CY 3200 and CY 4000.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark at the Core Zone Boundary beyond CY 6000, and approach the benchmark at the Columbia River after CY 10,000. The peak intensity and area of the contamination plume are largest near the end of the period of analysis.

5.1.1.2 Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure

This section describes the groundwater analysis results for Tank Closure Alternative 2A, including long-term groundwater impacts of contaminant sources within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

5.1.1.2.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 2A are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, three major periods were identified for Tank Closure Alternative 2A, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 2A that are presented in this section would be common to all of the Tank Closure alternatives.

- The retrieval period was assumed to start in 2008 and end in CY 2193. Waste treatment operations were assumed to be complete for immobilized high-level radioactive waste (IHLW) and immobilized low-activity waste (ILAW) in 2093; starting in 2094, tanks and facilities would be maintained in operational standby condition for 100 years. It was assumed that 99 percent of waste volume would be retrieved from the tanks. The leakage rate for SSTs was assumed to be 15,140 liters (4,000 gallons) per SST. Releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system.

- The post–administrative control period was assumed to start in CY 2194 and continue through the 10,000-year period of analysis until CY 11,940. Releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system during the post–administrative control period. In addition, all remaining waste at the SST and DST farms (other tank farm sources) would be released to the vadose zone at the start of the post–administrative control period.

5.1.1.2.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 2A. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Tank Closure Alternative 2A is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 2A were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis.

The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-14}, which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 2A.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e. move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.2.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 2A in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms (see Figures 5–37 through 5–42). Three subtotals are plotted representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–37 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–38, the chemical hazard drivers. The predominant sources for tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers the predominant sources are both past leaks and other tank farm sources.

Figure 5–39 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–40, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone from cribs and trenches (ditches) and past leaks.

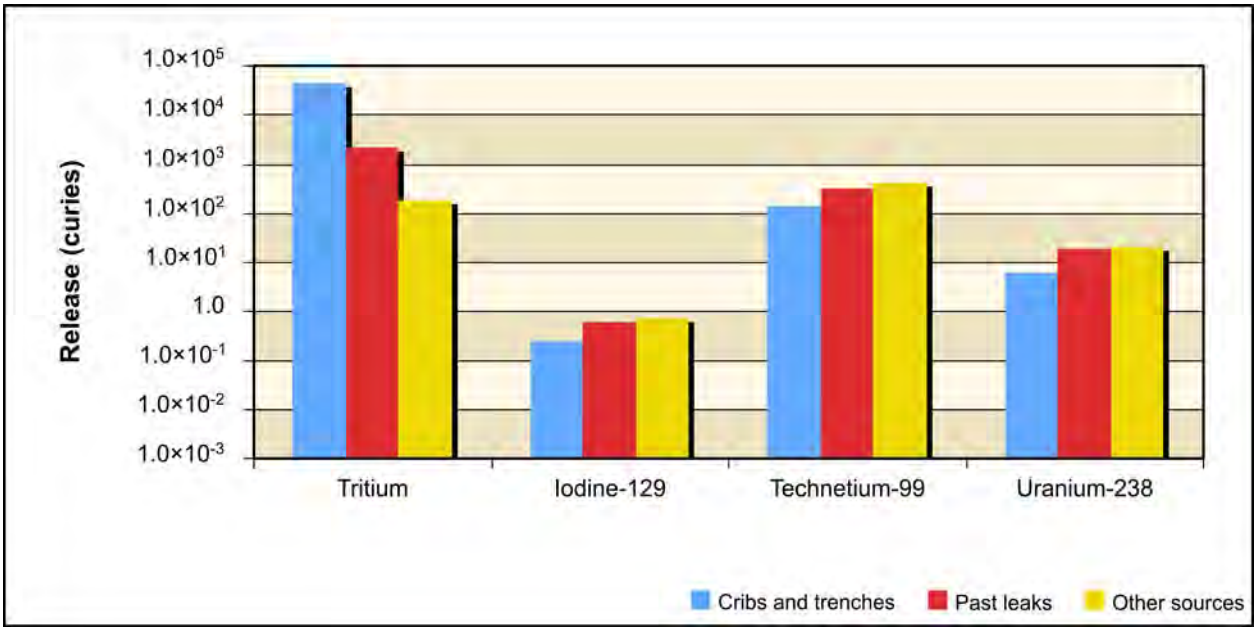


Figure 5–37. Tank Closure Alternative 2A Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

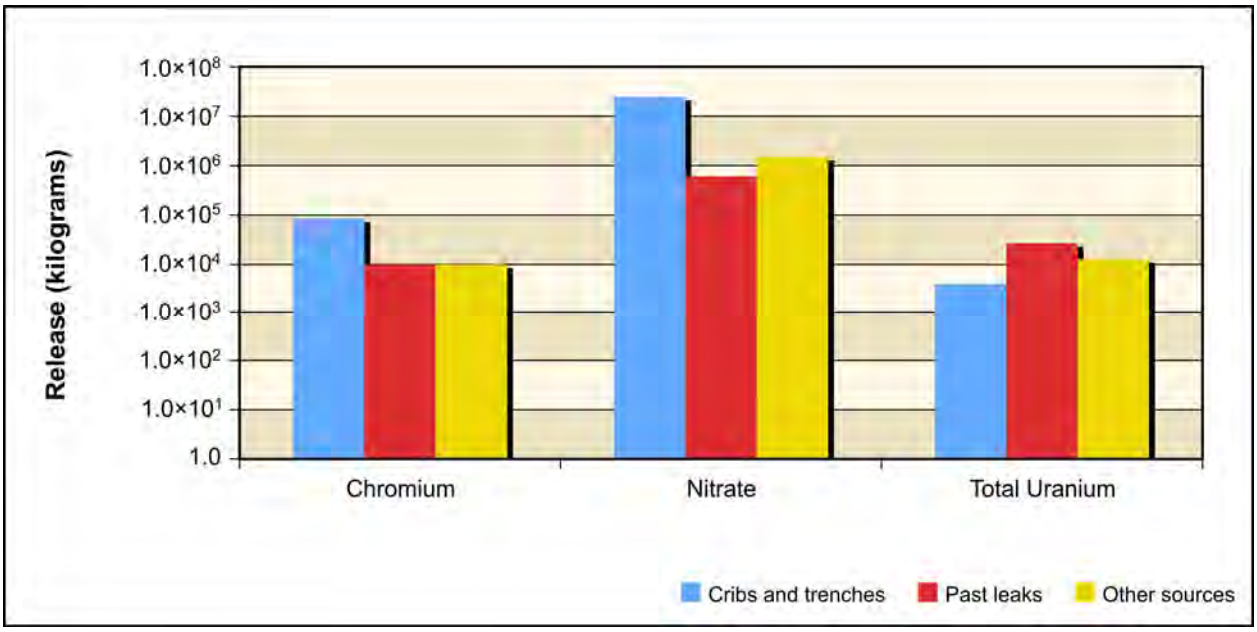


Figure 5–38. Tank Closure Alternative 2A Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

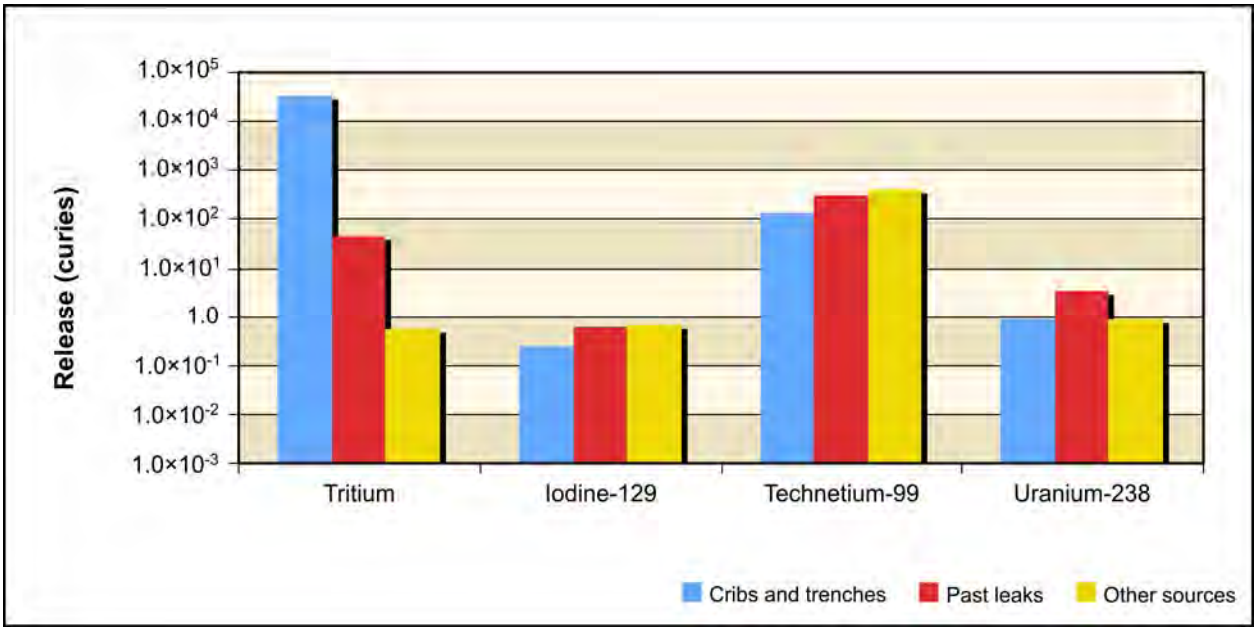


Figure 5–39. Tank Closure Alternative 2A Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

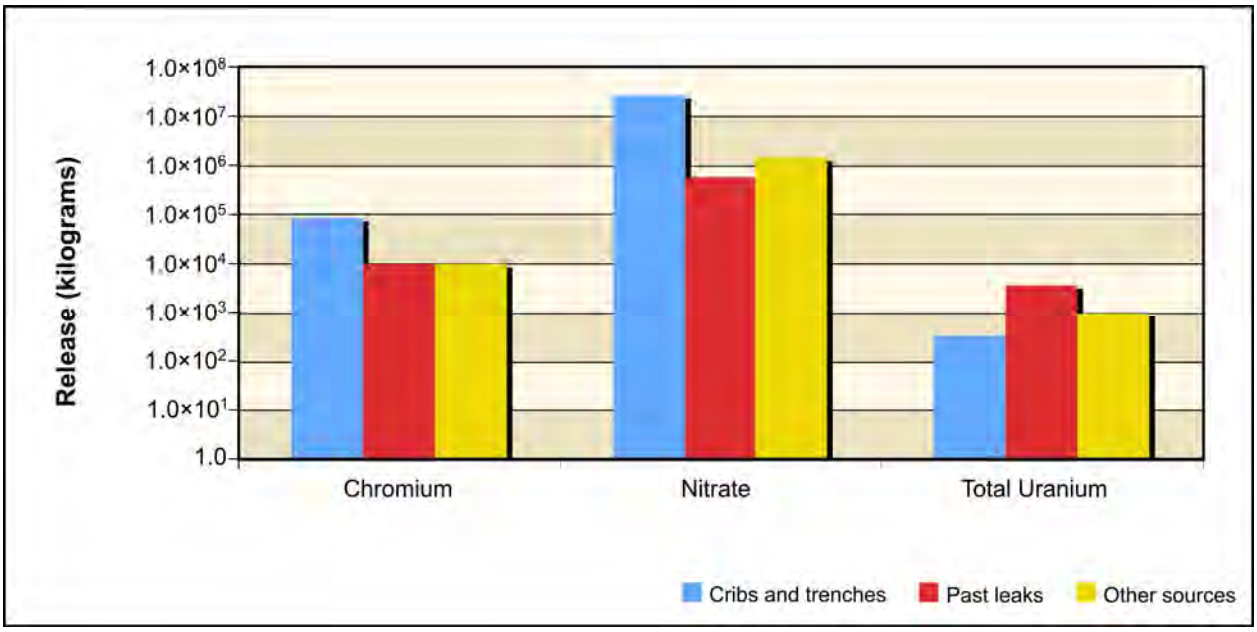


Figure 5–40. Tank Closure Alternative 2A Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For tritium, the amount released to groundwater is attenuated by radioactive decay in the vadose zone. For cribs and trenches (ditches), about 74 percent of the total inventory of tritium reached groundwater in the analysis; for past leaks, only 2 percent; and for other tank farm sources, only one-third of 1 percent of the inventory reached the water table. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process.

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 14 percent of uranium-238 and 8 percent of total uranium inventory reached groundwater during the period of analysis. For past leaks, about 18 percent of uranium-238 and 14 percent of total uranium of the total inventory reached groundwater during the period of analysis. For other tank farm sources, about 4 percent of uranium-238 and 7 percent of total uranium of the total inventory reached groundwater during the period of analysis. These results also suggest that uranium-238 and total uranium impacts would occur later in the post–administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–41 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–42, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reached the Columbia River during the period of analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. For uranium-238 and total uranium, the amount released to the Columbia River is less than that of the release to groundwater because of retardation. Overall, about 38 percent of the amount of uranium-238 and about 40 percent of total uranium released to groundwater reached the Columbia River during the period of analysis. These results also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post–administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

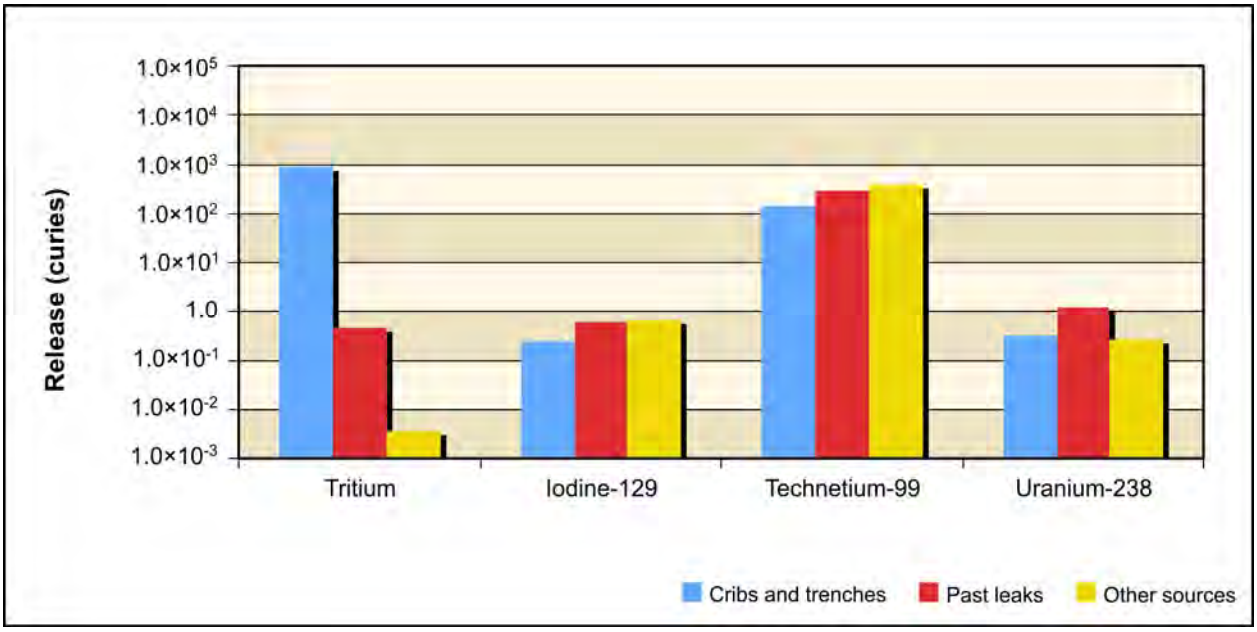


Figure 5–41. Tank Closure Alternative 2A Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

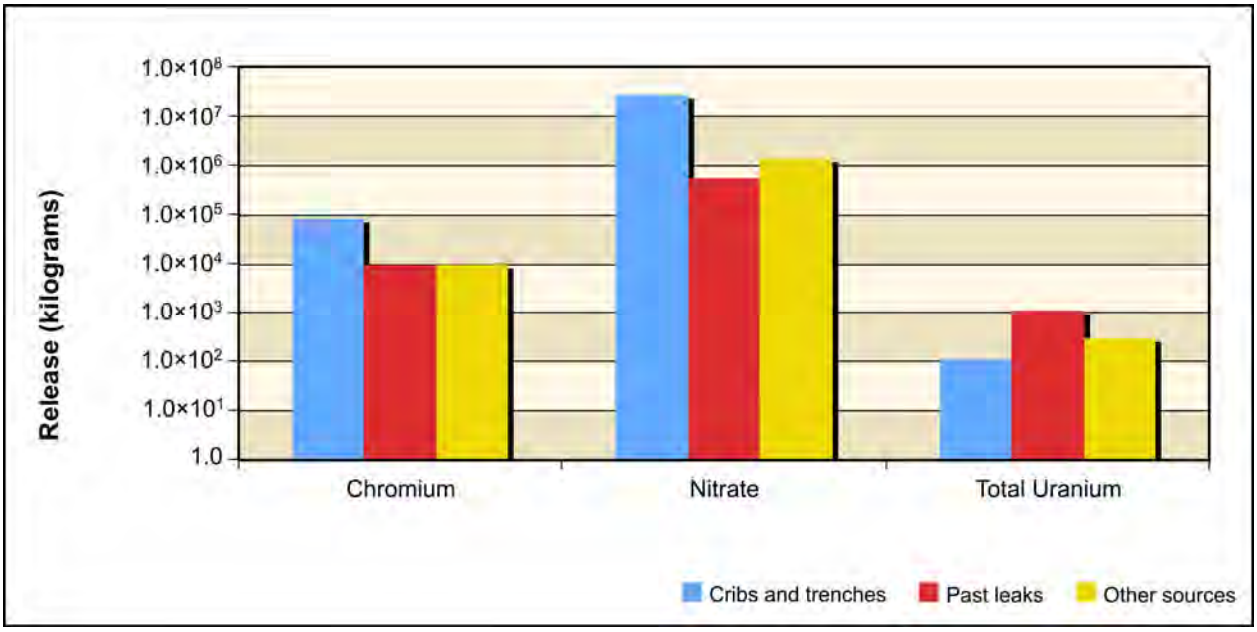


Figure 5–42. Tank Closure Alternative 2A Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.2.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 2A impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Table 5–2 and Figures 5–43 through 5–49). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–2 lists the maximum concentrations of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore.

Table 5–2. Tank Closure Alternative 2A Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	35	5,030	51	5,220	13	5,630	135	20,000
	(2052)	(2051)	(2050)	(2061)	(2050)	(2051)	(2050)	
Technetium-99	**1,590**	**31,700**	**2,820**	**15,000**	546	**27,800**	204	900
	(2055)	(2076)	(2050)	(2051)	(2096)	(2076)	(3464)	
Iodine-129	**3**	**50**	**5**	**30**	**1**	**43**	0.4	1
	(2057)	(2072)	(2050)	(2051)	(2089)	(2072)	(3355)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	3	**142**	7	**42**	11	**148**	1	15
	(11,707)	(11,814)	(11,714)	(11,799)	(11,763)	(11,828)	(11,783)	
Chemical in micrograms per liter								
Acetonitrile	1	0	0	0	0	1	0	100
	(3341)	(1940)	(3417)	(1940)	(1940)	(3551)	(3617)	
Chromium	12	**4,260**	**290**	**800**	17	**1,960**	32	100
	(2070)	(2085)	(2050)	(2050)	(2086)	(2066)	(2603)	
Nitrate	11,600	**1,640,000**	10,000	**168,000**	5,800	**1,100,000**	9,100	45,000
	(2068)	(2081)	(2073)	(2086)	(2083)	(2059)	(2400)	
Total uranium	1	**190**	8	20	15	**196**	1	30
	(11,805)	(11,839)	(9863)	(11,709)	(10,978)	(11,624)	(11,809)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

Figure 5–43 shows concentration versus time for tritium. Releases from cribs and trenches (ditches) cause groundwater concentrations to exceed benchmark concentrations by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore are over an order of magnitude below the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2040.

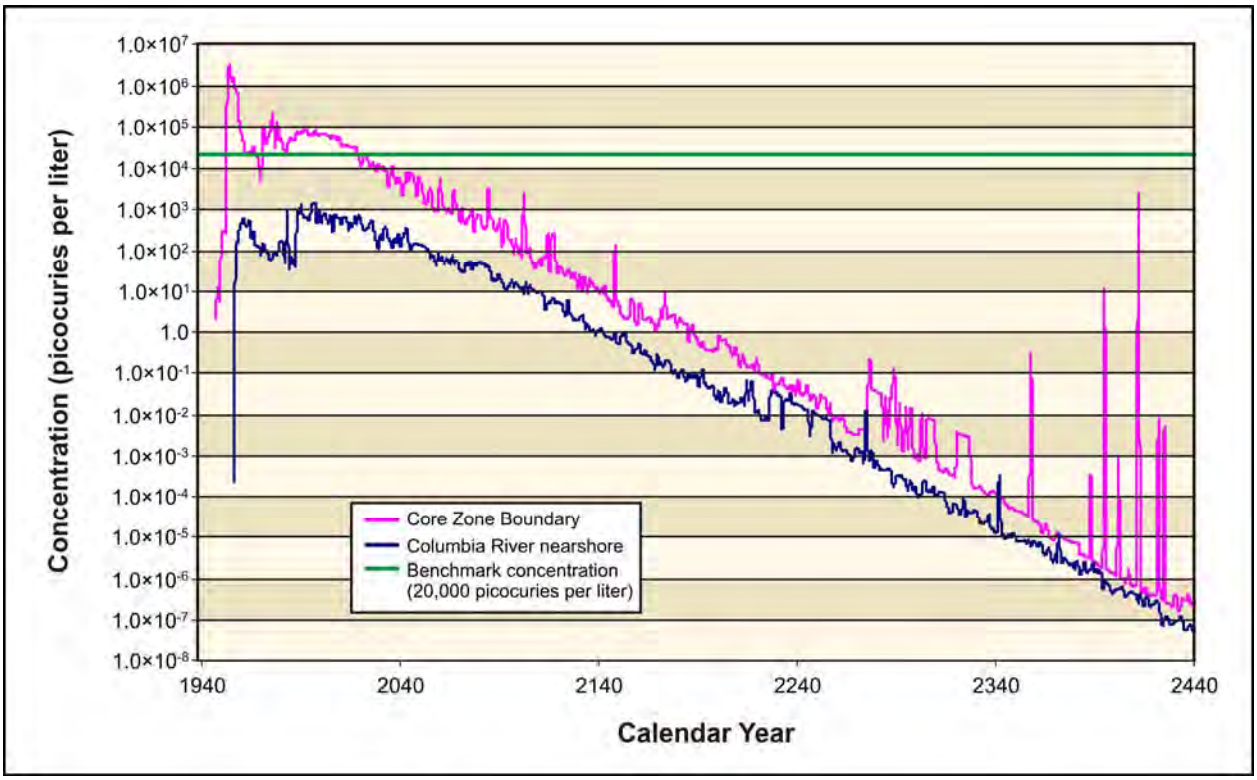


Figure 5–43. Tank Closure Alternative 2A Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–44 through 5–47 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from cribs and trenches (ditches) cause groundwater concentrations at the Core Zone Boundary to exceed benchmark concentrations by about two to three orders of magnitude during the early part of the period of analysis, but return to levels below the benchmark by CY 5000. During this time, groundwater concentrations at the Columbia River nearshore are about an order of magnitude less than the benchmark concentration and gradually decrease to around one to two orders of magnitude less than the benchmark concentration.

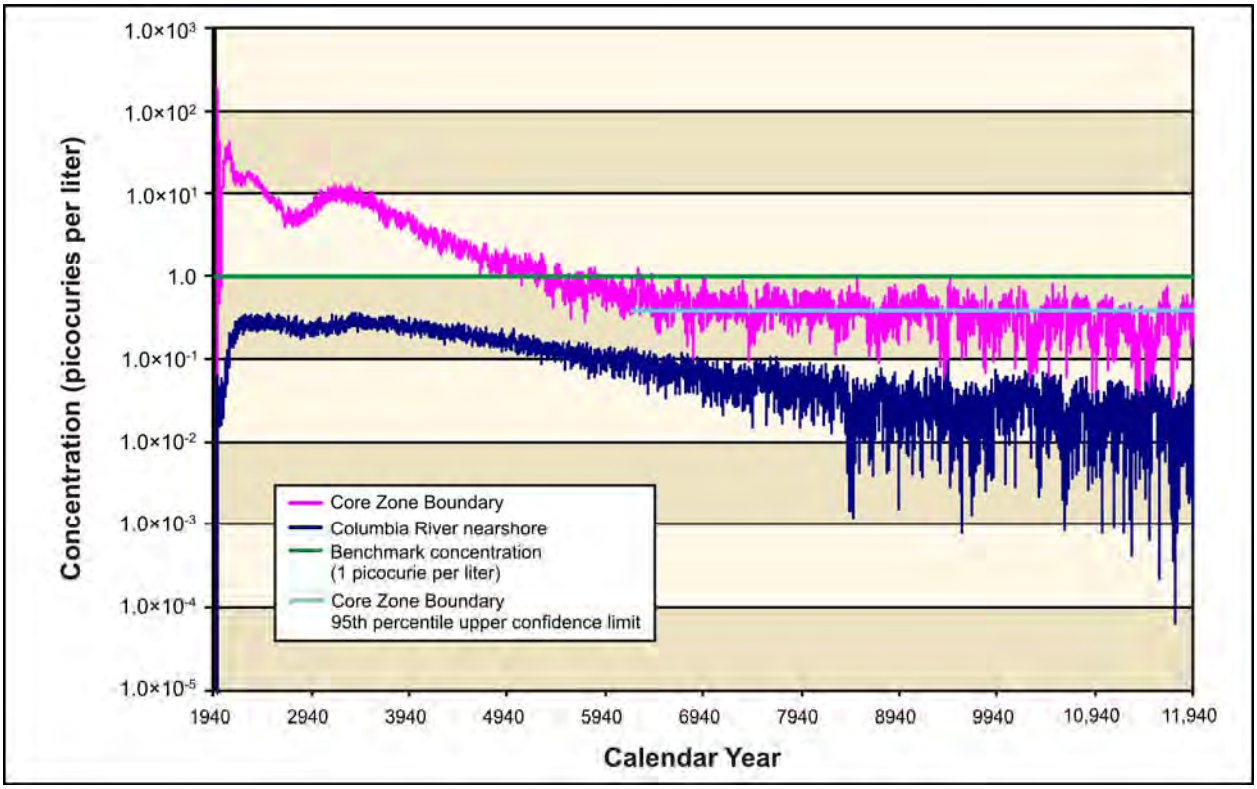


Figure 5–44. Tank Closure Alternative 2A Iodine-129 Concentration Versus Time

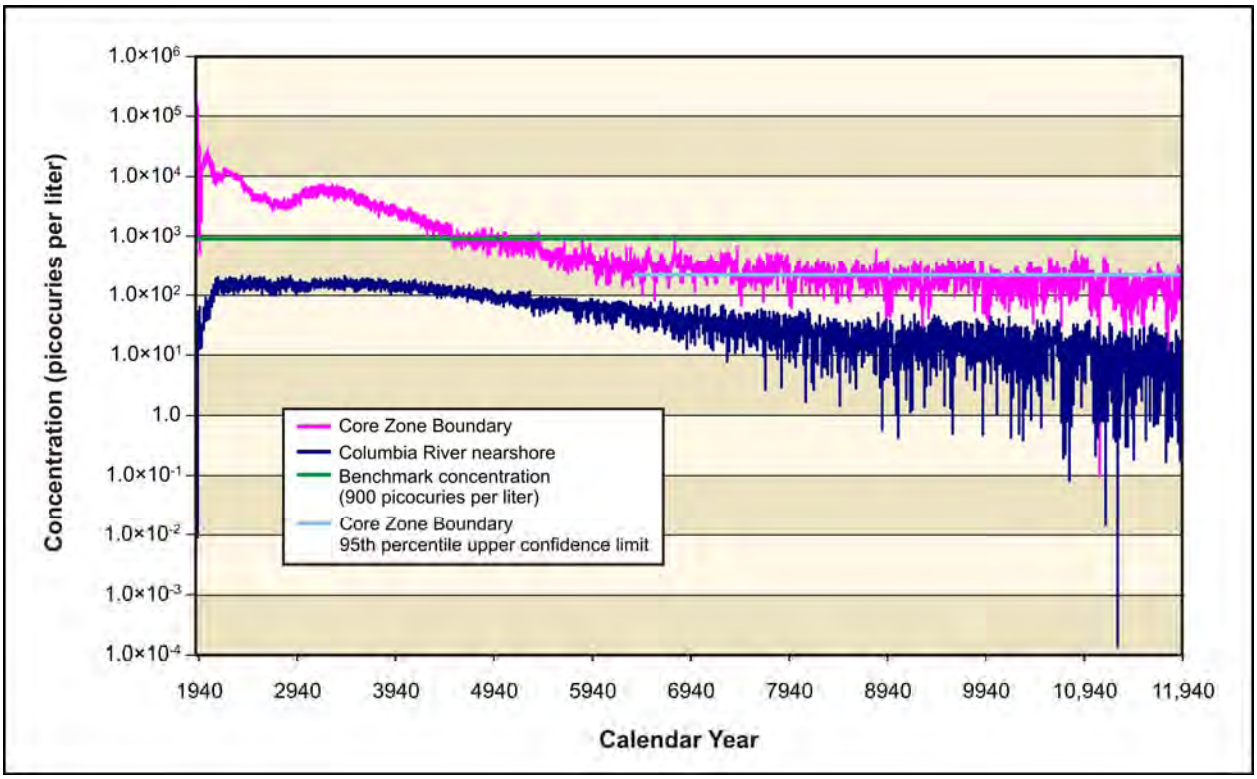


Figure 5–45. Tank Closure Alternative 2A Technetium-99 Concentration Versus Time

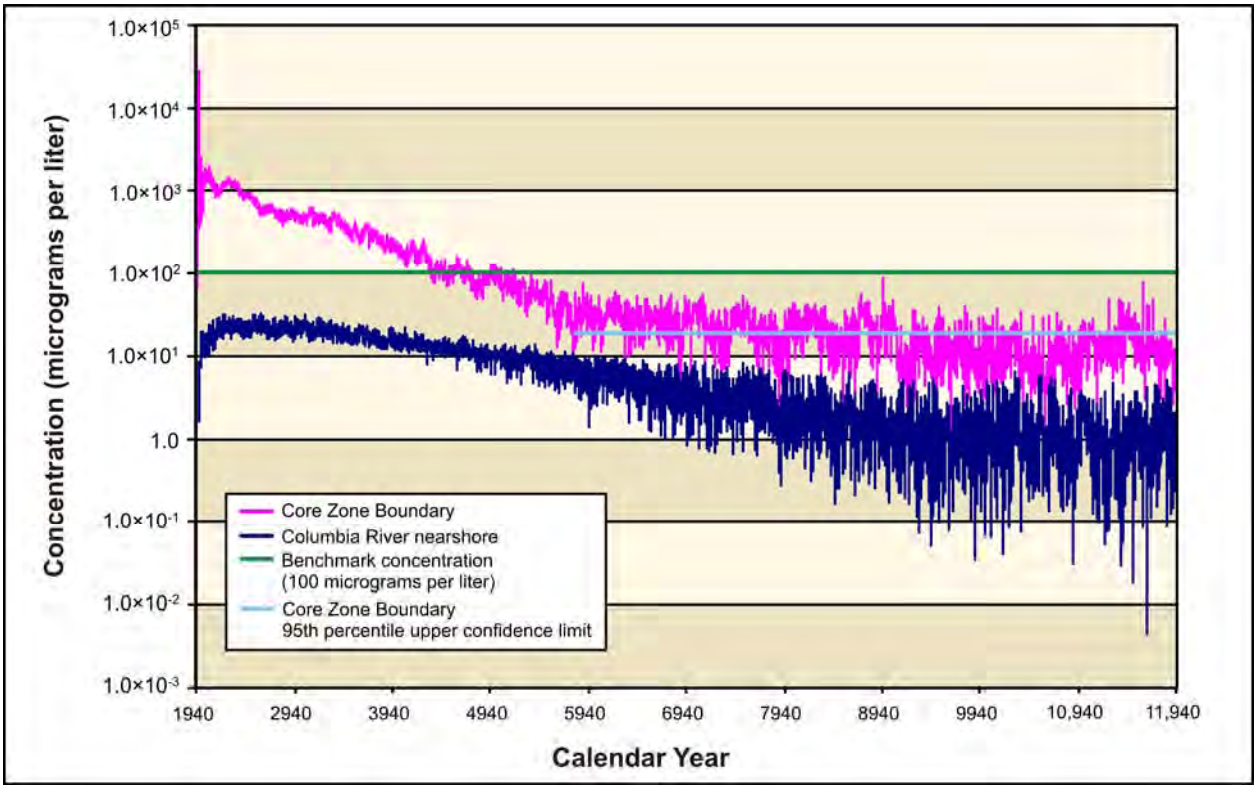


Figure 5–46. Tank Closure Alternative 2A Chromium Concentration Versus Time

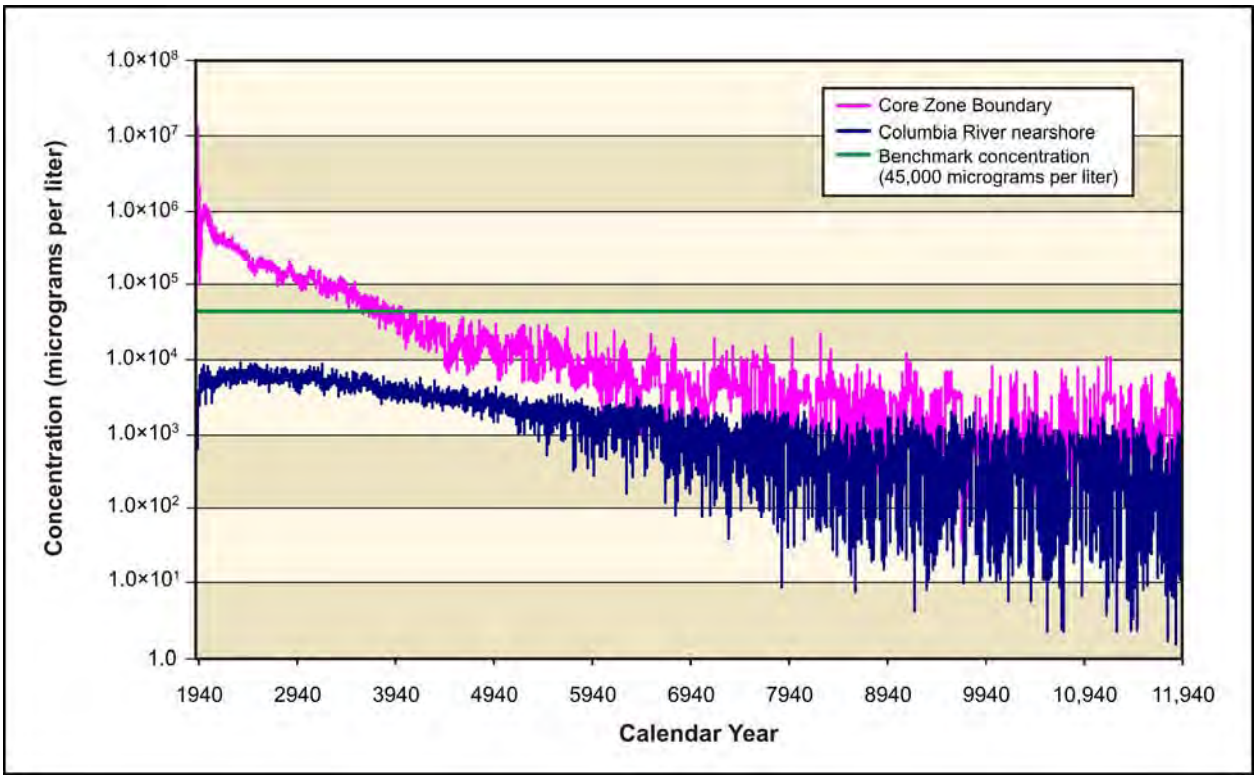


Figure 5–47. Tank Closure Alternative 2A Nitrate Concentration Versus Time

Figures 5–48 and 5–49 show concentration versus time for uranium-238 and total uranium. Early releases from cribs and trenches (ditches) result in groundwater concentrations that are one to two orders of magnitude lower than benchmark concentrations. Concentrations continue to rise throughout the duration of the period of analysis, first surpassing the benchmark concentration at the Core Zone Boundary near CY 5900 for uranium-238 and near CY 6900 for total uranium. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, but stay below an order of magnitude less than the benchmark concentration.

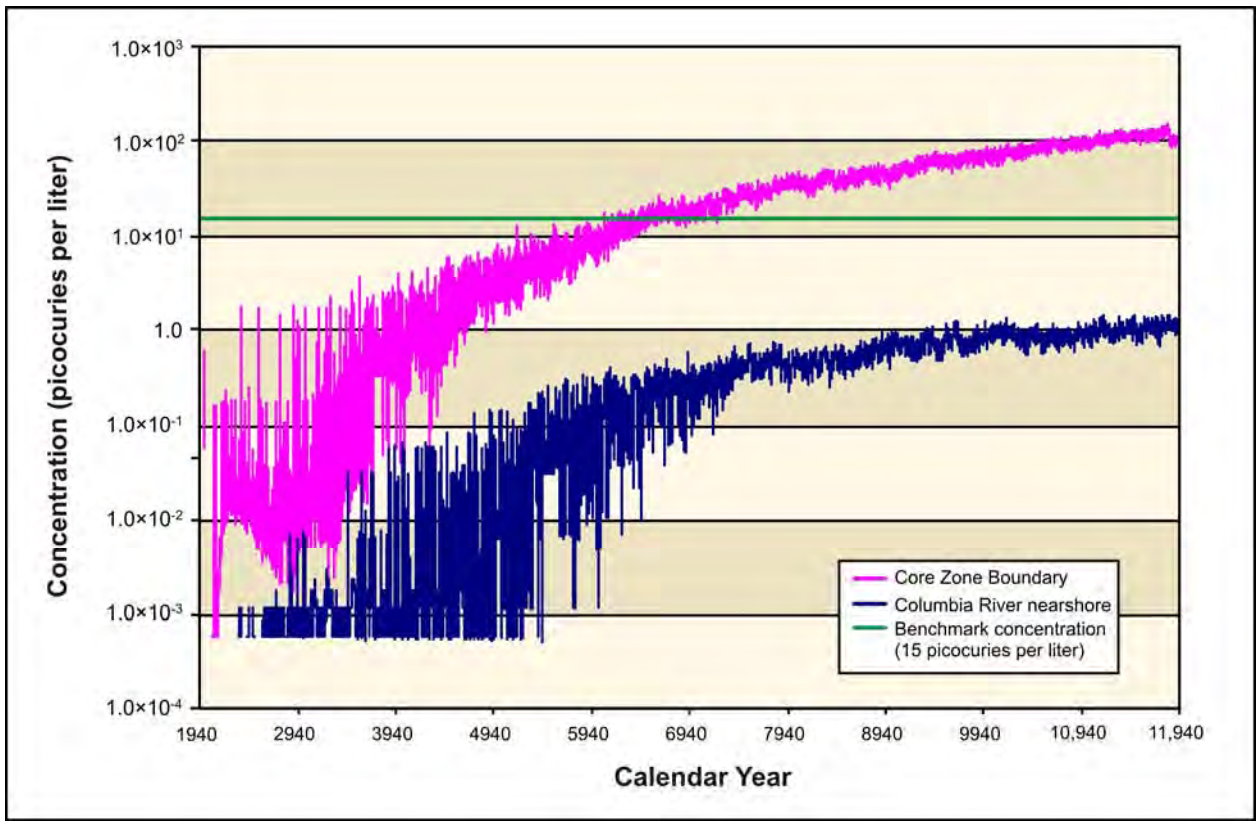


Figure 5–48. Tank Closure Alternative 2A Uranium-238 Concentration Versus Time

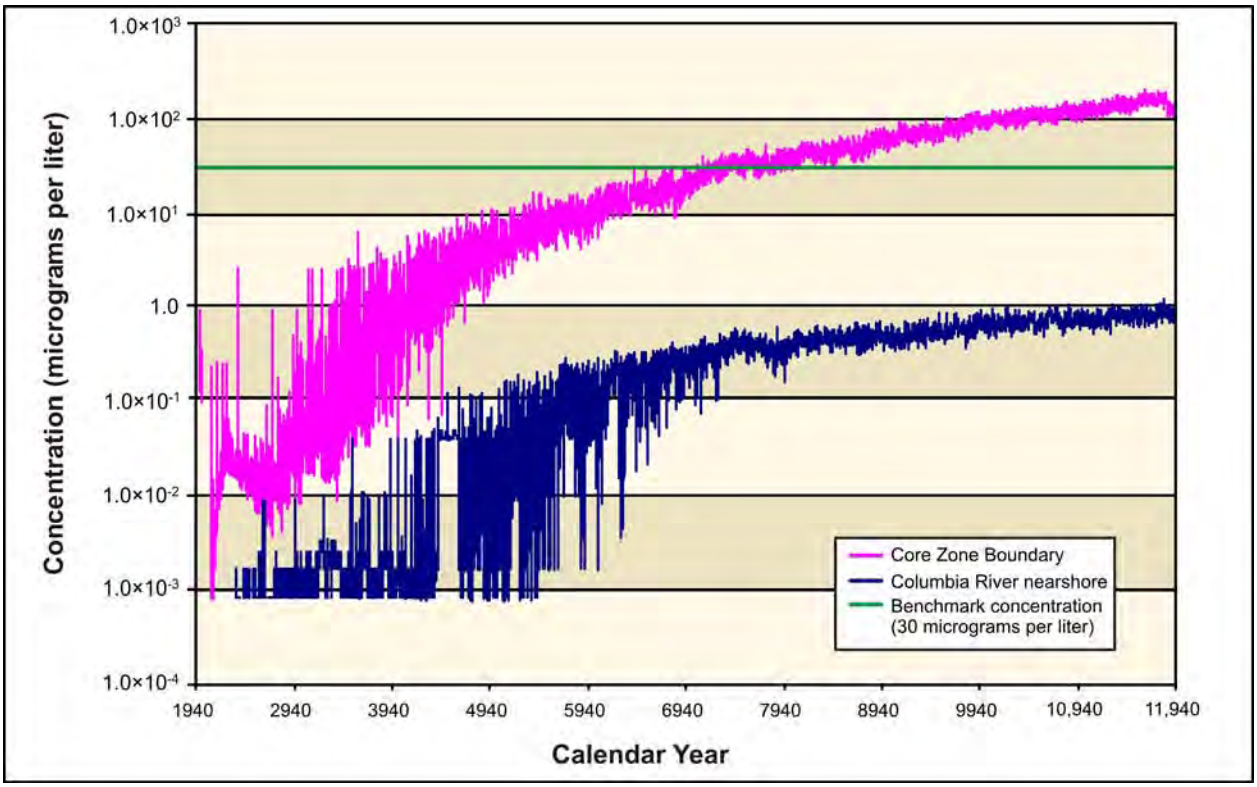


Figure 5–49. Tank Closure Alternative 2A Total Uranium Concentration Versus Time

5.1.1.2.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 2A in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–50 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 5 to 19 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135 (see Figure 5–51).

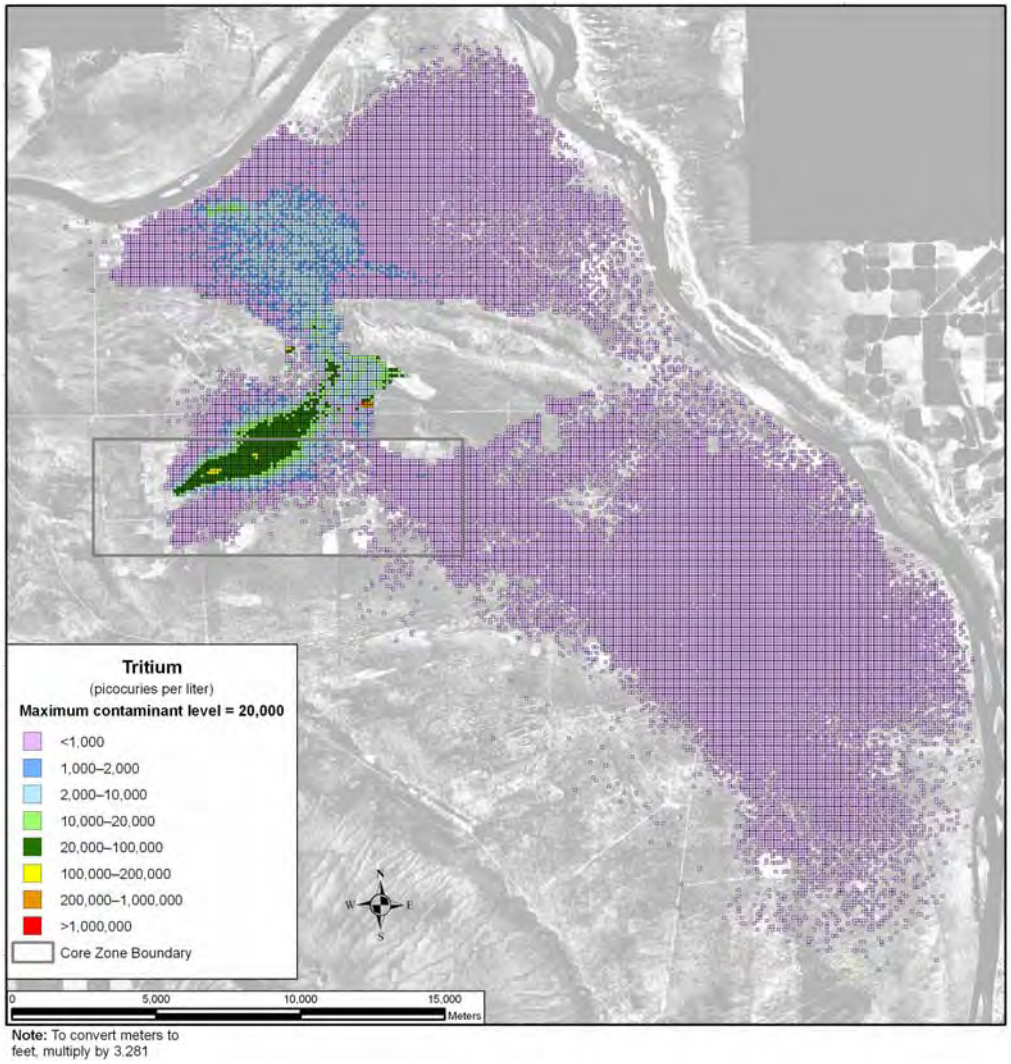


Figure 5–50. Tank Closure Alternative 2A Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

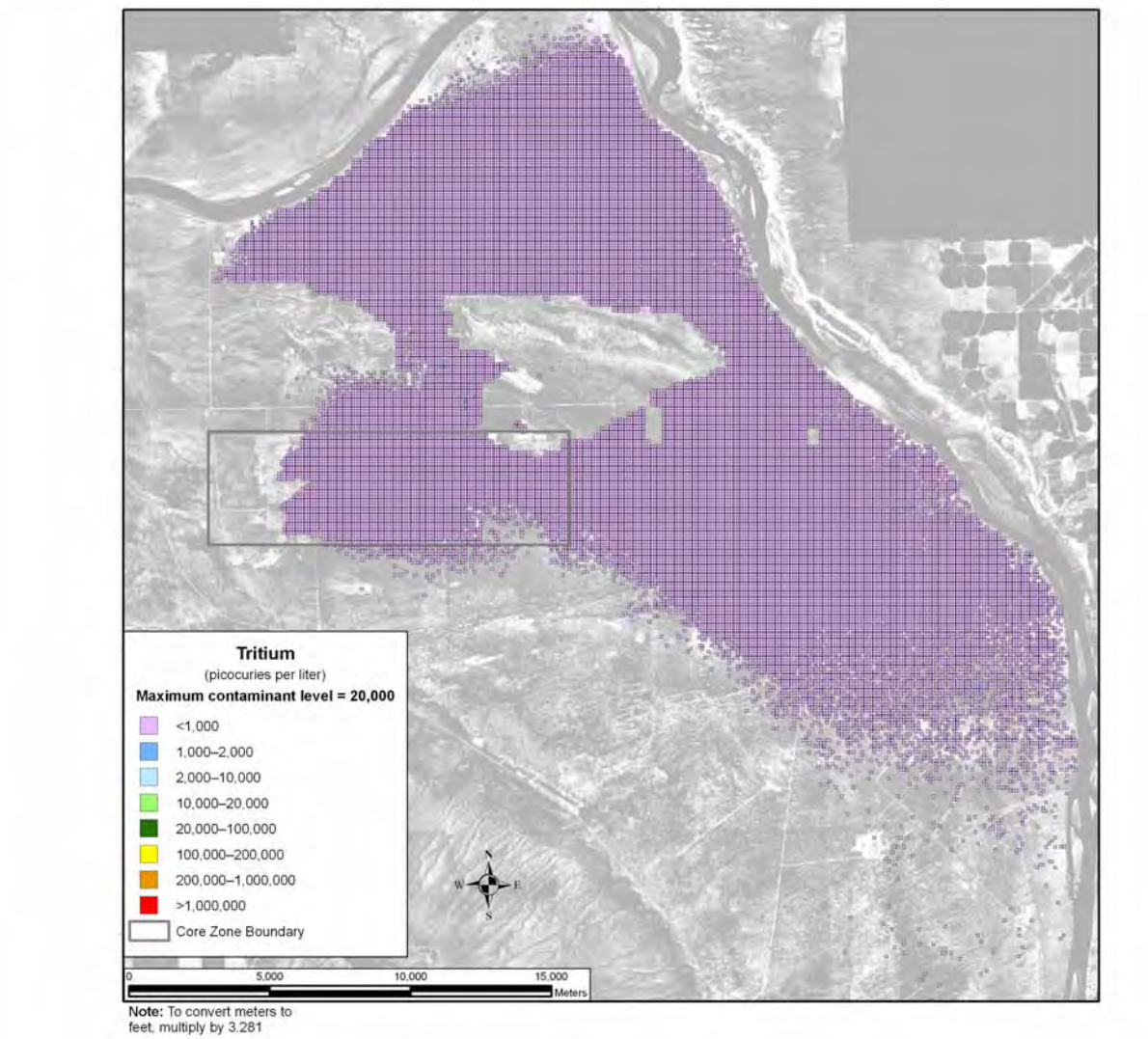


Figure 5–51. Tank Closure Alternative 2A Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

Figure 5–52 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks result in a low-concentration plume that extends over most of the site but exceeds the benchmark concentration in only a few patches in and around the Core Zone Boundary. In CY 2135, the iodine-129 concentration continues to exceed the benchmark concentration in a few areas, just north of the Core Zone Boundary in Gable Gap (see Figure 5–53). At CY 3890, the majority of the plume has concentrations below the benchmark concentration, although there is a high-concentration patch north of the Core Zone Boundary and east of the 200-East Area that remains above the benchmark (see Figure 5–54). By CY 7140, most of the mass in the plume has reached the Columbia River, with only isolated pockets of high-concentration areas where the groundwater flow velocities are extremely small (see Figure 5–55). Technetium-99 (see Figures 5–56 through 5–58), chromium (see Figures 5–59 through 5–61), and nitrate (see Figures 5–62 and 5–63) show similar spatial distributions at similarly selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

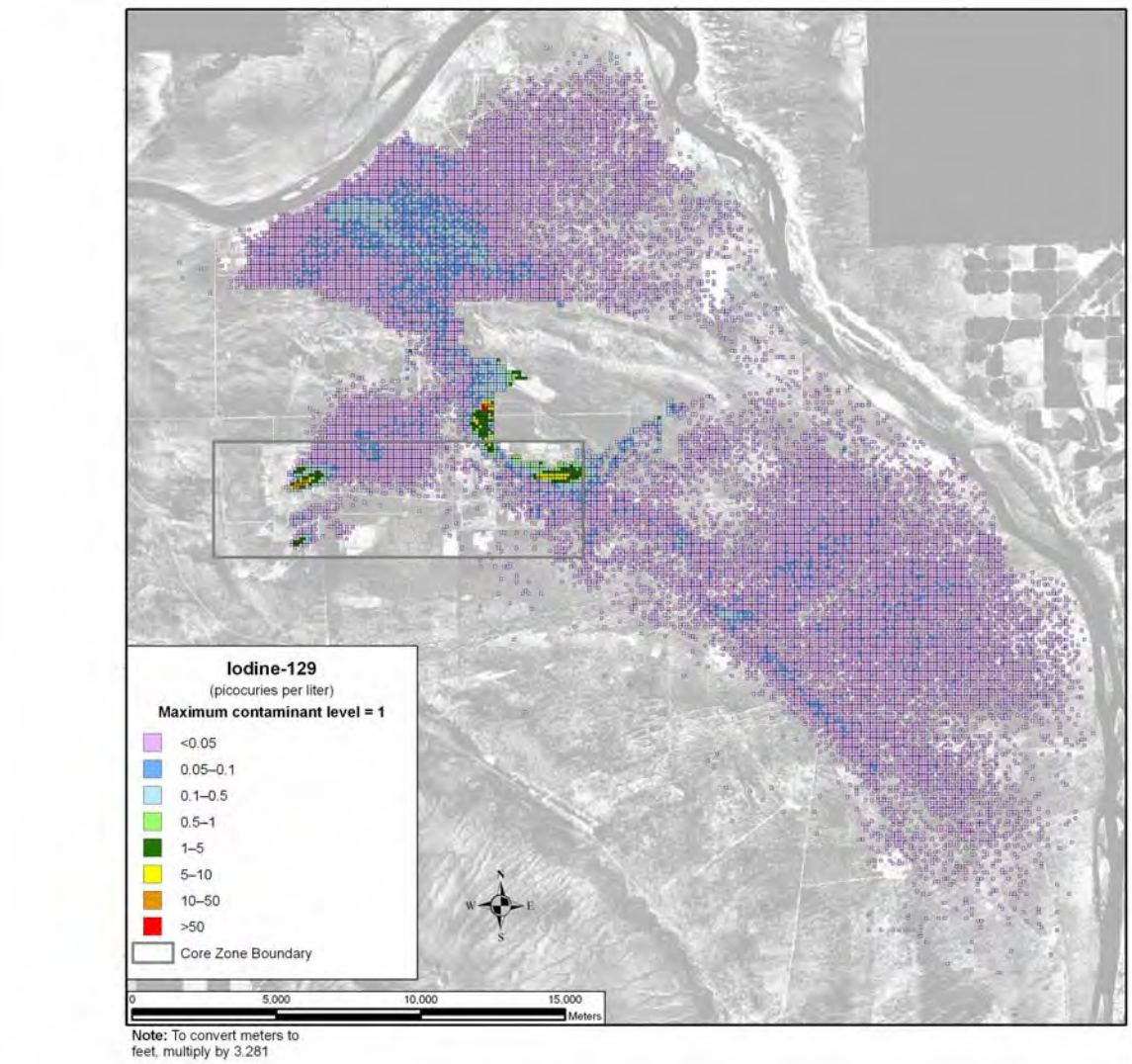


Figure 5–52. Tank Closure Alternative 2A Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

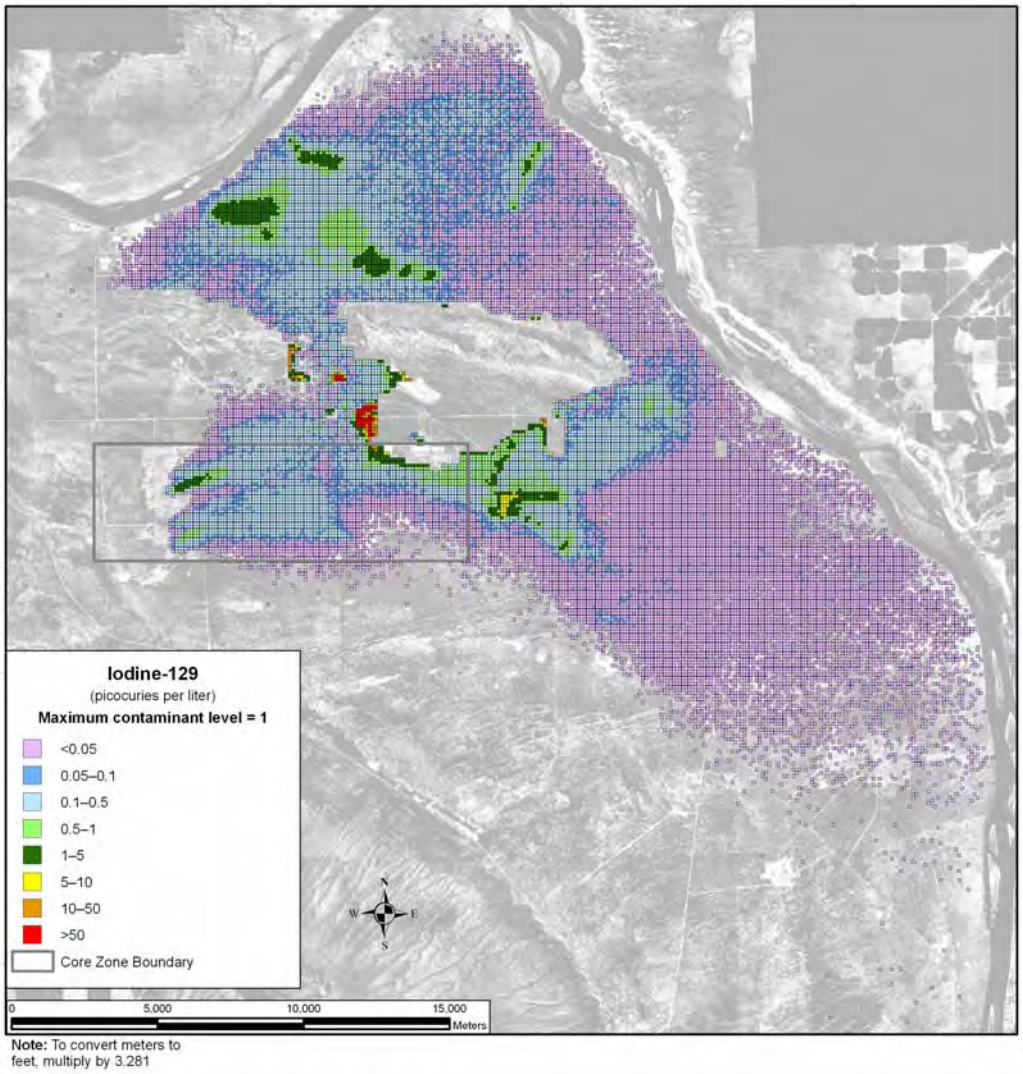


Figure 5–53. Tank Closure Alternative 2A Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135

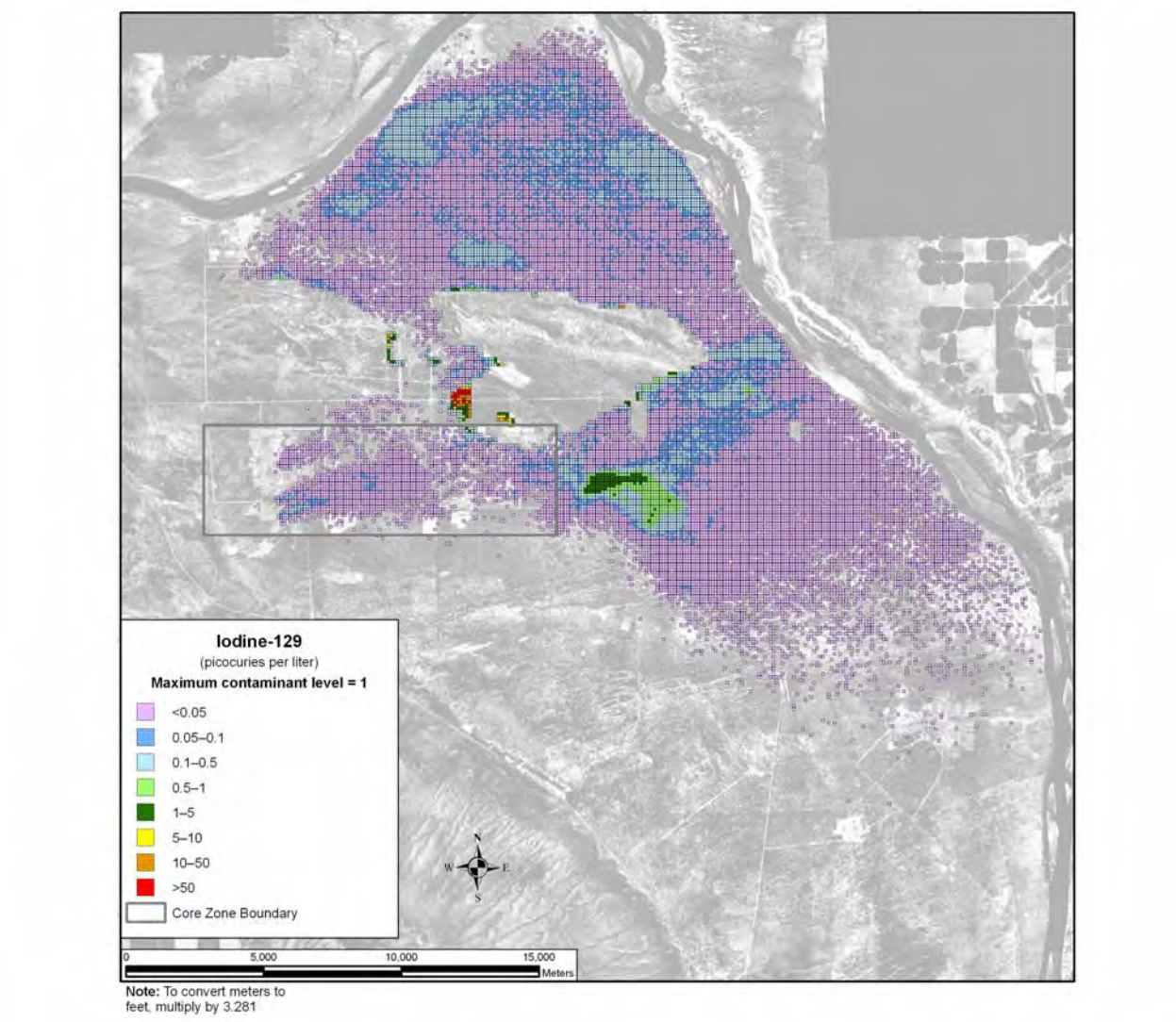


Figure 5–54. Tank Closure Alternative 2A Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

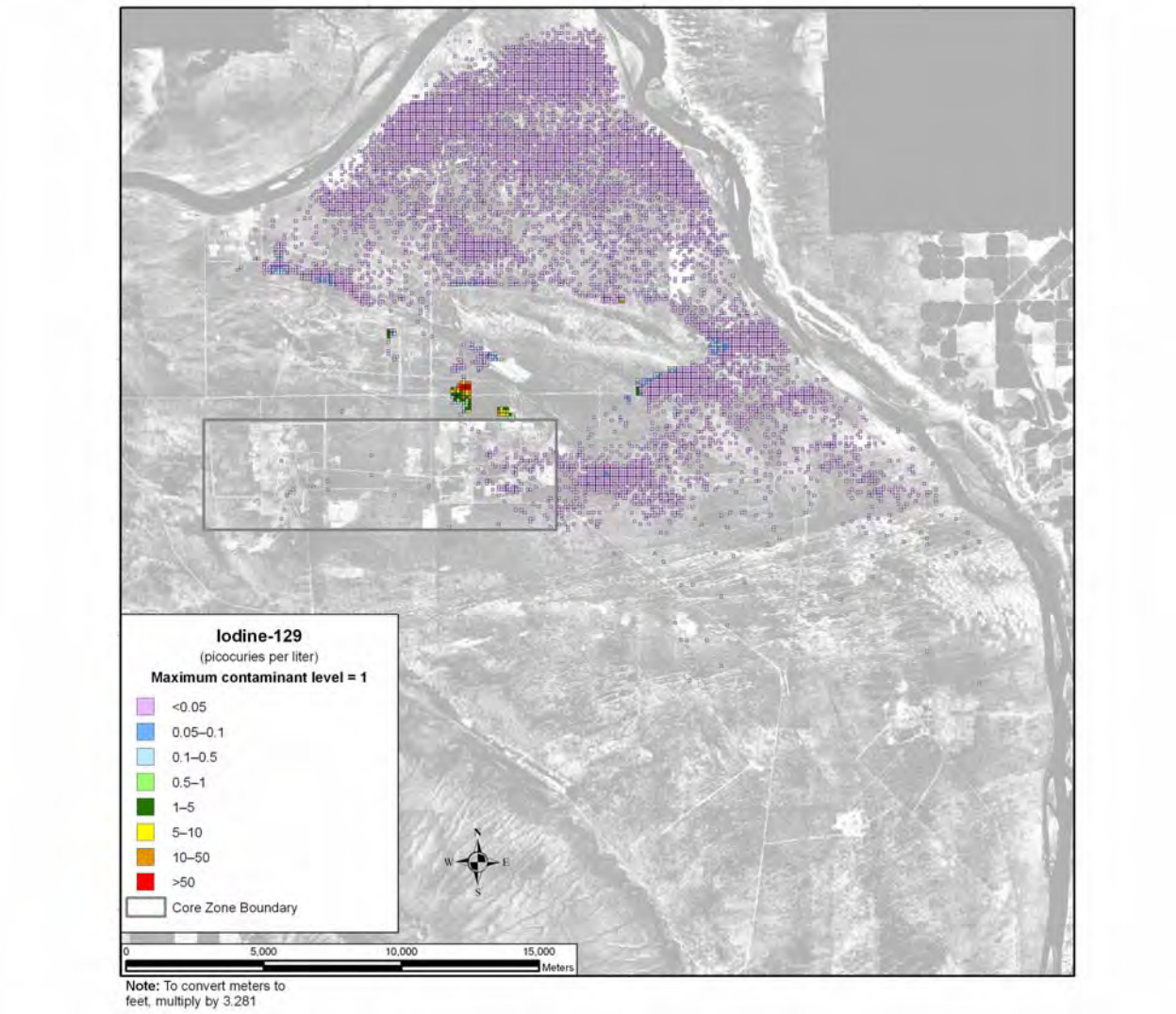


Figure 5–55. Tank Closure Alternative 2A Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

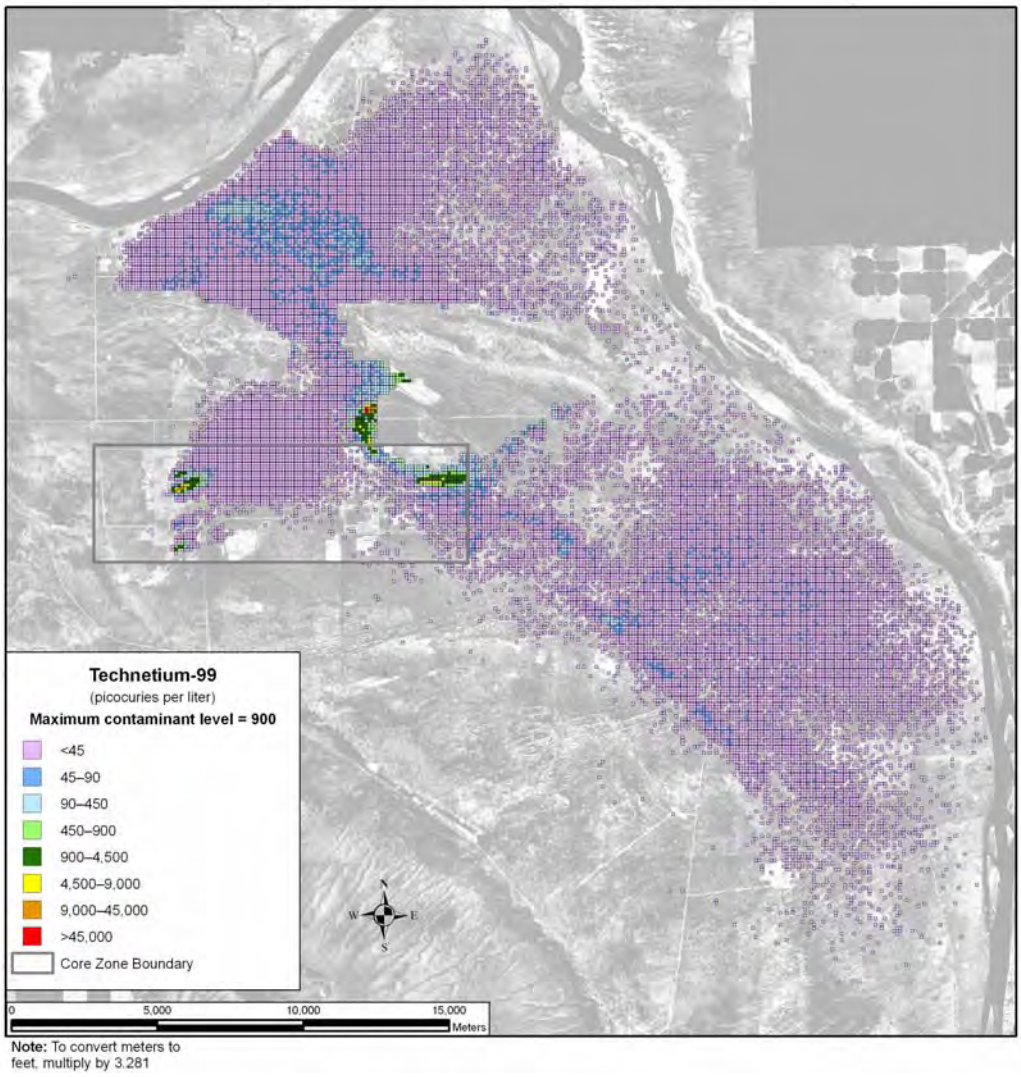


Figure 5–56. Tank Closure Alternative 2A Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

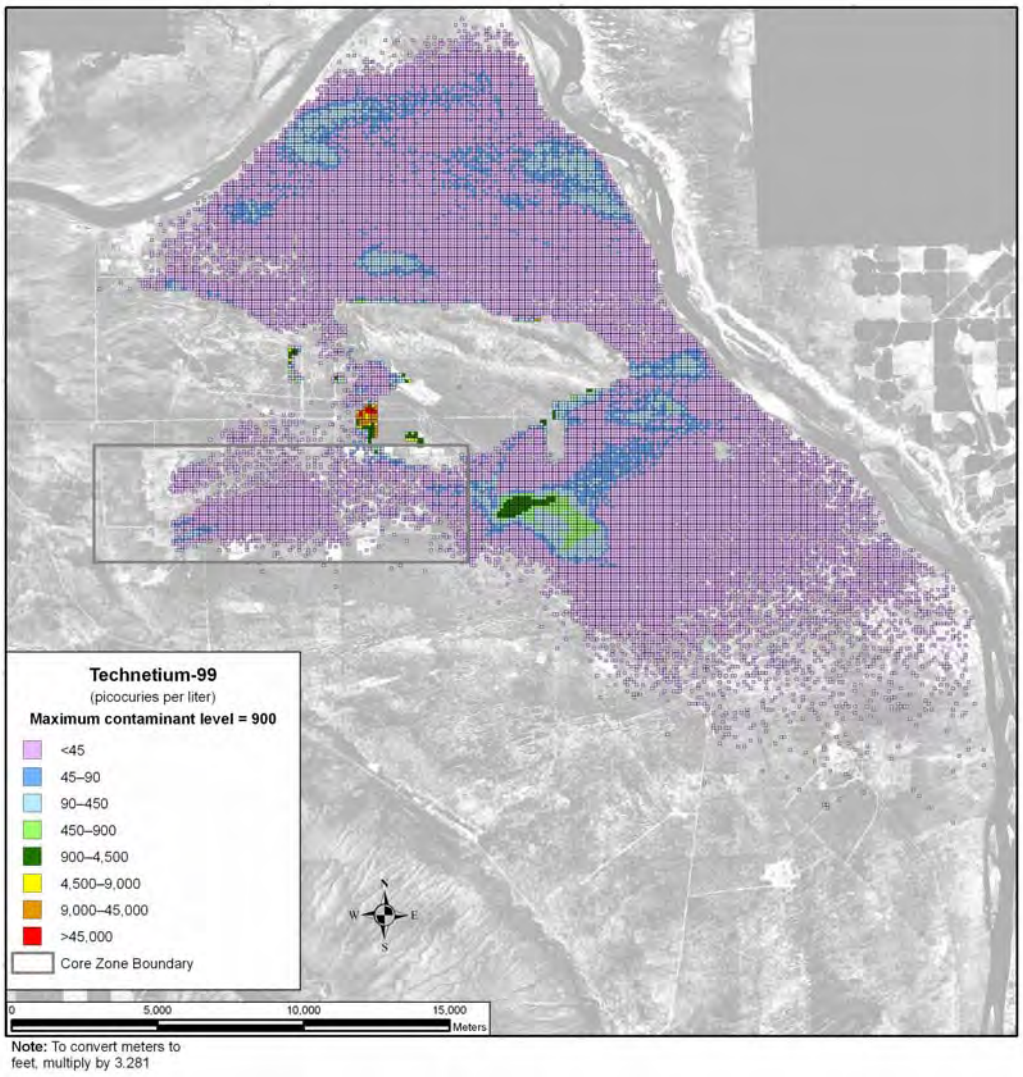


Figure 5–57. Tank Closure Alternative 2A Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

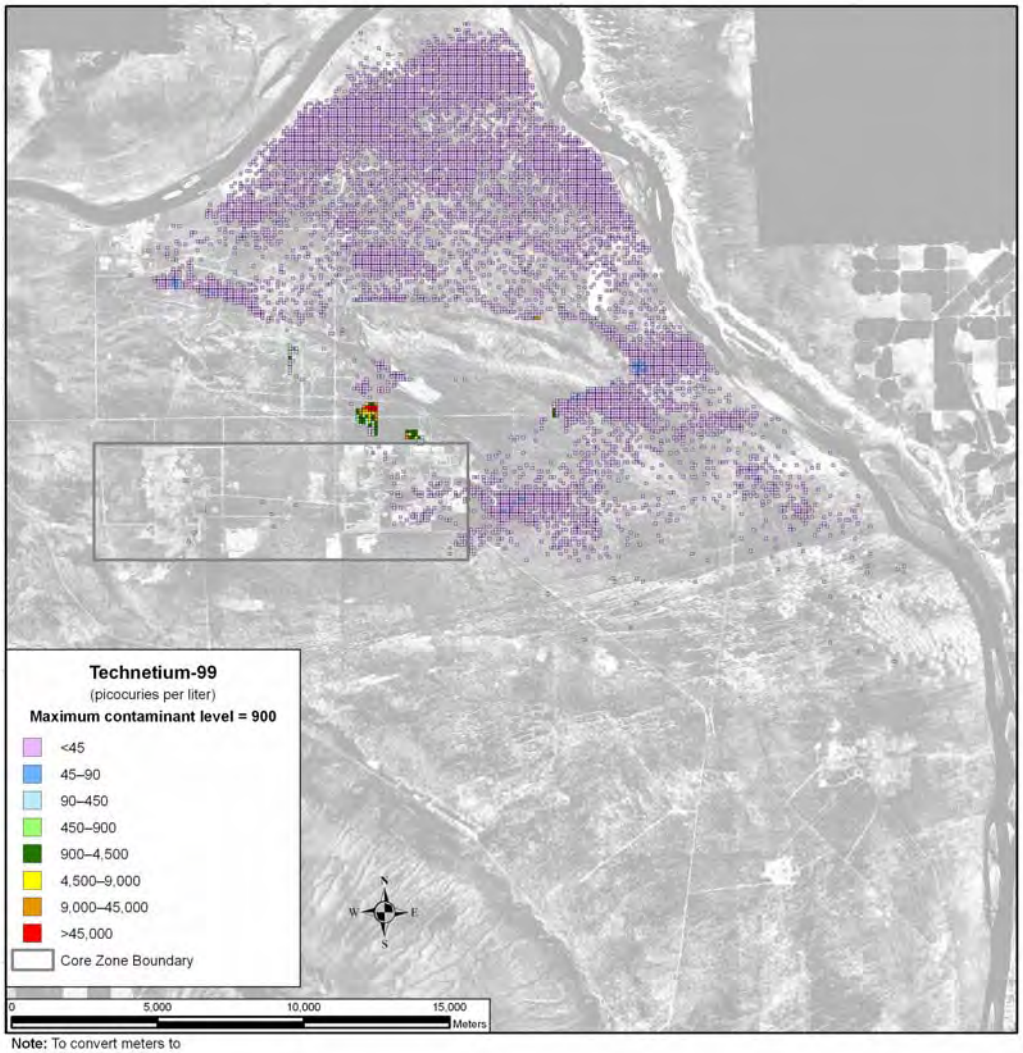


Figure 5–58. Tank Closure Alternative 2A Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

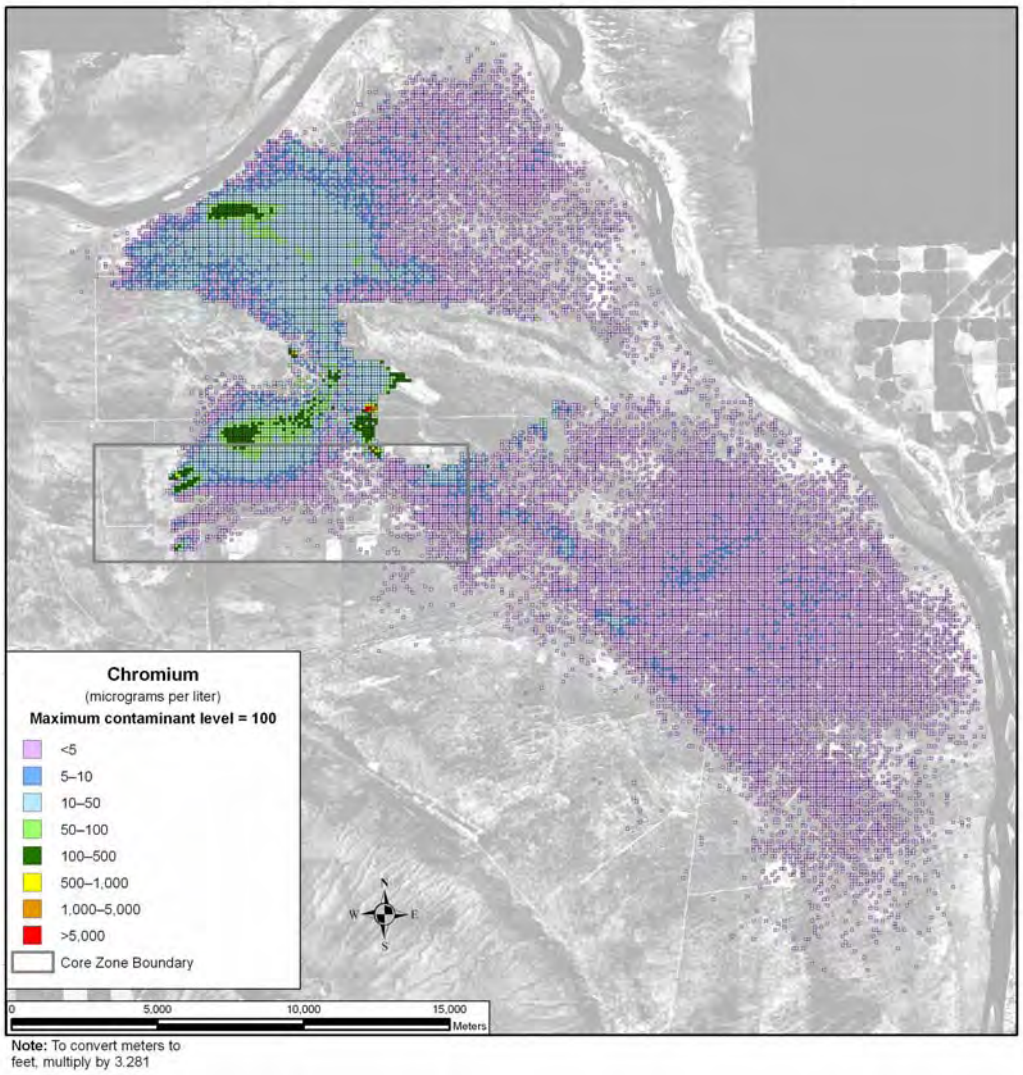


Figure 5–59. Tank Closure Alternative 2A Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

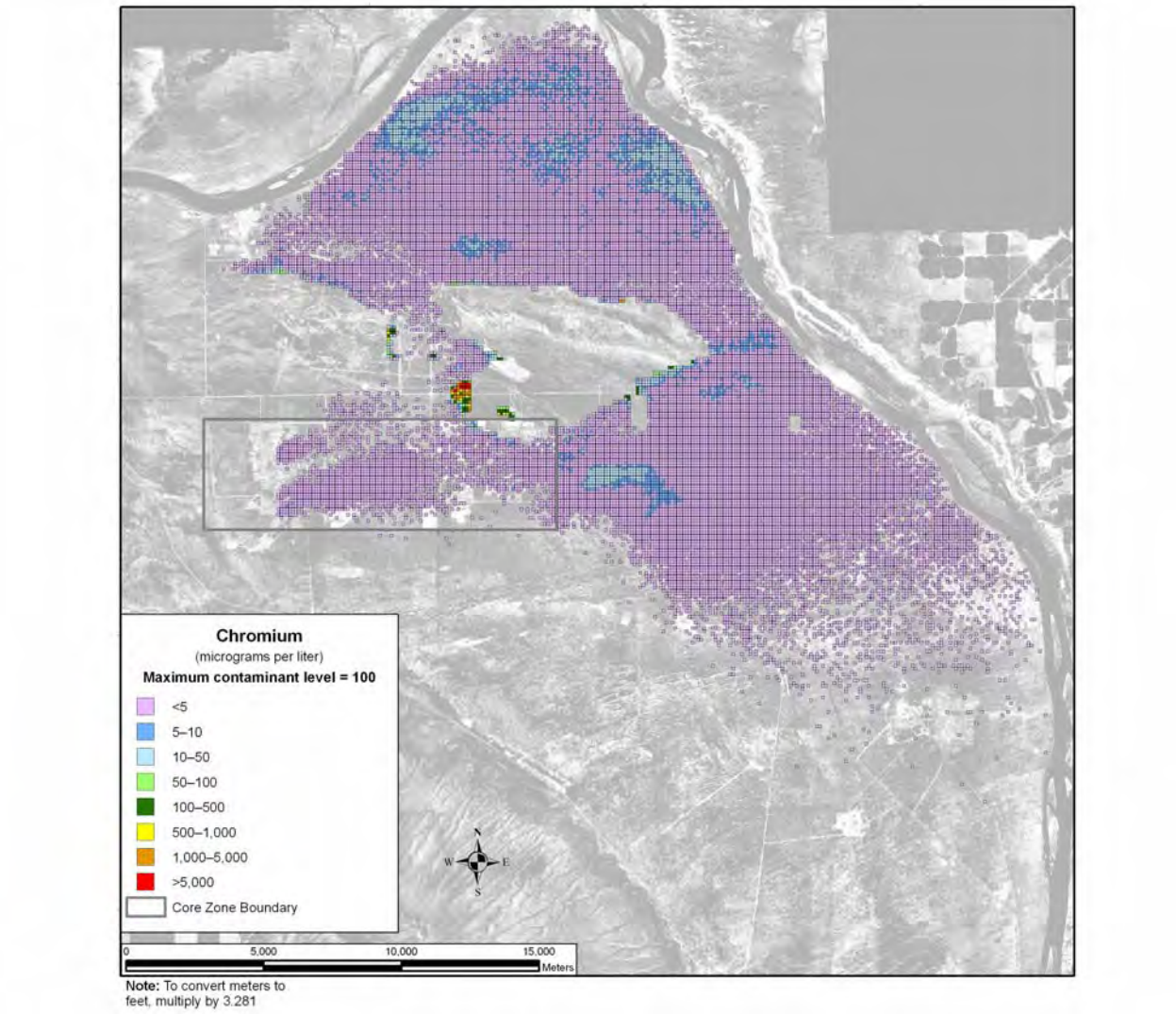


Figure 5–60. Tank Closure Alternative 2A Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

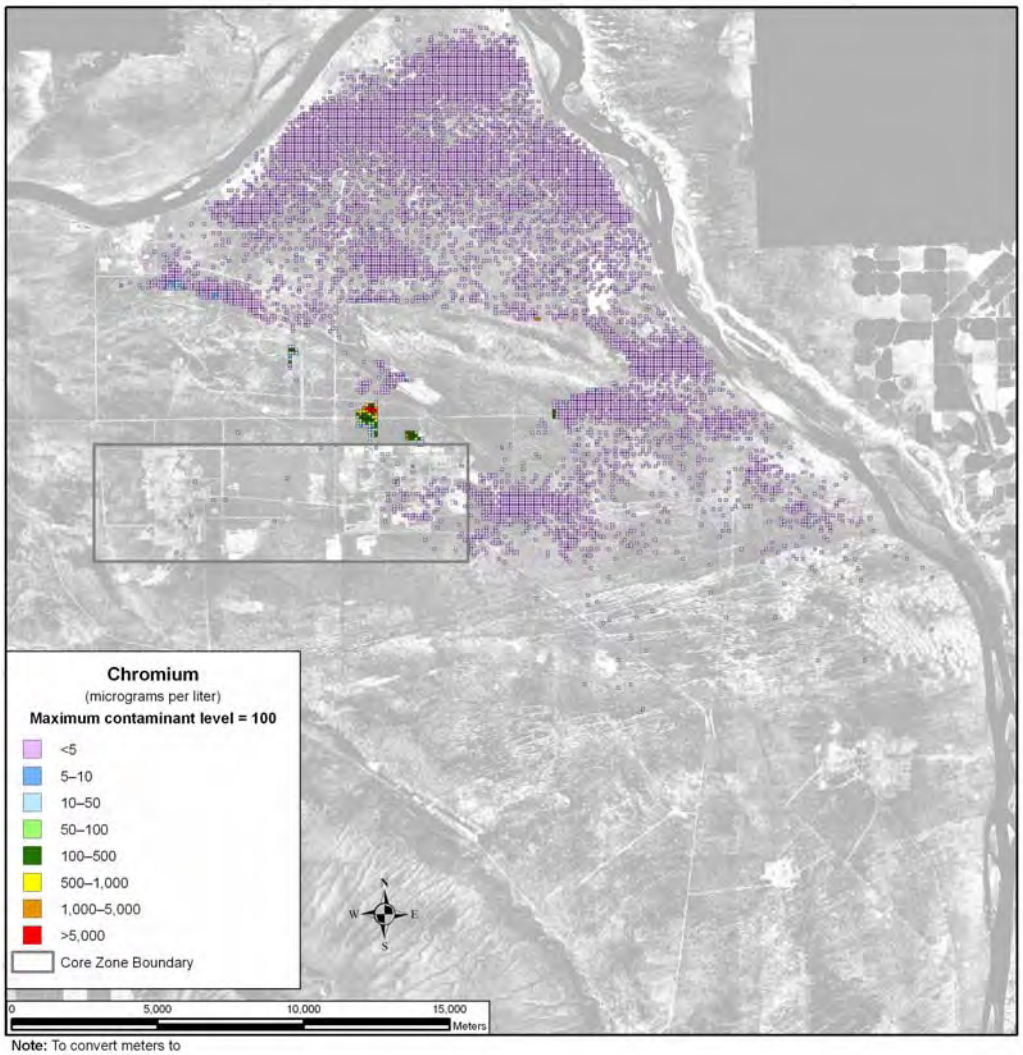


Figure 5–61. Tank Closure Alternative 2A Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

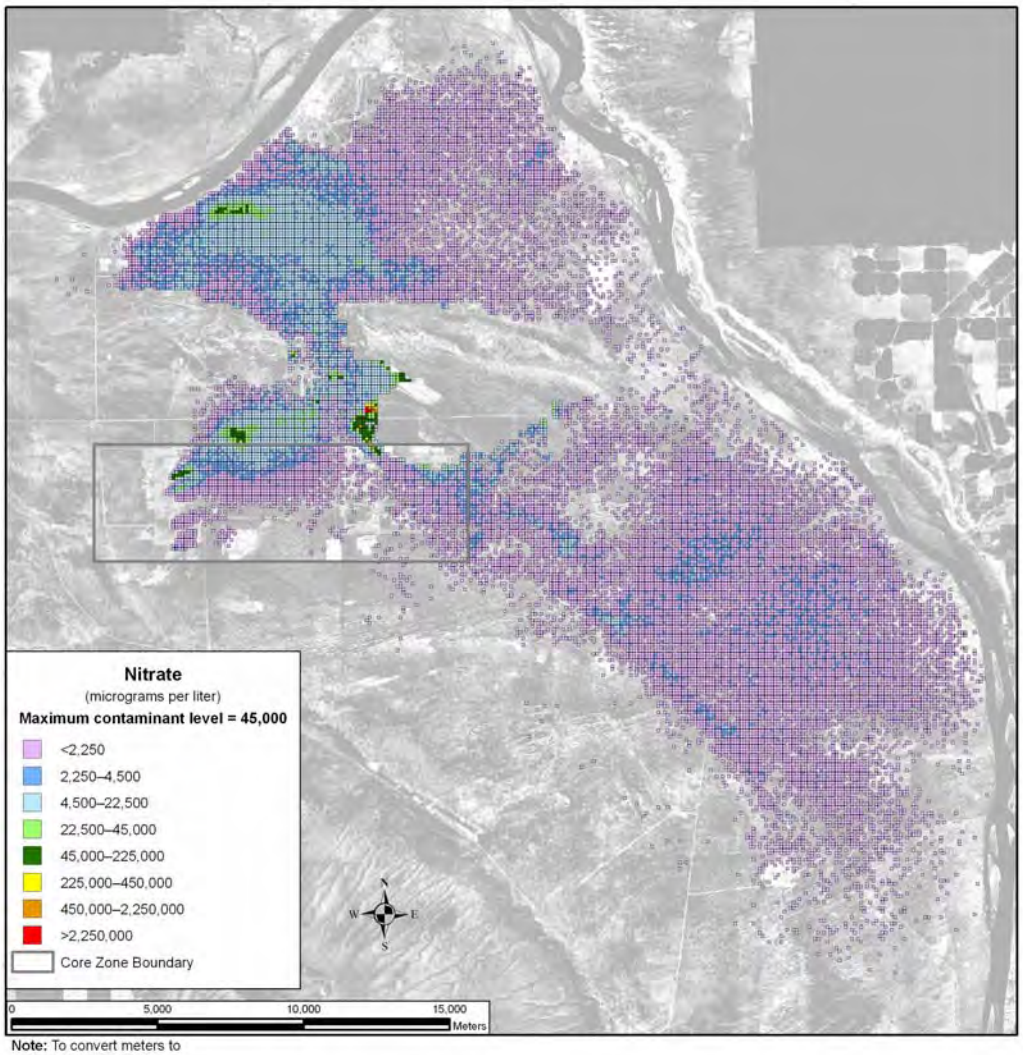


Figure 5–62. Tank Closure Alternative 2A Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

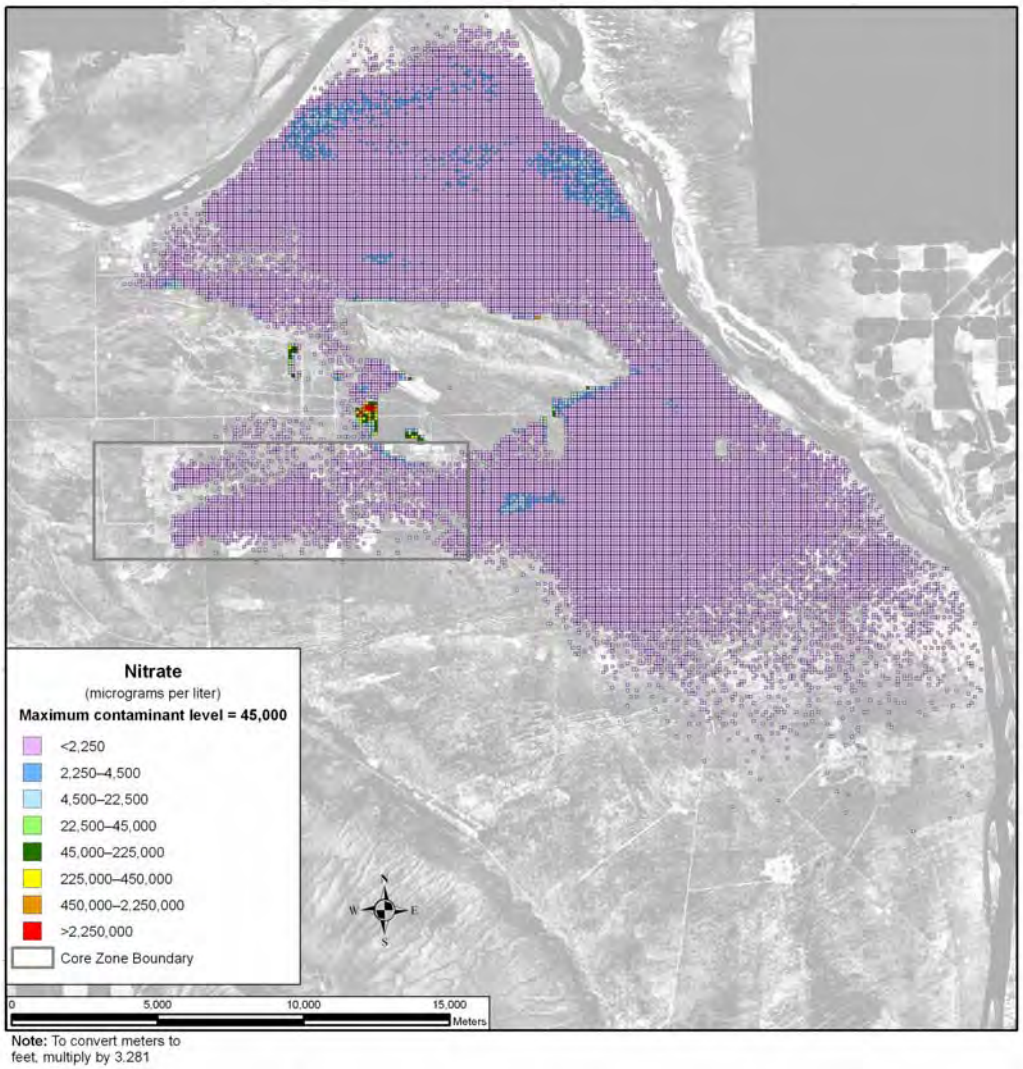


Figure 5–63. Tank Closure Alternative 2A Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–64 shows the distribution of uranium-238 during CY 2005. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration and is contained within the Core Zone Boundary. By CY 3890 (see Figure 5–65), the area of the plume has grown significantly, but there are no significant increases in peak concentration. By CY 7140, an area of high concentration has formed north of the Core Zone Boundary. At CY 11,885 (see Figure 5–66), the greatest development of the plume during the analysis period is seen, with areas north and east of the Core Zone Boundary reaching concentrations above the benchmark concentration. Figures 5–67 through 5–69 show the corresponding results for total uranium, which shows similar spatial distributions at similarly selected times. Concentrations east of the Core Zone Boundary do not exceed the benchmark concentration for total uranium, although the area north of the Core Zone Boundary does have concentrations above the benchmark concentration from CY 7140 to the end of the period of analysis.

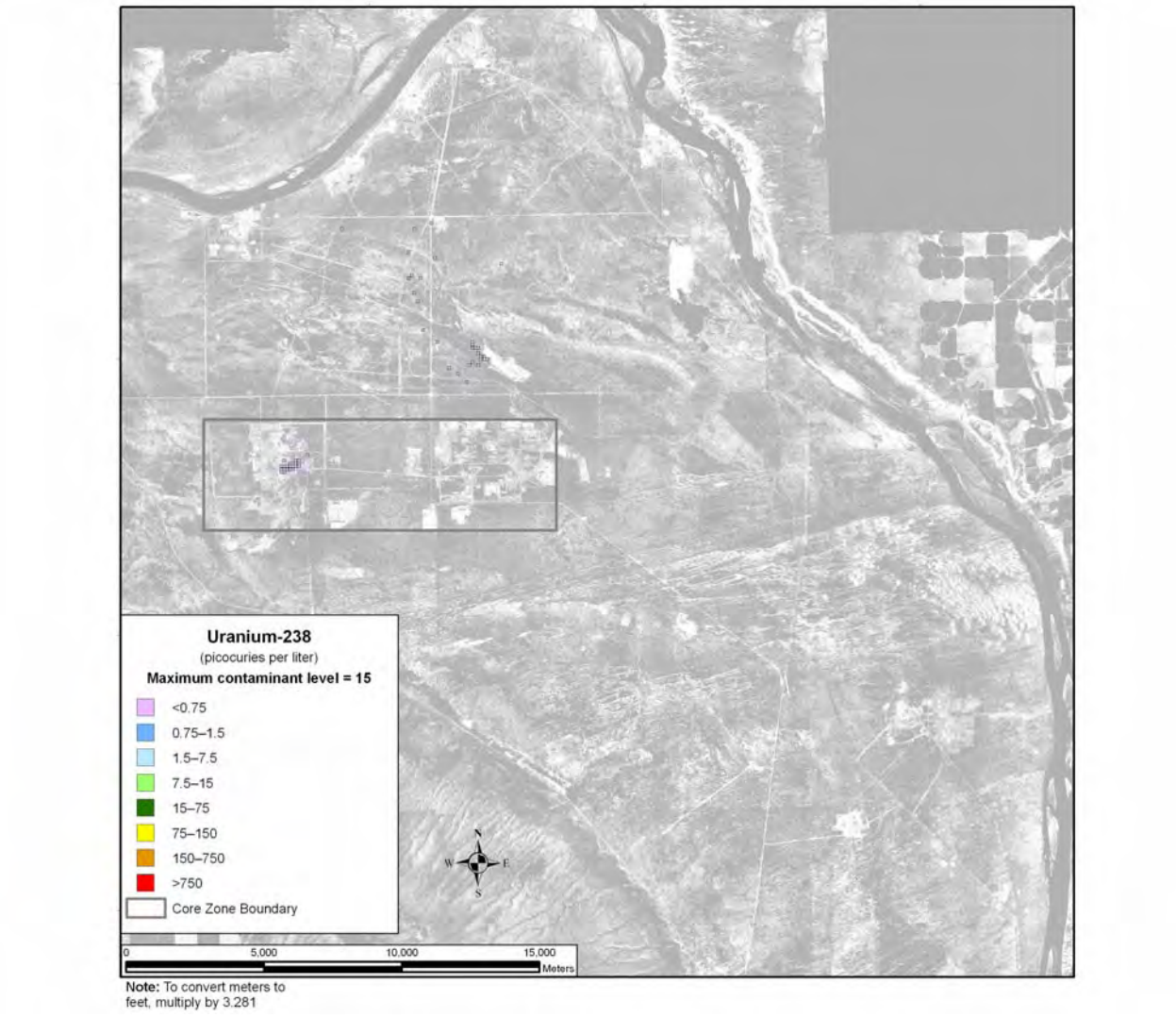


Figure 5–64. Tank Closure Alternative 2A Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

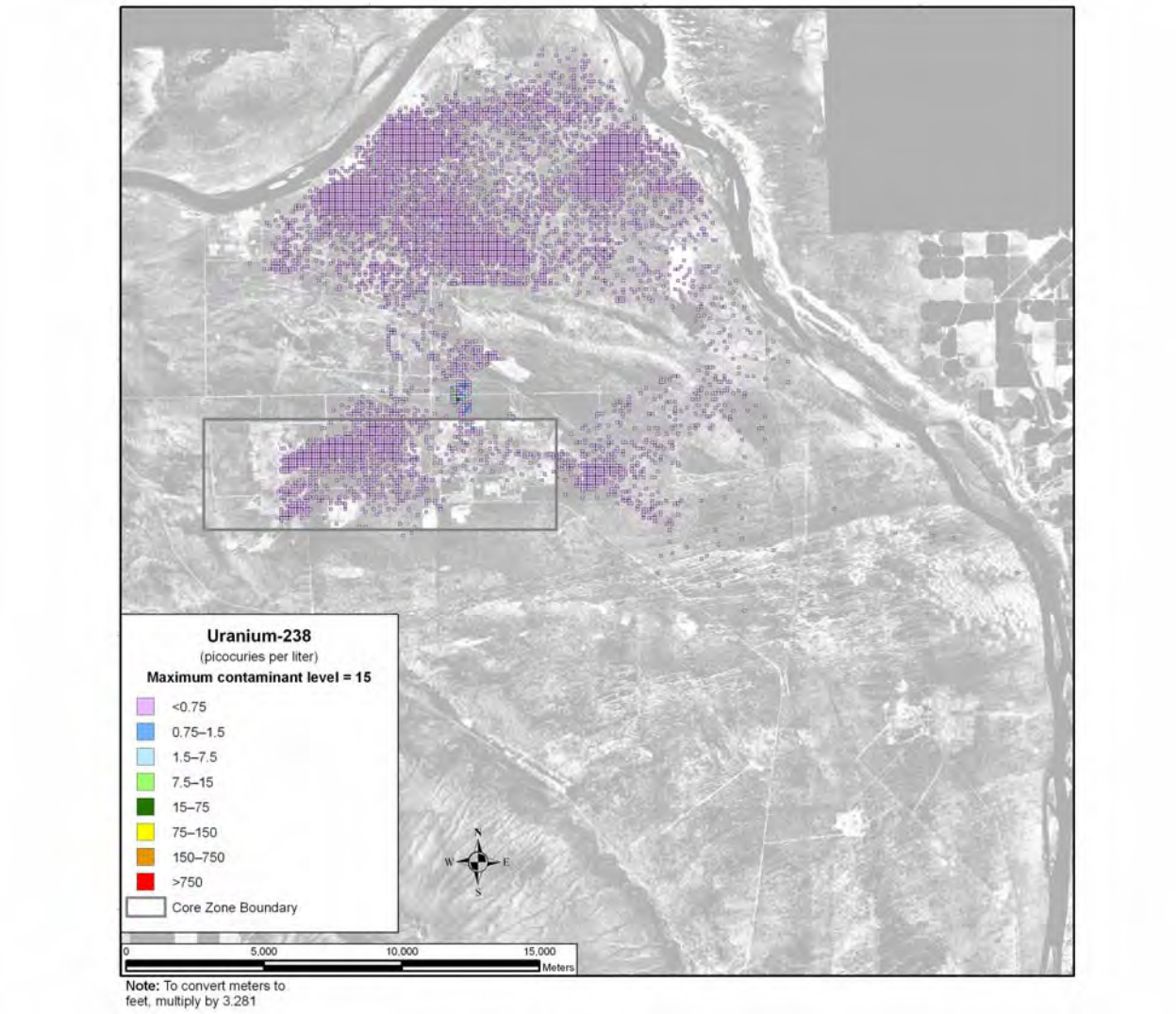


Figure 5–65. Tank Closure Alternative 2A Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890

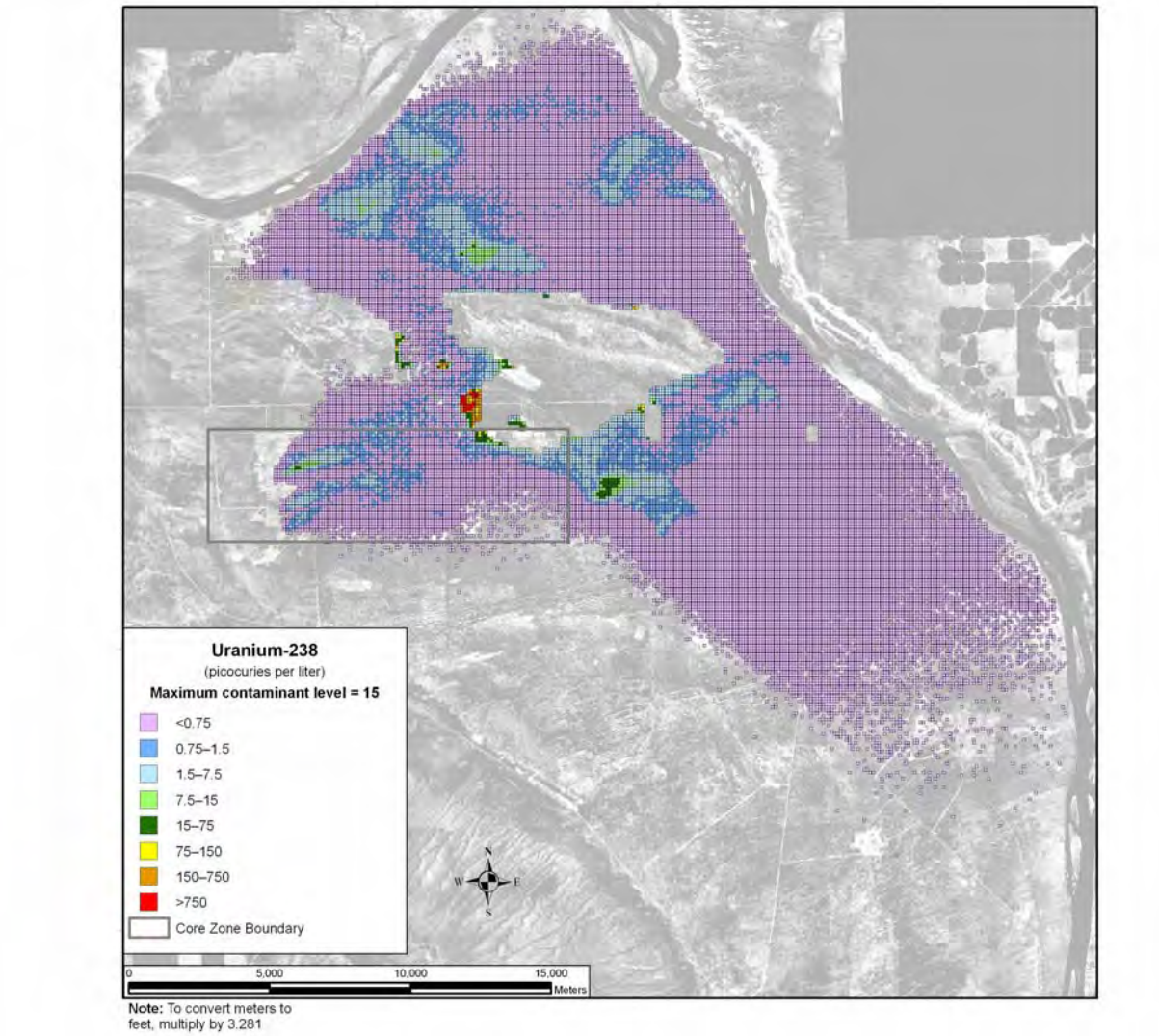


Figure 5–66. Tank Closure Alternative 2A Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

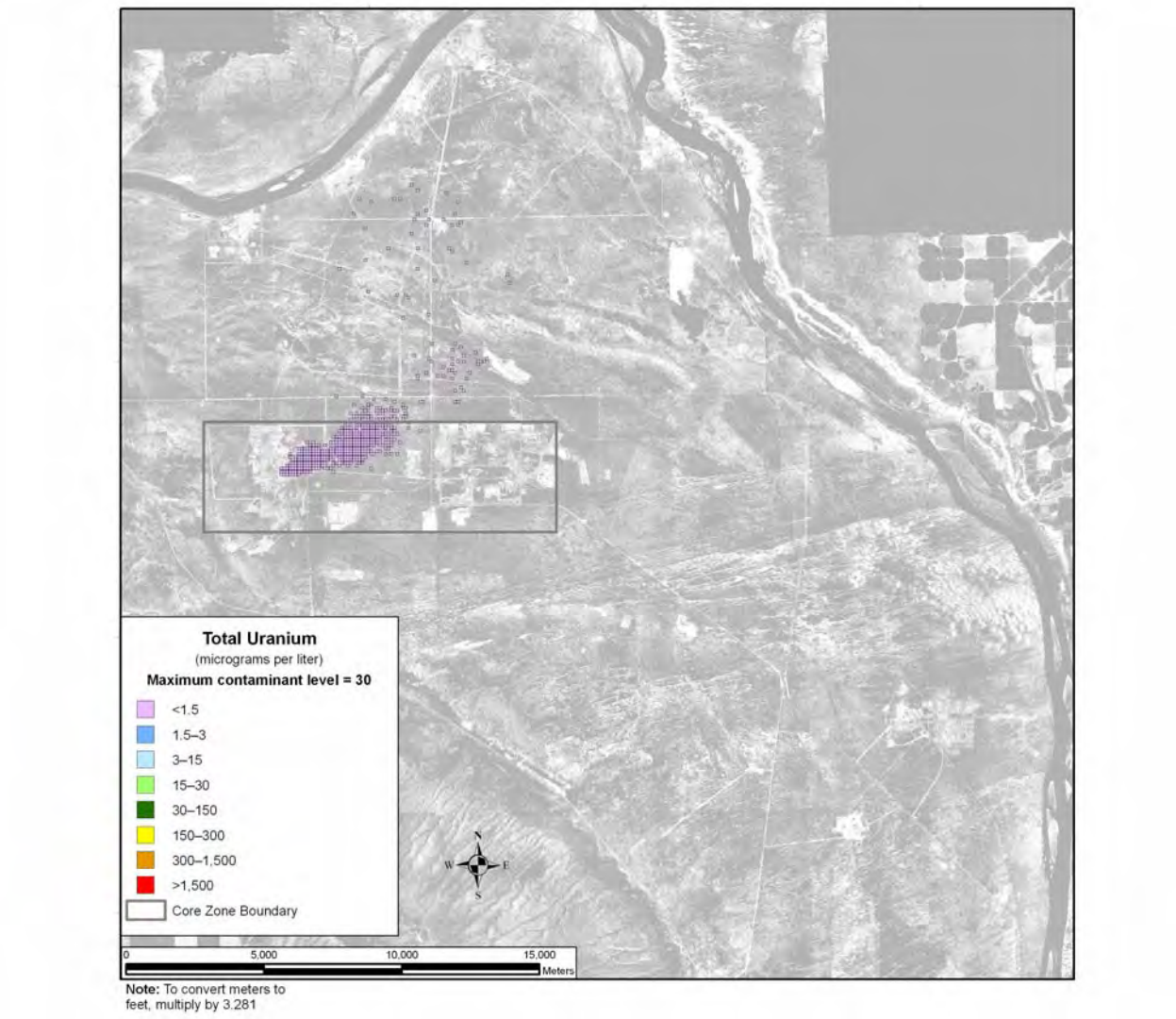


Figure 5–67. Tank Closure Alternative 2A Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135

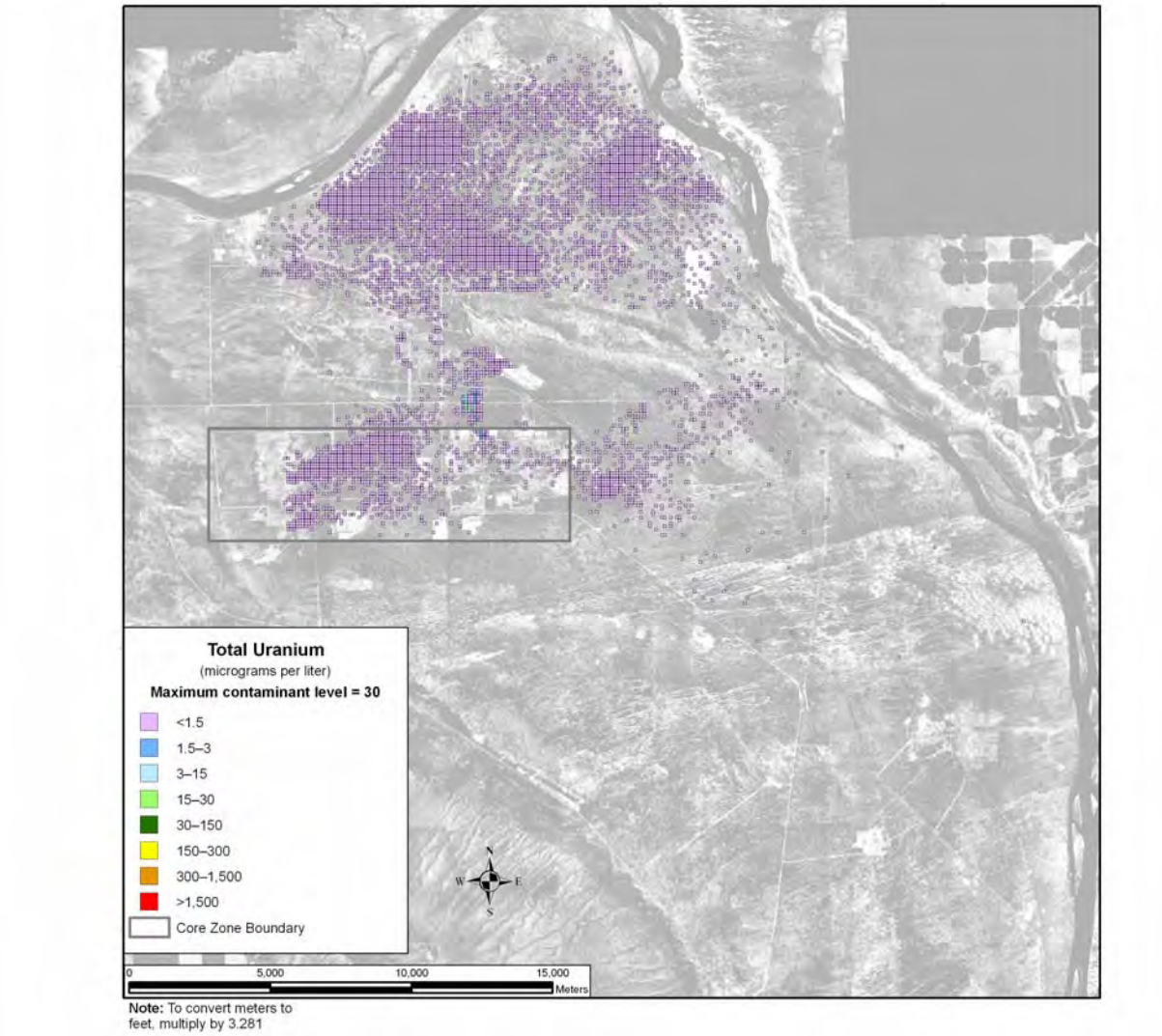


Figure 5–68. Tank Closure Alternative 2A Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890

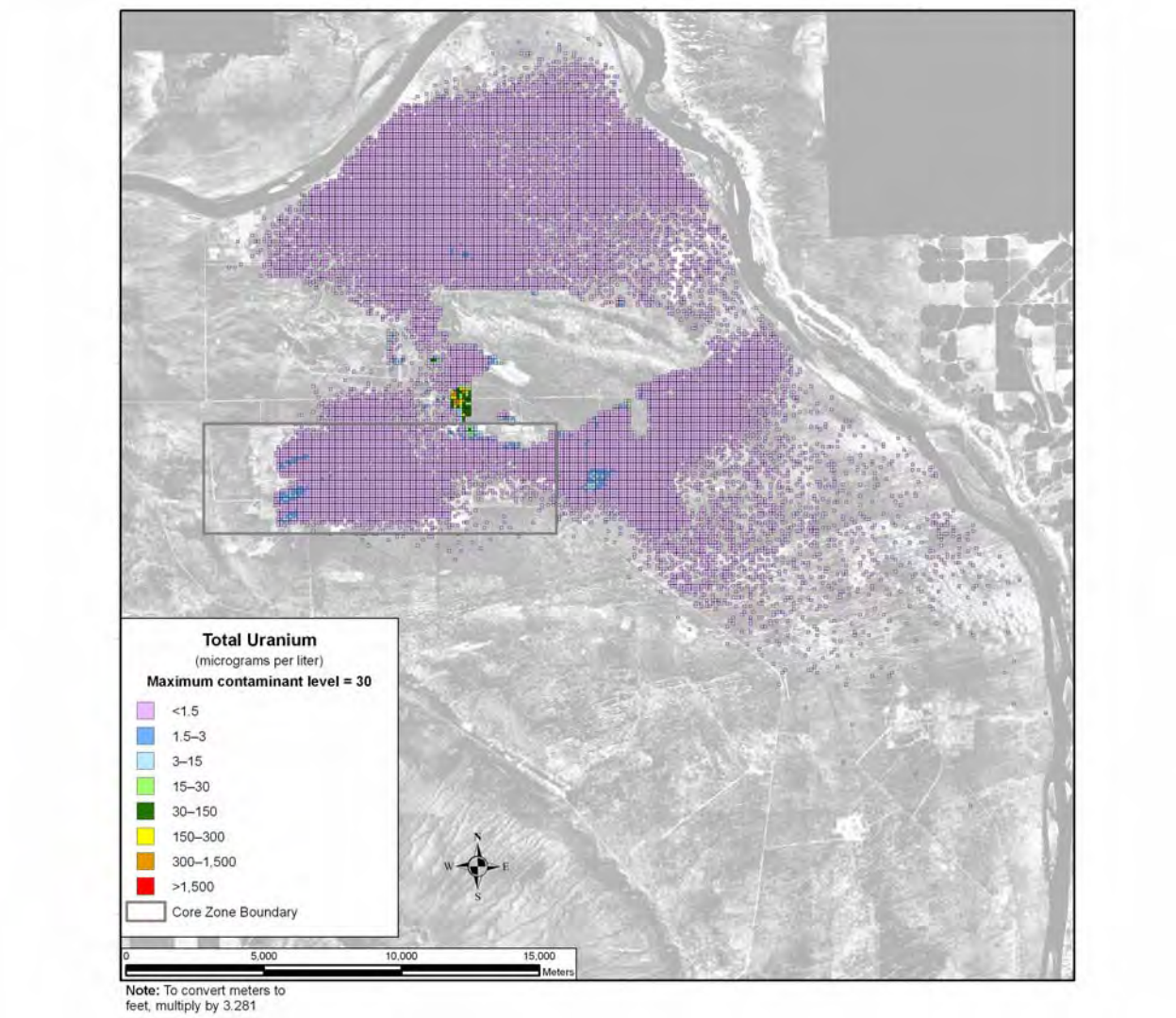


Figure 5–69. Tank Closure Alternative 2A Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 7140

Figures 5–70 through 5–72 show the area covered by concentrations above the benchmark concentration for iodine-129, technetium-99, and uranium-238. Iodine-129 spikes early in the simulation, covering a peak area of just over 9 square kilometers (3.5 square miles) around CY 2070. This area decreases rapidly until CY 2590, when it begins to rise again, peaking at 2.5 square kilometers (0.96 square miles) around CY 3240. The total area covered by the iodine-129 plume that is above the benchmark concentration drops below 1 square kilometer (0.38 square miles) around CY 5840, continuing its decline to approximately 0.8 square kilometers (0.3 square miles) by CY 9740 and remaining near that level for the remainder of the simulation. Technetium-99 shows a similar trend, peaking at approximately 5 square kilometers (1.9 square miles) in CY 2135 and reaching 0.5 square kilometers (0.19 square miles) in CY 9740. Uranium-238 shows a distinctly different pattern, without any area above the benchmark concentration until CY 4540. From CY 4540 until the end of the simulation, areas of uranium-238 concentrations above the benchmark slowly increase, never exceeding 2 square kilometers (0.77 square miles) during the simulation.

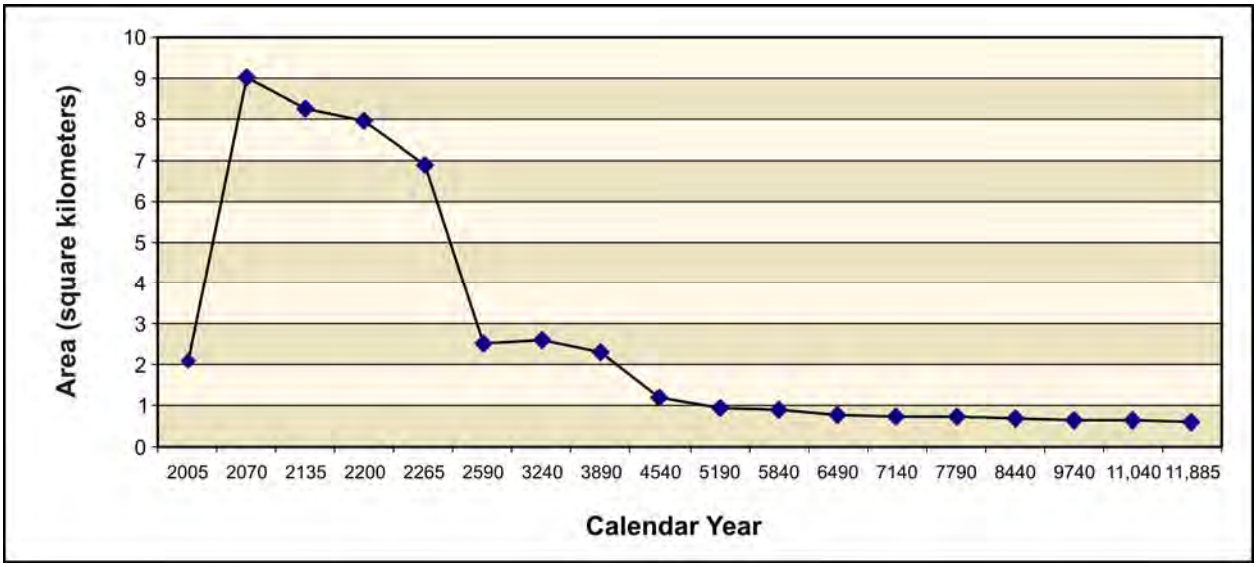


Figure 5–70. Tank Closure Alternative 2A Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

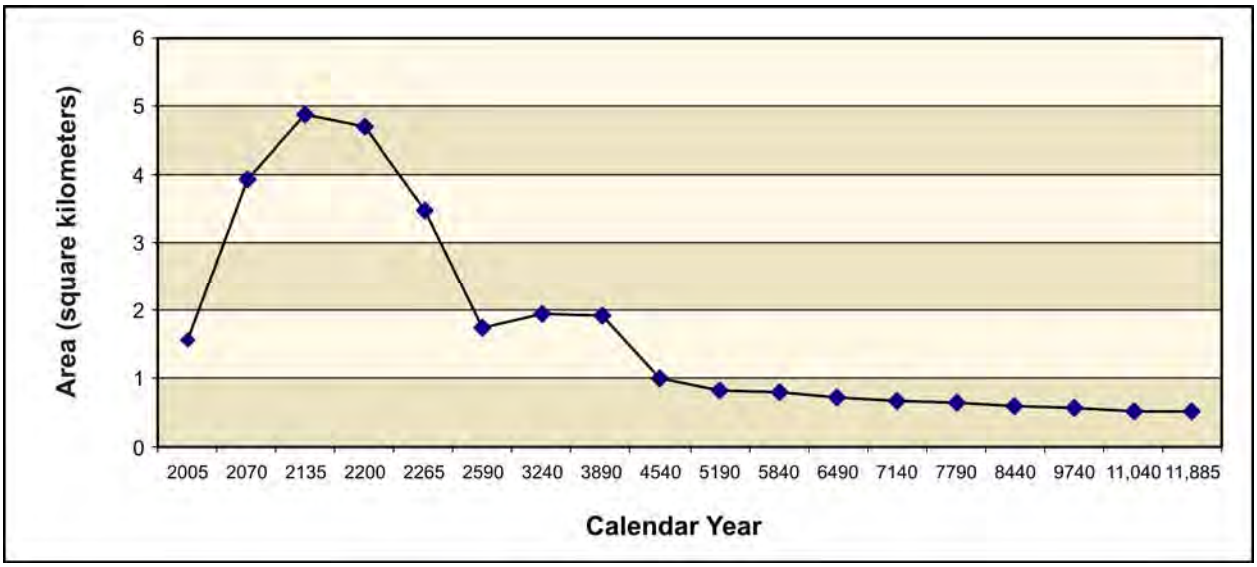


Figure 5–71. Tank Closure Alternative 2A Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

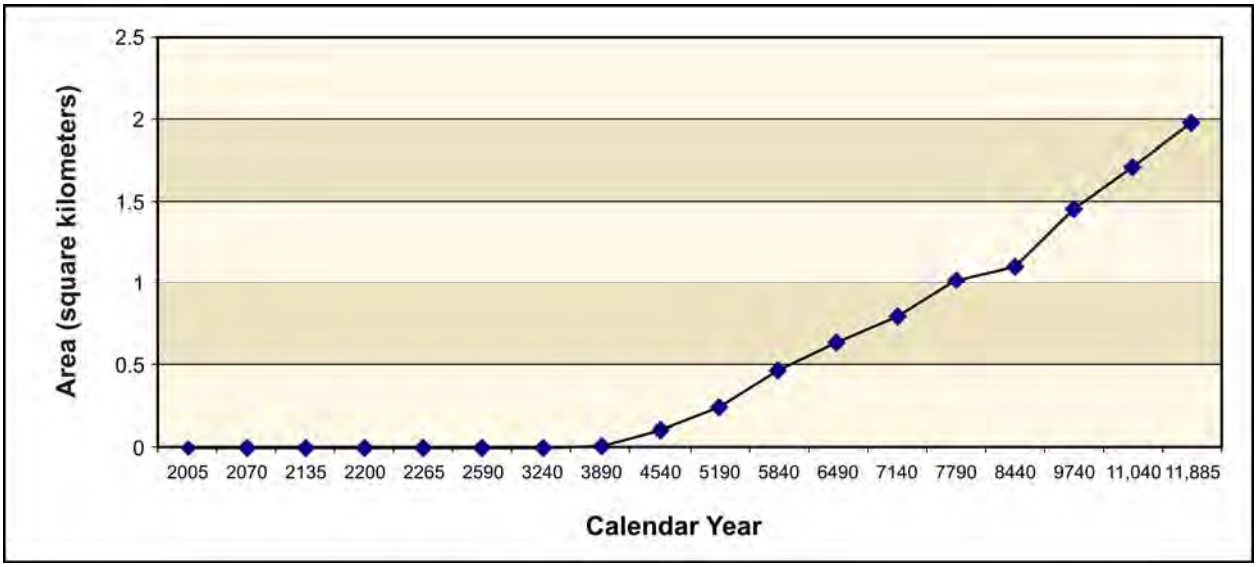


Figure 5–72. Tank Closure Alternative 2A Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.2.6 Summary of Impacts

Under Tank Closure Alternative 2A, releases from cribs and trenches (ditches), past leaks, and other tank farm sources available after the retrieval period are all major contributors in the analysis. The retrieval of waste from the SSTs lowers the contribution of other tank farm sources relative to Tank Closure Alternative 1.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude early in the analysis, between CY 2100 and 2200. These concentrations fall below the benchmark between 3,000 and 4,000 years into the analysis. Concentrations at the Columbia River remain below the benchmark concentration throughout the period of analysis.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about two orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2040, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. Concentrations at the Core Zone Boundary exceed the benchmark concentration in CY 5900 for uranium-238 and in CY 6900 for total uranium. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, but stay below an order of magnitude less than the benchmark concentration.

5.1.1.3 Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure

This section describes the groundwater analysis results for Tank Closure Alternative 2B, including long-term groundwater impacts of contaminant sources from within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

Activities under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would be similar in scope and timing. Tank waste would be retrieved to a volume corresponding to 99 percent retrieval, and residual material in tanks would be stabilized in place. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified Resource Conservation and Recovery Act (RCRA) Subtitle C barrier. From the long-term groundwater impact perspective, the results from the analyses of these alternatives are identical.

5.1.1.3.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 2B are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, three major periods were identified for Tank Closure Alternative 2B, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 2B that are presented in this section would be common to all of the Tank Closure alternatives.

- The retrieval period was assumed to start in 2008 and continue through CY 2145. This period includes retrieval, WTP pretreatment and treatment, landfill closure of the SST farm system, and 100 years of postclosure care. It was assumed that during the retrieval period, 99 percent of waste volume would be retrieved from the tanks. The SST farm system would be landfill-closed with a modified RCRA Subtitle C barrier. A retrieval leakage rate of 15,140 liters (4,000 gallons) per SST (other tank farm sources) was assumed to be released to the vadose zone during the first part of this period. Releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system.

- The post–administrative control period was assumed to start in CY 2146 and continue through the 10,000-year period of analysis until CY 11,940. Releases that occurred during the past-practice and retrieval periods would continue to migrate through the vadose zone and groundwater system during the post–administrative control period. In addition, the remaining other tank farm sources waste (e.g., residual waste, ancillary equipment) would be released to the vadose zone at the start of the post–administrative control period.

5.1.1.3.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 2B. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Tank Closure Alternative 2B is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 2B were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become

major contributors toward the end of the period of analysis. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-14}, which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 2B.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.3.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 2B in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms (see Figures 5–73 through 5–78). Three subtotals are plotted representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–73 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–74, the chemical hazard drivers. The predominant sources for tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The predominant contributing sources for the remaining COPC drivers are a combination of past leaks and other tank farm sources. This suggests that all three sources are important impact drivers under Tank Closure Alternative 2B.

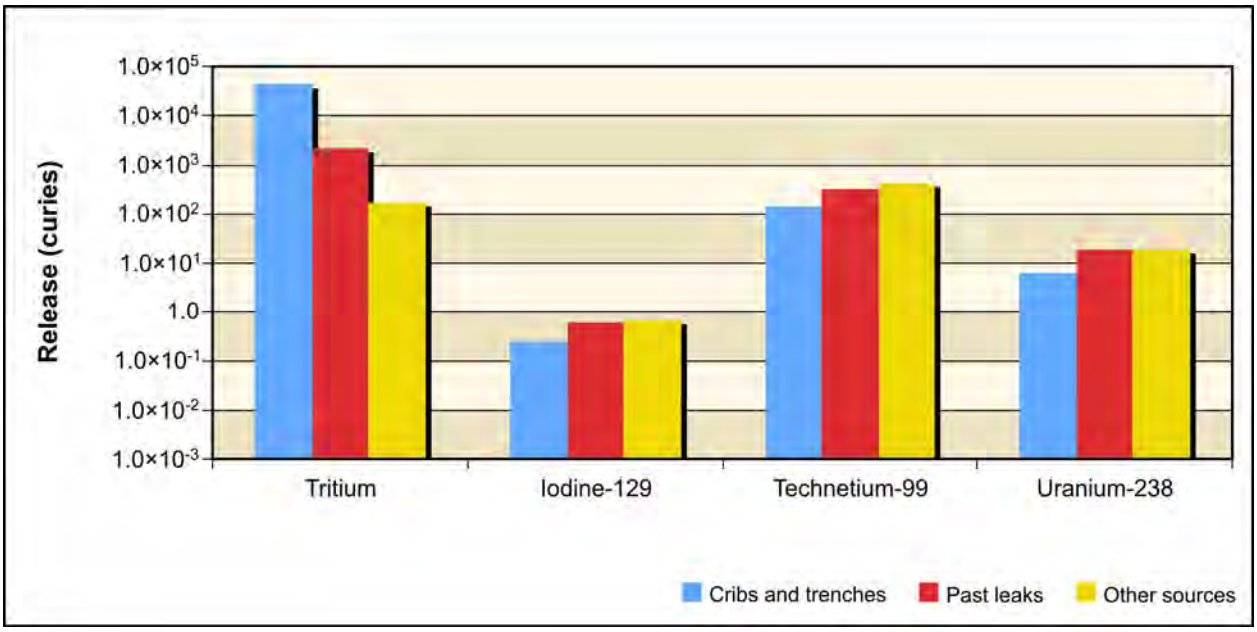


Figure 5–73. Tank Closure Alternative 2B Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

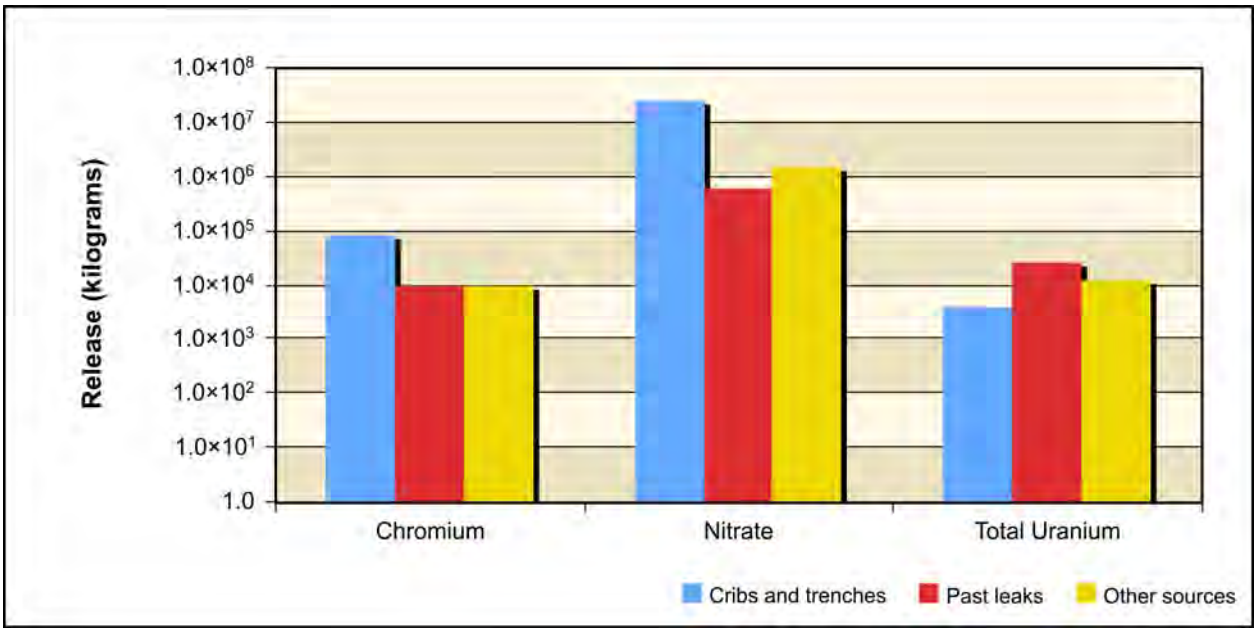


Figure 5–74. Tank Closure Alternative 2B Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–75 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–76, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

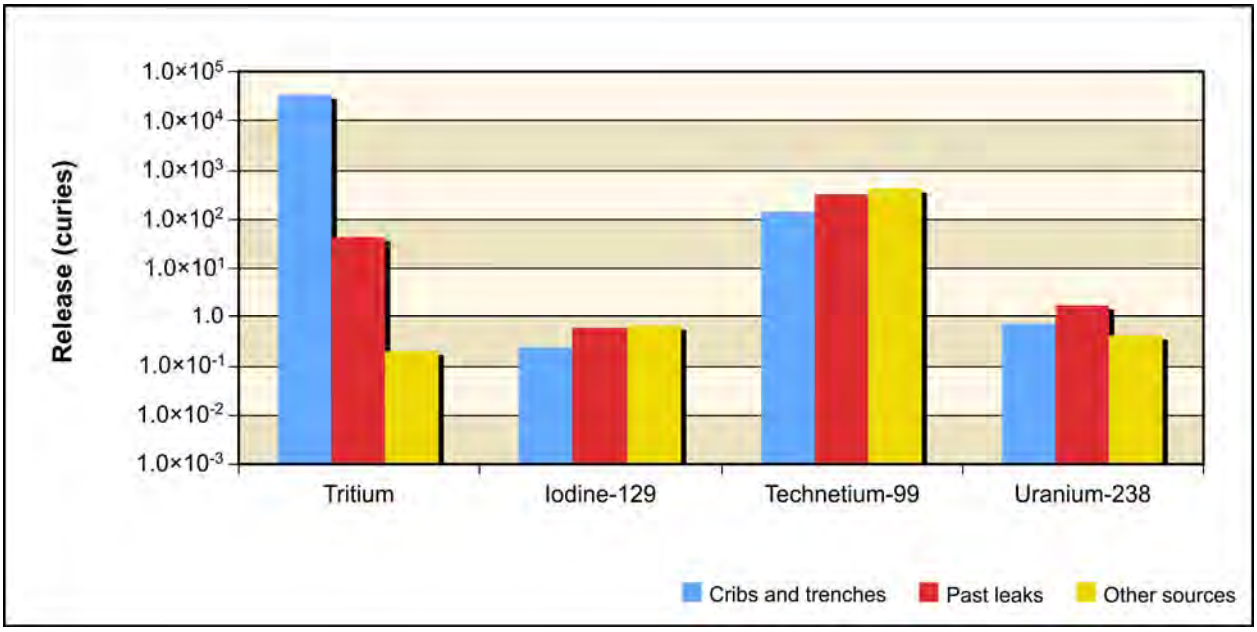


Figure 5–75. Tank Closure Alternative 2B Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

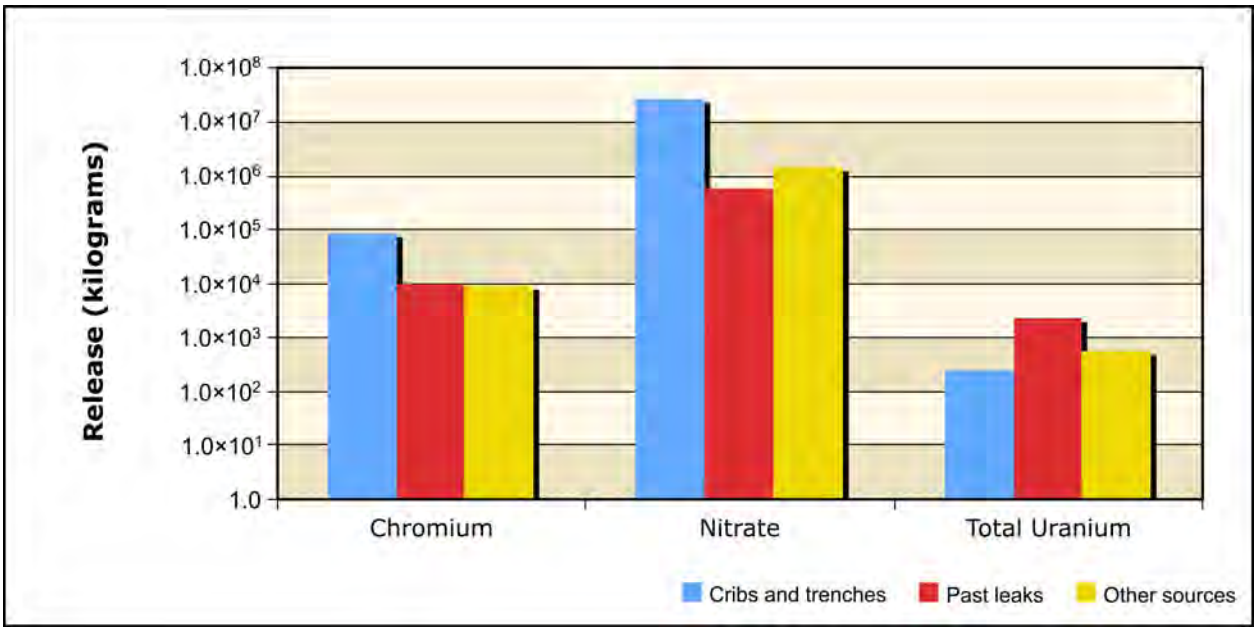


Figure 5–76. Tank Closure Alternative 2B Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For cribs and trenches (ditches) and past leaks, where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 10 percent of the total inventory of uranium-238 and total uranium reached groundwater during the period of analysis; for other tank farm sources, only about 3 percent of the total inventory reached groundwater during the period of analysis.

For tritium, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 70 percent of the total inventory reaches groundwater, for past leaks only about 3 percent, and for other tank farm sources, only about one-tenth of 1 percent of the inventory reached the water table. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts would occur later in the post–administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–77 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–78, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For uranium-238 and total uranium, the amount released to the Columbia River is less than that of the release to groundwater because of retardation. Overall, about 25 percent of the uranium-238 and total uranium released to groundwater during the period of analysis reached the Columbia River. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 2 percent of the tritium released to groundwater reached the Columbia River during the period of analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post–administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

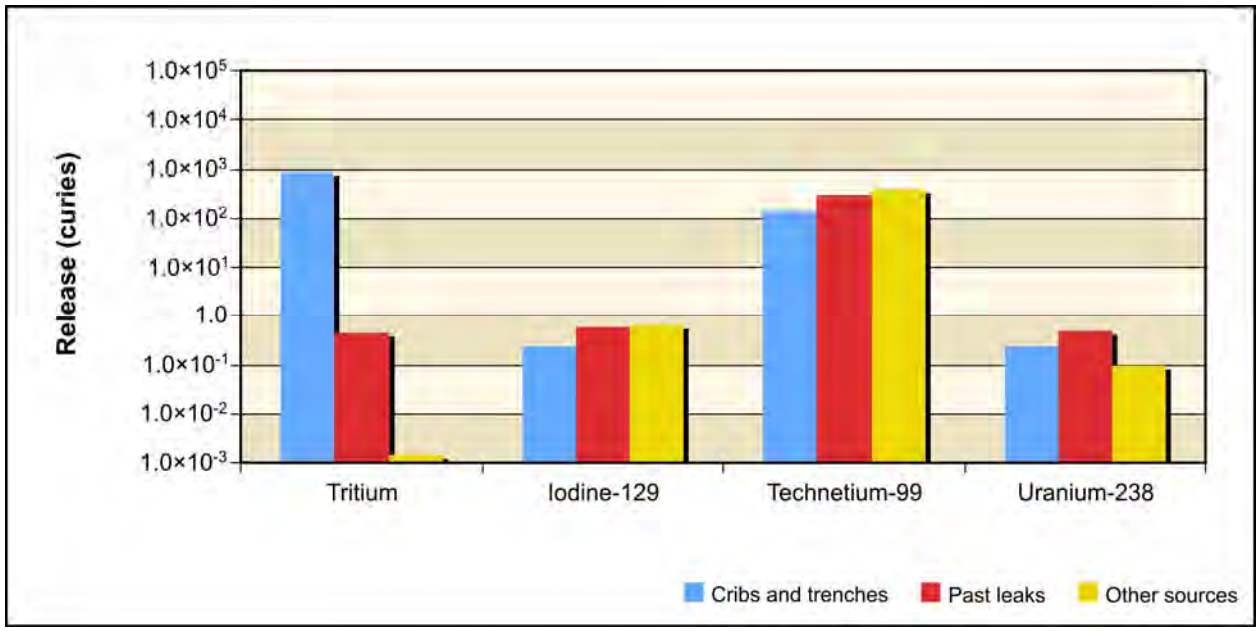


Figure 5–77. Tank Closure Alternative 2B Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

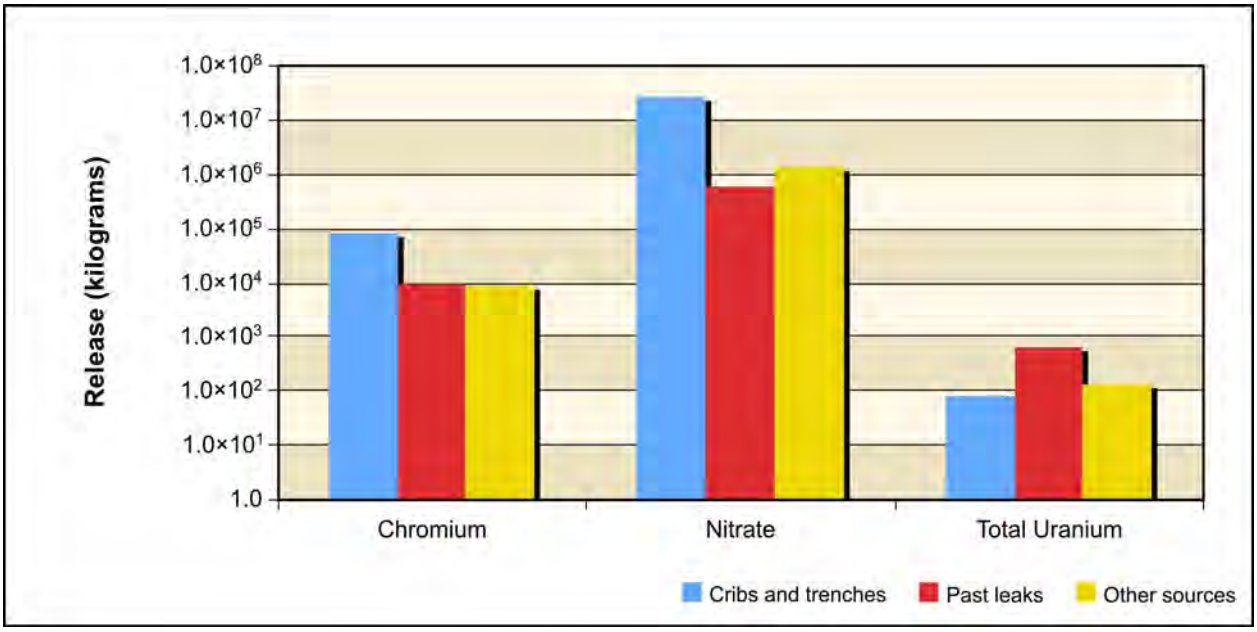


Figure 5–78. Tank Closure Alternative 2B Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.3.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 2B impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Table 5–3 and Figures 5–79 through 5–85). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–3 lists the maximum concentrations of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore.

Figure 5–79 shows concentration versus time for tritium. Releases from cribs and trenches (ditches) cause groundwater concentrations within the Core Zone Boundary to exceed benchmark concentrations by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore approach the benchmark concentration but stay about one order of magnitude below it. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium concentrations fall (and stay) below the benchmark concentration at the Core Zone Boundary after CY 2030.

Table 5–3. Tank Closure Alternative 2B Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	28	5,080	52	7,270	13	6,080	178	20,000
	(2051)	(2054)	(2050)	(2055)	(2050)	(2054)	(2050)	
Technetium-99	**1,450**	**30,000**	**2,660**	**15,200**	284	**25,900**	205	900
	(2058)	(2050)	(2050)	(2050)	(3499)	(2050)	(2480)	
Iodine-129	**3**	**40**	**5**	**30**	0.4	**34**	0.4	1
	(2053)	(2057)	(2050)	(2050)	(3708)	(2057)	(2876)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	1	**55**	6	**27**	8	**73**	1	15
	(11,755)	(11,739)	(11,765)	(11,780)	(11,441)	(11,691)	(11,871)	
Chemical in micrograms per liter								
Acetonitrile	1	0	0	0	0	1	0	100
	(3701)	(1940)	(3566)	(1940)	(1940)	(3829)	(4021)	
Chromium	9	**3,230**	**271**	**768**	10	**1,670**	34	100
	(2057)	(2055)	(2050)	(2050)	(2050)	(2050)	(2695)	
Nitrate	5,650	**1,540,000**	8,950	**133,000**	1,380	**1,010,000**	8,580	45,000
	(2057)	(2050)	(2050)	(2054)	(2068)	(2050)	(2450)	
Total uranium	0	**46**	8	11	12	**103**	1	30
	(11,795)	(11,792)	(11,602)	(11,840)	(11,599)	(11,683)	(11,146)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

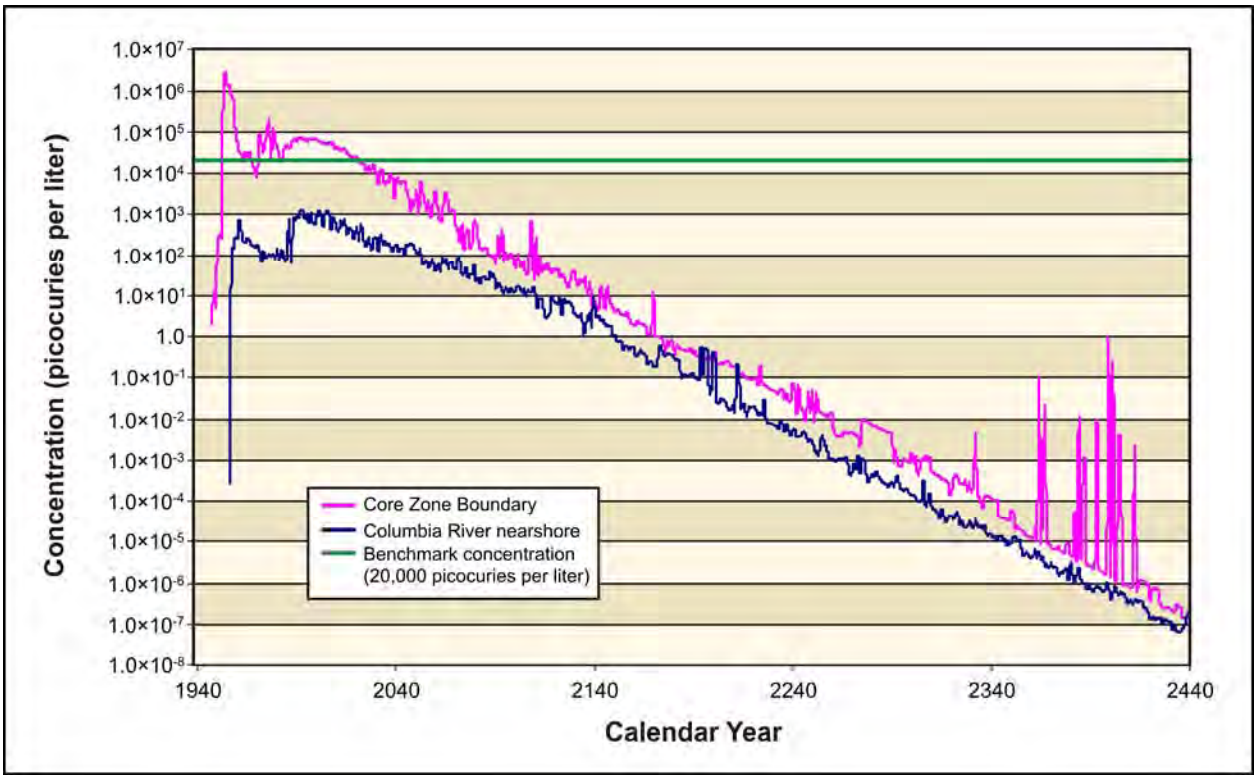


Figure 5–79. Tank Closure Alternative 2B Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–80 through 5–83 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from cribs and trenches (ditches) cause groundwater concentrations to exceed benchmark concentrations by about two to three orders of magnitude during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore approach the benchmark concentration but remain about one order of magnitude below the benchmark at peak-year conditions. Releases from past leaks and other tank farm sources cause groundwater concentrations to continue to exceed benchmark concentrations in the Core Zone Boundary by about one order of magnitude through about CY 8000 for iodine-129 and CY 5000 for the other conservative tracers. During this time, groundwater concentrations at the Columbia River nearshore are below the benchmark concentration and continue to decline through the end of the period of analysis.

Figures 5–84 and 5–85 show concentration versus time for uranium-238 and total uranium. Early releases from cribs and trenches (ditches) result in groundwater concentrations that are two to three orders of magnitude lower than benchmark concentrations. Releases from past leaks and other tank farm sources cause groundwater concentrations to rise in the Core Zone Boundary, nearing benchmark concentrations by about CY 8000. Concentrations continue to rise throughout the duration of the period of analysis, exceeding benchmark concentrations by approximately one-half of an order of magnitude at the end of the period of analysis (CY 11,940). Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis but remain below the benchmark concentration by over one order of magnitude at the end of the period of analysis (CY 11,940).

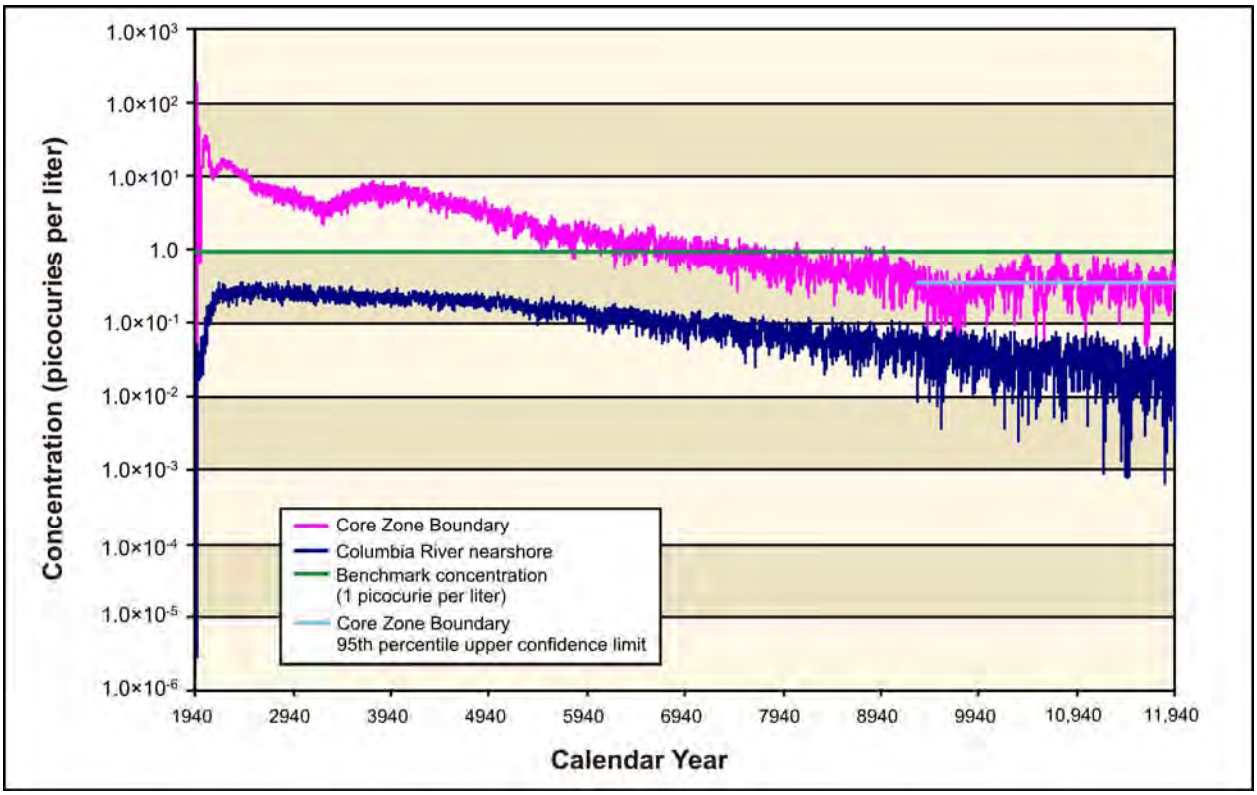


Figure 5–80. Tank Closure Alternative 2B Iodine-129 Concentration Versus Time

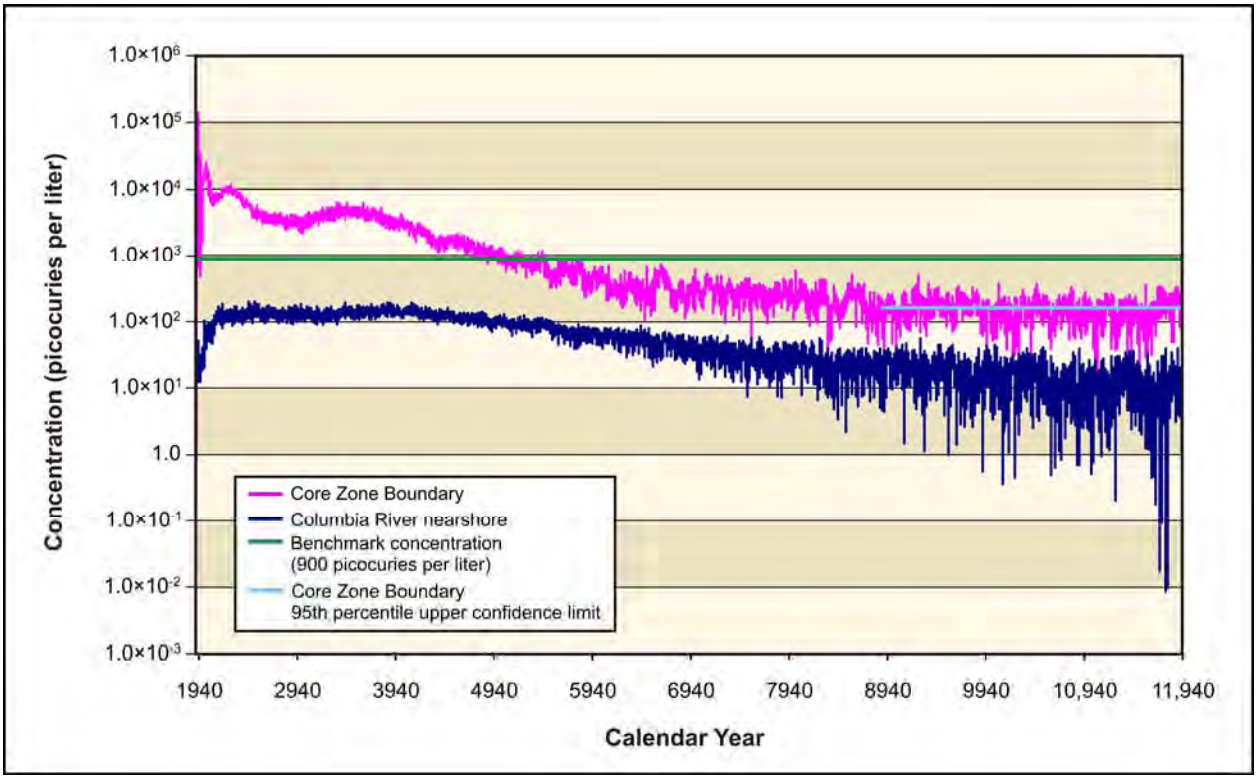


Figure 5–81. Tank Closure Alternative 2B Technetium-99 Concentration Versus Time

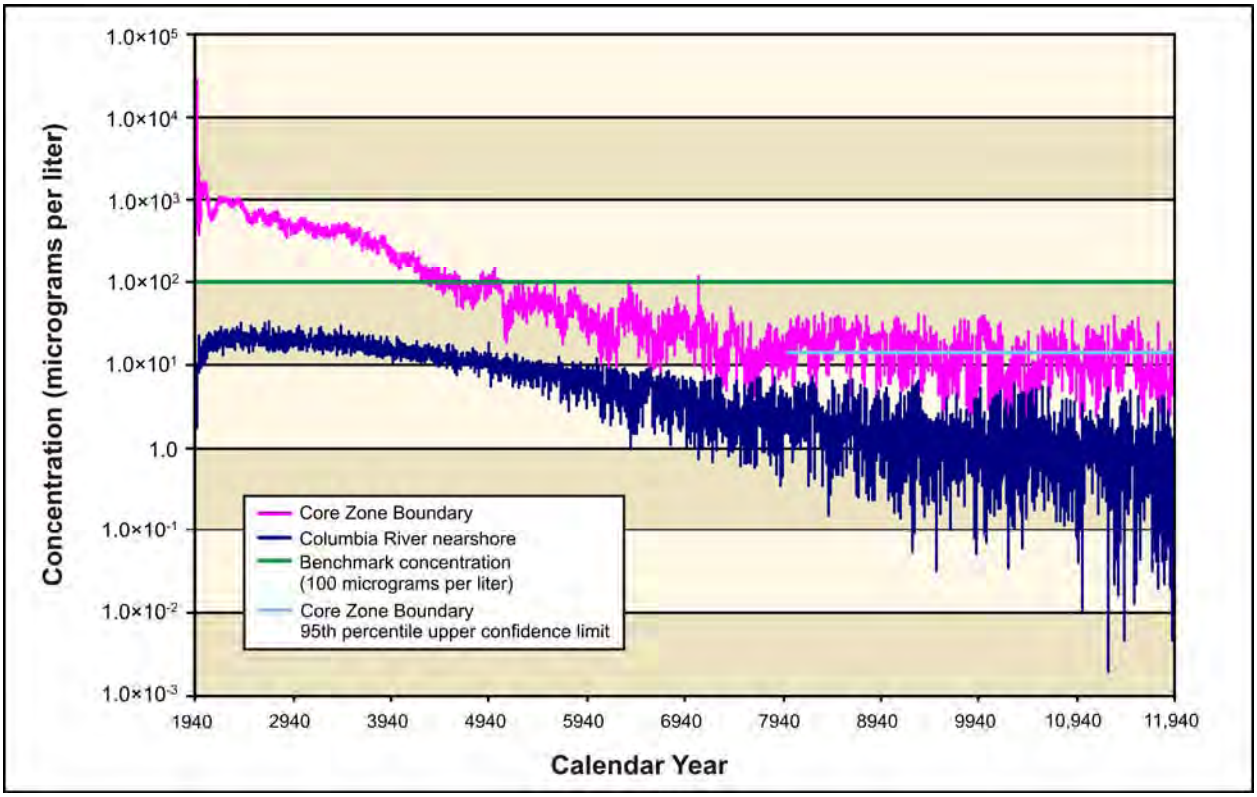


Figure 5–82. Tank Closure Alternative 2B Chromium Concentration Versus Time

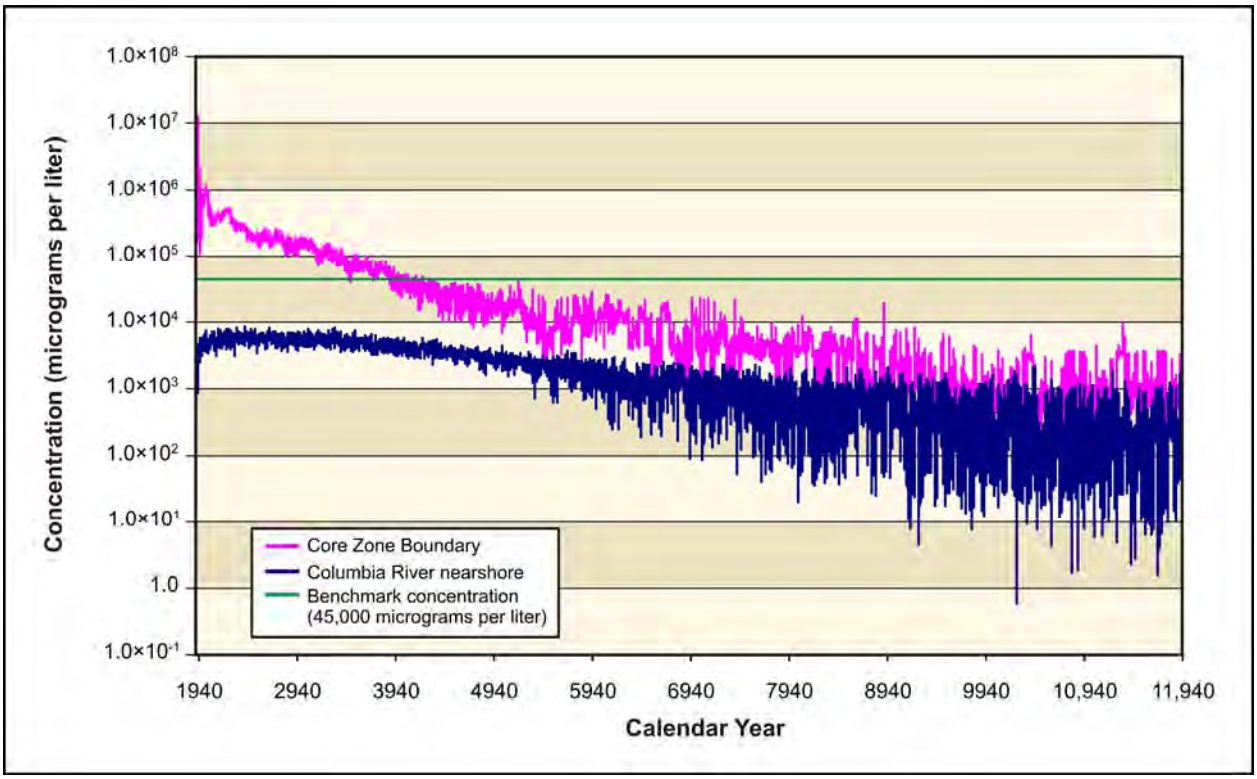


Figure 5–83. Tank Closure Alternative 2B Nitrate Concentration Versus Time

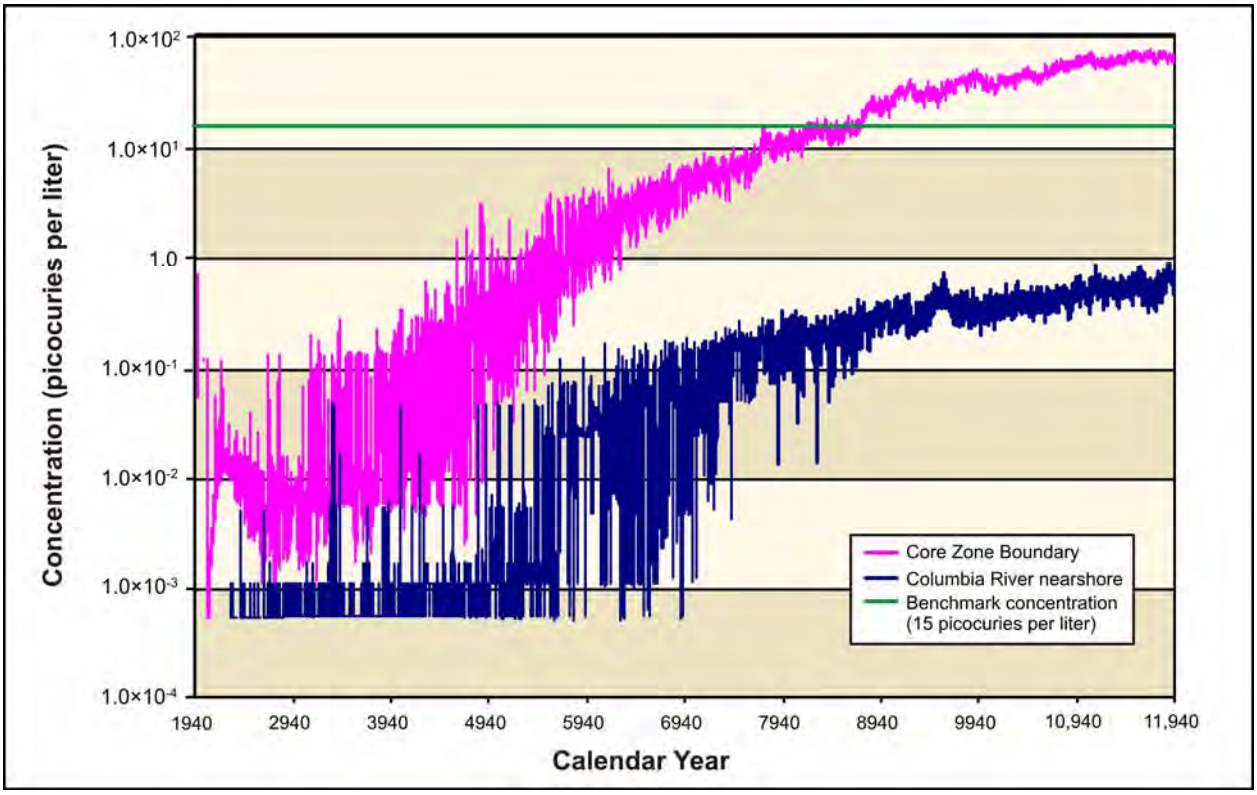


Figure 5–84. Tank Closure Alternative 2B Uranium-238 Concentration Versus Time

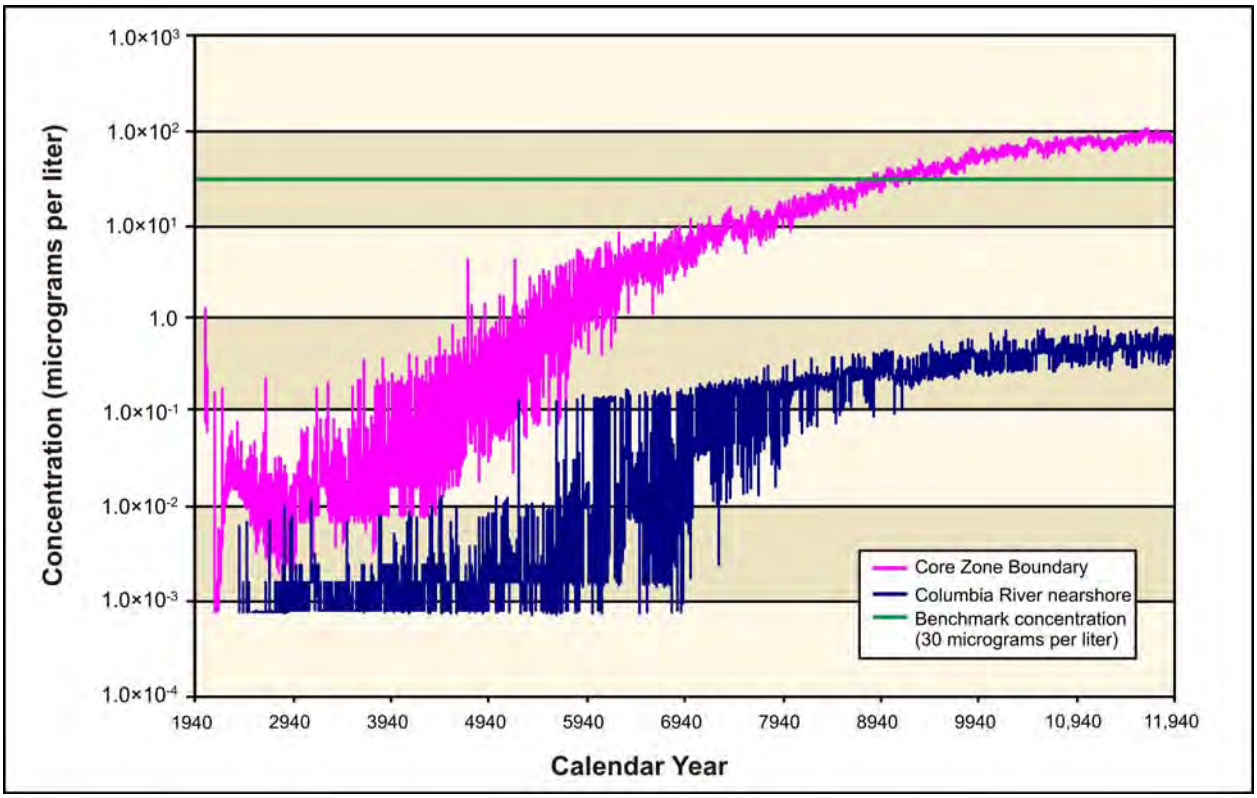


Figure 5–85. Tank Closure Alternative 2B Total Uranium Concentration Versus Time

5.1.1.3.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 2B in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–86 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 5 to 10 times greater than the benchmark, and mostly contained within the Core Zone Boundary. By CY 2135, the tritium plume has diminished to levels less than one-twentieth of the benchmark concentration (see Figure 5–87).

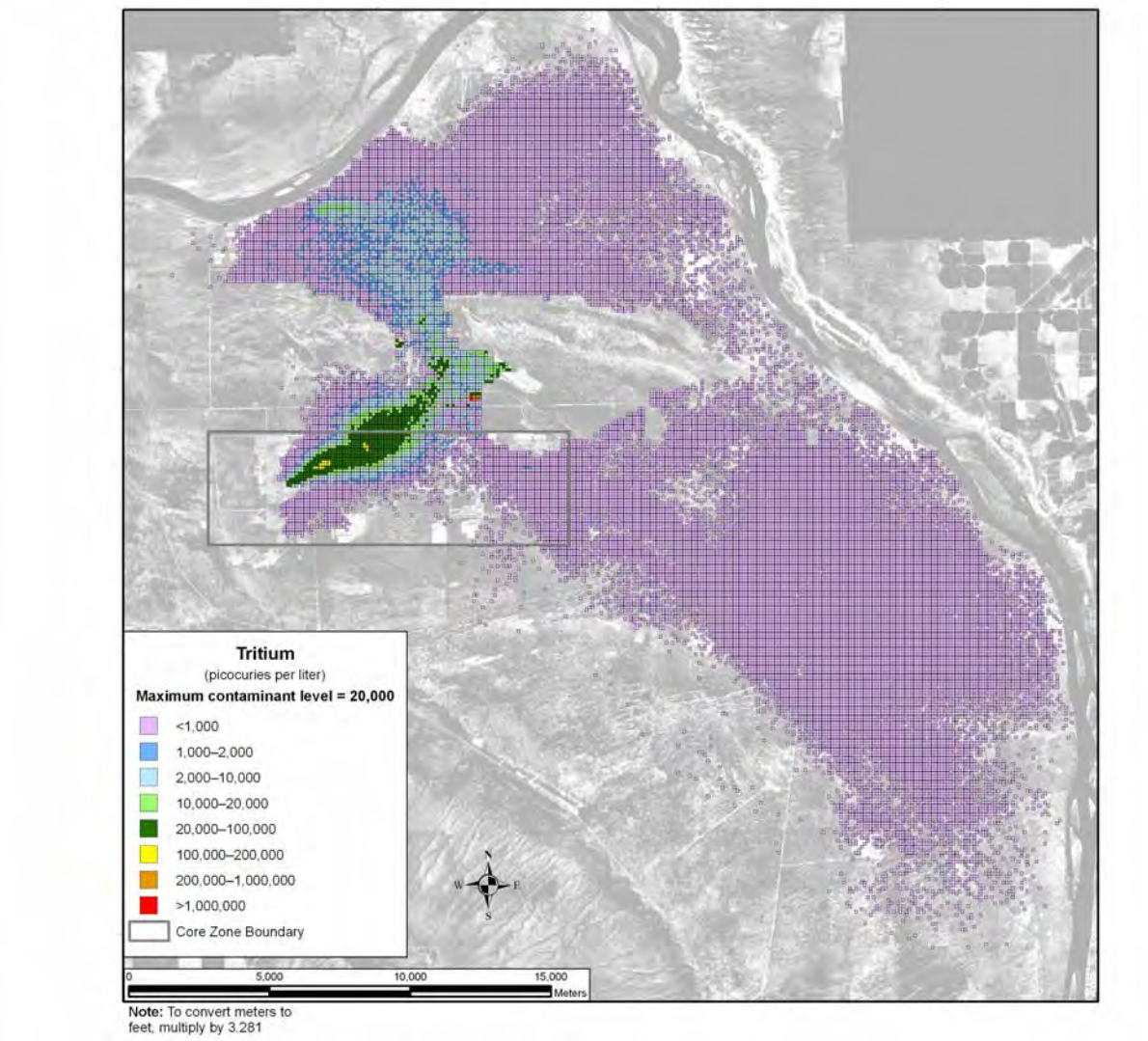


Figure 5–86. Tank Closure Alternative 2B Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

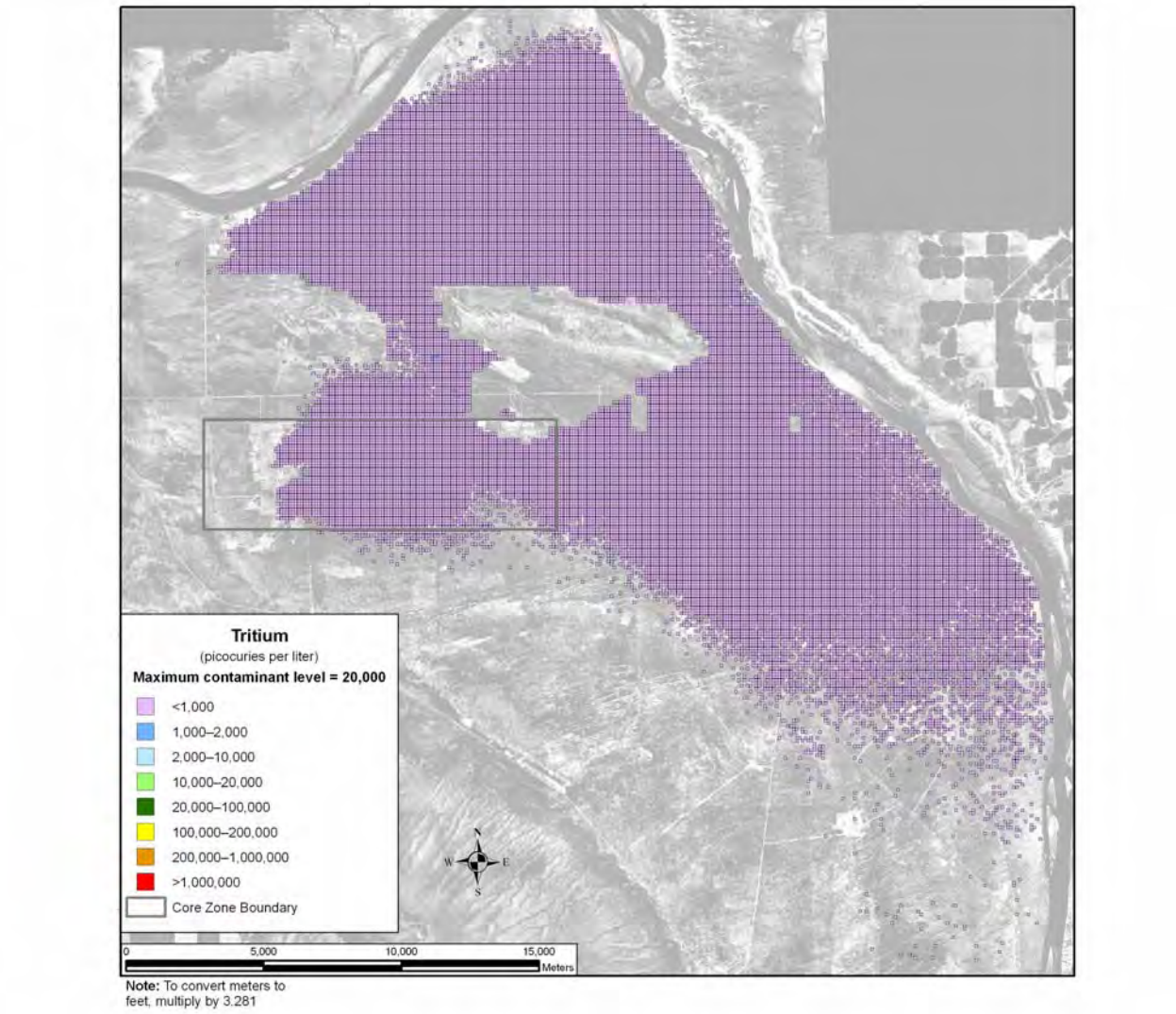


Figure 5–87. Tank Closure Alternative 2B Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

The conservative tracers (iodine-129, technetium-99, chromium, and nitrate) move at the rate of the pore water velocity and are discussed as a group, as they show similar spatial distributions. Figure 5–88 shows the spatial distribution of groundwater concentration of iodine-129 during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. During CY 2135, releases from other tank farm sources create another, less-intense plume (up to 5 to 10 times greater than the benchmark) that extends from the A Barrier toward the Columbia River (see Figure 5–89). By CY 7140, most of the mass in the plumes has reached the Columbia River, with only isolated pockets of high concentrations in Gable Gap (see Figure 5–90). Technetium-99, chromium, and nitrate show a similar spatial distribution at selected times (see Figures 5–91 through 5–99).

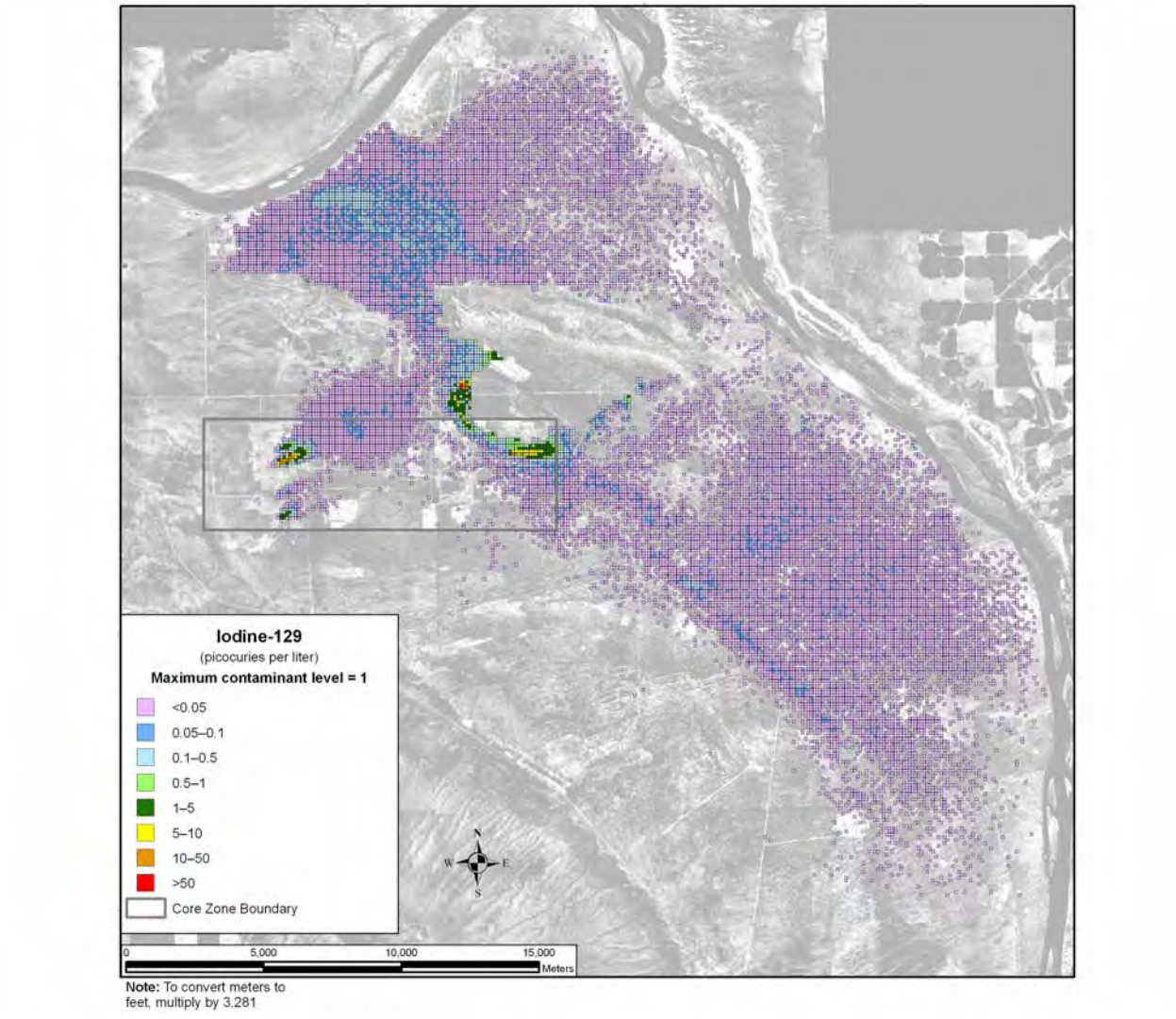


Figure 5–88. Tank Closure Alternative 2B Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

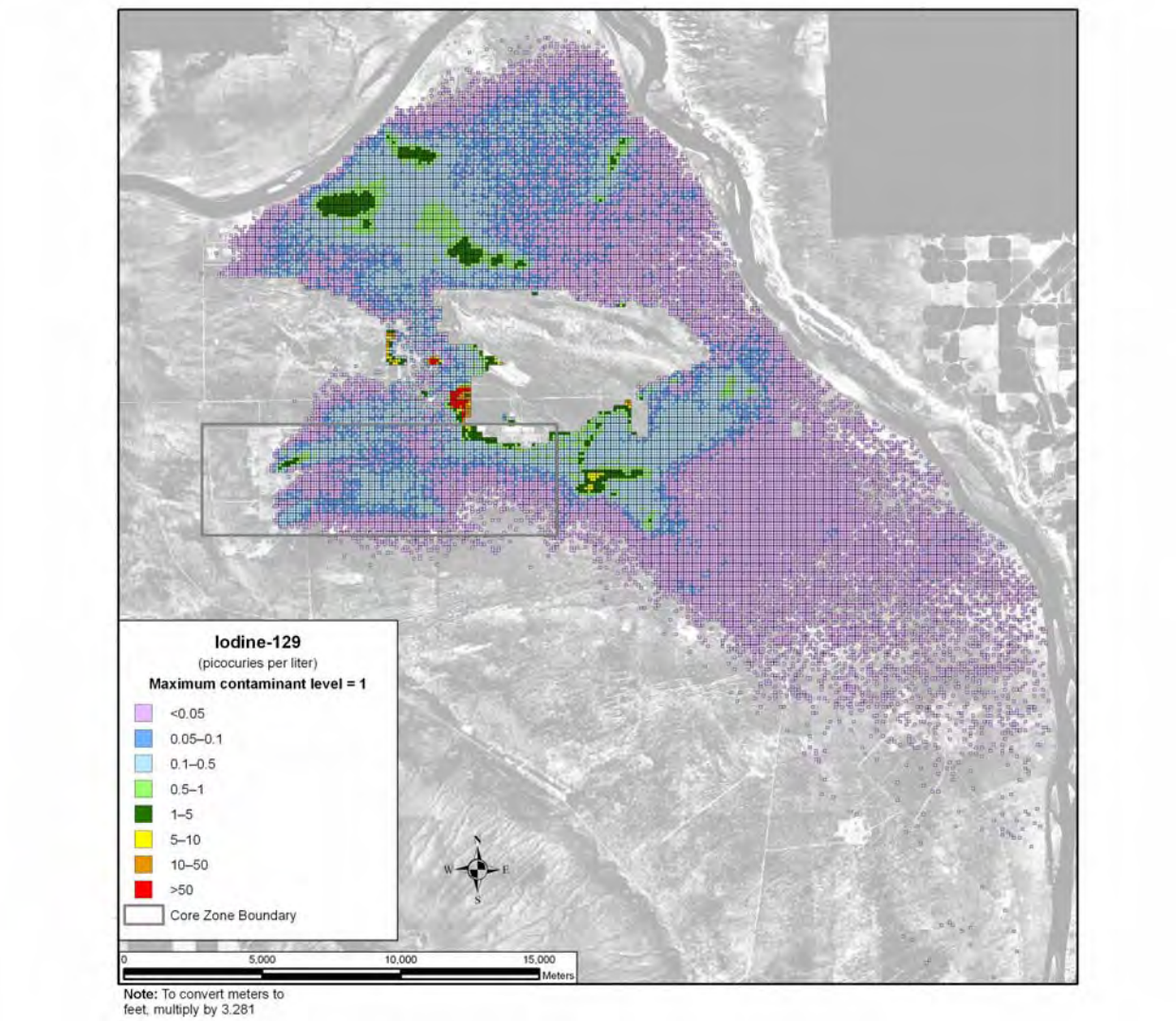


Figure 5–89. Tank Closure Alternative 2B Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135

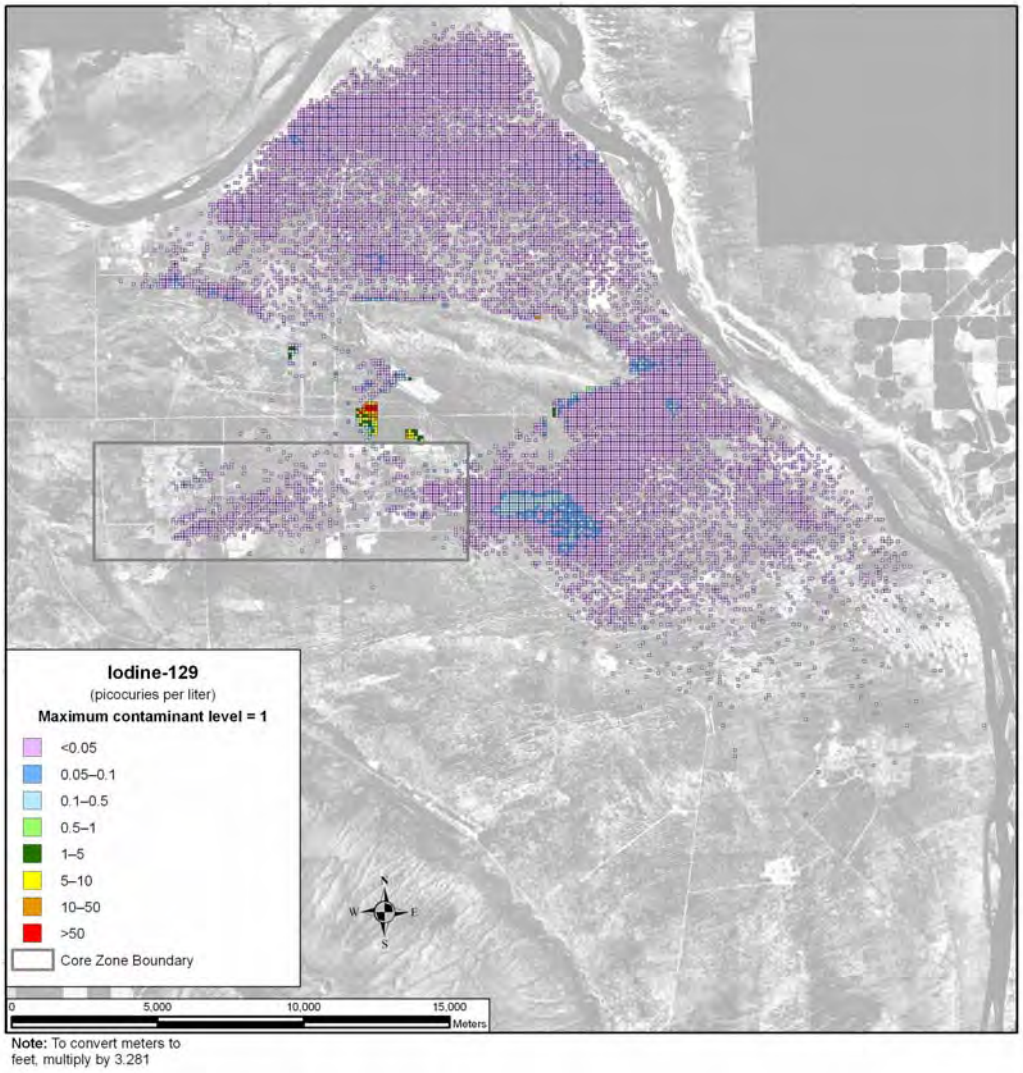


Figure 5–90. Tank Closure Alternative 2B Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

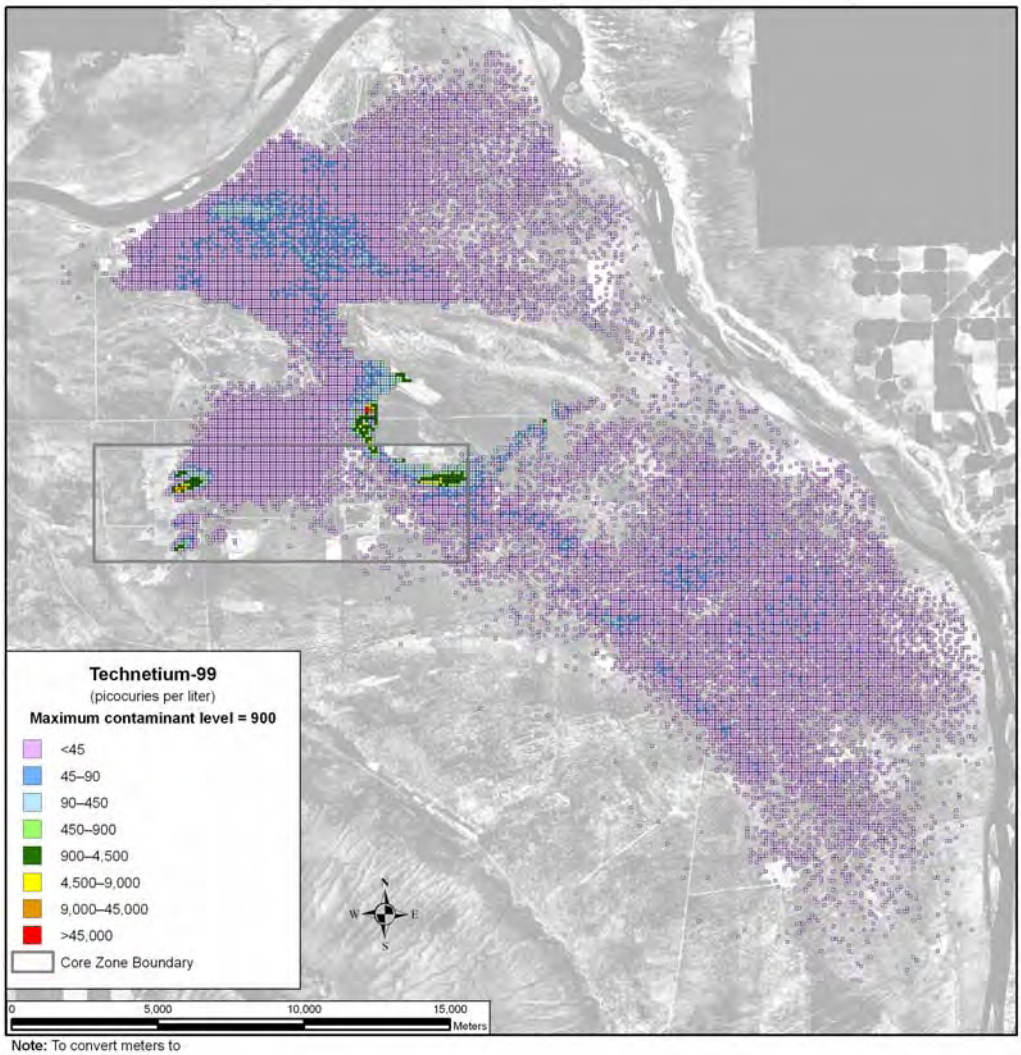


Figure 5–91. Tank Closure Alternative 2B Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

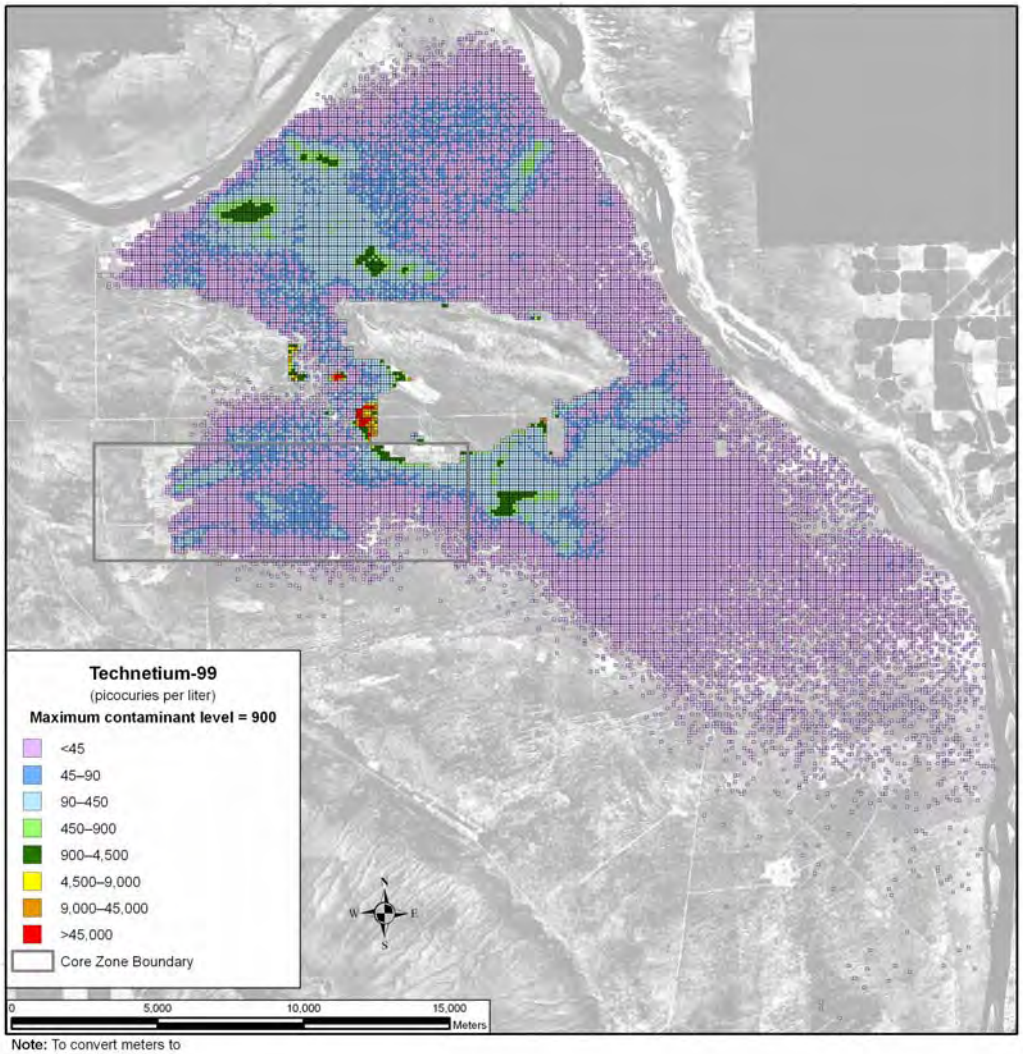


Figure 5–92. Tank Closure Alternative 2B Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2135

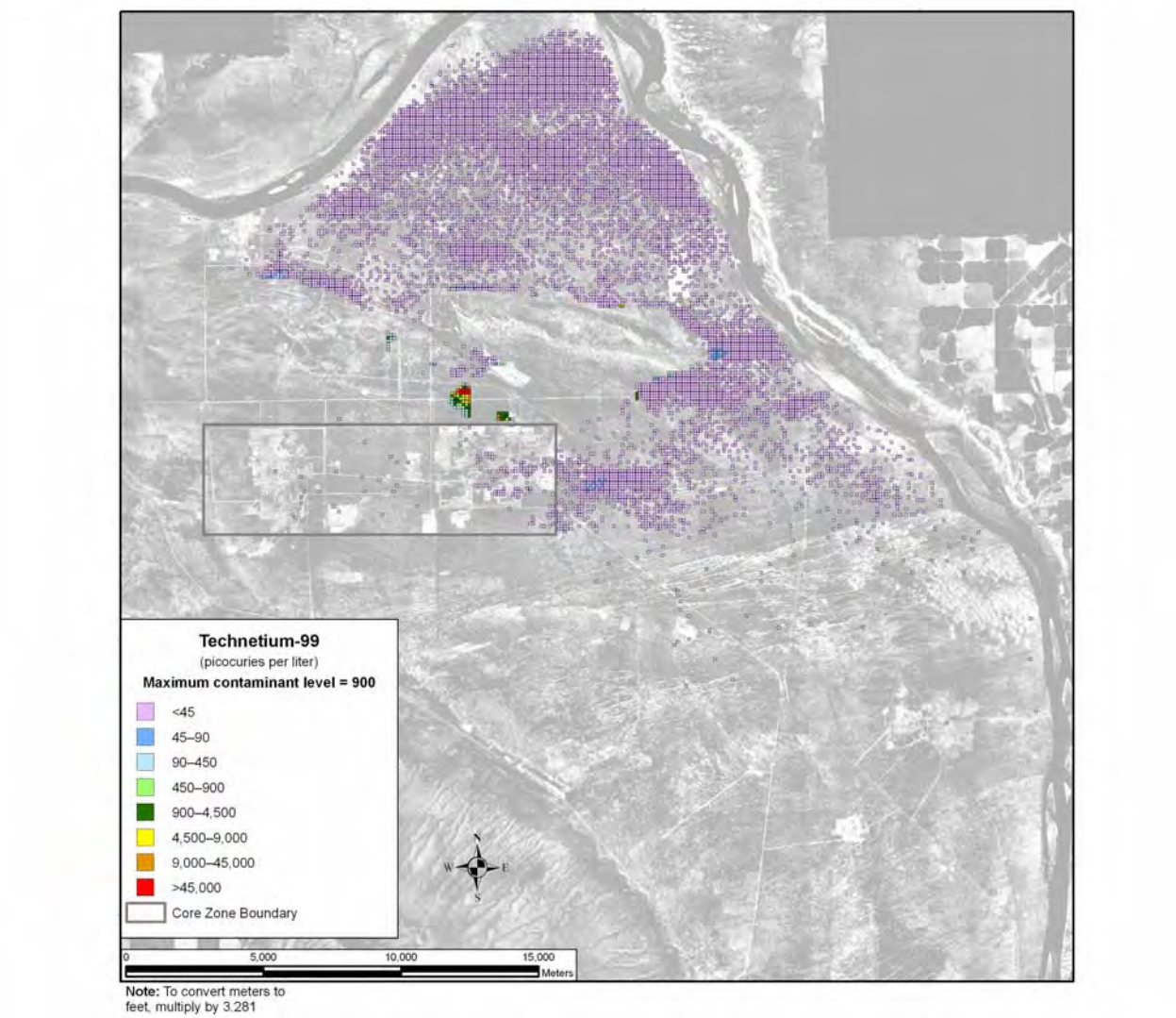


Figure 5–93. Tank Closure Alternative 2B Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

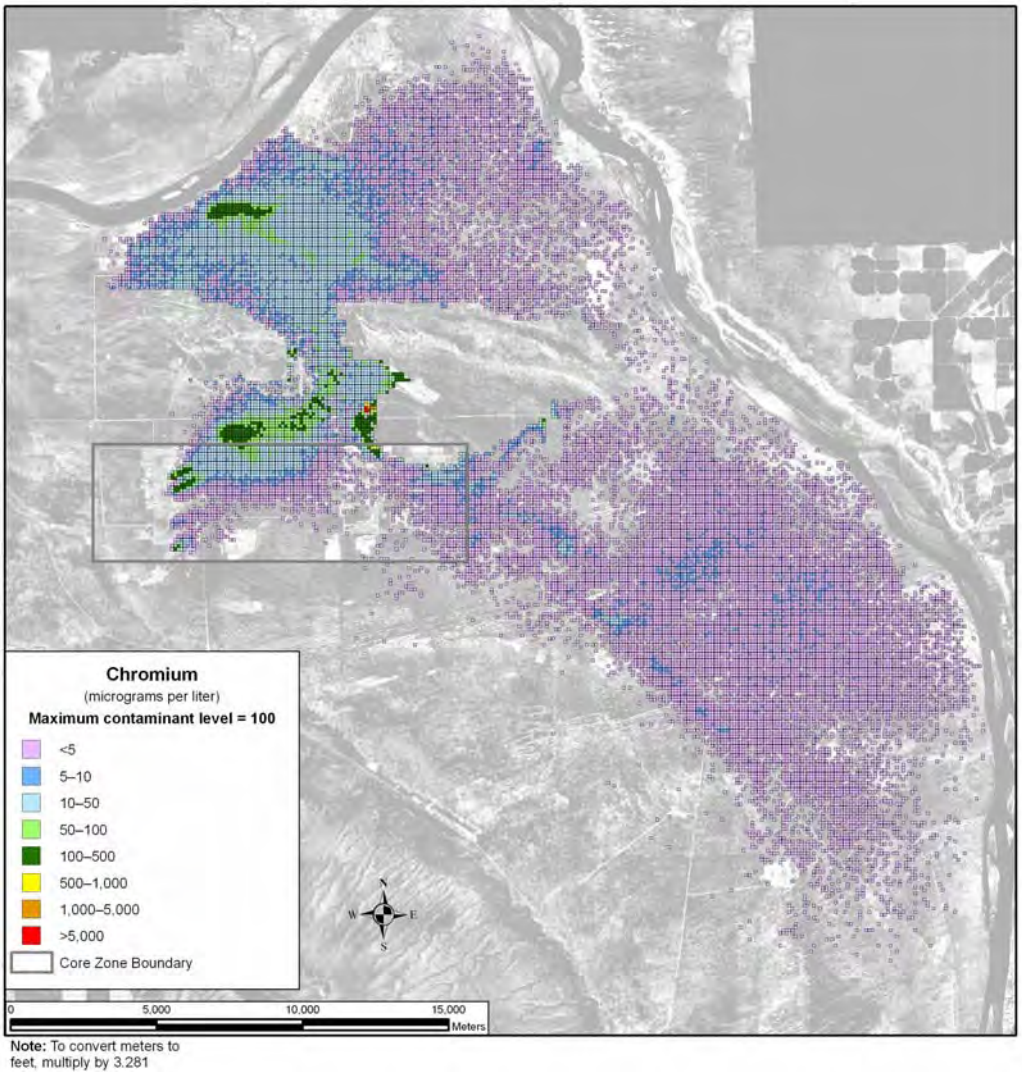


Figure 5–94. Tank Closure Alternative 2B Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

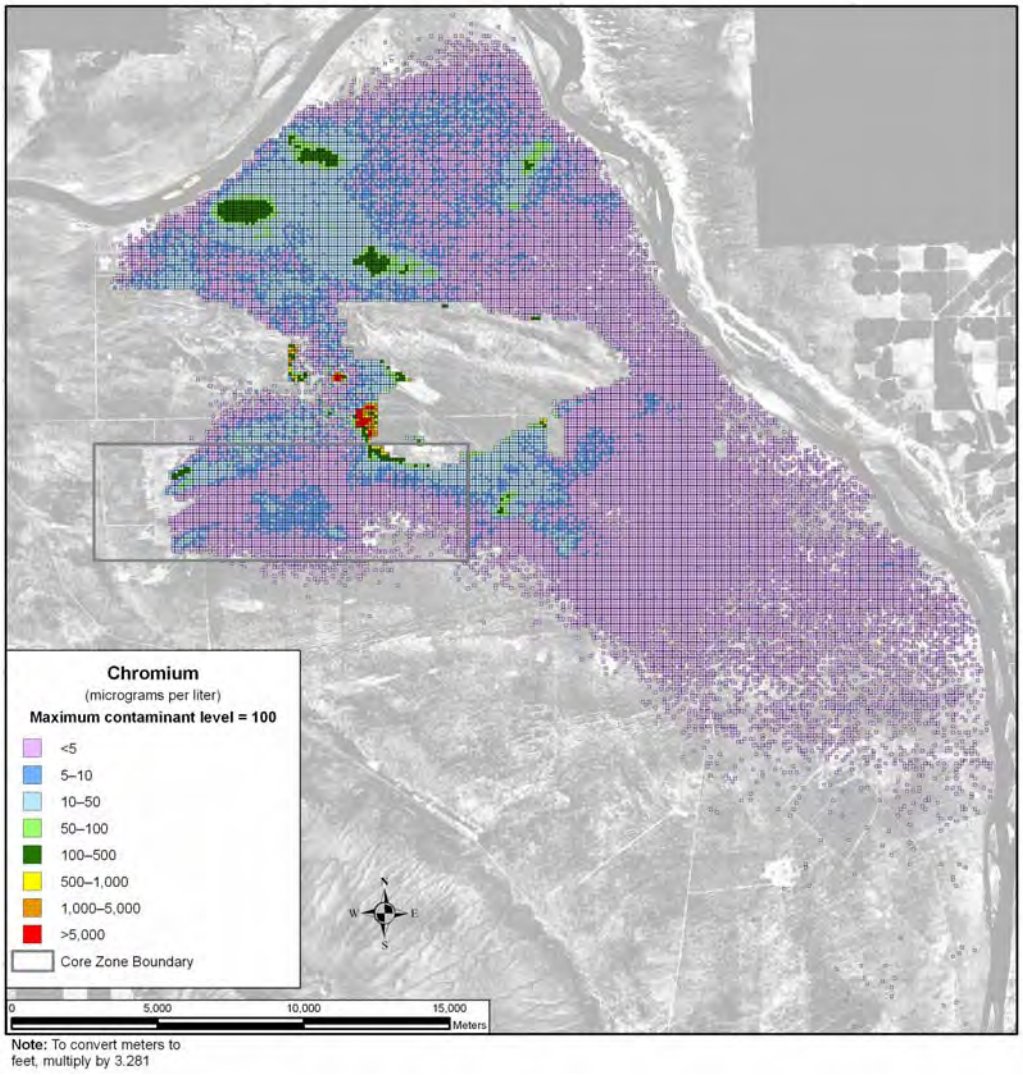


Figure 5–95. Tank Closure Alternative 2B Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2135

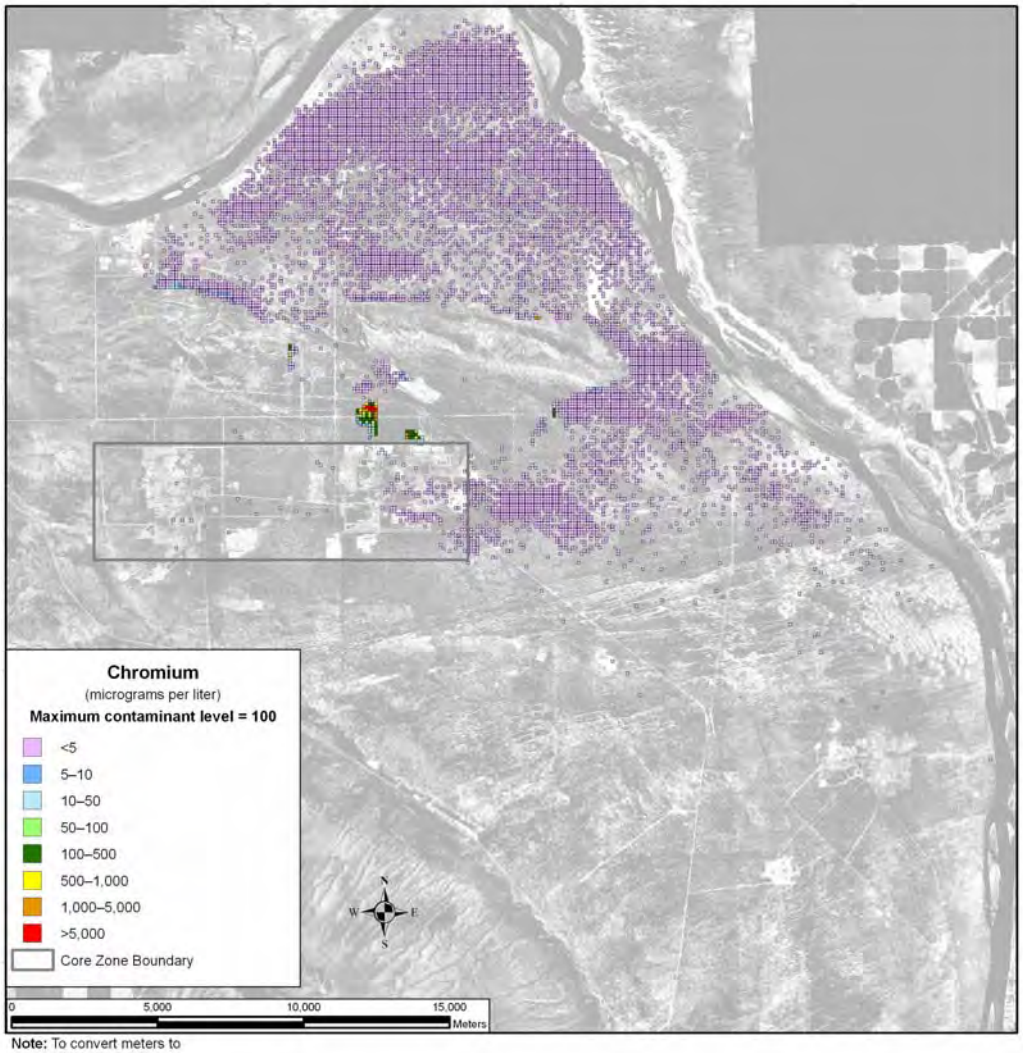


Figure 5–96. Tank Closure Alternative 2B Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

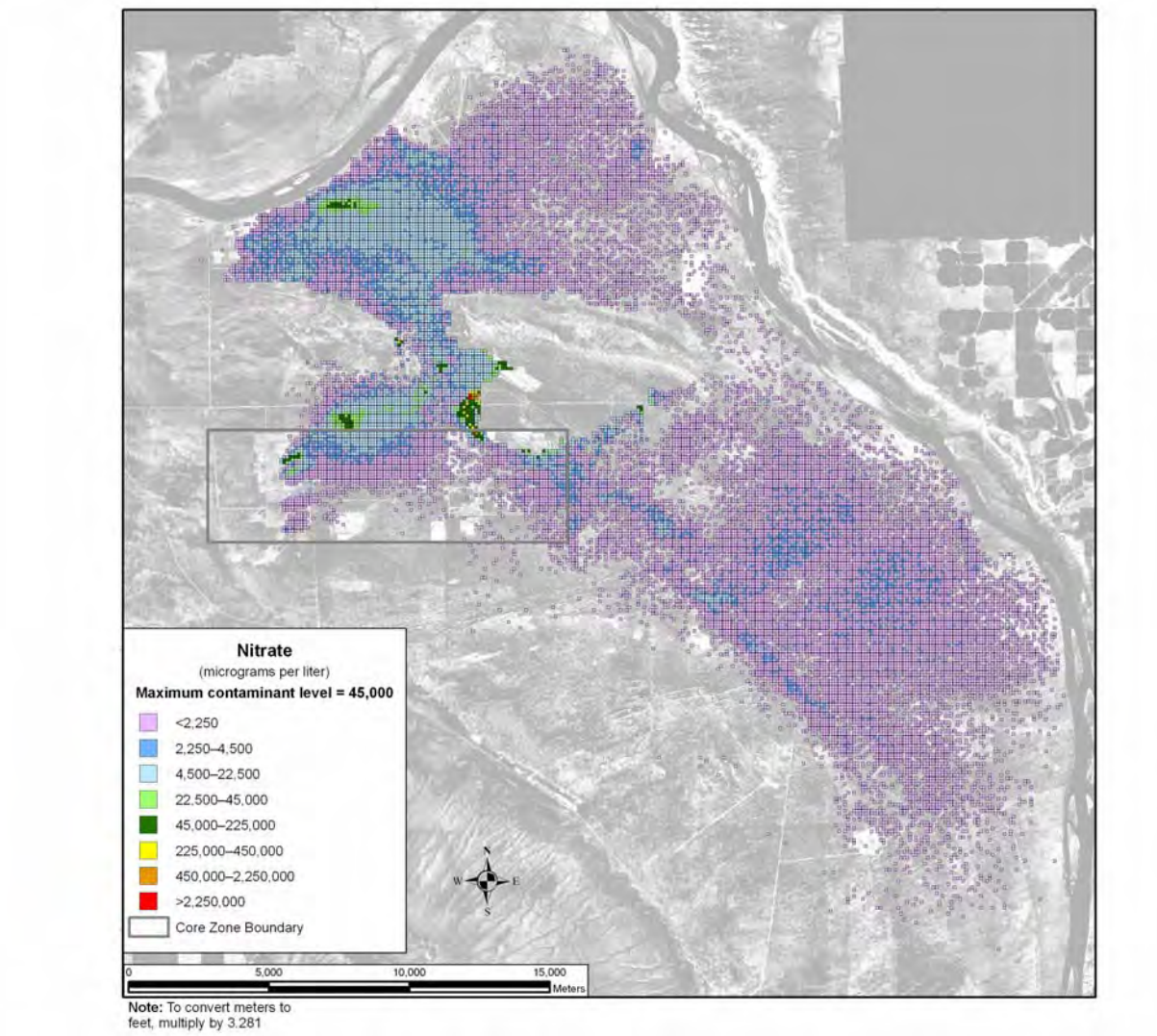


Figure 5–97. Tank Closure Alternative 2B Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

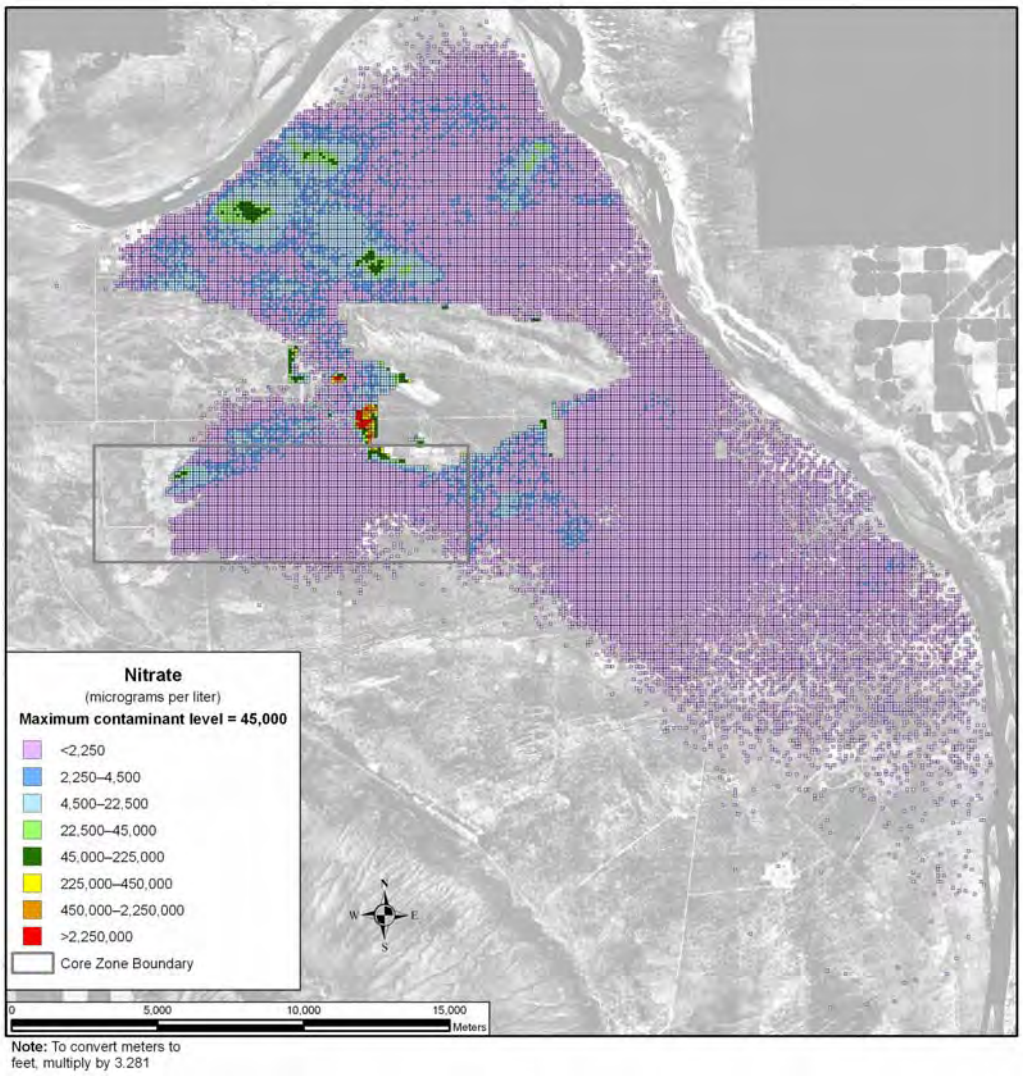


Figure 5–98. Tank Closure Alternative 2B Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2135

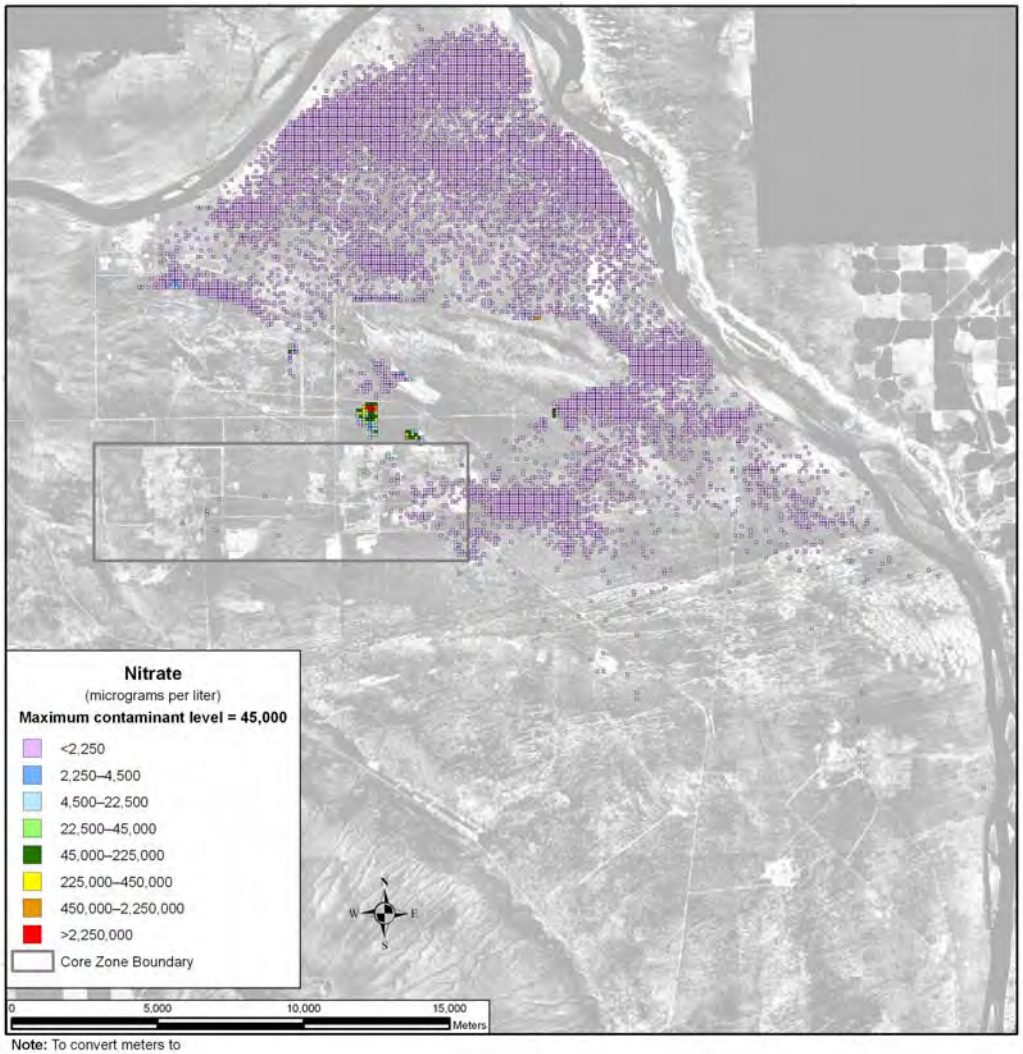


Figure 5–99. Tank Closure Alternative 2B Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Figure 5–100 shows the area in square kilometers in which groundwater concentrations of technetium-99 exceed the benchmark concentration in the analysis as a function of time. A peak area of about 4 square kilometers (1.5 square miles) occurs around CY 2135, followed by a fairly sharp decrease. Another peak area of about 2 square kilometers (0.77 square miles) occurs around CY 3890, followed by another decrease. By about CY 6000, the area with a concentration above the benchmark concentration begins to level out to around 0.5 square kilometers (0.2 square miles). Iodine-129 shows a pattern similar to that of technetium-99, as both constituents are conservative tracers (see Figure 5–101).

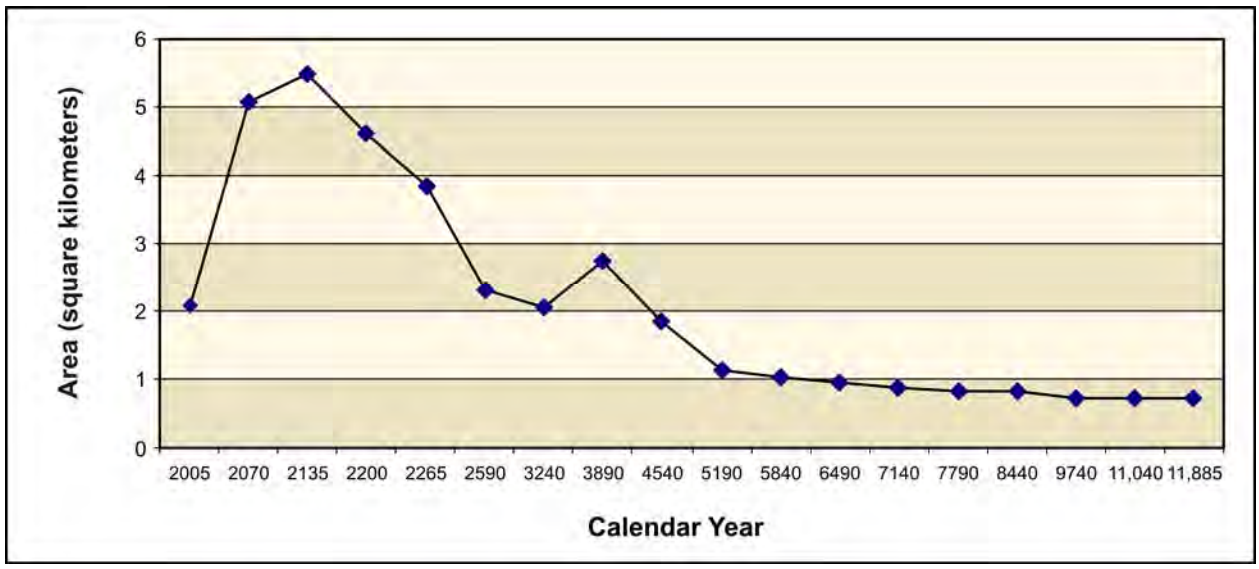


Figure 5–100. Tank Closure Alternative 2B Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

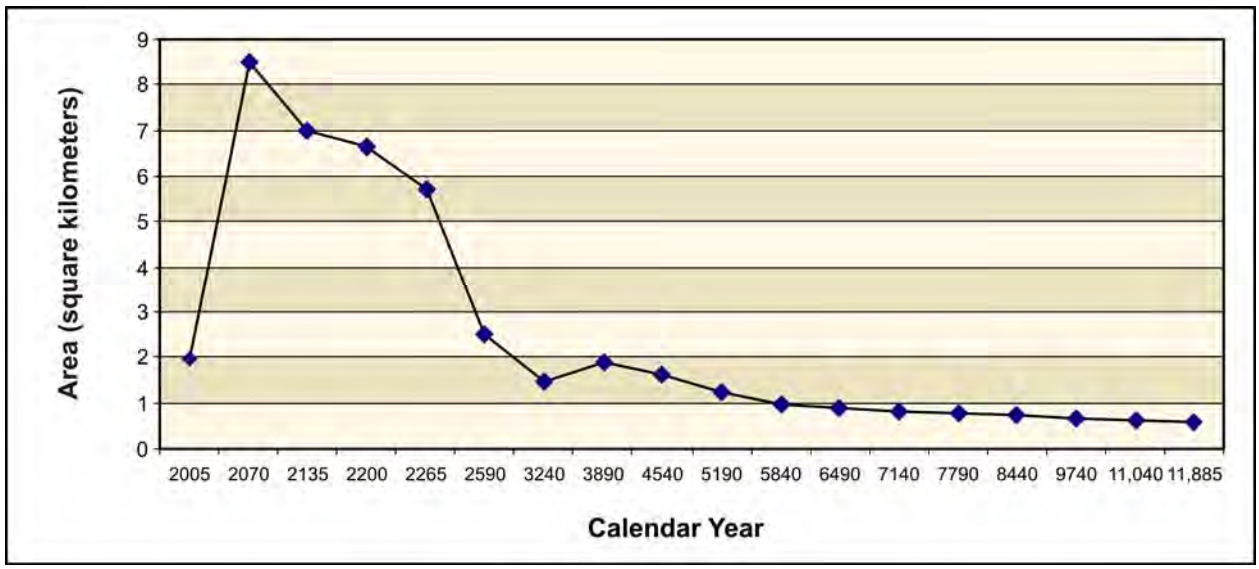


Figure 5–101. Tank Closure Alternative 2B Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Uranium-238 and total uranium show a different spatial distribution in the analysis over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–102 shows the distribution of uranium-238 during CY 2005. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration and is contained within the Core Zone Boundary. By CY 7140, the area of the plume has grown and extended to the Columbia River (see Figure 5–103). There is only a small area in Gable Gap that is 5 to 10 times greater in uranium-238 concentration than the benchmark concentration. By CY 11,885, the greatest development of the plume during the analysis period is seen, resulting primarily from past leaks and the release of other tank farm sources at the A Barrier and B Barrier (see Figure 5–104). Figures 5–105 through 5–107 show the corresponding results for total uranium.

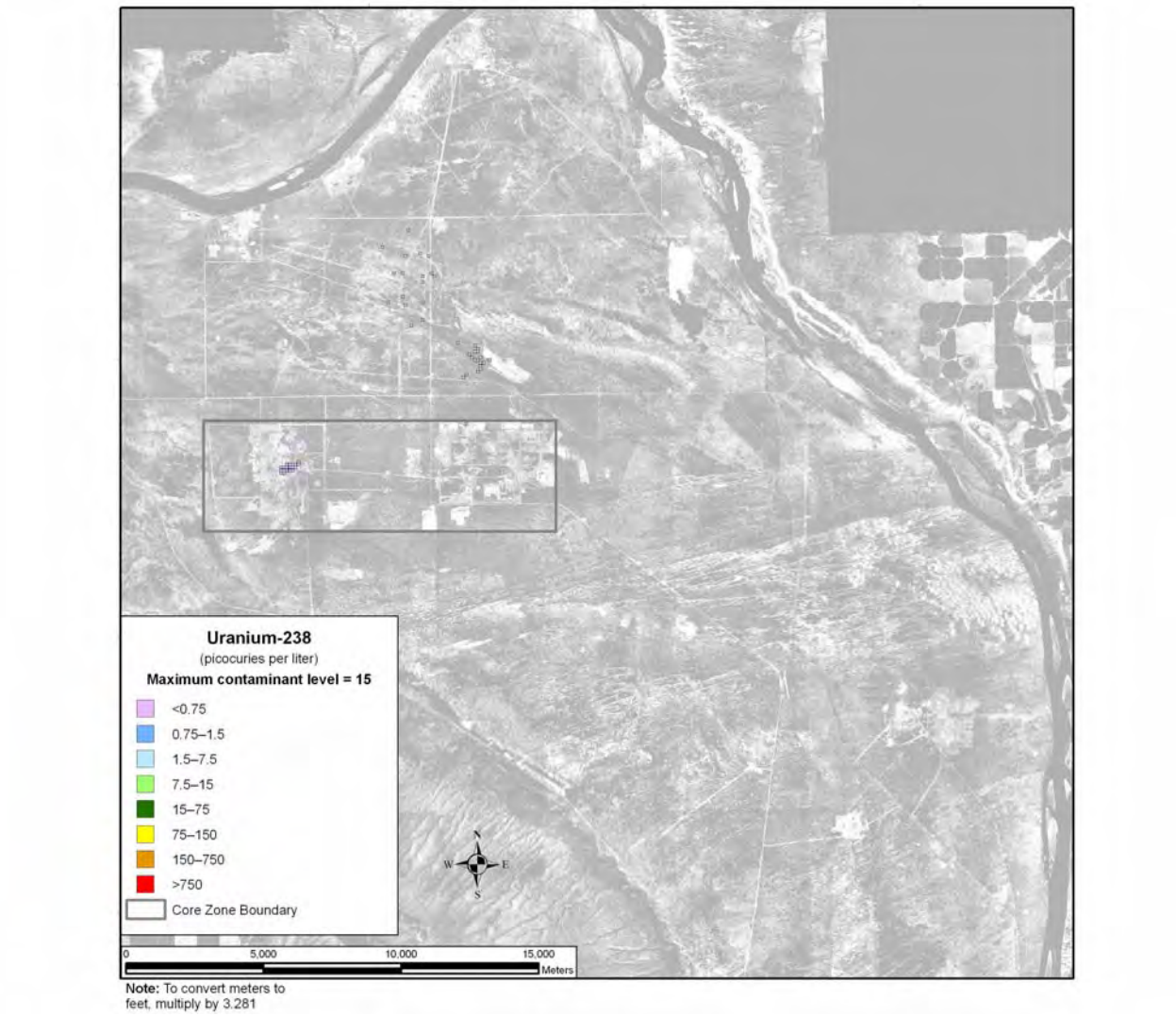


Figure 5–102. Tank Closure Alternative 2B Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

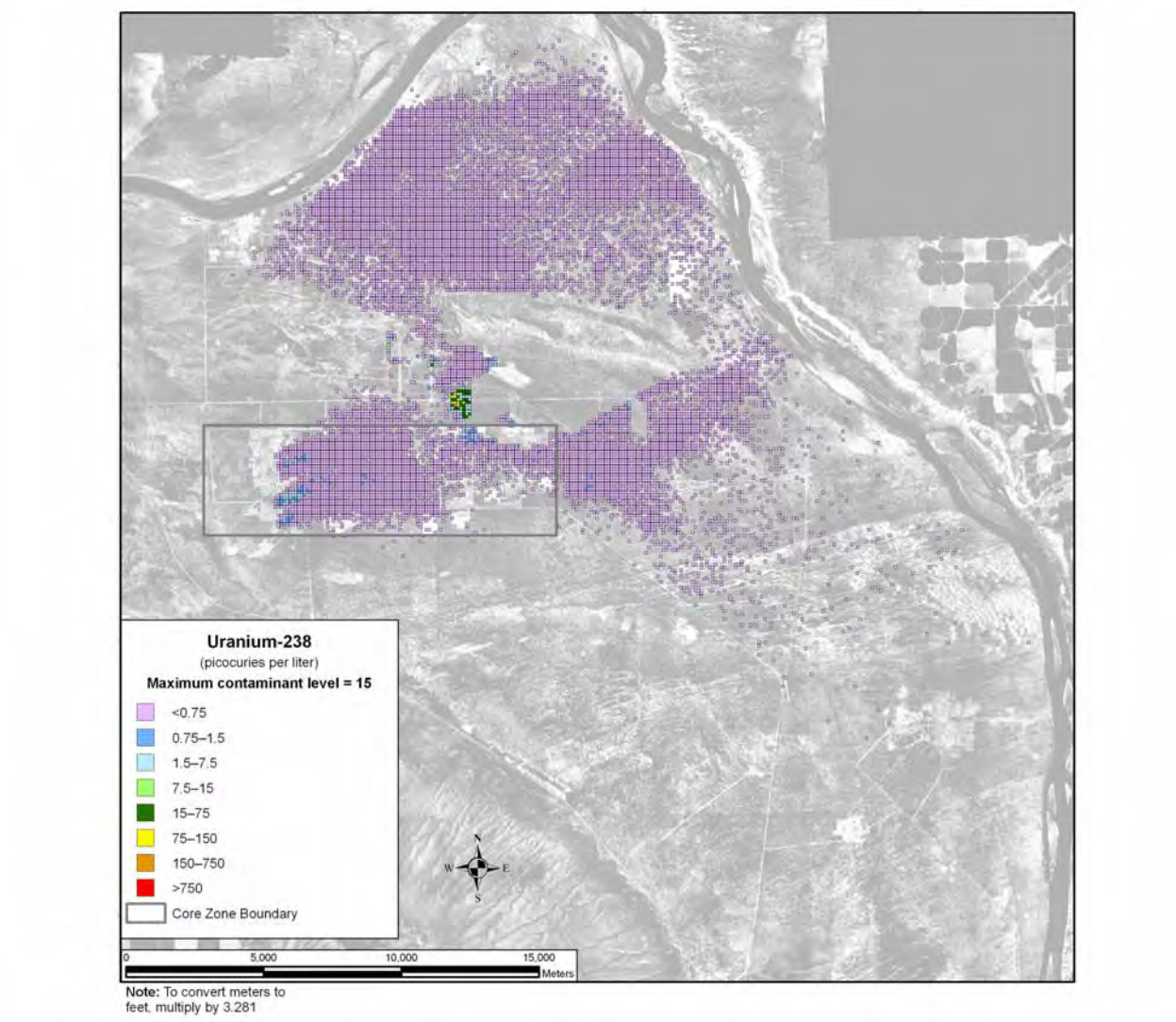


Figure 5–103. Tank Closure Alternative 2B Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 7140

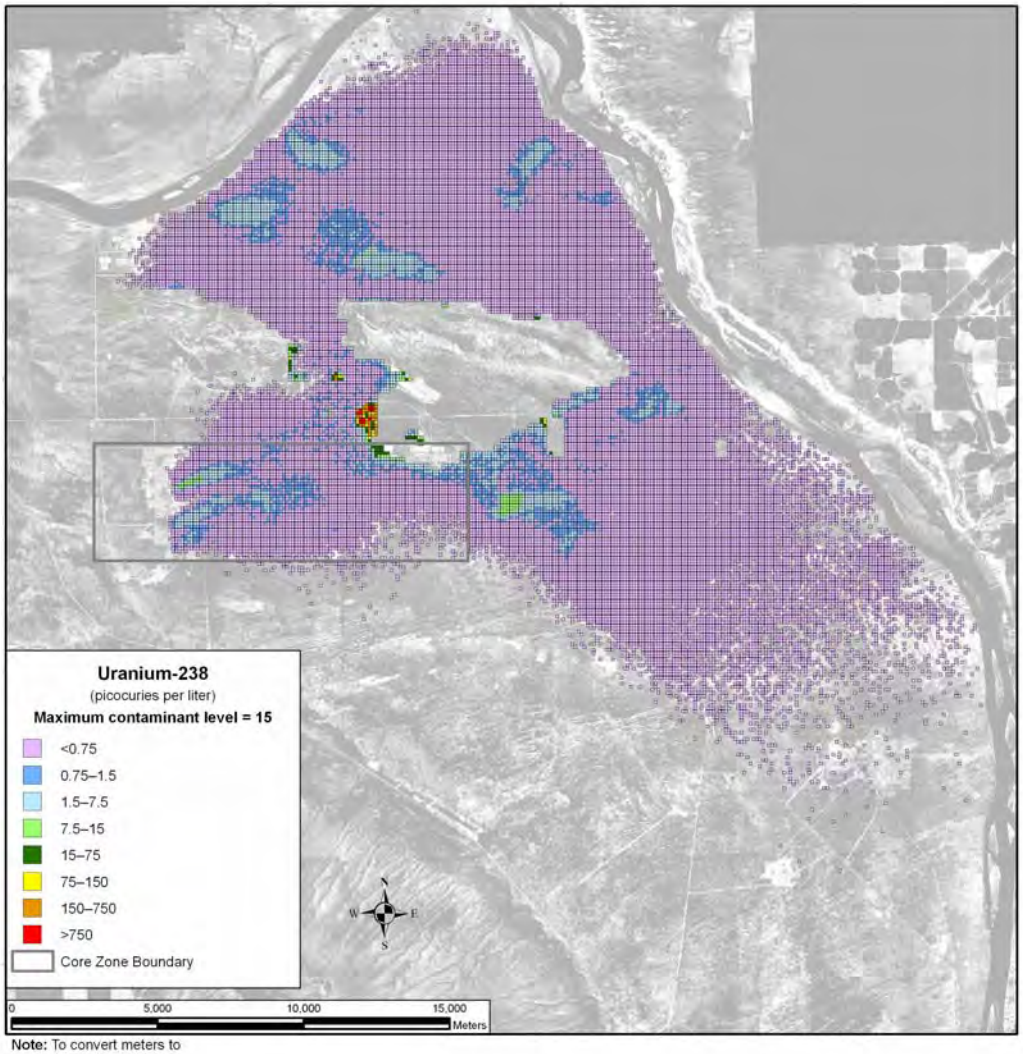


Figure 5–104. Tank Closure Alternative 2B Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

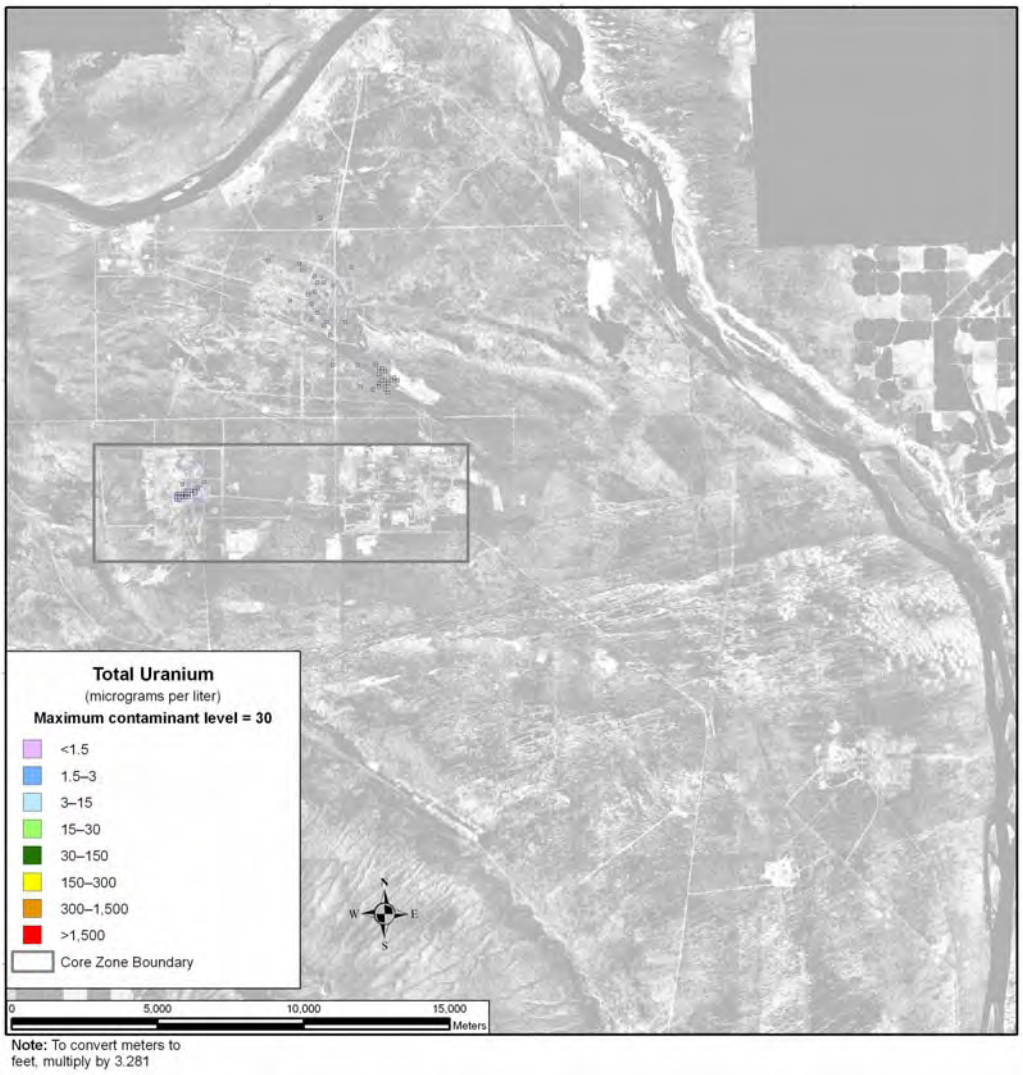


Figure 5–105. Tank Closure Alternative 2B Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

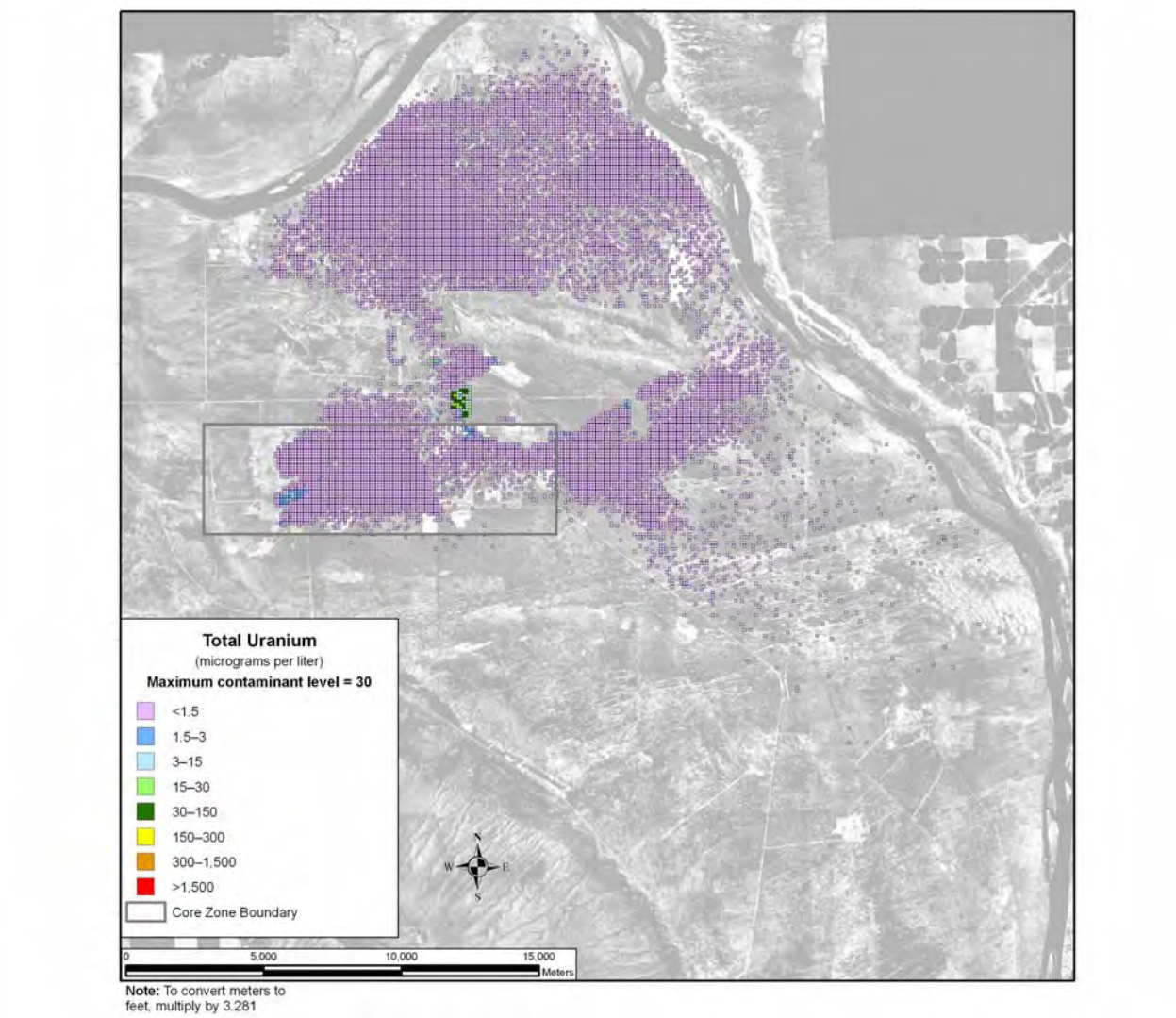


Figure 5–106. Tank Closure Alternative 2B Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 7140

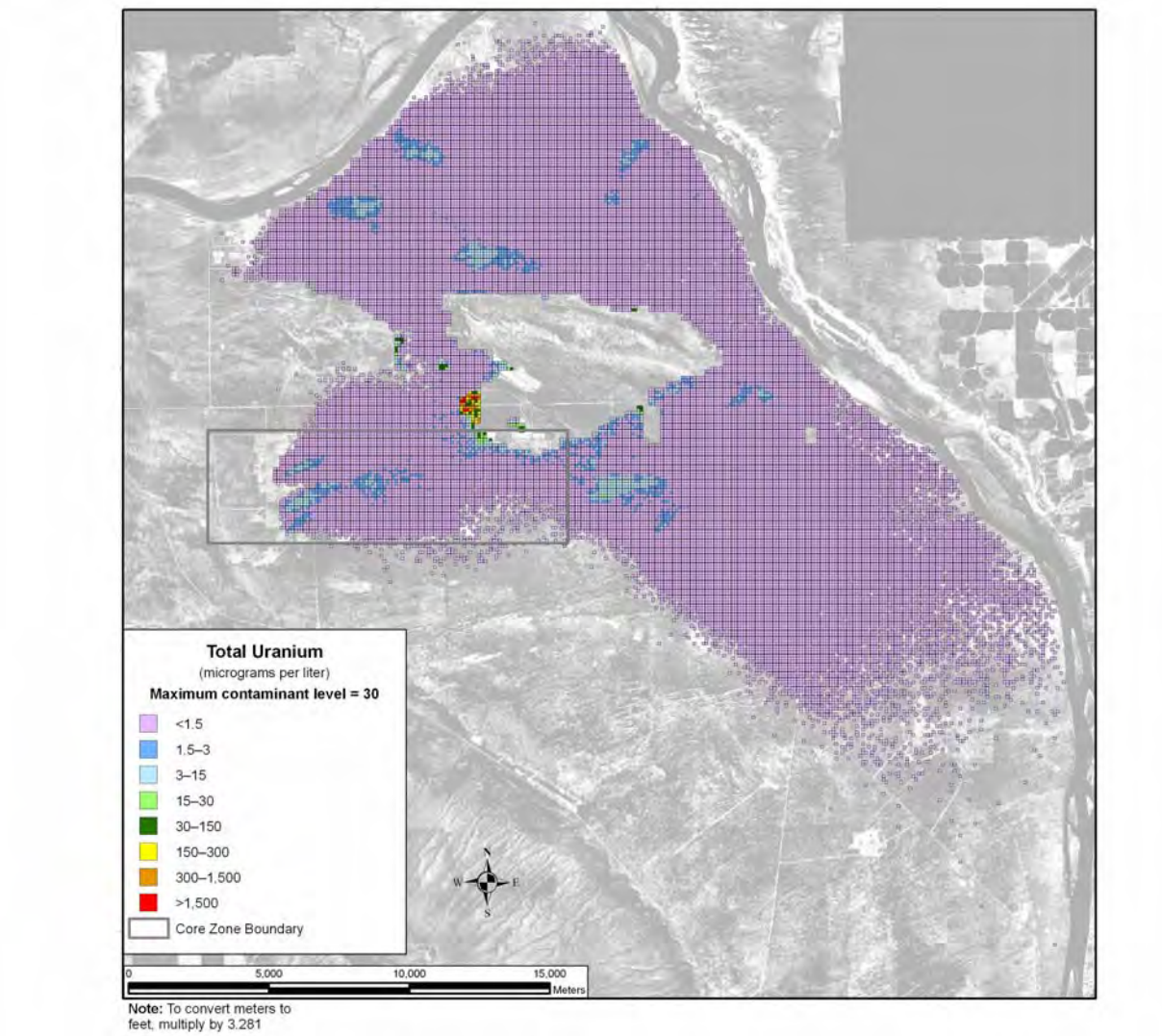


Figure 5–107. Tank Closure Alternative 2B Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

Uranium-238 does not exceed the benchmark concentration in any area until after CY 5190 (see Figure 5–108). A sharp increase in area with concentrations above the maximum contaminant level is seen after this time and continues to rise to over 1.25 square kilometers (0.48 square miles) through the end of the period of analysis (CY 11,940). It is expected that the majority of the uranium-238 would continue to migrate through the vadose zone after the period of analysis is over.

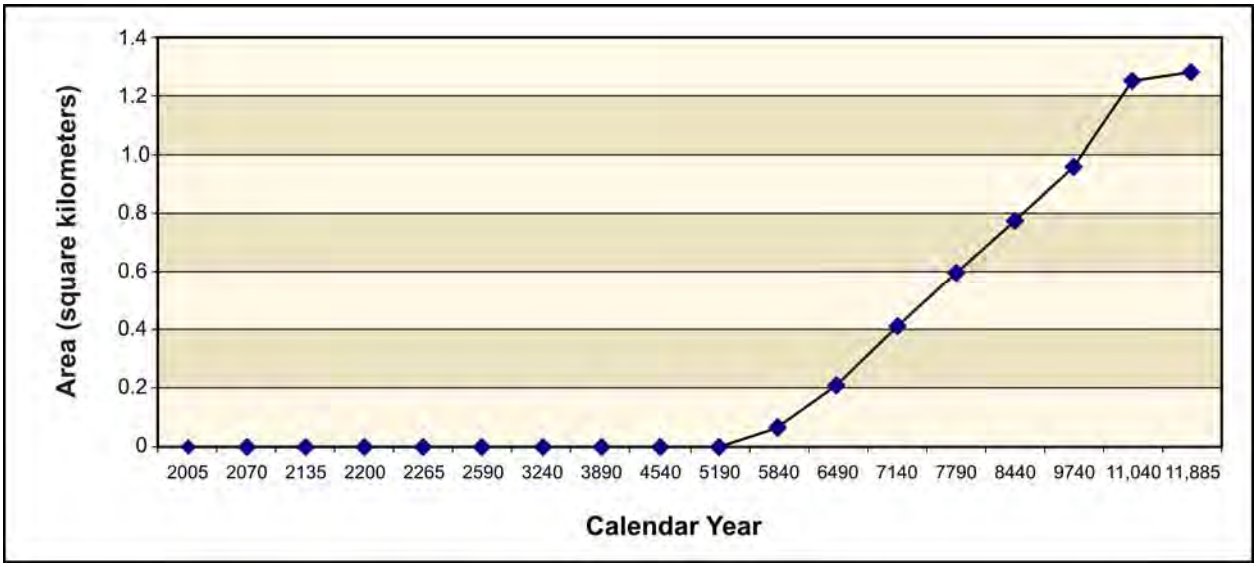


Figure 5–108. Tank Closure Alternative 2B Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.3.6 Summary of Impacts

Under Tank Closure Alternative 2B, concentrations of tritium at the Core Zone Boundary exceed the benchmark concentration by about two orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River nearshore approach but do not exceed the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium.

For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), concentrations at the Core Zone Boundary exceed benchmark standards by two to three orders of magnitude during the early part of the period of analysis and then gradually decline to around one order of magnitude below the benchmark, where they remain throughout the period of analysis. Concentrations at the Columbia River nearshore remain below the benchmark throughout the period of analysis.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark at the Core Zone Boundary beyond about CY 8000. Concentrations at the Columbia River nearshore rise throughout the period of analysis but remain below the benchmark by around one order of magnitude. The peak intensity and area of the contamination plume is at the end of the period of analysis.

5.1.1.4 Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Activities under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would be similar in scope and timing. Tank waste would be retrieved to a volume corresponding to 99 percent retrieval, and residual material in tanks would be stabilized in place. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. From the long-term groundwater impact perspective, the results from the analyses of these alternatives are identical. Refer to Section 5.1.1.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3A.

5.1.1.4.1 Actions and Timeframes Influencing Groundwater Impacts

Refer to Section 5.1.1.3.1 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3A.

5.1.1.4.2 COPC Drivers

Refer to Section 5.1.1.3.2 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3A.

5.1.1.4.3 Analysis of Release and Mass Balance

Refer to Section 5.1.1.3.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3A.

5.1.1.4.4 Analysis of Concentration Versus Time

Refer to Section 5.1.1.3.4 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3A.

5.1.1.4.5 Analysis of Spatial Distribution of Concentration

Refer to Section 5.1.1.3.5 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3A.

5.1.1.4.6 Summary of Impacts

Refer to Section 5.1.1.3.6 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3A.

5.1.1.5 Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Activities under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would be similar in scope and timing. Tank waste would be retrieved to a volume corresponding to 99 percent retrieval, and residual material in tanks would be stabilized in place. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. From the long-term groundwater impact perspective, the results from the analyses of these alternatives are identical. Refer to Section 5.1.1.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3B.

5.1.1.5.1 Actions and Timeframes Influencing Groundwater Impacts

Refer to Section 5.1.1.3.1 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3B.

5.1.1.5.2 COPC Drivers

Refer to Section 5.1.1.3.2 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3B.

5.1.1.5.3 Analysis of Release and Mass Balance

Refer to Section 5.1.1.3.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3B.

5.1.1.5.4 Analysis of Concentration Versus Time

Refer to Section 5.1.1.3.4 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3B.

5.1.1.5.5 Analysis of Spatial Distribution of Concentration

Refer to Section 5.1.1.3.5 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3B.

5.1.1.5.6 Summary of Impacts

Refer to Section 5.1.1.3.6 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3B.

5.1.1.6 Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Activities under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would be similar in scope and timing. Tank waste would be retrieved to a volume corresponding to 99 percent retrieval, and residual material in tanks would be stabilized in place. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. From the long-term groundwater impact perspective, the results from the analyses of these alternatives are identical. Refer to Section 5.1.1.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3C.

5.1.1.6.1 Actions and Timeframes Influencing Groundwater Impacts

Refer to Section 5.1.1.3.1 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3C.

5.1.1.6.2 COPC Drivers

Refer to Section 5.1.1.3.2 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3C.

5.1.1.6.3 Analysis of Release and Mass Balance

Refer to Section 5.1.1.3.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3C.

5.1.1.6.4 Analysis of Concentration Versus Time

Refer to Section 5.1.1.3.4 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3C.

5.1.1.6.5 Analysis of Spatial Distribution of Concentration

Refer to Section 5.1.1.3.5 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3C.

5.1.1.6.6 Summary of Impacts

Refer to Section 5.1.1.3.6 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 3C.

5.1.1.7 Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

This section describes the groundwater analysis results for Tank Closure Alternative 4, including long-term groundwater impacts of contaminant sources from within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

5.1.1.7.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 4 are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, three major periods were identified for Tank Closure Alternative 4, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 4 presented in this section would be common to all the Tank Closure alternatives.

- The retrieval period was assumed to start in 2008 and end in CY 2144. During this period, 99.9 percent of the waste would be retrieved from the tanks. A retrieval loss of 15,140 liters (4,000 gallons) per tank was assumed for all SSTs. Most tank farms would be landfill-closed with a modified RCRA Subtitle C barrier. The exceptions are the BX and SX tank farms, which would undergo clean closure.

- The post–administrative control period was assumed to start in CY 2145 and continue through the 10,000-year period of analysis until CY 11,940. Releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system during the post–administrative control period. All remaining waste would be available for release into the vadose zone at the start of the post–administrative control period.

5.1.1.7.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 4. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Tank Closure Alternative 4 is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 4 were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. There would be no chemical risk. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 4.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.7.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 4 in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms (see Figures 5–109 through 5–114). Three subtotals are plotted representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–109 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–110, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant sources for tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers the predominant sources are past leaks. This suggests that activities during the past-practice period are an important impact driver under Tank Closure Alternative 4.

Figure 5–111 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–112, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

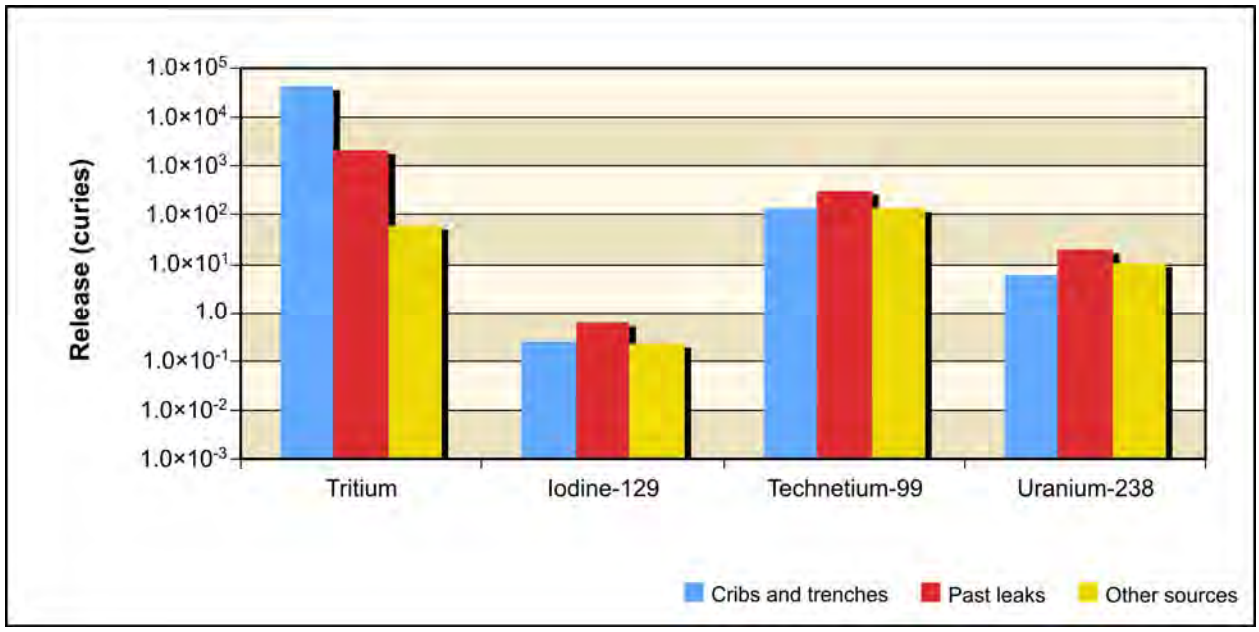


Figure 5–109. Tank Closure Alternative 4 Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

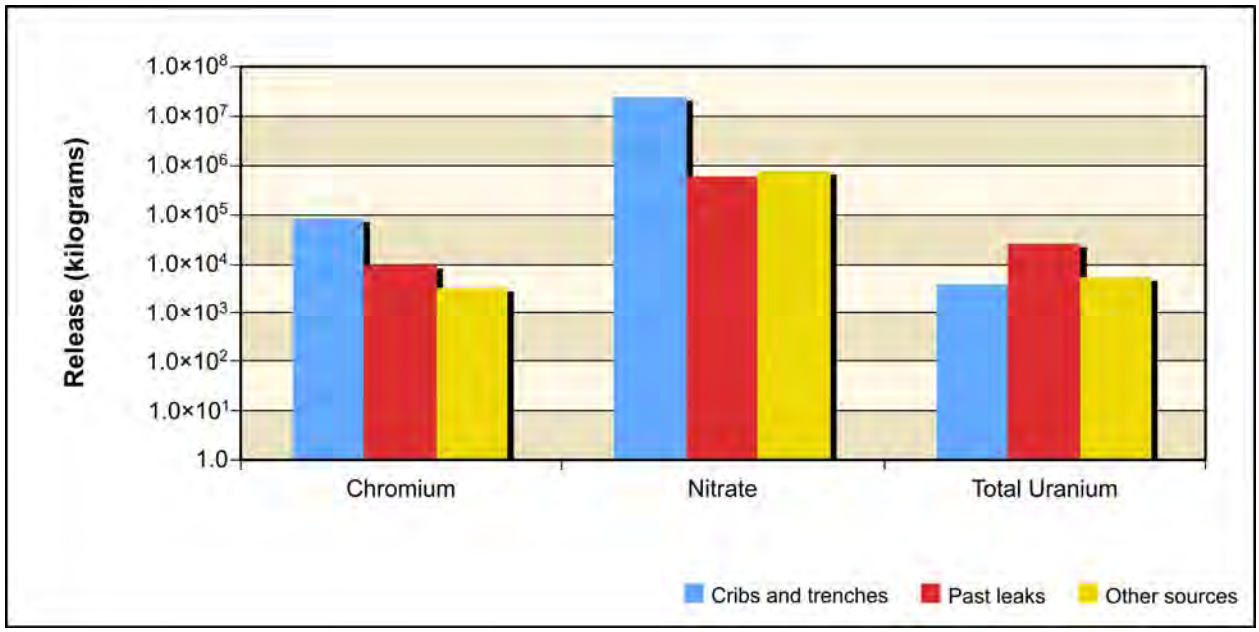


Figure 5–110. Tank Closure Alternative 4 Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

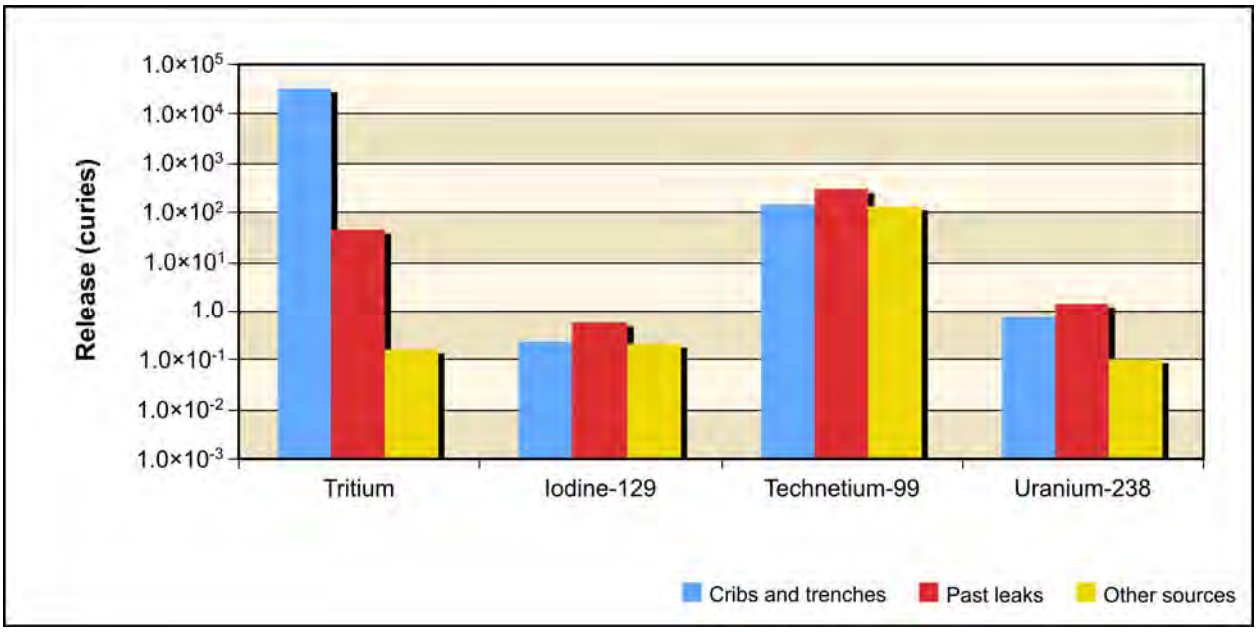


Figure 5–111. Tank Closure Alternative 4 Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

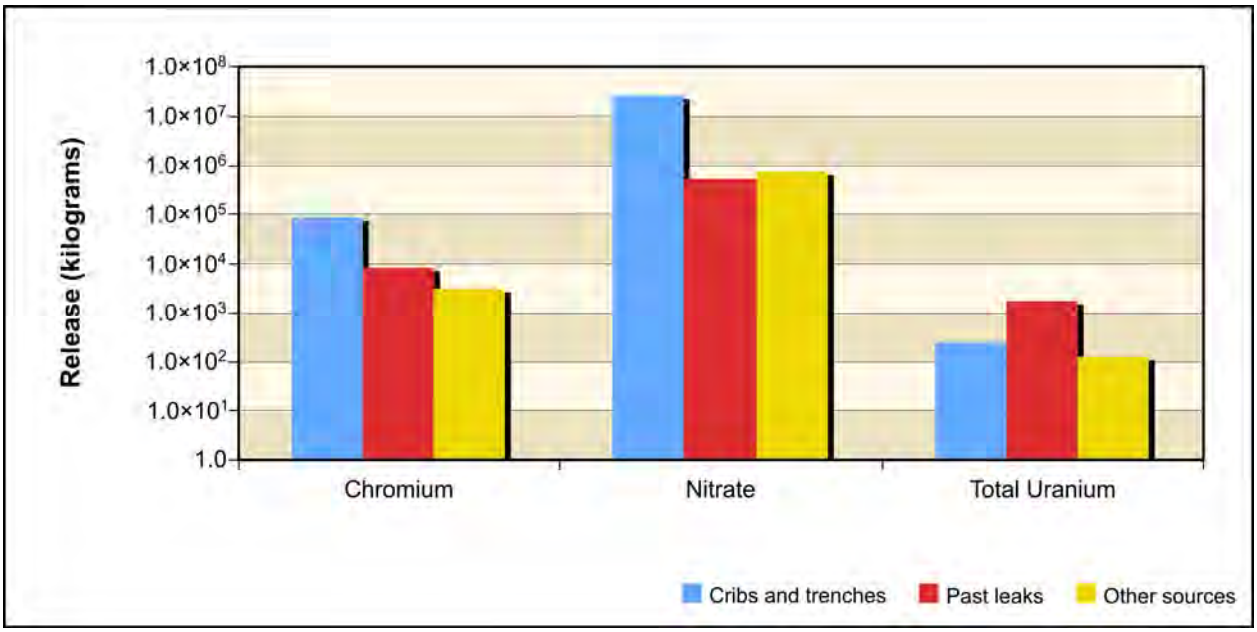


Figure 5–112. Tank Closure Alternative 4 Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For cribs and trenches (ditches) and past leaks, where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 10 percent of the total inventory reached groundwater during the period of analysis; for other tank farm sources, only about 2 percent of the total inventory reached groundwater during the period of analysis.

For tritium, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 70 percent of the total inventory reached groundwater in the analysis; for past leaks, only 2 percent; and for other tank farm sources, only one-third of 1 percent reached the water table. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts would occur later in the post-remediation period because of the long travel times in the vadose zone for these COPCs.

Figure 5–113 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–114, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For uranium-238 and total uranium, the amount released to the Columbia River is less than that of the release to groundwater because of retardation. Overall, about 25 percent of the amount released to groundwater during the period of analysis reached the Columbia River. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reached the Columbia River during the period of analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post-remediation period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

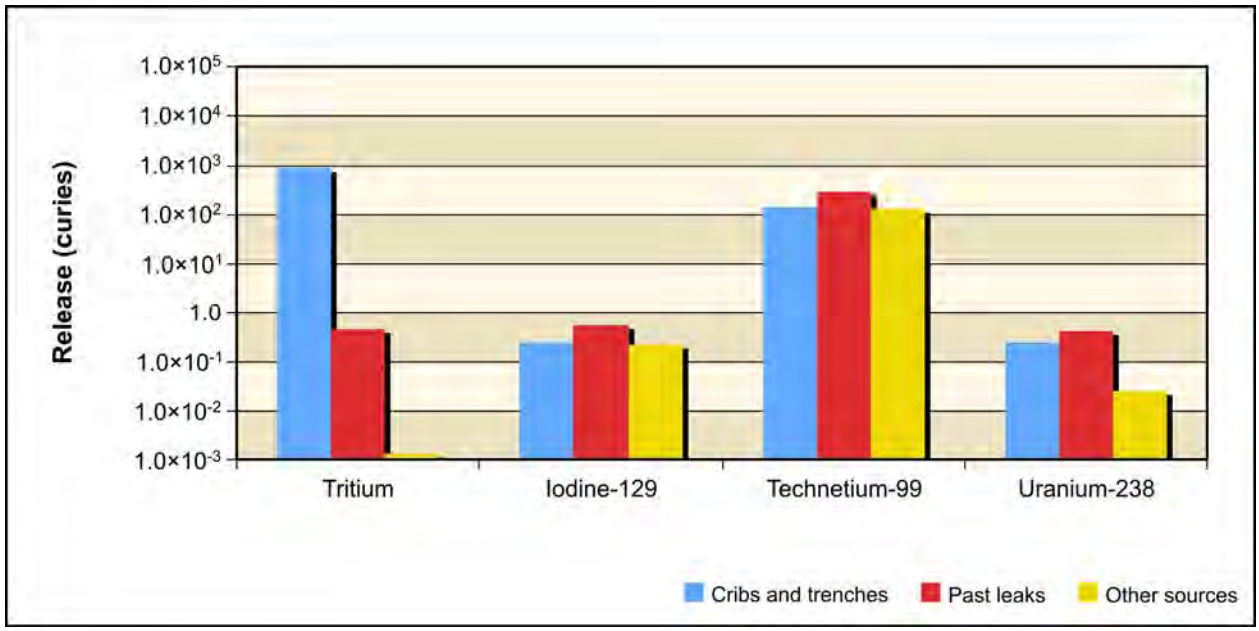


Figure 5–113. Tank Closure Alternative 4 Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

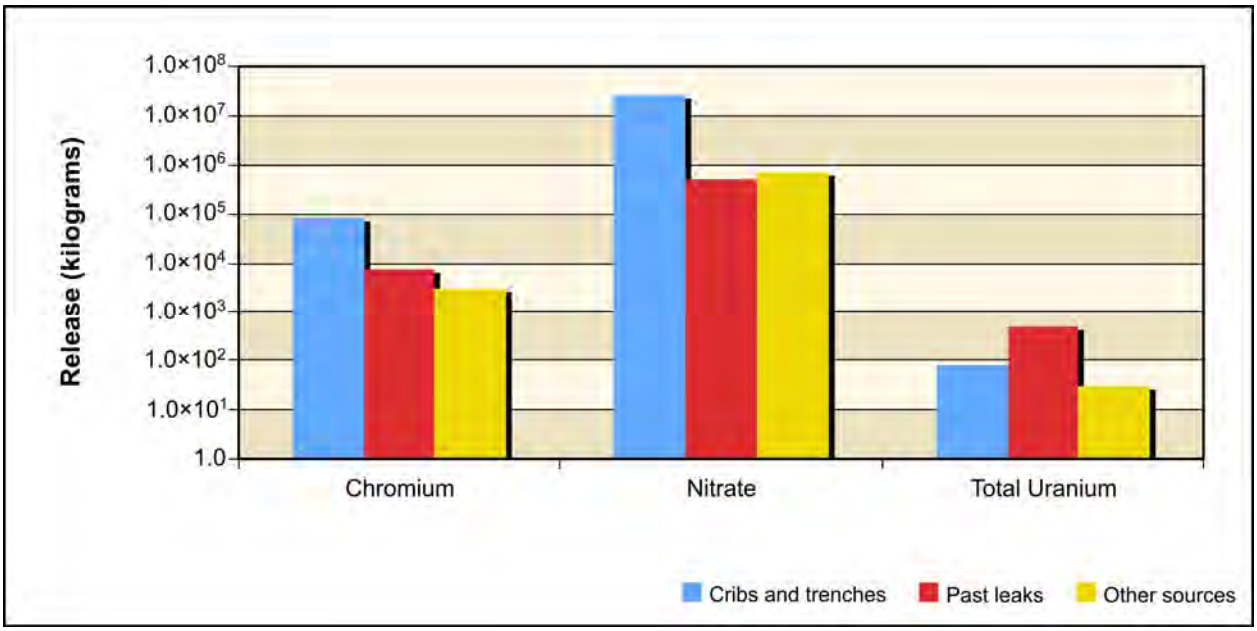


Figure 5–114. Tank Closure Alternative 4 Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.7.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 4 impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Table 5–4 and Figures 5–115 through 5–121). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–4 lists the maximum concentrations of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore.

Figure 5–115 shows concentration versus time for tritium. Releases from cribs and trenches (ditches) cause groundwater concentrations to exceed benchmark concentrations by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore remain over an order of magnitude below the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2050.

Table 5–4. Tank Closure Alternative 4 Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	28	5,060	4	7,270	13	6,060	178	20,000
	(2051)	(2054)	(2062)	(2055)	(2050)	(2054)	(2050)	
Technetium-99	**1,460**	**28,200**	214	**15,200**	180	**24,100**	191	900
	(2058)	(2050)	(2060)	(2050)	(2060)	(2050)	(2480)	
Iodine-129	**3**	**38**	0.4	**30**	0.3	**31**	0.3	1
	(2053)	(2057)	(2052)	(2050)	(2052)	(2057)	(2181)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	0	**36**	1	**26**	8	**48**	1	15
	(11,814)	(11,742)	(11,795)	(11,780)	(11,441)	(11,529)	(11,891)	
Chemical in micrograms per liter								
Chromium	9	**3,220**	36	**768**	10	**1,650**	34	100
	(2057)	(2055)	(2057)	(2050)	(2050)	(2050)	(2695)	
Nitrate	5,530	**1,540,000**	1,400	**133,000**	1,230	**1,010,000**	8,490	45,000
	(2056)	(2050)	(2059)	(2054)	(2067)	(2050)	(2450)	
Total uranium	0	14	1	11	12	**63**	1	30
	(11,819)	(11,678)	(11,828)	(11,840)	(11,599)	(11,690)	(11,577)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

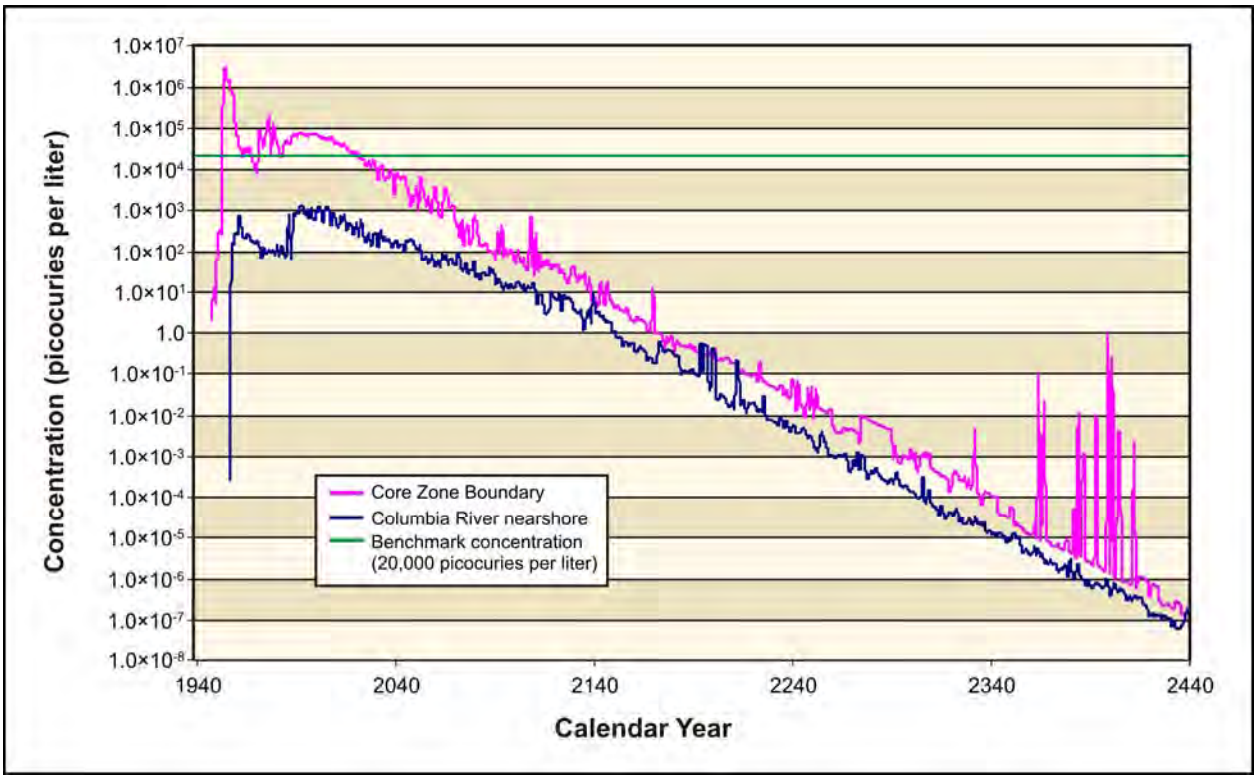


Figure 5–115. Tank Closure Alternative 4 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–116 through 5–119 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from cribs and trenches (ditches) cause groundwater concentrations to exceed benchmark concentrations by about two to three orders of magnitude during the early part of the period of analysis at the Core Zone Boundary. During this time, groundwater concentrations at the Columbia River nearshore approach but do not exceed the benchmark concentration. Technetium-99 and nitrate concentrations fall below the benchmark concentration at the Core Zone Boundary around CY 4000, while iodine-129 and chromium fall below the benchmark around CY 5000. Concentrations for all four conservative tracers decline over the remainder of the period of analysis.

Figures 5–120 and 5–121 show concentration versus time for uranium-238 and total uranium. Early releases from cribs and trenches (ditches) result in groundwater concentrations that are one to two orders of magnitude lower than benchmark concentrations. These concentrations continue to rise throughout the duration of the period of analysis. Uranium-238 concentrations exceed the benchmark concentration around CY 8000, while total uranium concentrations exceed the benchmark around CY 9500. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis but remain over an order of magnitude below the benchmark concentration for the duration of the simulation.

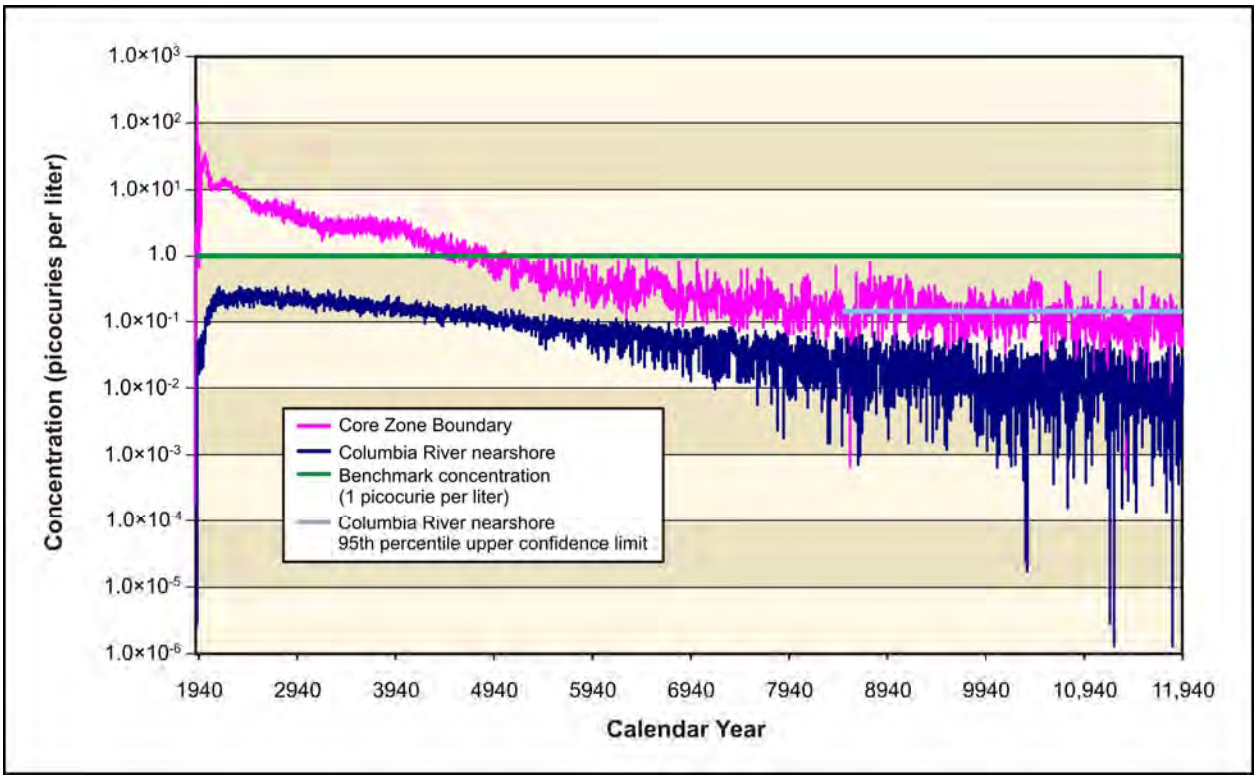


Figure 5–116. Tank Closure Alternative 4 Iodine-129 Concentration Versus Time

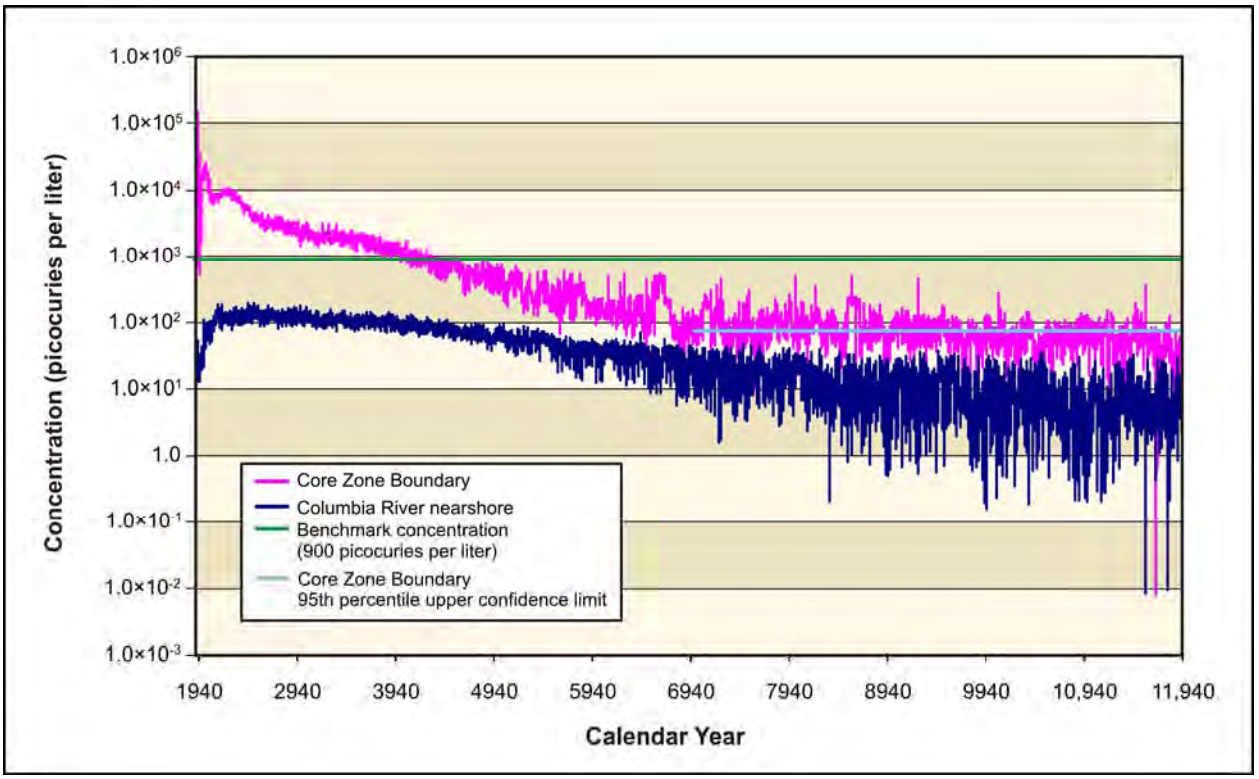


Figure 5–117. Tank Closure Alternative 4 Technetium-99 Concentration Versus Time

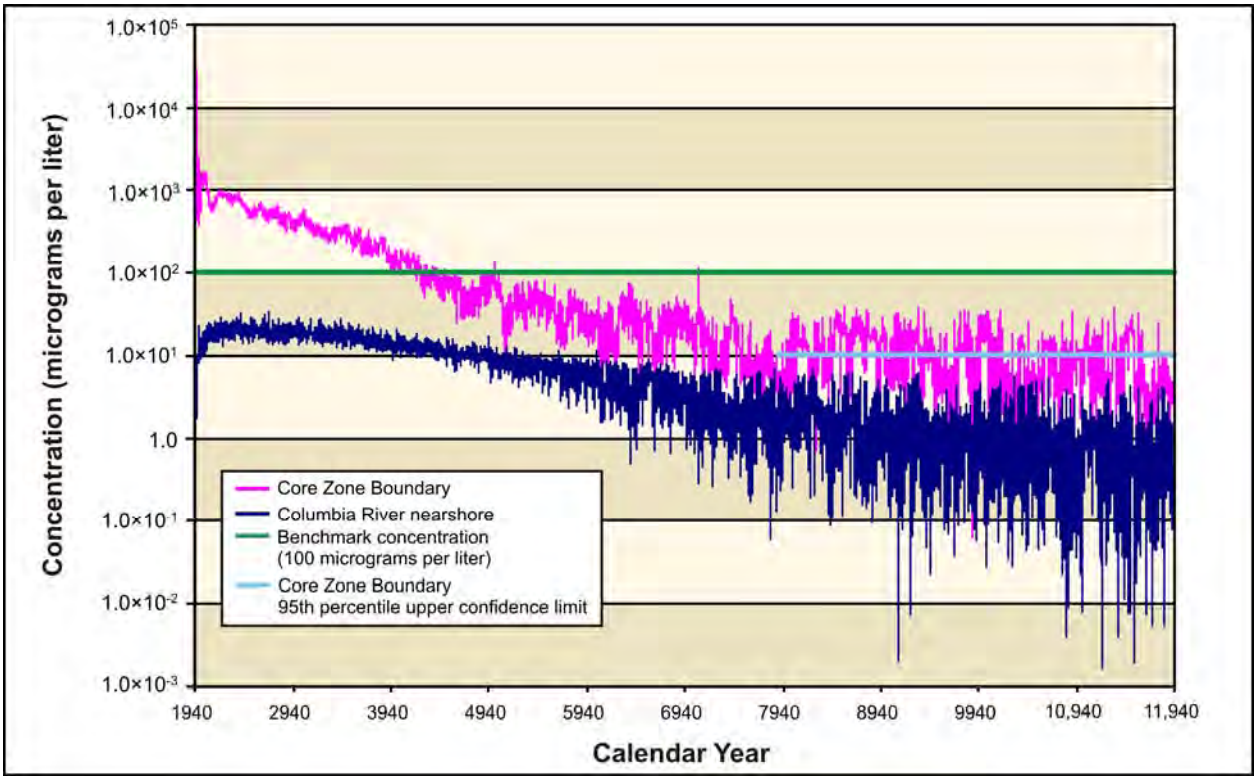


Figure 5–118. Tank Closure Alternative 4 Chromium Concentration Versus Time

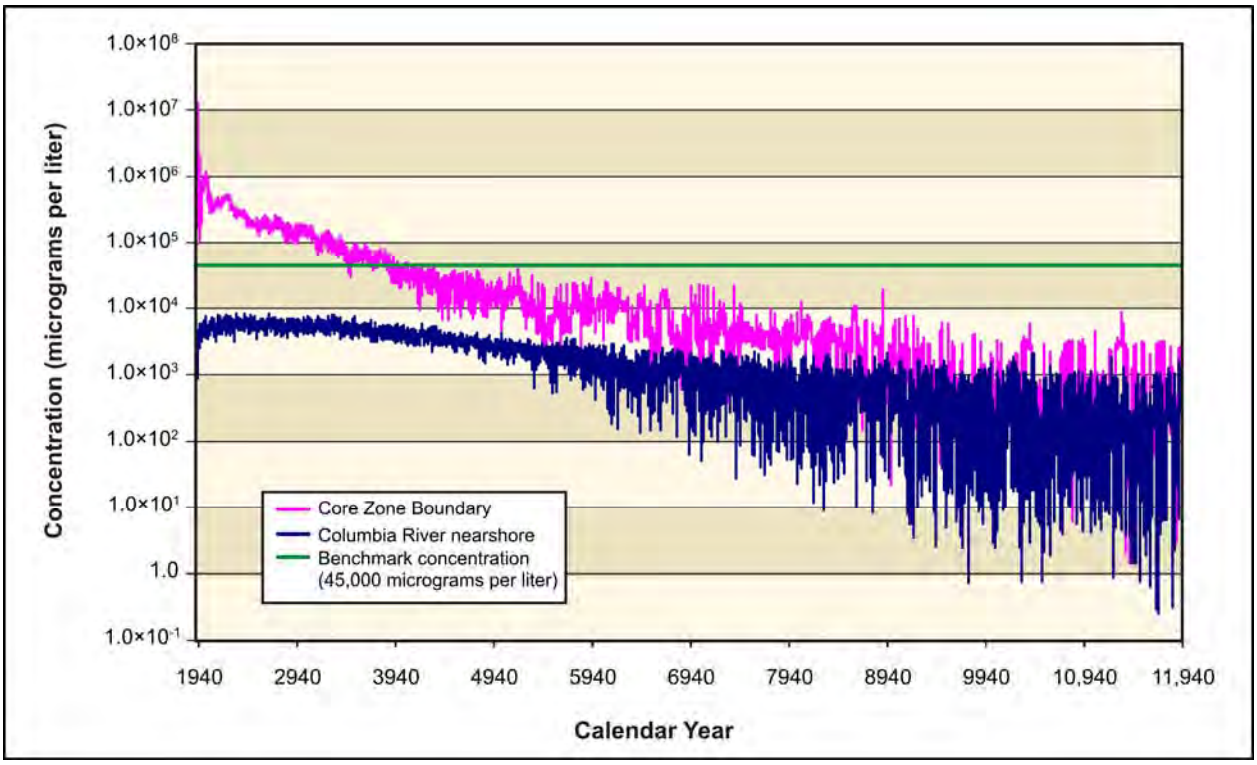


Figure 5–119. Tank Closure Alternative 4 Nitrate Concentration Versus Time

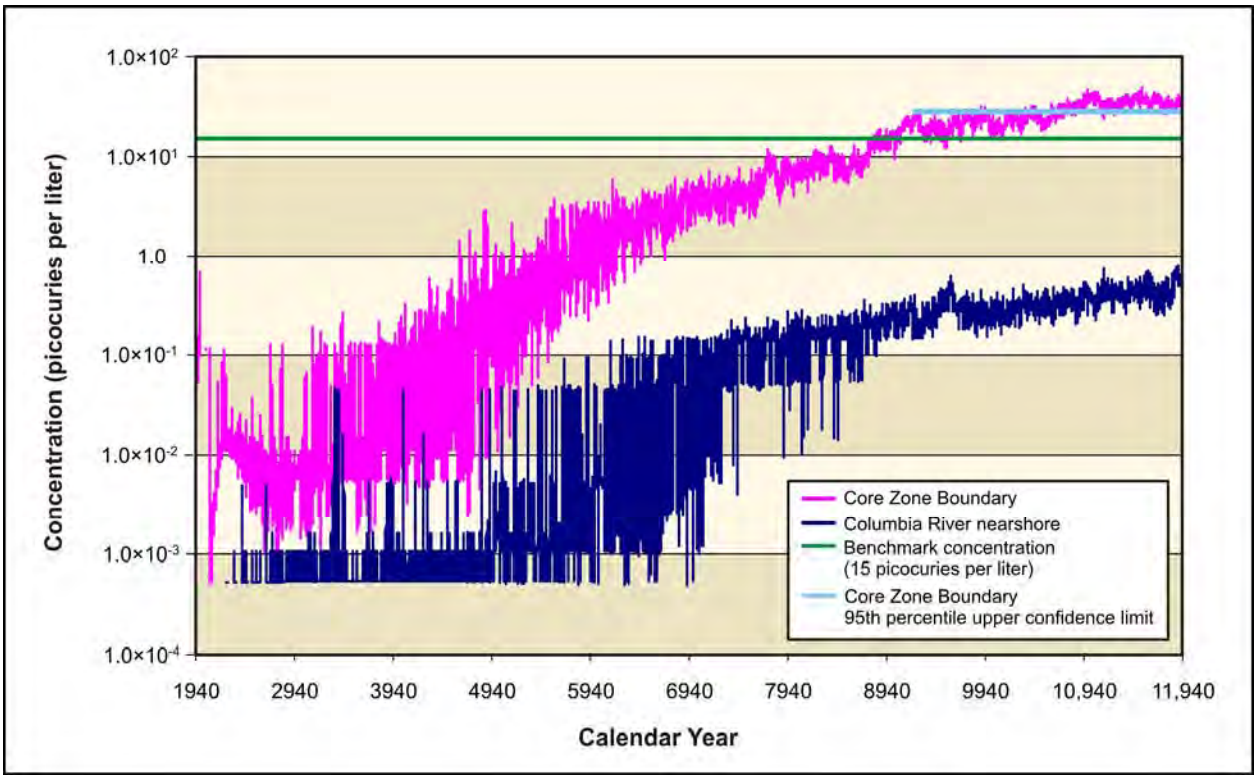


Figure 5–120. Tank Closure Alternative 4 Uranium-238 Concentration Versus Time

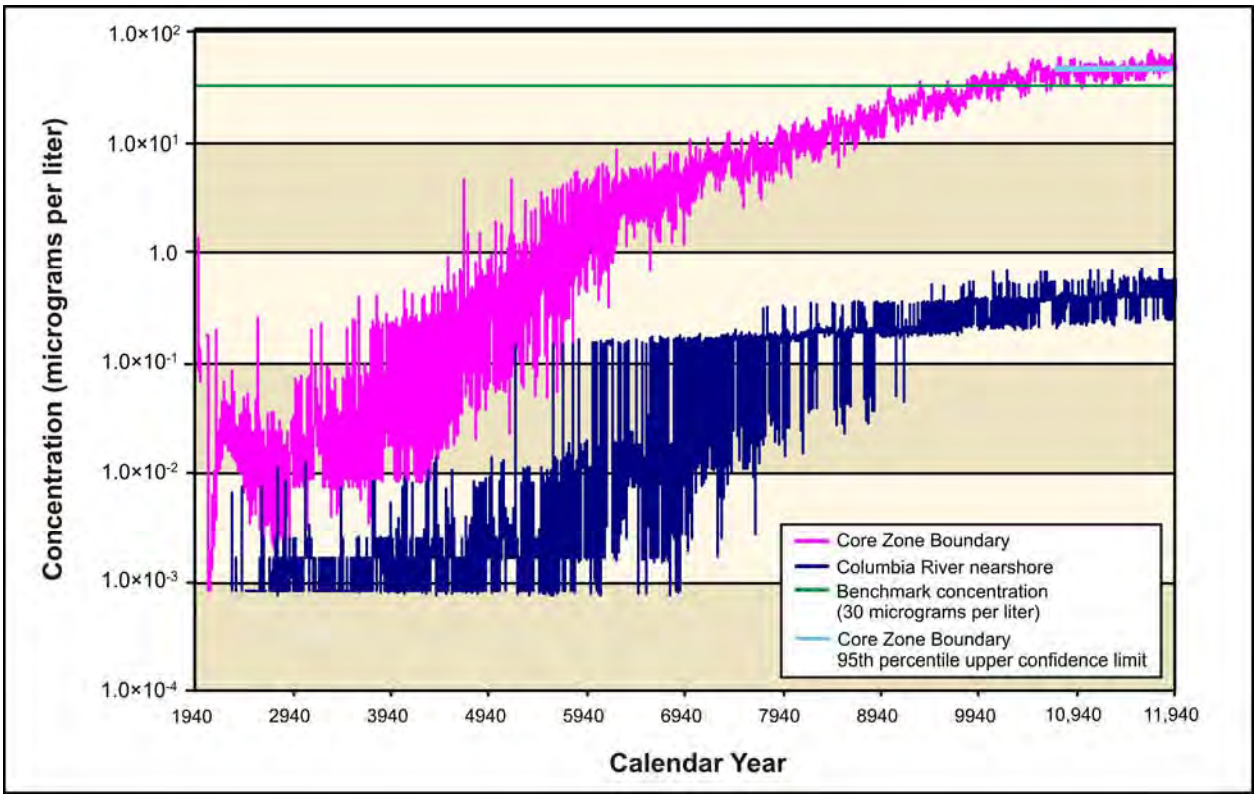


Figure 5–121. Tank Closure Alternative 4 Total Uranium Concentration Versus Time

5.1.1.7.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 4 in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Figures 5–122 through 5–146). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–122 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135 (see Figure 5–123).

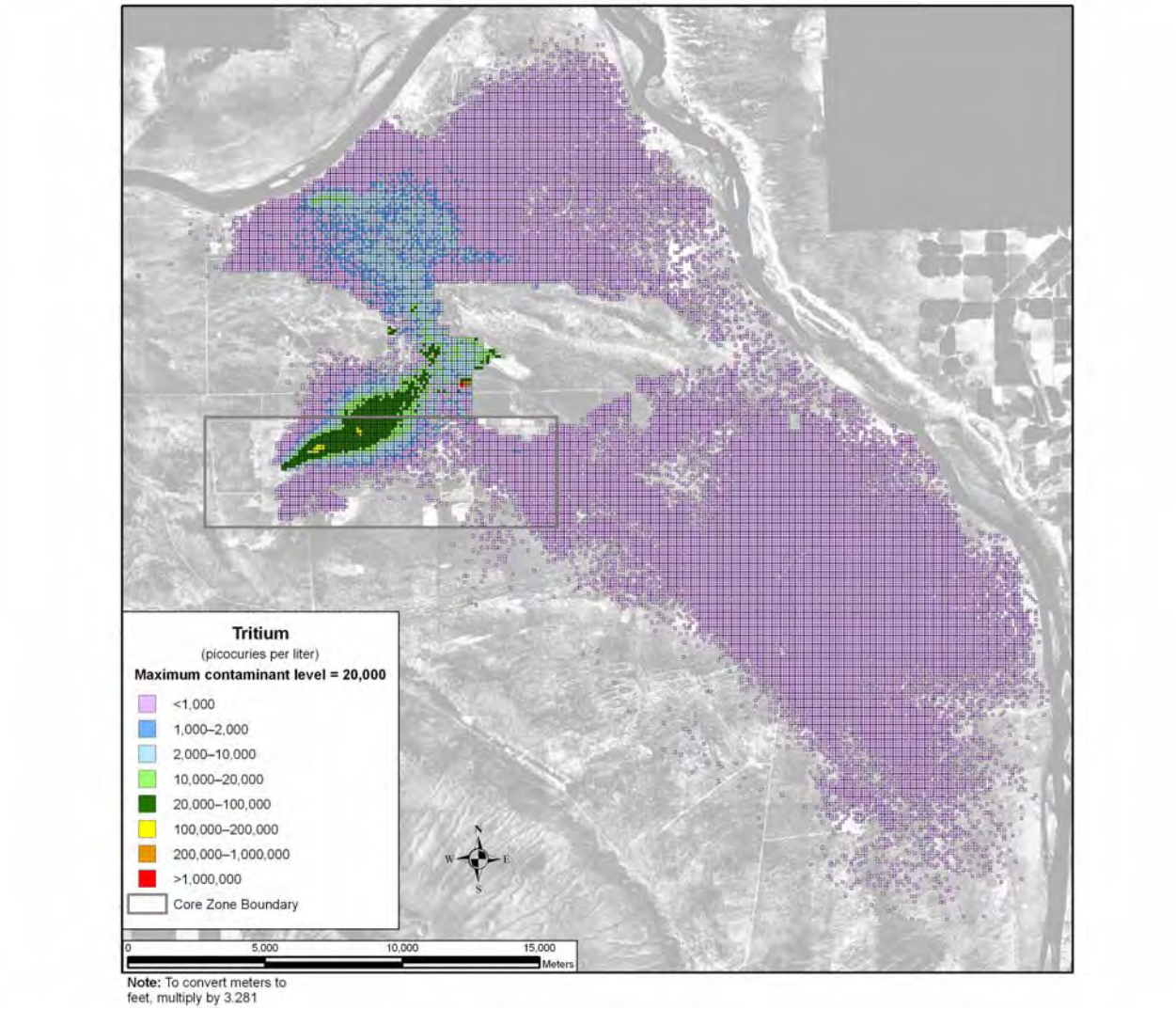


Figure 5–122. Tank Closure Alternative 4 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

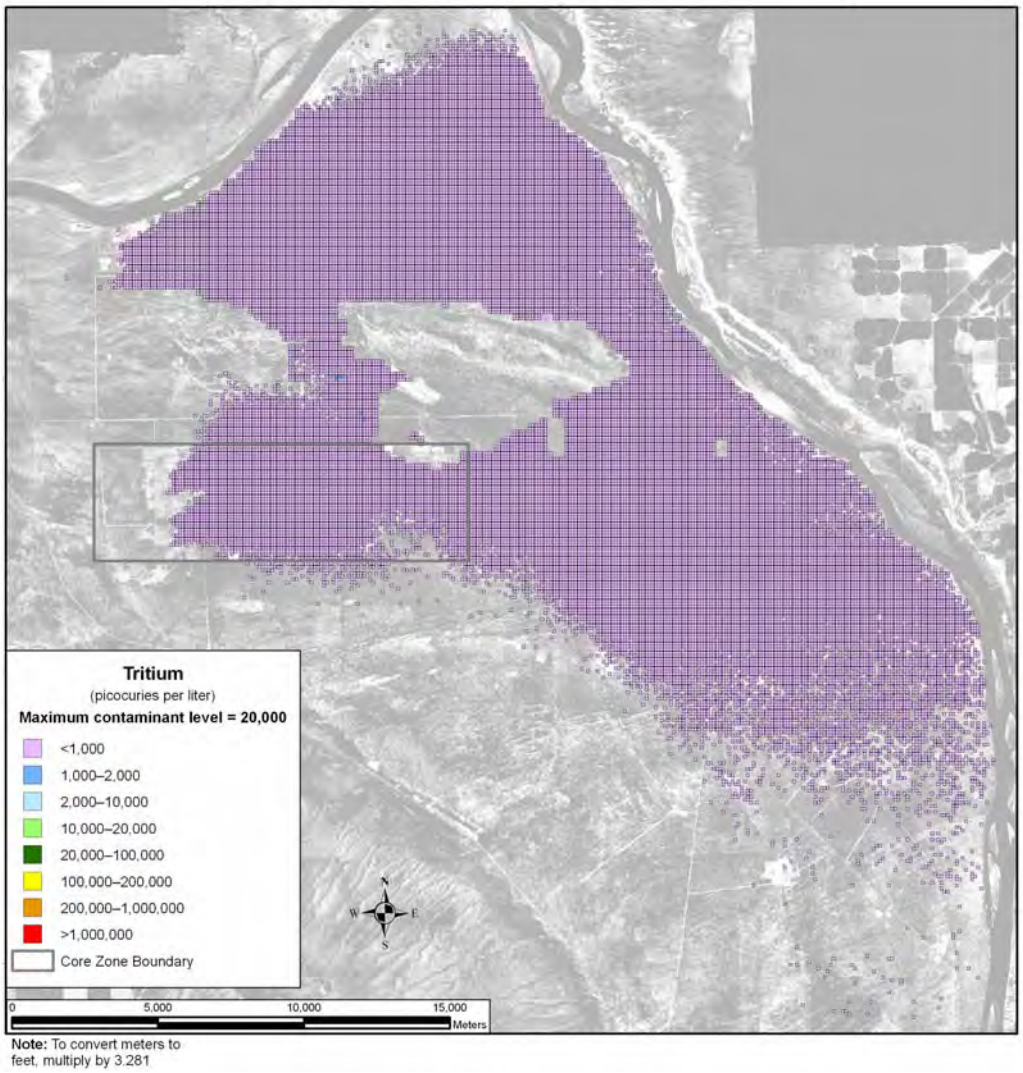


Figure 5–123. Tank Closure Alternative 4 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

Plume distribution for iodine-129 during CY 2005 is shown in Figure 5–124. By CY 2135 (see Figure 5–125), areas of concentrations above the benchmark concentration exist east of the Core Zone Boundary, north of the 200-East Area, and in three separate areas north of Gable Gap. By CY 7140, most of the mass in the plume has reached the Columbia River, with only isolated pockets of high-concentration areas where the groundwater flow velocities are extremely small (see Figure 5–126). Technetium-99 (see Figures 5–127 through 5–129), chromium (see Figures 5–130 through 5–132), and nitrate (see Figures 5–133 through 5–135) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

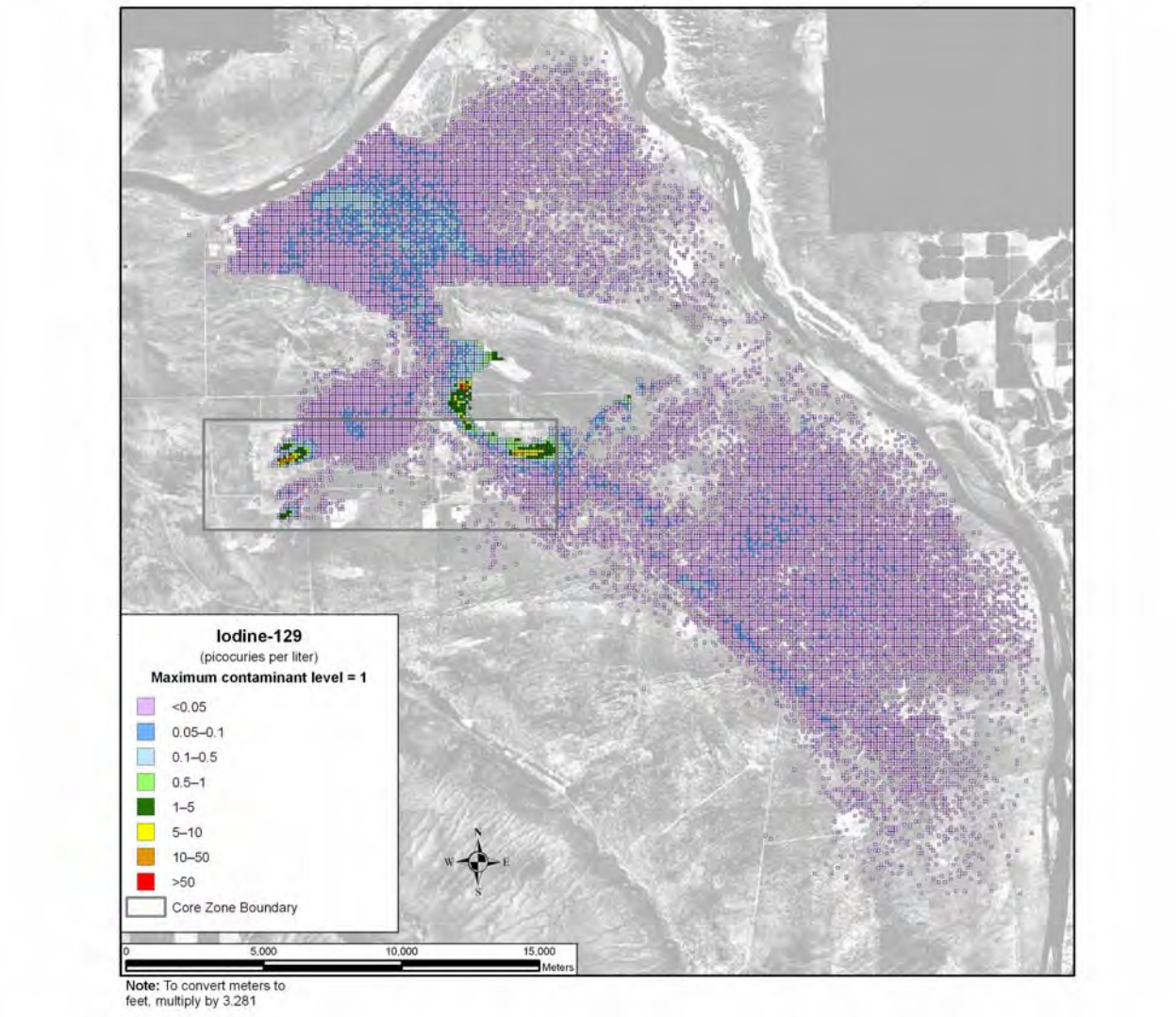


Figure 5–124. Tank Closure Alternative 4 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

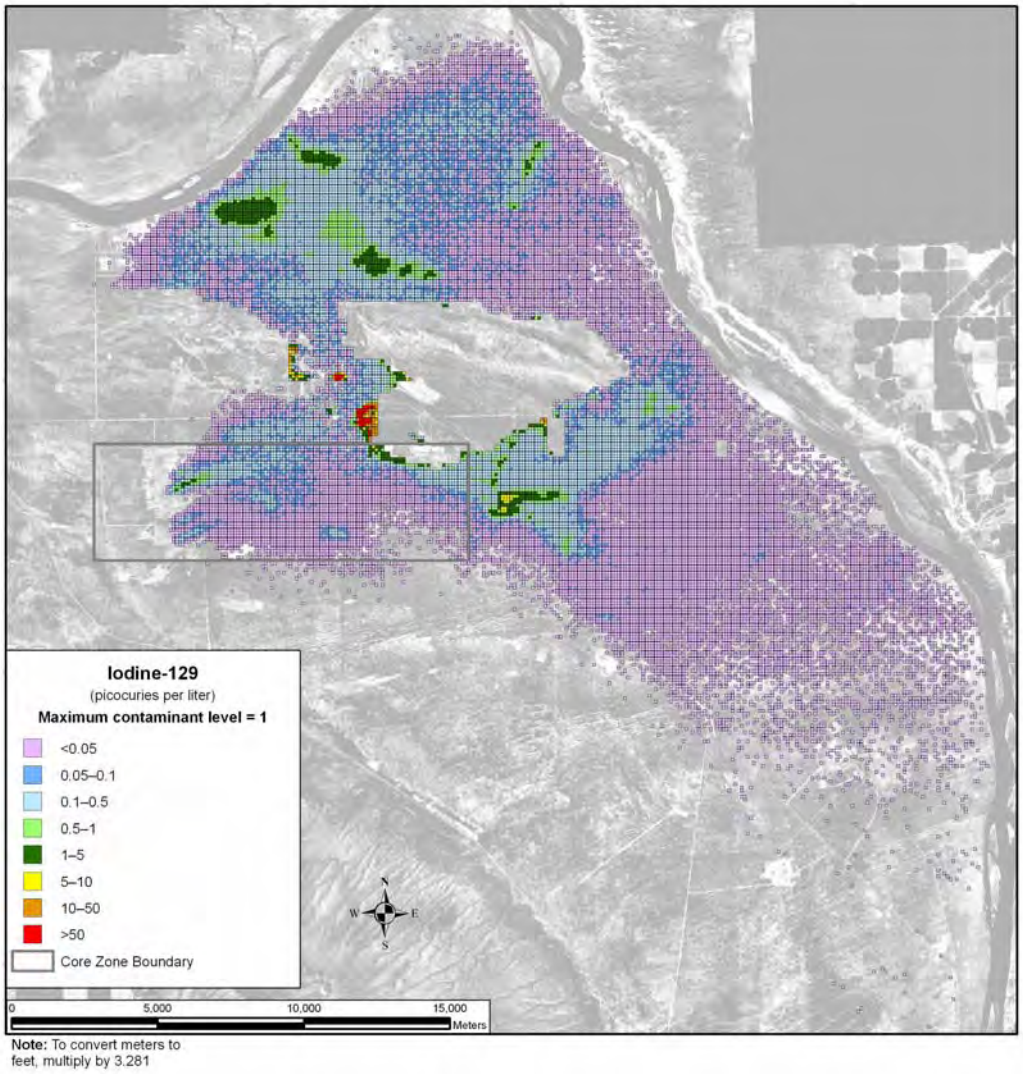


Figure 5–125. Tank Closure Alternative 4 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135

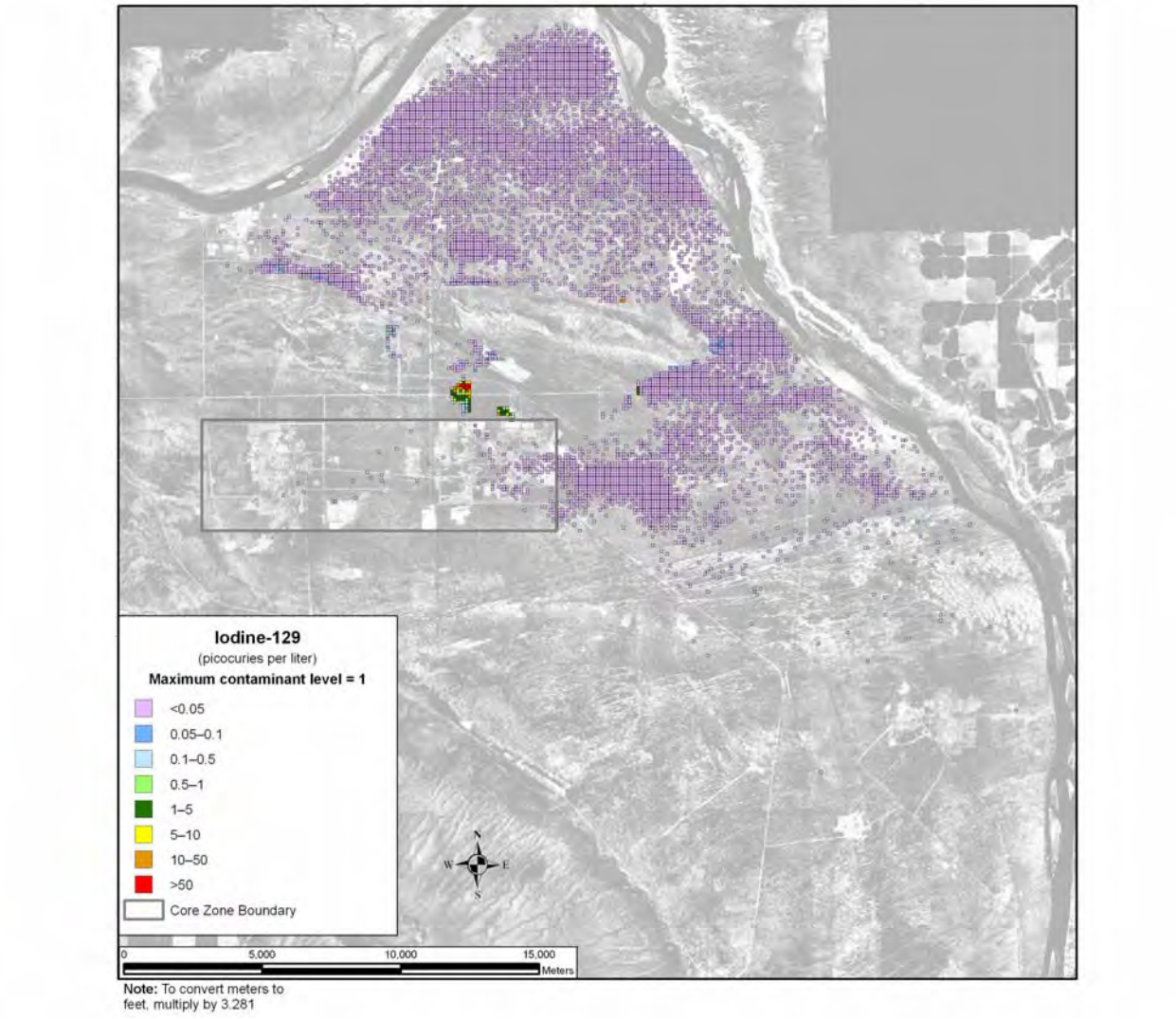


Figure 5–126. Tank Closure Alternative 4 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

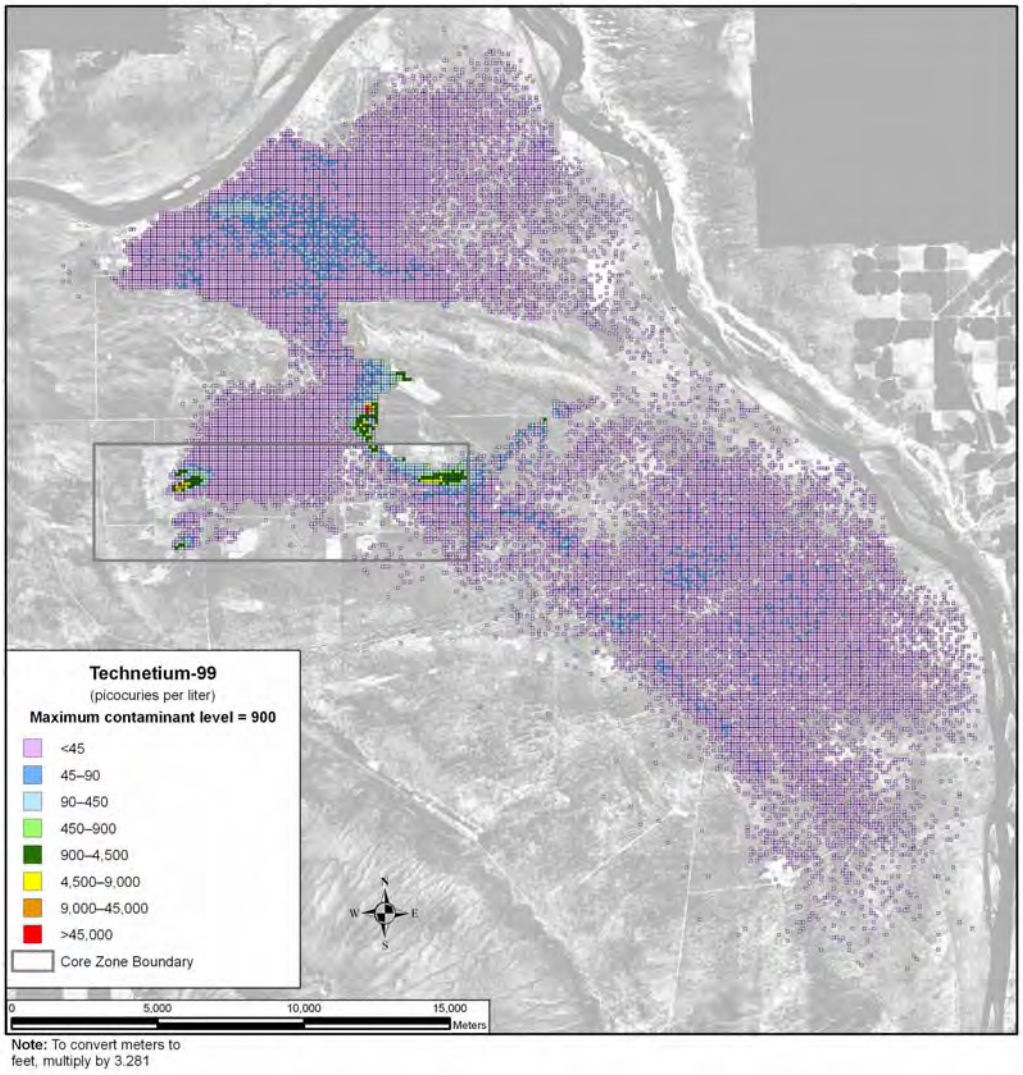


Figure 5–127. Tank Closure Alternative 4 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

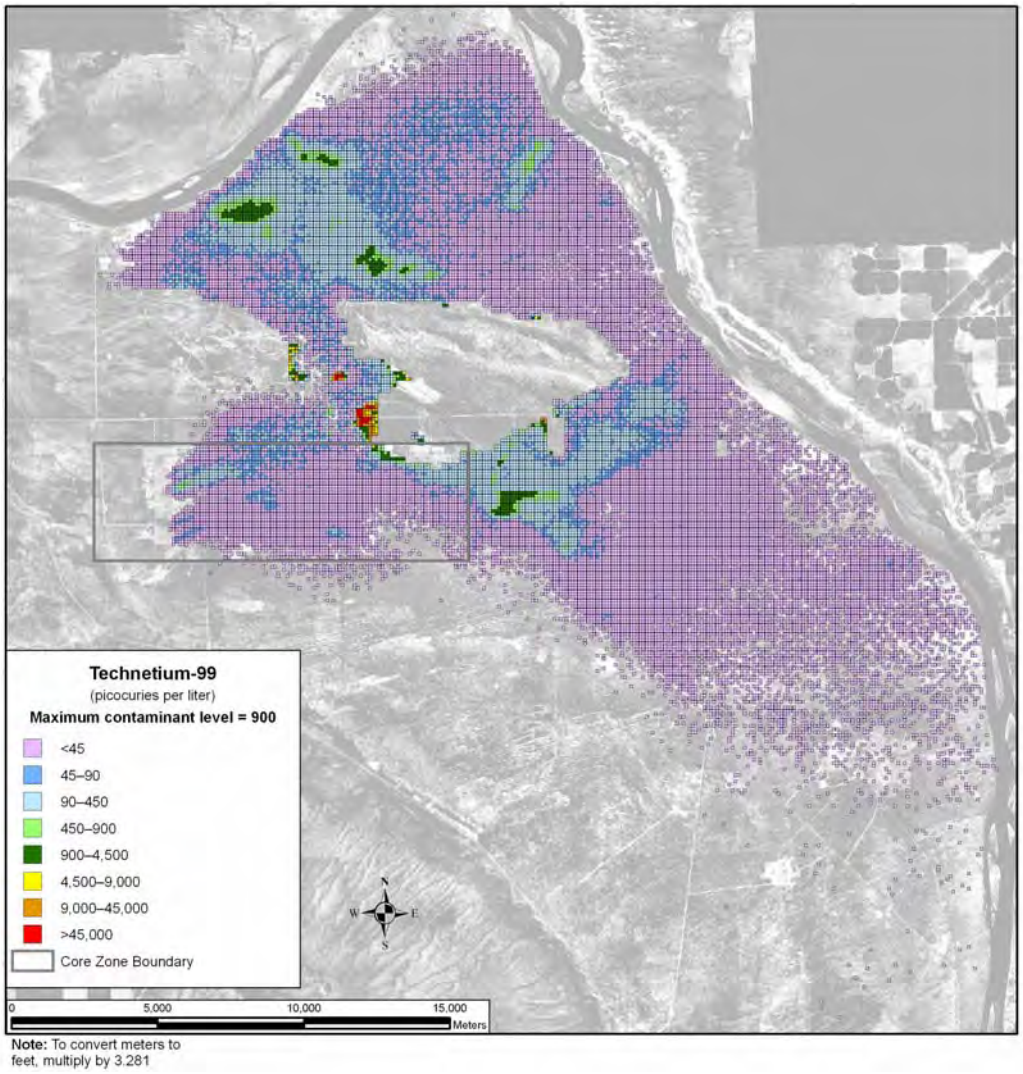


Figure 5–128. Tank Closure Alternative 4 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2135

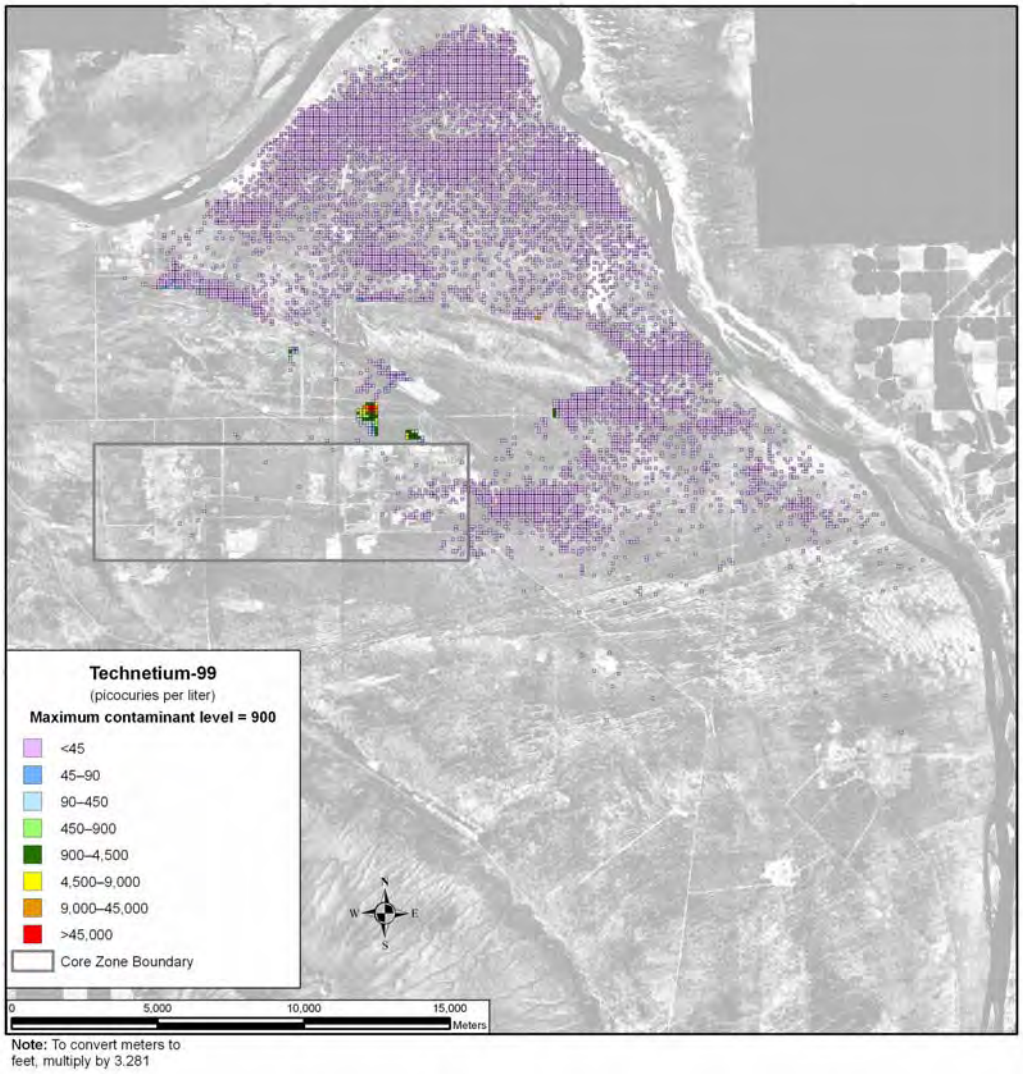


Figure 5–129. Tank Closure Alternative 4 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

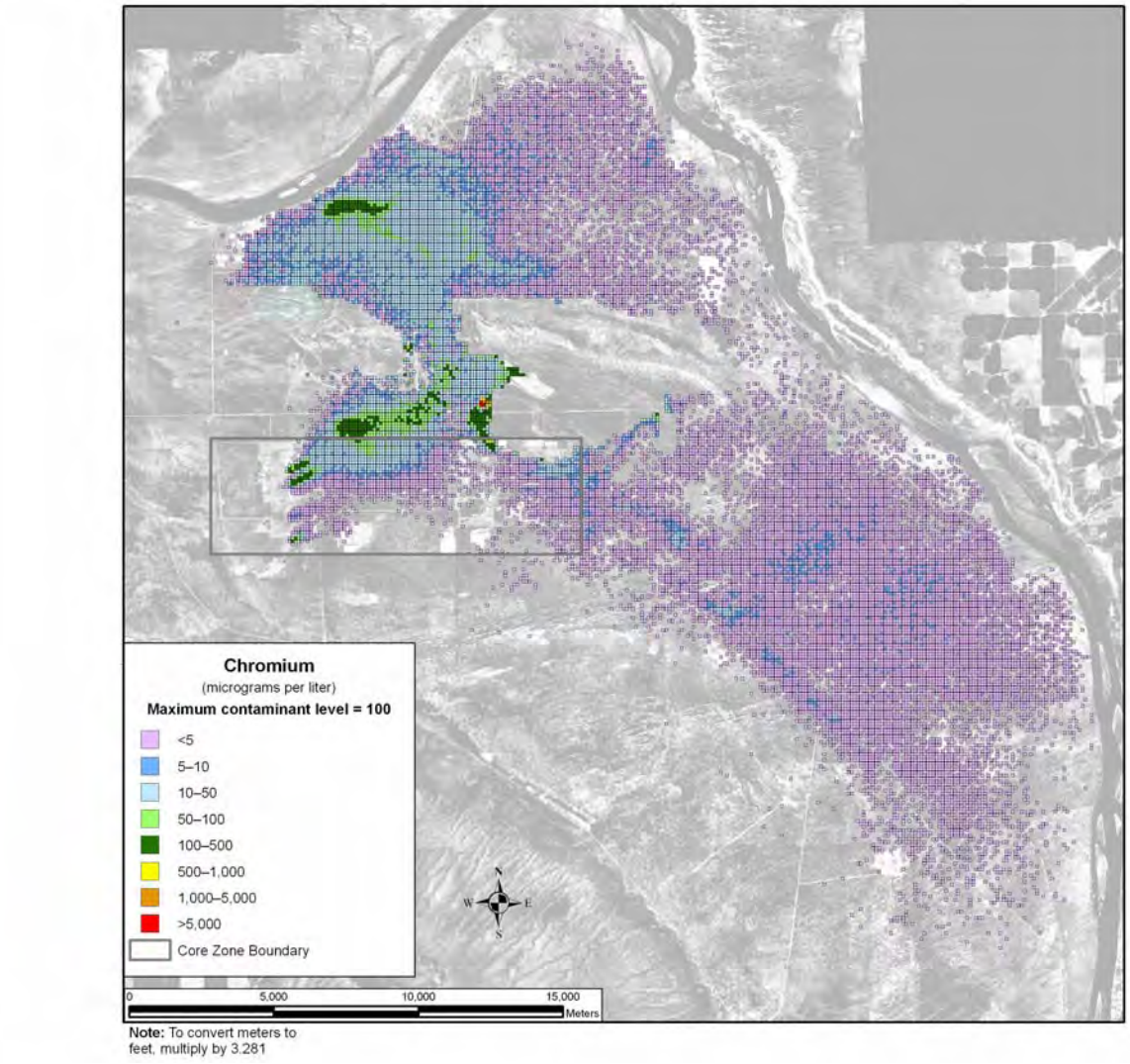


Figure 5–130. Tank Closure Alternative 4 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

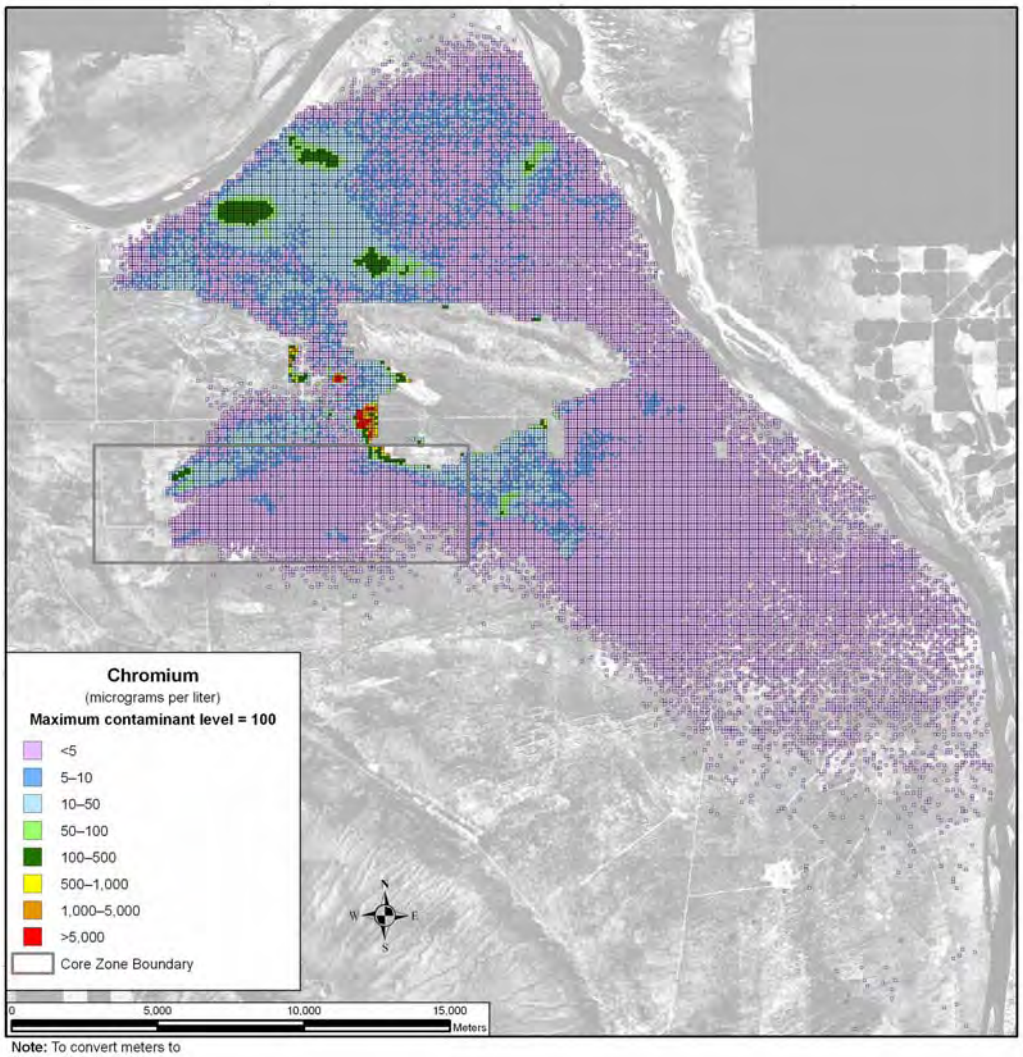


Figure 5–131. Tank Closure Alternative 4 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2135

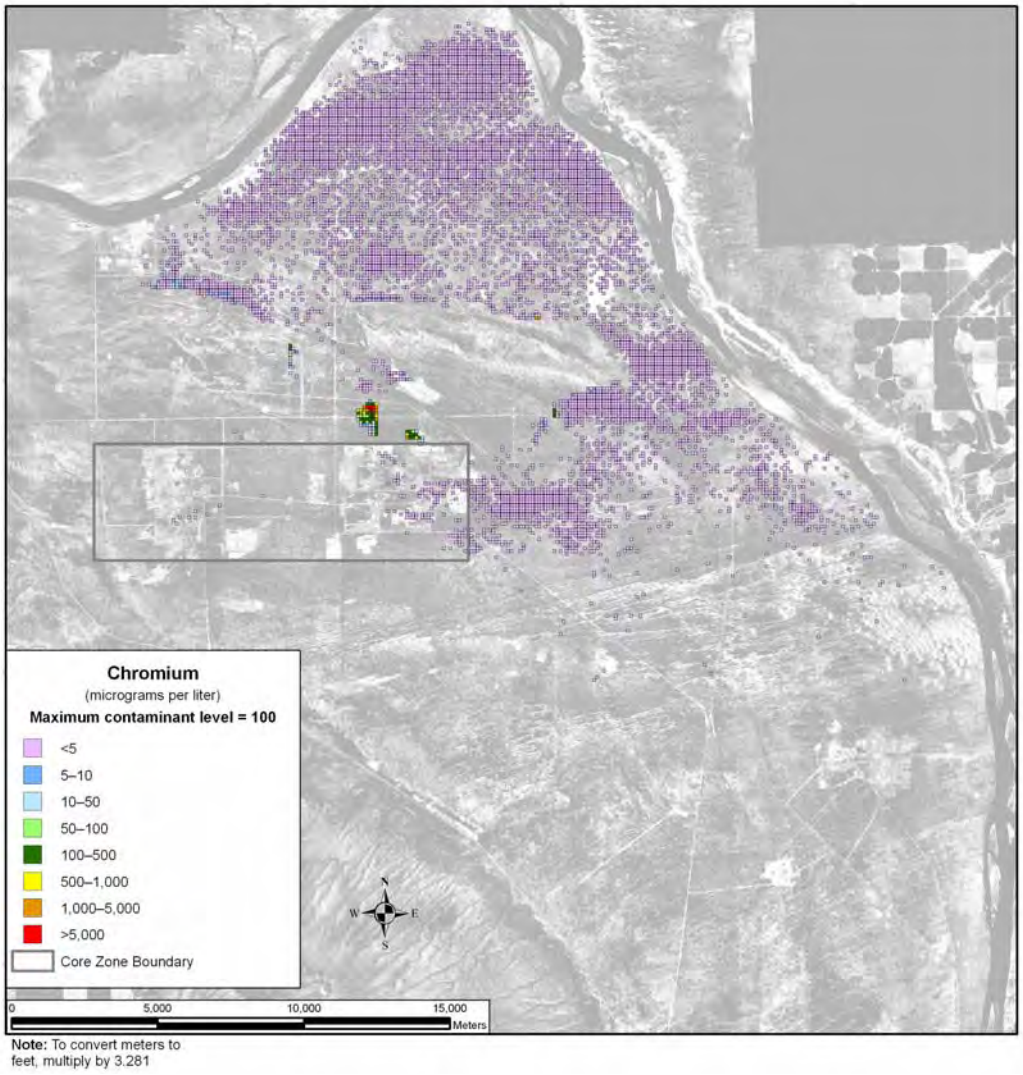


Figure 5–132. Tank Closure Alternative 4 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

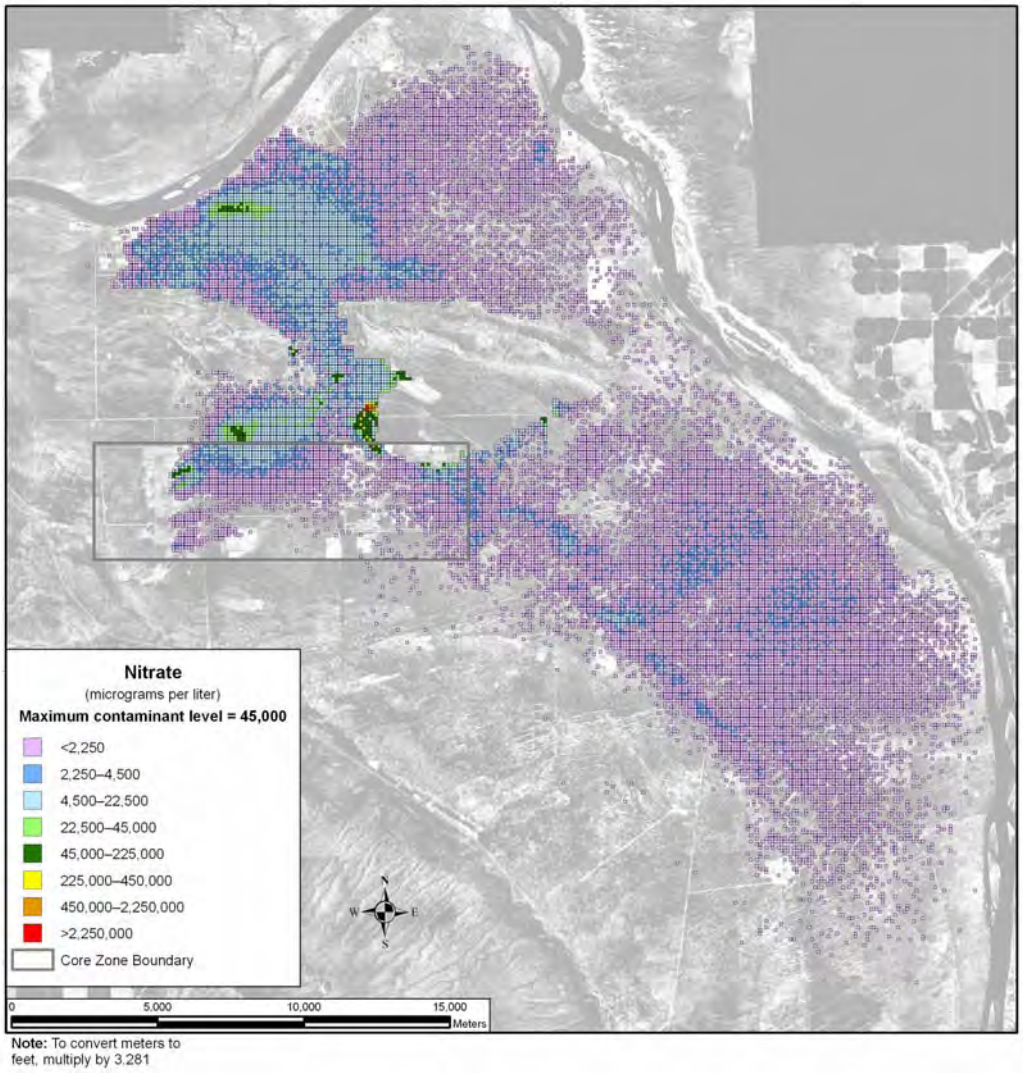


Figure 5–133. Tank Closure Alternative 4 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

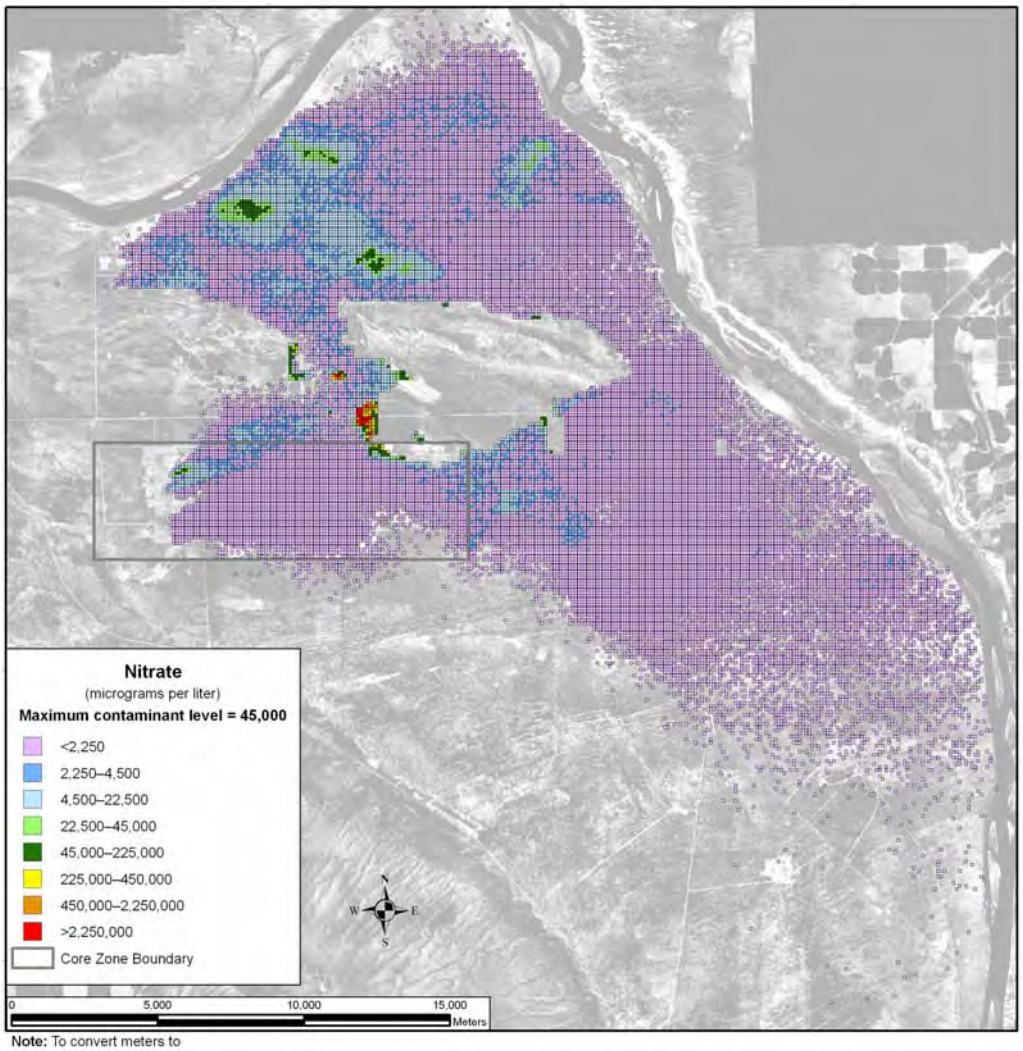


Figure 5–134. Tank Closure Alternative 4 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2135

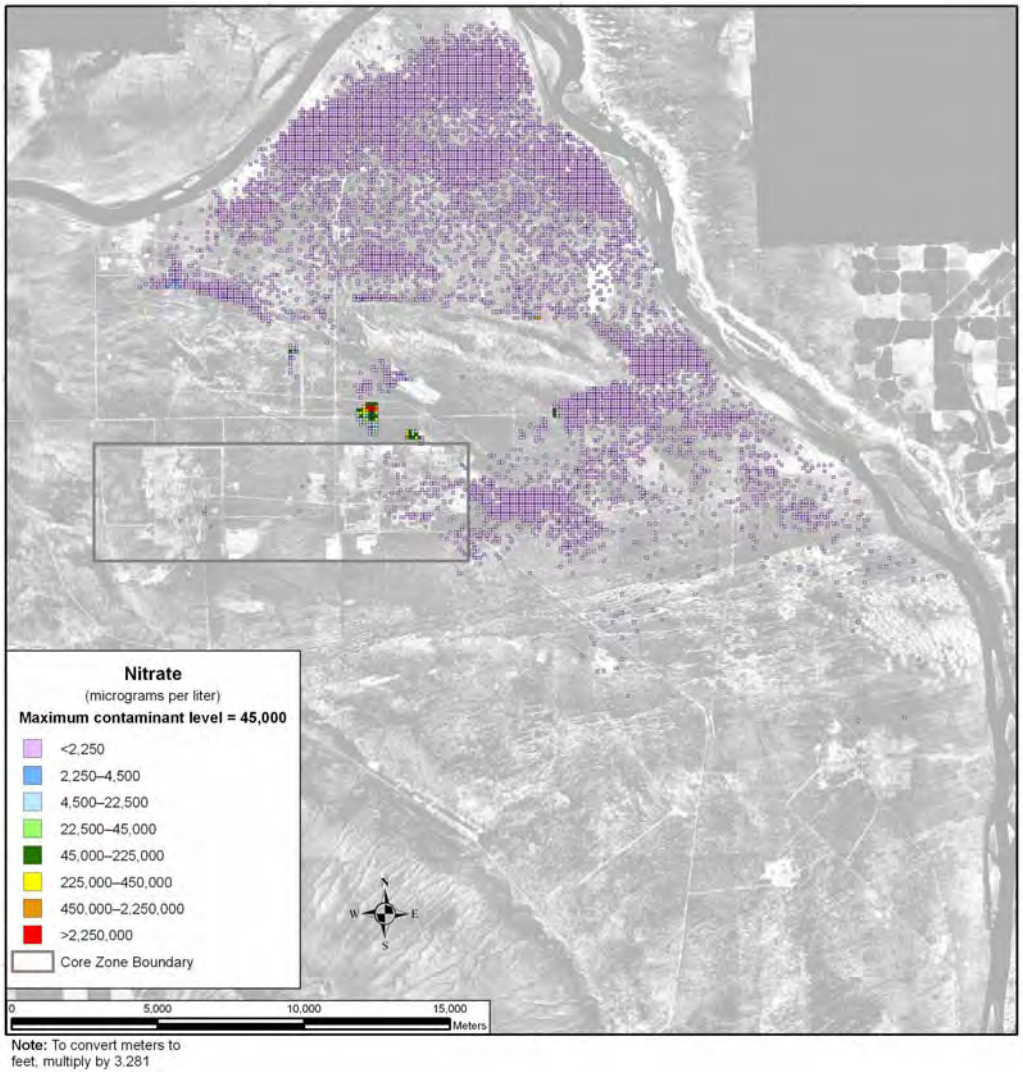


Figure 5–135. Tank Closure Alternative 4 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium show a different spatial distribution in the analysis over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. The distribution of uranium-238 during CY 2005 is shown in Figure 5–136. By CY 2135 (see Figure 5–137), the area of the plume has grown, but there are no significant increases in peak concentration. By CY 7140 (see Figure 5–138), some areas of higher concentration begin to appear in the western part of the Core Zone Boundary and in the area north of the Core Zone Boundary. At CY 11,885 (see Figure 5–139), the greatest development of the plume during the analysis period is seen, resulting primarily from releases during the past-practice period. At this point, a small area of high concentrations has developed just north of the 200-East Area. Figures 5–140 through 5–143 show the corresponding results for total uranium, which has a similar distribution.

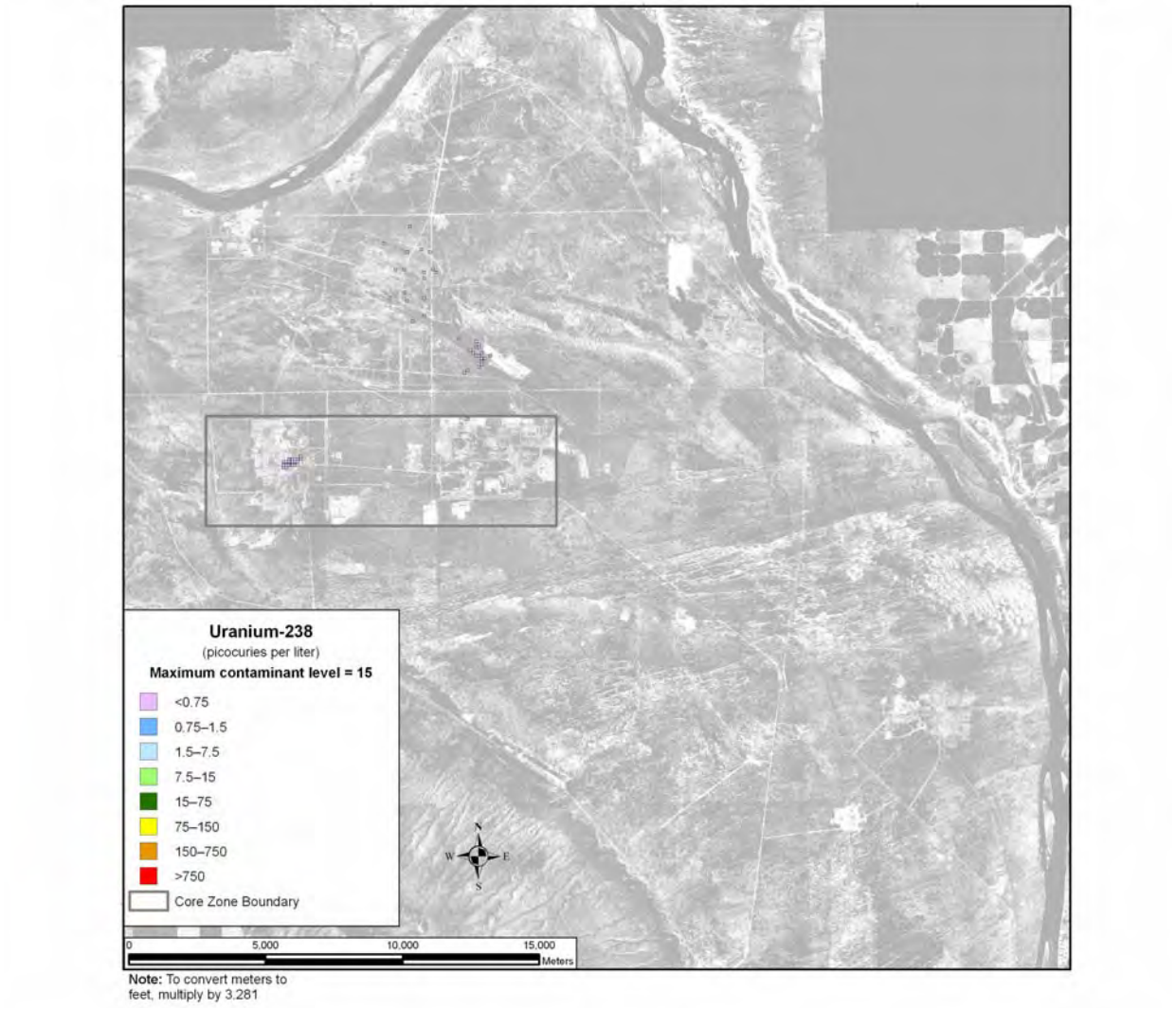


Figure 5–136. Tank Closure Alternative 4 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

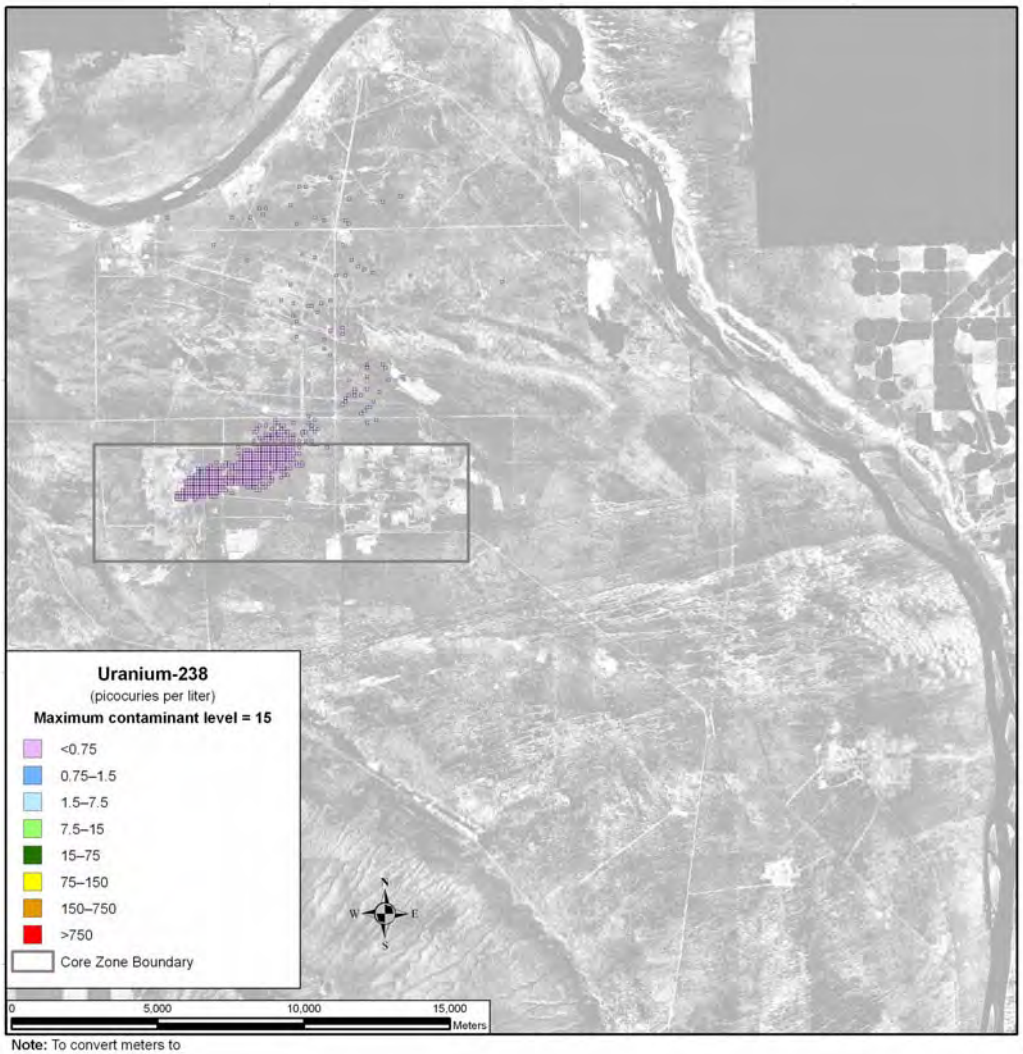


Figure 5–137. Tank Closure Alternative 4 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135

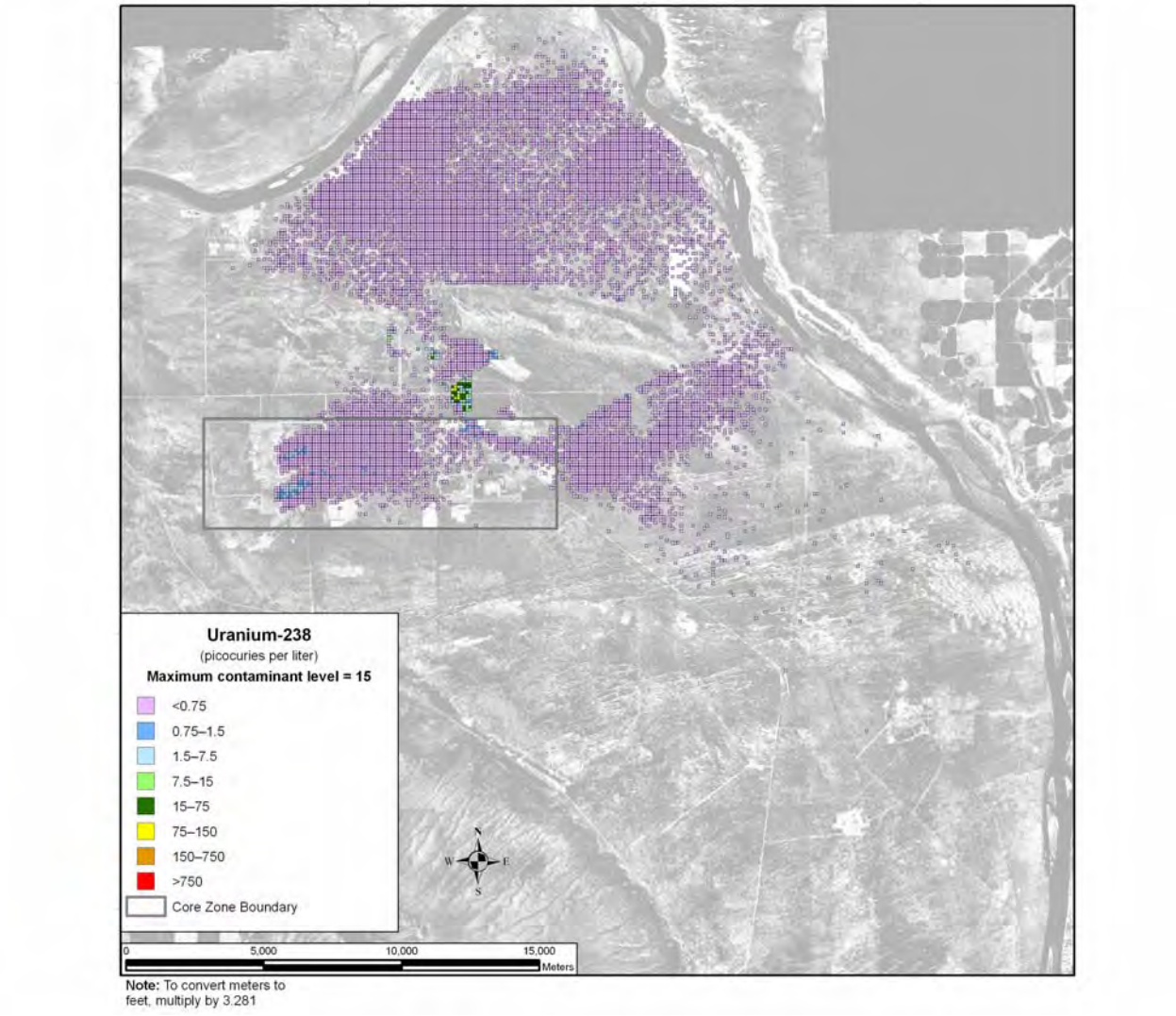


Figure 5–138. Tank Closure Alternative 4 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 7140

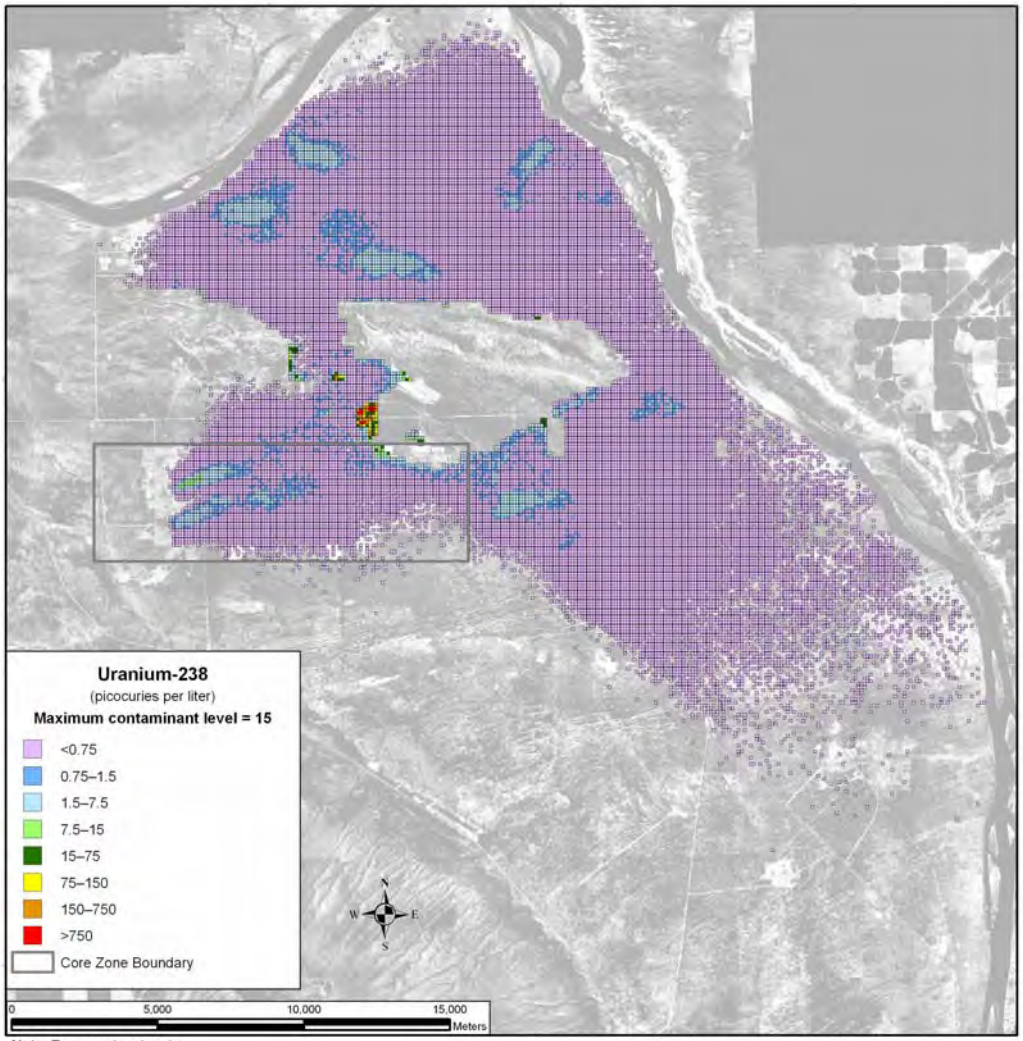


Figure 5–139. Tank Closure Alternative 4 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

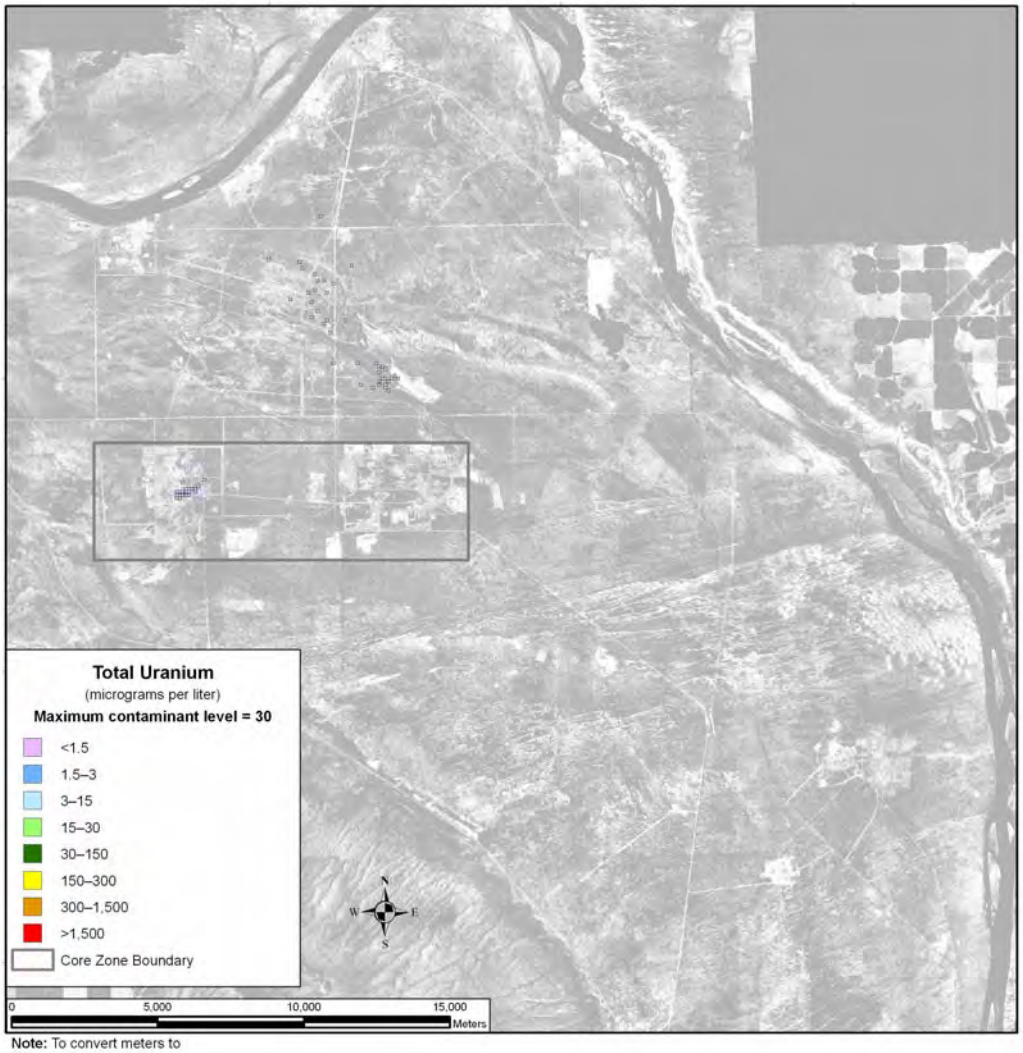


Figure 5–140. Tank Closure Alternative 4 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

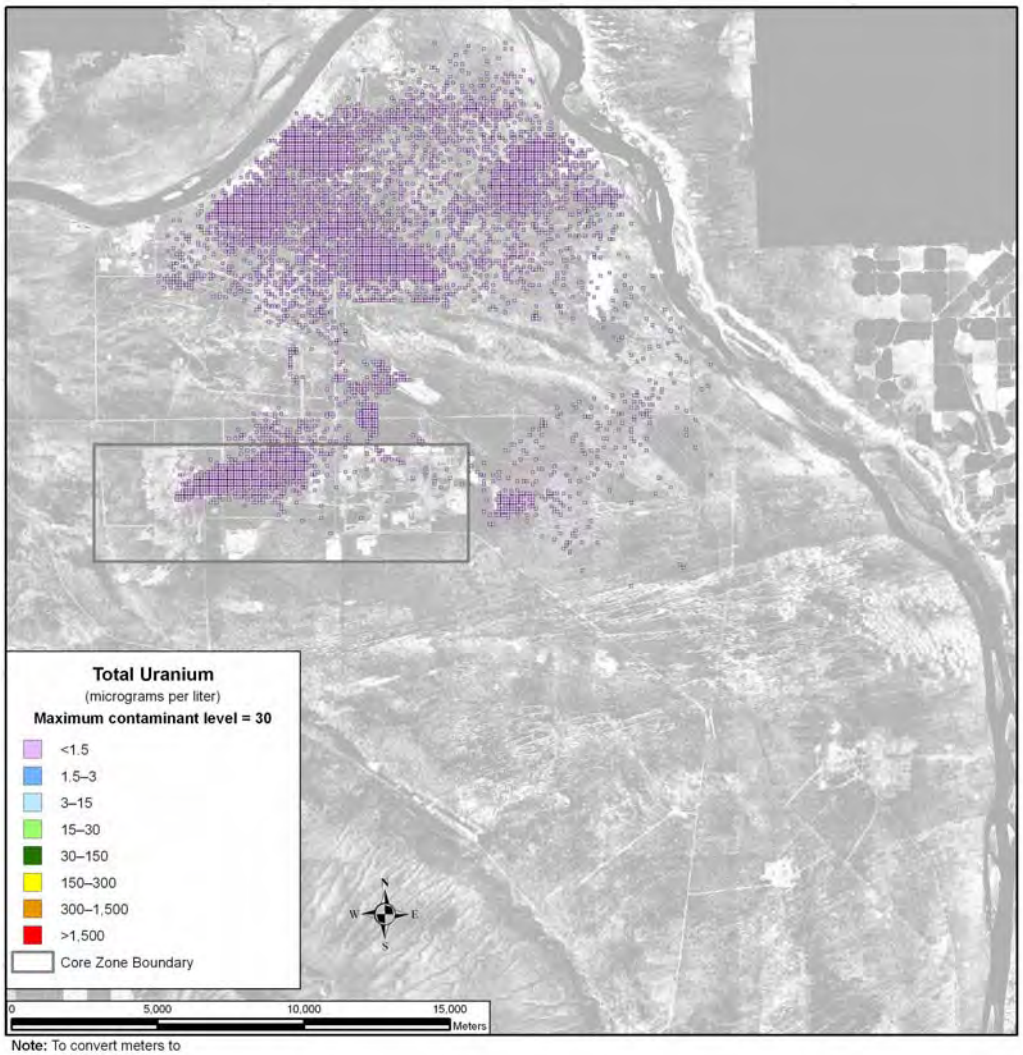


Figure 5–141. Tank Closure Alternative 4 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890

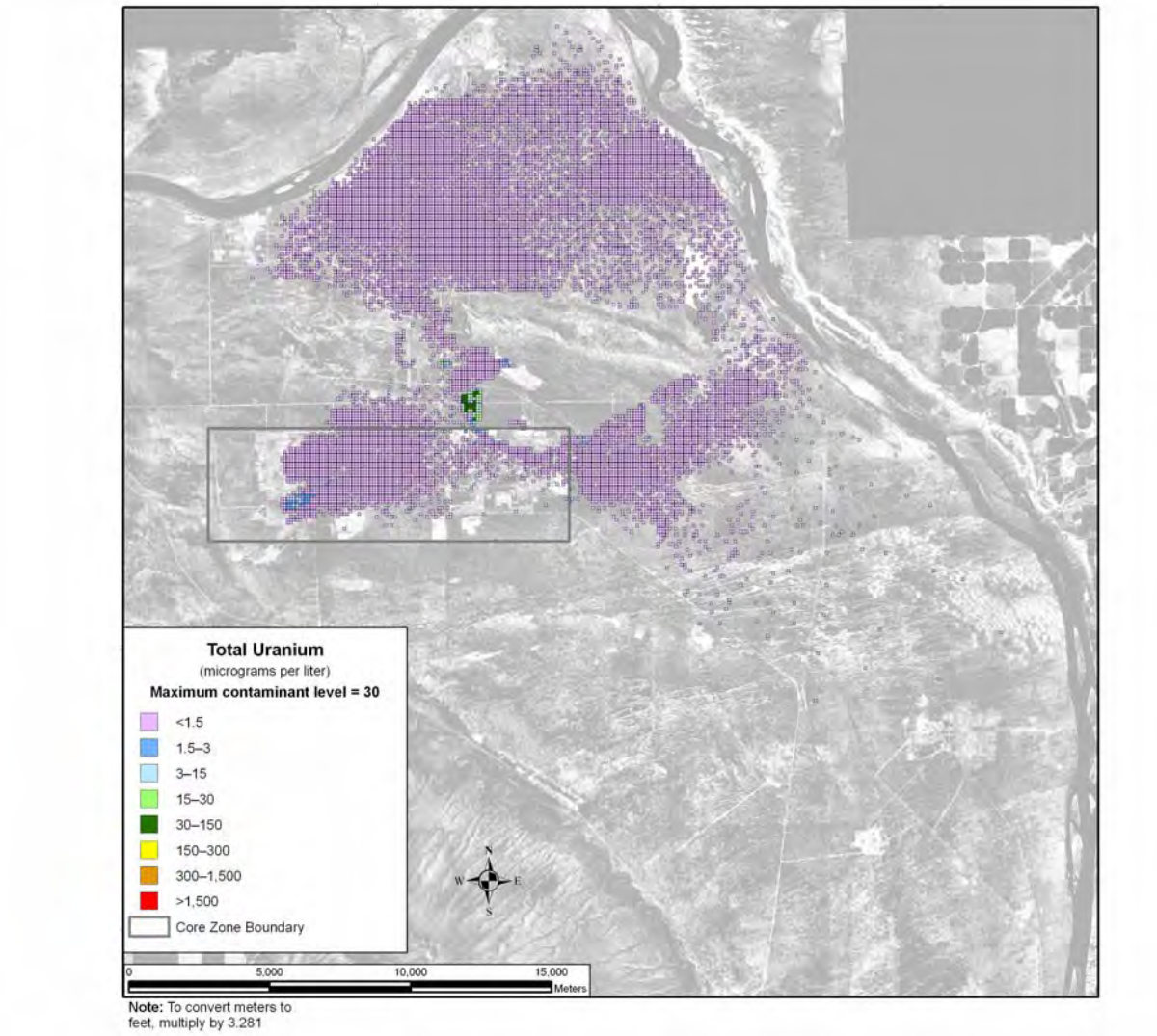


Figure 5–142. Tank Closure Alternative 4 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 7140

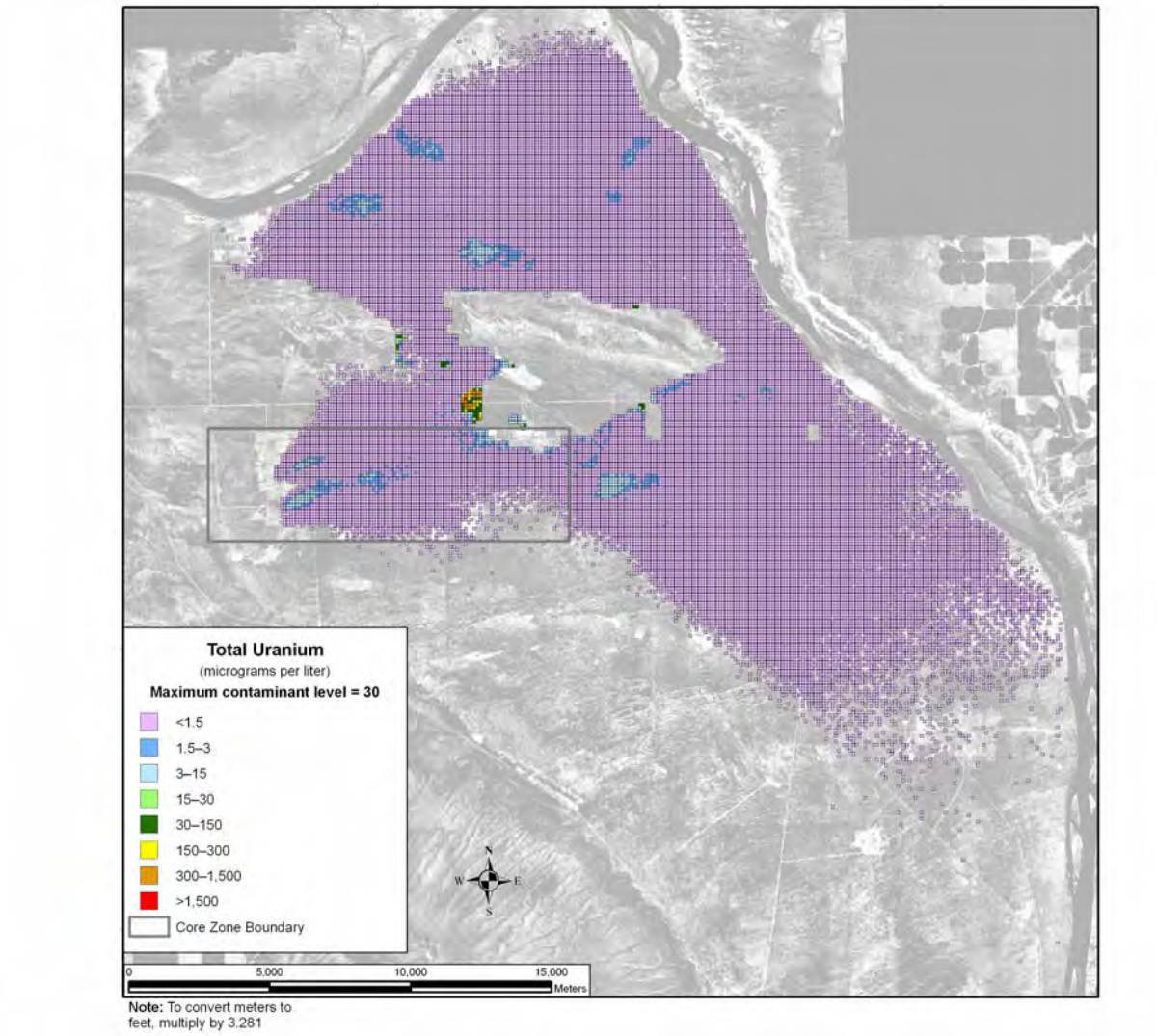


Figure 5–143. Tank Closure Alternative 4 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

Figures 5–144 through 5–146 show the area covered by concentrations above the benchmark concentration for iodine-129, technetium-99, and uranium-238. Iodine-129 spikes early in the simulation, covering a peak area of just over 4 square kilometers (1.5 square miles) around CY 2135. The total area covered by the iodine-129 plume that is above the benchmark concentration drops below 1.1 square kilometers (0.4 square miles) around CY 3890, continuing its decline to 0.5 square kilometers (0.2 square miles) by CY 9740 and remaining near that level for the remainder of the simulation. Technetium-99 shows a similar trend, peaking at just over 8 square kilometers (3 square miles) in CY 2070 and reaching 0.5 square kilometers (0.2 square miles) in CY 7790. Uranium-238 shows a distinctly different pattern, without any area above the benchmark concentration until CY 5840. From CY 5840 until the end of the simulation, areas of uranium-238 concentrations above the benchmark concentration slowly increase, never exceeding 1.1 square kilometers (0.4 square miles).

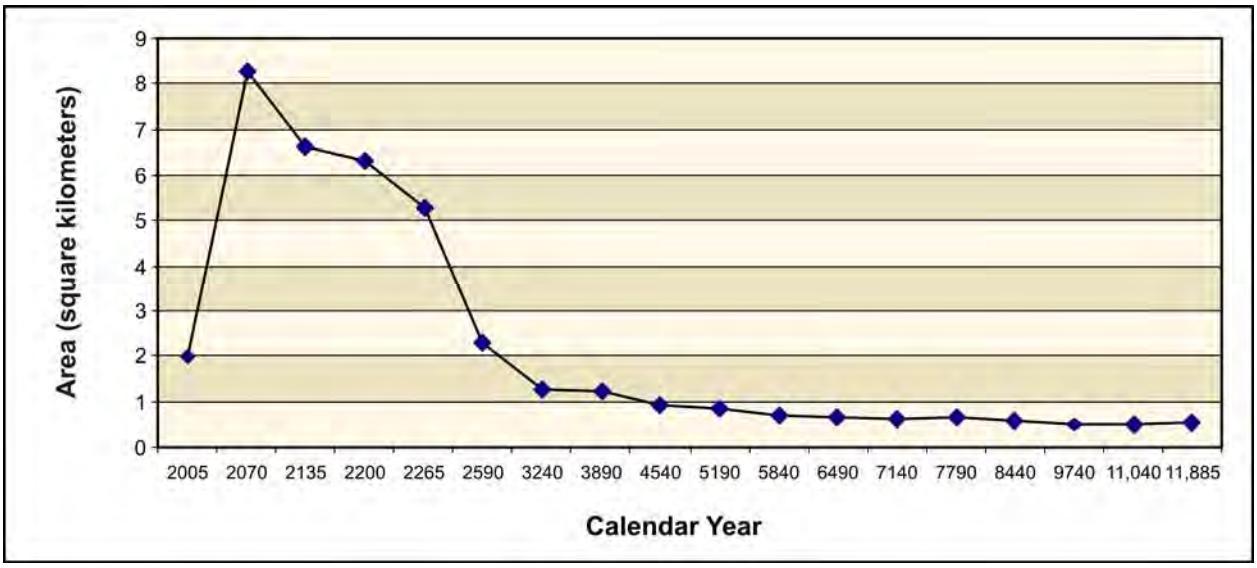


Figure 5–144. Tank Closure Alternative 4 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

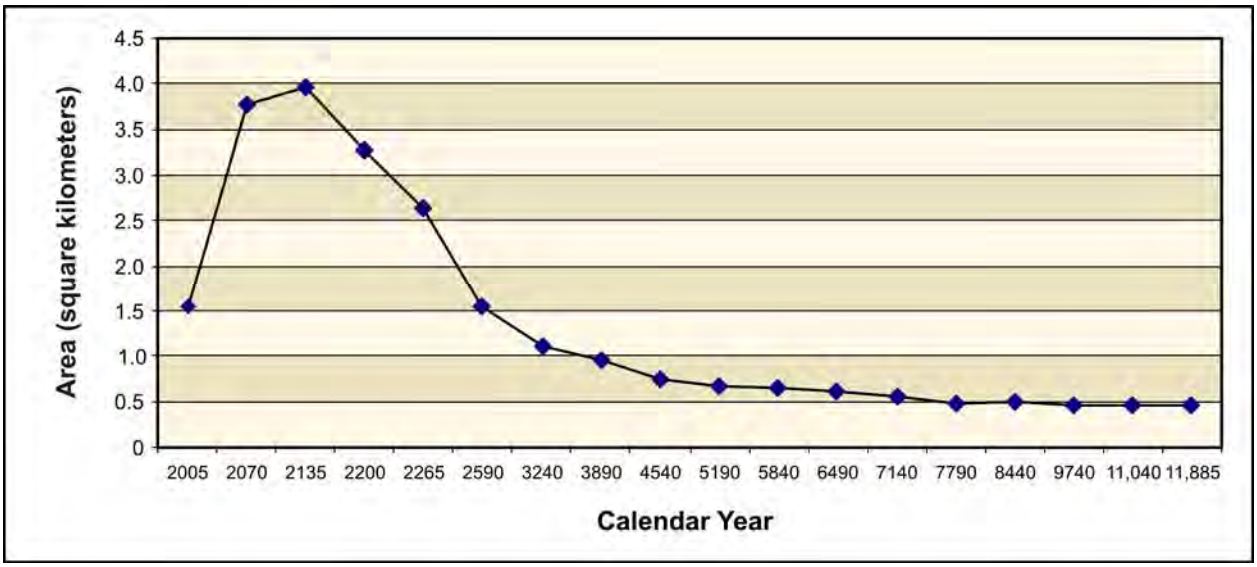


Figure 5–145. Tank Closure Alternative 4 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

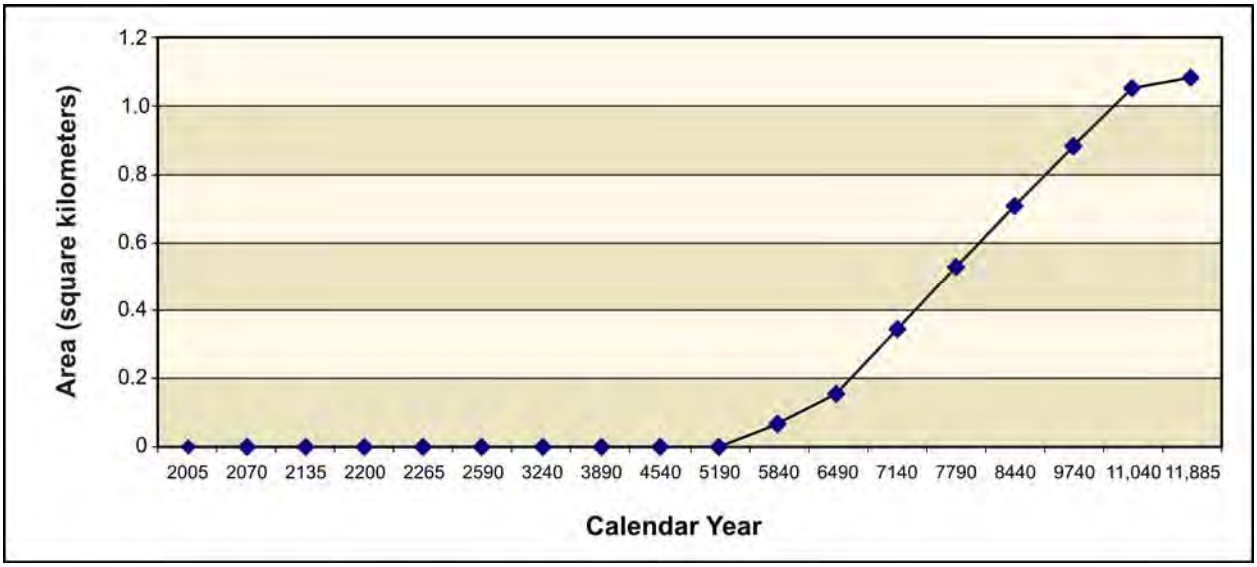


Figure 5–146. Tank Closure Alternative 4 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.7.6 Summary of Impacts

Under Tank Closure Alternative 4, discharges to cribs and trenches (ditches) and past leaks are the predominant contributors. Other tank farm sources, available after the remediation period, are a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by about one order of magnitude during most of the period of analysis. Concentrations at the Columbia River are about two to three orders of magnitude smaller. The intensities and areas of these groundwater plumes peak around CY 2070.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2050, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark concentration at the Core Zone Boundary beyond CY 8000, and remain below the benchmark concentration at the Columbia River nearshore. The intensity and area of the contamination plume continue to increase until the end of the analysis period.

5.1.1.8 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

This section describes the groundwater analysis results for Tank Closure Alternative 5, including long-term groundwater impacts of sources from within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

5.1.1.8.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 5 are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, three major periods were identified for Tank Closure Alternative 5, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades would be complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. Refer to Tank Closure Alternative 1 (see Section 5.1.1) for groundwater impacts during the past-practice period.

- The retrieval period was assumed to start in 2008 and end in CY 2139. During this period, 90 percent of the waste would be retrieved from the tanks. A retrieval loss of 15,140 liters (4,000 gallons) per tank was assumed for all SSTs, with no leakage from DSTs or miscellaneous underground storage tanks. The SST farm system would be landfill-closed with a Hanford barrier. Releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system.

- The post–administrative control period was assumed to start in CY 2140 and continue through the 10,000-year period of analysis until CY 11,940. During this post–administrative control period, releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system. In addition, all remaining waste at the SST farms (other tank farm sources) would be released to the vadose zone at the start of the post–administrative control period.

5.1.1.8.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 5. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Tank Closure Alternative 5 is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 5 were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-13}, which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 5.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers.

Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.8.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 5 in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms (see Figures 5–147 through 5–152). Three subtotals are plotted representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–147 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–148, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 90 percent of the inventory was removed during the period of analysis by supplemental treatment technologies). The predominant sources for tritium are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers the predominant sources are other tank farm sources. This suggests that other tank farm sources, which are released in the analysis during the post–administrative control period, are an important impact driver under Tank Closure Alternative 5.

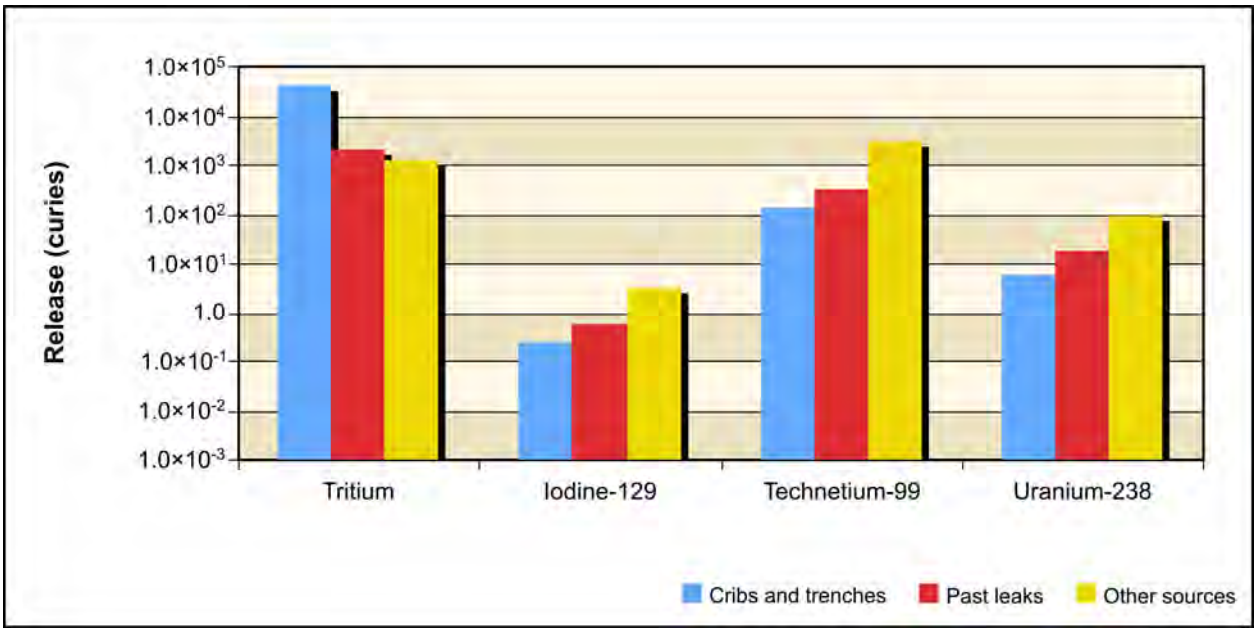


Figure 5–147. Tank Closure Alternative 5 Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

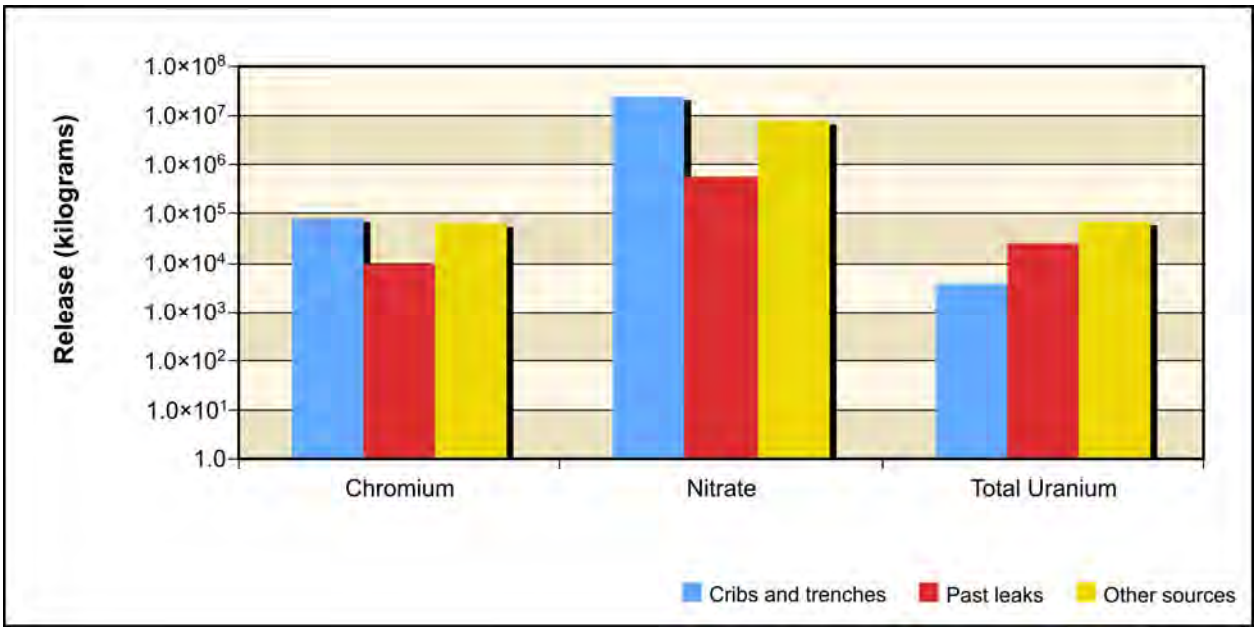


Figure 5–148. Tank Closure Alternative 5 Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–149 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–150, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

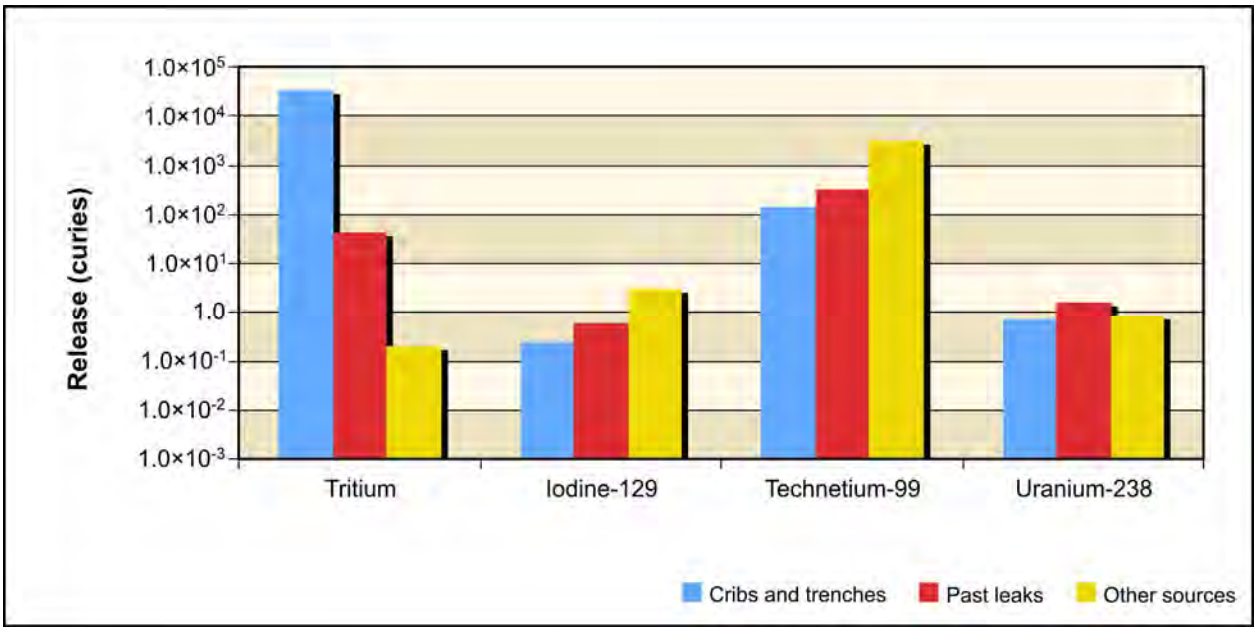


Figure 5–149. Tank Closure Alternative 5 Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

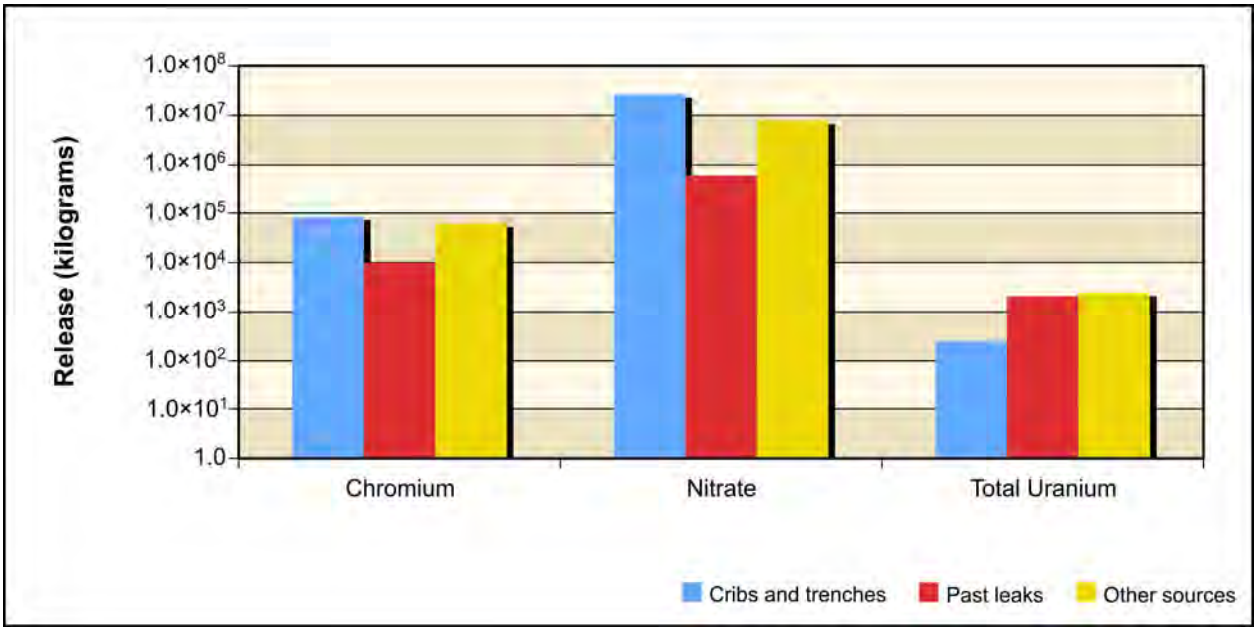


Figure 5–150. Tank Closure Alternative 5 Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For cribs and trenches (ditches) and past leaks, where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 10 percent of the total inventory reached groundwater during the period of analysis; for other tank farm sources, only about 2 percent reached groundwater.

For tritium, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 70 percent of the total inventory reached groundwater in the analysis; for past leaks, only 2 percent; and for other tank farm sources, only one-third of 1 percent reached the water table. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts would occur later in the post–administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–151 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–152, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For uranium-238 and total uranium, the amount released to the Columbia River is less than that of the release to groundwater because of retardation. Overall, about 25 percent of the amount released to groundwater during the period of analysis reached the Columbia River. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reached the Columbia River during the period of analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post–administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

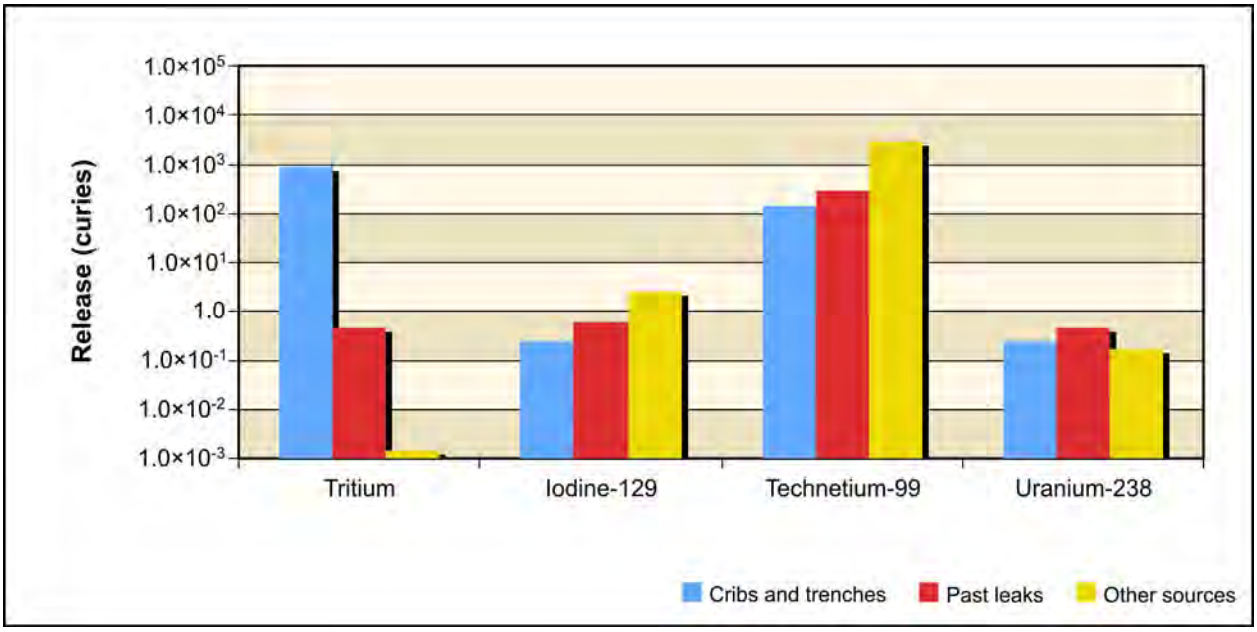


Figure 5–151. Tank Closure Alternative 5 Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

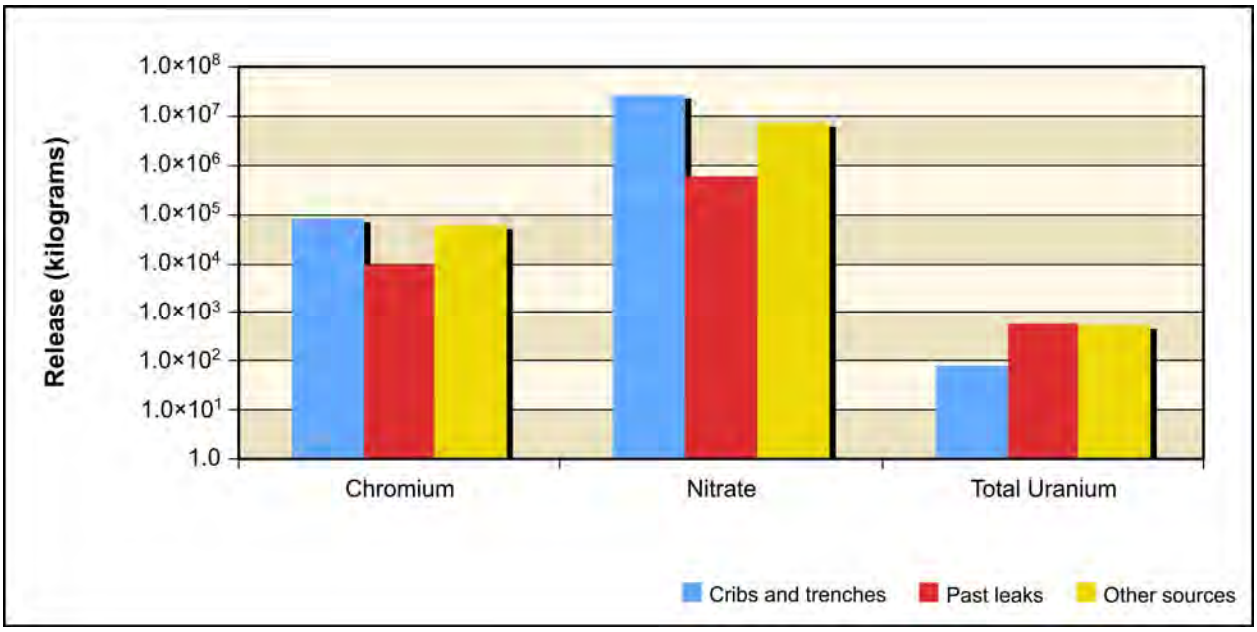


Figure 5–152. Tank Closure Alternative 5 Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.8.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 5 impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Table 5–5 and Figures 5–153 through 5–159). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–5 lists the maximum concentrations of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore.

Figure 5–153 shows concentration versus time for tritium. Releases from cribs and trenches (ditches) cause groundwater concentrations to exceed benchmark concentrations by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore approach the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

Figures 5–154 through 5–157 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from cribs and trenches (ditches) cause groundwater concentrations to exceed benchmark concentrations by about two to three orders of magnitude during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore approach but do not exceed the benchmark concentration. Releases from other tank farm sources cause groundwater concentrations at the Core Zone Boundary to exceed benchmark concentrations by about one order of magnitude during the middle and latter parts of the period of analysis (around CY 3000 to 5000). During this time, groundwater concentrations at the Columbia River nearshore do not approach the benchmark concentration.

Table 5–5. Tank Closure Alternative 5 Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	28	5,070	52	7,270	13	6,070	178	20,000
	(2051)	(2054)	(2050)	(2055)	(2050)	(2054)	(2050)	
Technetium-99	**3,040**	**22,500**	**3,340**	**15,300**	**1,780**	**35,700**	724	900
	(4338)	(2050)	(3931)	(2050)	(4022)	(4326)	(5017)	
Iodine-129	**3**	**42**	**5**	**19**	0.8	**34**	0.5	1
	(2059)	(2057)	(2050)	(2051)	(4694)	(2057)	(7030)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	1	**67**	**15**	**25**	9	**102**	1	15
	(11,845)	(11,739)	(11,727)	(11,780)	(11,750)	(11,735)	(11,594)	
Chemical in micrograms per liter								
Acetonitrile	8	0	2	0	0	12	1	100
	(4221)	(1940)	(4208)	(1940)	(1940)	(4510)	(4297)	
Chromium	29	**3,210**	**289**	**782**	36	**1,730**	35	100
	(4094)	(2055)	(2050)	(2050)	(3847)	(3891)	(2695)	
Nitrate	6,510	**1,540,000**	13,200	**133,000**	4,510	**1,010,000**	8,750	45,000
	(4099)	(2050)	(3586)	(2054)	(3794)	(2050)	(2450)	
Total uranium	0	**83**	**33**	15	15	**204**	1	30
	(11,795)	(11,798)	(11,473)	(11,815)	(11,821)	(11,805)	(11,935)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

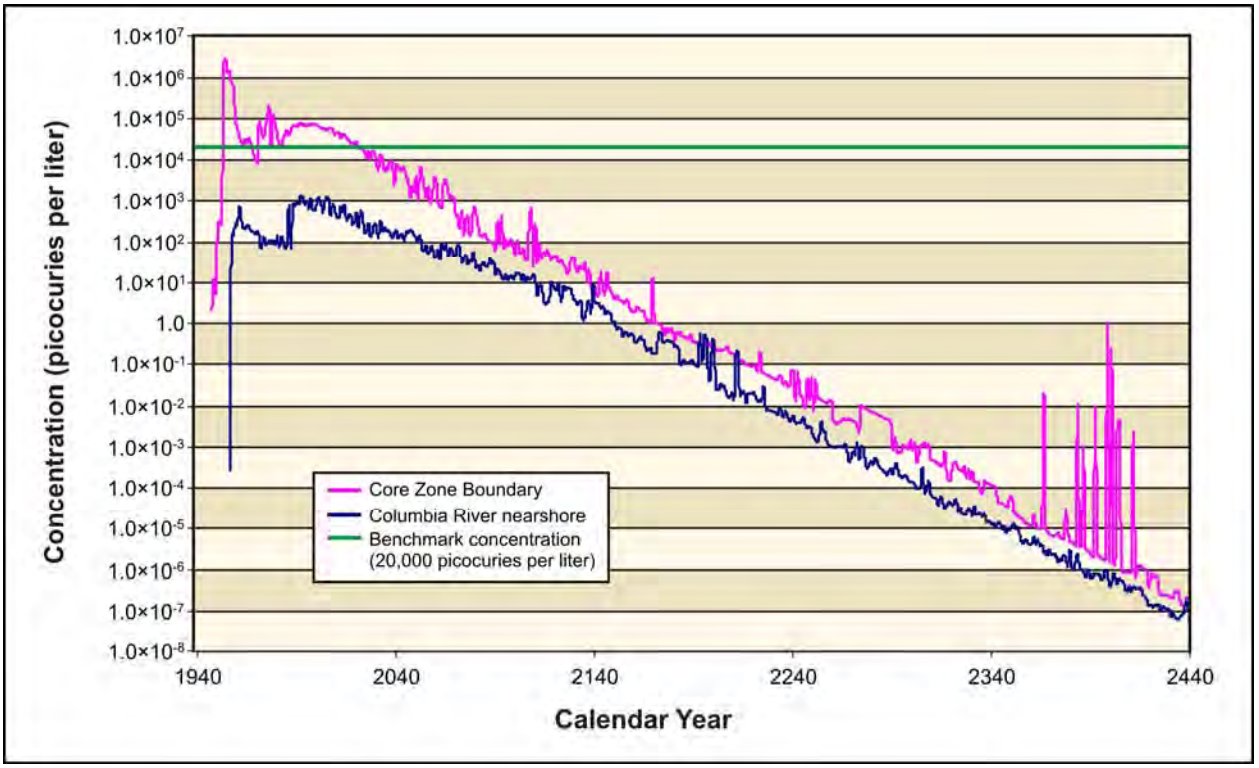


Figure 5–153. Tank Closure Alternative 5 Hydrogen-3 (Tritium) Concentration Versus Time

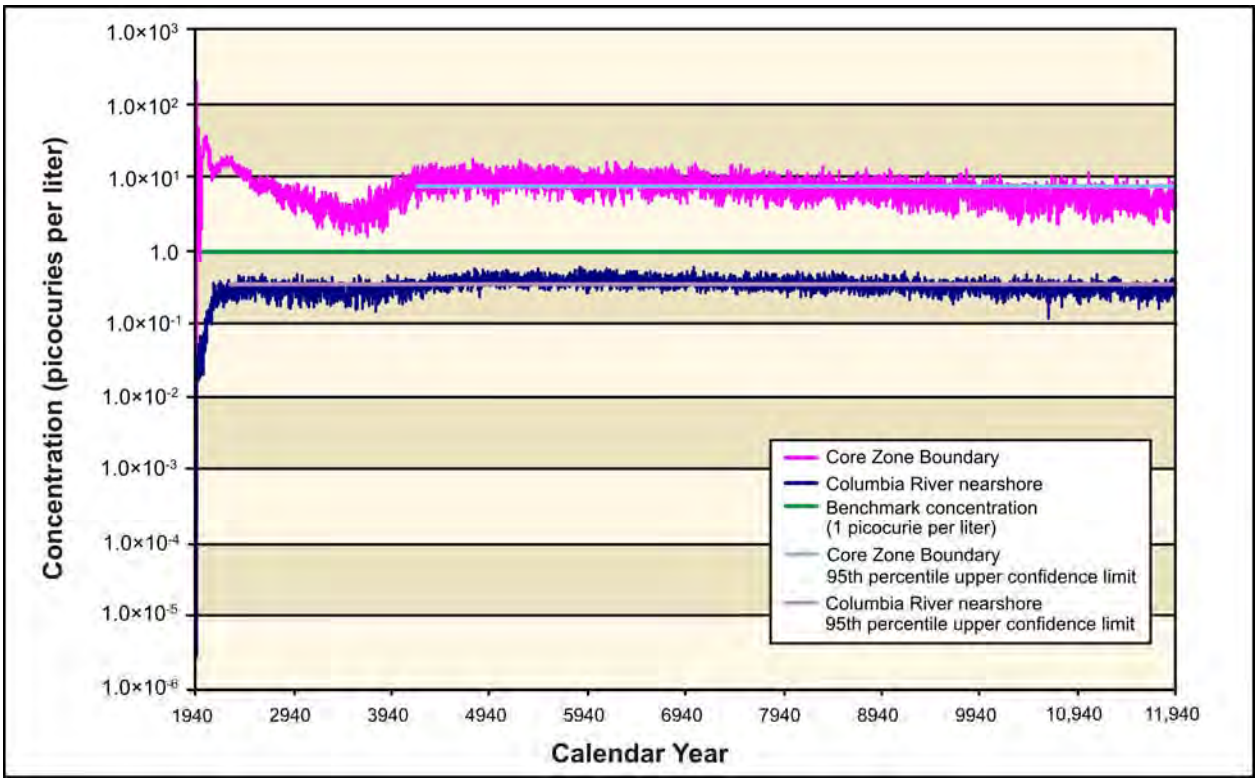


Figure 5–154. Tank Closure Alternative 5 Iodine-129 Concentration Versus Time

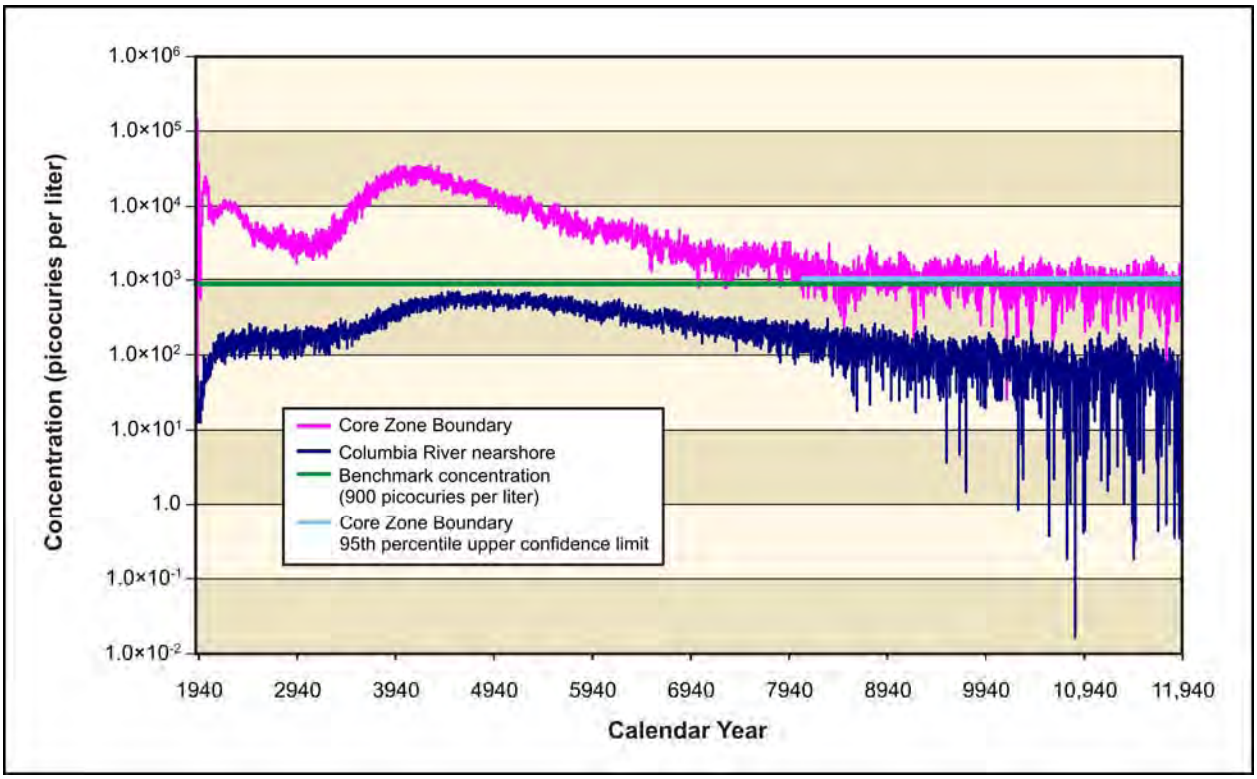


Figure 5–155. Tank Closure Alternative 5 Technetium-99 Concentration Versus Time

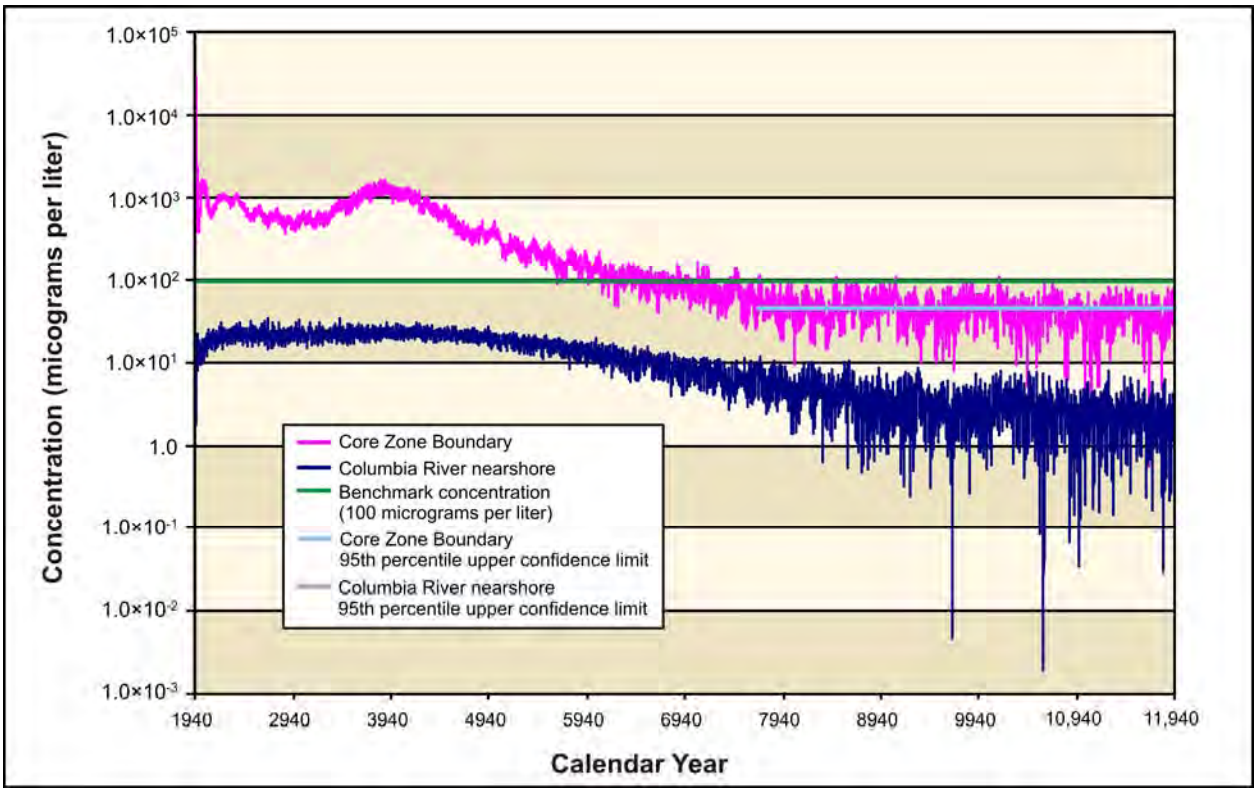


Figure 5–156. Tank Closure Alternative 5 Chromium Concentration Versus Time

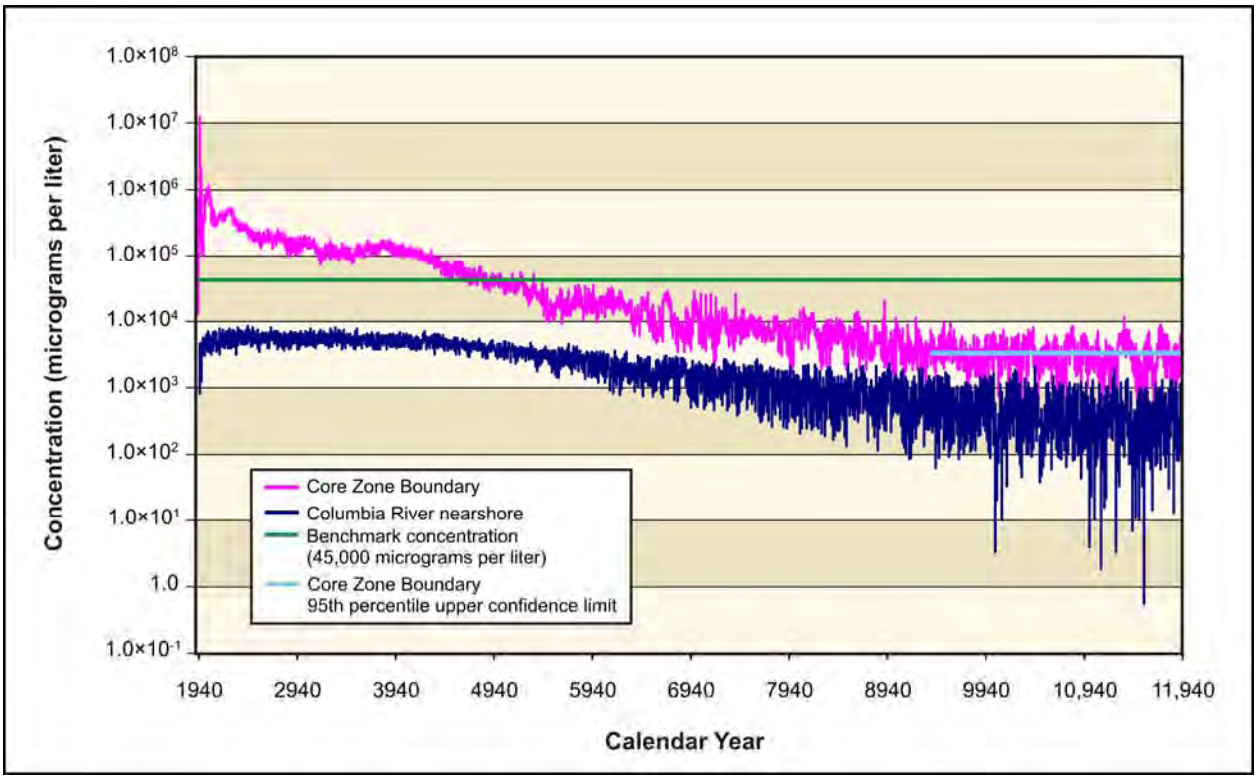


Figure 5–157. Tank Closure Alternative 5 Nitrate Concentration Versus Time

Figures 5–158 and 5–159 show concentration versus time for uranium-238 and total uranium. Early releases from cribs and trenches (ditches) result in groundwater concentrations that are one to two orders of magnitude lower than benchmark concentrations. Releases from other tank farm sources cause groundwater concentrations to rise, nearing benchmark concentrations by CY 8200 for uranium-238 and by CY 8400 for total uranium. Concentrations continue to rise throughout the duration of the period of analysis, exceeding benchmark concentrations by about one order of magnitude at the end of the period of analysis. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, nearing an order of magnitude less than the benchmark concentration by CY 11,940.

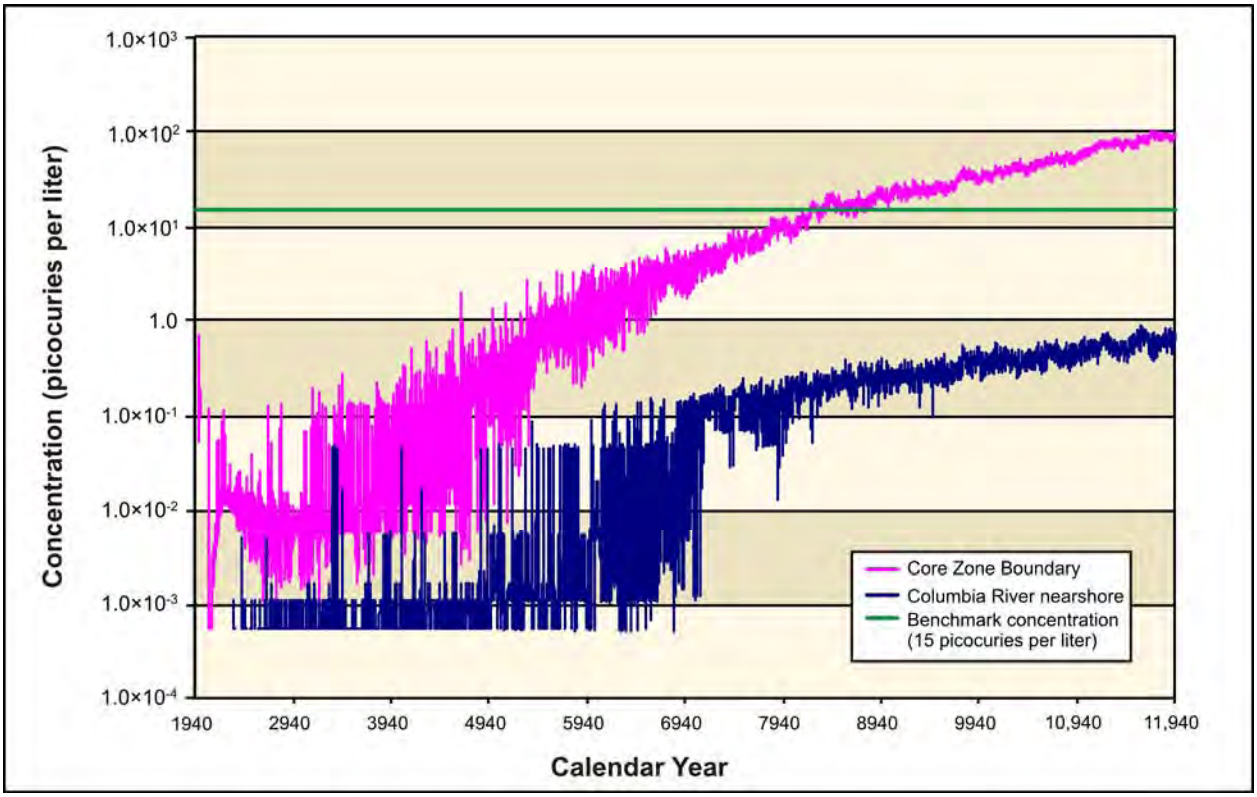


Figure 5–158. Tank Closure Alternative 5 Uranium-238 Concentration Versus Time

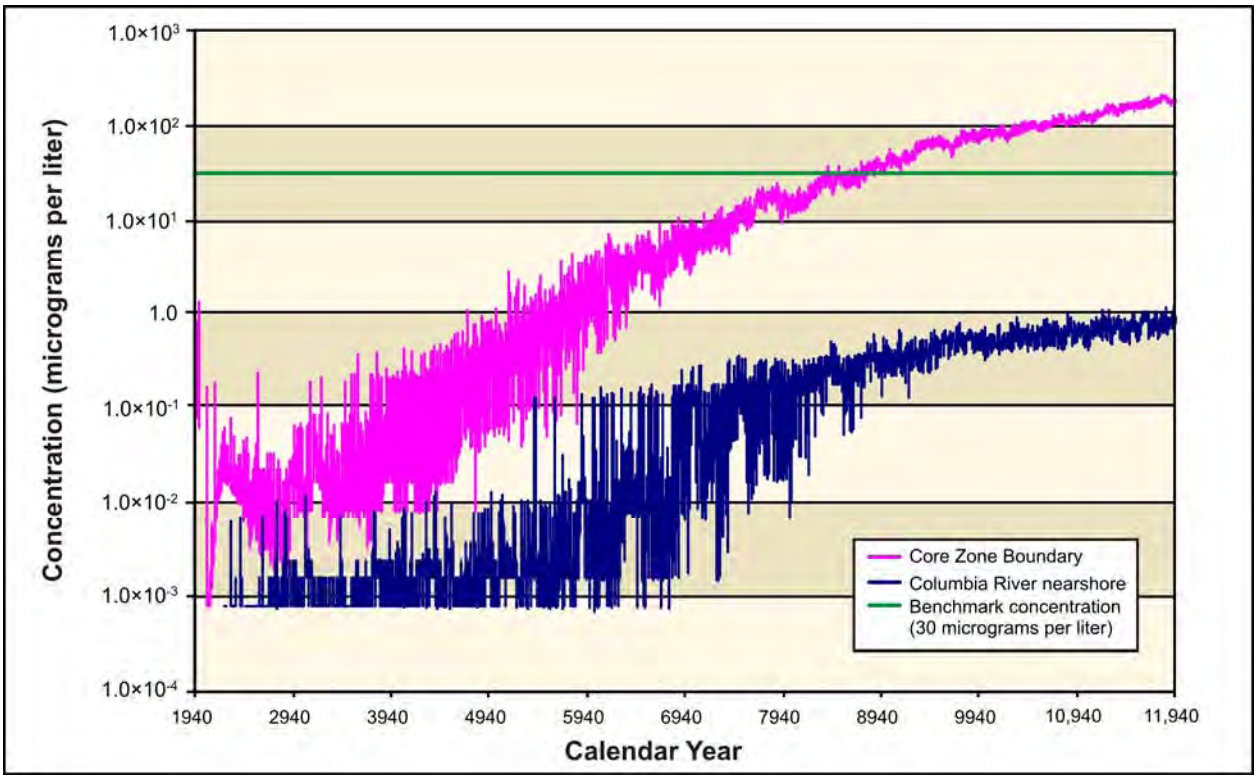


Figure 5–159. Tank Closure Alternative 5 Total Uranium Concentration Versus Time

5.1.1.8.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 5 in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Figures 5–160 through 5–182). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–160 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135 (see Figure 5–161).

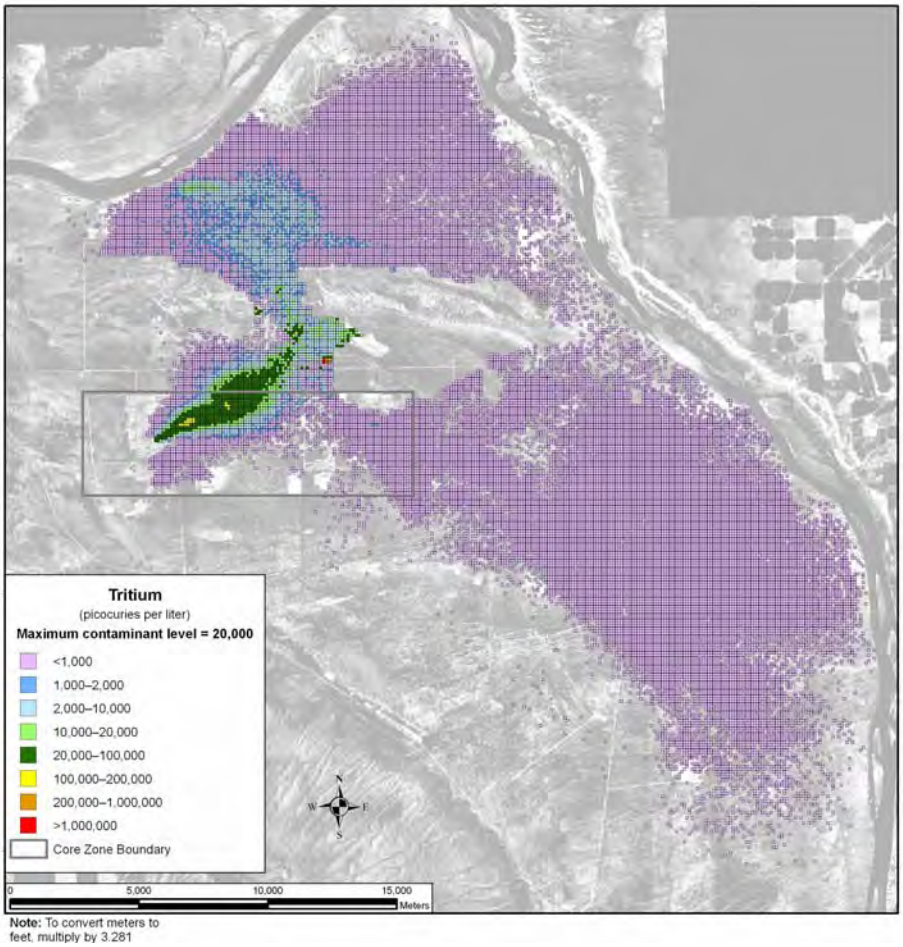


Figure 5–160. Tank Closure Alternative 5 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

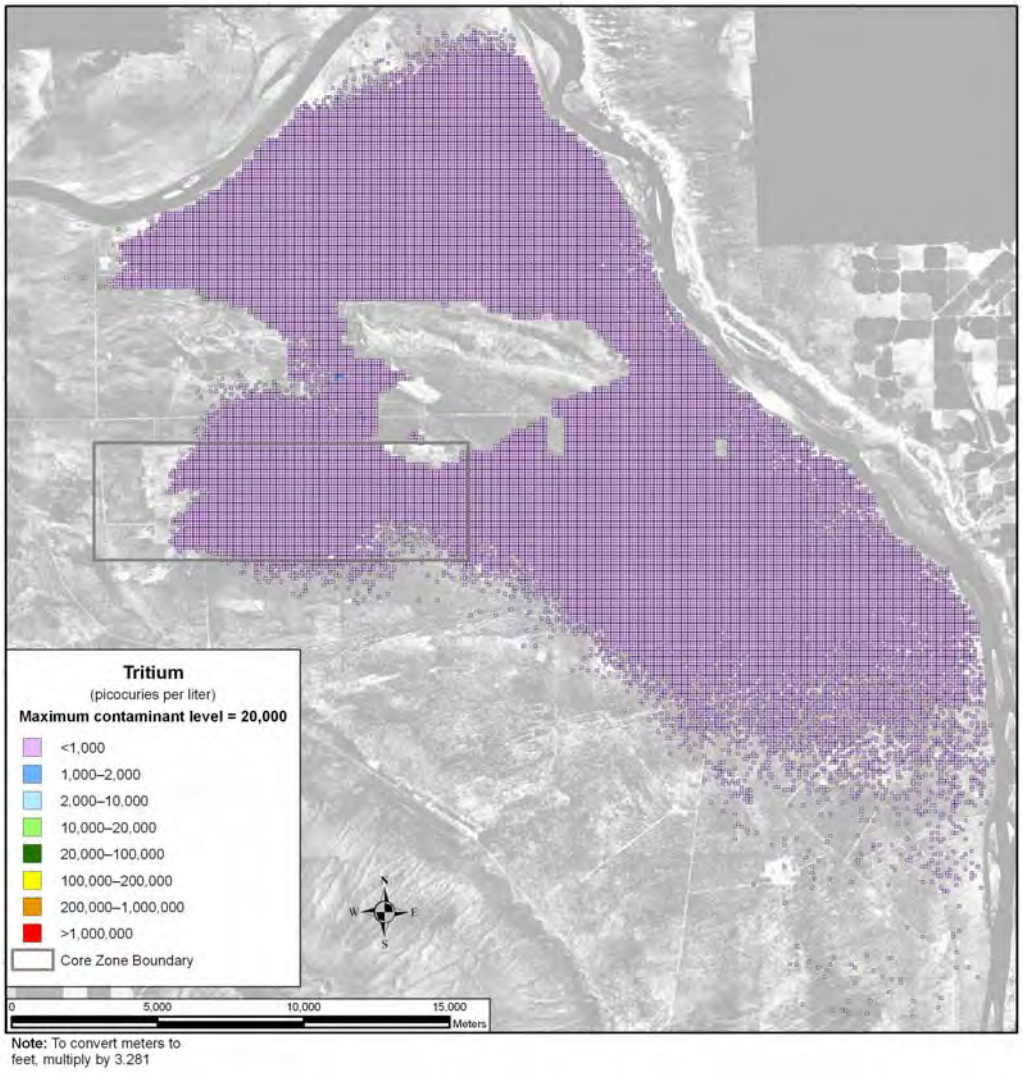


Figure 5–161. Tank Closure Alternative 5 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

Figure 5–162 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Analysis releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, S Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 30 times greater than the benchmark, and mostly contained within the Core Zone Boundary. During CY 2135, releases from other tank farm sources create a large plume exceeding the benchmark concentration, extending from the A Barrier to the Columbia River (see Figure 5–163). By CY 7140, most of the mass in the plume has reached the Columbia River, with only isolated pockets of high-concentration areas where the groundwater flow velocities are extremely small (see Figure 5–164). Technetium-99 (see Figures 5–165 through 5–167), chromium (see Figures 5–168 through 5–170), and nitrate (see Figure 5–171 through 5–173) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

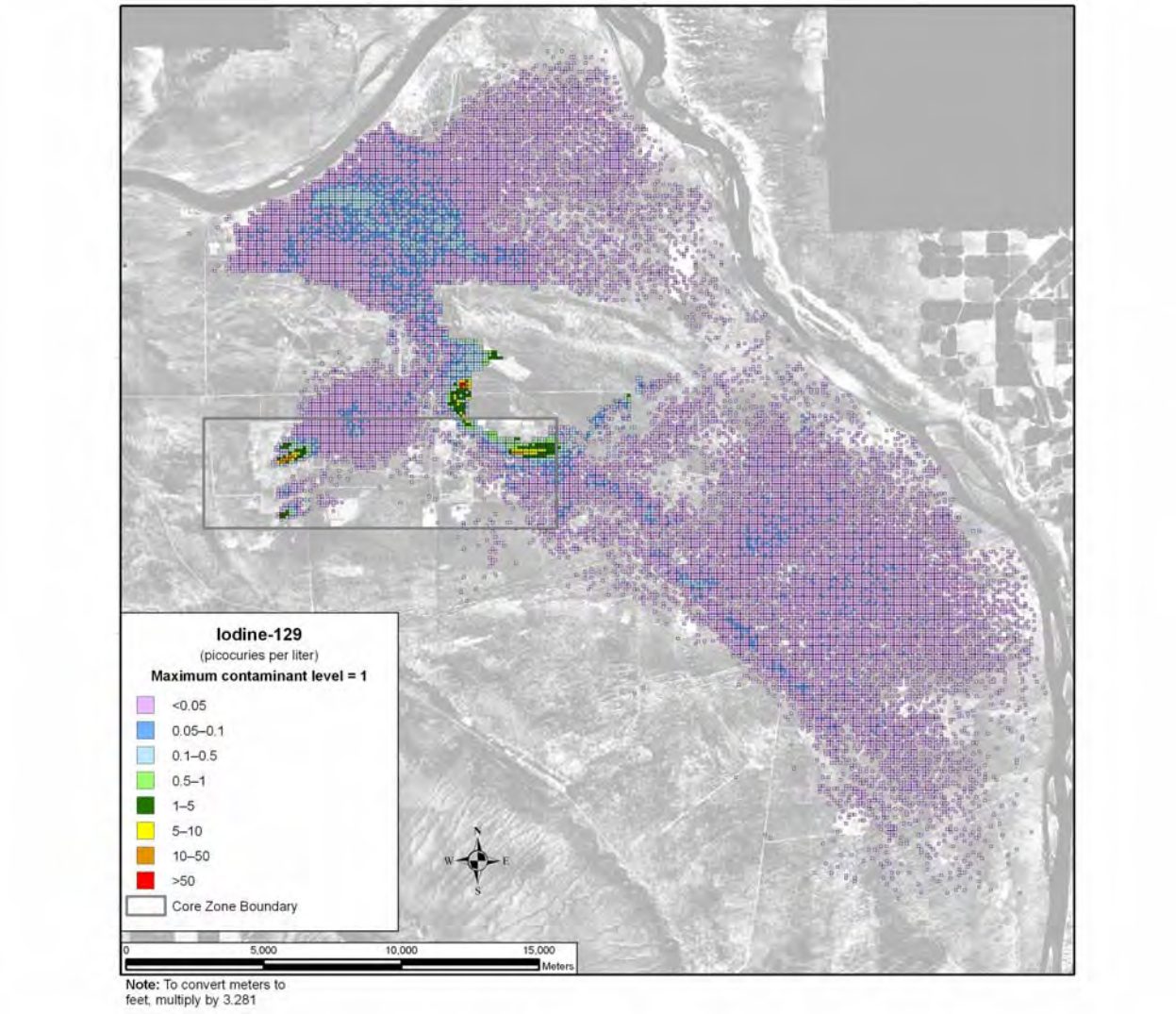


Figure 5–162. Tank Closure Alternative 5 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

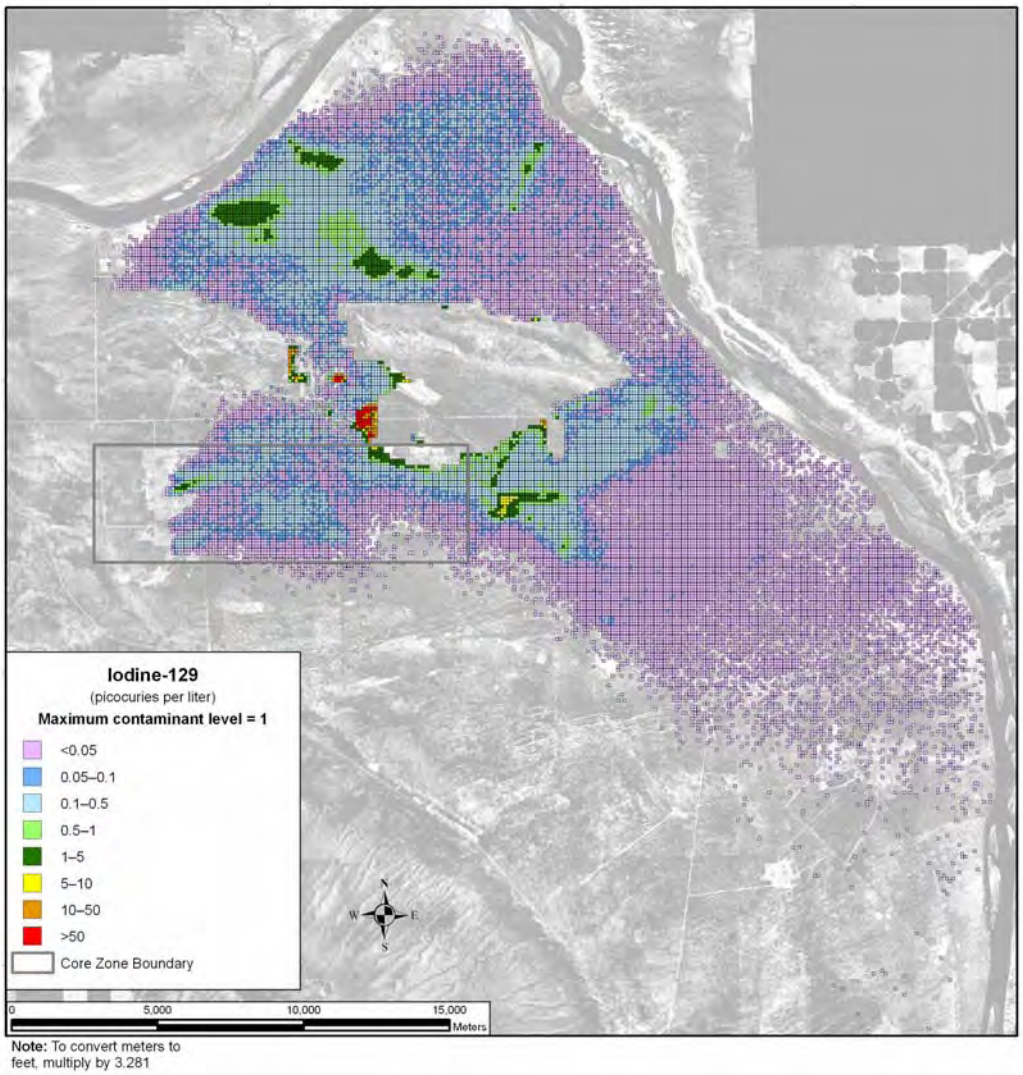
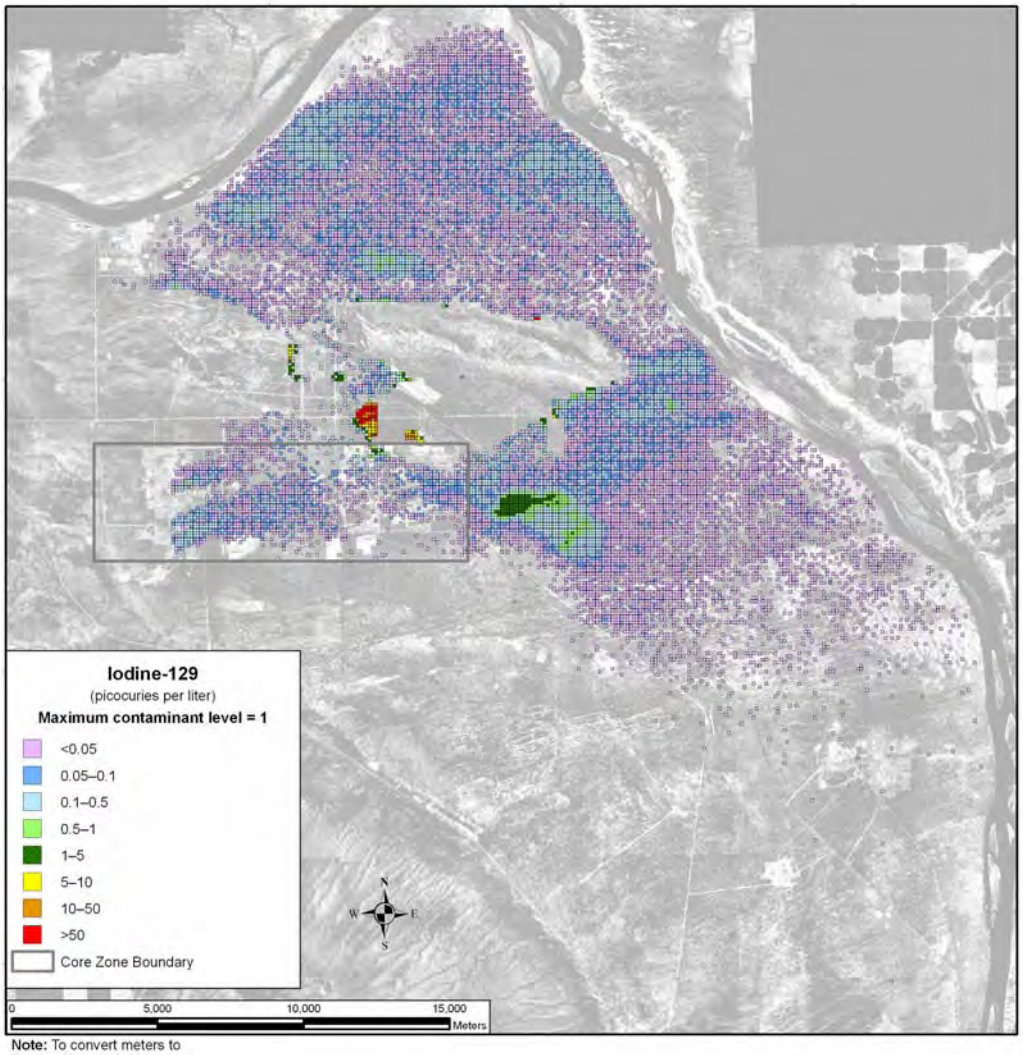


Figure 5–163. Tank Closure Alternative 5 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–164. Tank Closure Alternative 5 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

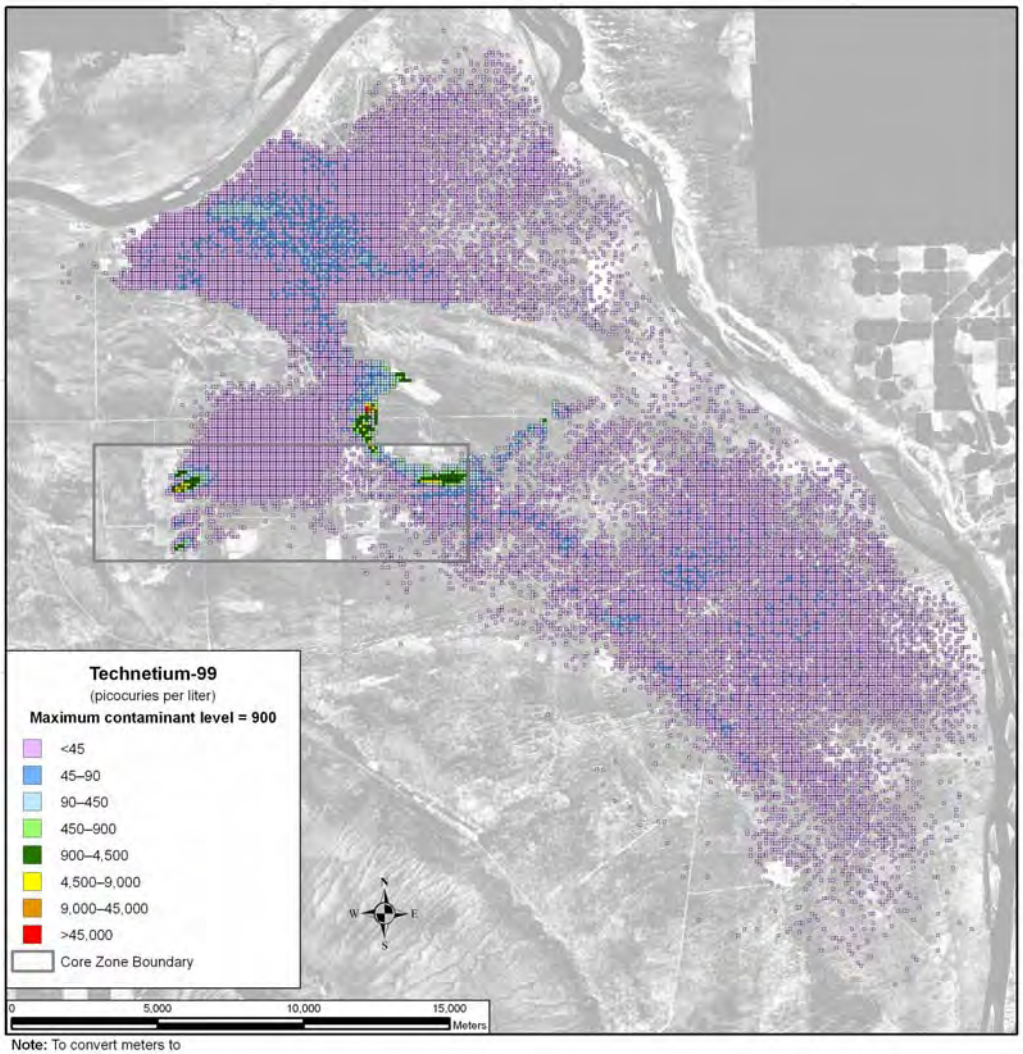


Figure 5–165. Tank Closure Alternative 5 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

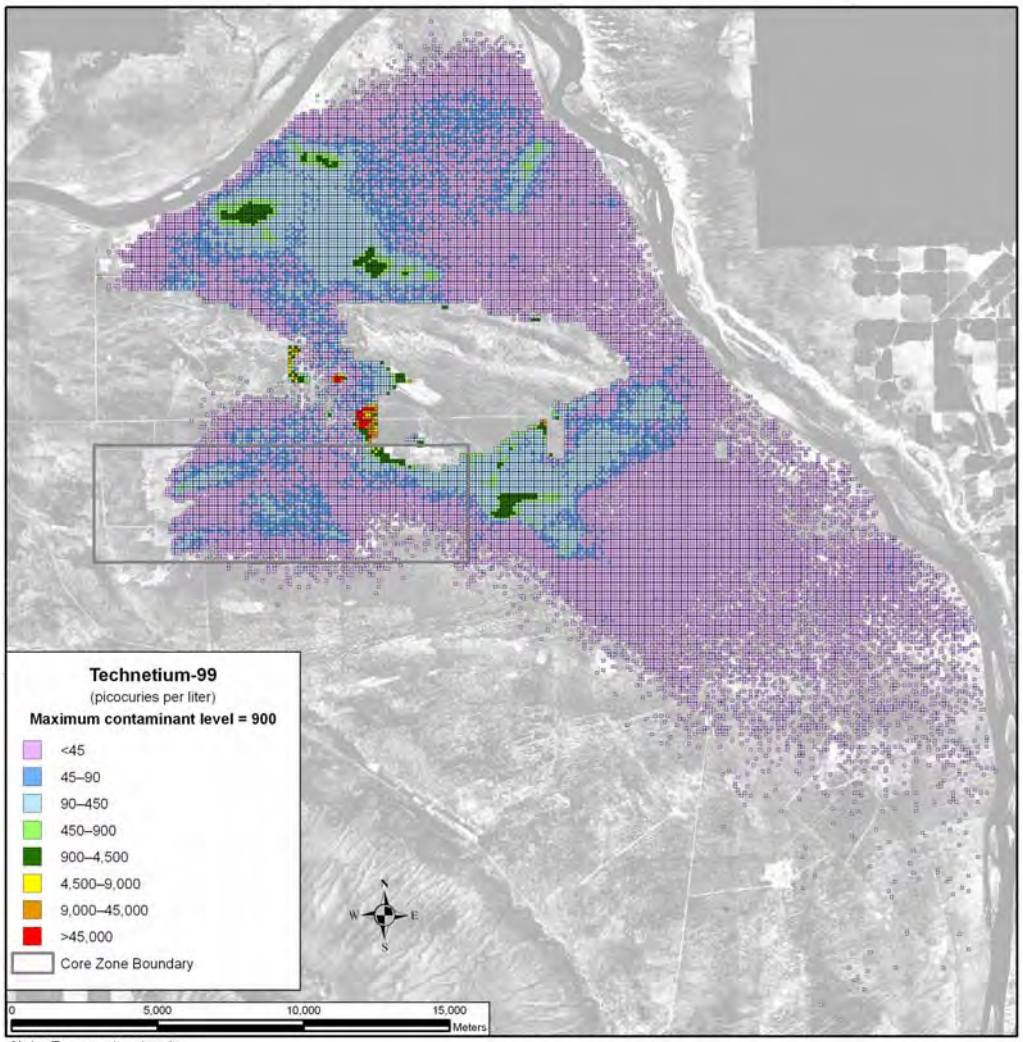


Figure 5–166. Tank Closure Alternative 5 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2135

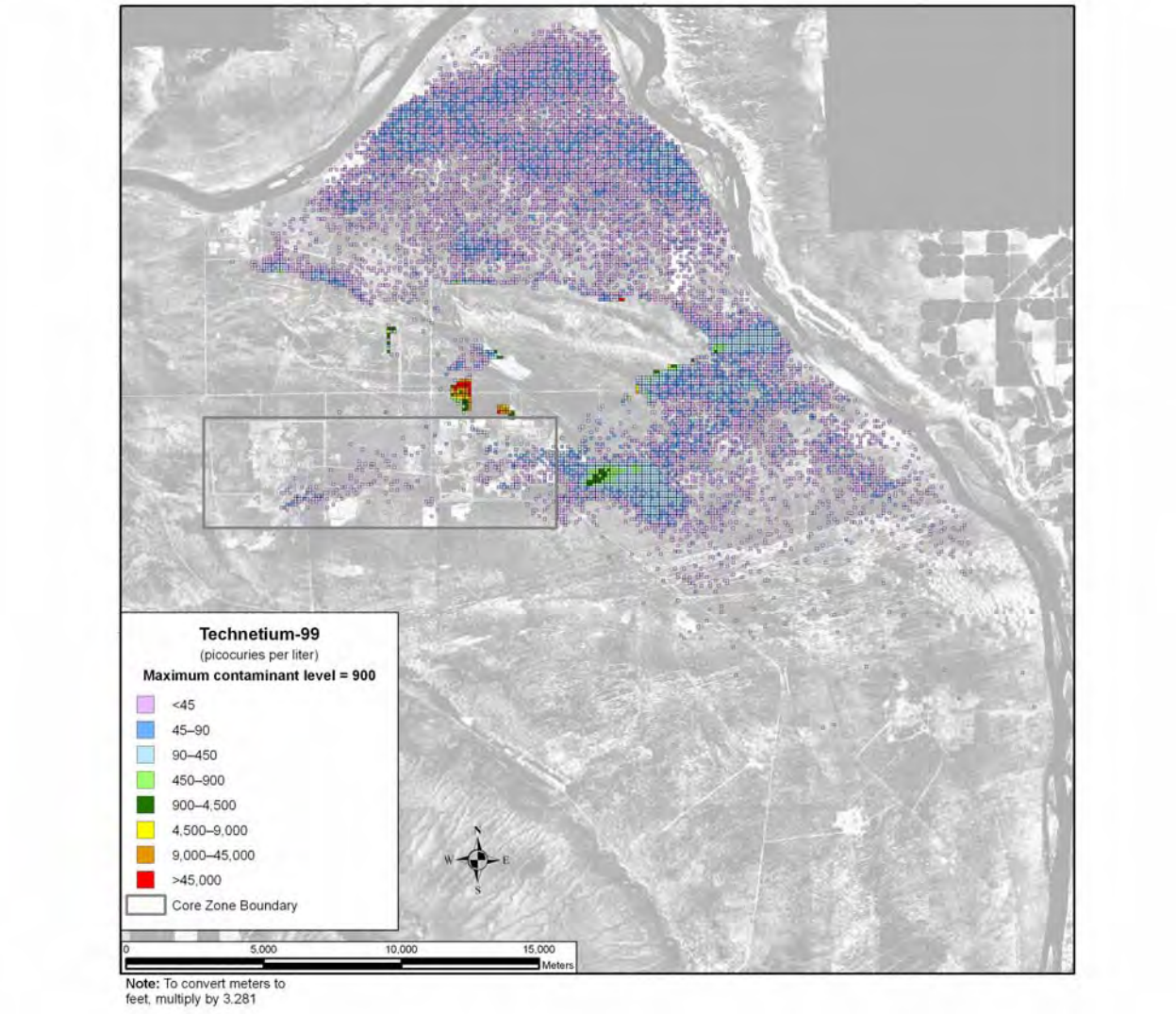


Figure 5–167. Tank Closure Alternative 5 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

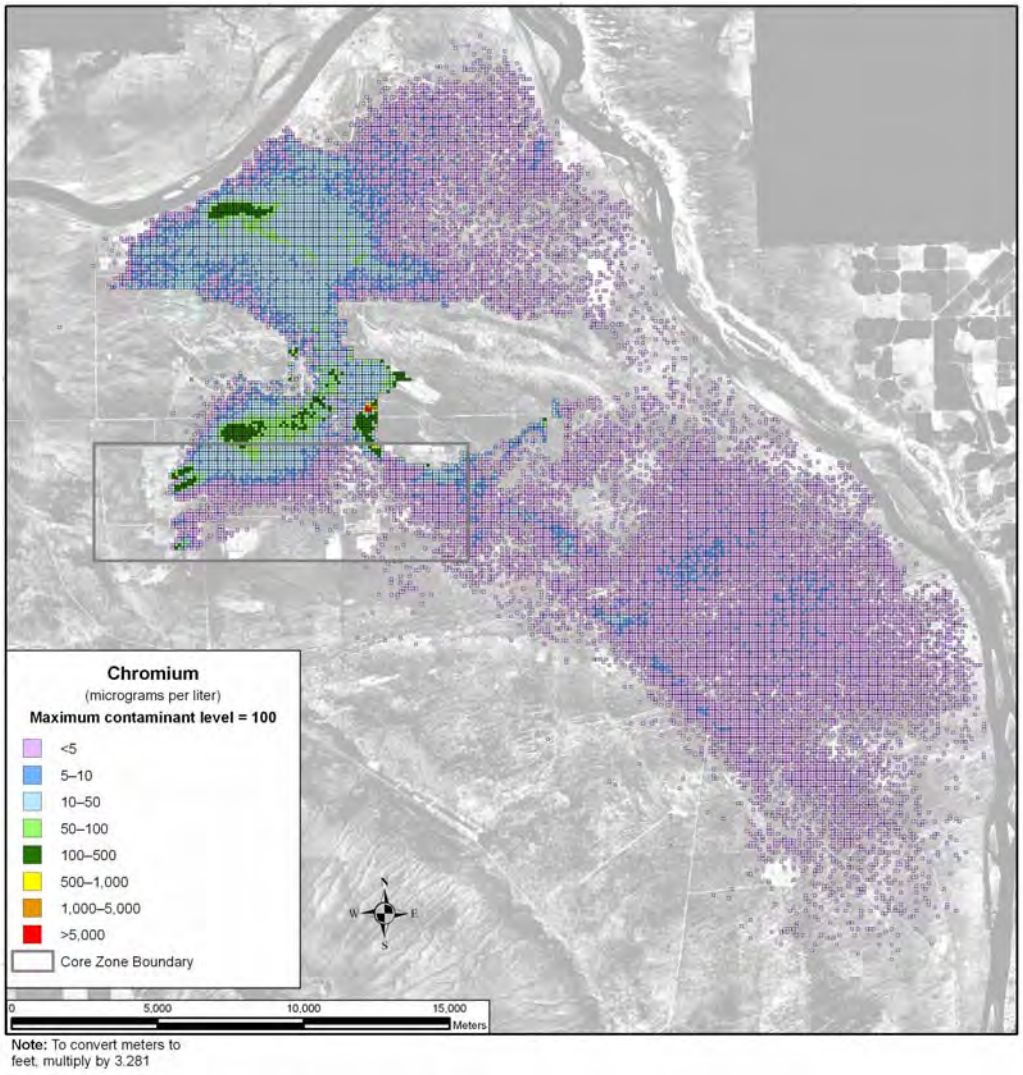


Figure 5–168. Tank Closure Alternative 5 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

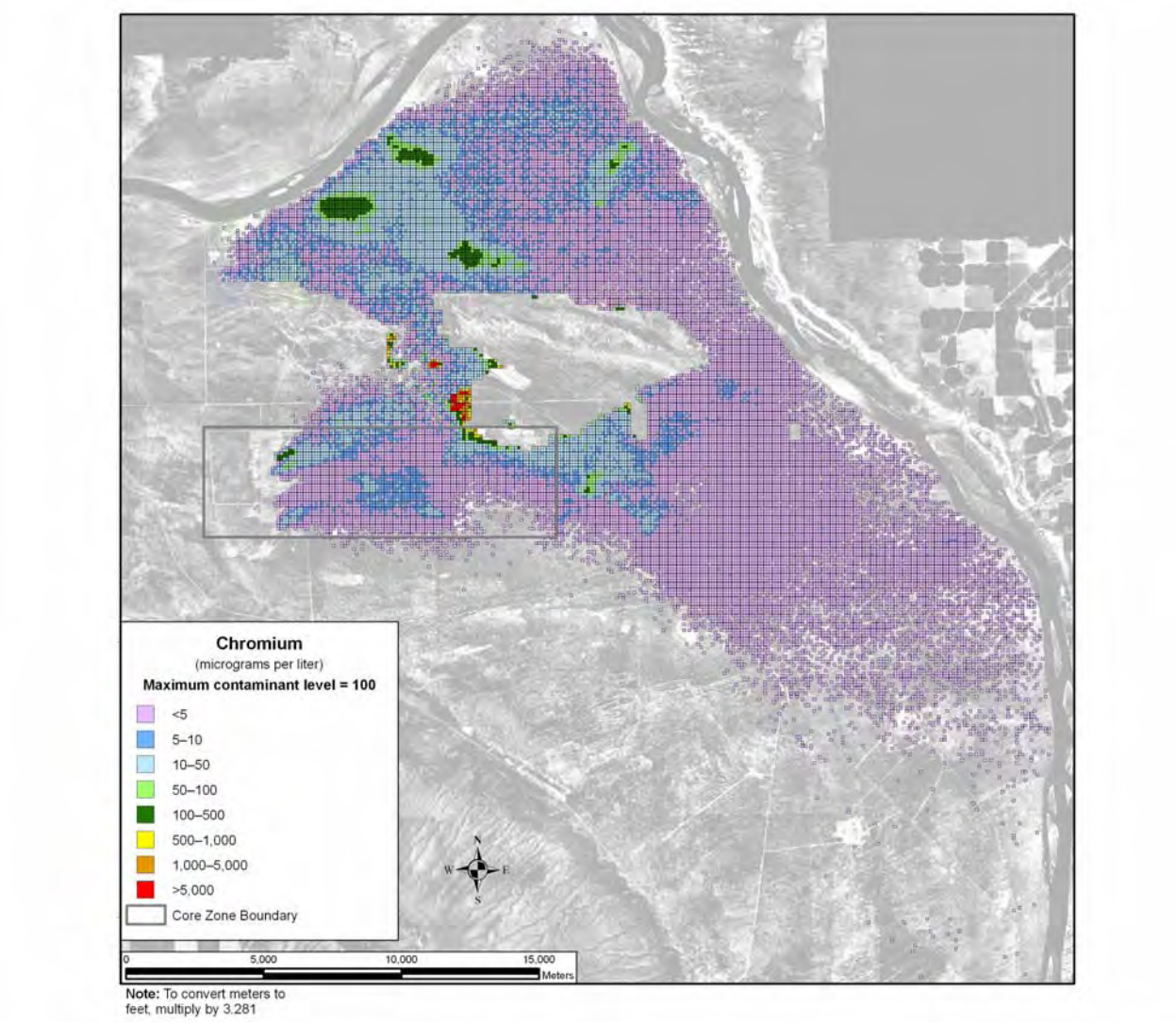


Figure 5–169. Tank Closure Alternative 5 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2135

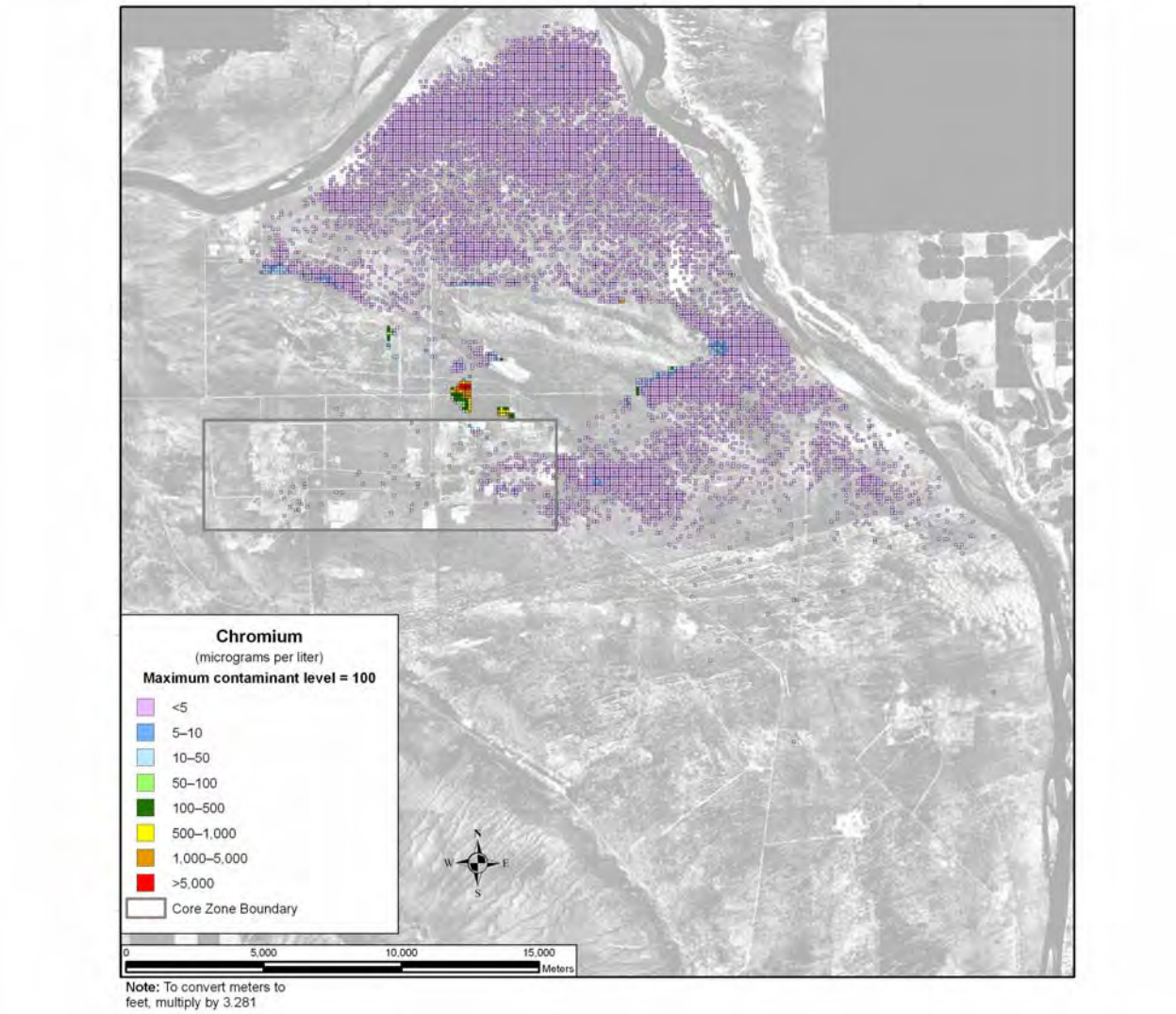


Figure 5–170. Tank Closure Alternative 5 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

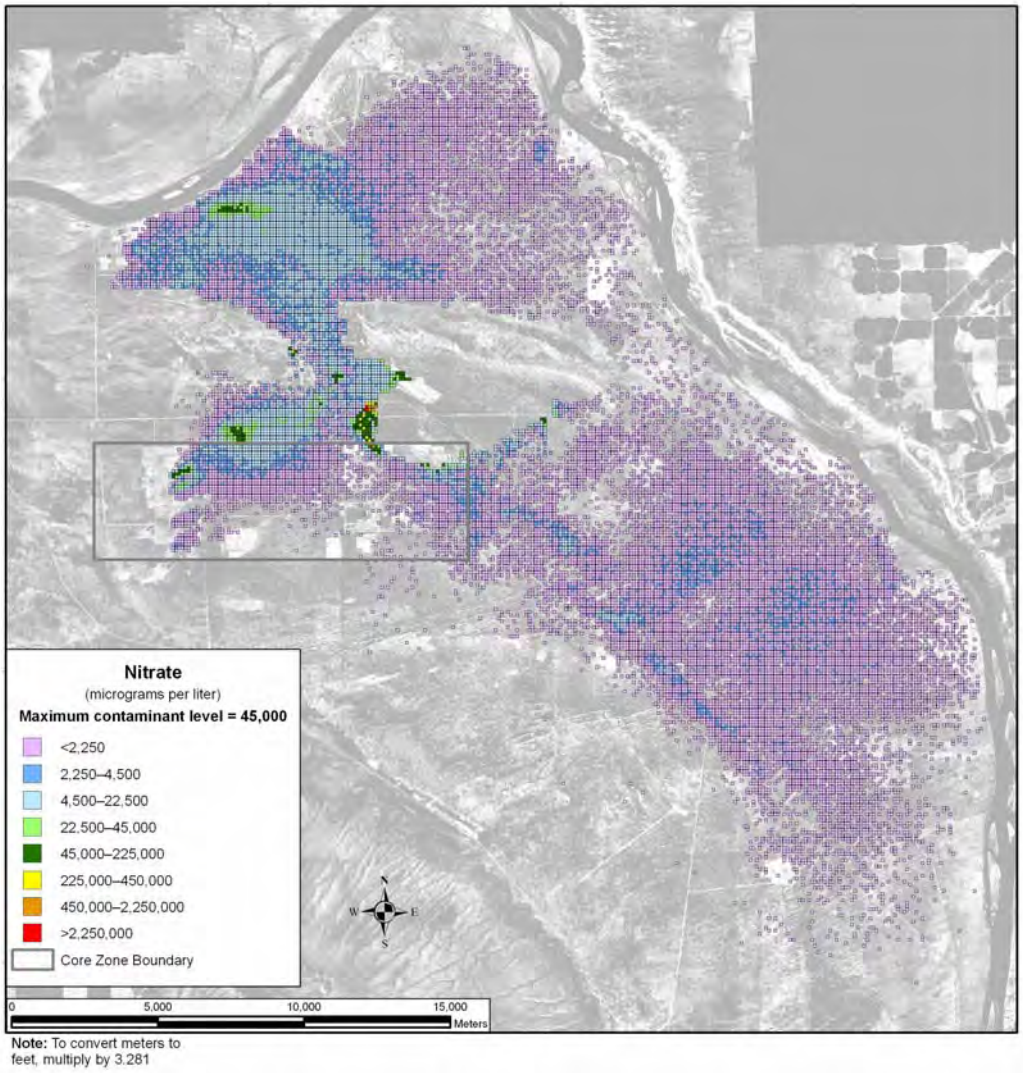


Figure 5–171. Tank Closure Alternative 5 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

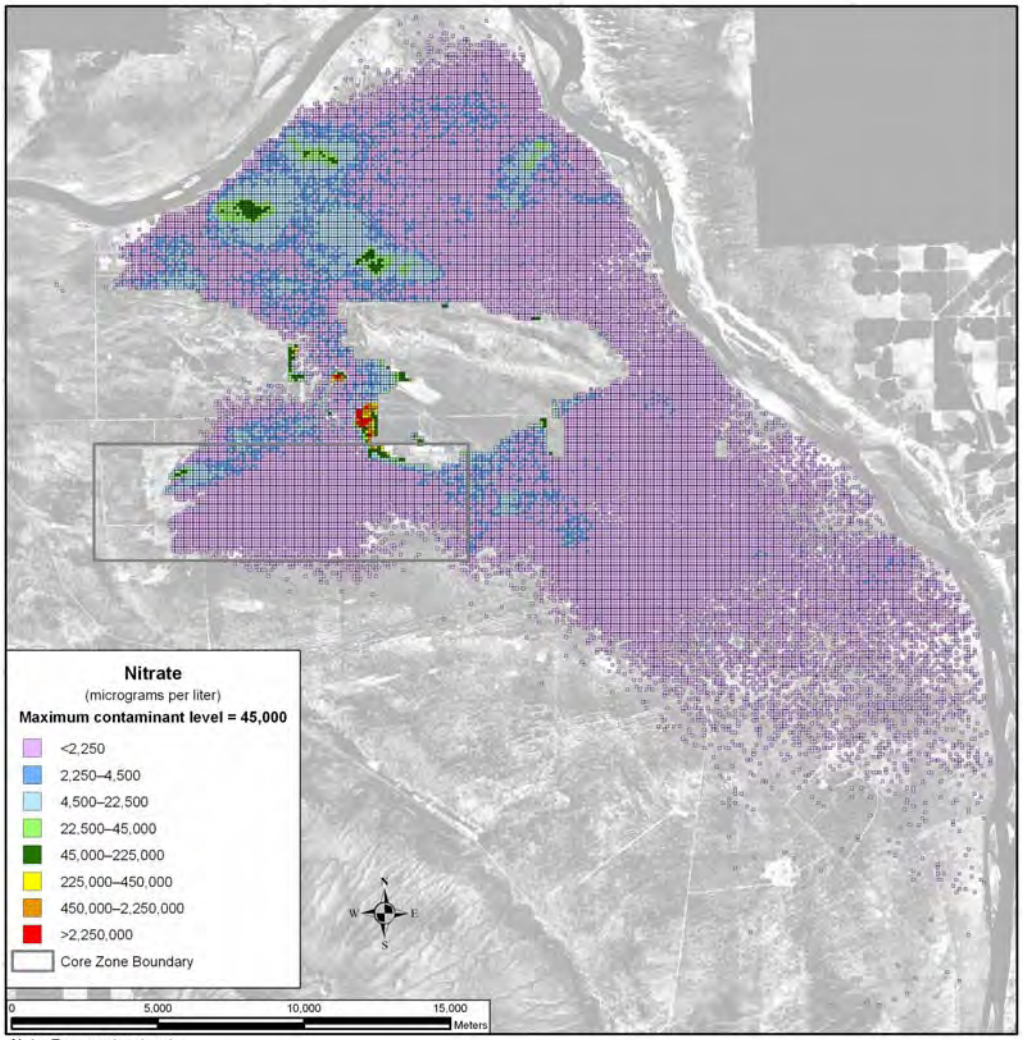


Figure 5–172. Tank Closure Alternative 5 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2135

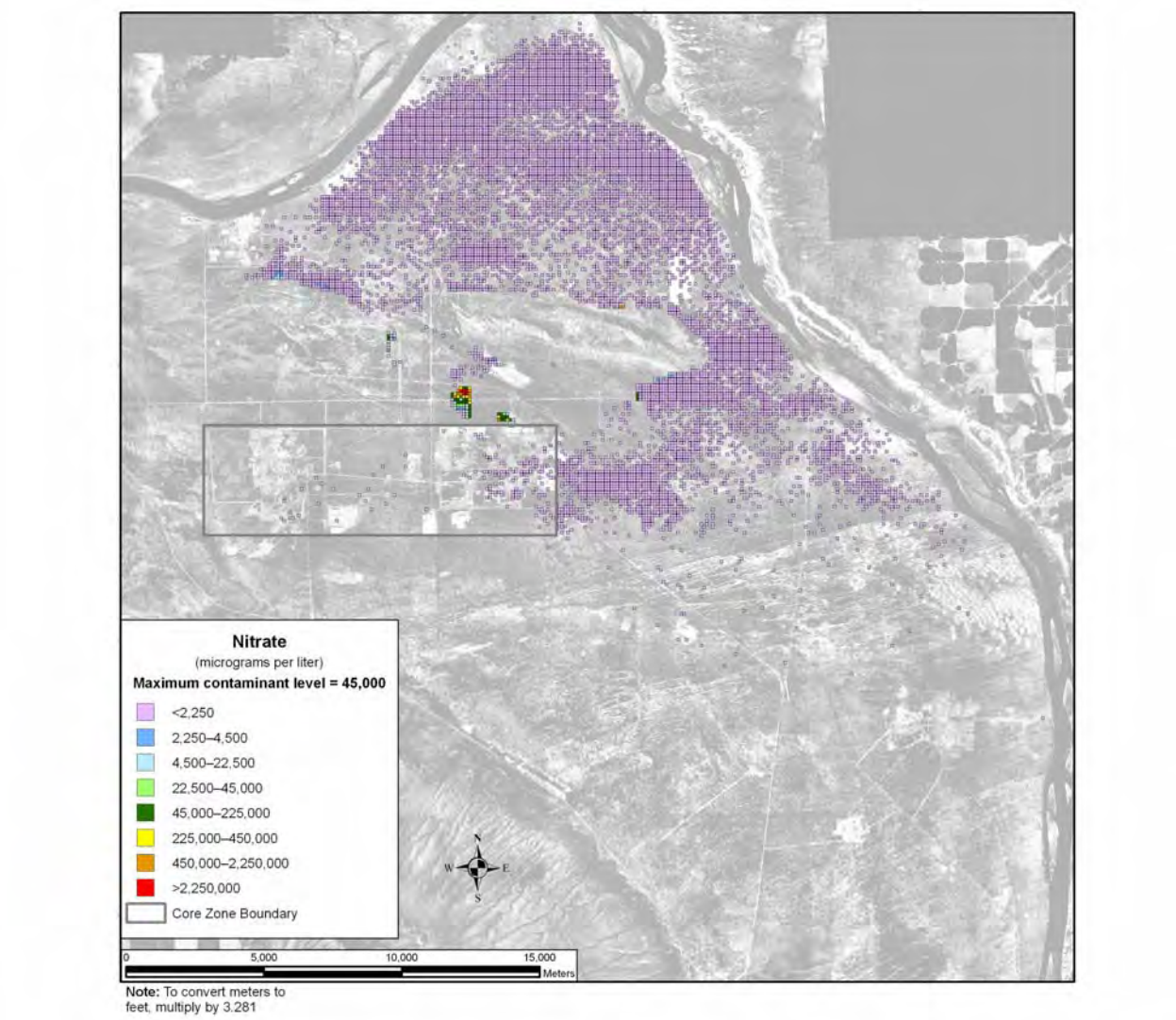


Figure 5–173. Tank Closure Alternative 5 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium show a different spatial distribution in the analysis over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–174 shows the distribution of uranium-238 during CY 2005. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration and is contained within the Core Zone Boundary. By CY 7140 (see Figure 5–175), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–176), the greatest development of the plume during the analysis period is seen, resulting primarily from the release of other tank farm sources at the A and B Barriers. Figures 5–177 through 5–179 show the corresponding results for total uranium.

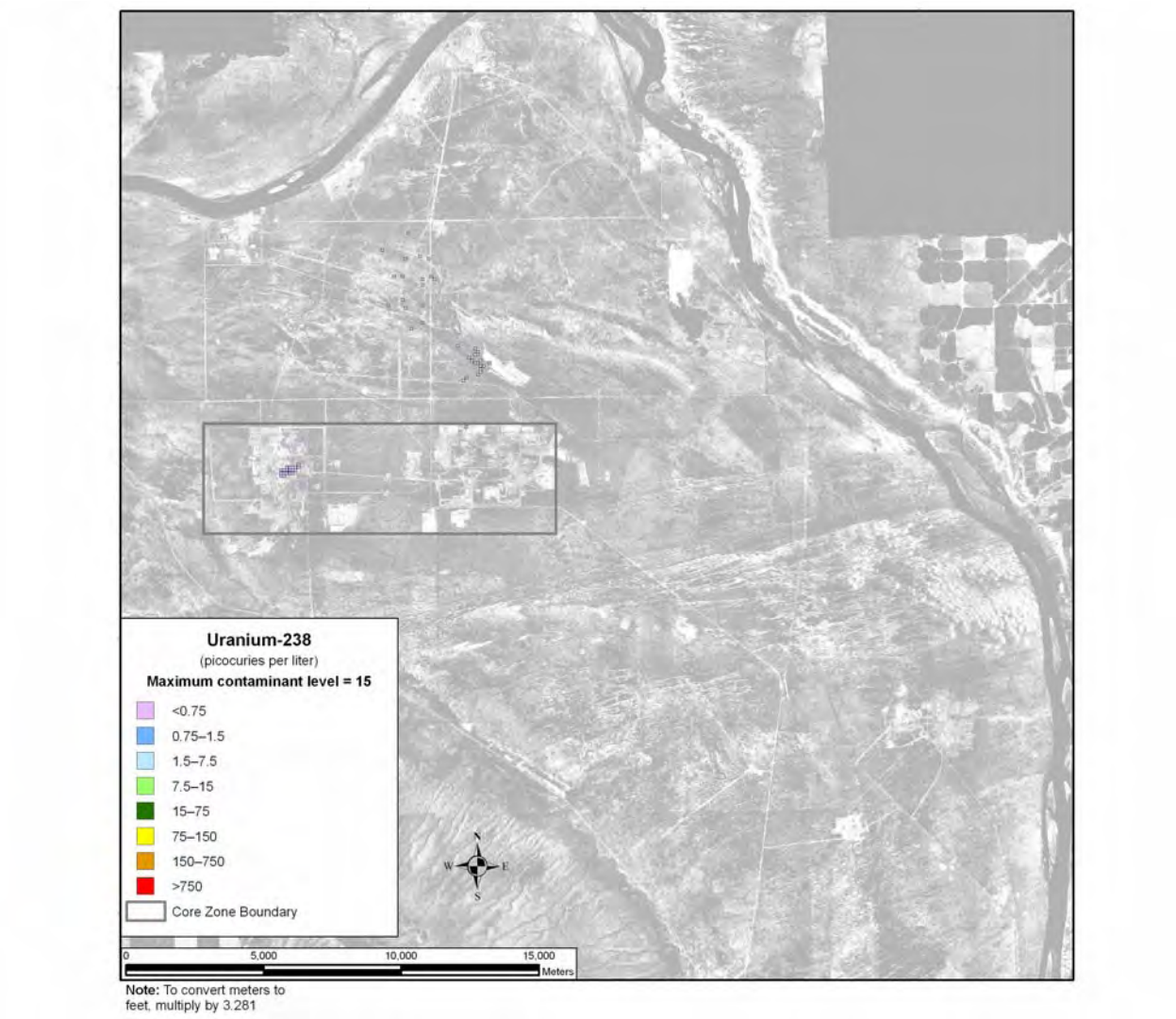


Figure 5–174. Tank Closure Alternative 5 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

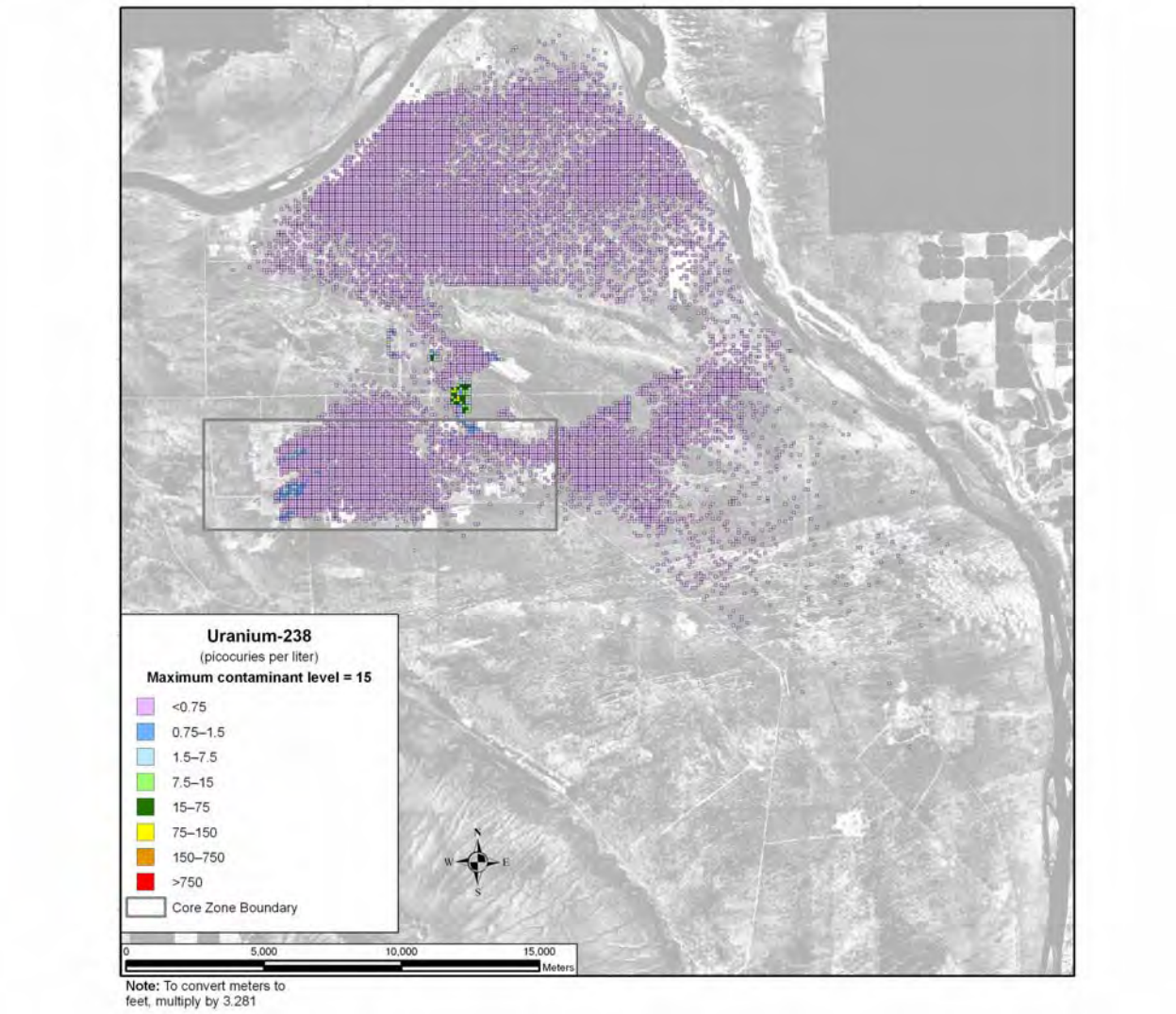


Figure 5–175. Tank Closure Alternative 5 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 7140

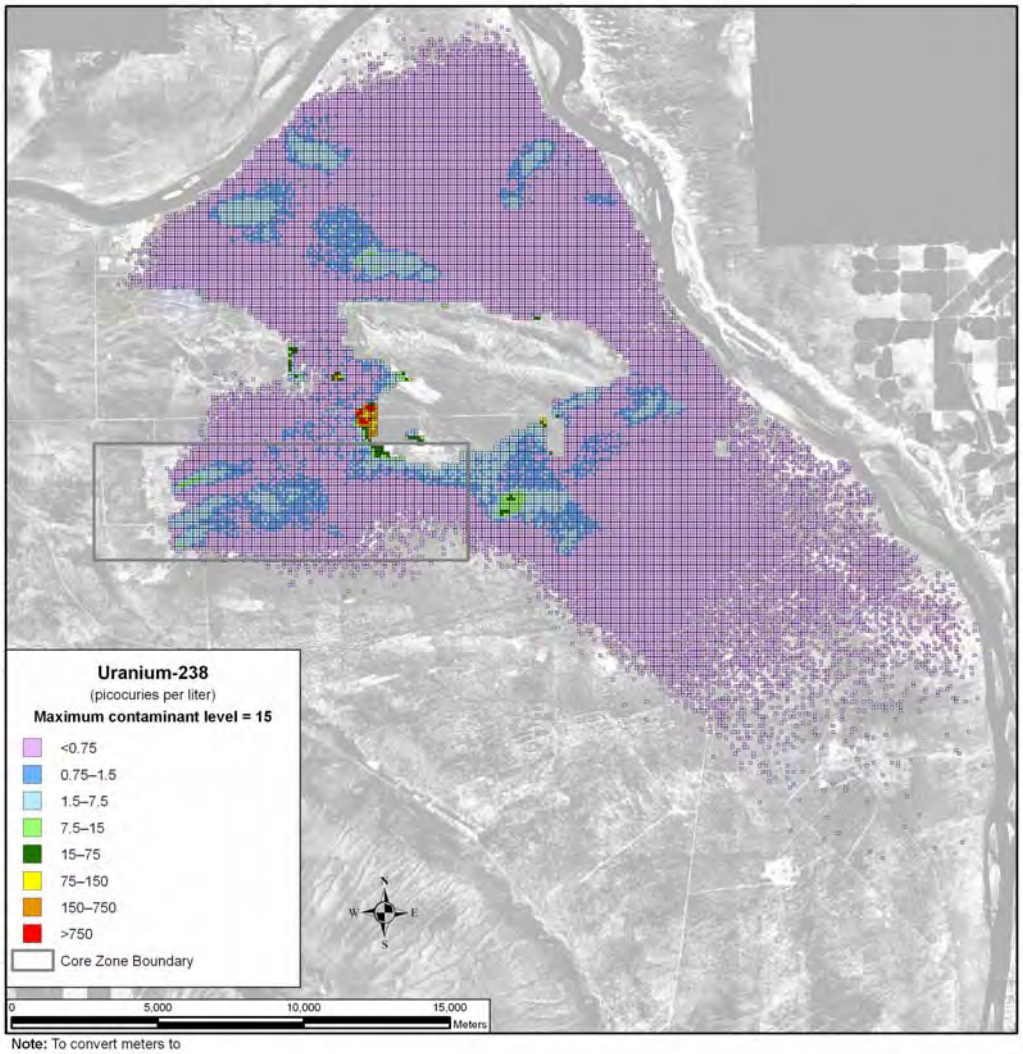


Figure 5–176. Tank Closure Alternative 5 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

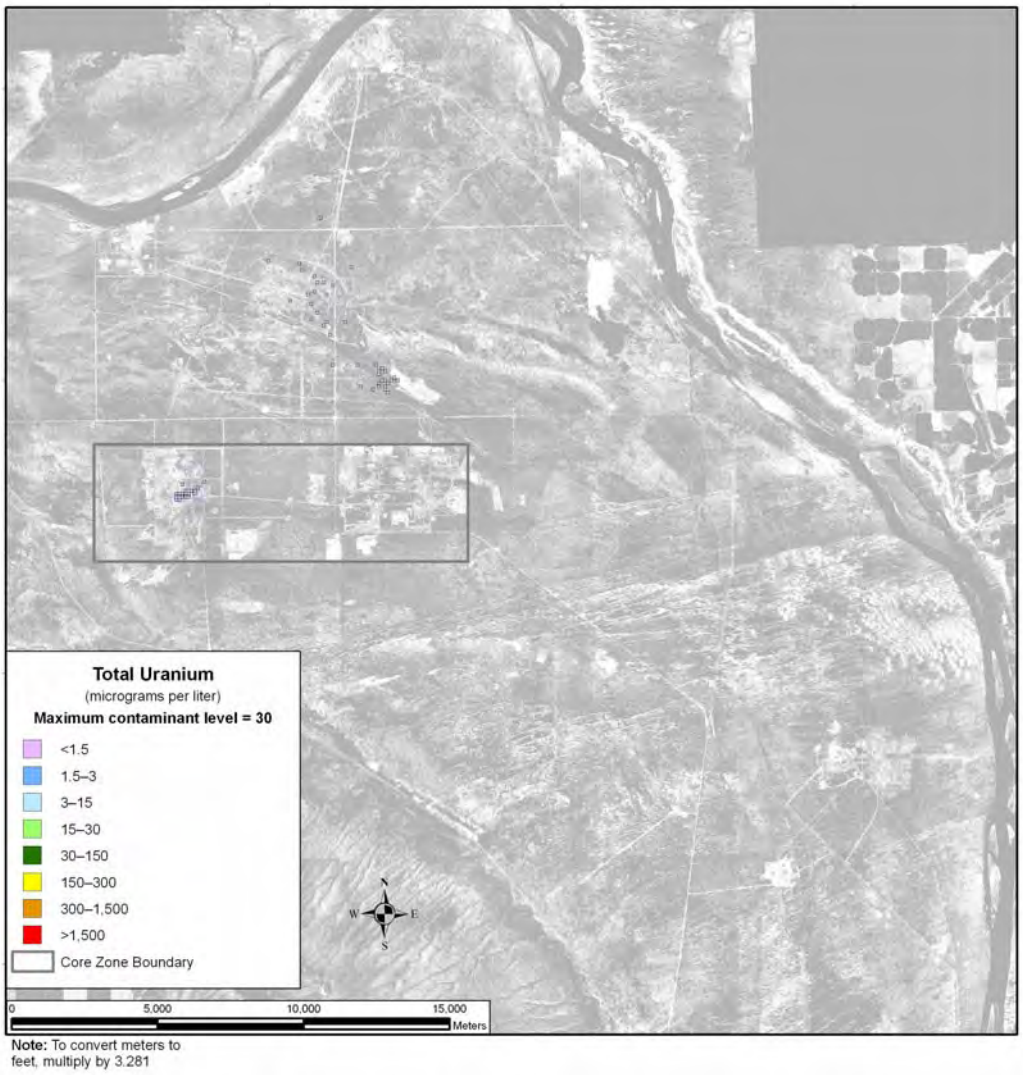


Figure 5–177. Tank Closure Alternative 5 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

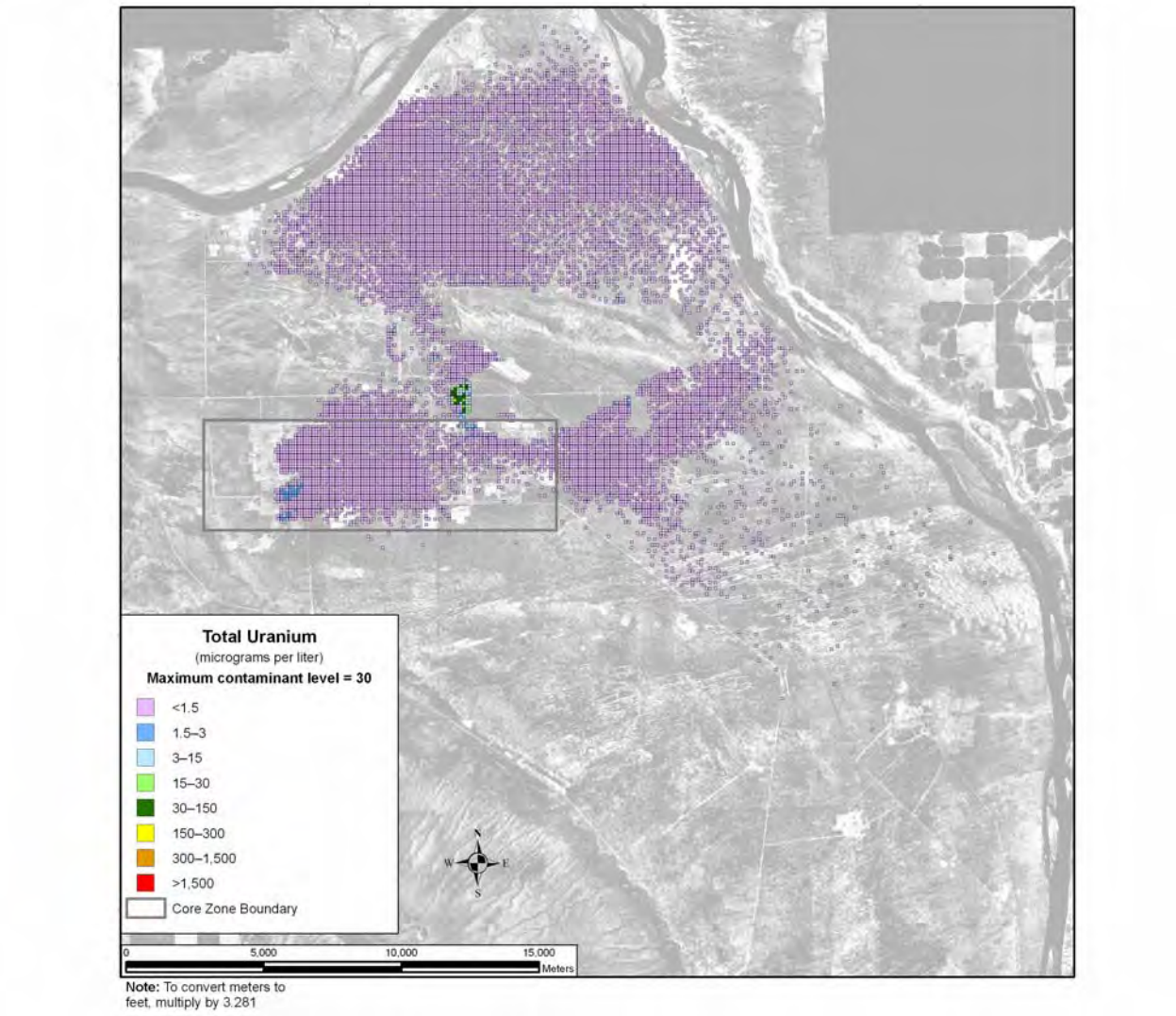


Figure 5–178. Tank Closure Alternative 5 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 7140

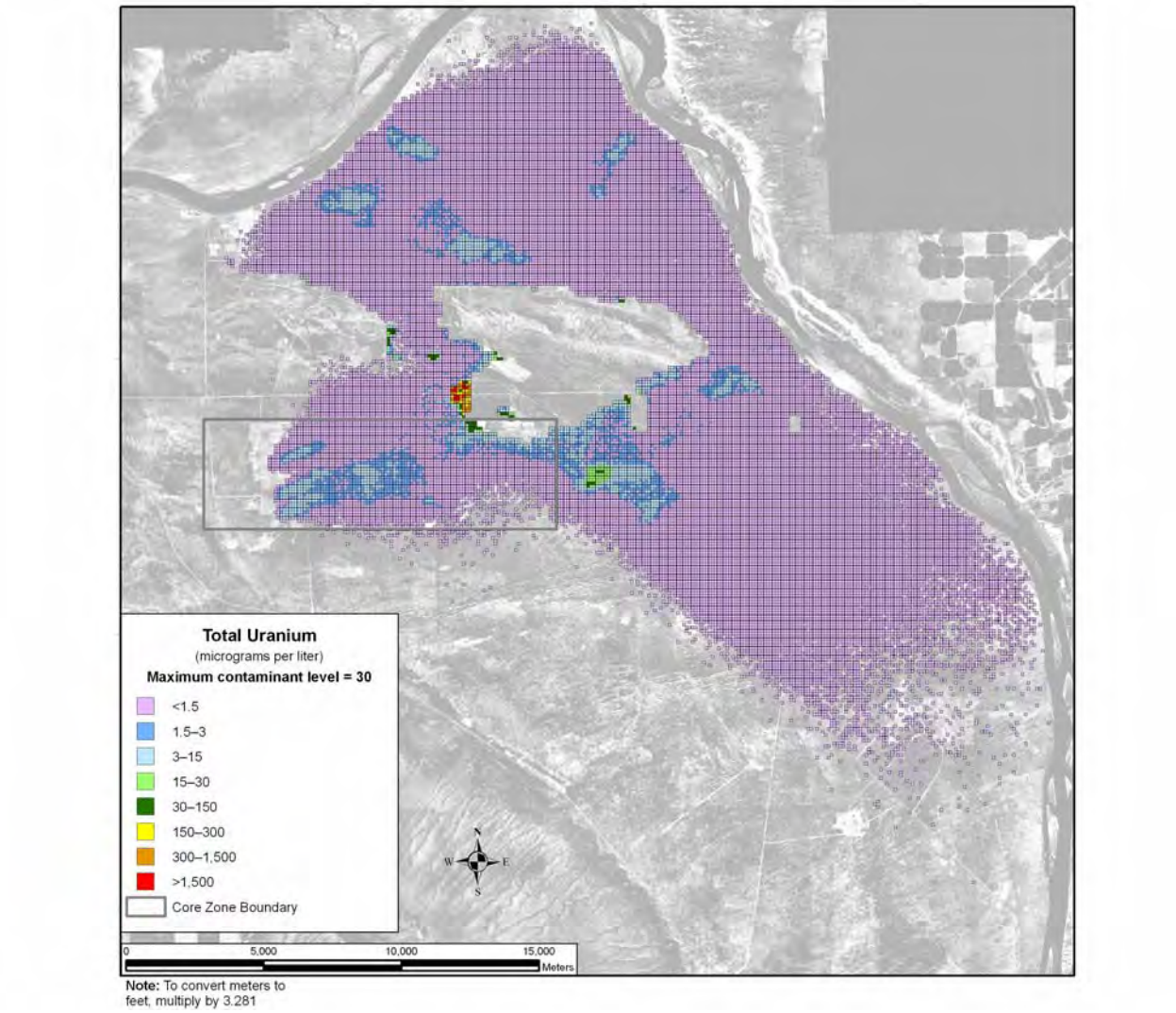


Figure 5–179. Tank Closure Alternative 5 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

Figures 5–180 through 5–182 show the area covered by concentrations above the benchmark concentration for iodine-129, technetium-99, and uranium-238. Iodine-129 spikes early in the simulation, covering a peak area of just over 8 square kilometers (3 square miles) around CY 2070. The total area covered by the iodine-129 plume that is above the benchmark concentration drops below 2 square kilometers (0.77 square miles) by CY 3240. The plume then rises to almost 3 square kilometers (1.2 square miles) in CY 5190, after which it declines to less than 2 square kilometers (0.77 square miles) by CY 11,885. Technetium-99 shows a similar, more-gradual trend, peaking at over 4 square kilometers (1.5 square miles) in CY 2135, and decreasing to less than 2 square kilometers (0.77 square miles) in CY 3240. The plume then increases to greater than 10 square kilometers (3.8 square miles) in CY 4540, then declines rapidly to around 2 square kilometers (0.77 square miles), and then it levels off around 1 square kilometer (0.38 square miles) by CY 11,885. Uranium-238 shows a distinctly different pattern, without any area above the benchmark concentration until CY 5840. From CY 5840 until the end of the simulation, areas of uranium-238 concentrations above the benchmark concentration slowly increase, exceeding 1.4 square kilometers (0.54 square miles) at the end of the simulation.

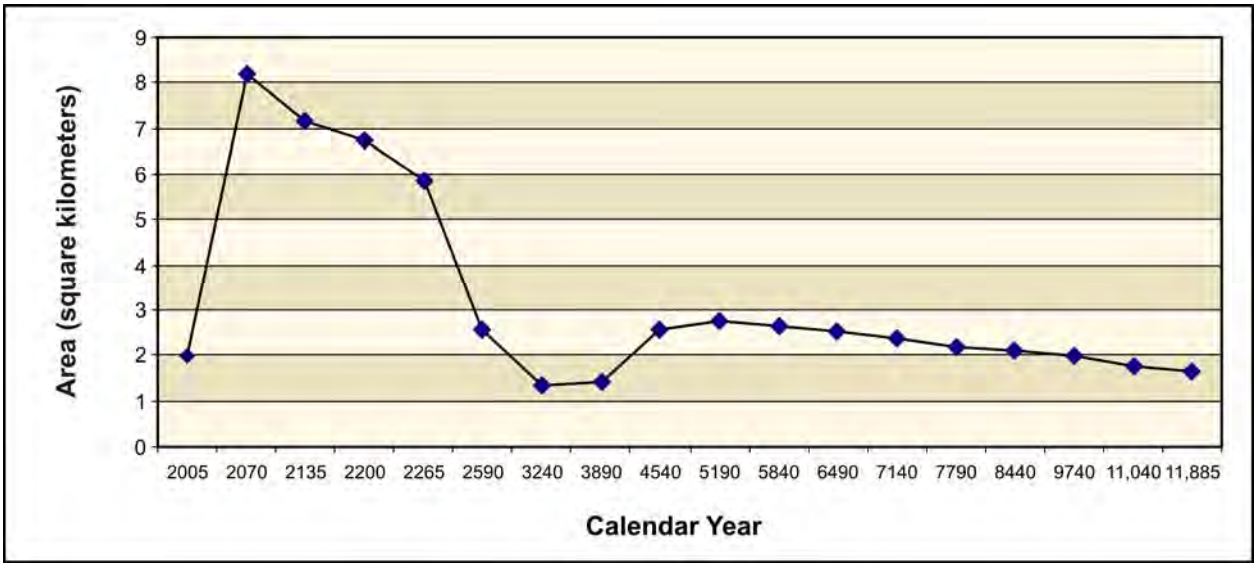


Figure 5–180. Tank Closure Alternative 5 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

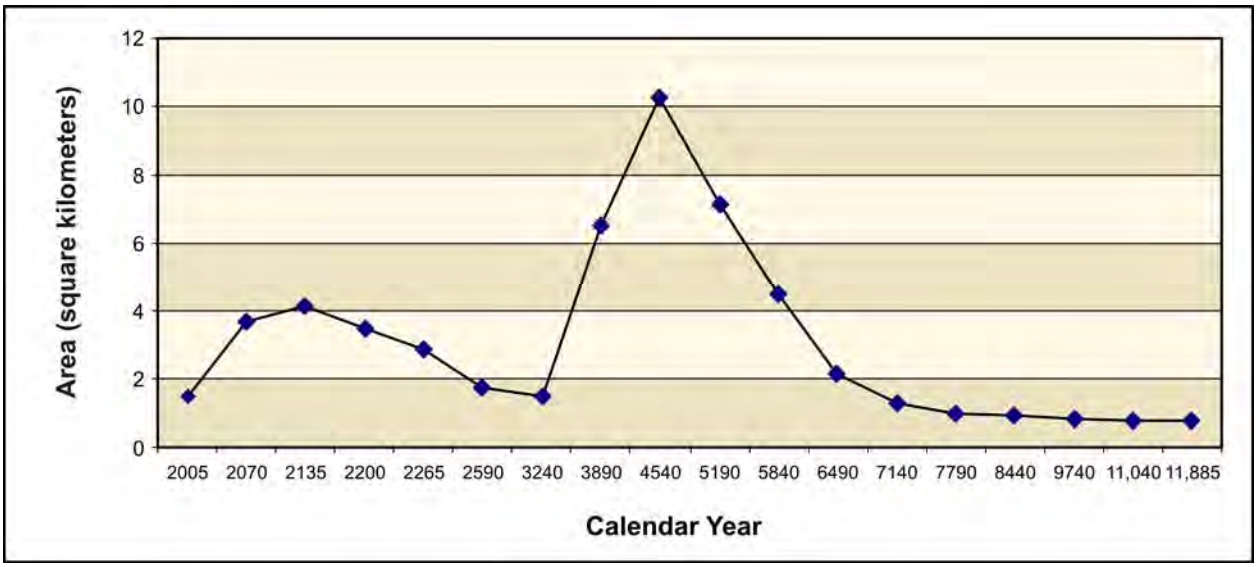


Figure 5–181. Tank Closure Alternative 5 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

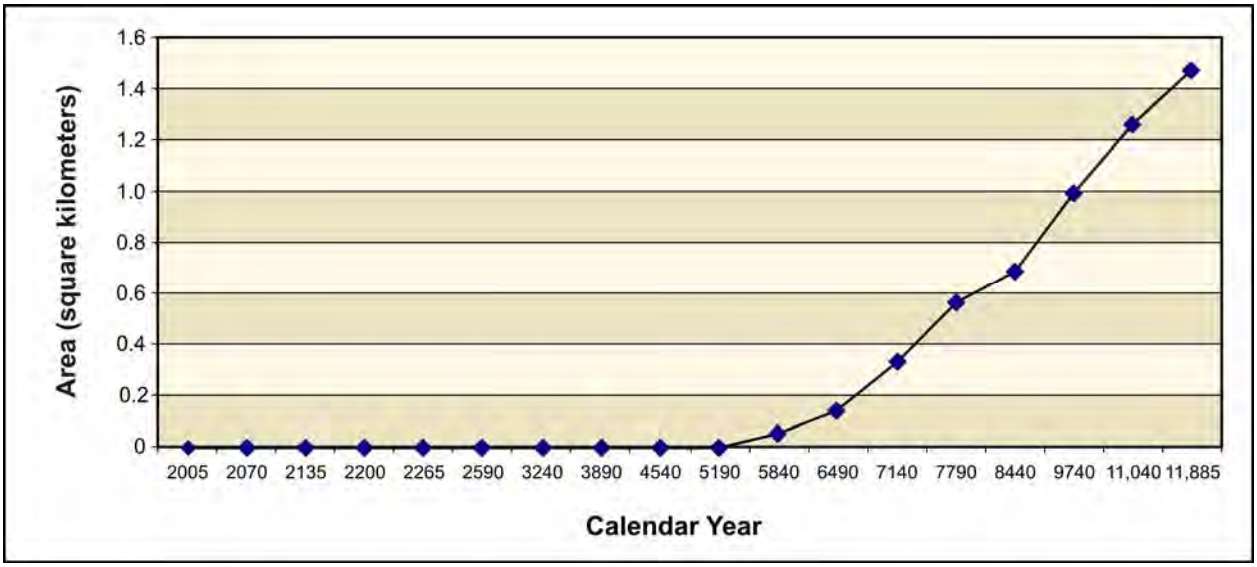


Figure 5–182. Tank Closure Alternative 5 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.8.6 Summary of Impacts

Under Tank Closure Alternative 5, in general, the inventory remaining in the tank farms, available for release to the environment at the start of the post–administrative control period, is the predominant contributor in the analysis. Discharges to cribs and trenches (ditches) and past leaks are a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by two to three orders of magnitude during most of the period of analysis. Concentrations at the Columbia River are about two orders of magnitude smaller. The intensities and areas of these groundwater plumes peak around CY 4540.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark concentration at the Core Zone Boundary beyond CY 8200, and approach the benchmark concentration at the Columbia River after CY 11,885. The peak intensity and area of the contamination plume are largest near the end of the period of analysis.

5.1.1.9 Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure, Base and Option Cases

This section describes the groundwater analysis results for Tank Closure Alternative 6A, including long-term groundwater impacts of sources within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

Under Tank Closure Alternative 6A, Base Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier.

Under Tank Closure Alternative 6A, Option Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. In addition, the adjacent cribs and trenches (ditches) would be clean-closed.

5.1.1.9.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 6A are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, three major periods were identified for Tank Closure Alternative 6A, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 6A that are presented in this section would be common to all of the Tank Closure alternatives.

- The retrieval period was assumed to start in 2008 and end in CY 2250. During this period, 99.9 percent of the waste would be retrieved from the tanks and all tank farms would be clean-closed.

- The post–administrative control period was assumed to start in CY 2251 and continue through the 10,000-year period of analysis until CY 11,940.

5.1.1.9.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 6A. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Tank Closure Alternative 6A is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 6A were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers, although their contribution to risk and hazard are not dominant during the year of peak risk or hazard. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-11}, which is negligible for

purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 6A.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.9.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 6A in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms (see Figures 5–183 through 5–194). Two subtotals are plotted representing releases from cribs and trenches (ditches) and past leaks. Amounts released from other tank farm sources are negligible for the purposes of this discussion. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–183 shows the estimated release to the vadose zone for the radiological risk drivers under the Base Case, which would include use of a modified RCRA Subtitle C barrier, and Figure 5–184, the chemical hazard drivers. The predominant sources for tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers the predominant sources are from past leaks. This suggests that past leaks, which were released during the past-practice period, as well as the cribs and trenches (ditches), are both important impact drivers under Tank Closure Alternative 6A, Base Case.

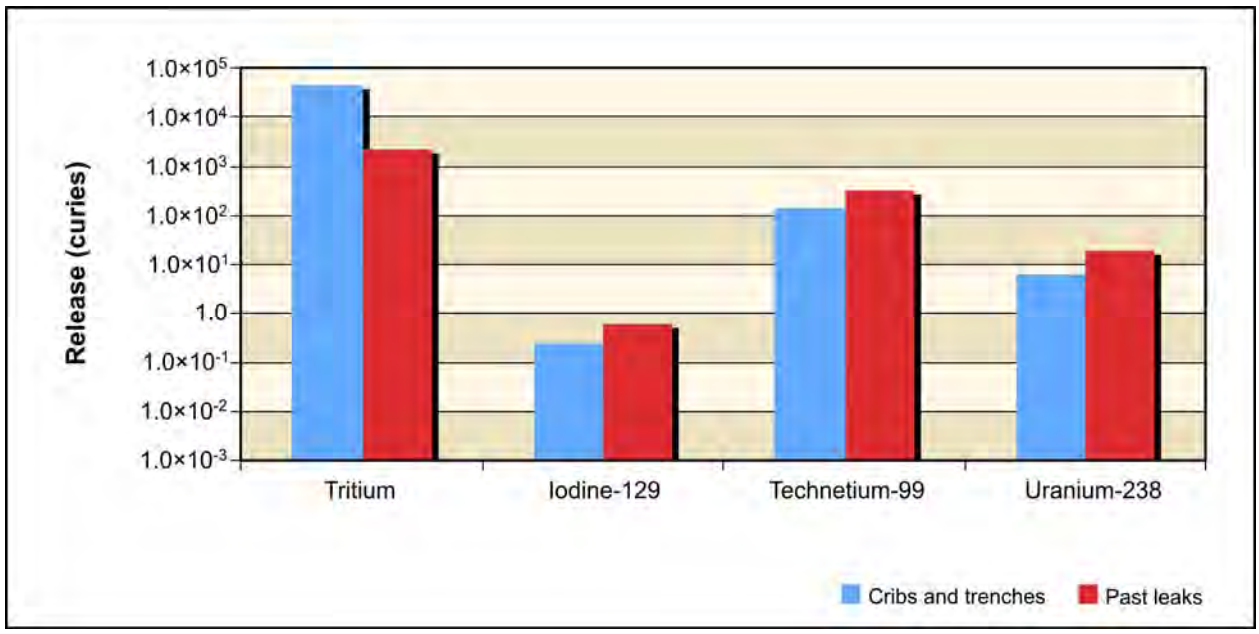


Figure 5–183. Tank Closure Alternative 6A, Base Case, Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

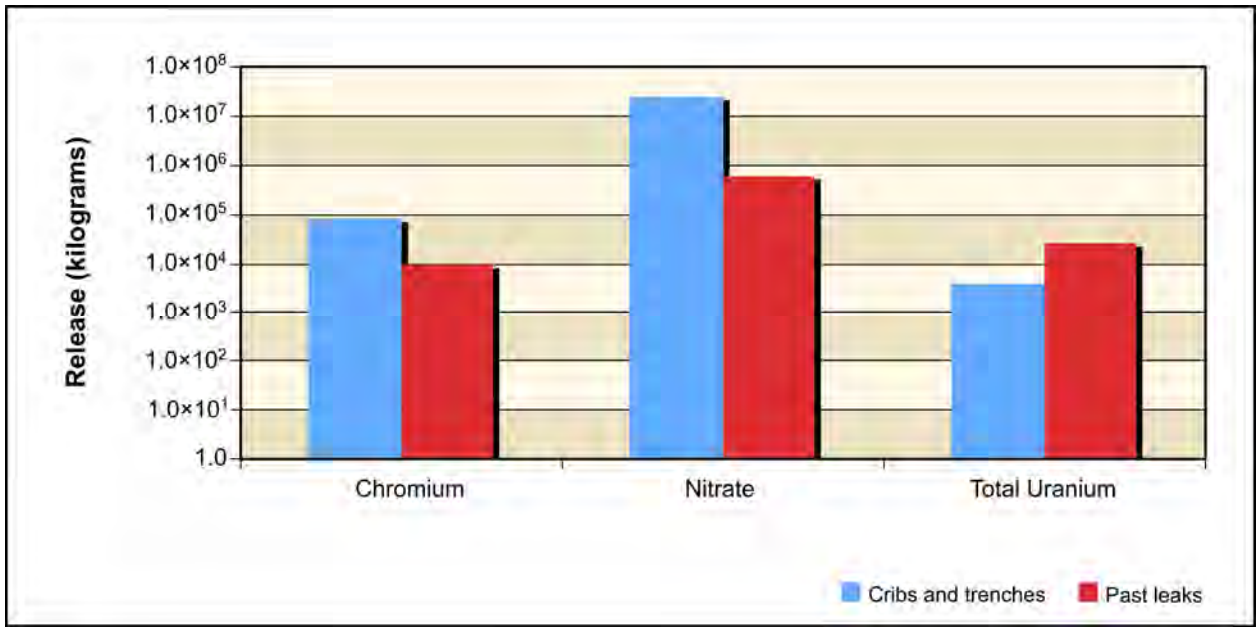


Figure 5–184. Tank Closure Alternative 6A, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–185 shows the estimated release to the vadose zone for the radiological risk drivers under the Option Case, which would include clean closure of cribs and trenches (ditches), and Figure 5–186, the chemical hazard drivers. The predominant sources for tritium, the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), uranium-238, and total uranium are similar to those in the vadose zone under the Base Case.

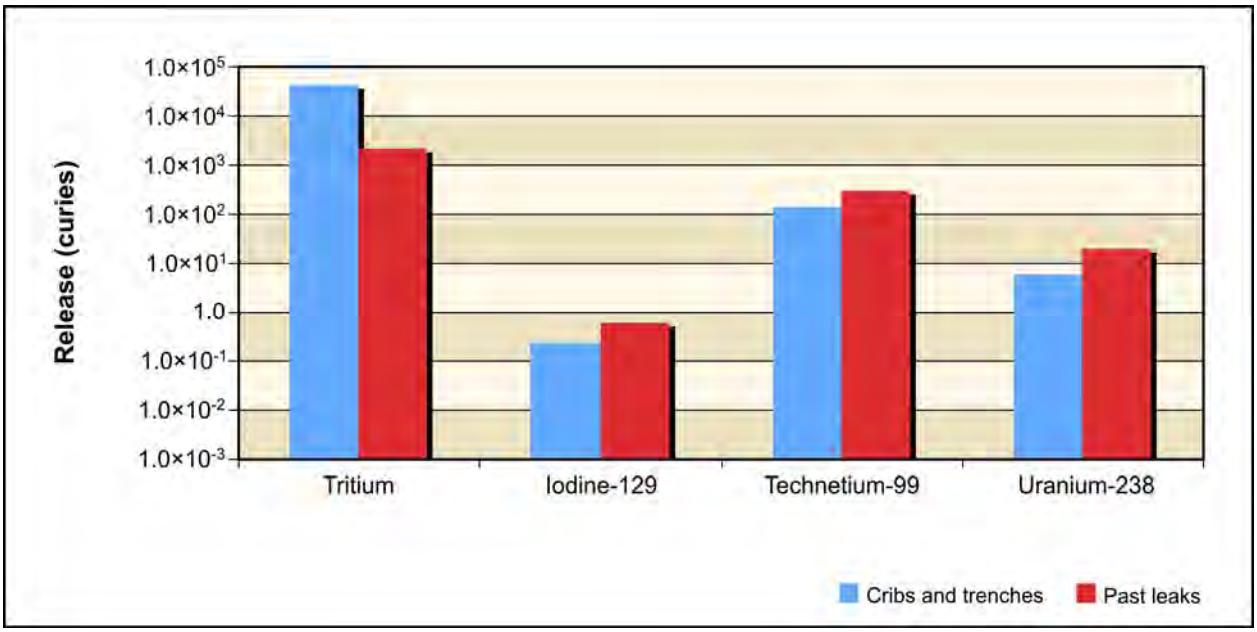


Figure 5–185. Tank Closure Alternative 6A, Option Case, Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

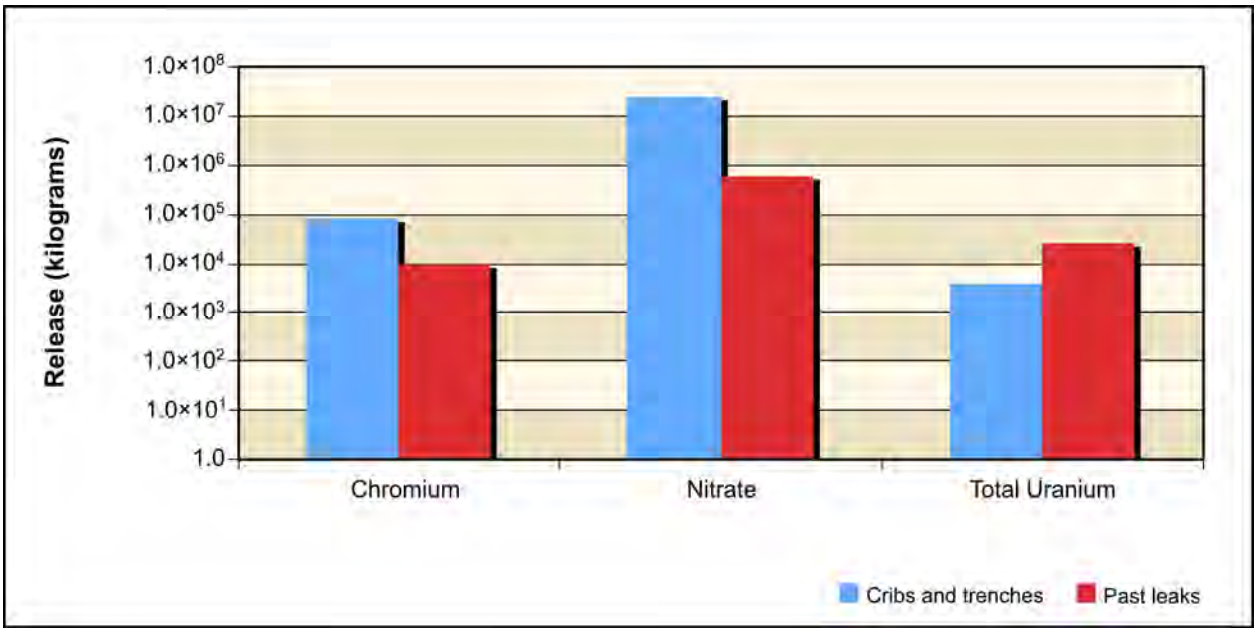


Figure 5–186. Tank Closure Alternative 6A, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–187 shows the estimated release to groundwater for the radiological risk drivers under the Base Case and Figure 5–188, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

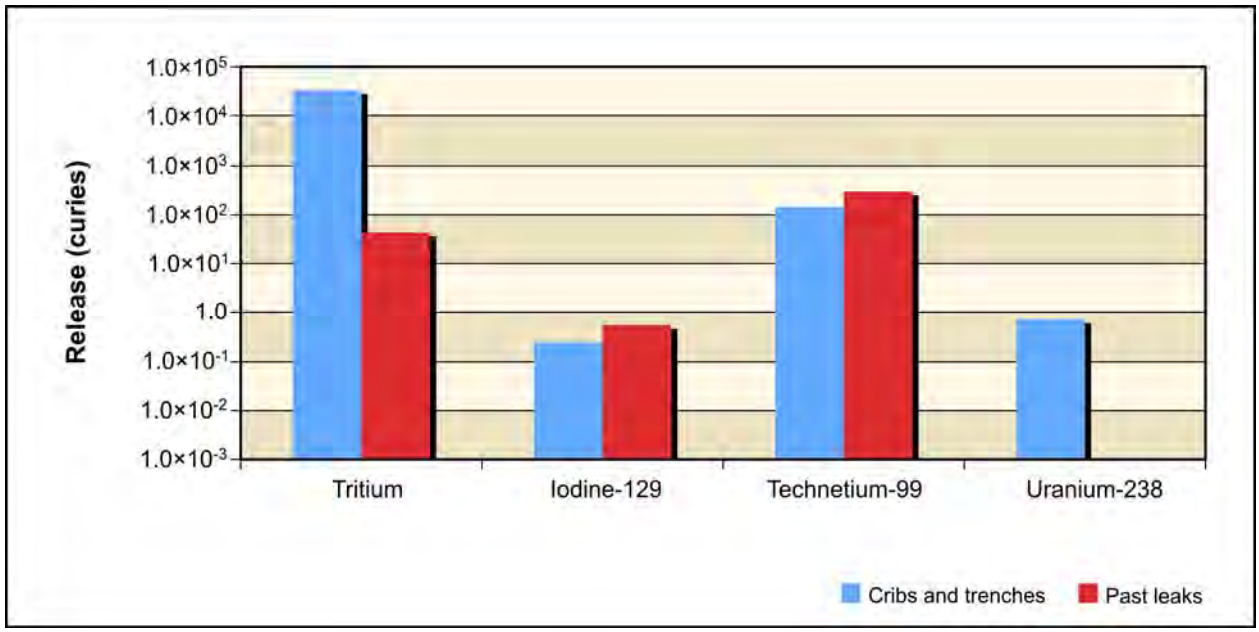


Figure 5–187. Tank Closure Alternative 6A, Base Case, Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

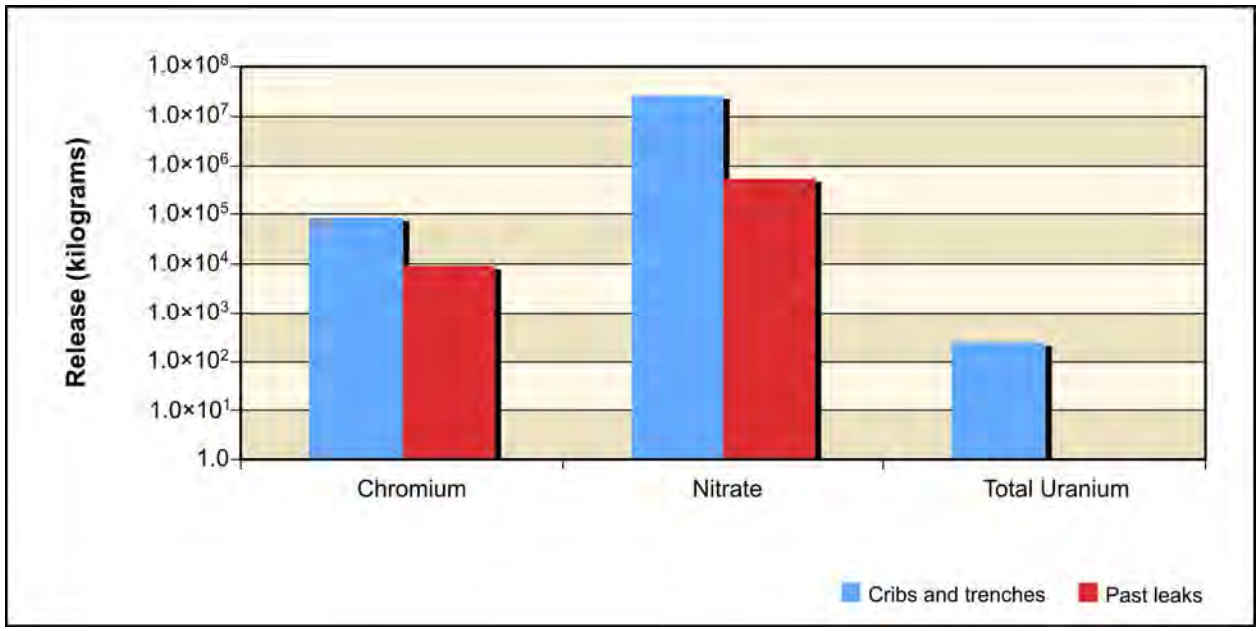


Figure 5–188. Tank Closure Alternative 6A, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of retardation. The amount of attenuation depends on the rate of moisture movement through the vadose zone. For cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 10 percent of the total inventory reached groundwater during the period of analysis; for past leaks, essentially none of the total inventory reached groundwater during the period of analysis.

For tritium, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 74 percent of the total inventory reached groundwater in the analysis; for past leaks, only 2 percent reached groundwater. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts would occur later in the post–administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–189 shows the estimated release to groundwater for the radiological risk drivers under the Option Case and Figure 5–190, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is about 7 percent less than the amount released to the vadose zone.

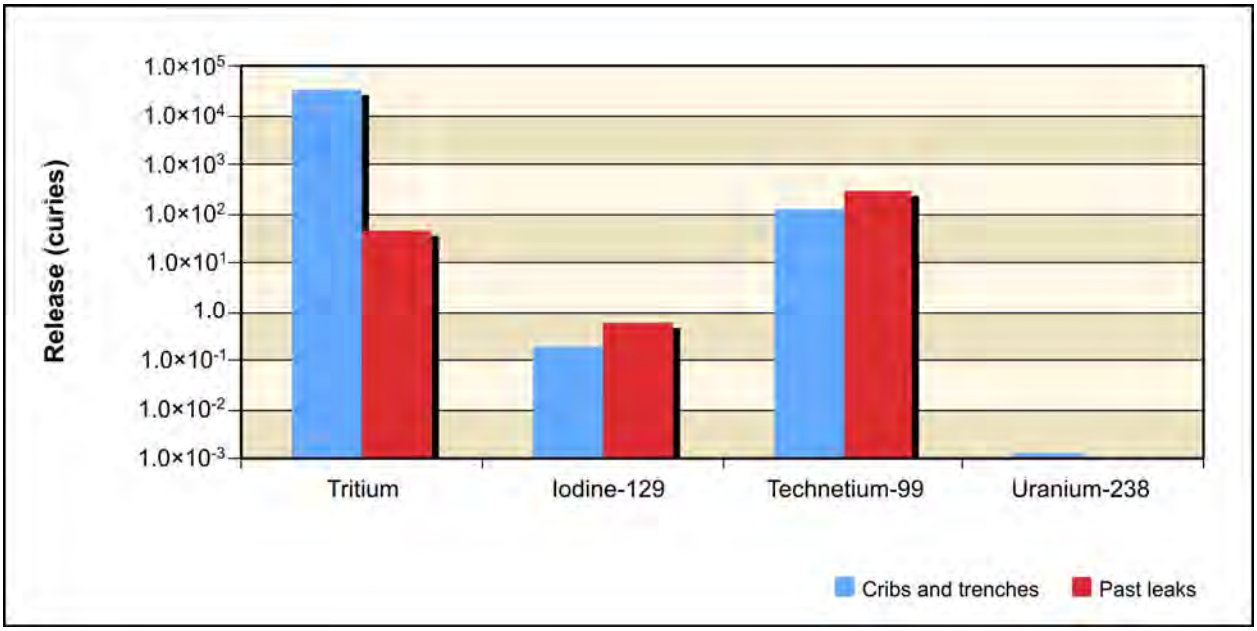


Figure 5–189. Tank Closure Alternative 6A, Option Case, Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

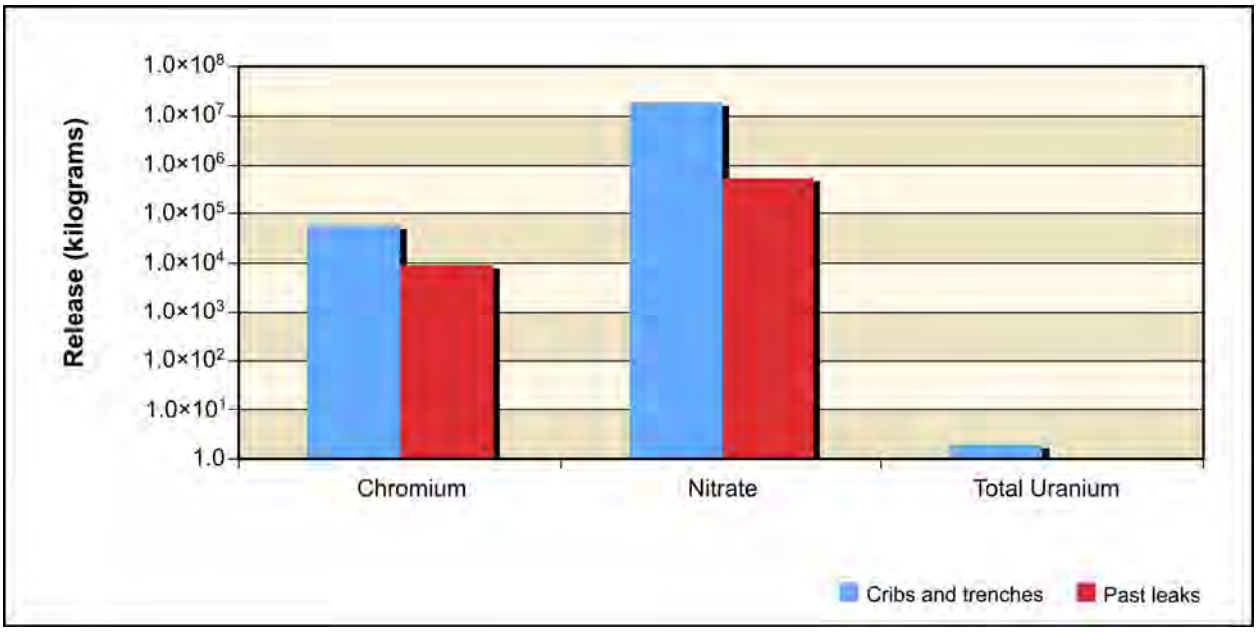


Figure 5–190. Tank Closure Alternative 6A, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), essentially none of the total inventory reached groundwater during the period of analysis. For past leaks, essentially none of the total inventory reached groundwater during the period of analysis.

For tritium, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 85 percent of the total inventory reached groundwater in the analysis; for past leaks, only 2 percent reached groundwater. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts would decrease over time because the long travel times in the vadose zone for these COPCs allow much of what was released to be collected and treated when the cribs and trenches (ditches) are removed and their deep plumes remediated.

Figure 5–191 shows the estimated release to the Columbia River for the radiological risk drivers under the Base Case and Figure 5–192, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

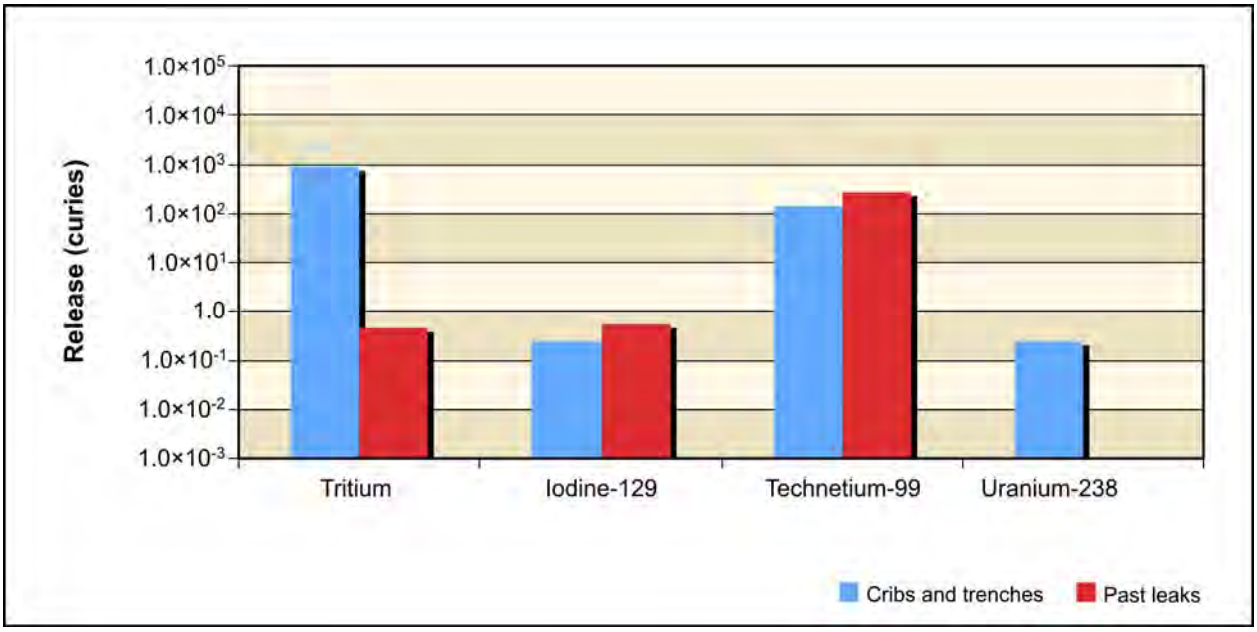


Figure 5–191. Tank Closure Alternative 6A, Base Case, Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

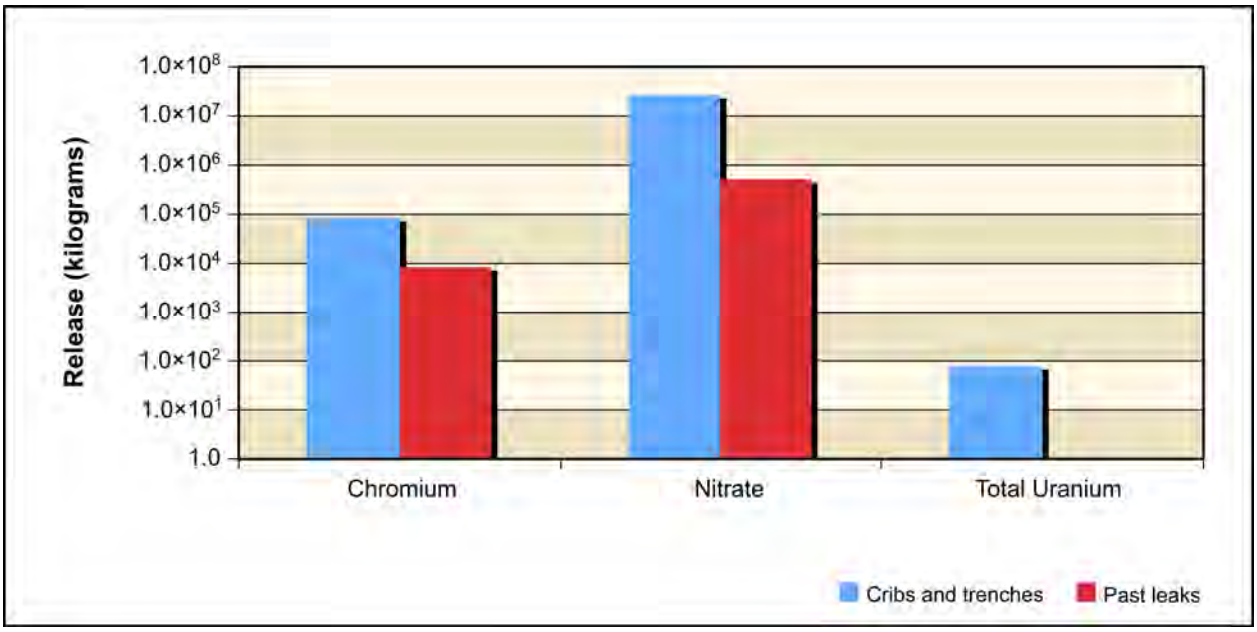


Figure 5–192. Tank Closure Alternative 6A, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to the Columbia River is less than that of the release to groundwater because of retardation. For cribs and trenches (ditches), about 40 percent of the amount released to groundwater during the period of analysis reached the Columbia River.

For tritium, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 3 percent of the tritium released to groundwater reached the Columbia River. For past leaks, only about 1 percent of the tritium released to groundwater reached the Columbia River. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post–administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

Figure 5–193 shows the estimated release to the Columbia River for the radiological risk drivers under the Option Case and Figure 5–194, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For uranium-238 and total uranium, the amount released to the Columbia River from the groundwater is effectively zero, as essentially no uranium reached the groundwater from the vadose zone in the analysis. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 3 percent of the tritium released to groundwater reached the Columbia River in the analysis. For past leaks, only about 1 percent of the tritium released to groundwater reached the Columbia River in the analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium would not impact the Columbia River, as much of what was released would be collected when the cribs and trenches (ditches) are removed and their deep plumes remediated.

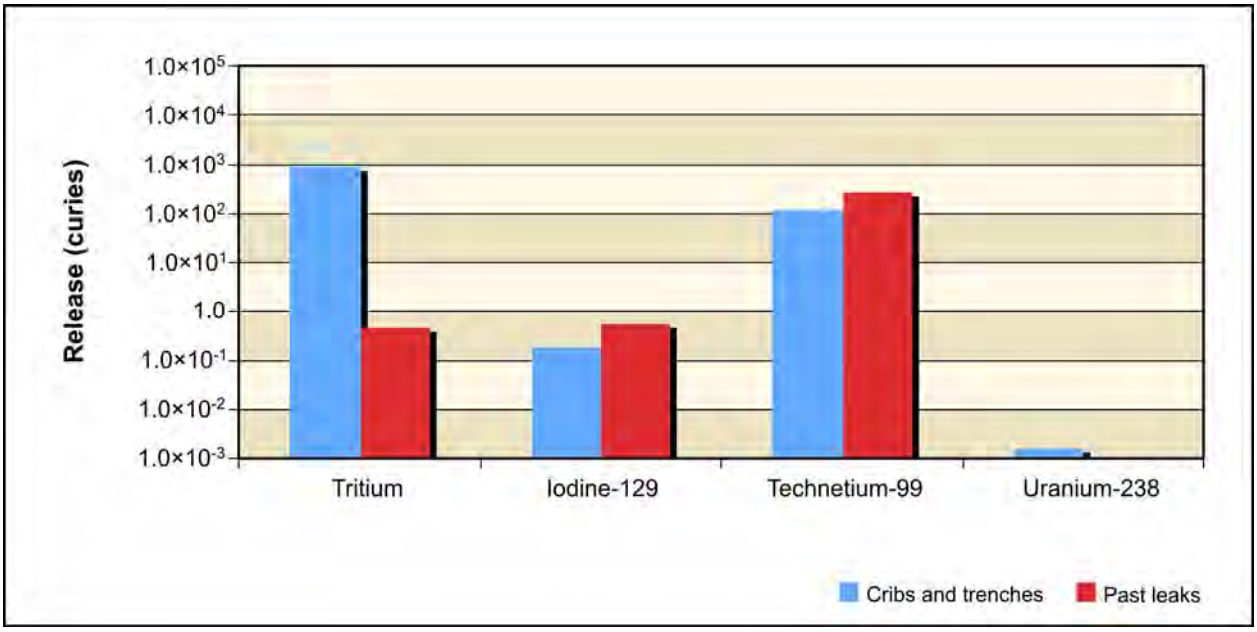


Figure 5–193. Tank Closure Alternative 6A, Option Case, Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

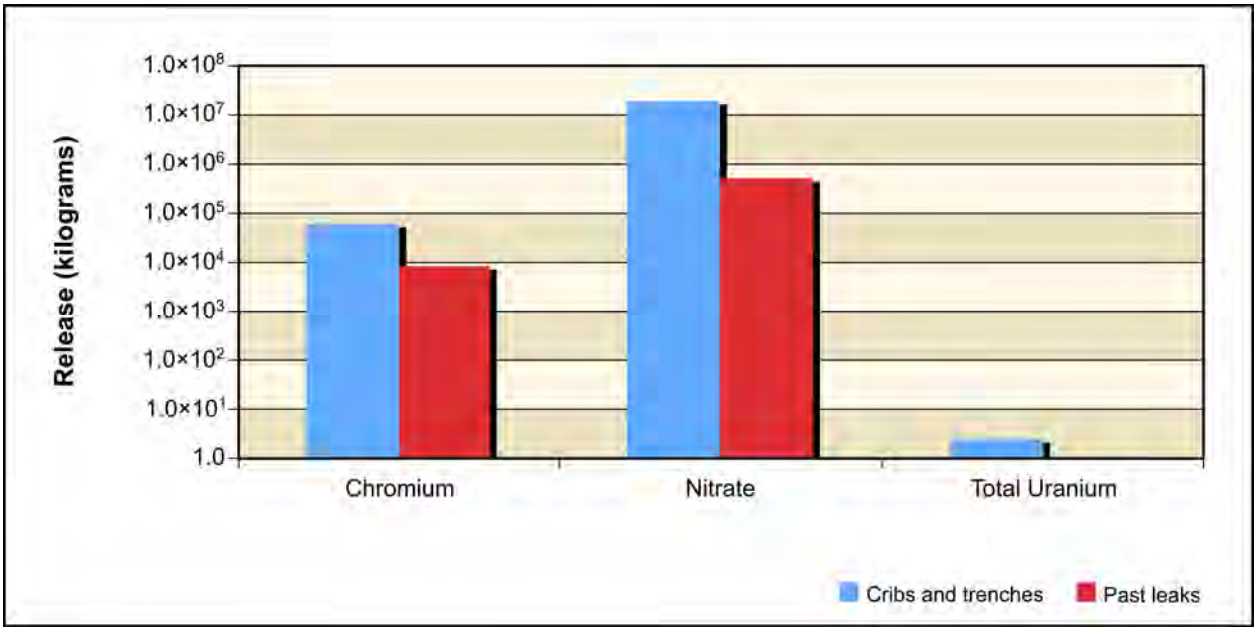


Figure 5–194. Tank Closure Alternative 6A, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.9.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 6A impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Tables 5–6 and 5–7 and Figures 5–195 through 5–208). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Tables 5–6 and 5–7 list the maximum concentrations under the Base and Option Cases for the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore.

Figure 5–195 shows the concentration versus time for tritium under the Base Case. Releases from cribs and trenches (ditches) causes the groundwater concentrations at the Core Zone Boundary to exceed the benchmark concentrations by about two orders of magnitude for a short period of time during the early part of the period of analysis, around CY 1956. During the same period of time, the Columbia River nearshore concentrations peaked at about one order of magnitude below the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration.

Table 5–6. Tank Closure Alternative 6A, Base Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	26	5,000	51	7,310	13	6,000	178	20,000
	(2052)	(2054)	(2050)	(2055)	(2052)	(2054)	(2050)	
Technetium-99	**1,350**	**29,100**	**2,680**	**15,200**	150	**24,700**	169	900
	(2056)	(2050)	(2050)	(2051)	(2064)	(2050)	(2515)	
Iodine-129	**3**	**41**	**5**	**31**	0.3	**31**	0.3	1
	(2053)	(2057)	(2050)	(2050)	(2070)	(2057)	(2579)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	0	**34**	0	13	0	10	0	15
	(1940)	(11,742)	(2166)	(11,780)	(1940)	(11,758)	(11,844)	
Chemical in micrograms per liter								
Chromium	8	**3,180**	**289**	**761**	10	**1,660**	33	100
	(2050)	(2050)	(2050)	(2050)	(2050)	(2050)	(2695)	
Nitrate	475	**1,540,000**	8,550	**133,000**	667	**1,010,000**	8,410	45,000
	(2051)	(2050)	(2050)	(2054)	(2054)	(2050)	(2450)	
Total uranium	0	10	0	4	0	7	0	30
	(2160)	(11,678)	(2166)	(11,755)	(2167)	(11,678)	(11,508)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

Table 5–7. Tank Closure Alternative 6A, Option Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	26	5,140	51	5,190	13	6,990	170	20,000
	(2052)	(2050)	(2050)	(2050)	(2052)	(2050)	(2057)	
Technetium-99	**1,350**	**25,000**	**2,680**	**15,200**	150	**21,000**	181	900
	(2056)	(2055)	(2050)	(2051)	(2064)	(2056)	(2502)	
Iodine-129	**3**	**45**	**5**	**31**	0.3	**35**	0.3	1
	(2053)	(2057)	(2050)	(2050)	(2070)	(2057)	(2308)	
Chemical in micrograms per liter								
Chromium	8	**3,790**	**289**	**772**	10	**1,660**	29	100
	(2050)	(2088)	(2050)	(2051)	(2050)	(2051)	(2256)	
Nitrate	475	**1,670,000**	8,550	**154,000**	667	**1,180,000**	7,930	45,000
	(2051)	(2056)	(2050)	(2102)	(2054)	(2056)	(2460)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

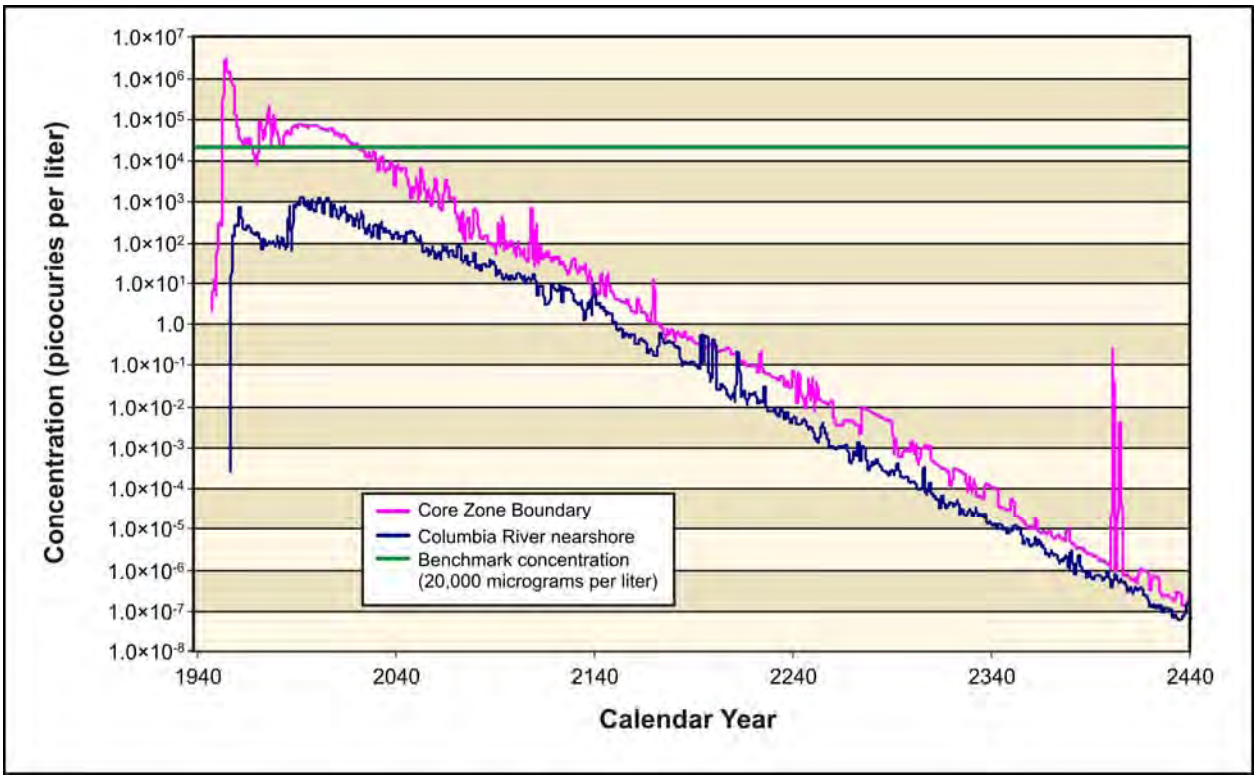


Figure 5–195. Tank Closure Alternative 6A, Base Case, Hydrogen-3 (Tritium) Concentration Versus Time

The concentration versus time for tritium under the Option Case is essentially identical to that of the Base Case (see Figure 5–196).

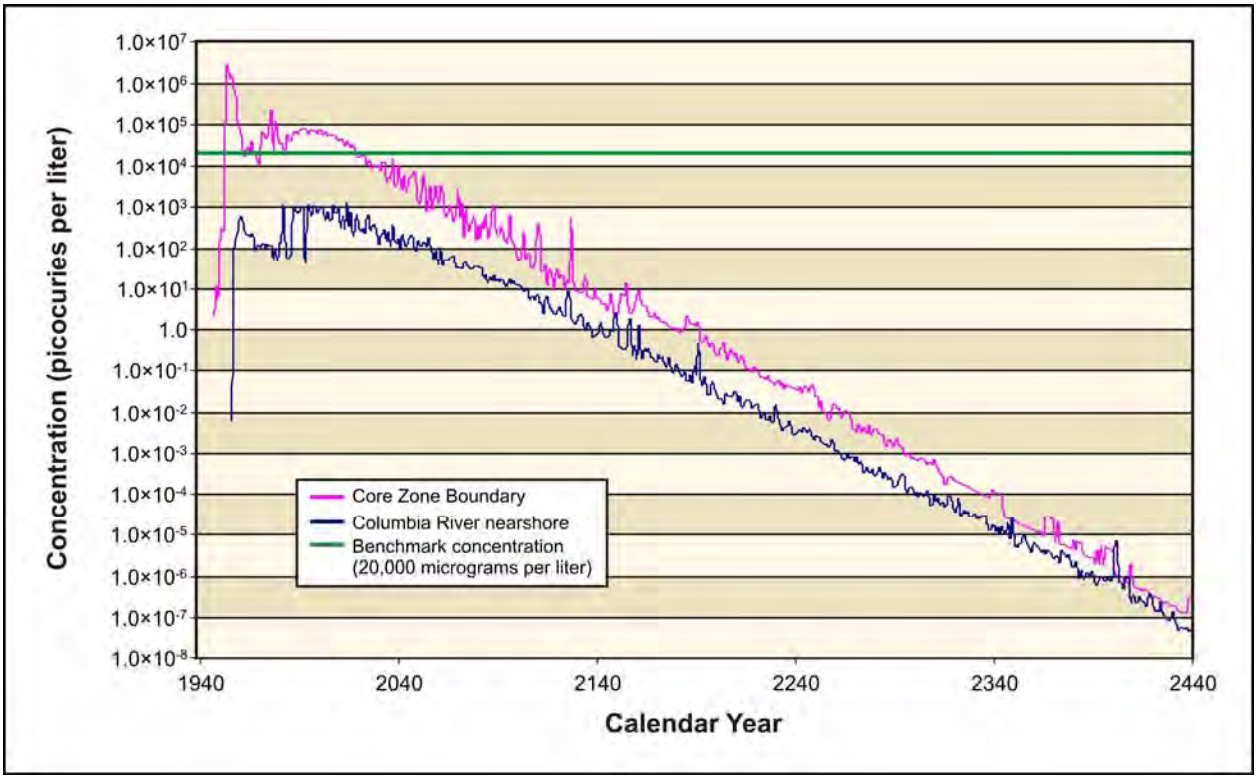


Figure 5–196. Tank Closure Alternative 6A, Option Case, Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–197 through 5–200 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Base Case. All of the conservative tracers show similar patterns. Releases from cribs and trenches (ditches) cause groundwater concentrations in the Core Zone Boundary to exceed benchmark concentrations by about two orders of magnitude during the early part of the period of analysis in CY 1956. The concentrations in the Columbia River nearshore never met or exceeded the benchmark but came to within about one-half to one order of magnitude.

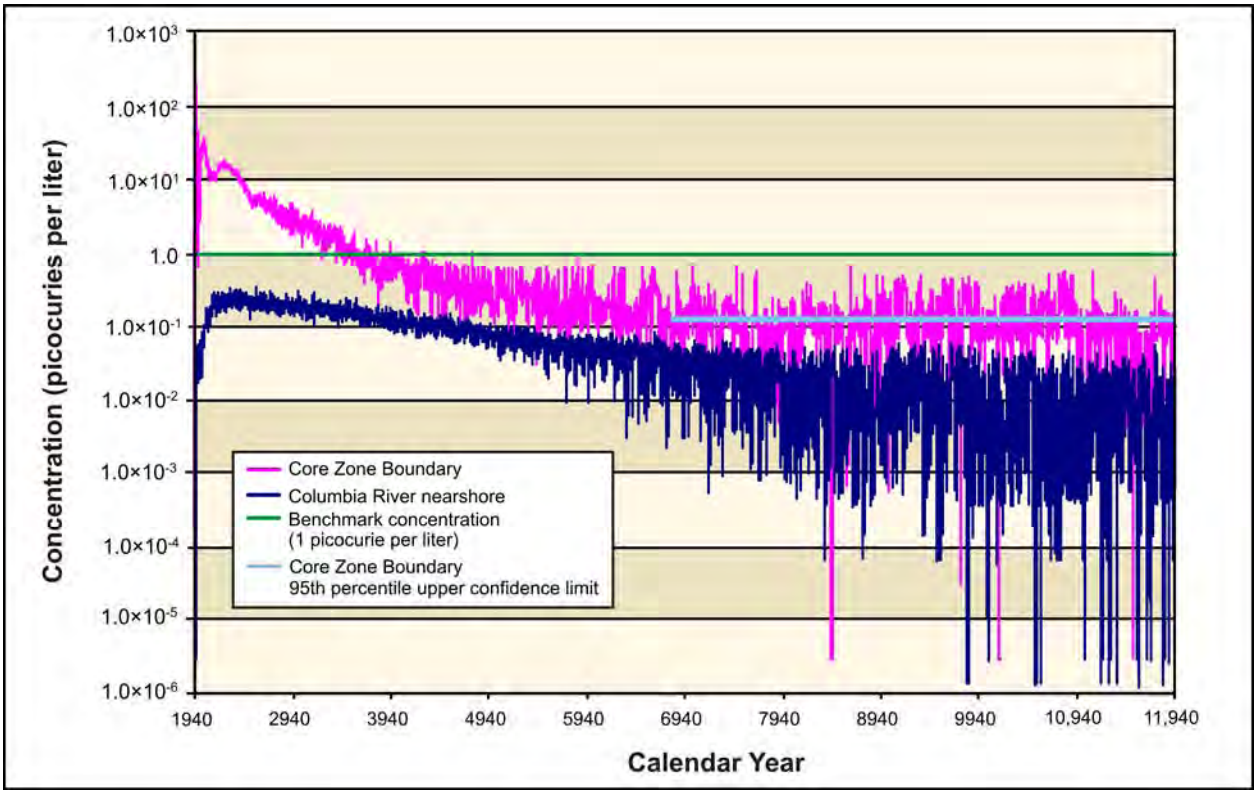


Figure 5–197. Tank Closure Alternative 6A, Base Case, Iodine-129 Concentration Versus Time

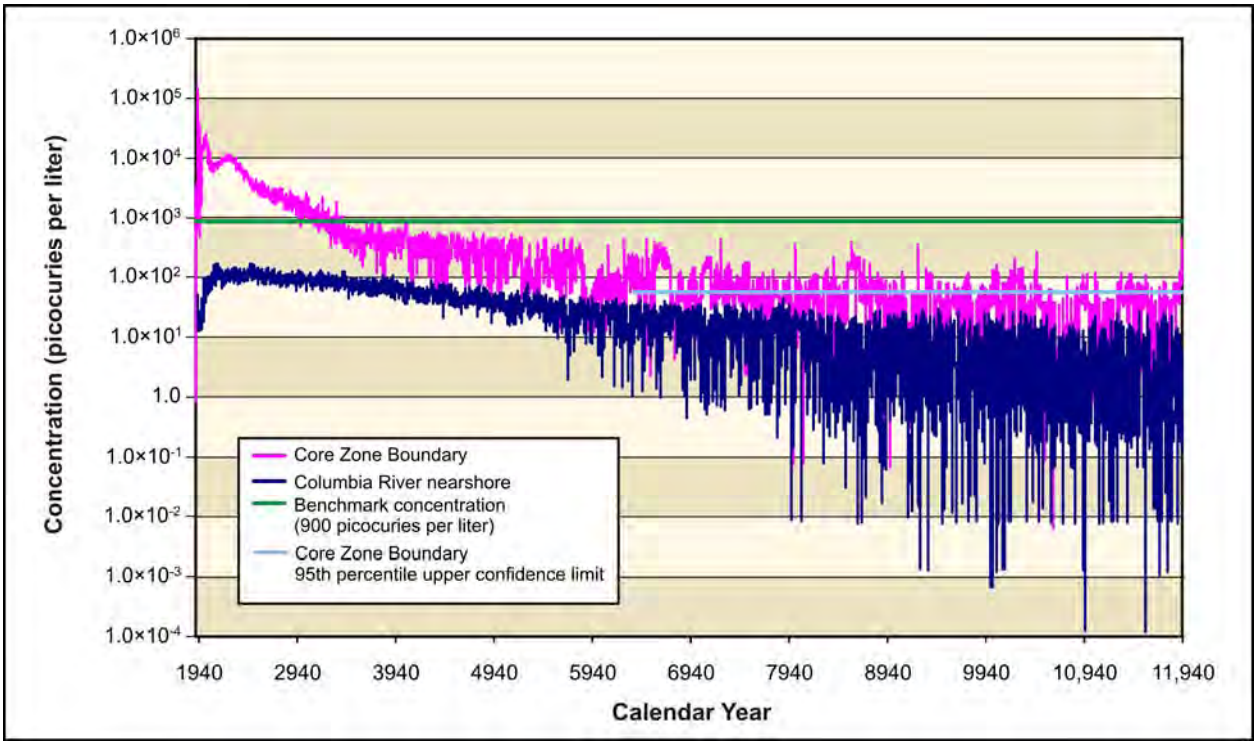


Figure 5–198. Tank Closure Alternative 6A, Base Case, Technetium-99 Concentration Versus Time

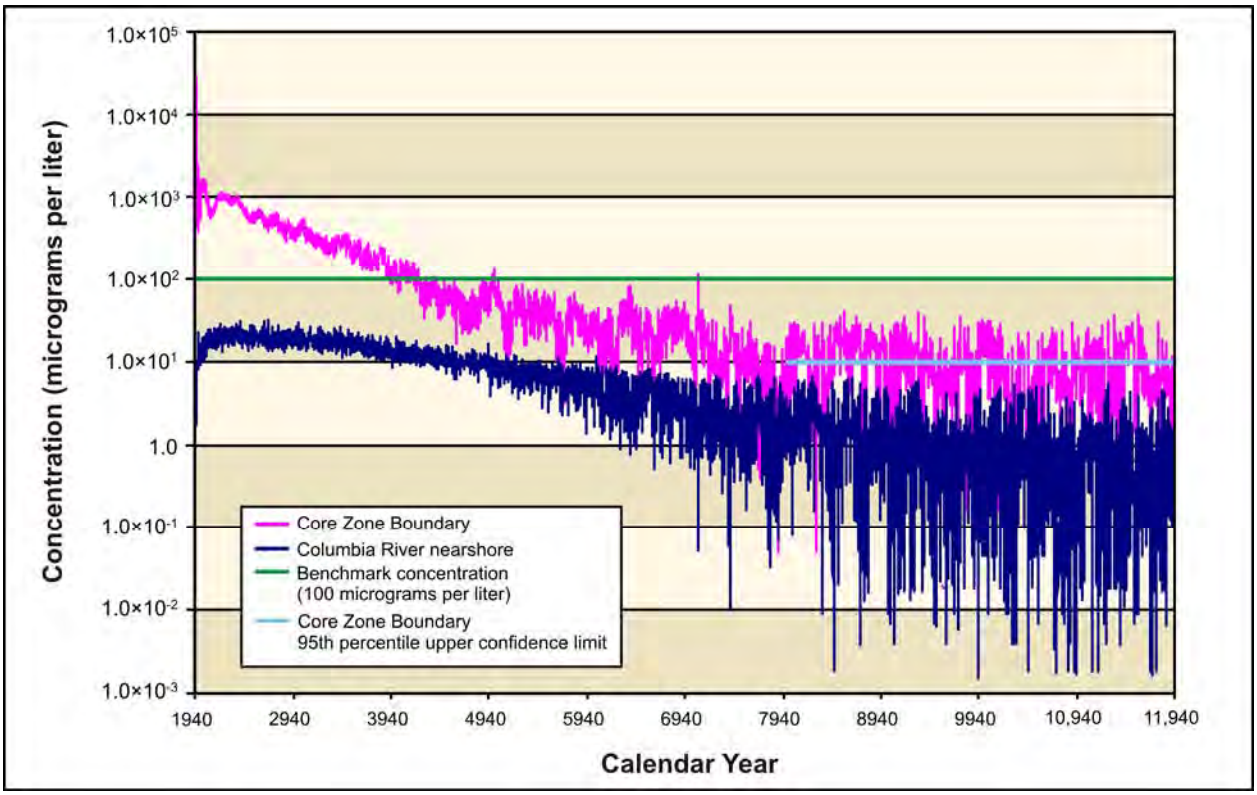


Figure 5–199. Tank Closure Alternative 6A, Base Case, Chromium Concentration Versus Time

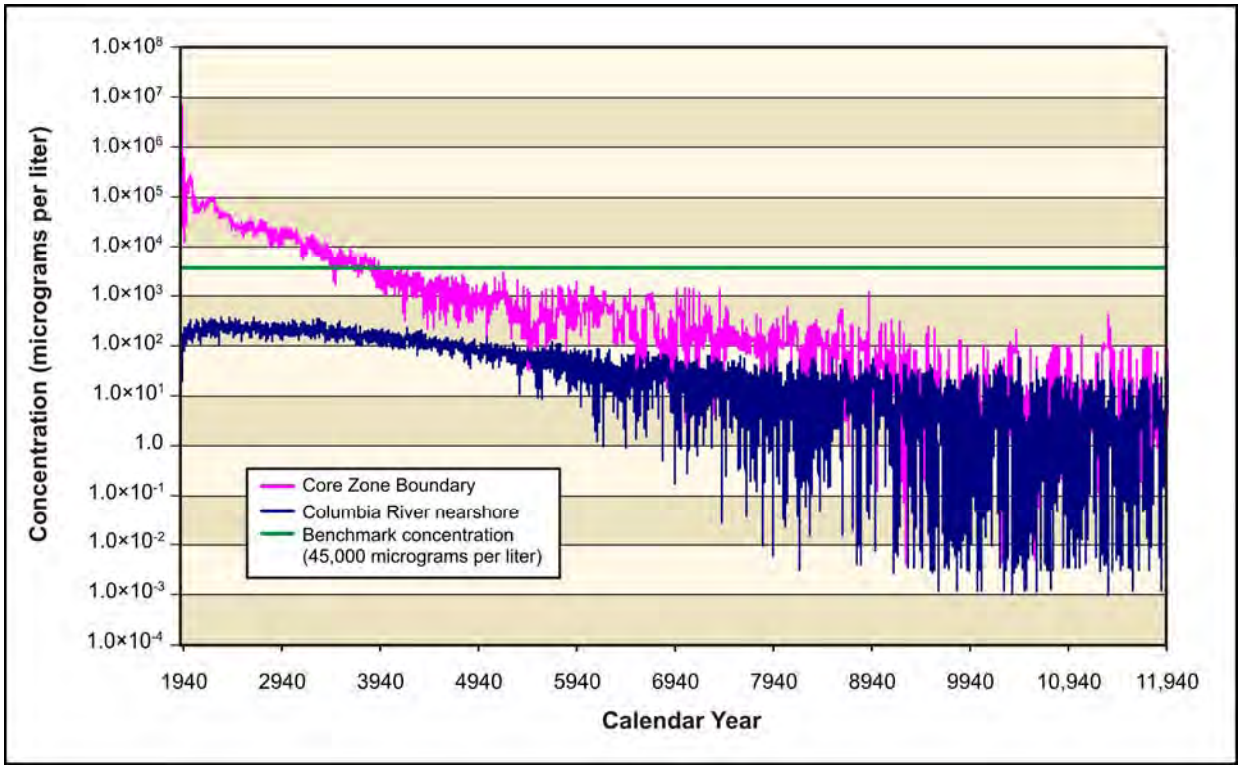


Figure 5–200. Tank Closure Alternative 6A, Base Case, Nitrate Concentration Versus Time

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) versus time under the Option Case are essentially identical to those under the Base Case (see Figures 5–201 through 5–204).

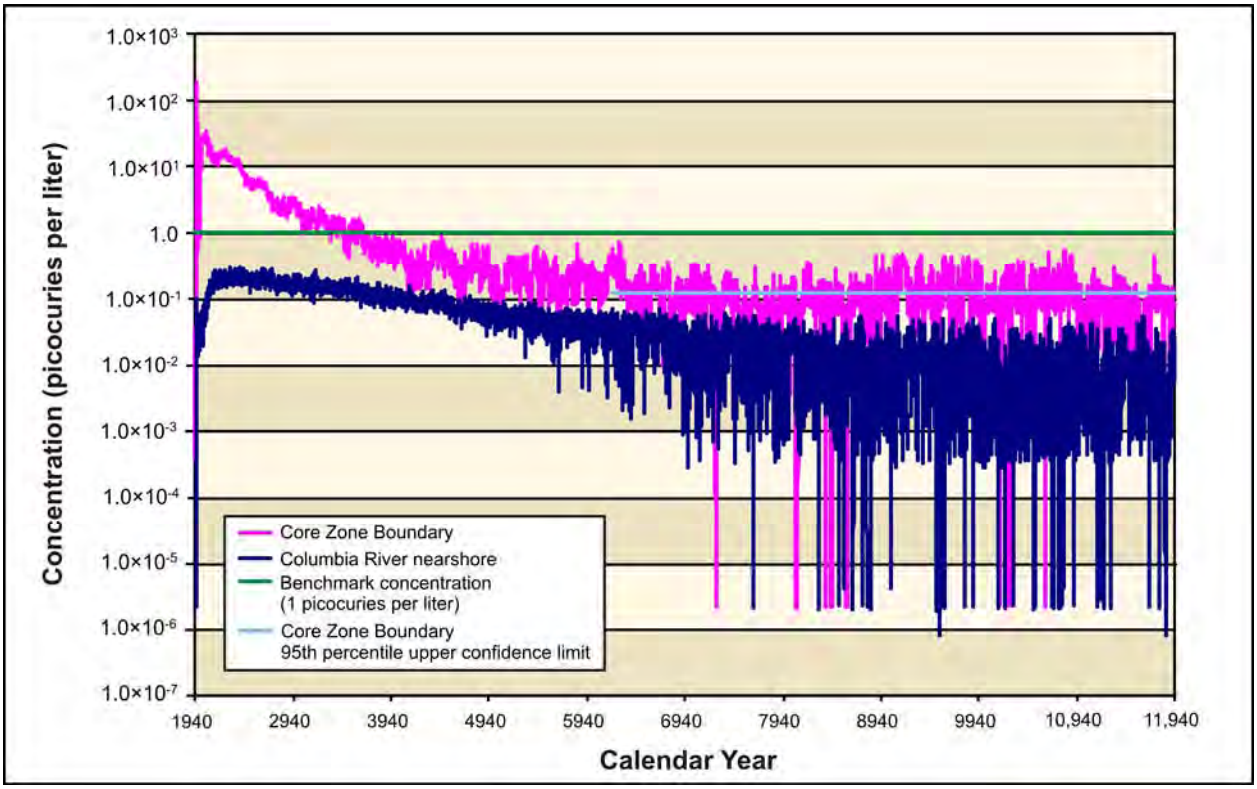


Figure 5–201. Tank Closure Alternative 6A, Option Case, Iodine-129 Concentration Versus Time

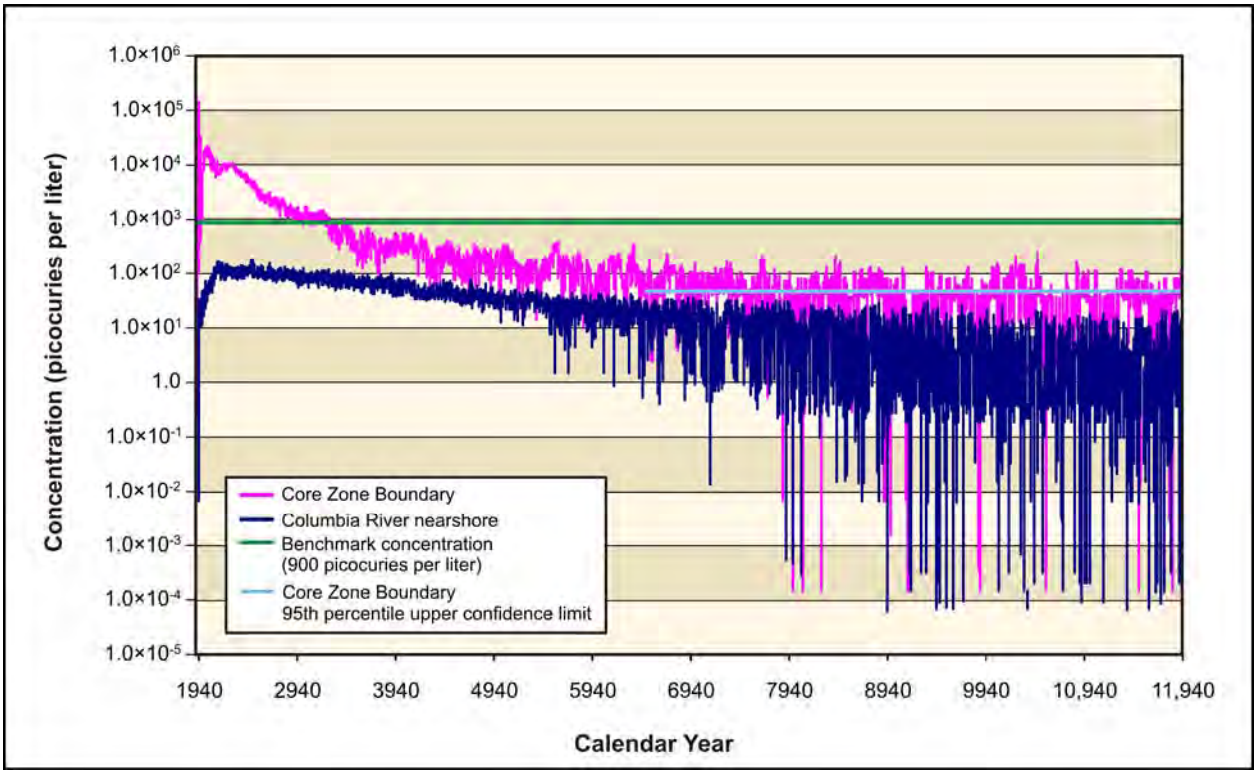


Figure 5–202. Tank Closure Alternative 6A, Option Case, Technetium-99 Concentration Versus Time

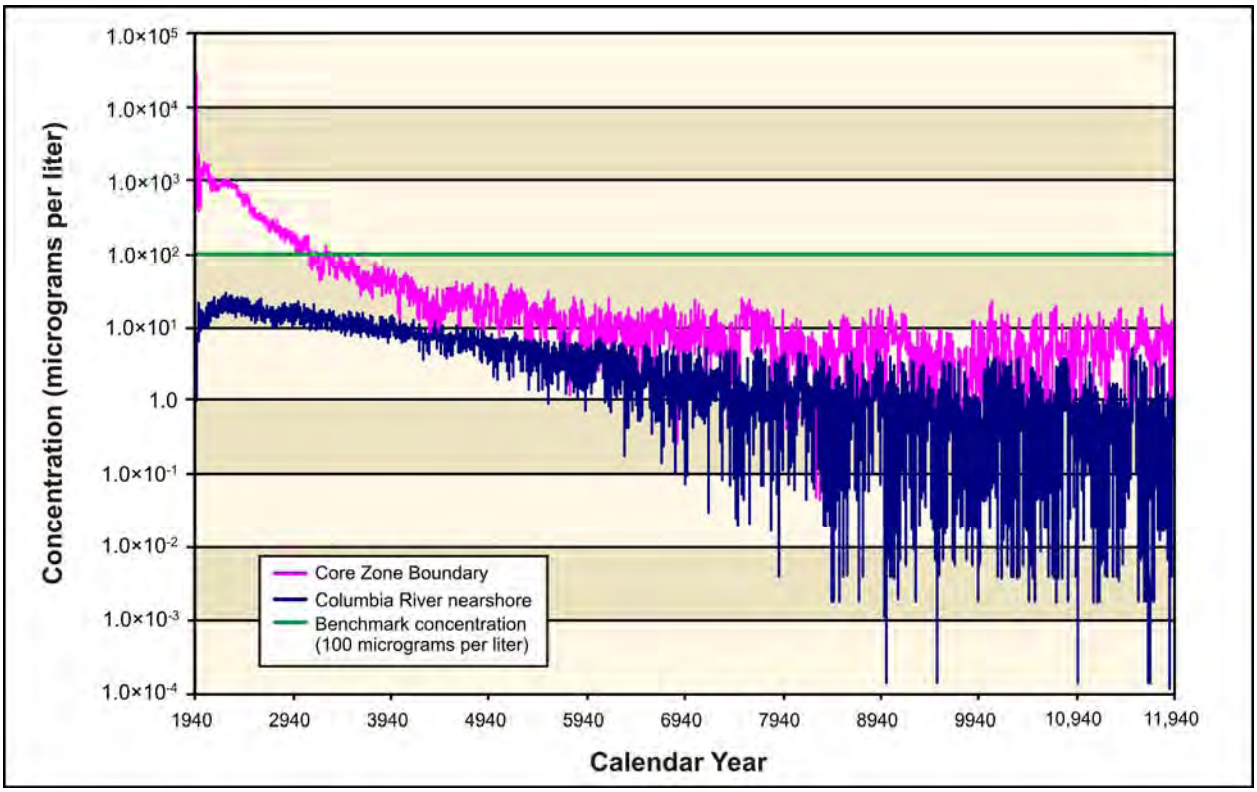


Figure 5–203. Tank Closure Alternative 6A, Option Case, Chromium Concentration Versus Time

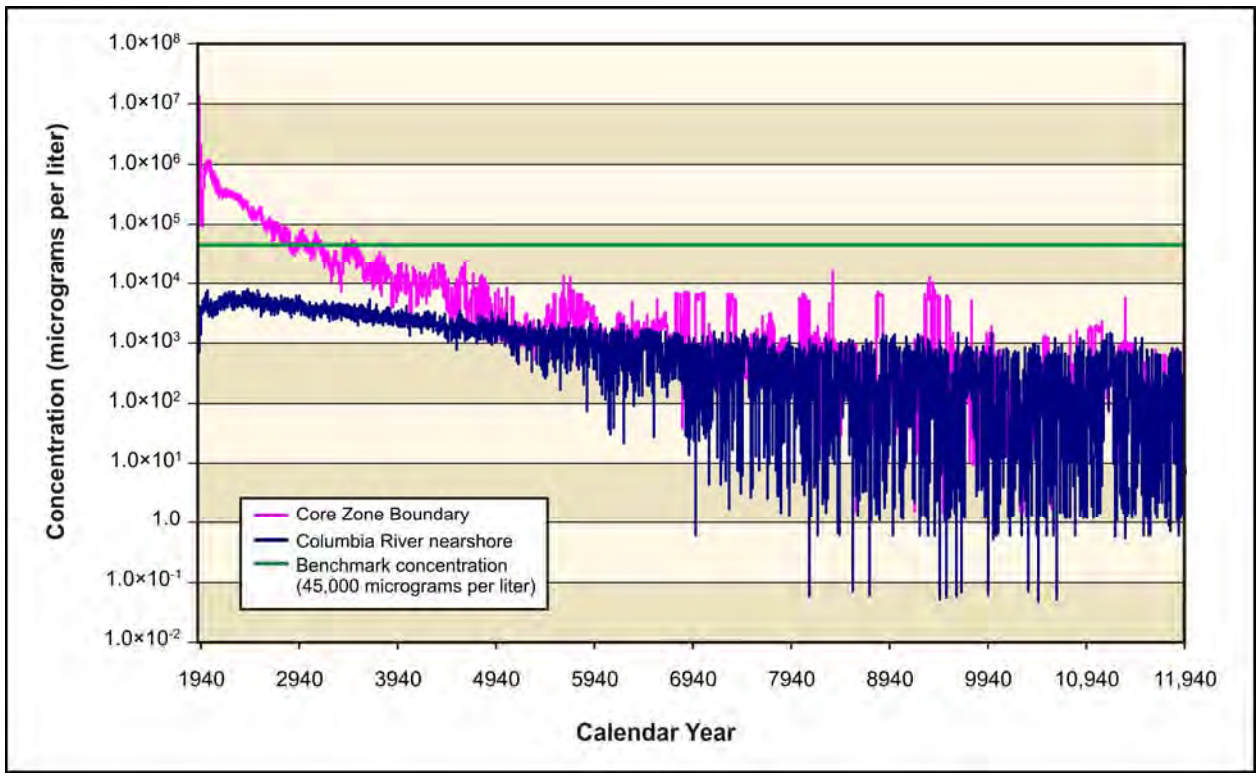


Figure 5–204. Tank Closure Alternative 6A, Option Case, Nitrate Concentration Versus Time

Figures 5–205 and 5–206 show concentration versus time for uranium-238 and total uranium under the Base Case. Although uranium-238 concentrations in the Core Zone Boundary began to approach the benchmark concentration toward the latter part of the period of analysis, they never reached it. Total uranium concentrations at the Core Zone Boundary also began to increase toward the end of the period of analysis but never came to within one order of magnitude of the benchmark. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never came to within about two orders of magnitude below the benchmark.

Under the Option Case, uranium-238 concentrations in the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark concentration, except for a short spike to about one order of magnitude below the benchmark at the beginning of the period of analysis (see Figure 5–207). At around CY 7500, the uranium-238 Core Zone Boundary concentrations fell to about four orders of magnitude below the benchmark. The Columbia River nearshore concentrations of uranium-238 stayed fairly constant at about four orders of magnitude below the benchmark. Total uranium concentrations at the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark (see Figure 5–208). The Columbia River nearshore concentrations of total uranium remained fairly constant at around four and a half orders of magnitude below the benchmark.

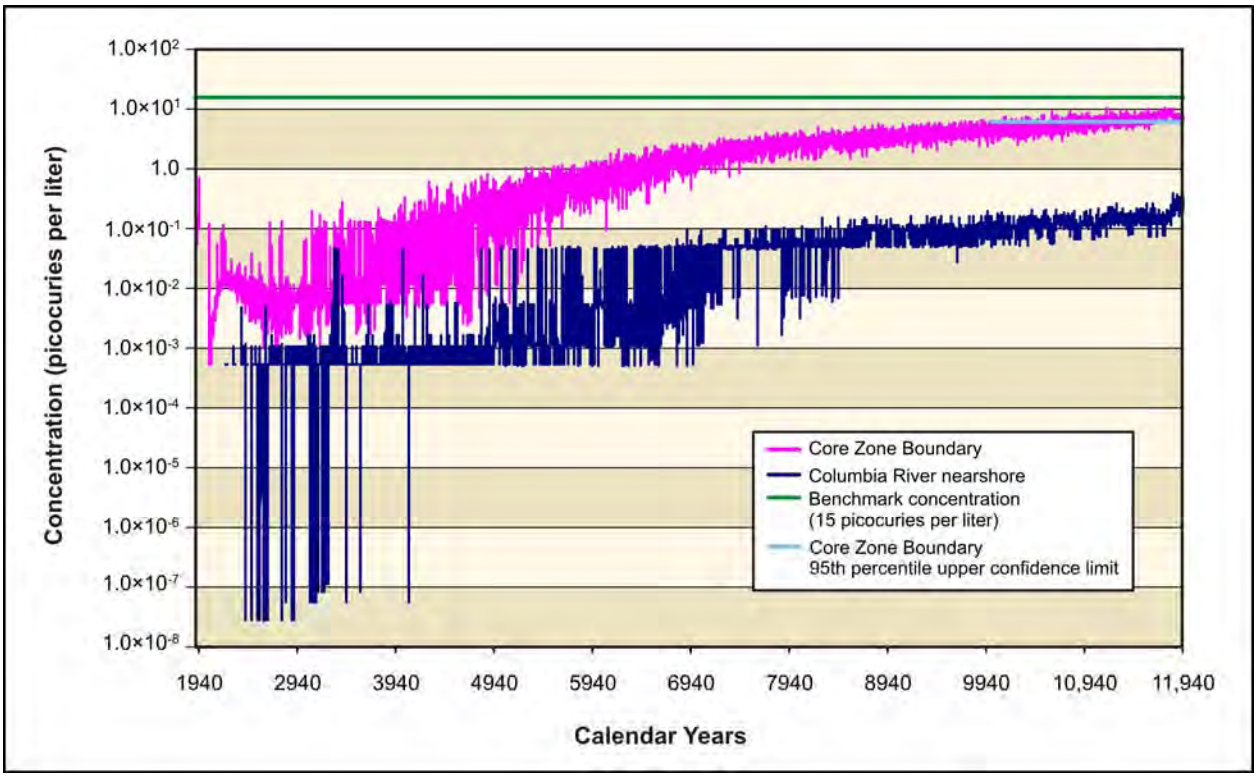


Figure 5–205. Tank Closure Alternative 6A, Base Case, Uranium-238 Concentration Versus Time

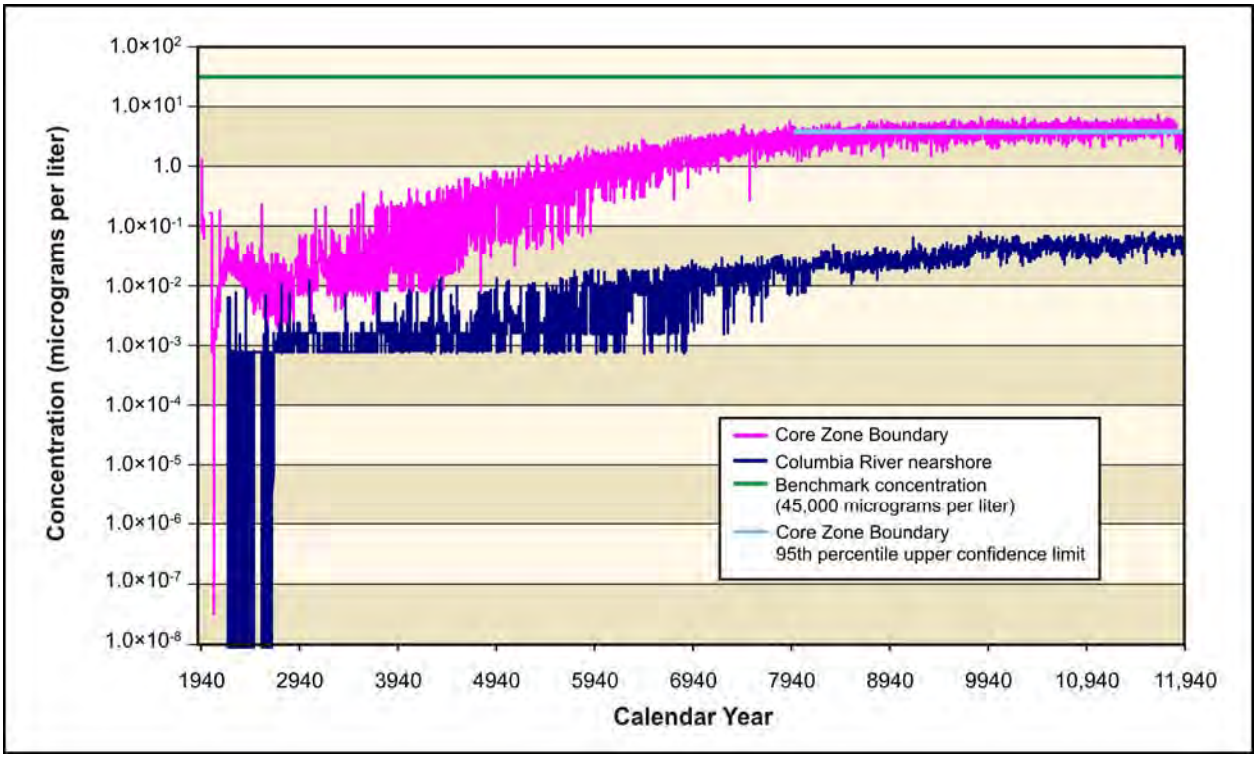


Figure 5–206. Tank Closure Alternative 6A, Base Case, Total Uranium Concentration Versus Time

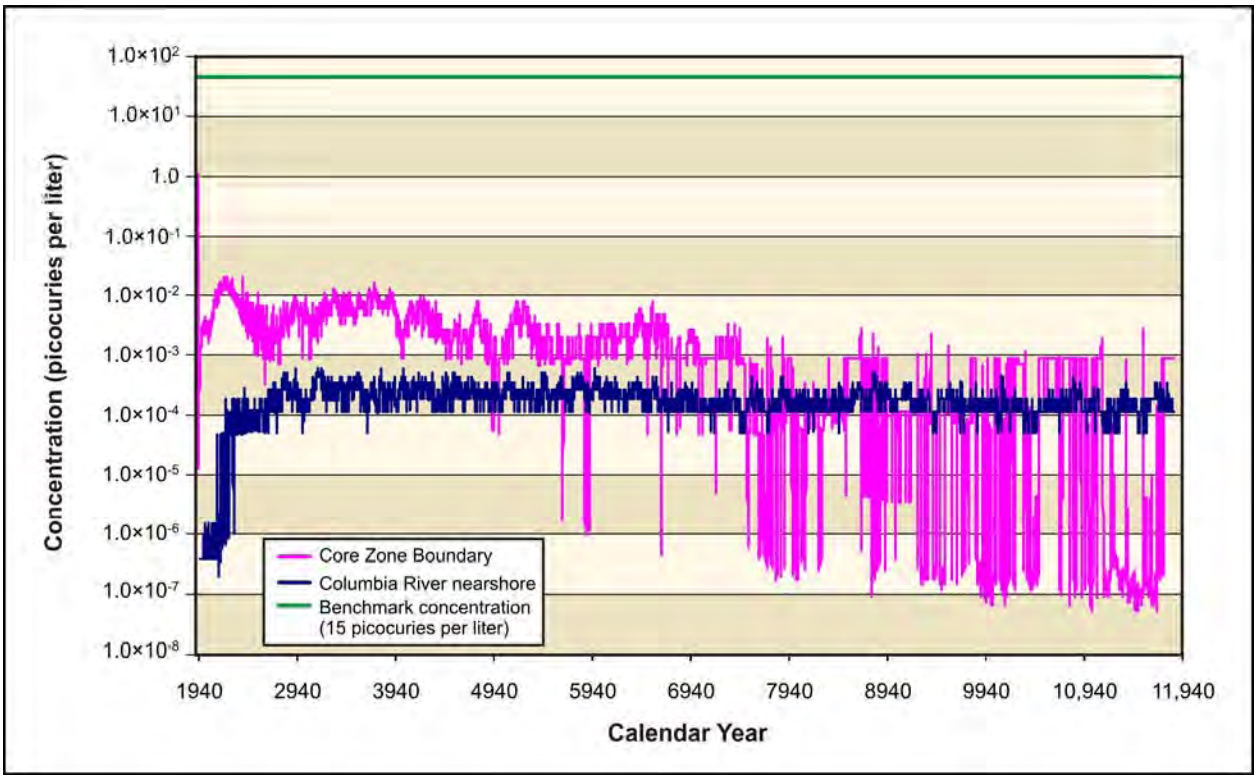


Figure 5–207. Tank Closure Alternative 6A, Option Case, Uranium-238 Concentration Versus Time

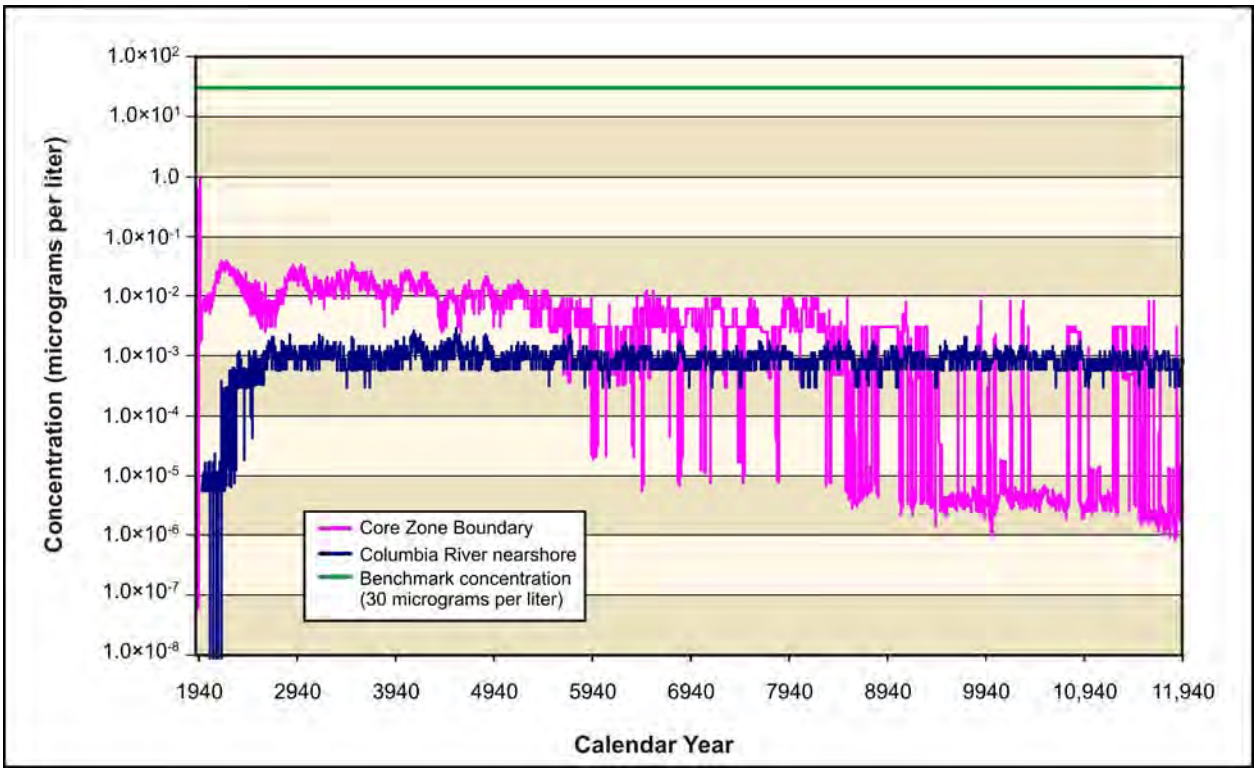


Figure 5–208. Tank Closure Alternative 6A, Option Case, Total Uranium Concentration Versus Time

5.1.1.9.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 6A in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Figures 5–209 through 5–253). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–209 shows the spatial distribution of groundwater concentration for tritium during CY 2005 under the Base Case, which would include use of a modified RCRA Subtitle C barrier. Analysis releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark concentration, and mostly contained within the Core Zone Boundary. The overall tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135, although a few minor traces, from about one-twentieth to one-tenth below the benchmark, can be found in Gable Gap (see Figure 5–210).

The spatial distribution of groundwater concentrations for tritium under the Option Case, which would include removal of the six sets of cribs and trenches (ditches) and remediation of their plumes within the vadose zone, is essentially identical to that under the Base Case (see Figures 5–211 and 5–212).

Figure 5–213 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005 under the Base Case. Analysis releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 30 times greater than the benchmark, and mostly contained within the Core Zone Boundary. By CY 2135, the contaminant plumes have spread further north through Gable Gap and further east toward the Columbia River (see Figure 5–214). In the plume north of Gable Gap, contaminant levels have begun to meet the benchmark concentration. In the east, just outside of the Core Zone Boundary, levels have risen to 5 to 10 times above the benchmark. By CY 7140, most of the mass in the plume has reached the Columbia River, with only a small pocket with high concentrations in the southern region of Gable Gap extending north from the B Barrier (see Figure 5–215). Technetium-99 (see Figures 5–216 through 5–218), chromium (see Figures 5–219 through 5–221), and nitrate (see Figures 5–222 through 5–224) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all essentially conservative tracers (i.e., move at the rate of the pore water velocity) during the period of analysis.

The spatial distribution of groundwater concentrations of the conservative tracers under the Option Case is essentially identical to that under the Base Case (see Figures 5–225 through 5–236).

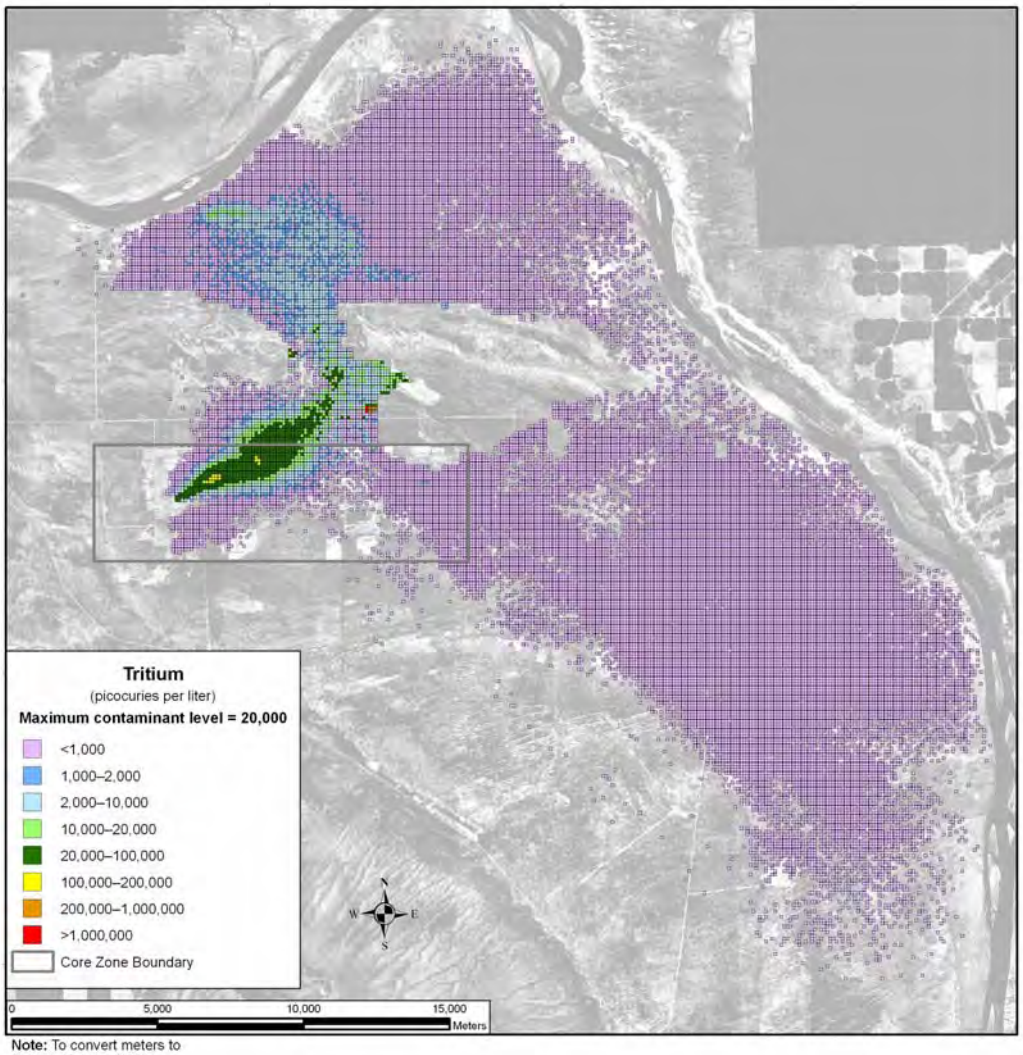


Figure 5–209. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

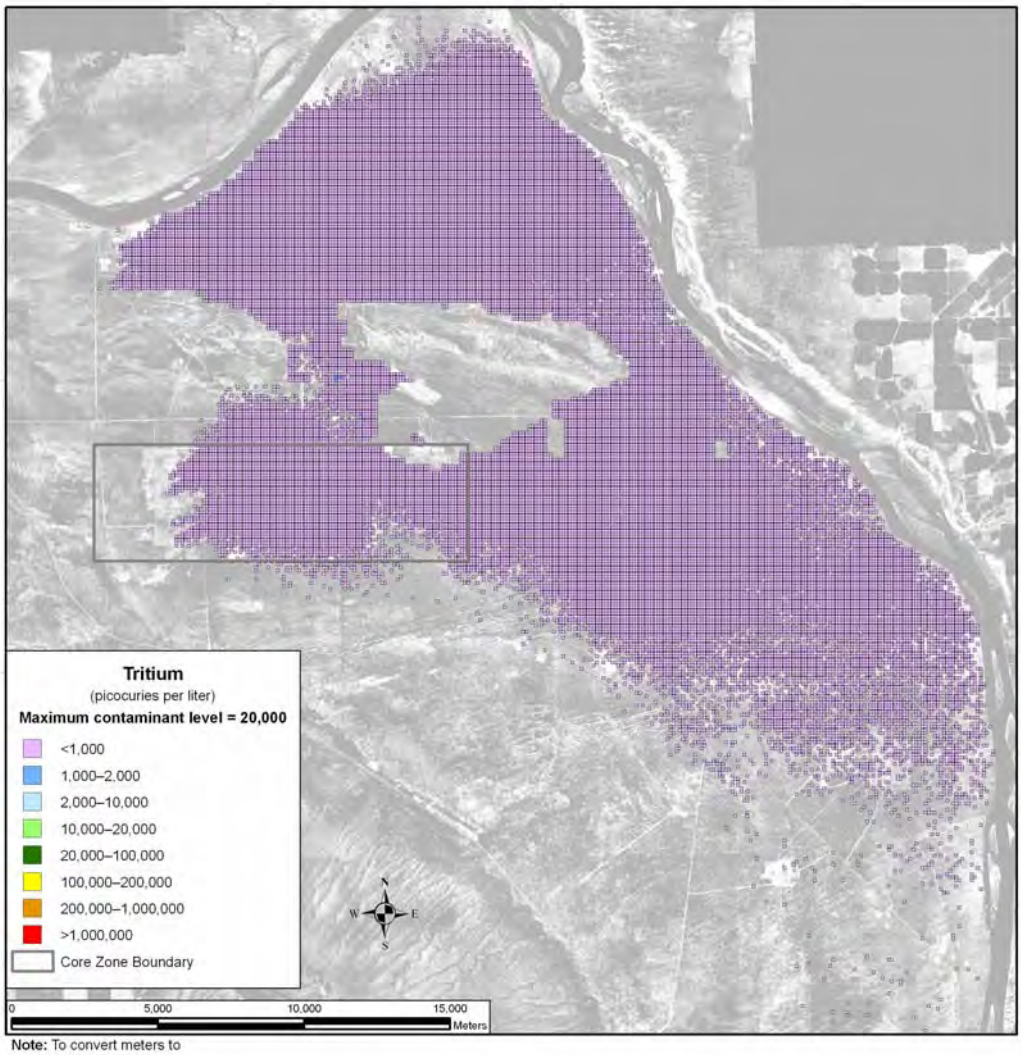


Figure 5–210. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

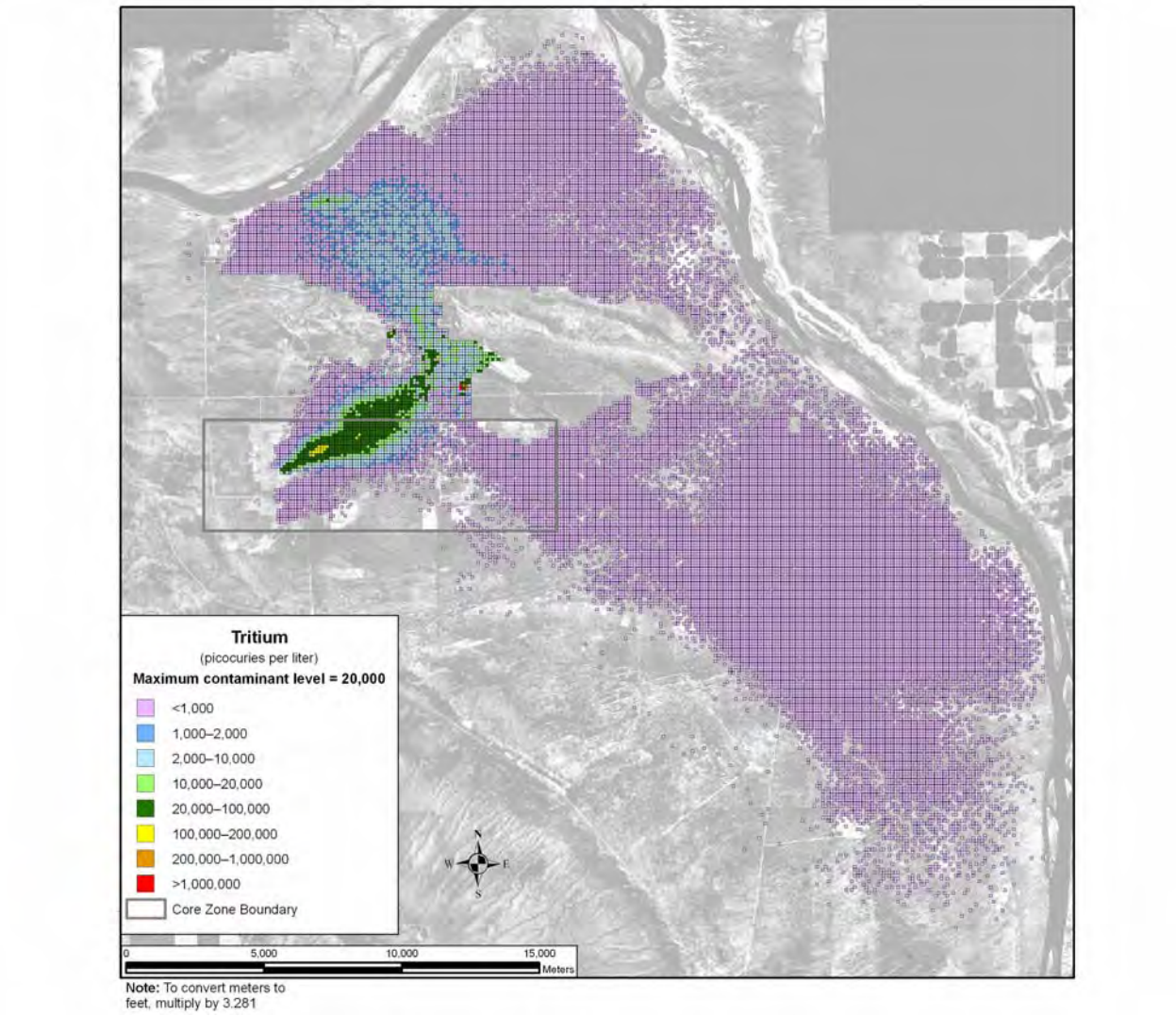


Figure 5–211. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

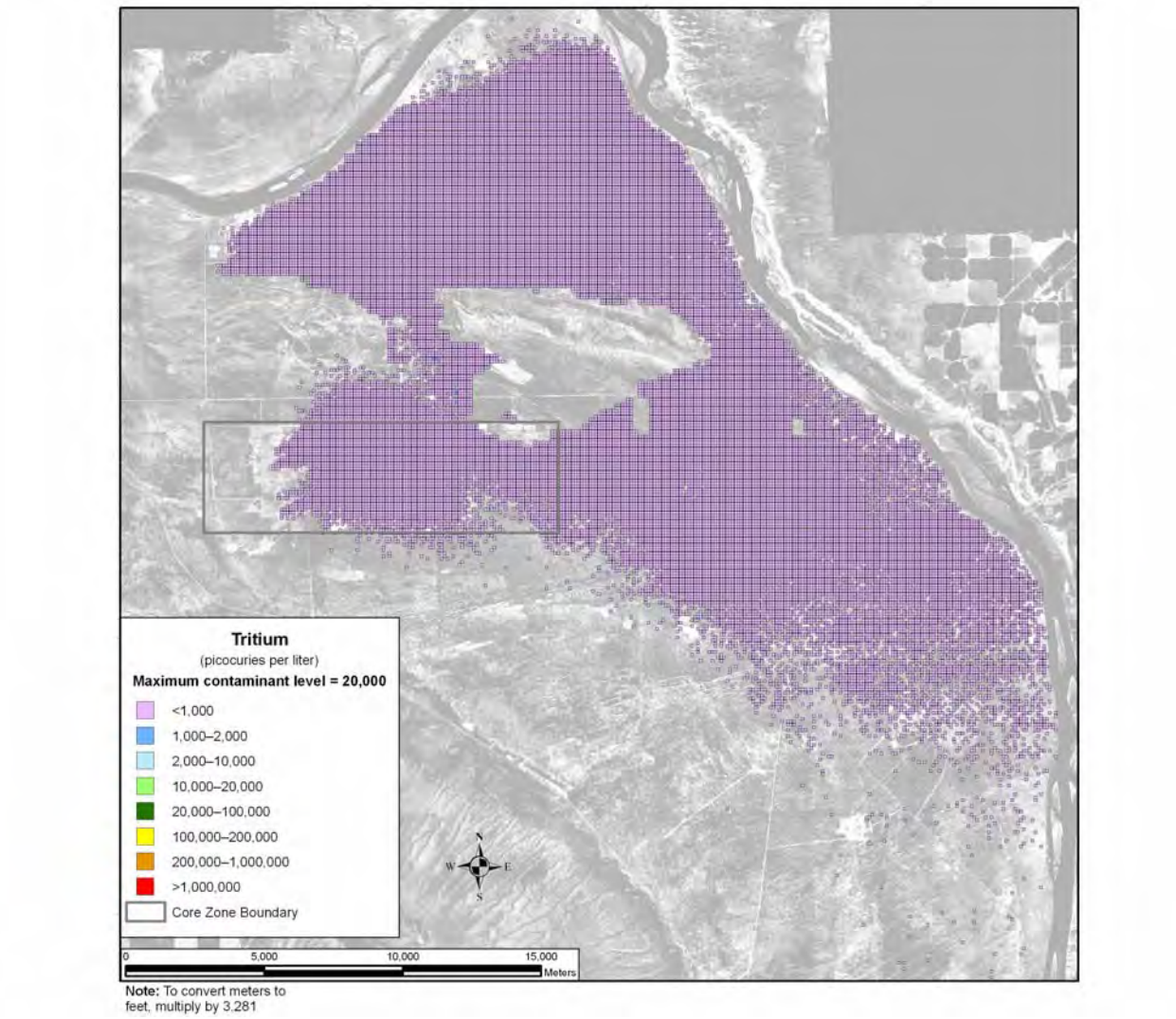


Figure 5–212. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

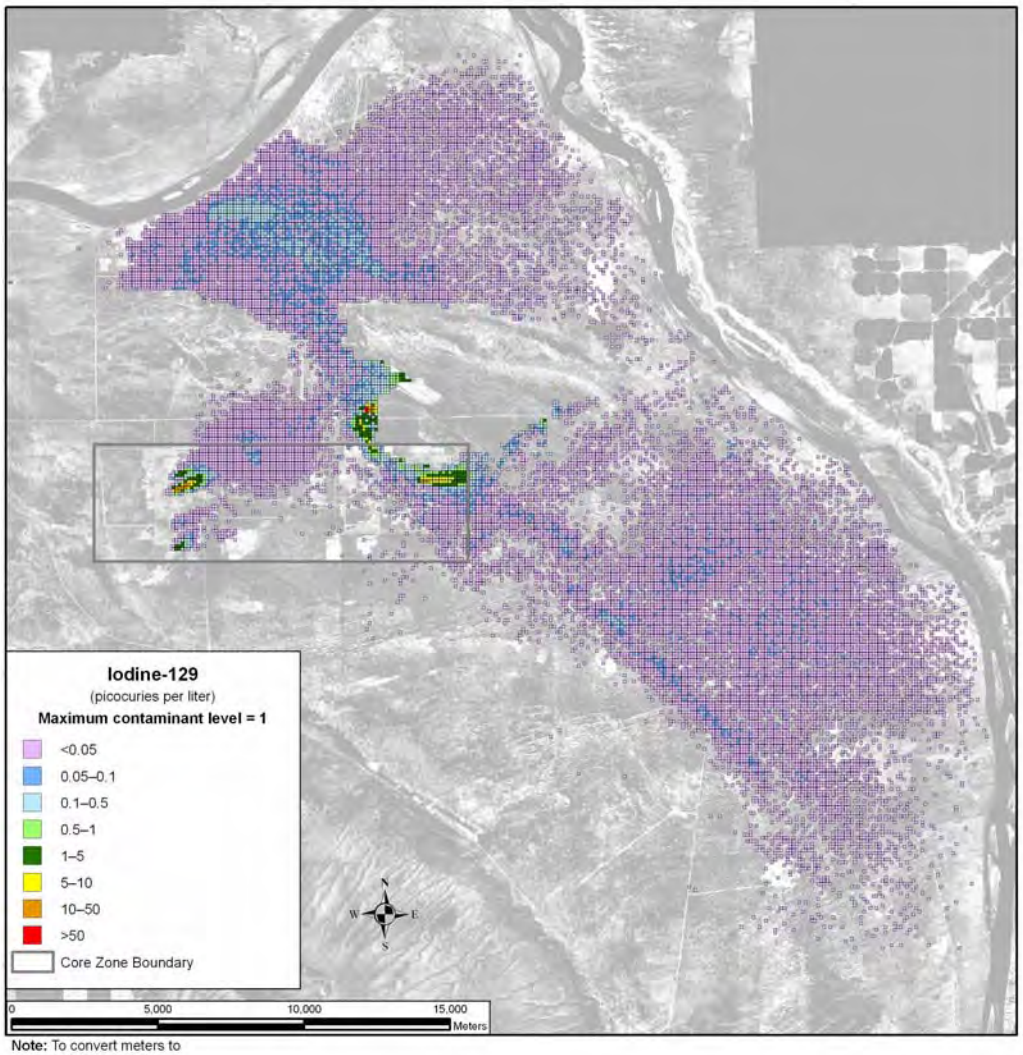


Figure 5–213. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

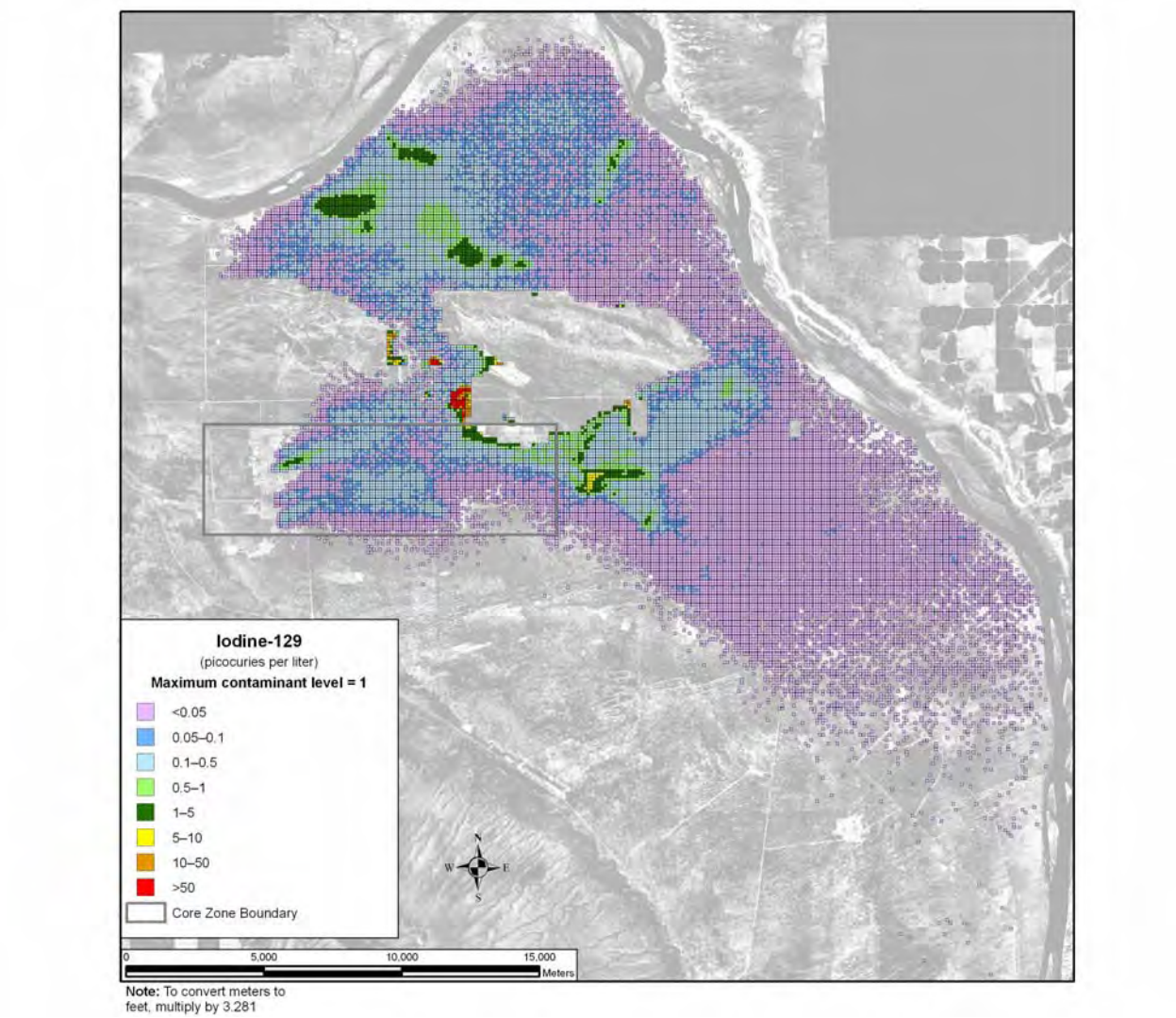


Figure 5–214. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135

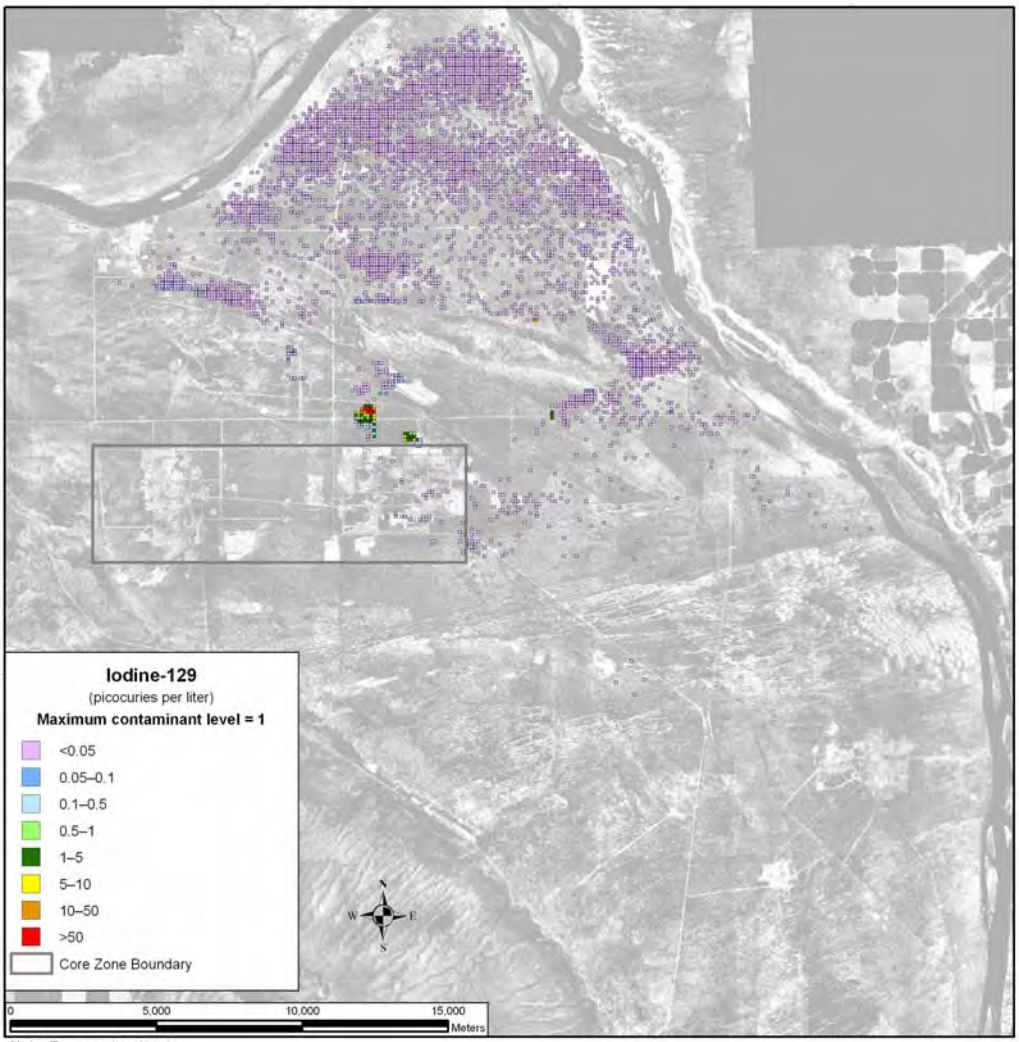


Figure 5–215. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

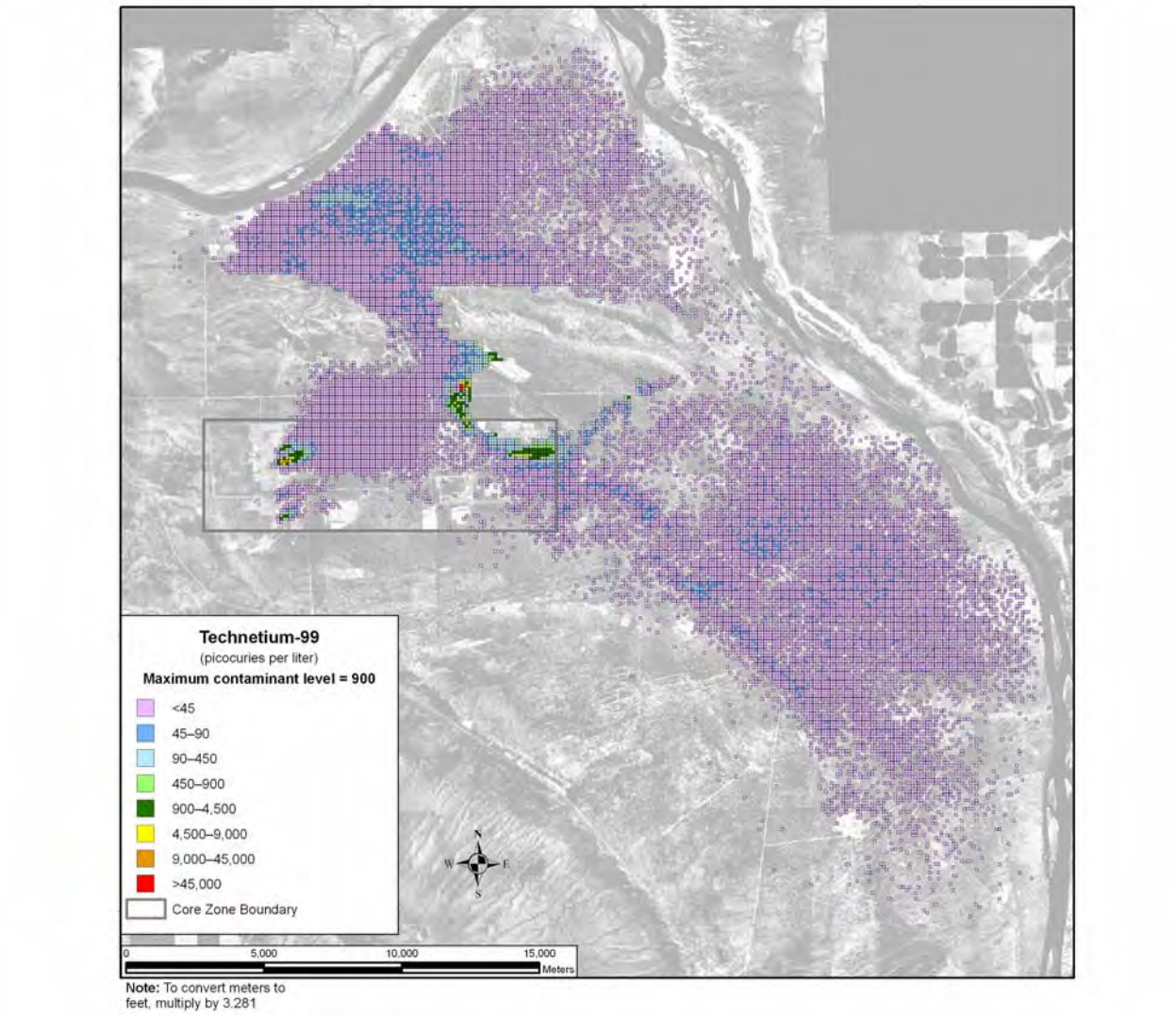


Figure 5–216. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

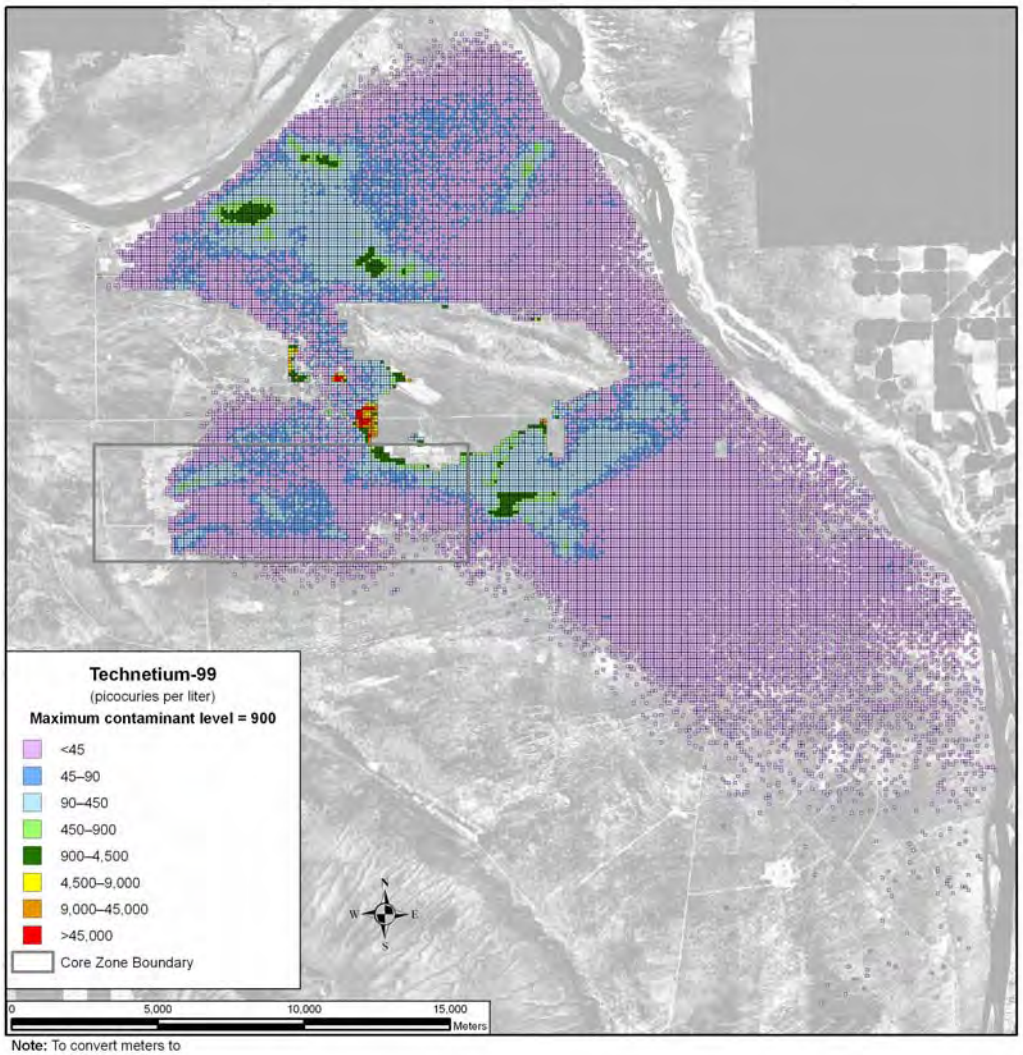


Figure 5–217. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2135

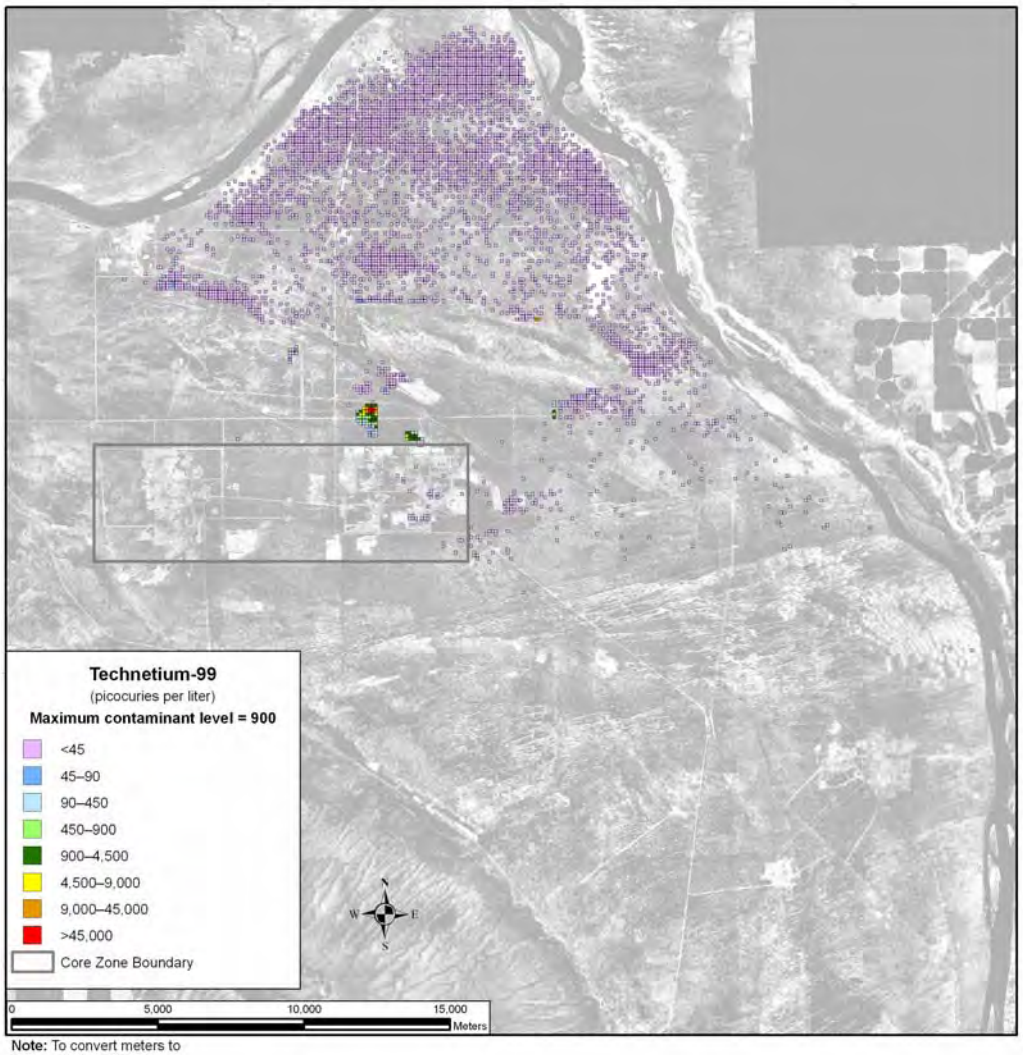


Figure 5–218. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

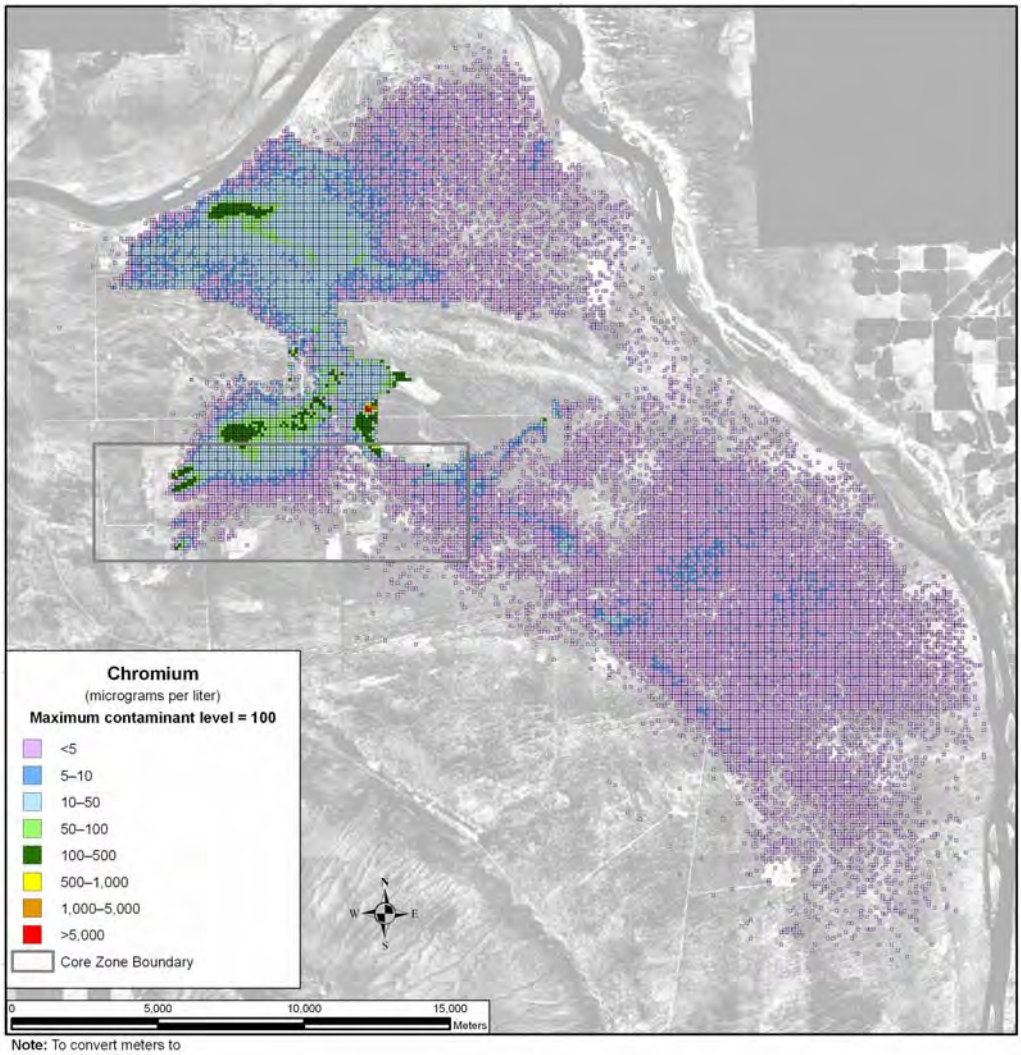


Figure 5–219. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

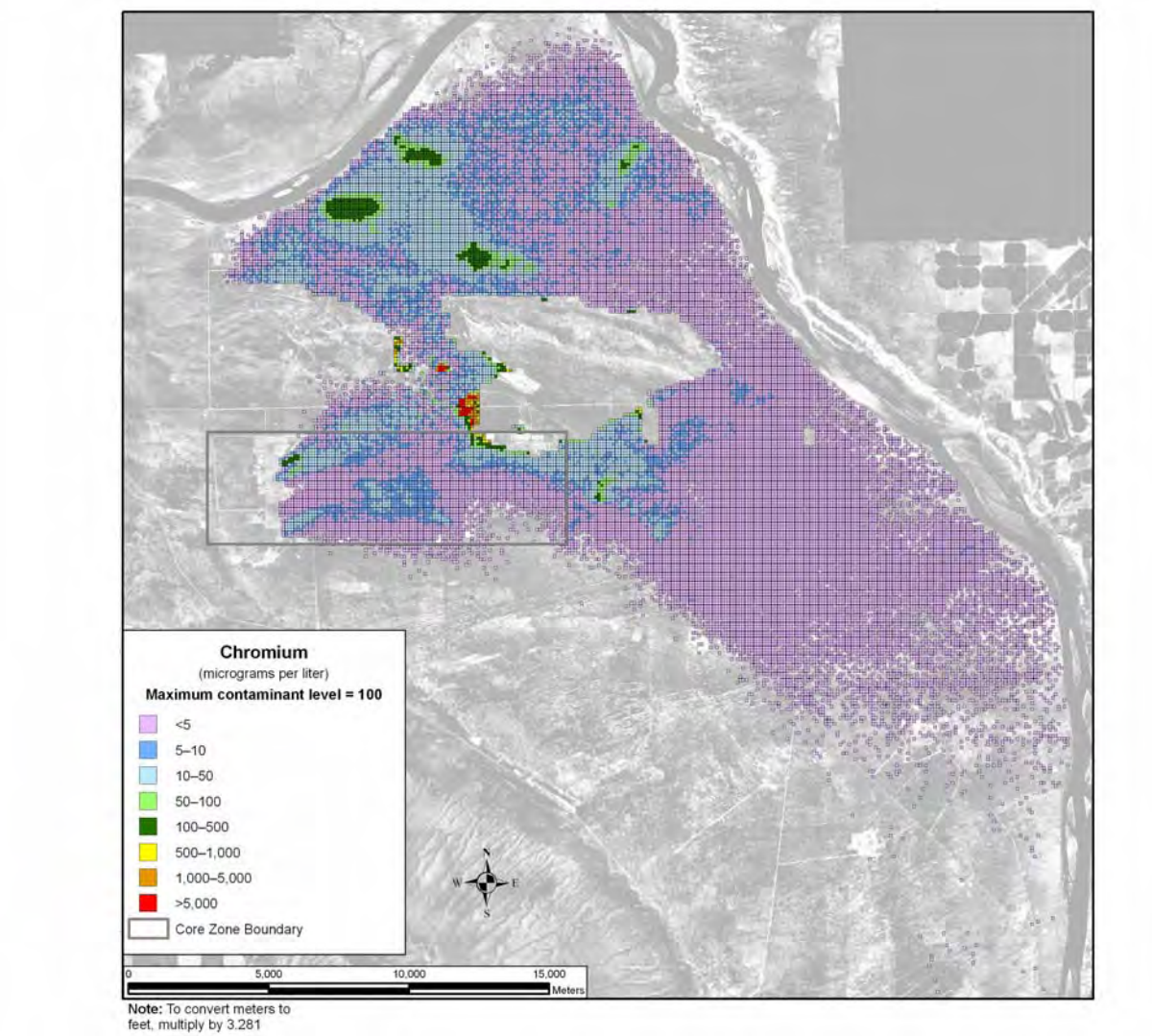


Figure 5–220. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2135

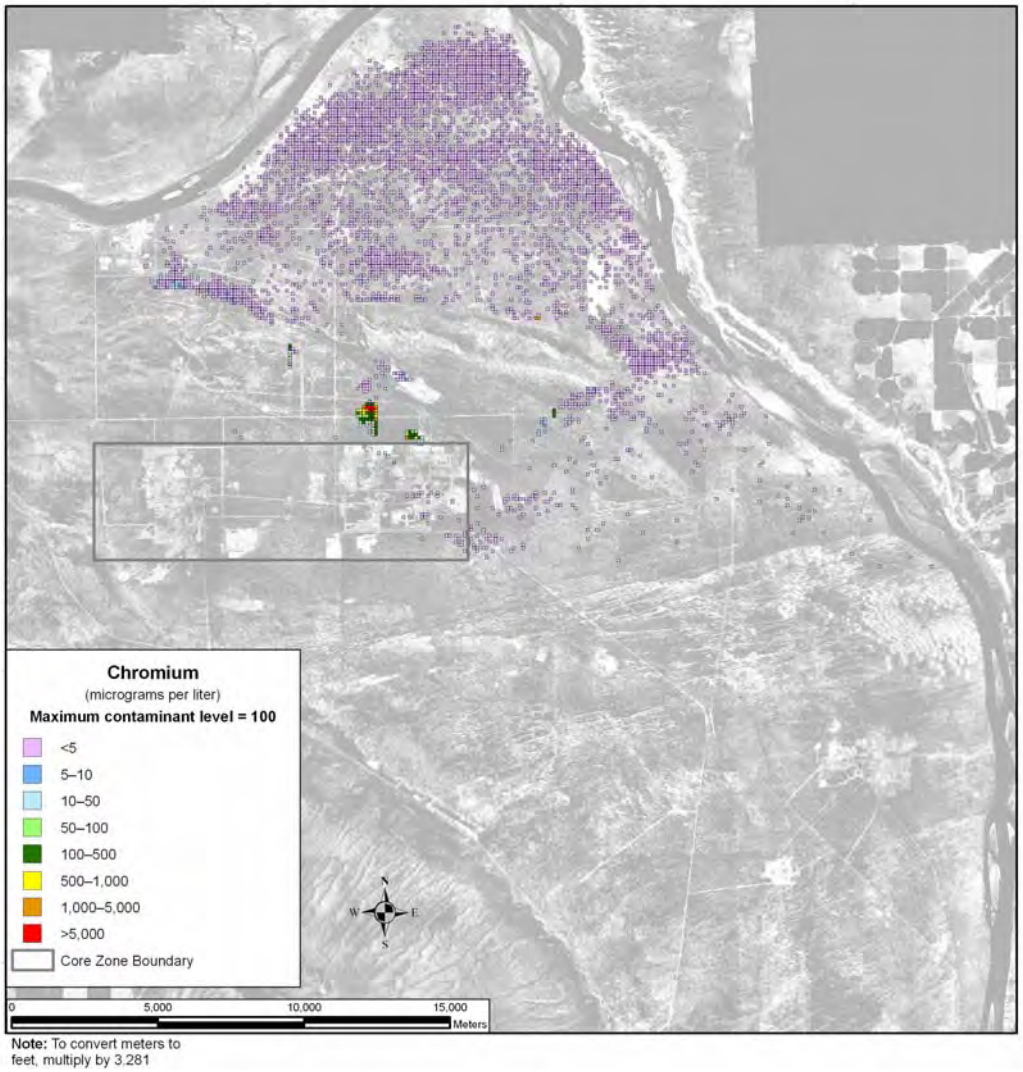


Figure 5–221. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

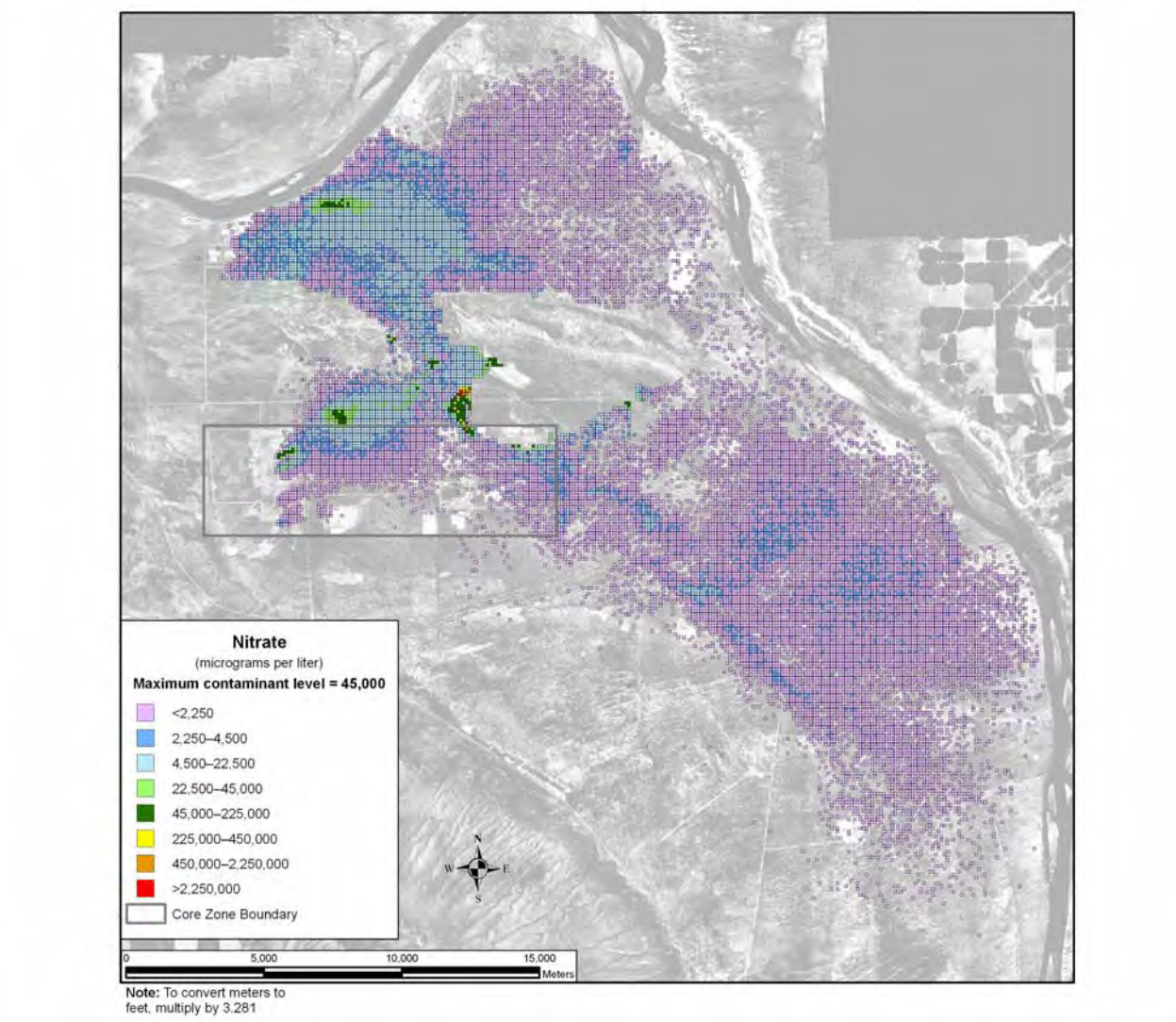


Figure 5–222. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

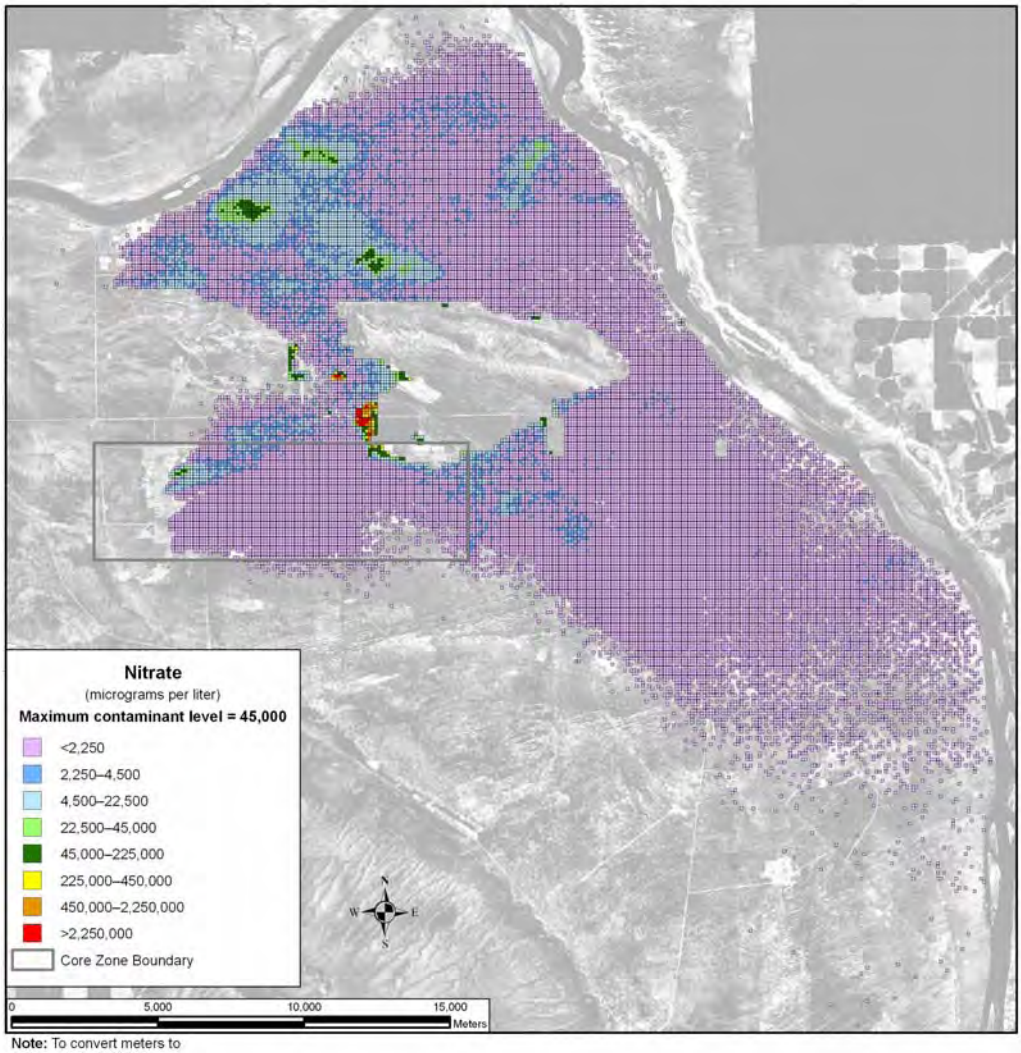


Figure 5–223. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2135

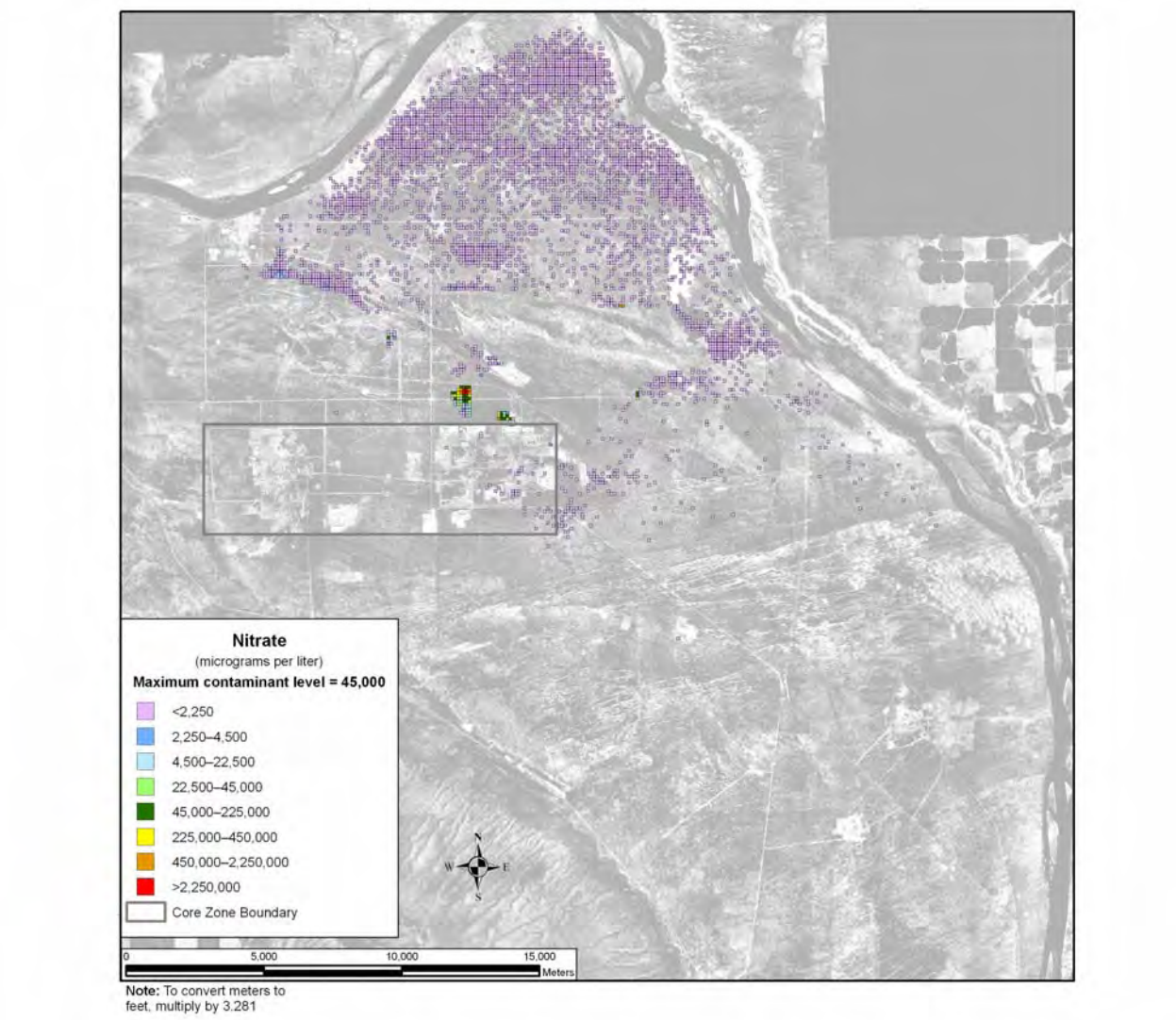


Figure 5–224. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

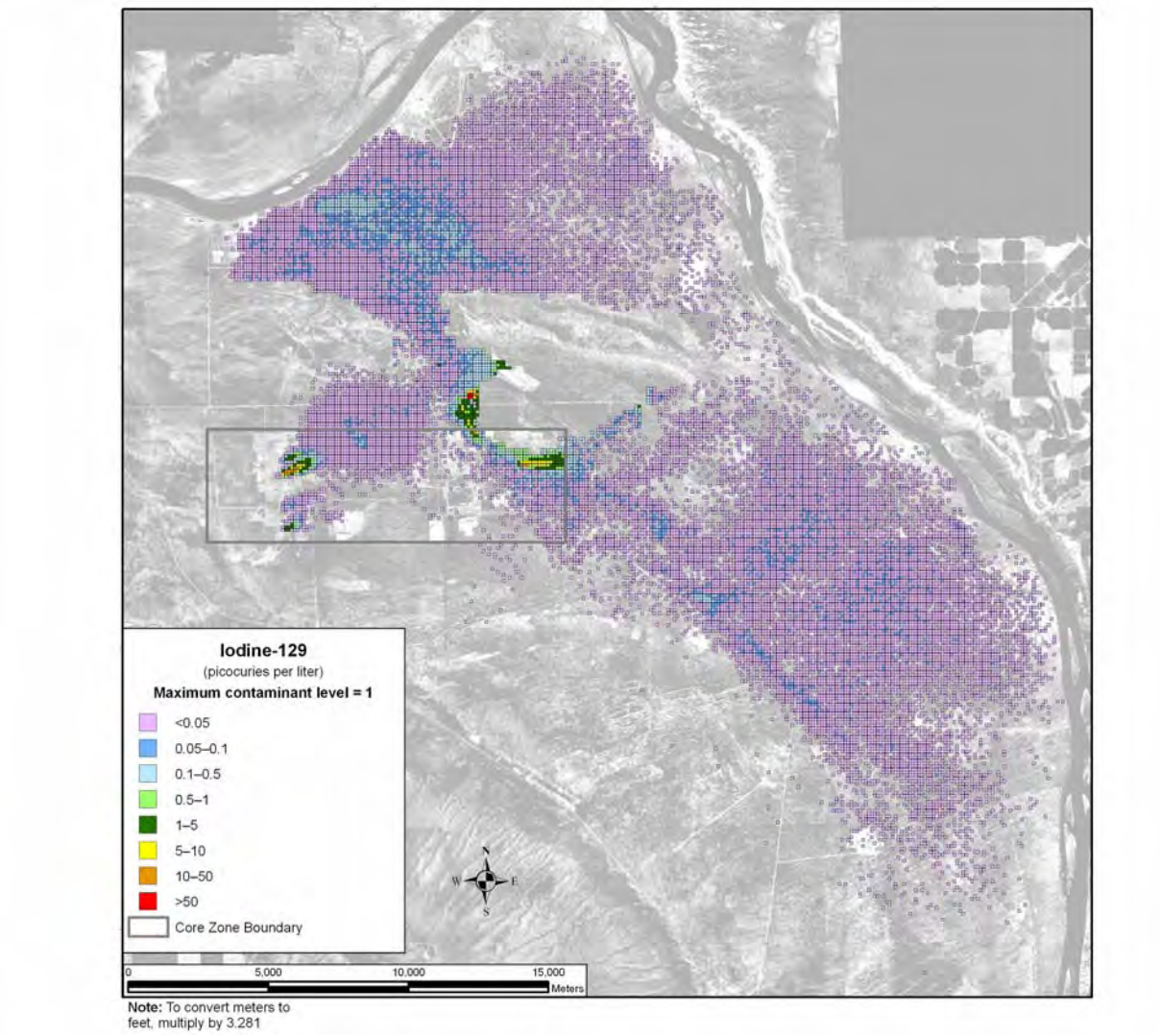


Figure 5–225. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

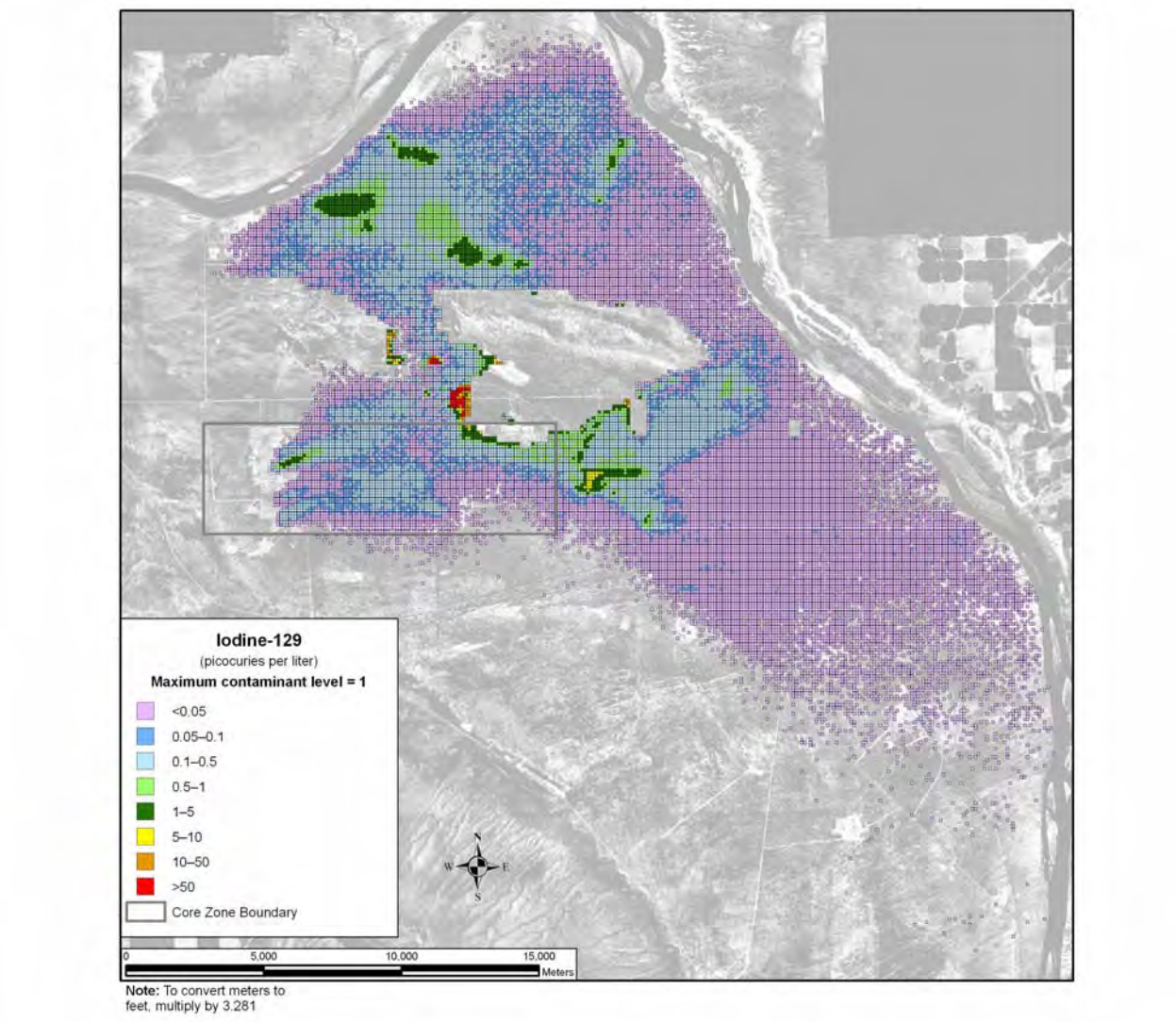
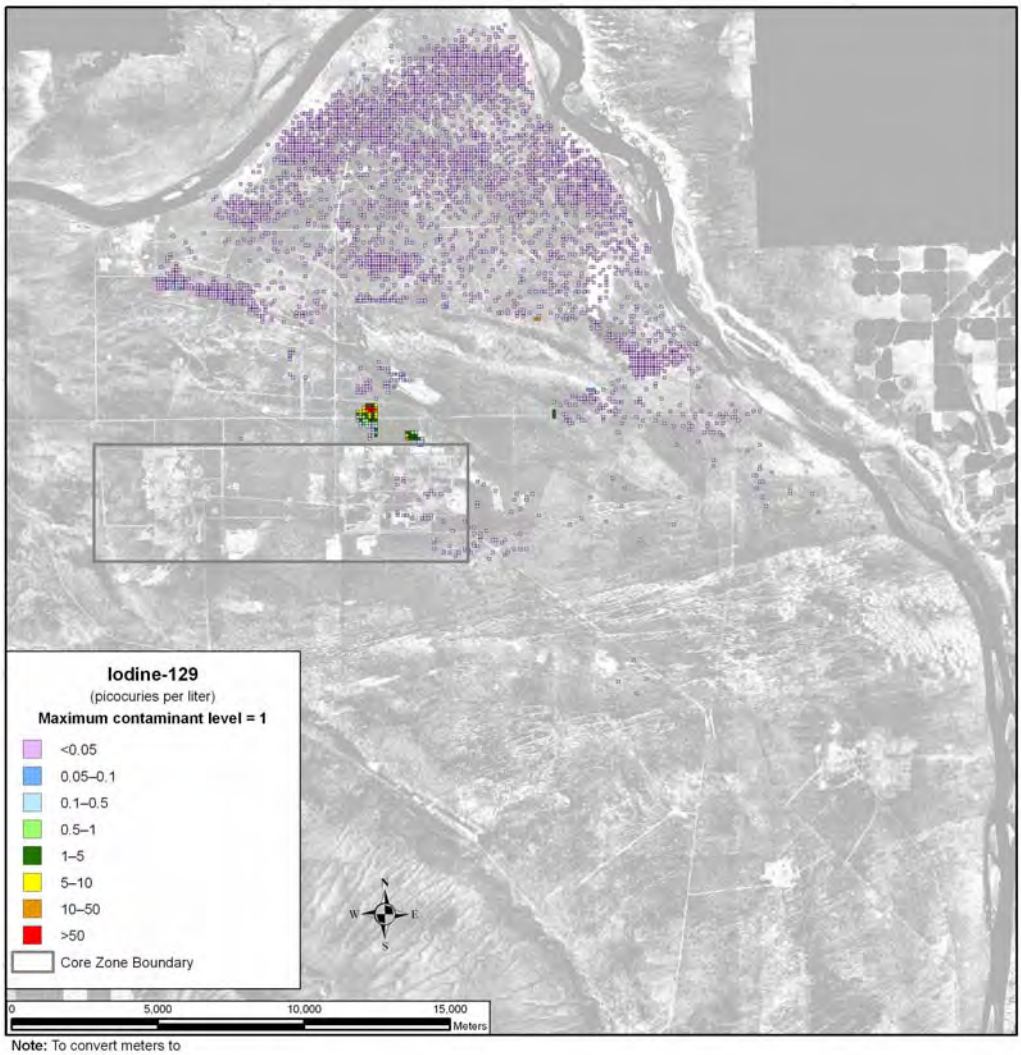


Figure 5–226. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–227. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

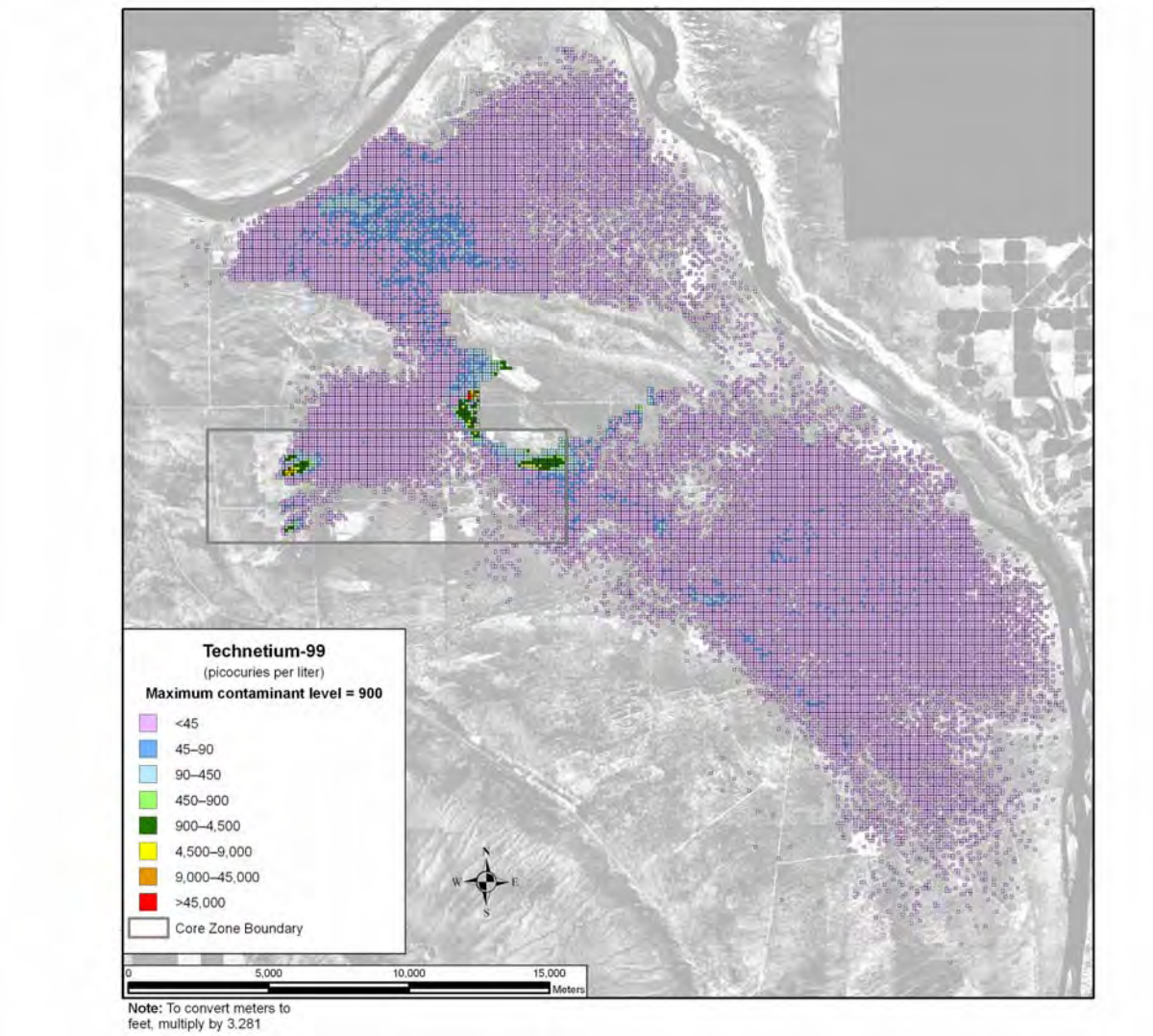


Figure 5–228. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

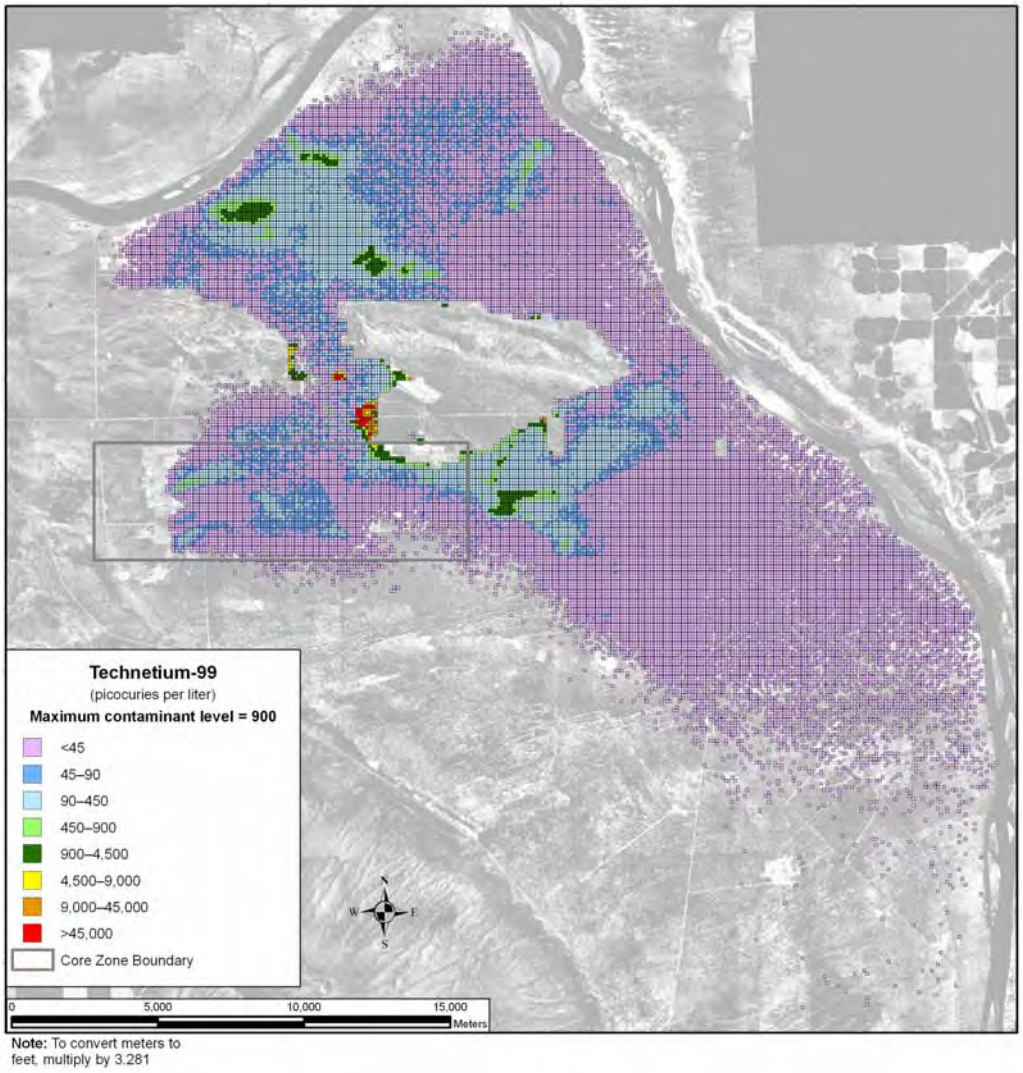


Figure 5–229. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2135

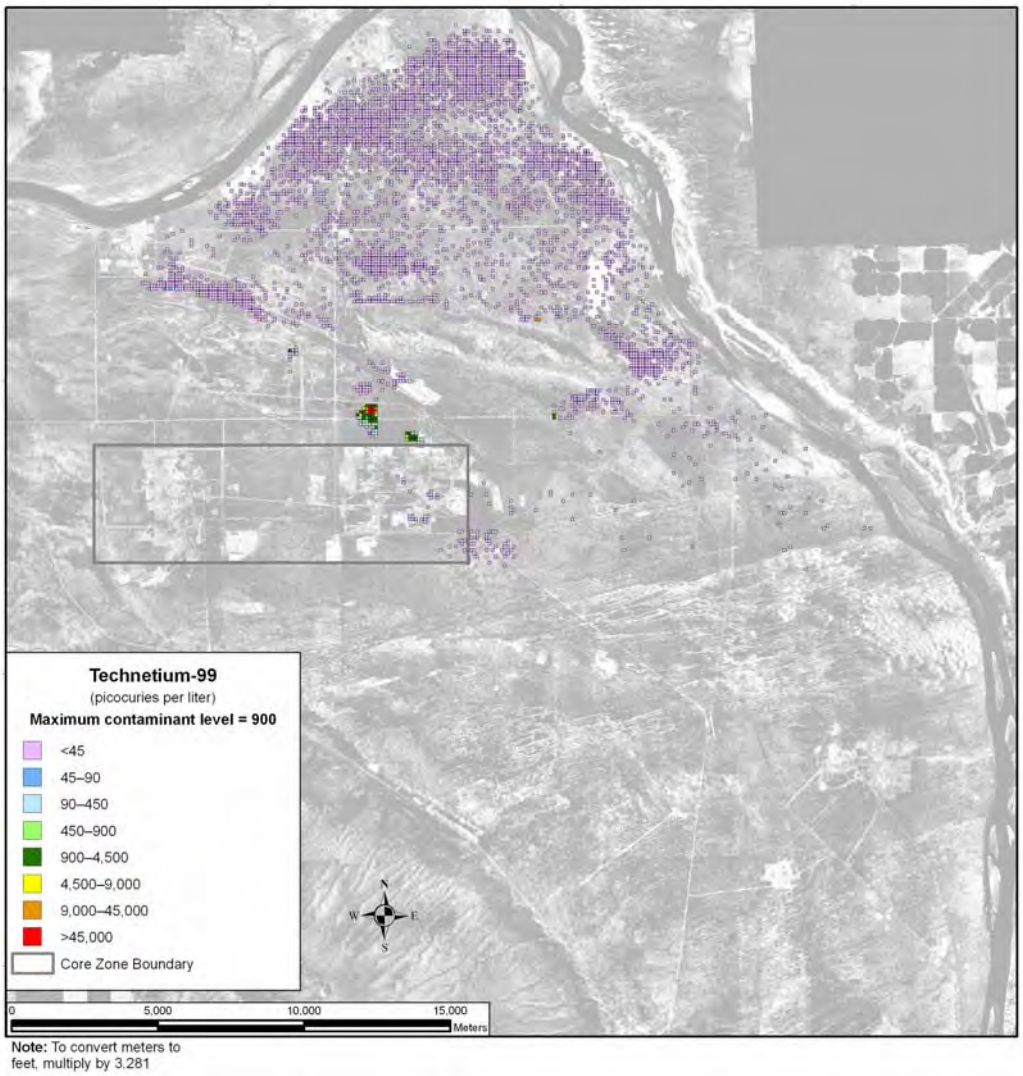


Figure 5–230. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

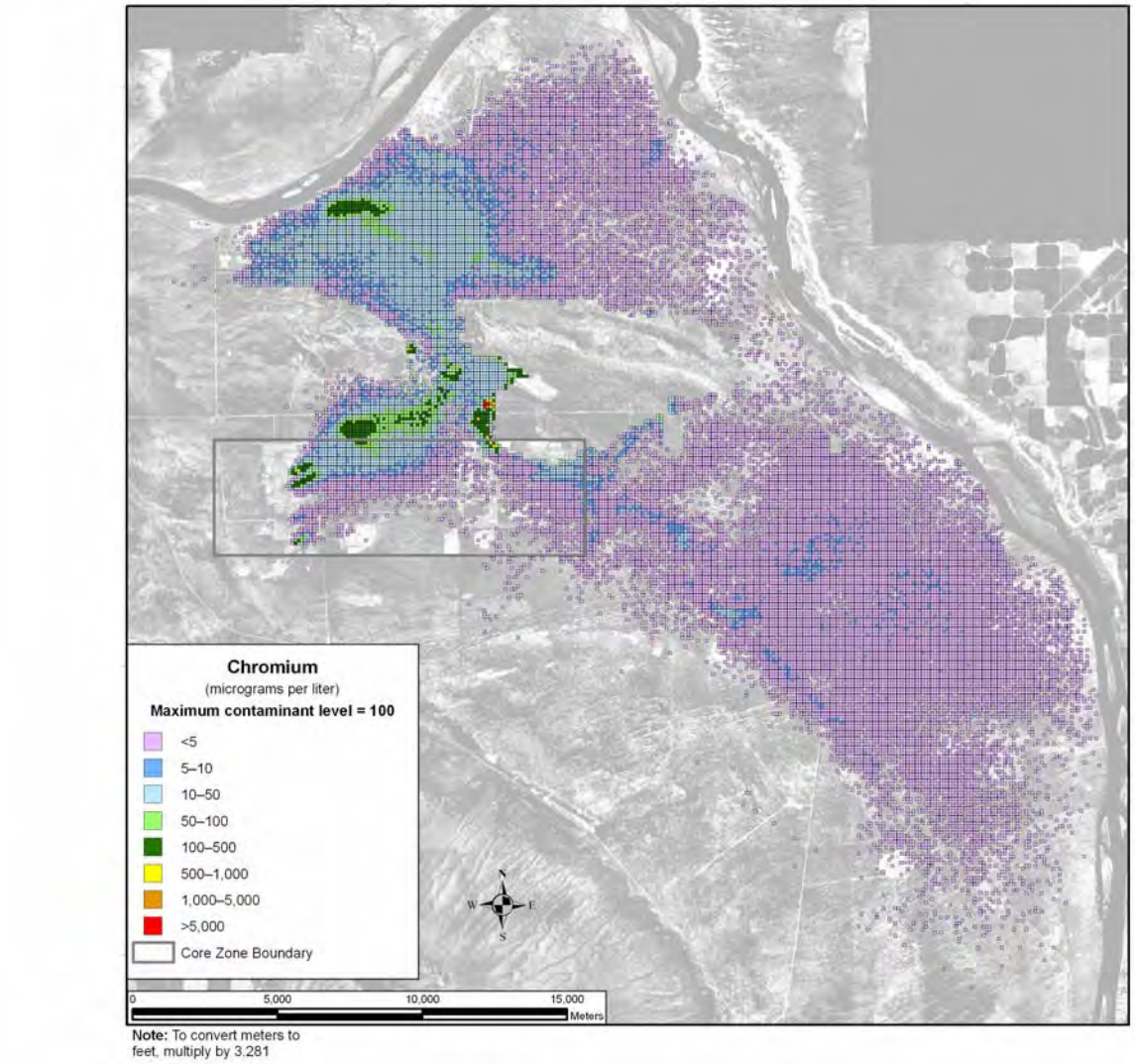


Figure 5–231. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

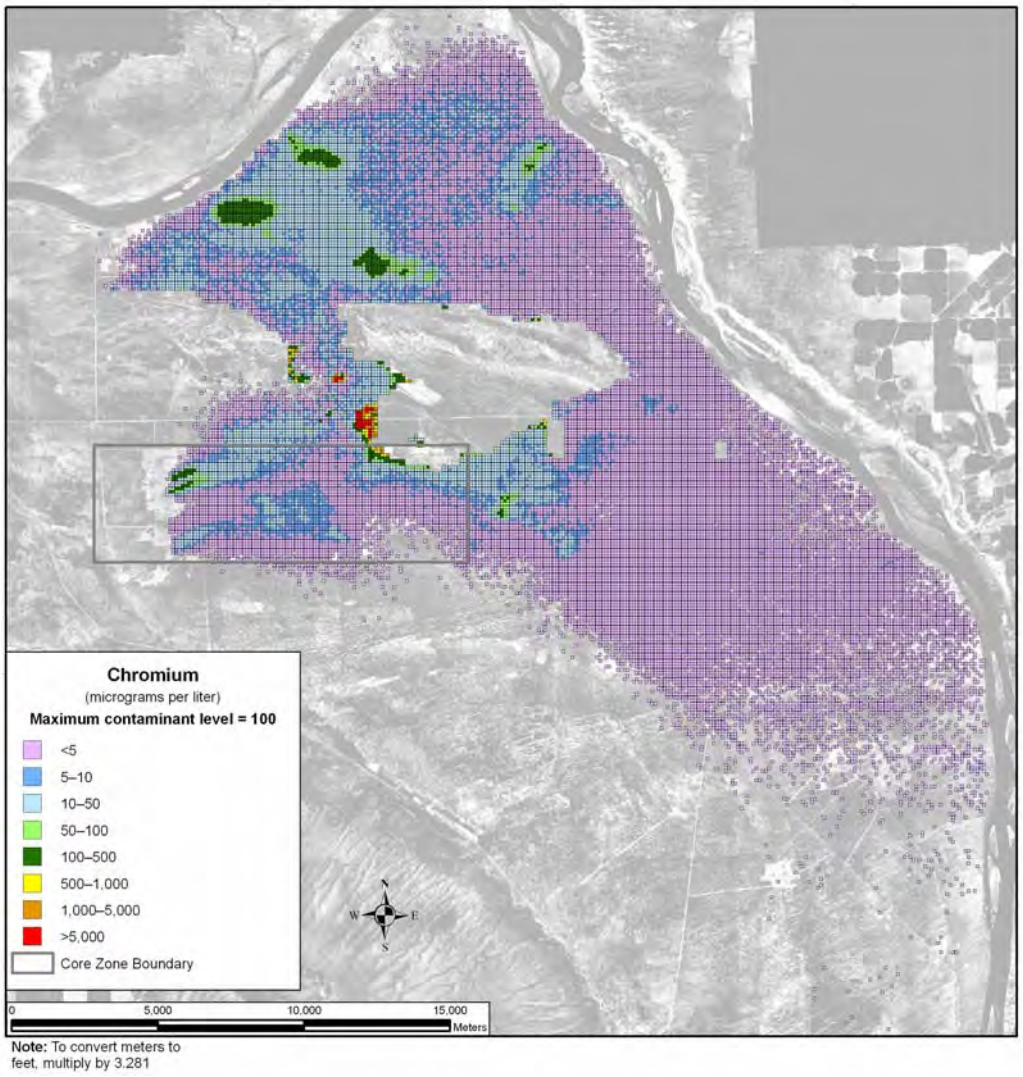


Figure 5–232. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2135

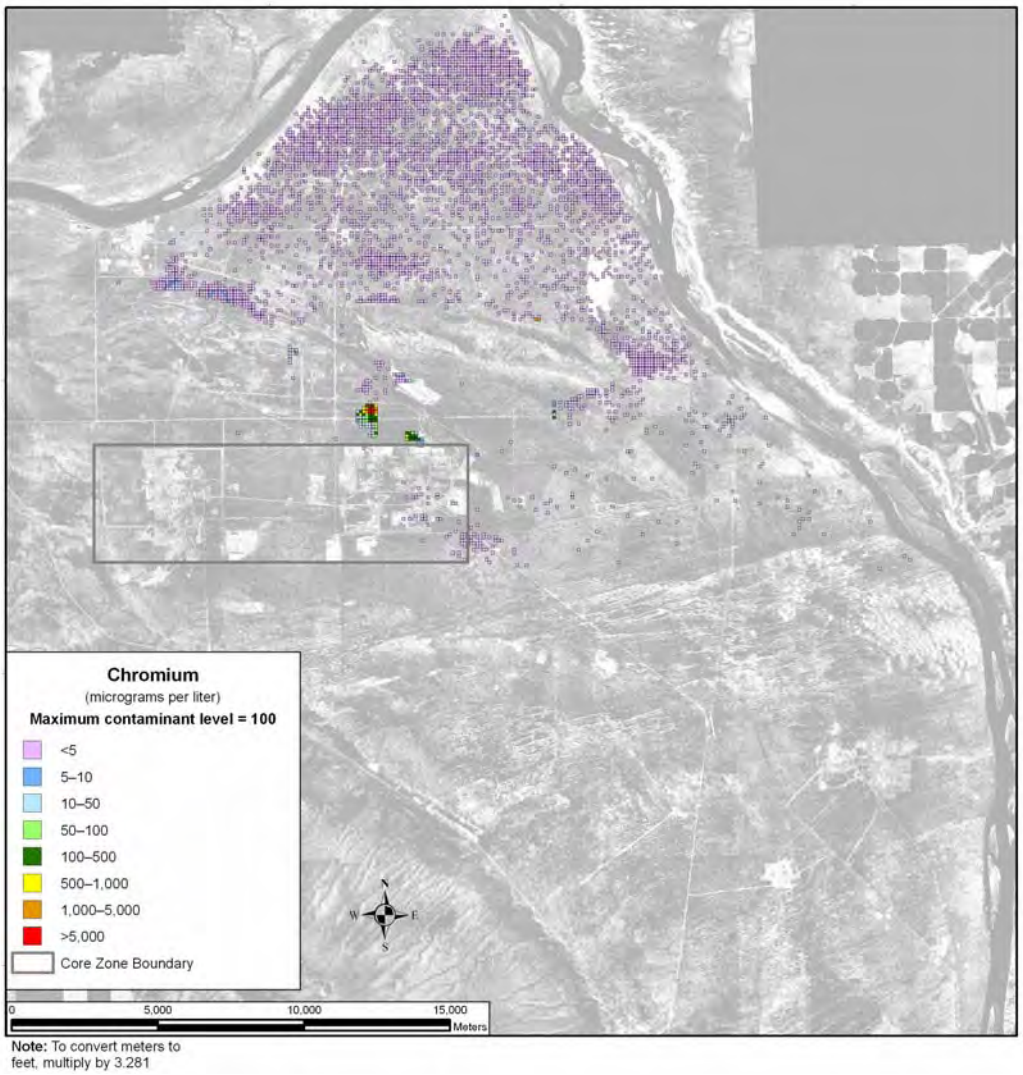


Figure 5–233. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

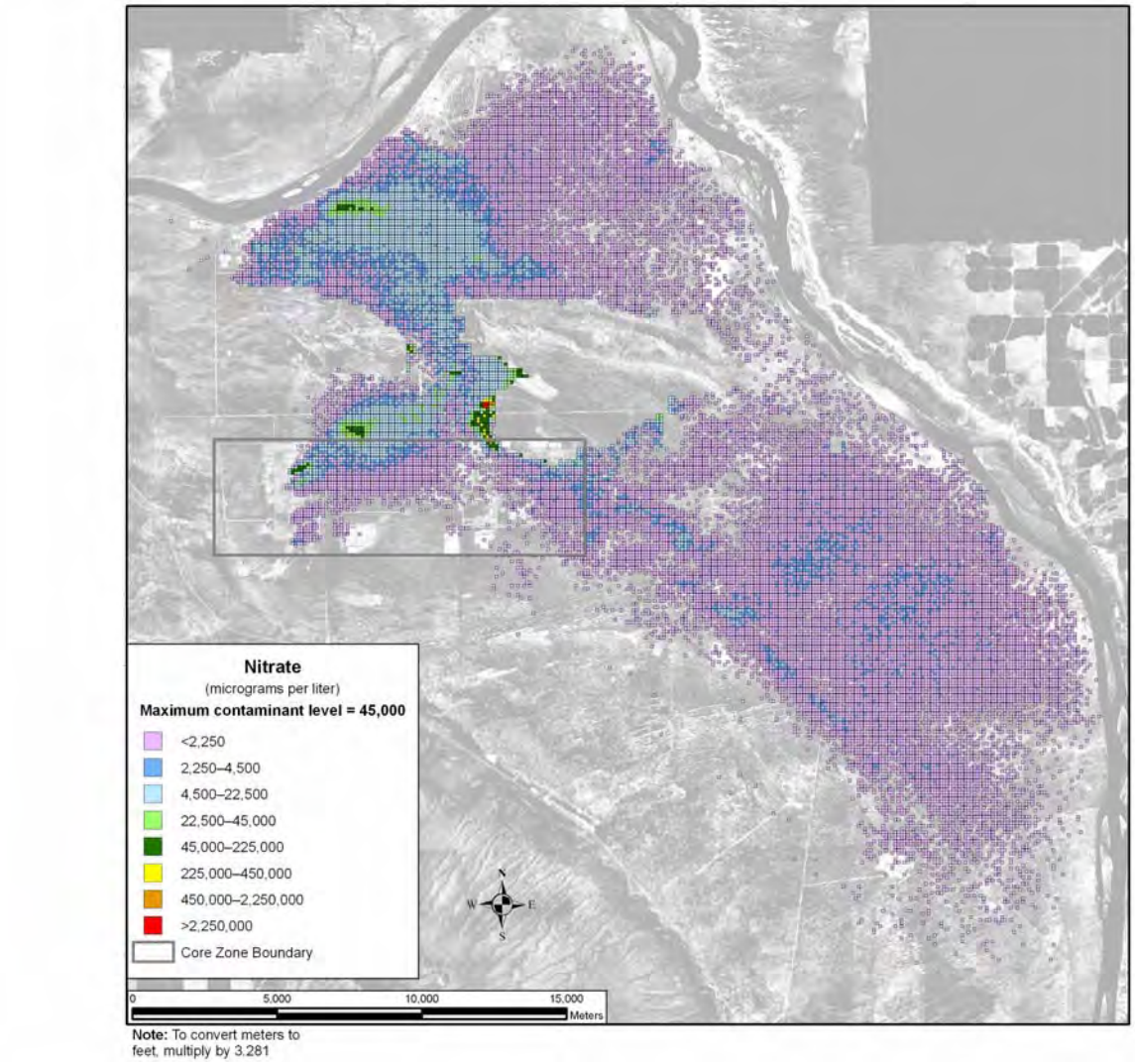


Figure 5–234. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

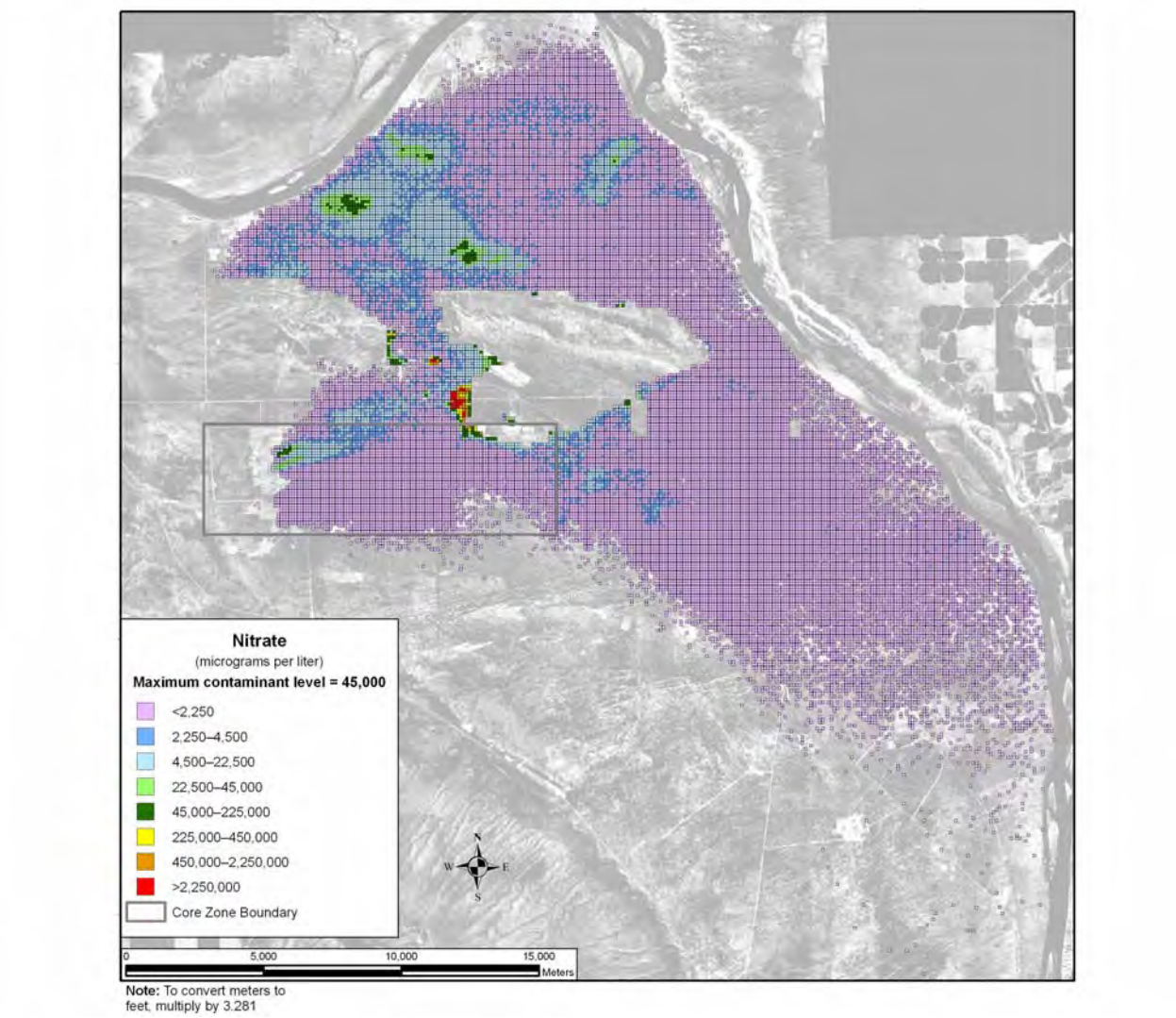


Figure 5–235. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2135

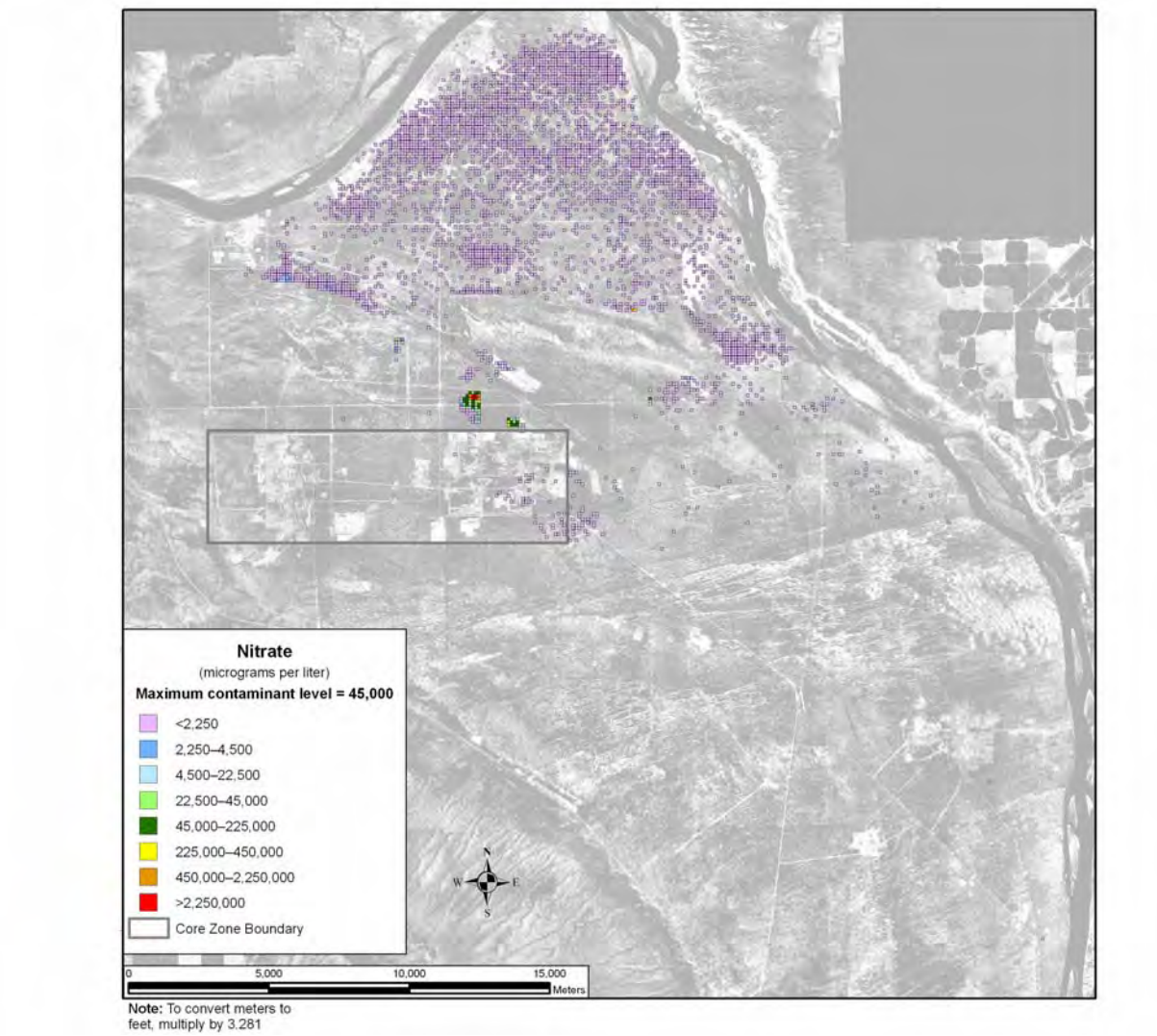


Figure 5–236. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium under the Base Case are not as mobile as those COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–237 shows the distribution of uranium-238 during CY 2005. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration and is contained within the Core Zone Boundary. By CY 7140, the area of the plume has grown and extended to the Columbia River (see Figure 5–238). Most of the plume is significantly below the benchmark except for a small pocket with high concentrations in the southern region of Gable Gap extending north from the B Barrier. At CY 11,885, the greatest development of the plume during the analysis period is seen (see Figure 5–239). The only area with a significant level of contaminant concentration is the area in the southern region of Gable Gap that originates from the B Barrier. Figures 5–240 through 5–242 show similar results for total uranium.

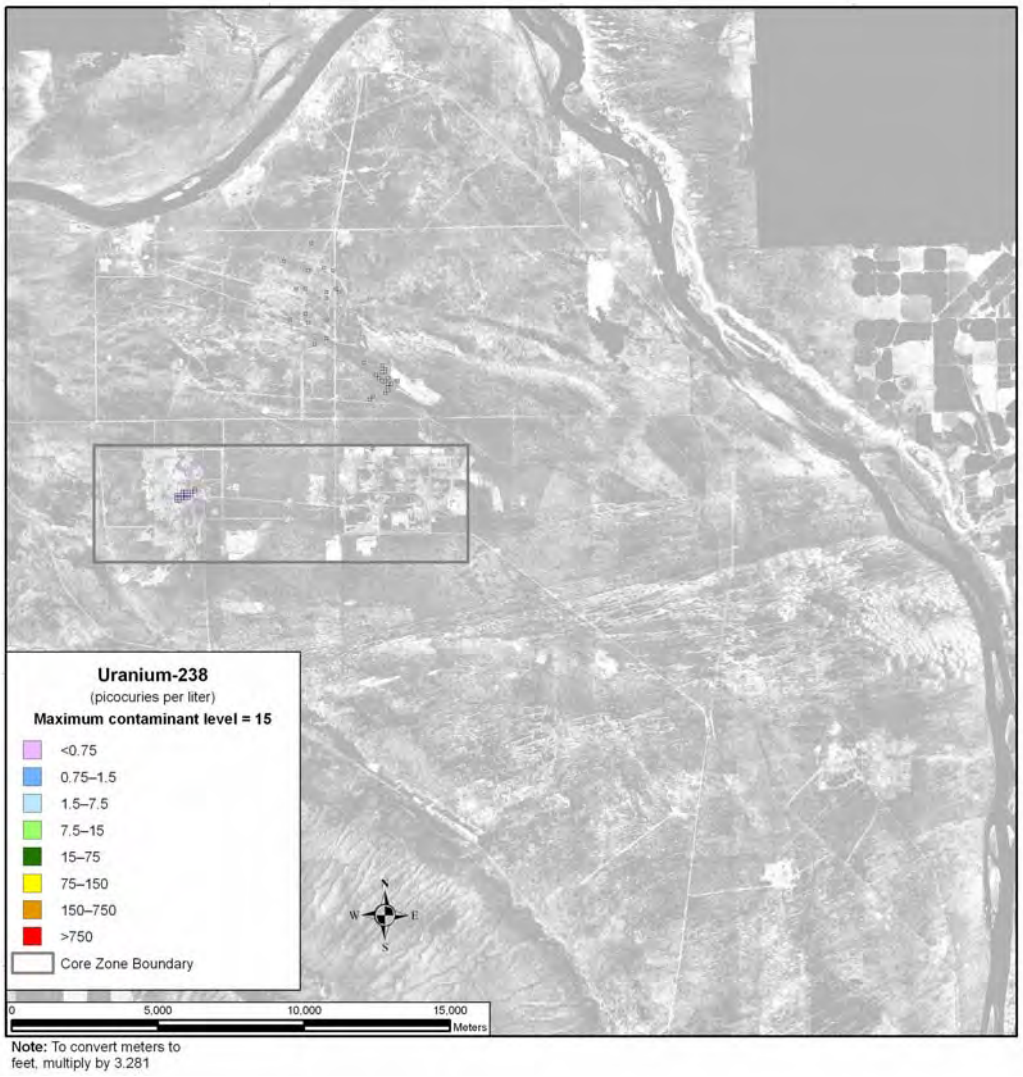


Figure 5–237. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

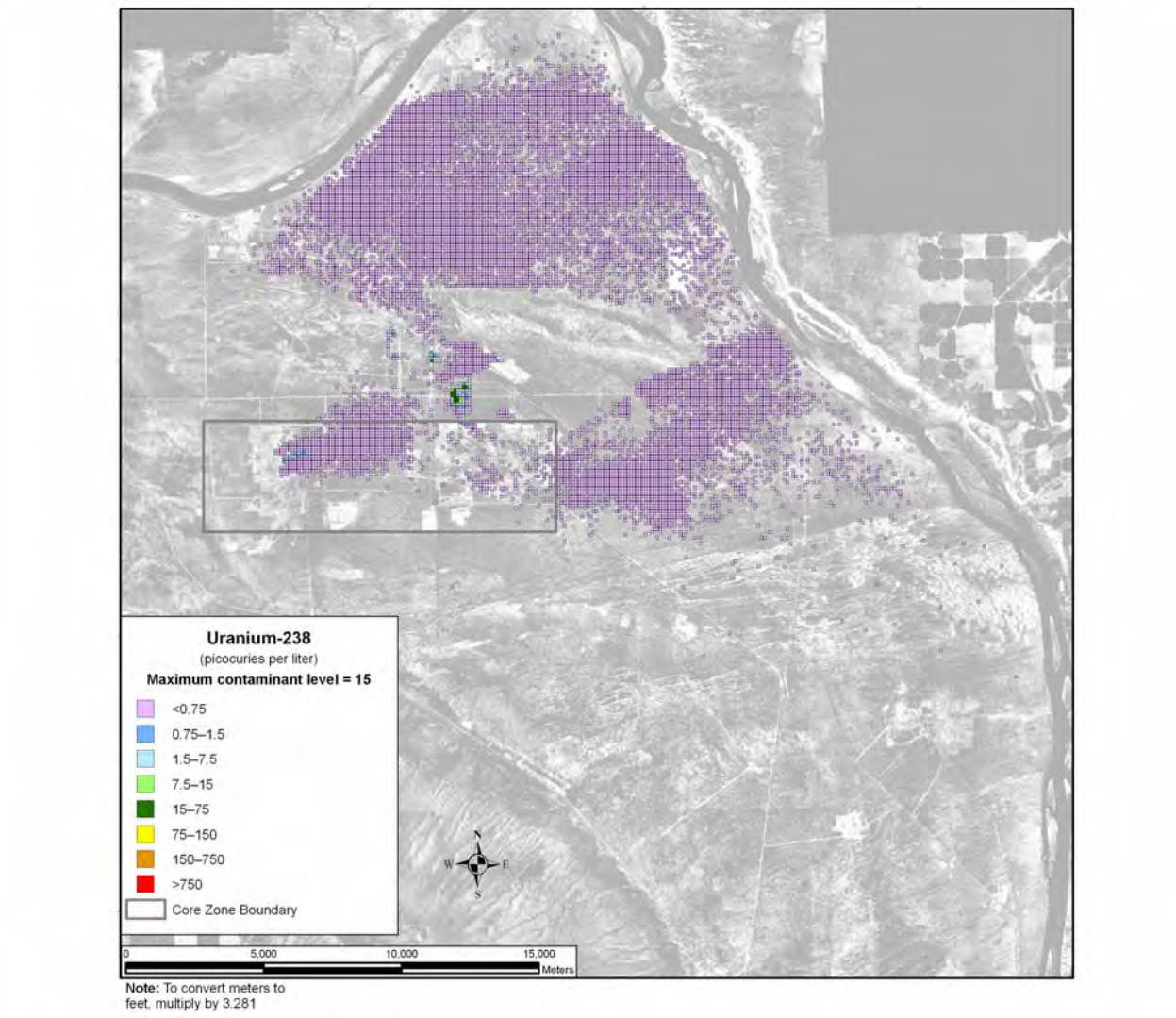


Figure 5–238. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 7140

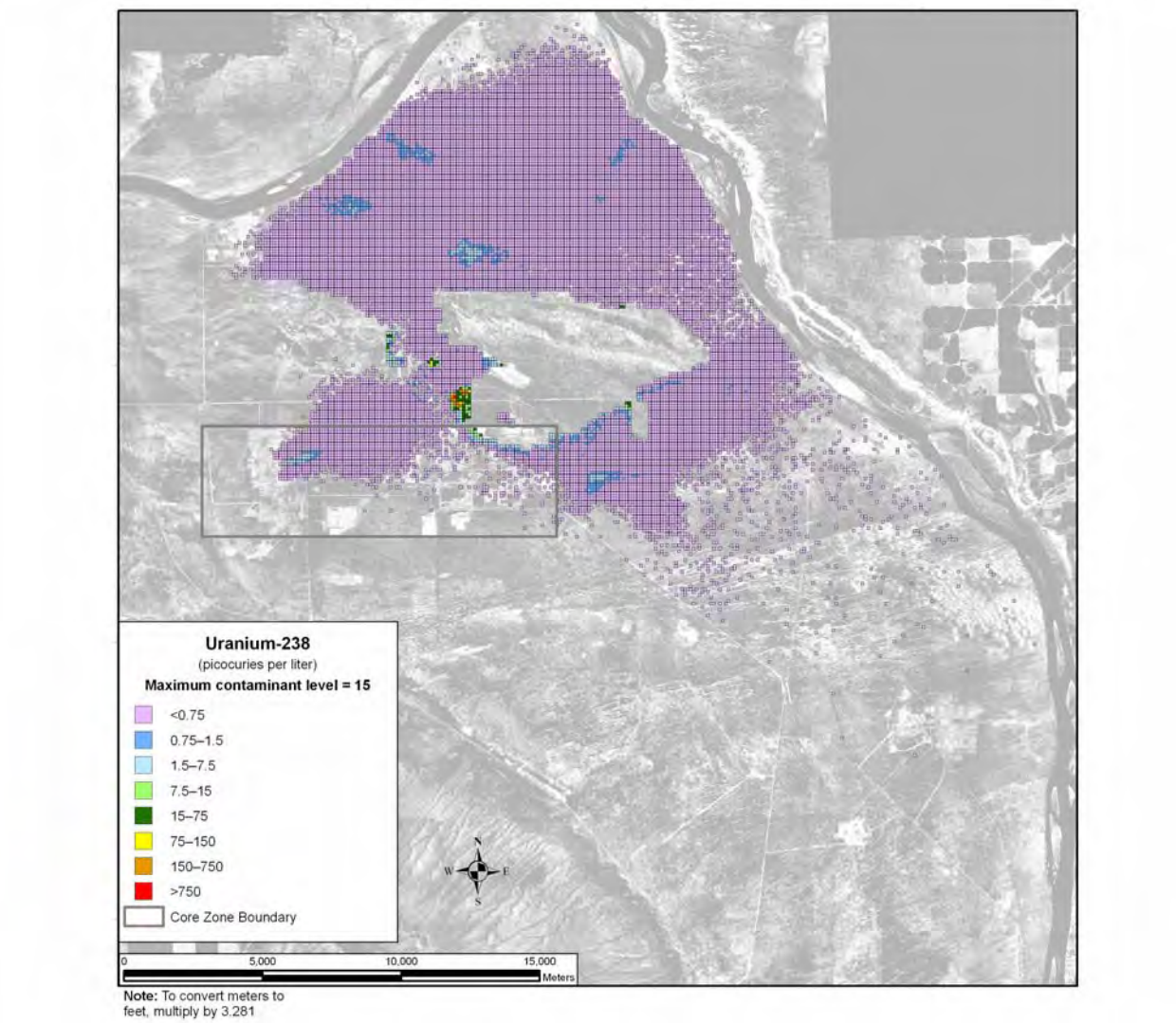


Figure 5–239. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

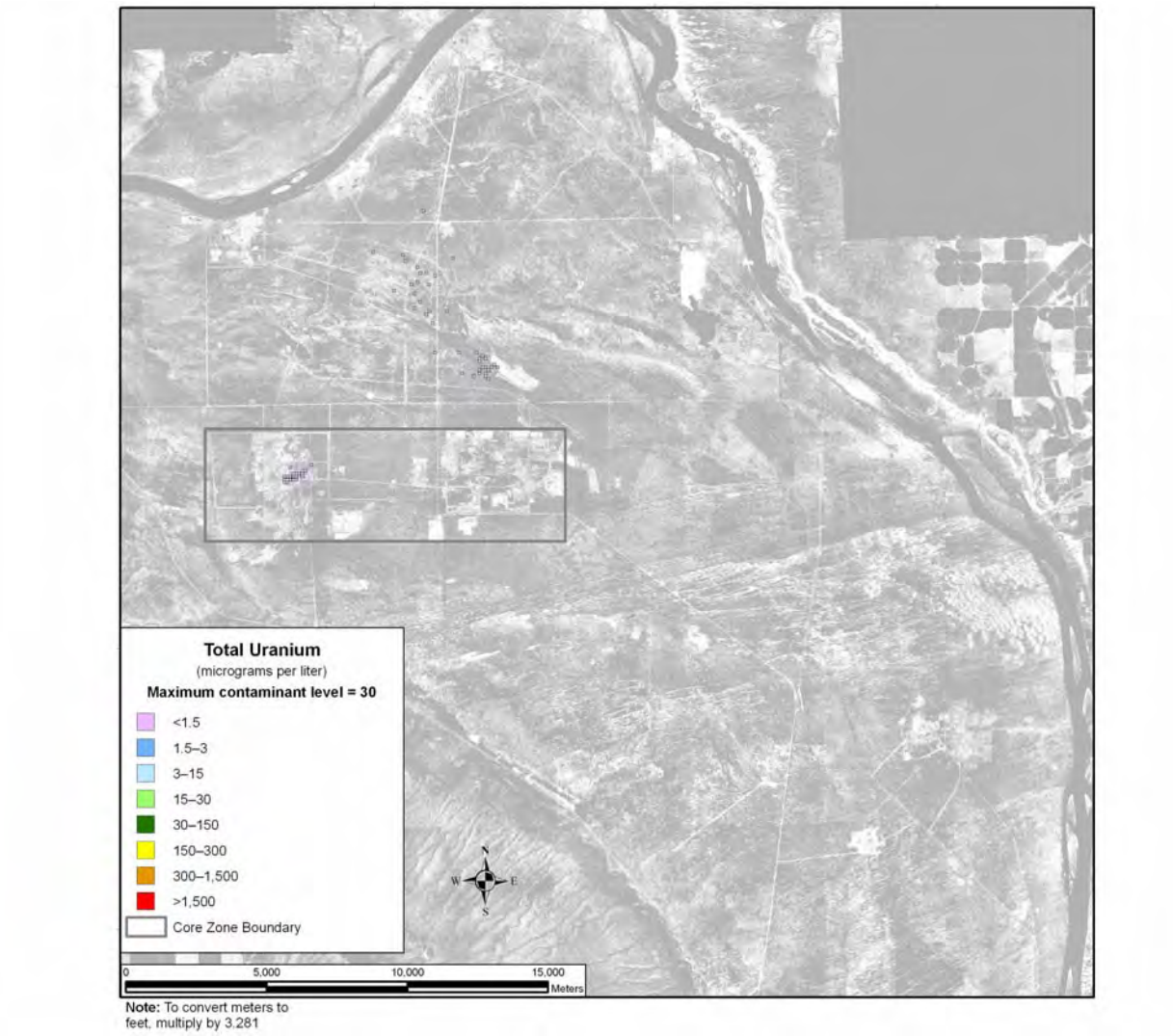


Figure 5–240. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

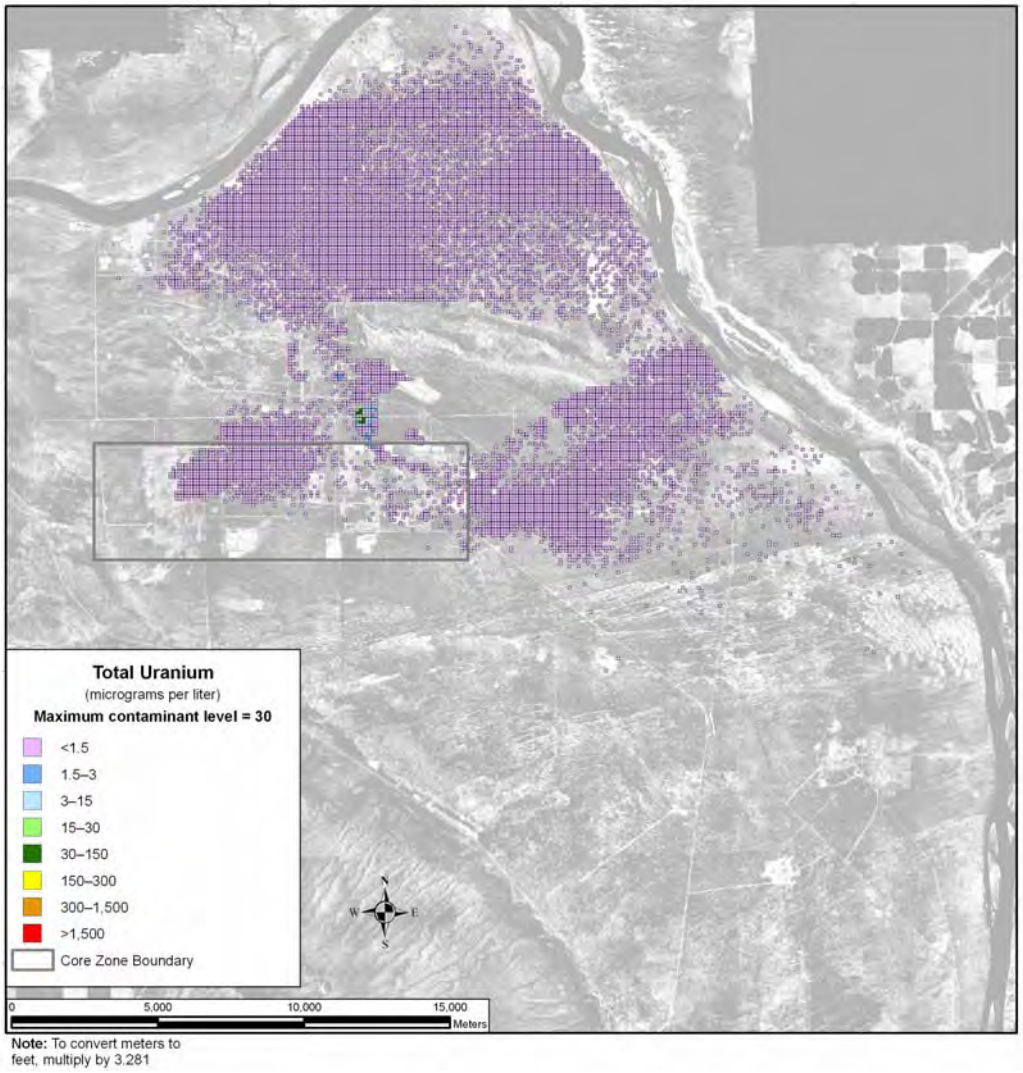


Figure 5–241. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 7140

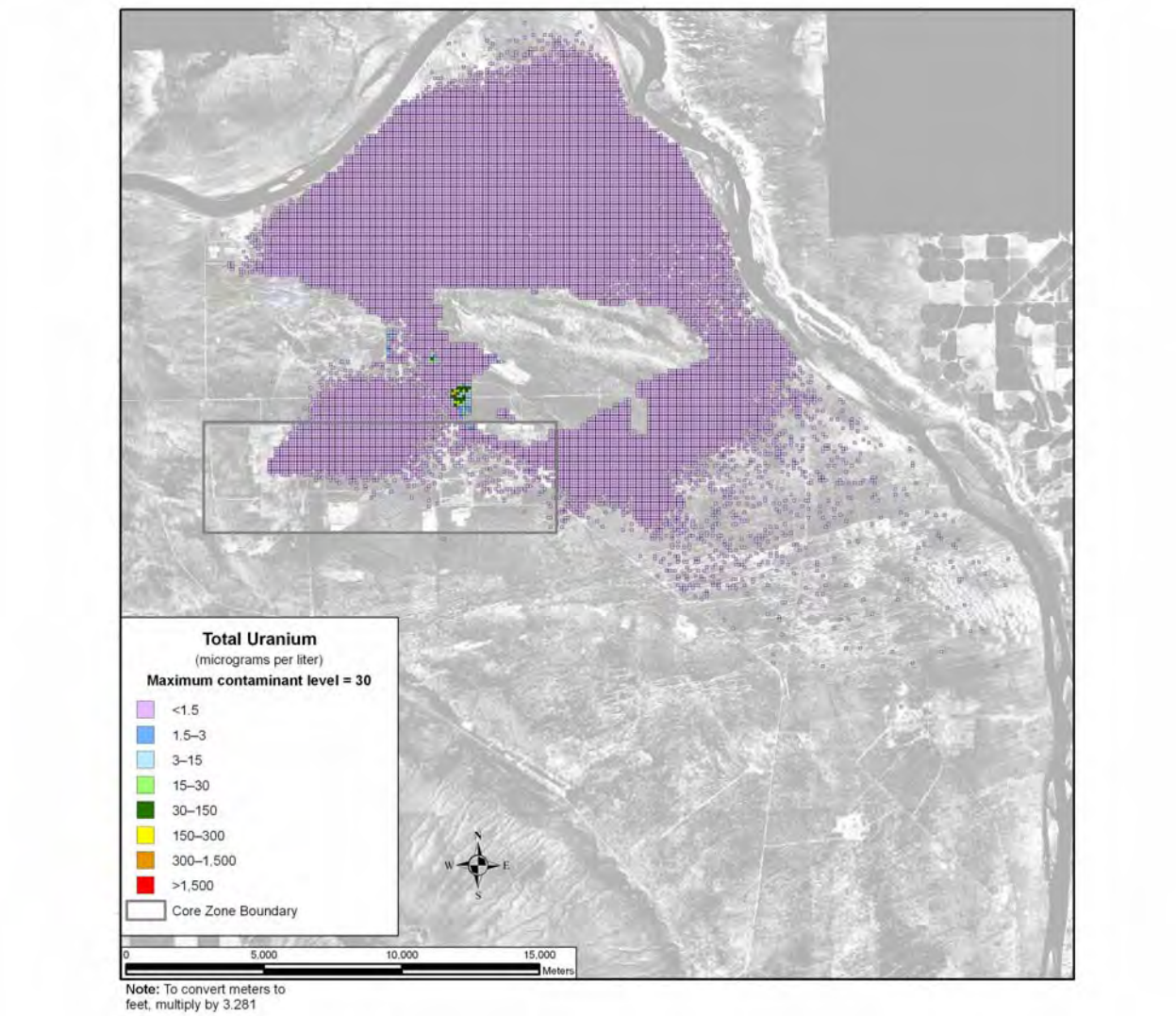


Figure 5–242. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

Figure 5–243 shows the distribution of uranium-238 during CY 2005 under the Option Case. There are two plumes associated with this case, one originating from the T Barrier and the other from the B Barrier. Although there are no significant contaminant concentrations, the plumes under the Option Case are much larger than under the Base Case. By CY 2135, the contaminant plume has grown and reached the Columbia River, but there are still no significant peaks in concentration levels (see Figure 5–244). By CY 11,885, while the greatest development of the plume occurred under the Base Case, the contaminant plume under the Option Case has begun to recede (see Figure 5–245). This recession is due to the removal of the six sets of cribs and trenches (ditches) and the remediation of their contaminant plumes. Figures 5–246 through 5–248 show similar results for total uranium.

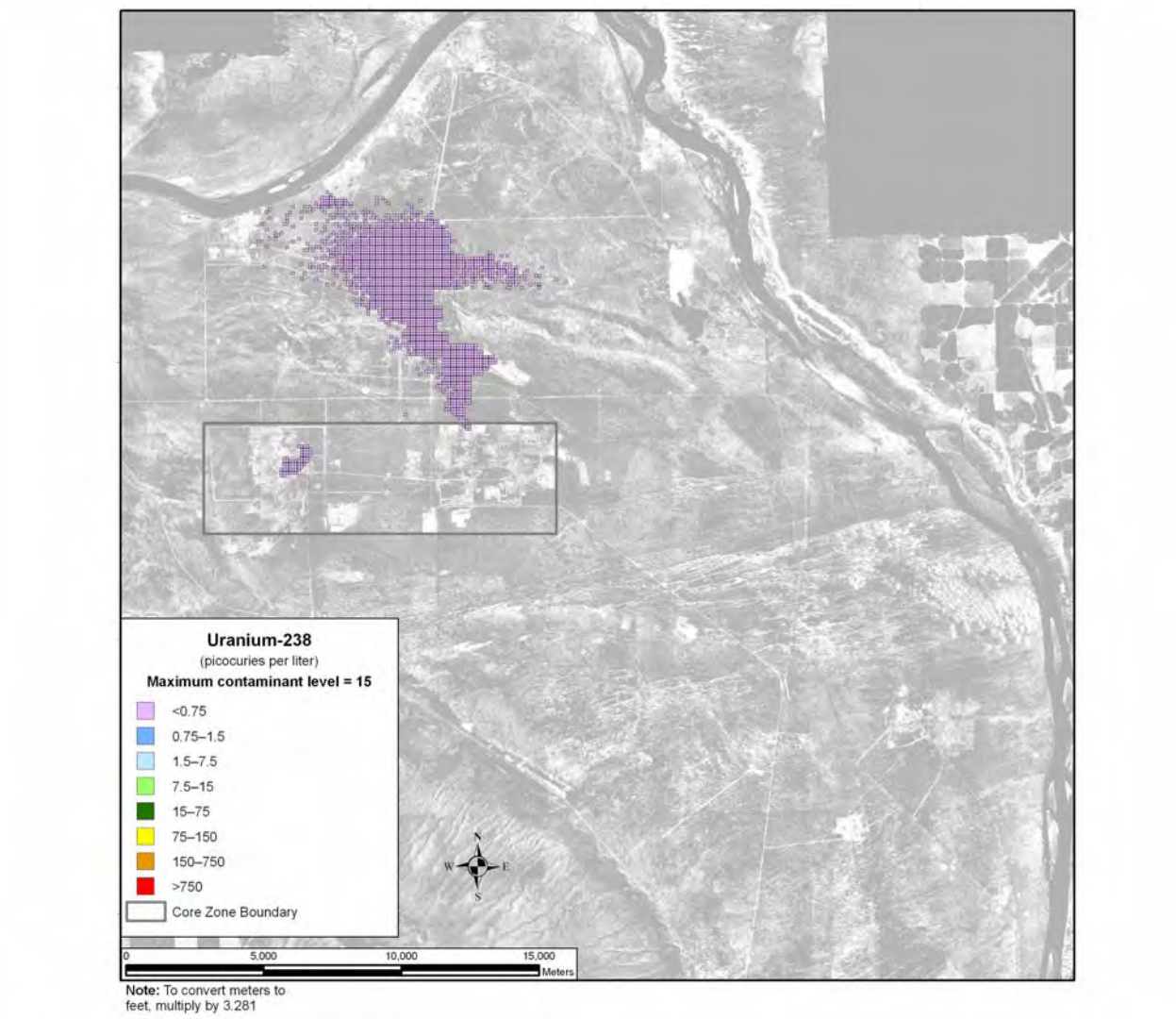


Figure 5–243. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

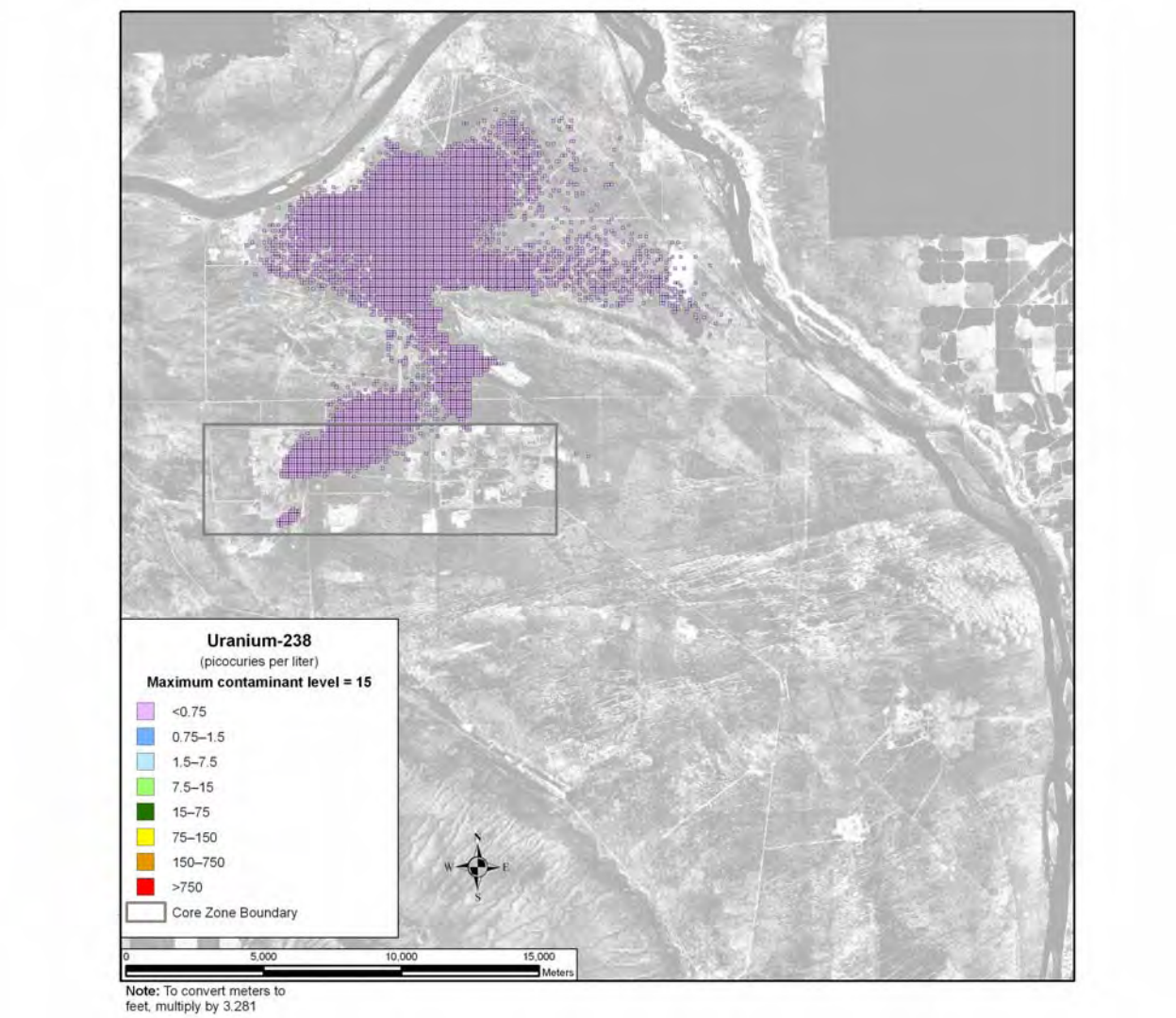


Figure 5–244. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135

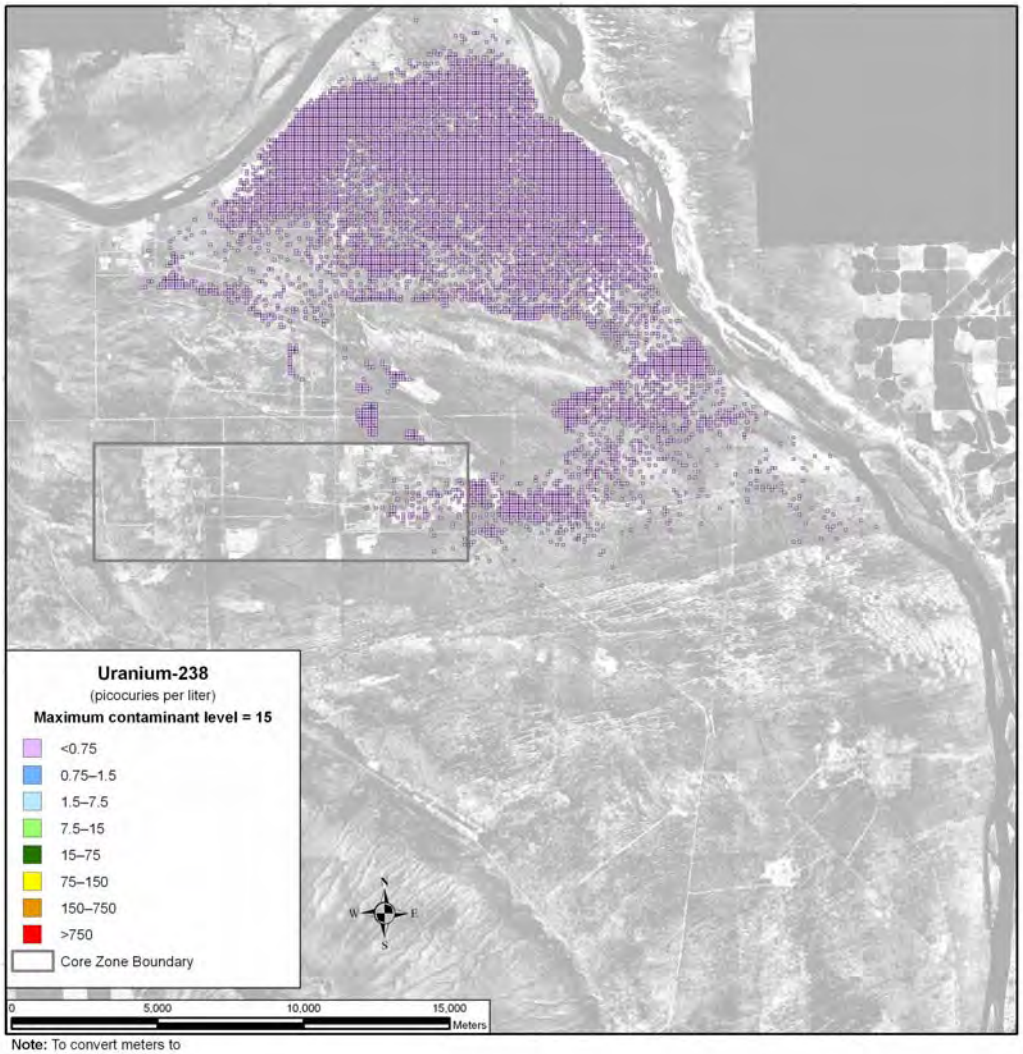


Figure 5–245. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

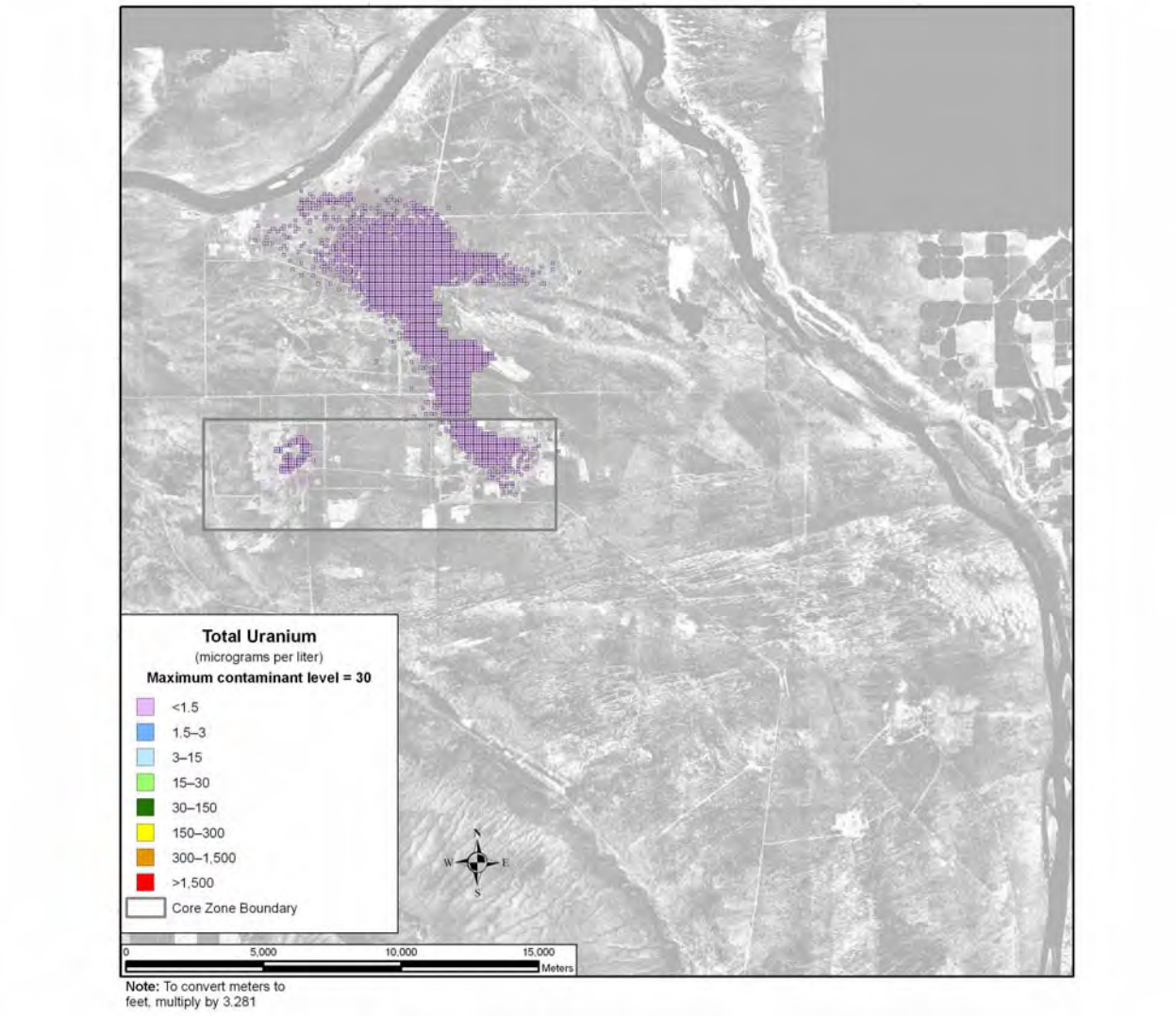


Figure 5–246. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

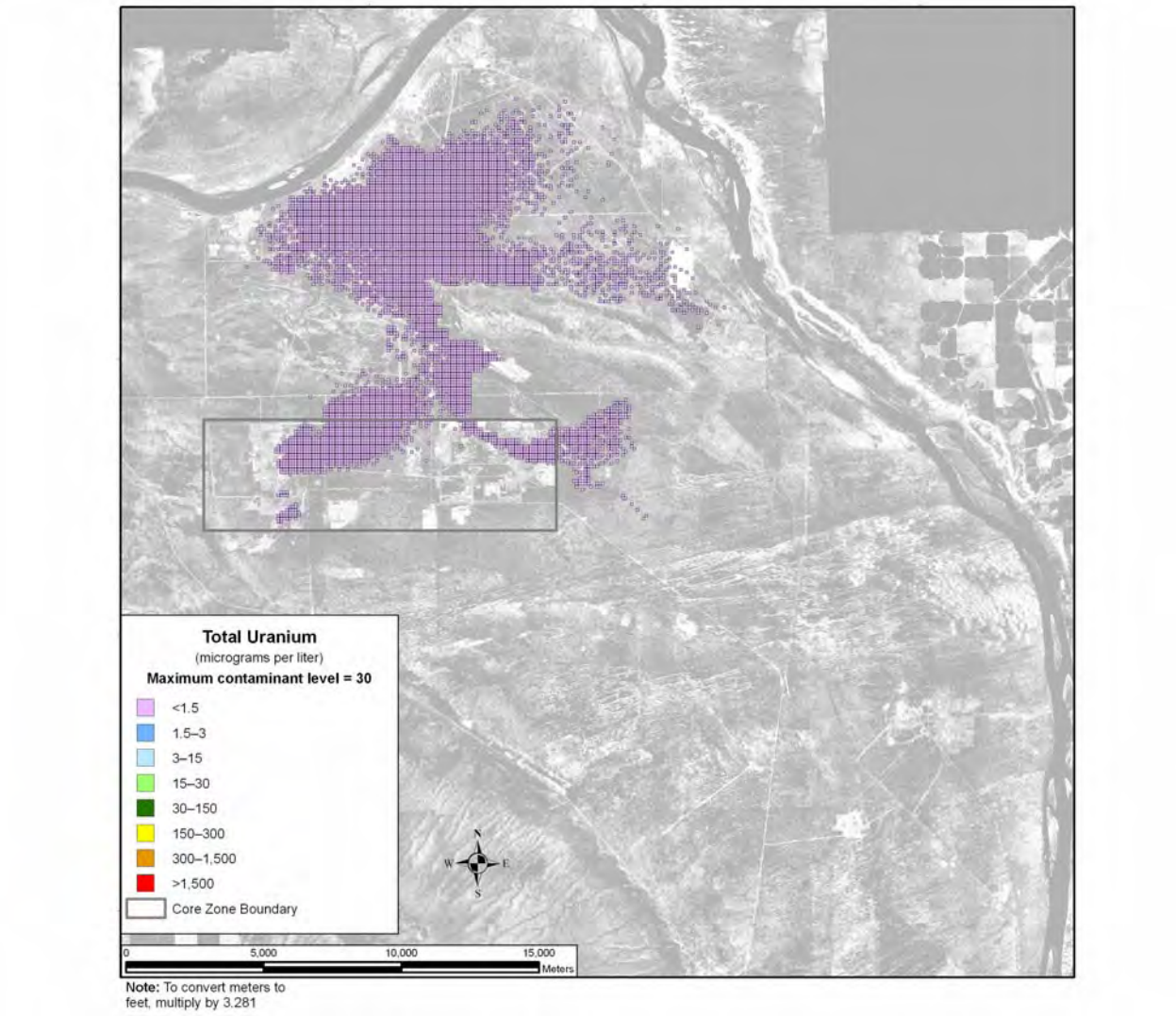


Figure 5–247. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135

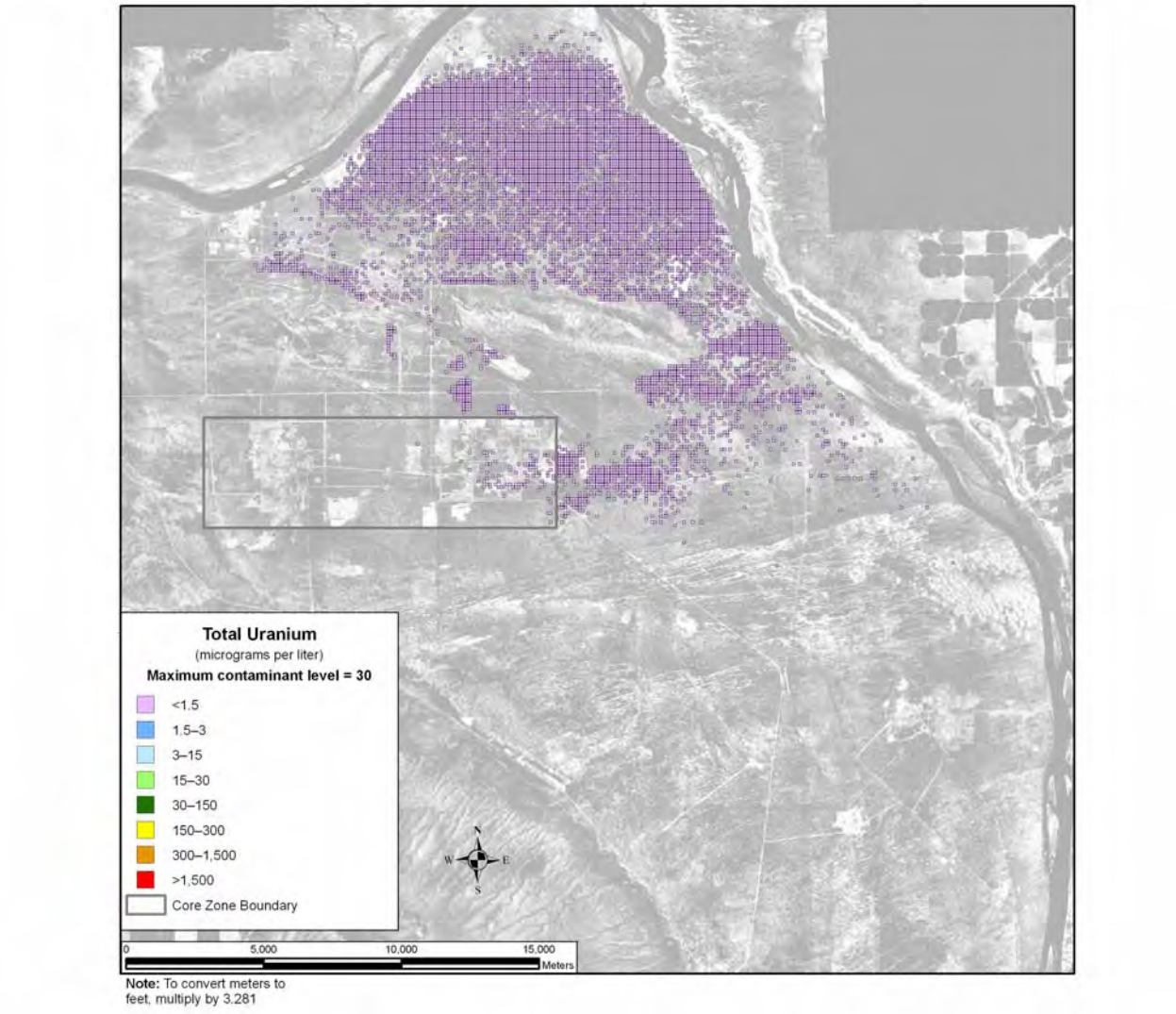


Figure 5–248. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

Figure 5–249 shows the area in square kilometers in which groundwater concentrations of technetium-99 exceed the benchmark concentration in the analysis as a function of time under the Base Case. A peak of almost 4.5 square kilometers (1.7 square miles) occurs around CY 2135, followed by a fairly sharp decrease. By about CY 4000, the area with a concentration above the benchmark begins to level out around 0.5 square kilometers (0.19 square miles). Iodine-129 shows a similar pattern (see Figure 5–250), as both constituents are conservative tracers.

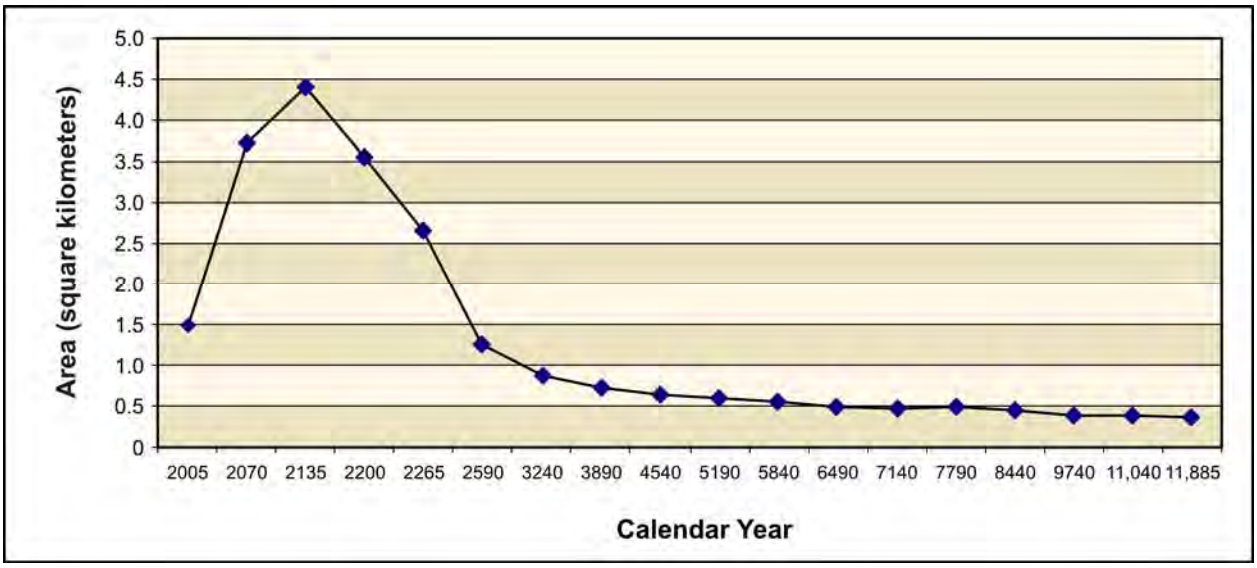


Figure 5–249. Tank Closure Alternative 6A, Base Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

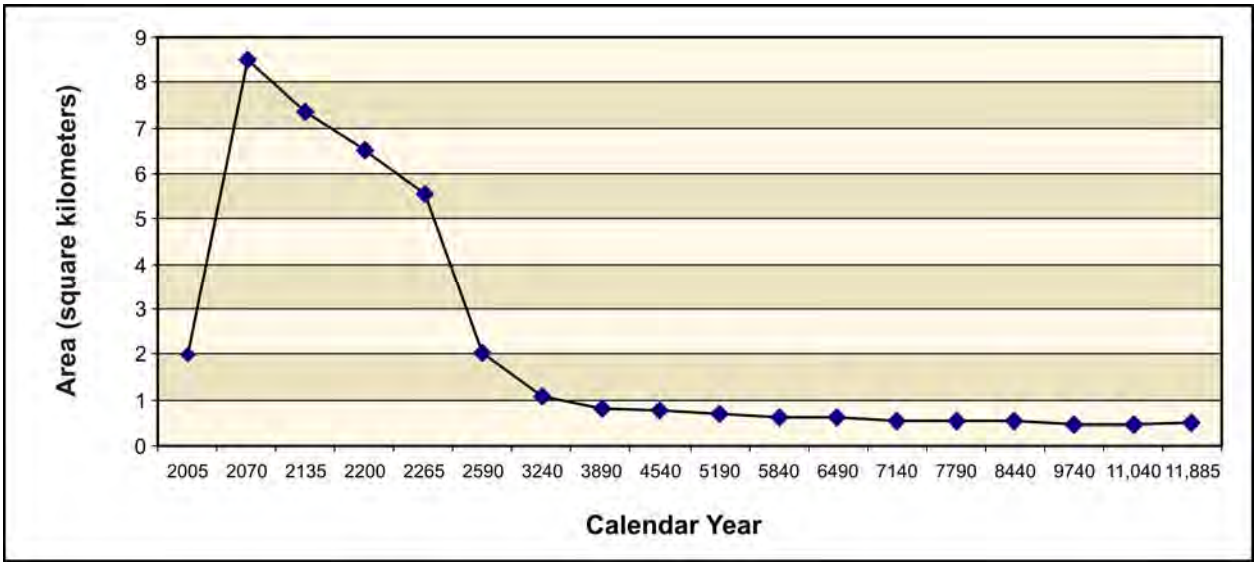


Figure 5–250. Tank Closure Alternative 6A, Base Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Option Case, the areas with concentrations of technetium-99 and iodine-129 above the benchmarks are essentially identical to those under the Base Case (see Figures 5–251 and 5–252).

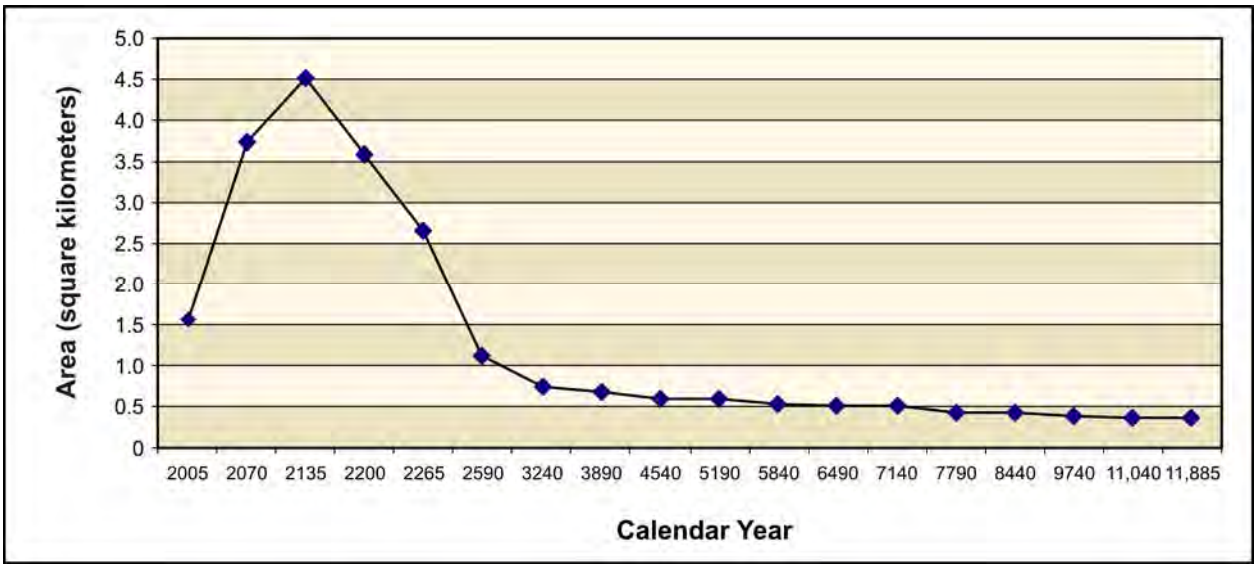


Figure 5–251. Tank Closure Alternative 6A, Option Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

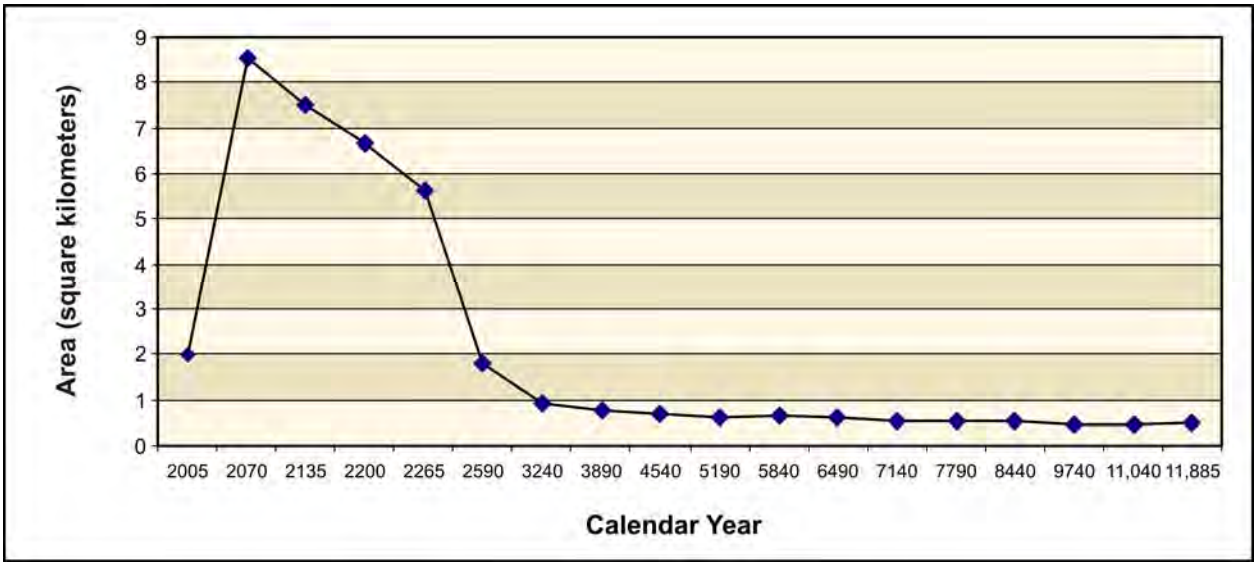


Figure 5–252. Tank Closure Alternative 6A, Option Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Base Case, uranium-238 did not register above the benchmark concentration in any area until after CY 5840 (see Figure 5–253). A sharp increase in area with concentrations above the maximum contaminant level occurs after CY 5840 and continues to rise through the end of the period of analysis (CY 11,940). It is expected that the majority of the uranium-238 would continue to migrate through the vadose zone after the period of analysis is over.

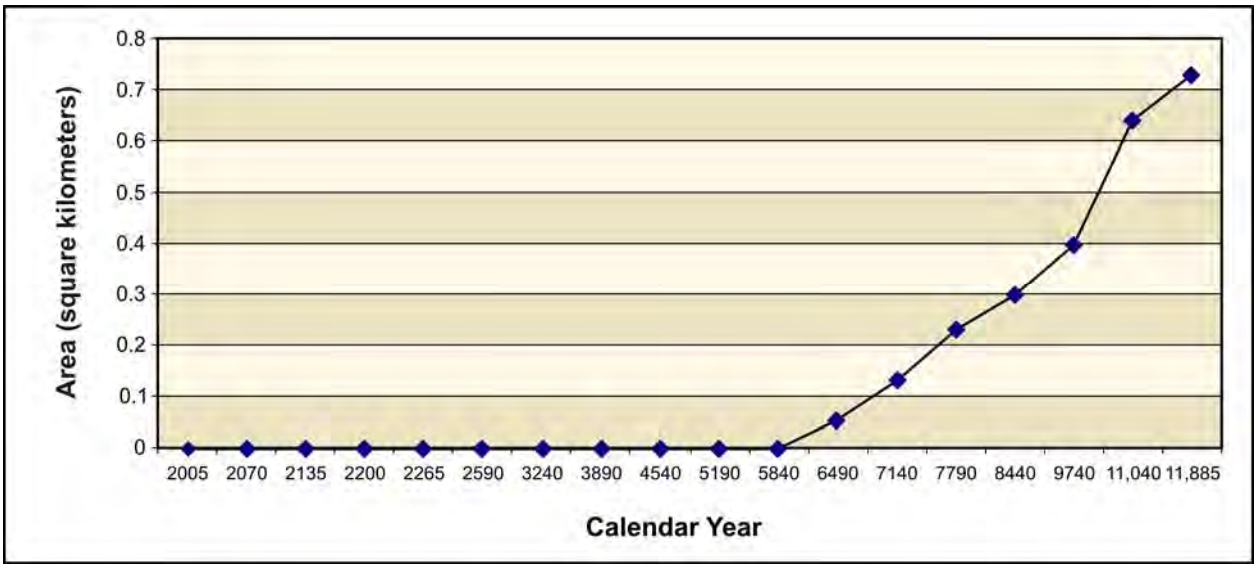


Figure 5–253. Tank Closure Alternative 6A, Base Case, Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Option Case, uranium-238 did not register above the benchmark concentration in any area during the period of analysis. This is a result of the high retardation rate and the removal and remediation of the cribs and trenches (ditches).

5.1.1.9.6 Summary of Impacts

For the conservative tracers under the Base Case, concentrations at the Core Zone Boundary exceeded the benchmark standards by about two orders of magnitude during the early part of the period of analysis, around CY 1956. Columbia River nearshore concentrations never reached the benchmark concentration and peaked at about one-half to one order of magnitude below it. The intensities and areas of these groundwater plumes peaked around CY 1956.

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Option Case are essentially identical to those under the Base Case.

For tritium under the Base Case, concentrations at the Core Zone Boundary exceed the benchmark by about two orders of magnitude for a short period of time during the early part of the period of analysis, around CY 1956. During the same period of time, the Columbia River nearshore concentrations peaked at about one order of magnitude below the benchmark. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium.

The concentrations of tritium under the Option Case are essentially identical to those under the Base Case.

For uranium-238 and total uranium under the Base Case, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species began to approach the benchmark at the Core Zone Boundary toward the latter part of the period of

analysis but never reached it. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never came to within about two orders of magnitude below the benchmark. The intensity and area of the contaminant plumes peaked at the end of the period of analysis.

Under the Option Case, uranium-238 concentrations in the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark, except for a short spike in the Core Zone Boundary to about one order of magnitude below the benchmark at the beginning of the period of analysis. The Columbia River nearshore concentrations stayed fairly constant at about four orders of magnitude below the benchmark. Total uranium concentrations at the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark. The Columbia River nearshore concentrations remained fairly constant at around four and a half orders of magnitude below the benchmark.

5.1.1.10 Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure, Base and Option Cases

This section describes the groundwater analysis results for Tank Closure Alternative 6B, including long-term groundwater impacts of contaminant sources within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

Tank Closure Alternative 6B, Base and Option Cases, resembles Tank Closure Alternative 6A, Base and Option Cases, except that waste retrieval and processing would proceed at a faster rate and closure would occur at an earlier date.

Under Tank Closure Alternative 6B, Base Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier.

Under Tank Closure Alternative 6B, Option Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. In addition, the adjacent cribs and trenches (ditches) would be clean-closed.

5.1.1.10.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 6B are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, three major periods were identified for Tank Closure Alternative 6B, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 6B that are presented in this section are common to all of the Tank Closure alternatives.

- The retrieval period was assumed to start in 2008 and end in CY 2101. During this period, 99.9 percent of the waste would be retrieved from the tanks and all tank farms would be clean-closed.

- The post–administrative control period was assumed to start in CY 2102 and continue through the 10,000-year period of analysis until CY 11,940.

5.1.1.10.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 6B. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Tank Closure Alternative 6B is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 6B were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers, although their contribution to risk and hazard are not dominant during the year of peak risk or hazard. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-11}, which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 6B.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.10.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 6B in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms (see Figures 5–254 through 5–265). Two subtotals are plotted representing releases from cribs and trenches (ditches) and from past leaks. Amounts released from other tank farm sources are negligible for the purposes of this discussion. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–254 shows the estimated release to the vadose zone for the radiological risk drivers under the Base Case, which would include use of a modified RCRA Subtitle C barrier, and Figure 5–255, the chemical hazard drivers. The predominant sources for tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers the predominant sources are from past leaks. This suggests that past leaks, which were released during the past-practice period, as well as the cribs and trenches (ditches) are both important impact drivers under Tank Closure Alternative 6B, Base Case.

Figure 5–256 shows the estimated release to the vadose zone for the radiological risk drivers under the Option Case, which would include clean closure of cribs and trenches (ditches), and Figure 5–257, the chemical hazard drivers. The predominant sources for tritium, the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), uranium-238, and total uranium are similar to those in the vadose zone under the Base Case.

Figure 5–258 shows the estimated release to groundwater for the radiological risk drivers under the Base Case and Figure 5–259, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

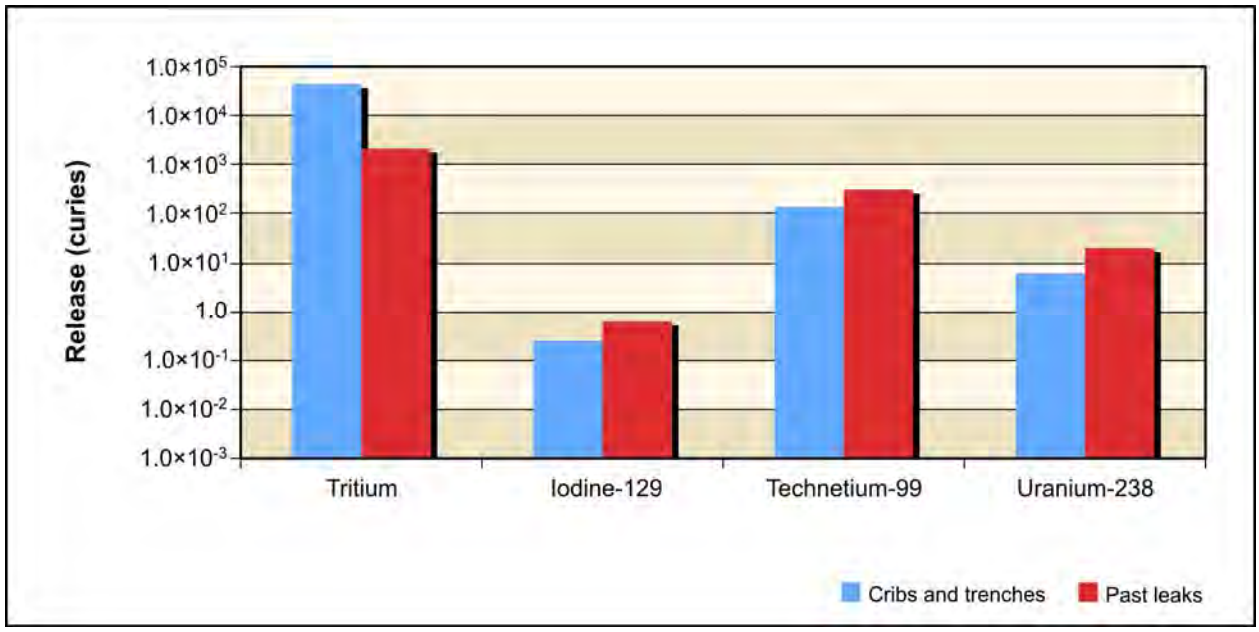


Figure 5–254. Tank Closure Alternative 6B, Base Case, Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

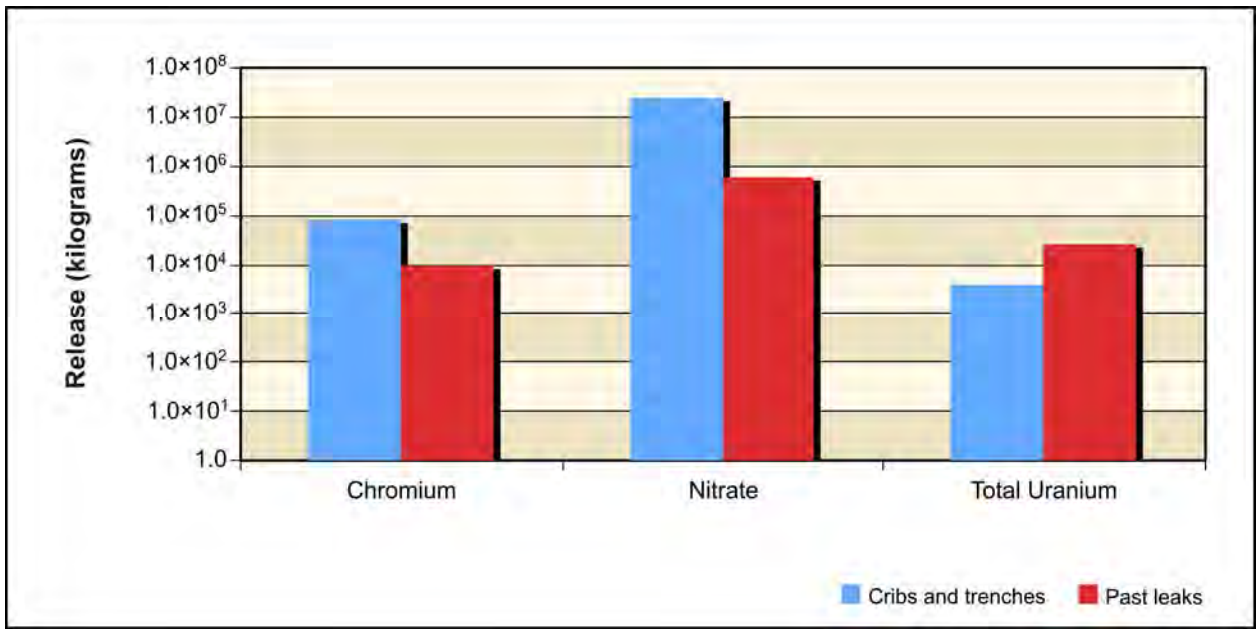


Figure 5–255. Tank Closure Alternative 6B, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

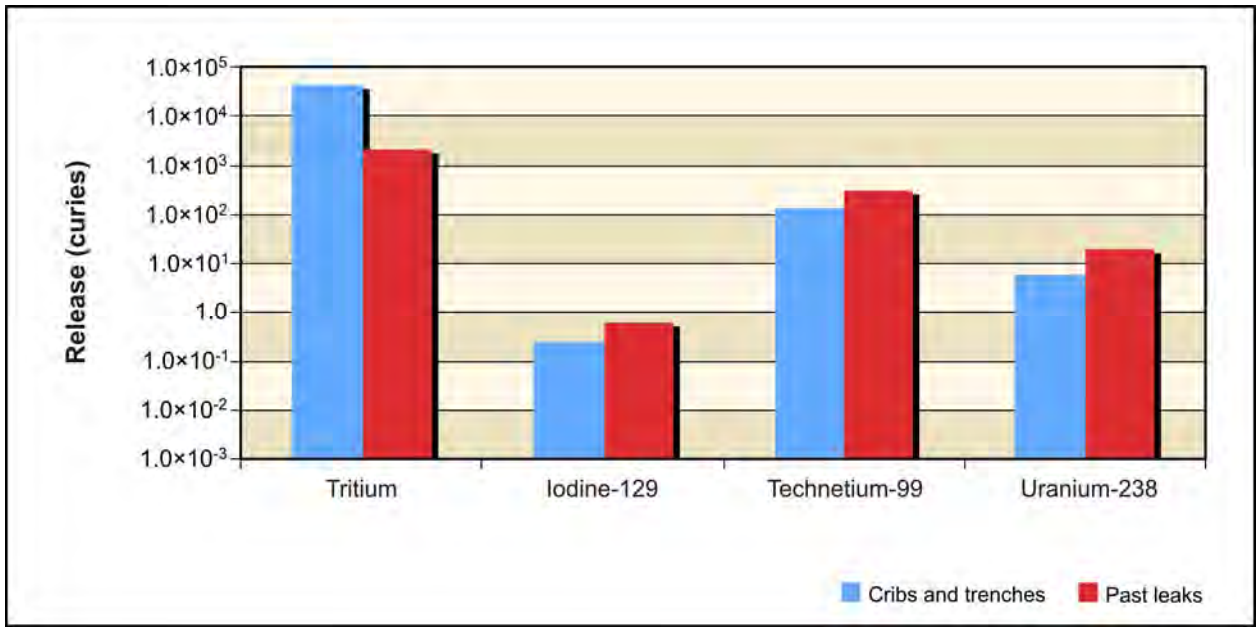


Figure 5–256. Tank Closure Alternative 6B, Option Case, Releases of Radiological Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

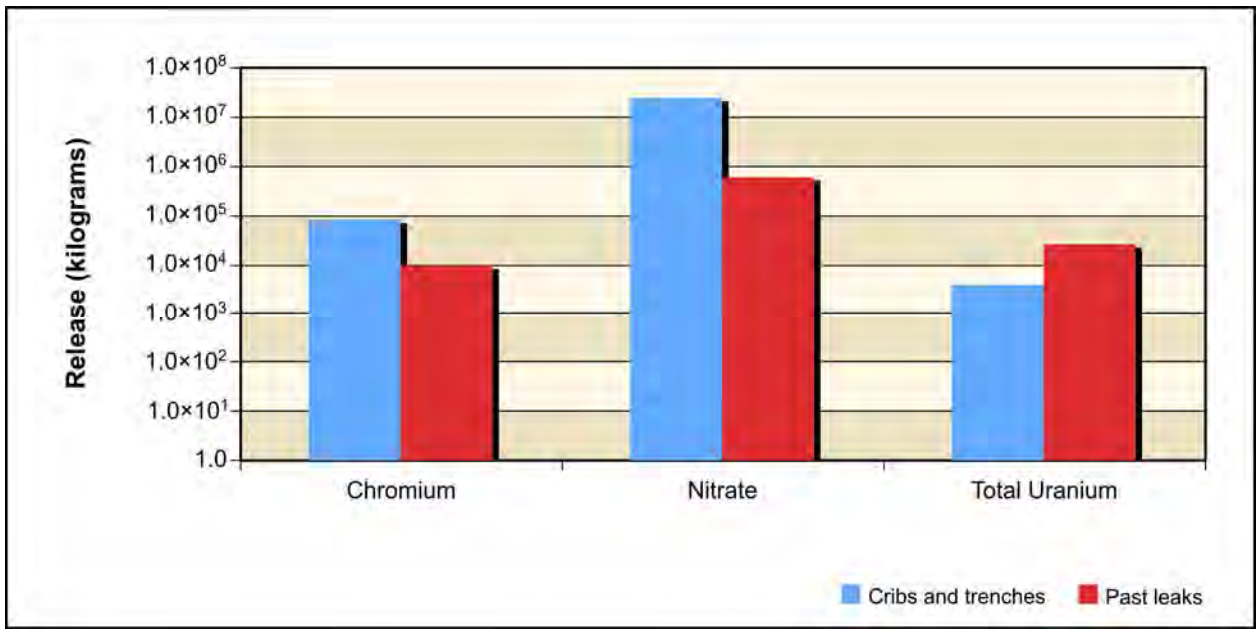


Figure 5–257. Tank Closure Alternative 6B, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

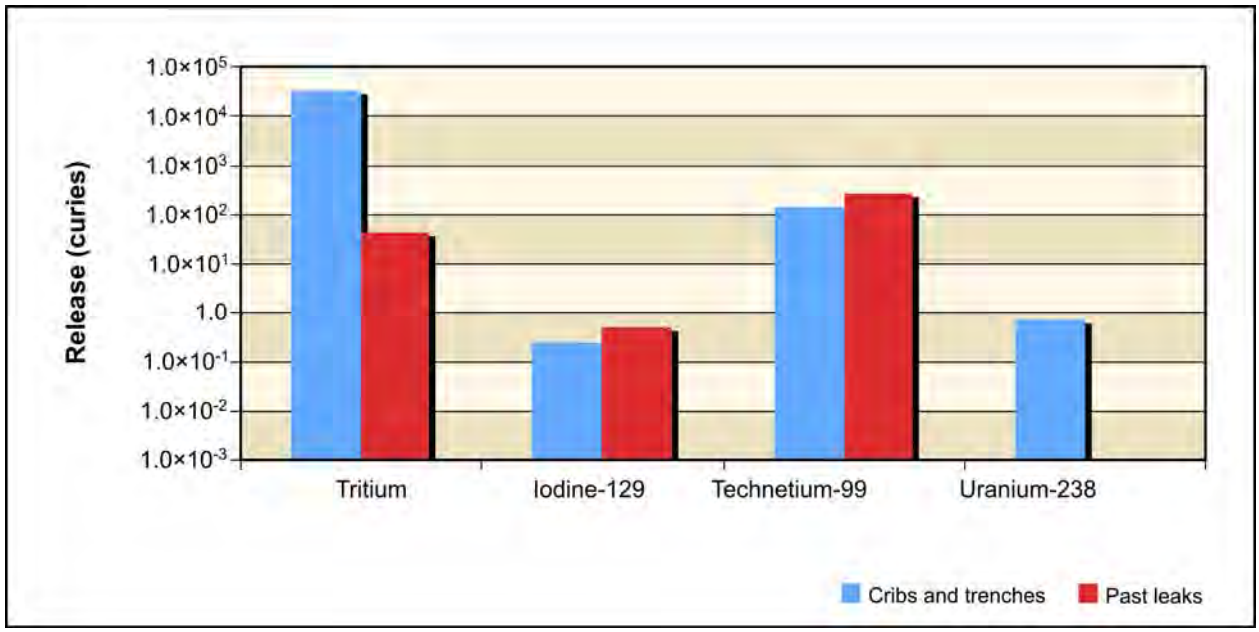


Figure 5–258. Tank Closure Alternative 6B, Base Case, Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

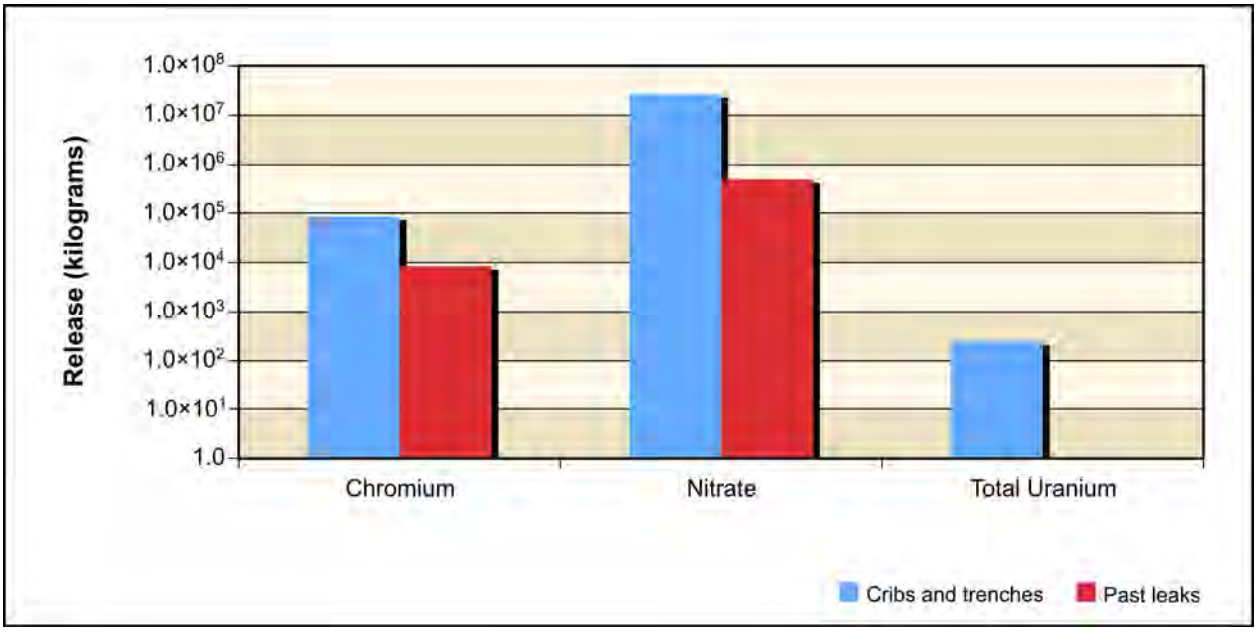


Figure 5–259. Tank Closure Alternative 6B, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For tritium, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 74 percent of the total inventory reached groundwater in the analysis; for past leaks, only 2 percent reached groundwater. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts would occur later in the post–administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–260 shows the estimated release to groundwater for the radiological risk drivers under the Option Case and Figure 5–261, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is about 7 percent less than the amount released to the vadose zone.

For uranium-238 and total uranium, the amount released to groundwater is less than that of the release to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), essentially none of the total inventory reached groundwater during the period of analysis. For past leaks, essentially none of the total inventory reached groundwater during the period of analysis.

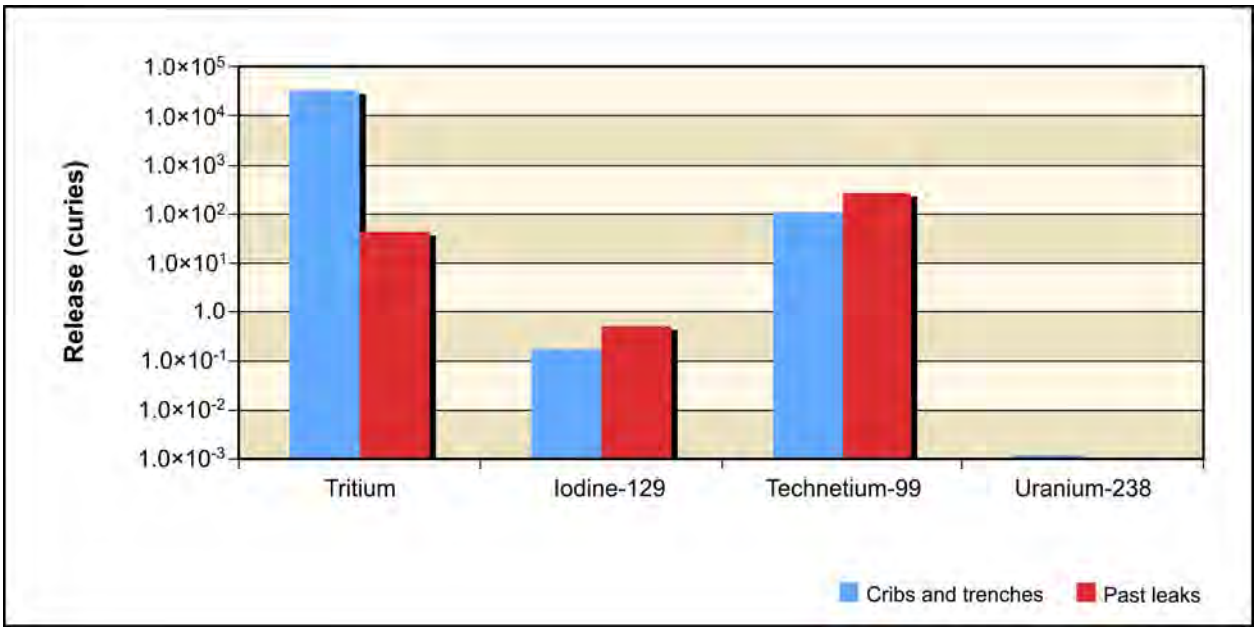


Figure 5–260. Tank Closure Alternative 6B, Option Case, Releases of Radiological Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

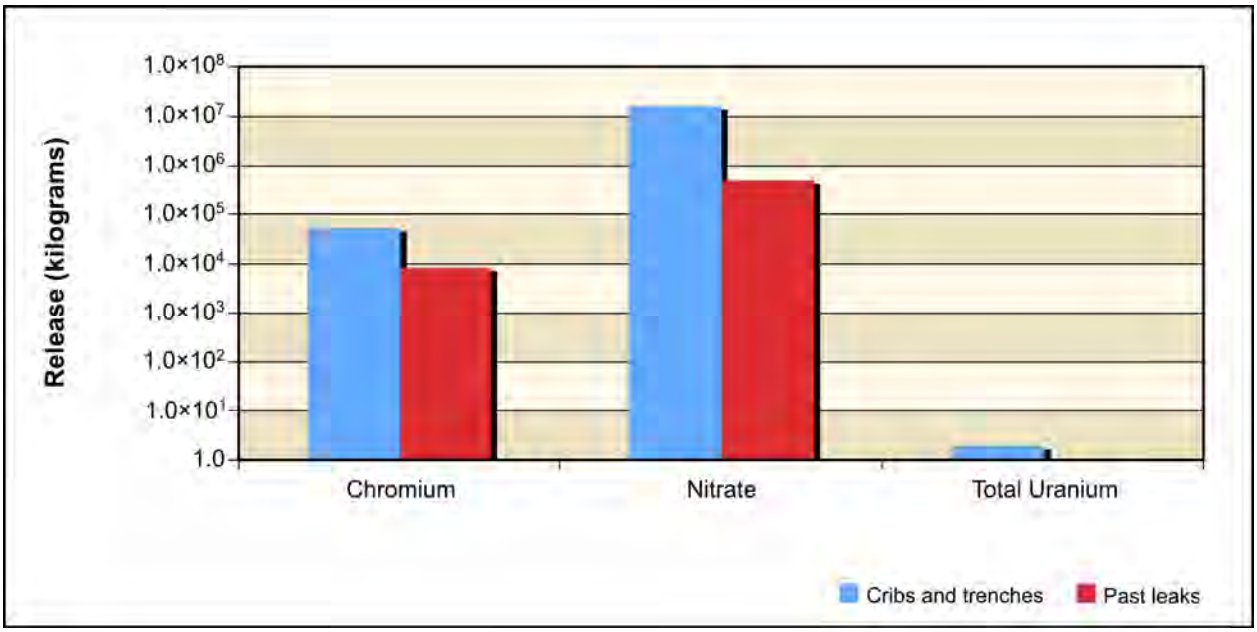


Figure 5–261. Tank Closure Alternative 6B, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For tritium, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 85 percent of the total inventory reached groundwater in the analysis; for past leaks, only 2 percent reached groundwater. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches), and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts would decrease over time because the long travel times in the vadose zone for these COPCs allow much of what was released to be collected and treated when the cribs and trenches (ditches) are removed and their deep plumes remediated.

Figure 5–262 shows the estimated release to the Columbia River for the radiological risk drivers under the Base Case and Figure 5–263, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

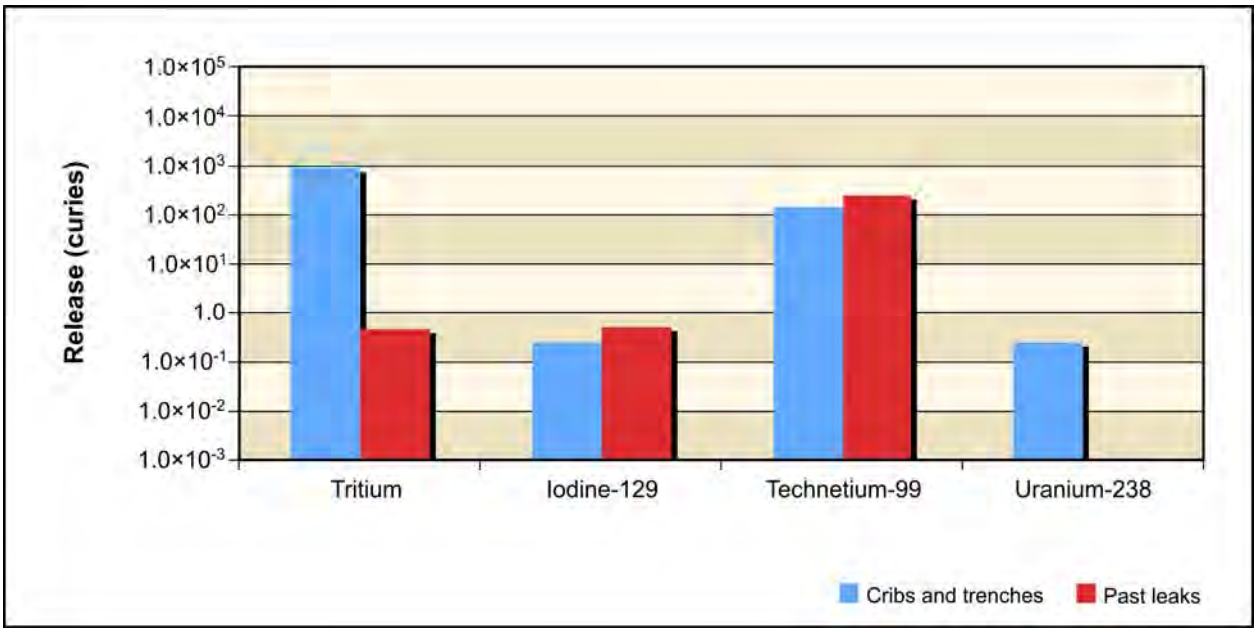


Figure 5–262. Tank Closure Alternative 6B, Base Case, Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

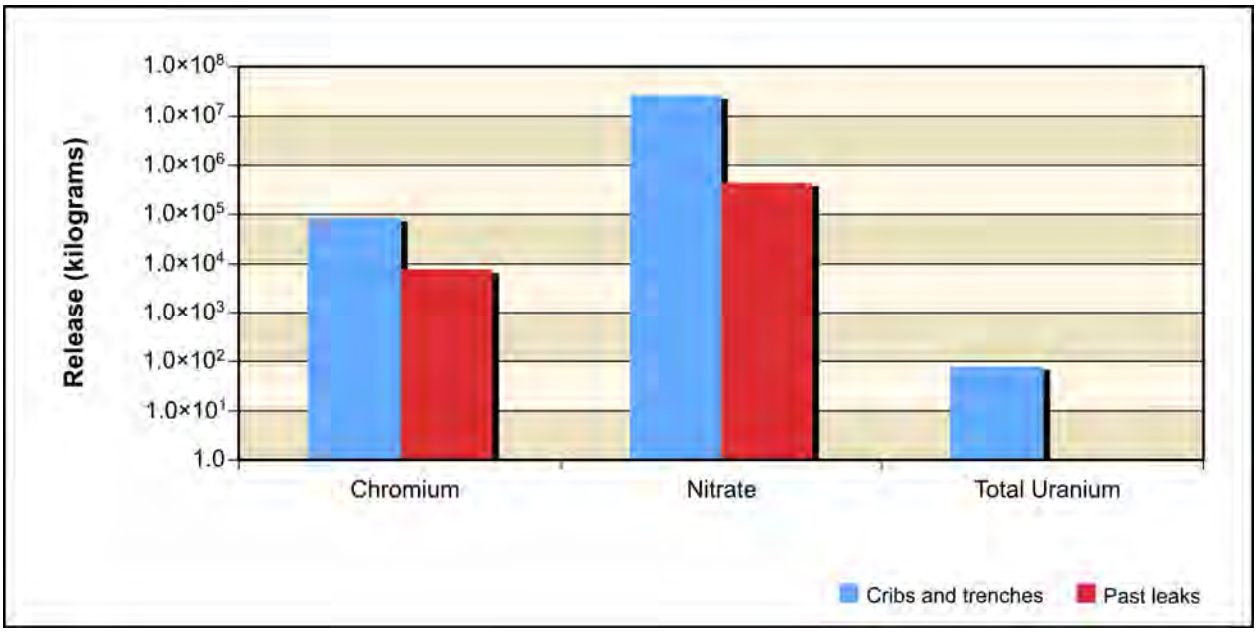


Figure 5–263. Tank Closure Alternative 6B, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to the Columbia River is less than that of the release to groundwater because of retardation. For cribs and trenches (ditches), about 40 percent of the amount released to groundwater during the period of analysis reached the Columbia River.

For tritium, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 3 percent of the tritium released to groundwater reached the Columbia River during the period of analysis. For past leaks, only about 1 percent of the tritium released to groundwater reached the Columbia River. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post–administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

Figure 5–264 shows the estimated release to the Columbia River for the radiological risk drivers under the Option Case and Figure 5–265, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

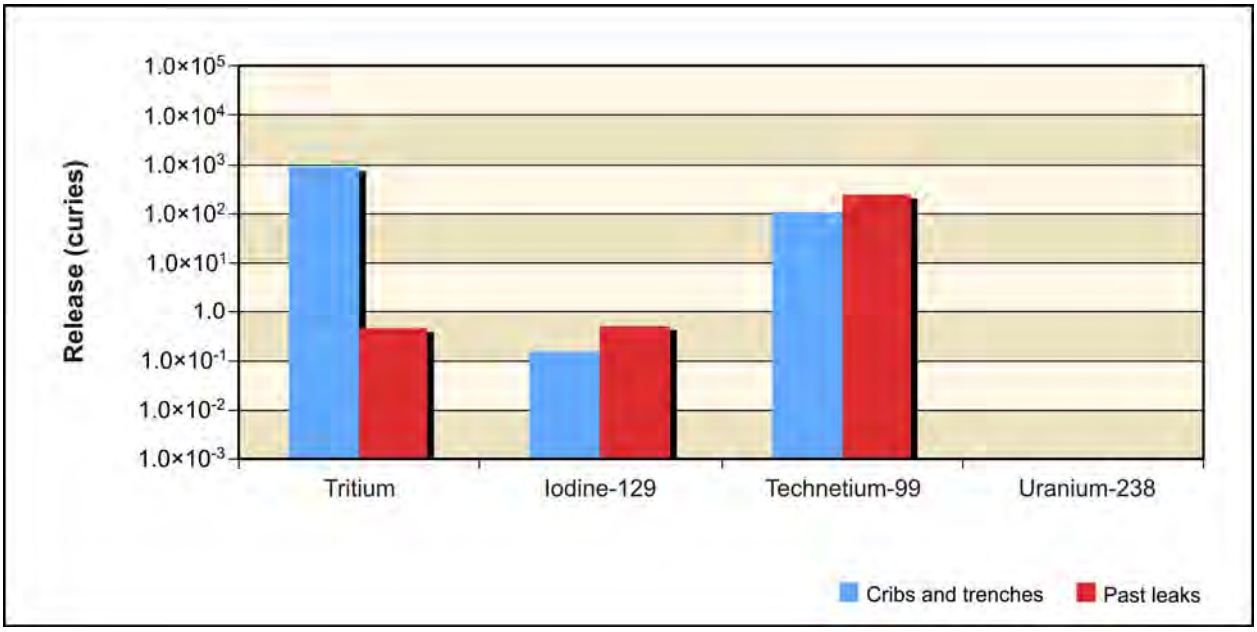


Figure 5–264. Tank Closure Alternative 6B, Option Case, Releases of Radiological Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

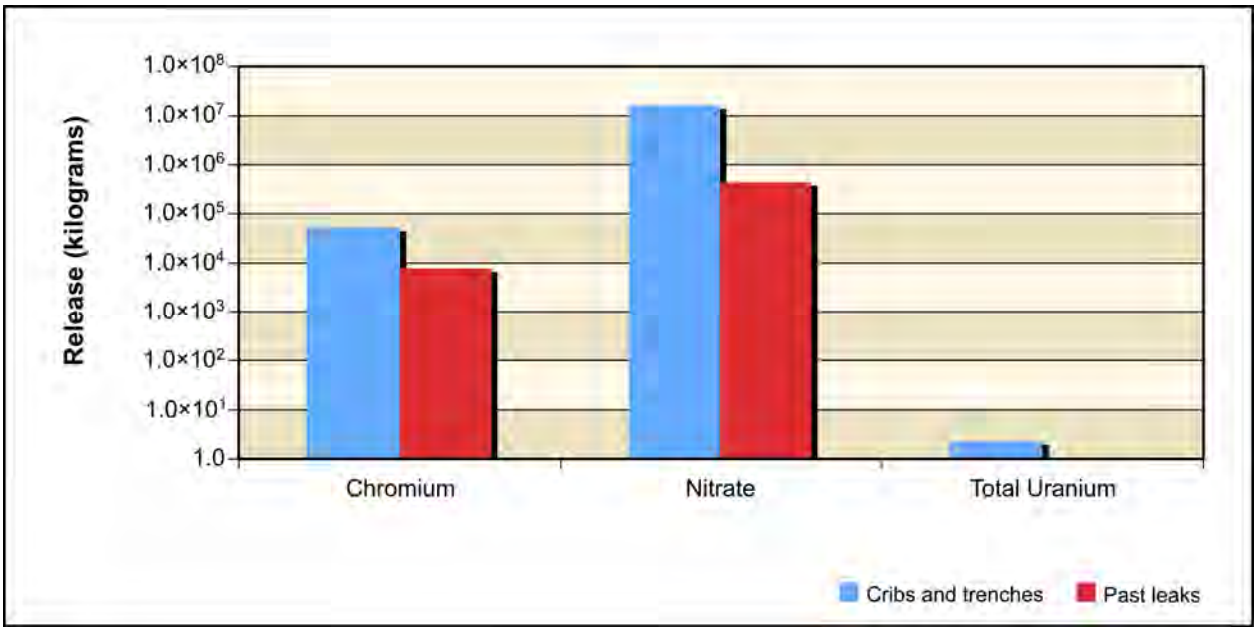


Figure 5–265. Tank Closure Alternative 6B, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to the Columbia River from the groundwater is effectively zero, as essentially no uranium reached the groundwater from the vadose zone. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 3 percent of the tritium released to groundwater reached the Columbia River during the period of analysis. For past leaks, only about 1 percent of the tritium released to groundwater reached the Columbia River. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium would not impact the Columbia River, as much of what was released is to be collected when the cribs and trenches (ditches) are removed and their deep plumes remediated.

5.1.1.10.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 6B impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Tables 5–8 and 5–9 and Figures 5–266 through 5–279). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Tables 5–8 and 5–9 list the maximum concentrations under the Base and Option Cases of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore.

Figure 5–266 shows the concentration versus time for tritium under the Base Case. Releases from cribs and trenches (ditches) cause the groundwater concentrations at the Core Zone Boundary to exceed the benchmark concentrations by about two orders of magnitude for a short period of time during the early part of the period of analysis, around CY 1956. During the same period of time, the Columbia River nearshore concentrations peaked at about one order of magnitude below the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration.

The concentrations of tritium versus time under the Option Case are essentially identical to those under the Base Case (see Figure 5–267).

Figures 5–268 through 5–271 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Base Case. All of the conservative tracers show similar patterns. Releases from cribs and trenches (ditches) cause groundwater concentrations in the Core Zone Boundary to exceed benchmark concentrations by about two orders of magnitude during the early part of the period of analysis in CY 1956. The Columbia River nearshore concentrations never met or exceeded the benchmark concentration, but came to within about one-half to one order of magnitude.

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) versus time under the Option Case are essentially identical to those under the Base Case (see Figures 5–272 through 5–275).

Table 5–8. Tank Closure Alternative 6B, Base Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	30	5,010	46	7,300	13	6,000	178	20,000
	(2051)	(2054)	(2050)	(2055)	(2052)	(2054)	(2050)	
Technetium-99	**1,390**	**29,300**	**2,560**	**15,500**	140	**24,800**	168	900
	(2050)	(2050)	(2050)	(2051)	(2060)	(2050)	(2214)	
Iodine-129	**3**	**39**	**5**	**29**	0.3	**31**	0.3	1
	(2050)	(2057)	(2050)	(2050)	(2054)	(2057)	(2319)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	0	**34**	0	13	0	10	0	15
	(1940)	(11,742)	(1940)	(11,780)	(1940)	(11,758)	(11,844)	
Chemical in micrograms per liter								
Chromium	7	**3,180**	**283**	**771**	9	**1,660**	33	100
	(2050)	(2055)	(2050)	(2050)	(2050)	(2050)	(2695)	
Nitrate	511	**1,540,000**	8,650	**133,000**	624	**1,010,000**	8,420	45,000
	(2059)	(2050)	(2050)	(2051)	(2057)	(2050)	(2450)	
Total uranium	0	10	0	4	0	7	0	30
	(1940)	(11,678)	(1940)	(11,755)	(1940)	(11,678)	(11,508)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

Table 5–9. Tank Closure Alternative 6B, Option Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter								
Hydrogen-3 (tritium)	30	4,870	46	6,680	13	5,190	172	20,000
	(2051)	(2073)	(2050)	(2067)	(2052)	(2073)	(2088)	
Technetium-99	**1,390**	**27,000**	**2,560**	**15,500**	140	**22,700**	162	900
	(2050)	(2058)	(2050)	(2051)	(2060)	(2058)	(2304)	
Iodine-129	**3**	**38**	**5**	**29**	0.3	**30**	0.3	1
	(2050)	(2051)	(2050)	(2050)	(2054)	(2052)	(2319)	
Chemical in microgram per liter								
Chromium	7	**3,770**	**283**	**778**	9	**1,760**	28	100
	(2050)	(2087)	(2050)	(2050)	(2050)	(2061)	(2166)	
Nitrate	511	**1,690,000**	8,650	**154,000**	624	**1,230,000**	7,110	45,000
	(2059)	(2053)	(2050)	(2084)	(2057)	(2053)	(2056)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern.

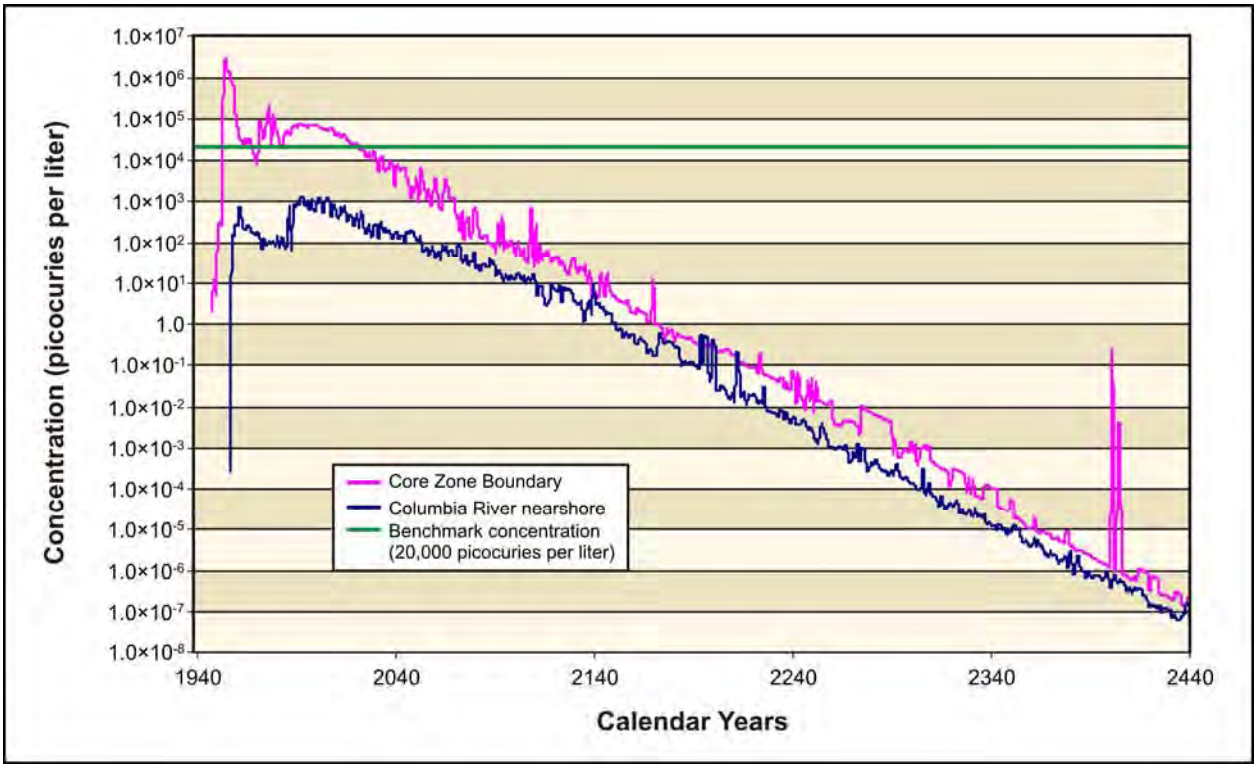


Figure 5–266. Tank Closure Alternative 6B, Base Case, Hydrogen-3 (Tritium) Concentration Versus Time

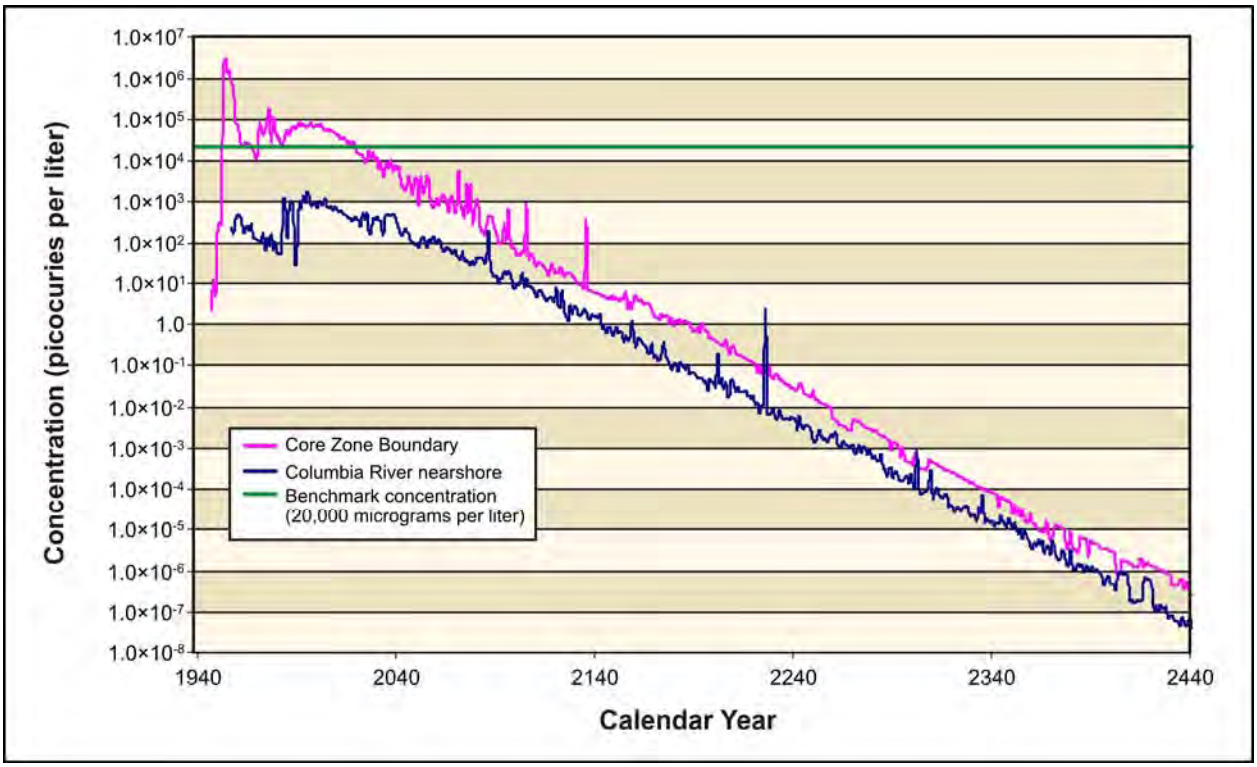


Figure 5–267. Tank Closure Alternative 6B, Option Case, Hydrogen-3 (Tritium) Concentration Versus Time

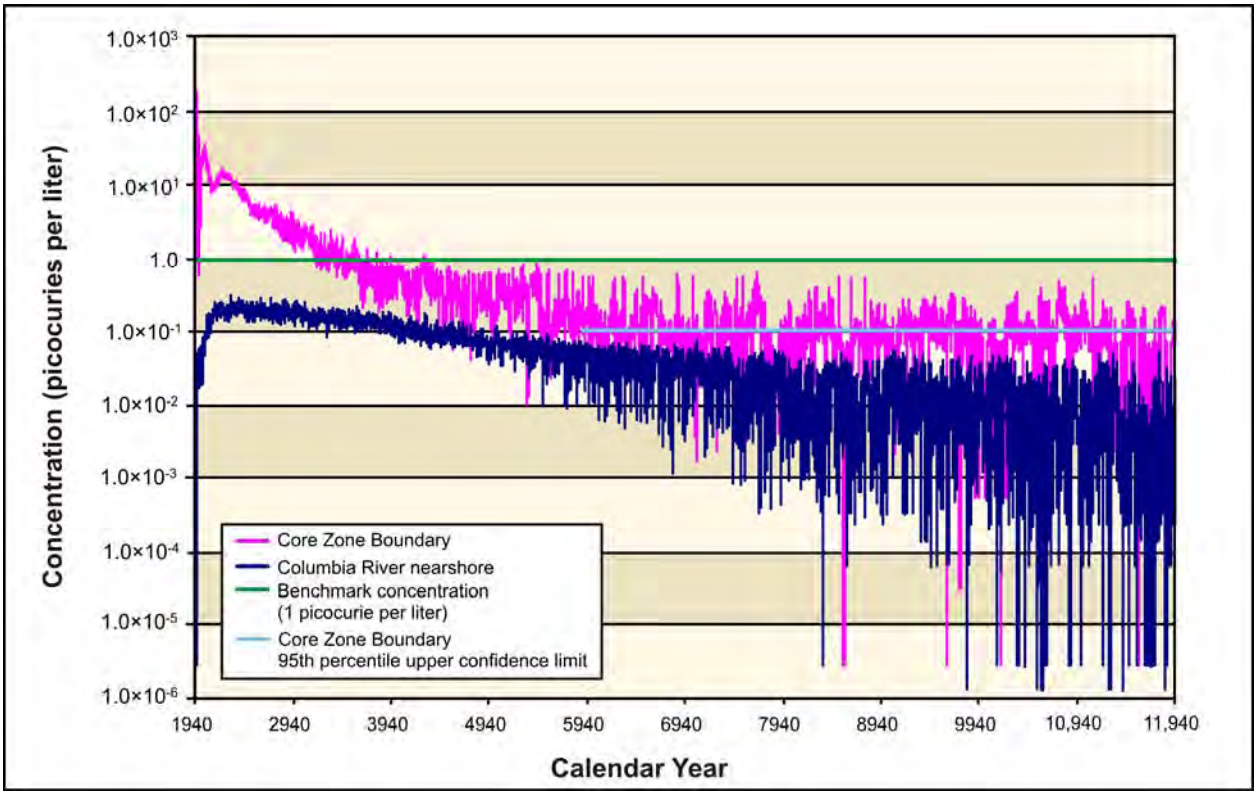


Figure 5–268. Tank Closure Alternative 6B, Base Case, Iodine-129 Concentration Versus Time

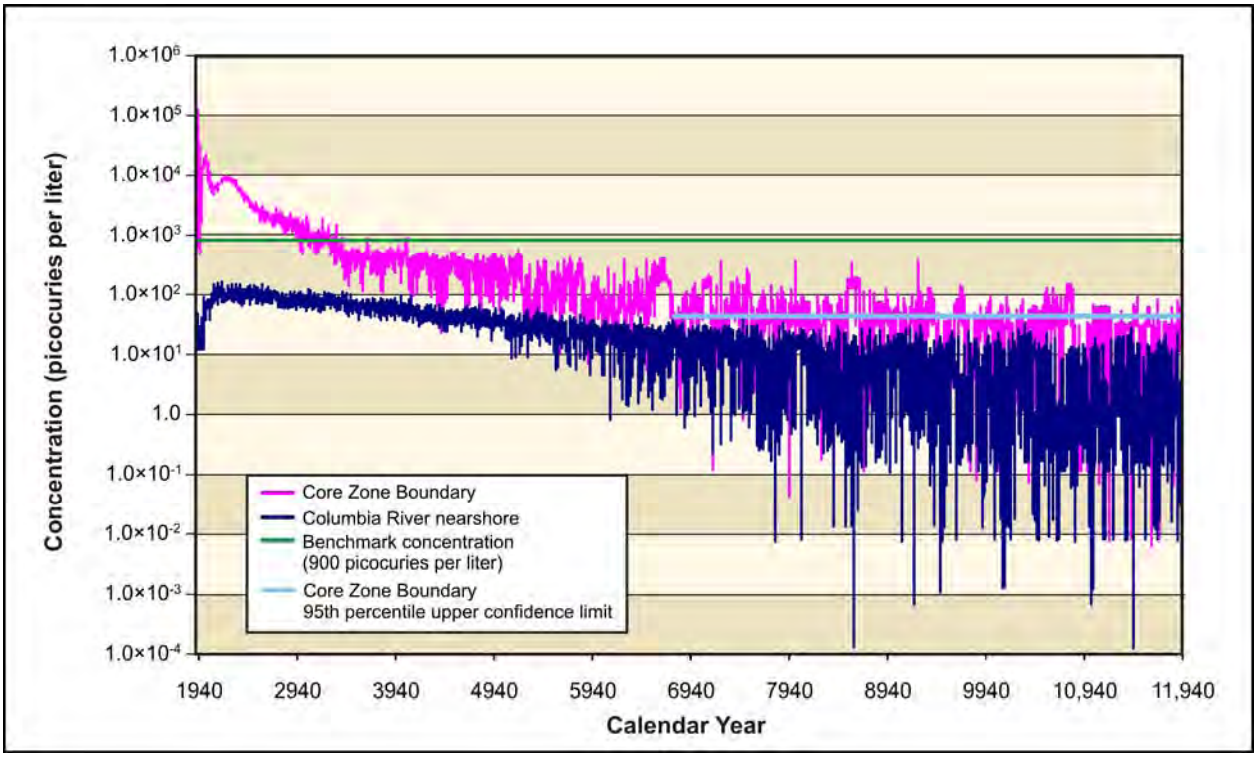


Figure 5–269. Tank Closure Alternative 6B, Base Case, Technetium-99 Concentration Versus Time

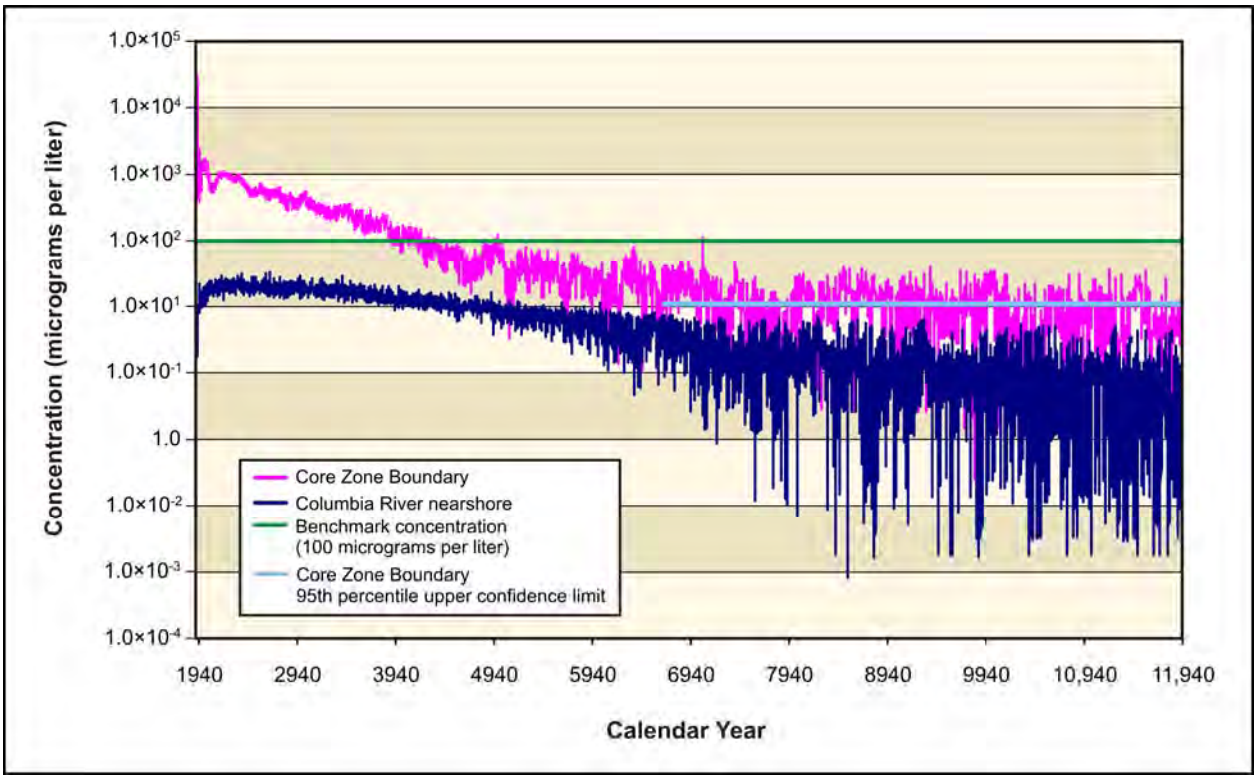


Figure 5–270. Tank Closure Alternative 6B, Base Case, Chromium Concentration Versus Time

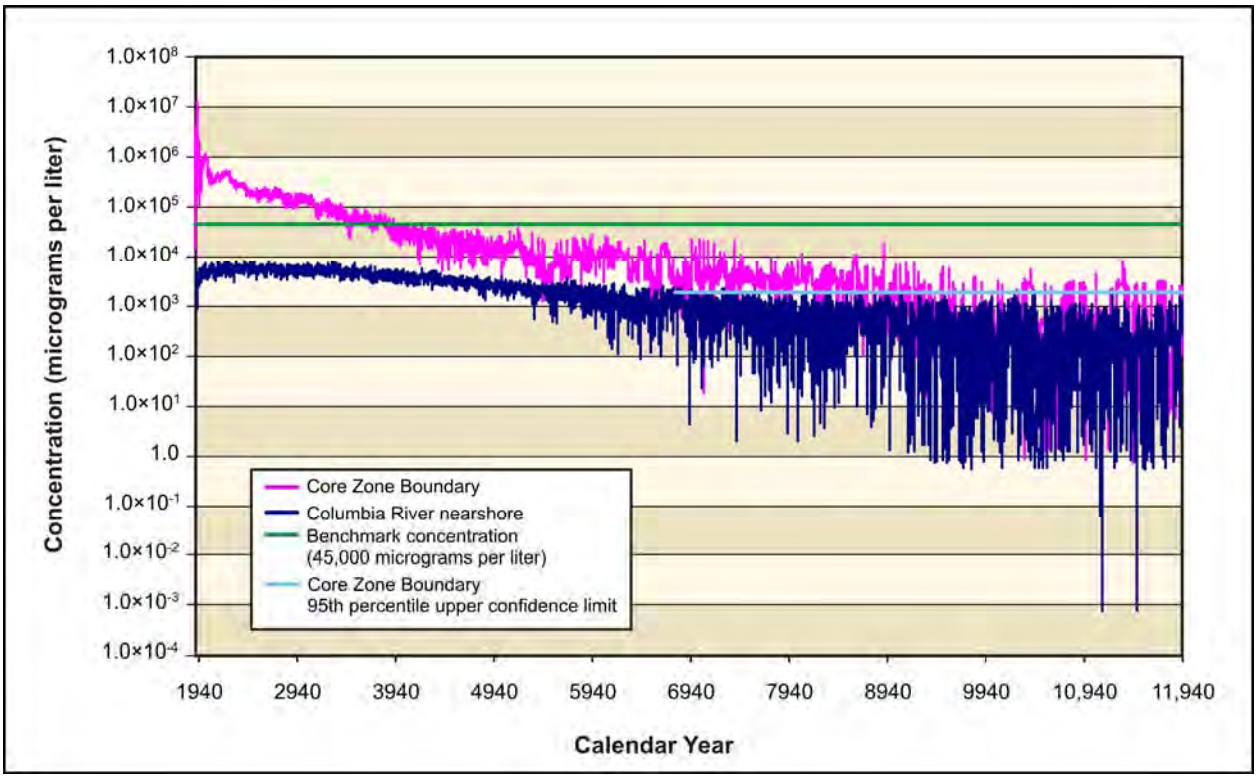


Figure 5–271. Tank Closure Alternative 6B, Base Case, Nitrate Concentration Versus Time

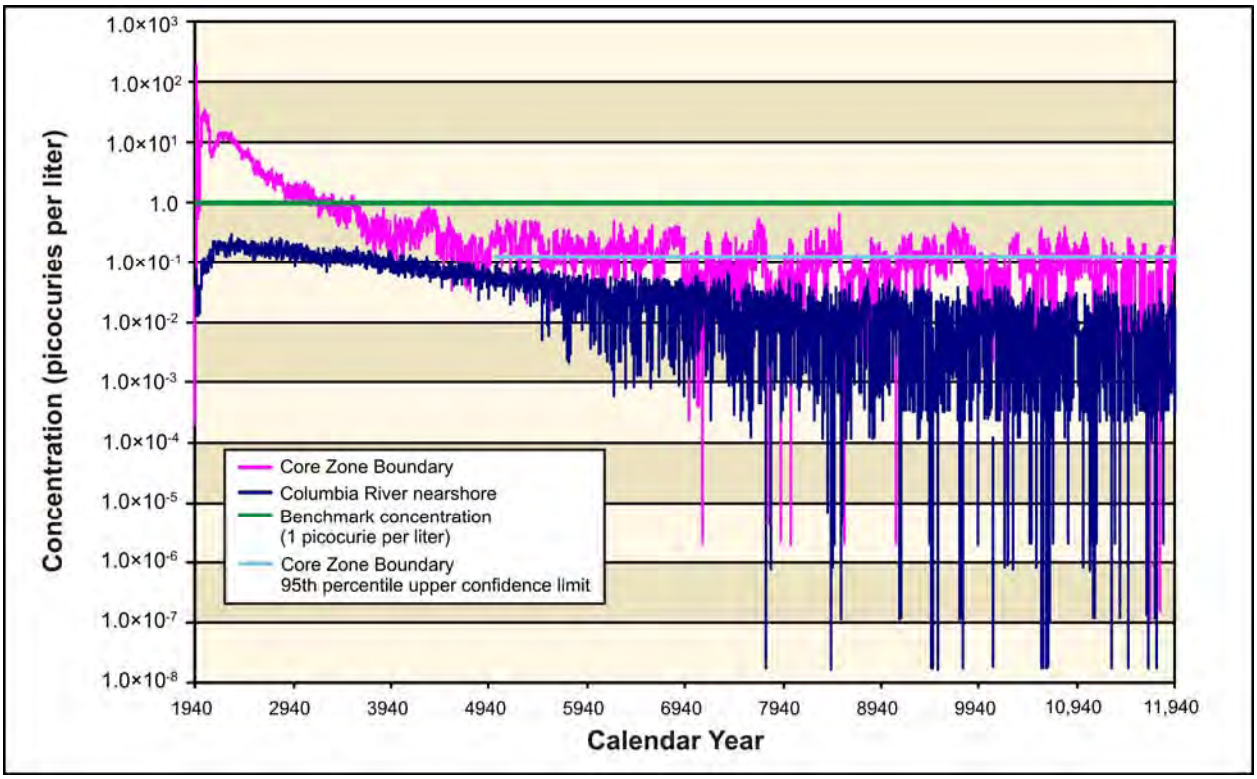


Figure 5–272. Tank Closure Alternative 6B, Option Case, Iodine-129 Concentration Versus Time

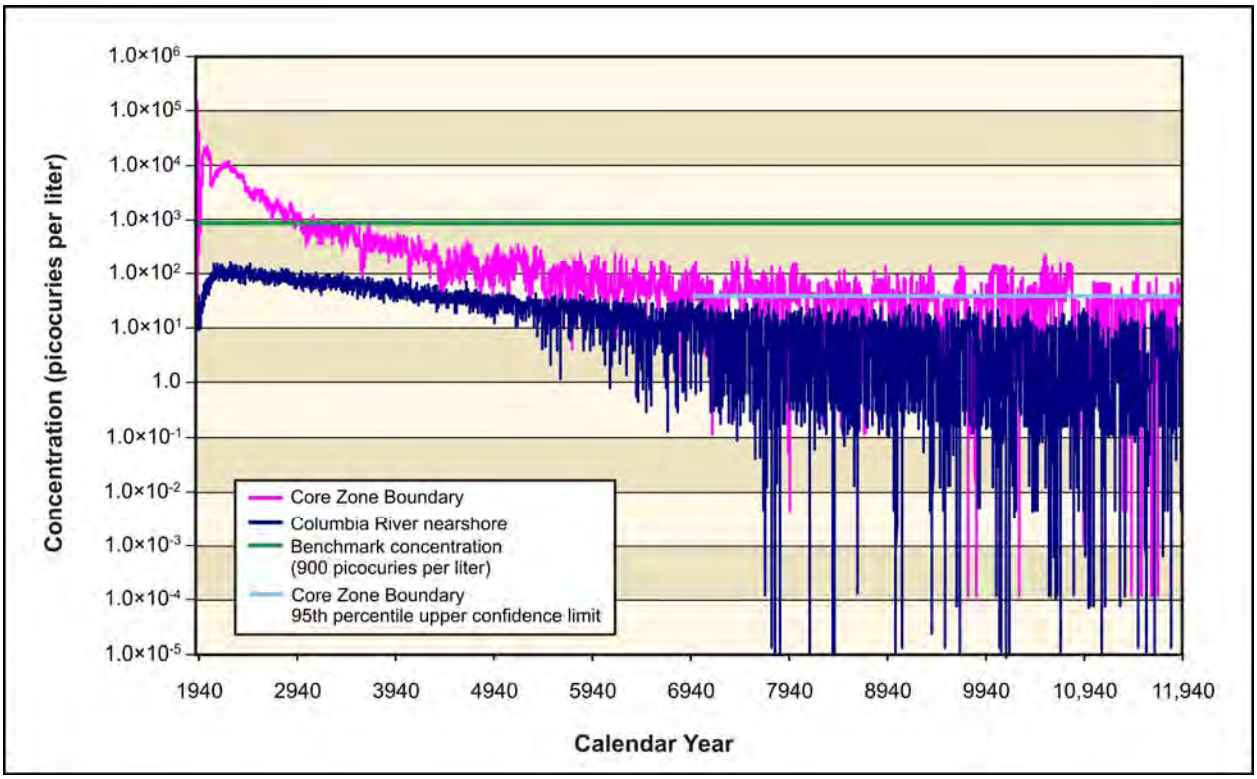


Figure 5–273. Tank Closure Alternative 6B, Option Case, Technetium-99 Concentration Versus Time

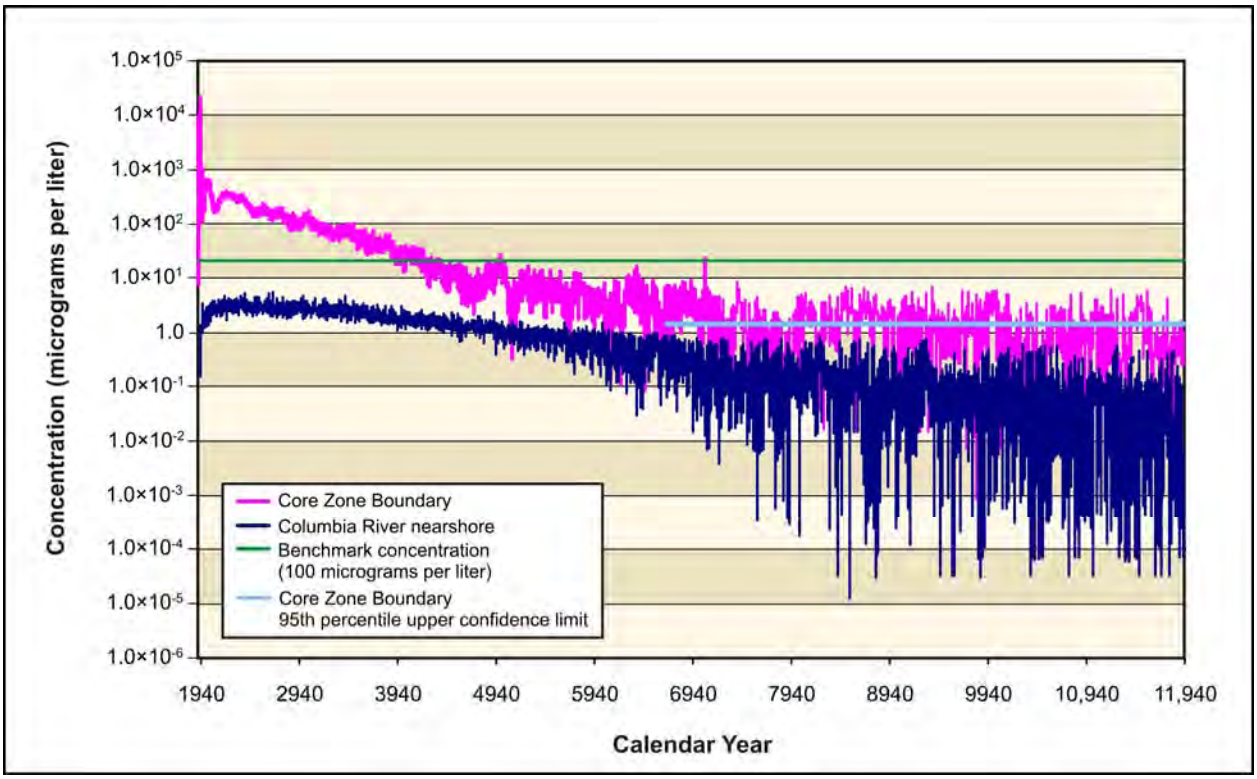


Figure 5–274. Tank Closure Alternative 6B, Option Case, Chromium Concentration Versus Time

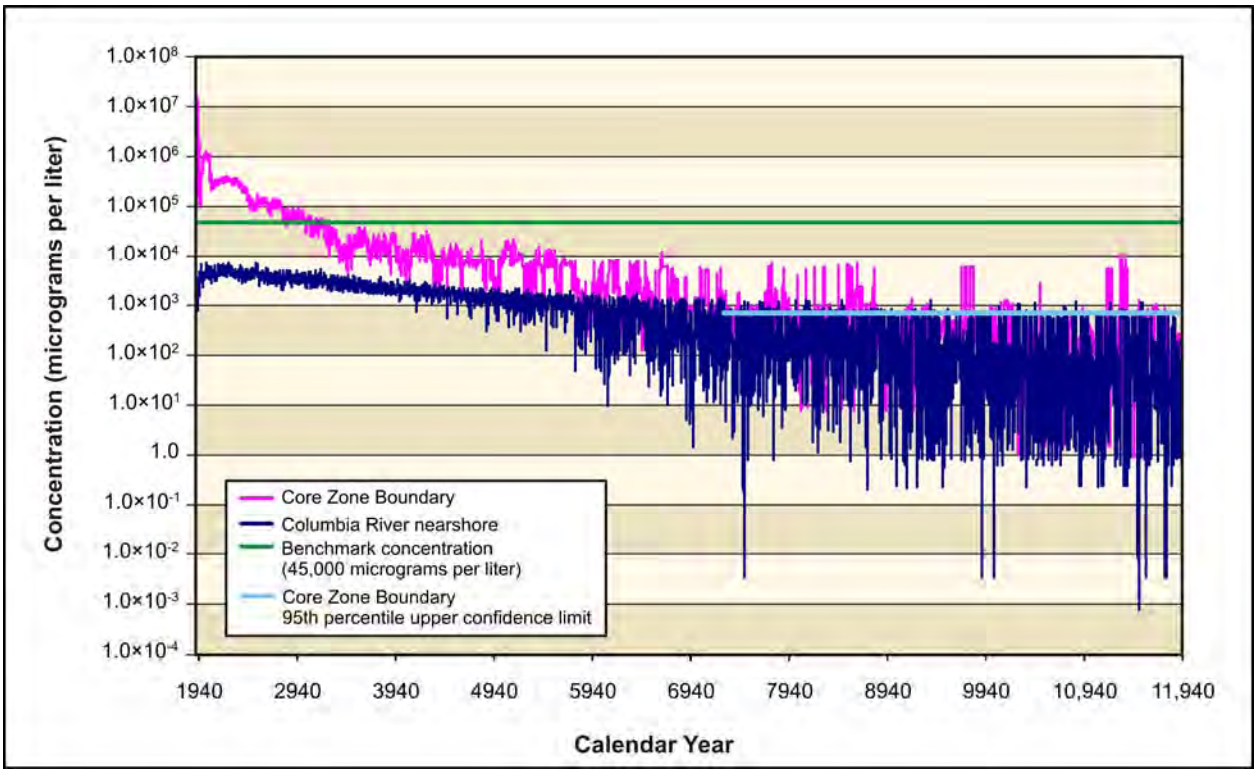


Figure 5–275. Tank Closure Alternative 6B, Option Case, Nitrate Concentration Versus Time

Figures 5–276 and 5–277 show concentration versus time for uranium-238 and total uranium under the Base Case. Although uranium-238 concentrations in the Core Zone Boundary began to approach the benchmark toward the latter part of the period of analysis, they never reached it. Total uranium concentrations at the Core Zone Boundary also began to increase toward the end of the period of analysis but never came to within one order of magnitude of the benchmark. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never came to within about two orders of magnitude below the benchmark.

Under the Option Case, uranium-238 concentrations in the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark concentration, except for a short spike to about one order of magnitude below the benchmark at the beginning of the period of analysis (see Figure 5–278). At around CY 7500, the uranium-238 Core Zone Boundary concentrations fell to about four orders of magnitude below the benchmark. The Columbia River nearshore concentrations of uranium-238 stayed fairly constant at about four orders of magnitude below the benchmark. Total uranium concentrations at the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark (see Figure 5–279). The Columbia River nearshore concentrations of total uranium remained fairly constant at around four and a half orders of magnitude below the benchmark.

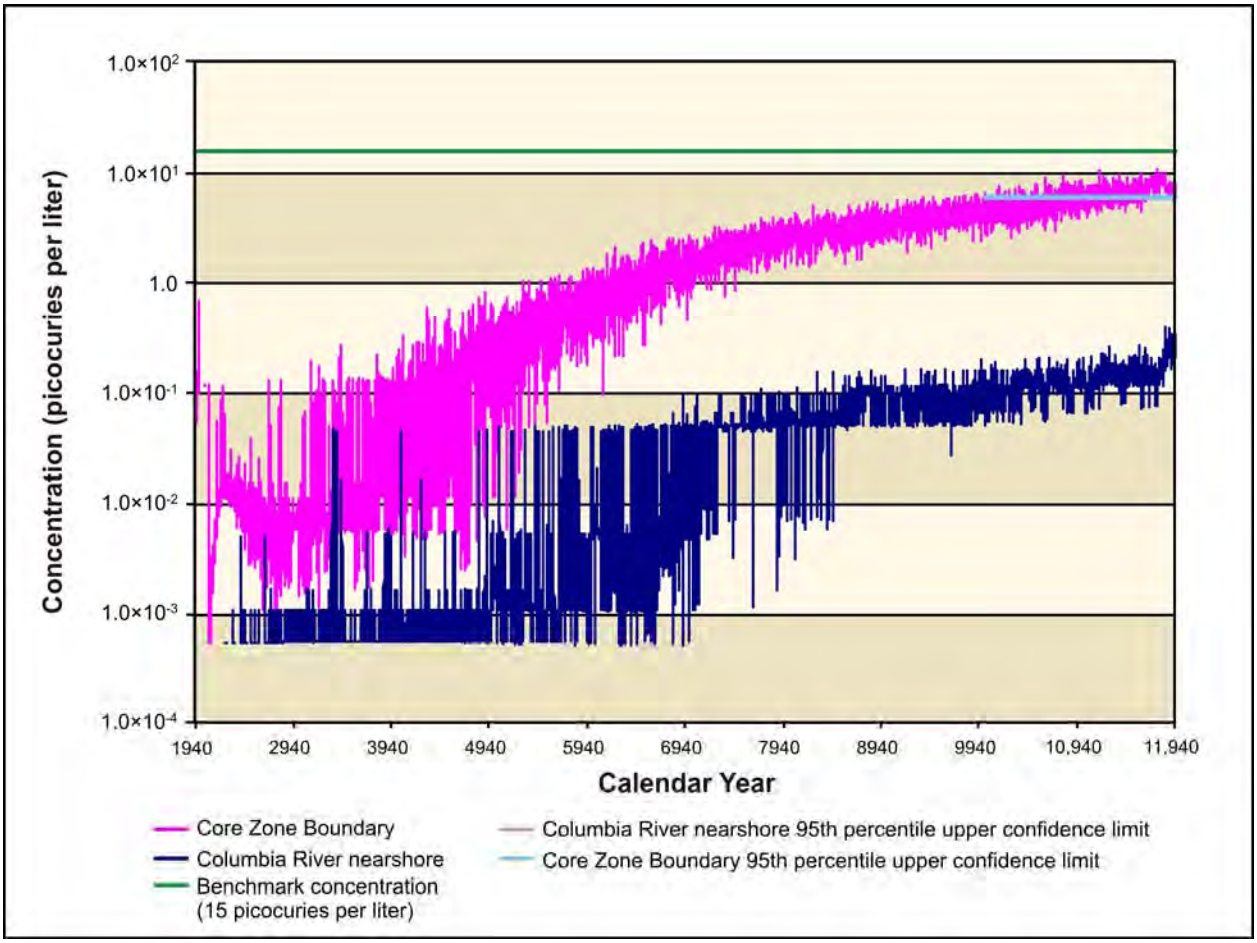


Figure 5–276. Tank Closure Alternative 6B, Base Case, Uranium-238 Concentration Versus Time

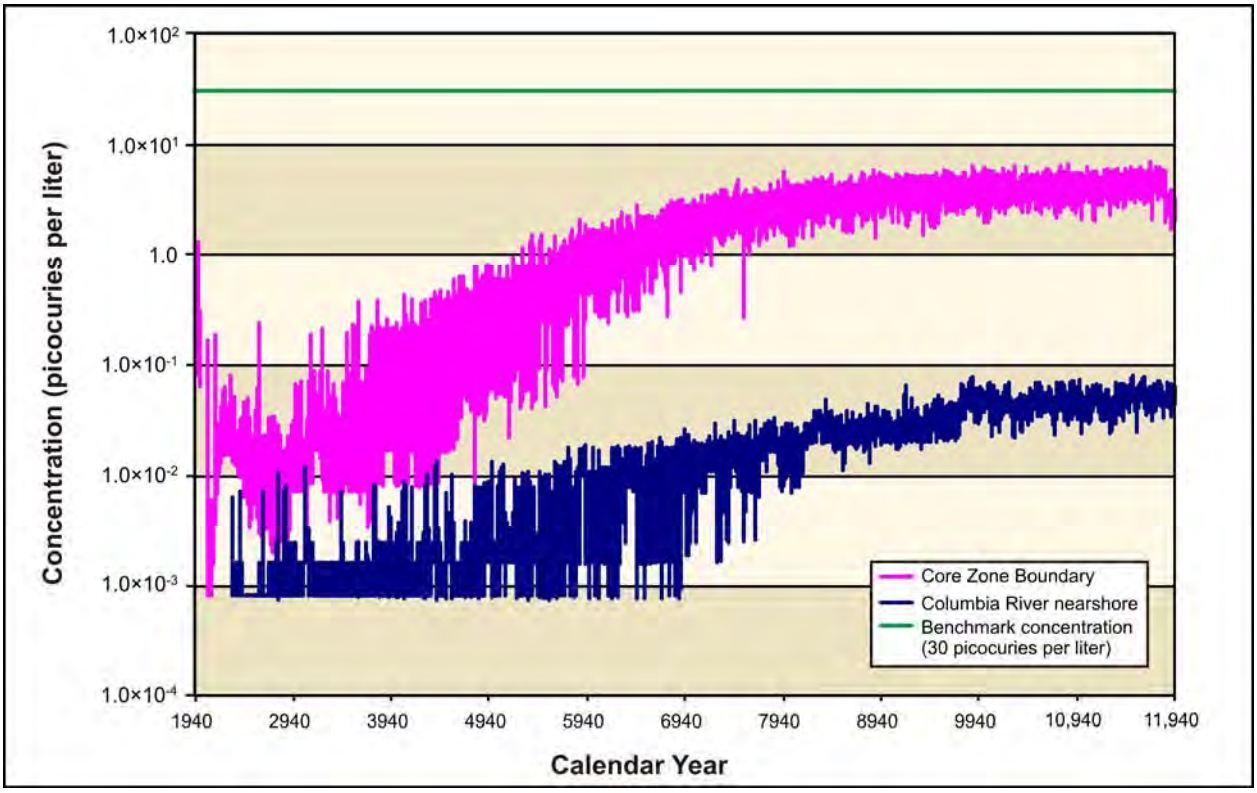


Figure 5–277. Tank Closure Alternative 6B, Base Case, Total Uranium Concentration Versus Time

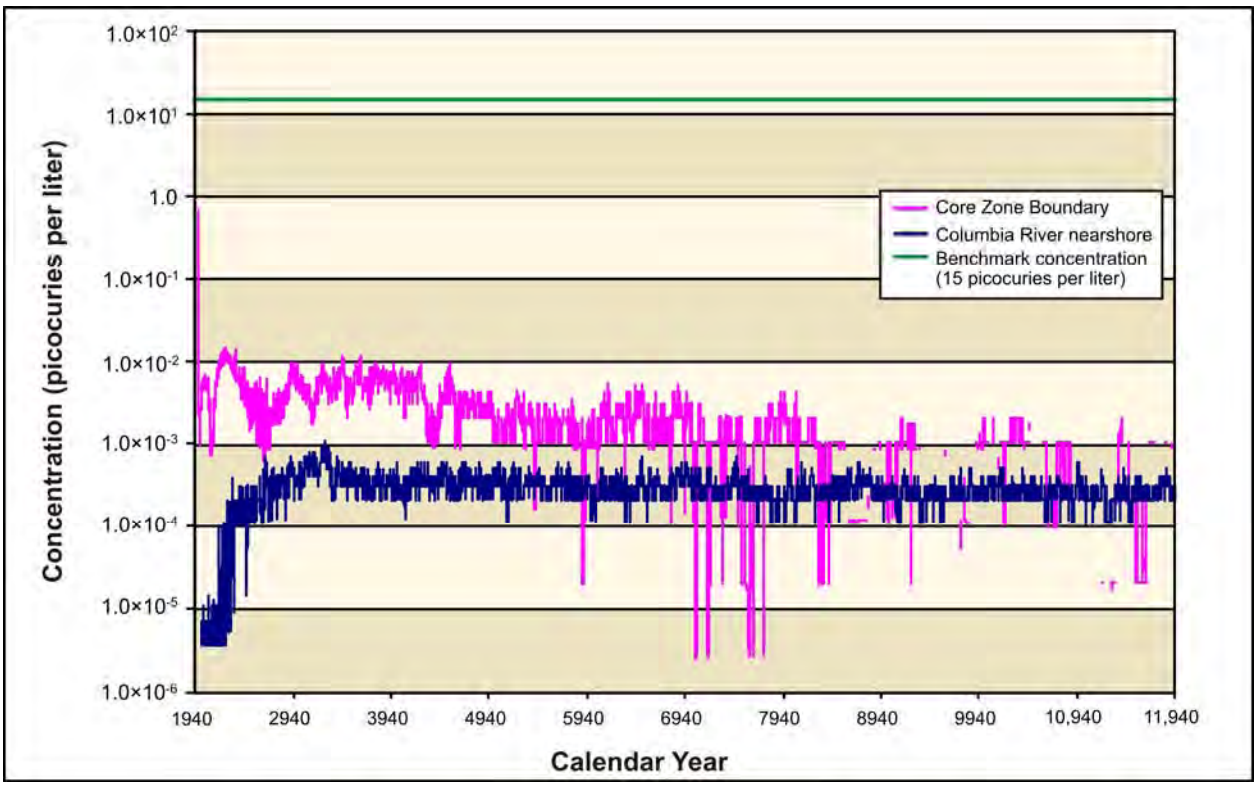


Figure 5–278. Tank Closure Alternative 6B, Option Case, Uranium-238 Concentration Versus Time

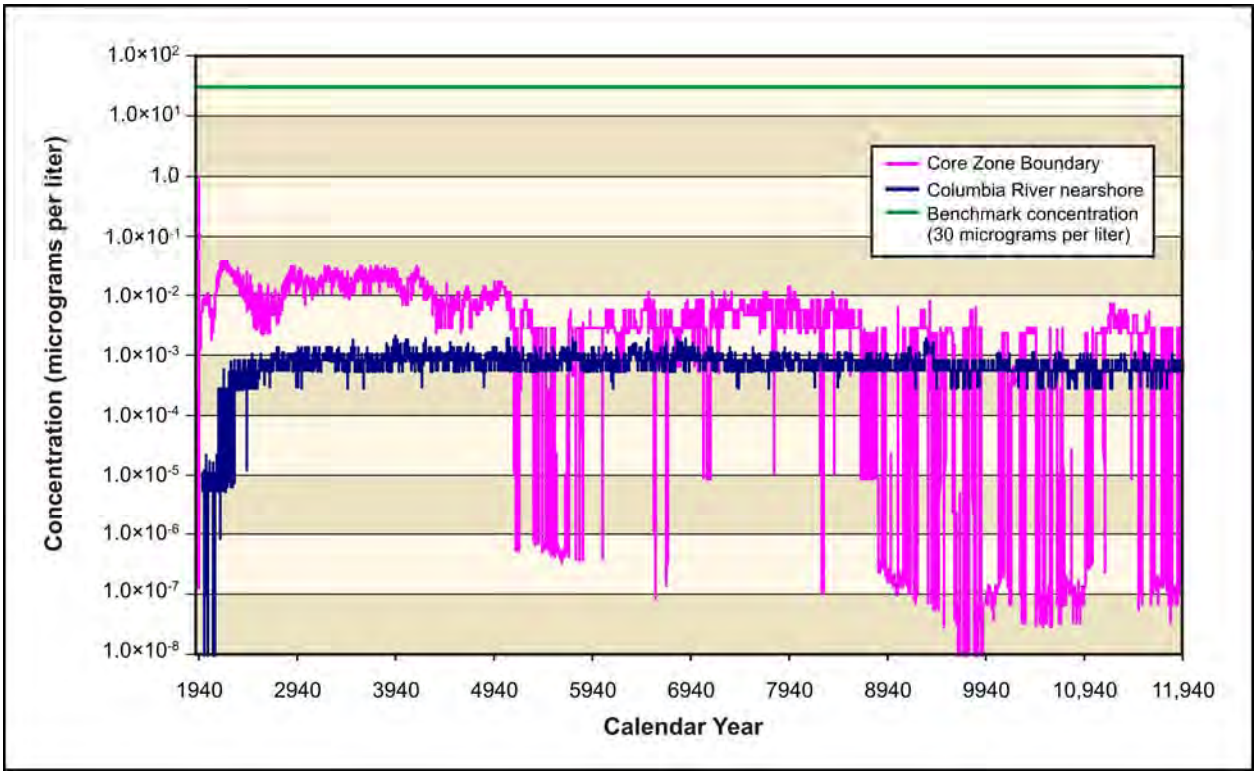


Figure 5–279. Tank Closure Alternative 6B, Option Case, Total Uranium Concentration Versus Time

5.1.1.10.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 6B in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Figures 5–280 through 5–324). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–280 shows the spatial distribution of groundwater concentration for tritium during CY 2005 under the Base Case. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. The overall tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135, although a few minor traces from about one-twentieth to one-tenth below the benchmark can be found in Gable Gap (see Figure 5–281).

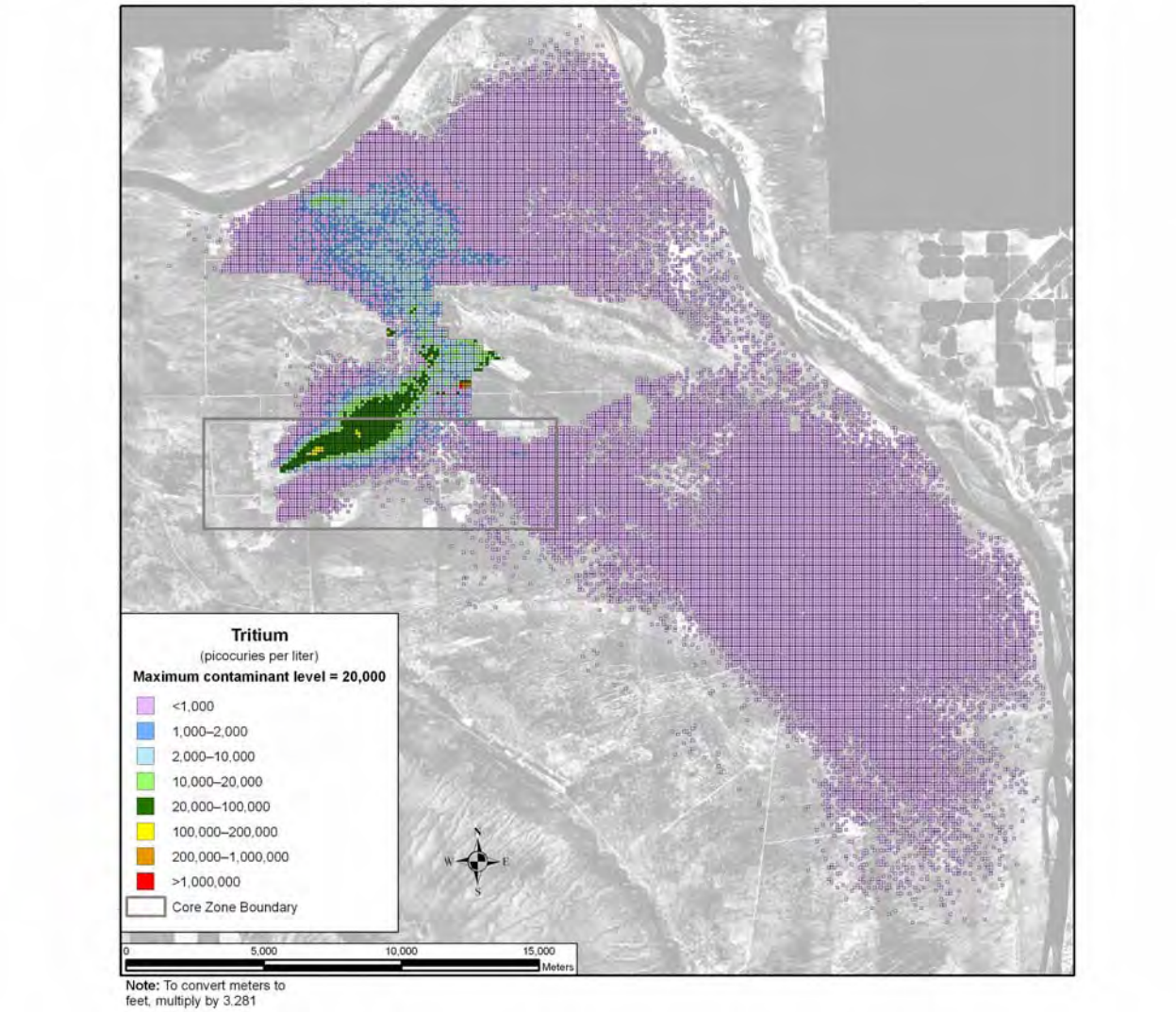


Figure 5–280. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

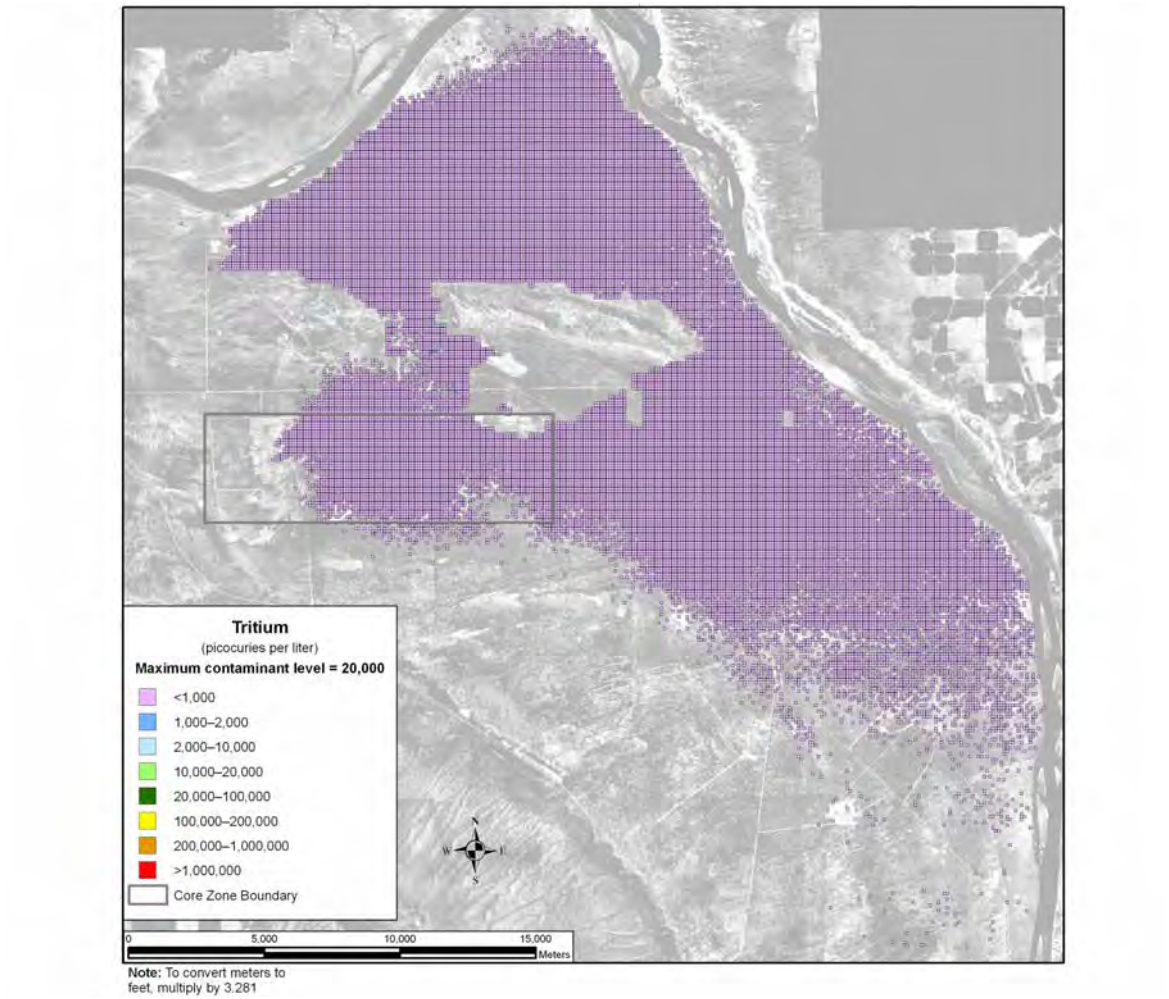


Figure 5–281. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

The spatial distribution of groundwater concentrations for tritium under the Option Case, which would include removal of the six sets of cribs and trenches (ditches) and remediation of their plumes within the vadose zone, is essentially identical to that under the Base Case (see Figures 5–282 and 5–283).

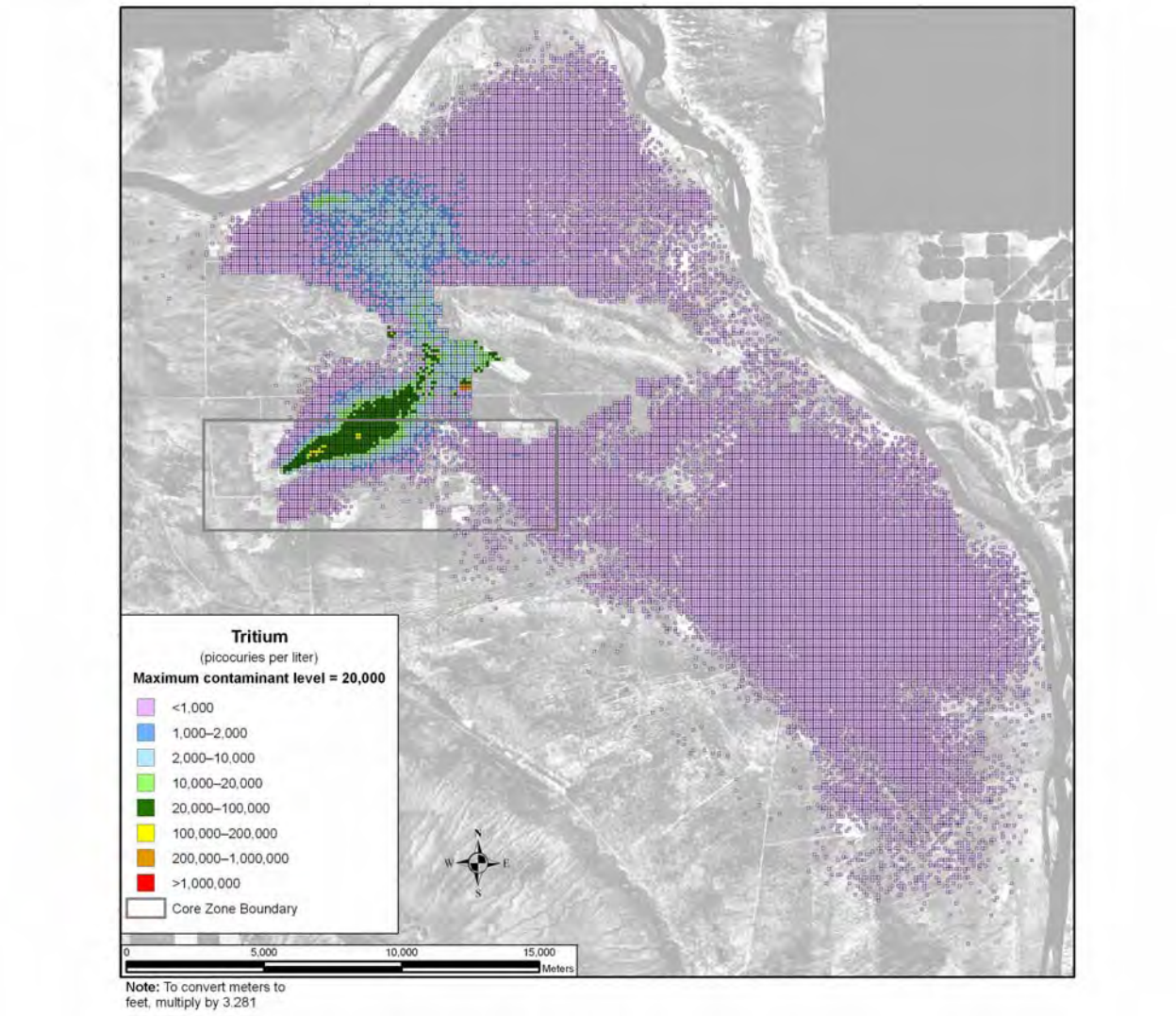


Figure 5–282. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

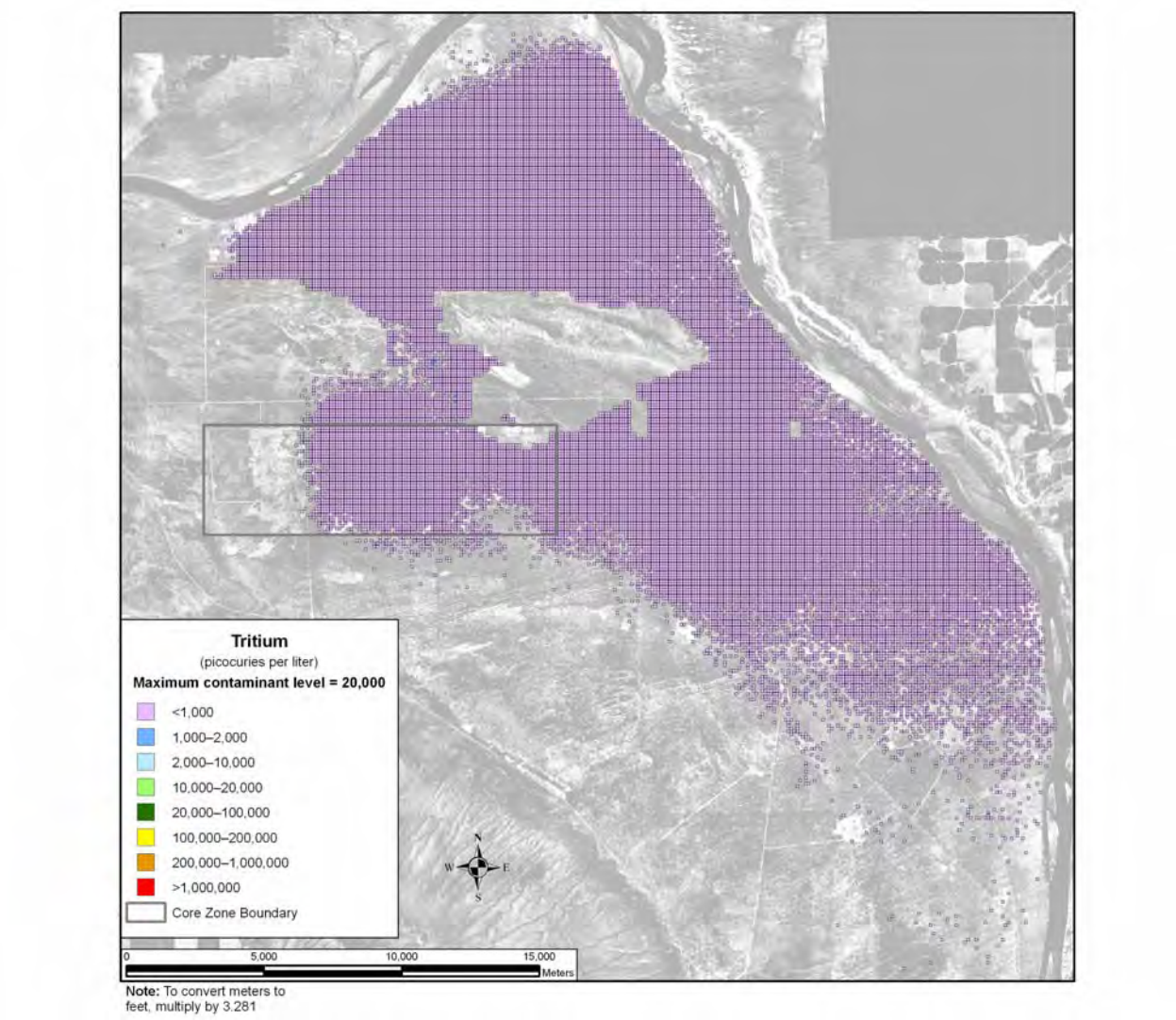


Figure 5–283. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

Figure 5–284 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005 under the Base Case. Analysis releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 30 times greater than the benchmark, and mostly contained within the Core Zone Boundary. By CY 2135, the contaminant plumes have spread further north through Gable Gap and further east toward the Columbia River (see Figure 5–285). In the plume north of Gable Gap, contaminant levels have begun to meet the benchmark. In the east, just outside of the Core Zone Boundary, levels have risen 5 to 10 times above the benchmark. By CY 7140, most of the mass in the plume has reached the Columbia River, with only a small pocket with high concentrations in the southern region of Gable Gap extending north from the B Barrier (see Figure 5–286). Technetium-99, chromium, and nitrate (see Figures 5–287 through 5–295) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

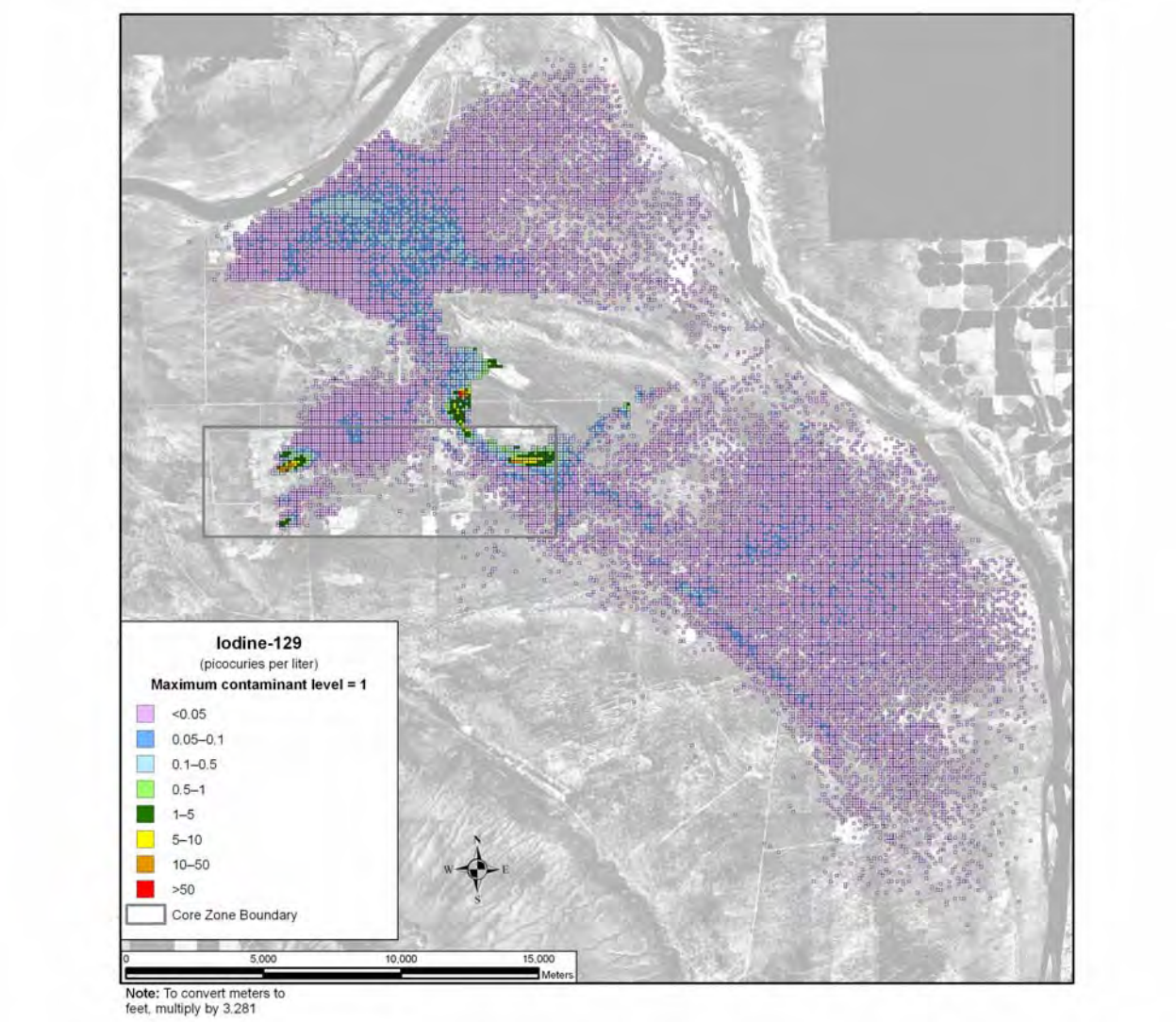


Figure 5–284. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

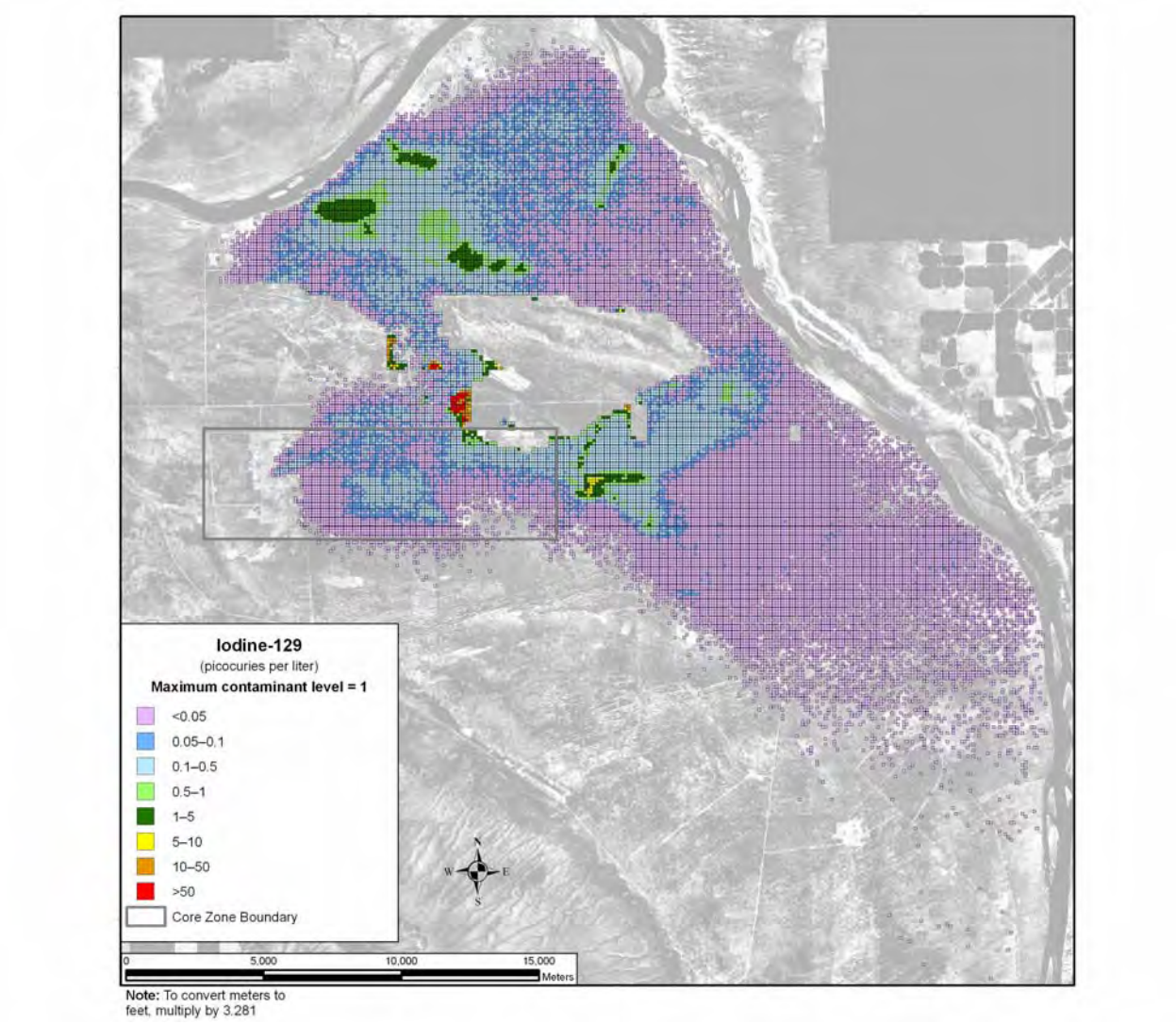


Figure 5–285. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135

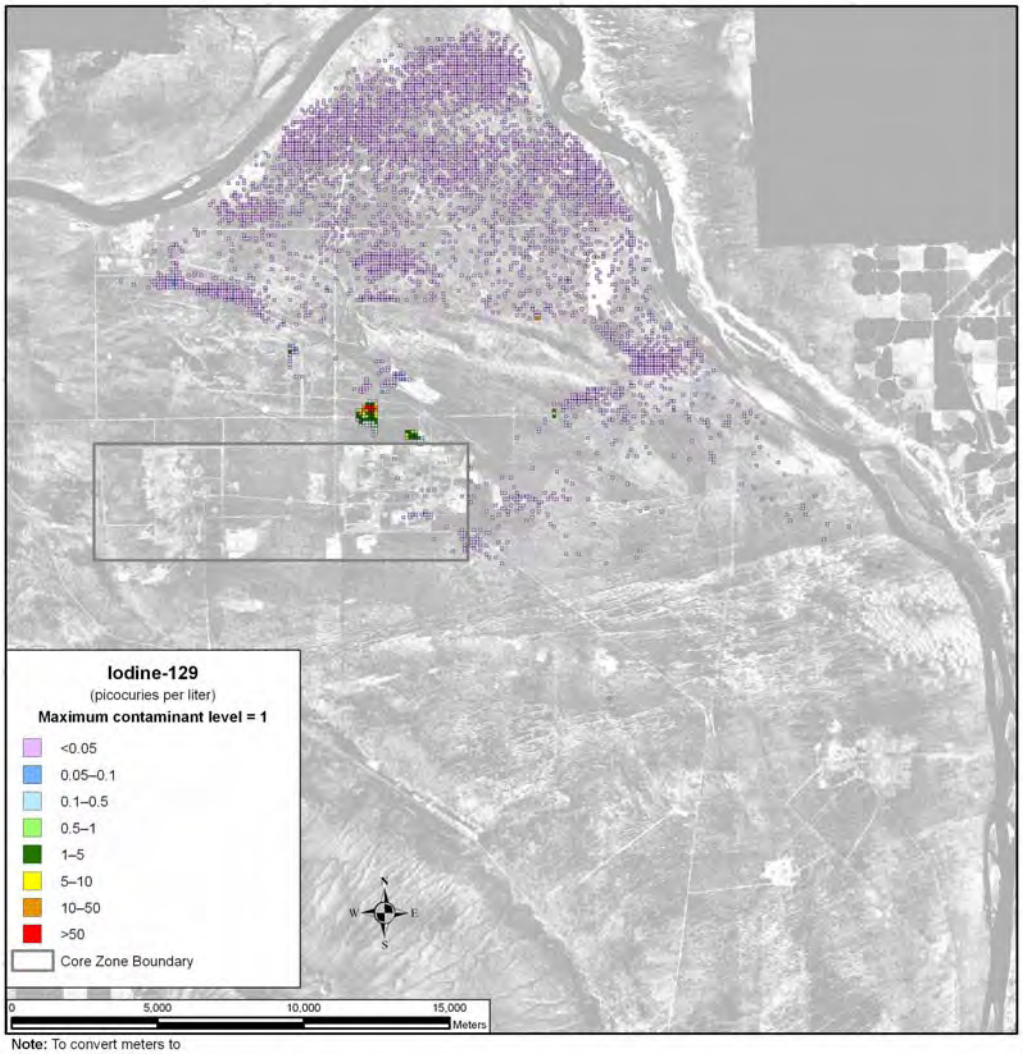


Figure 5–286. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

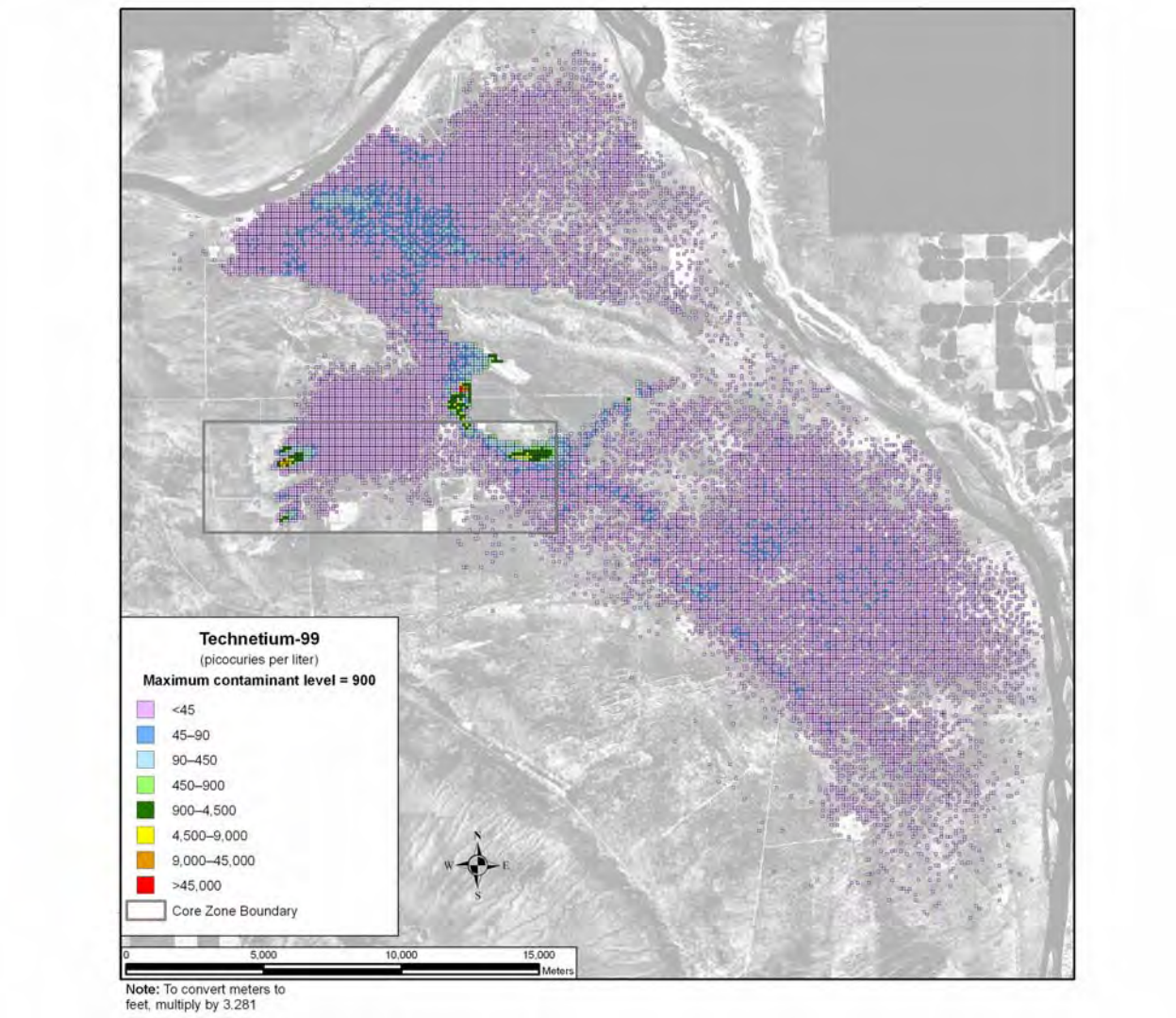


Figure 5–287. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

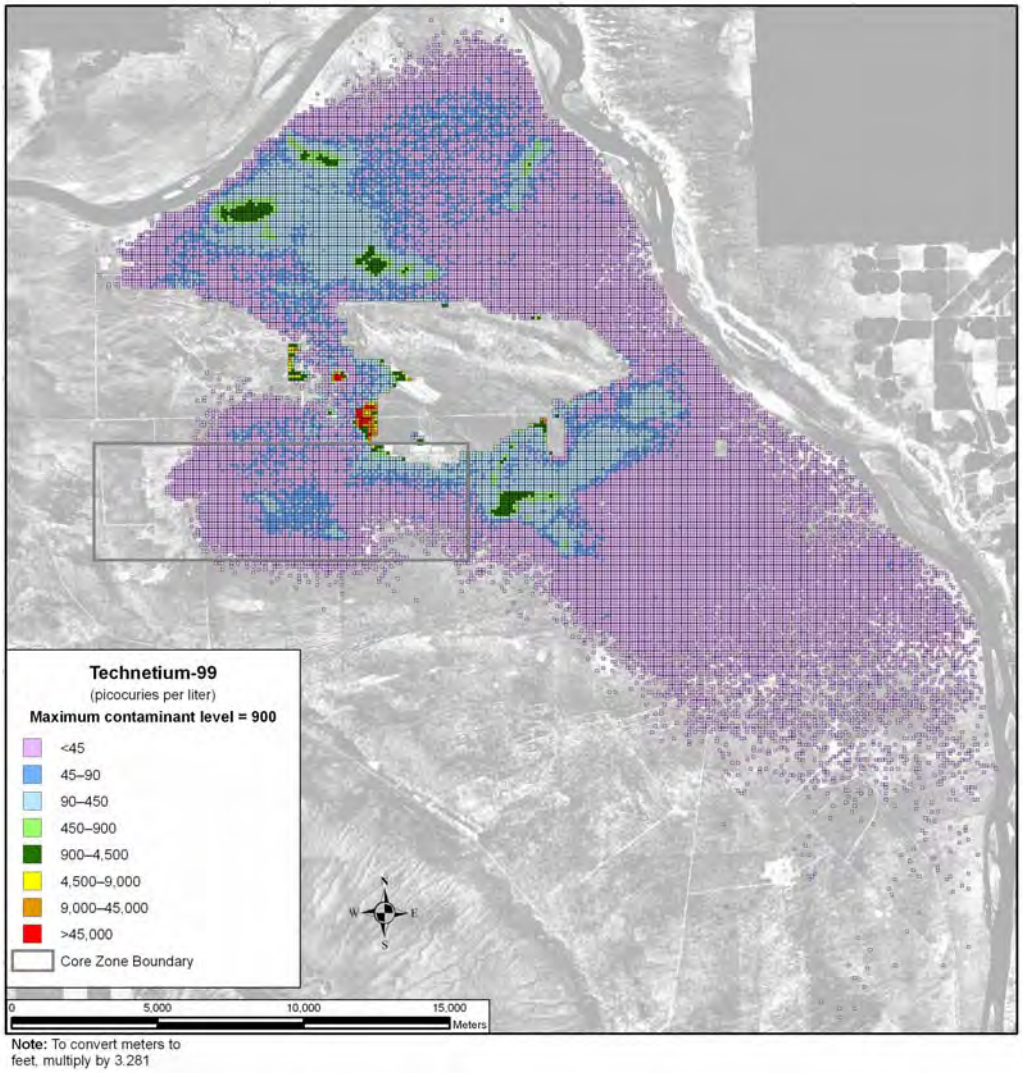


Figure 5–288. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2135

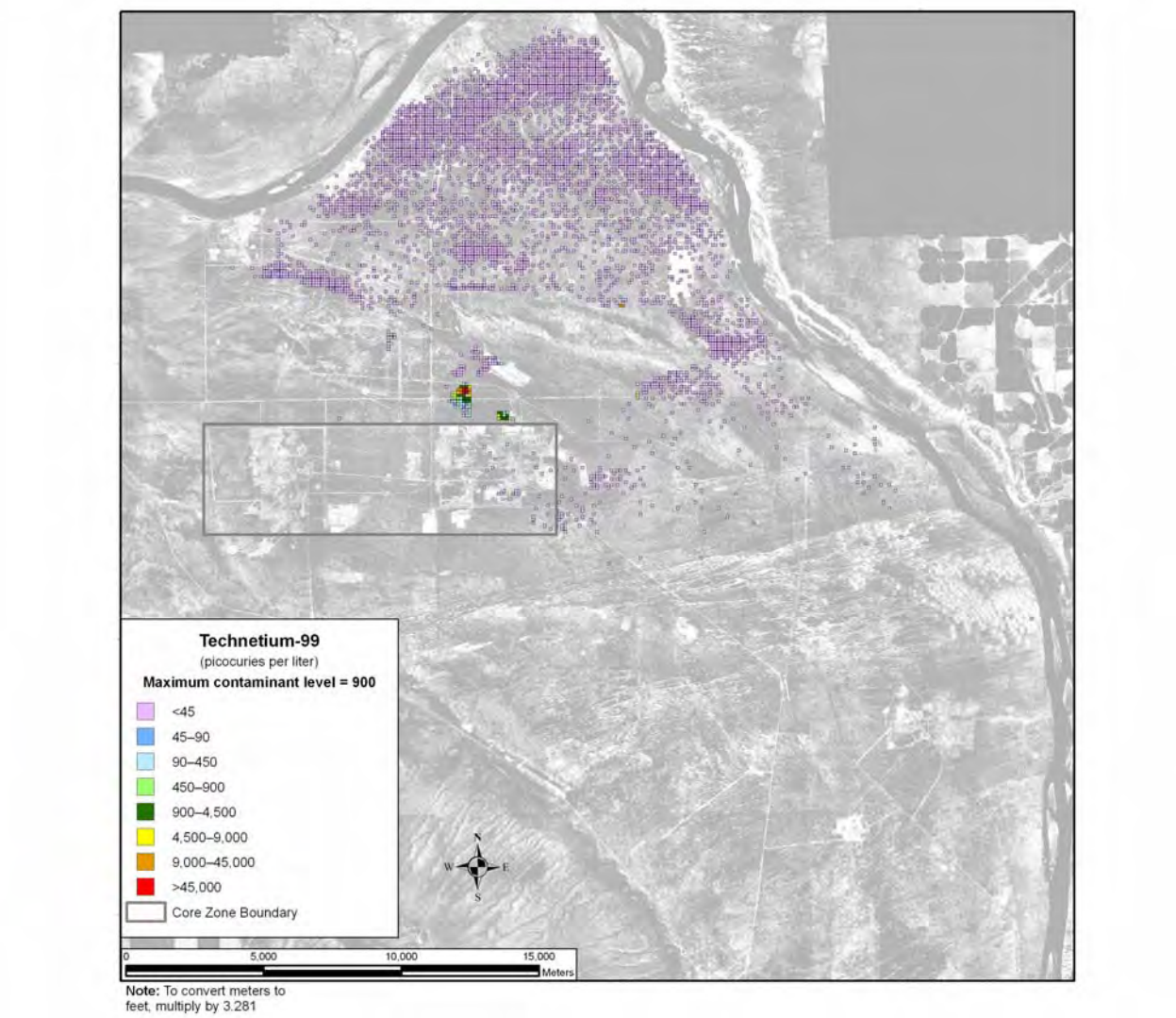


Figure 5–289. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

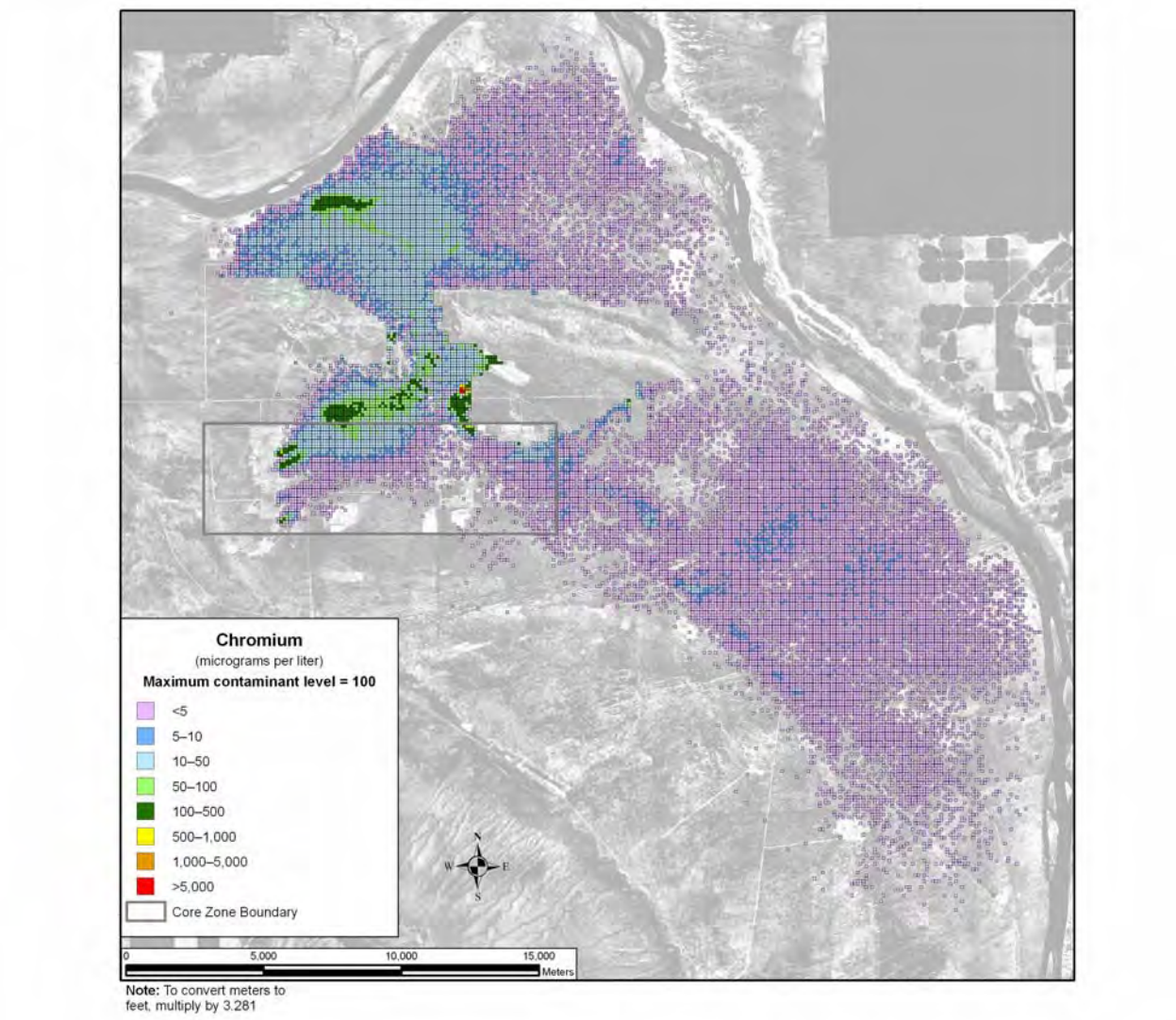


Figure 5–290. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

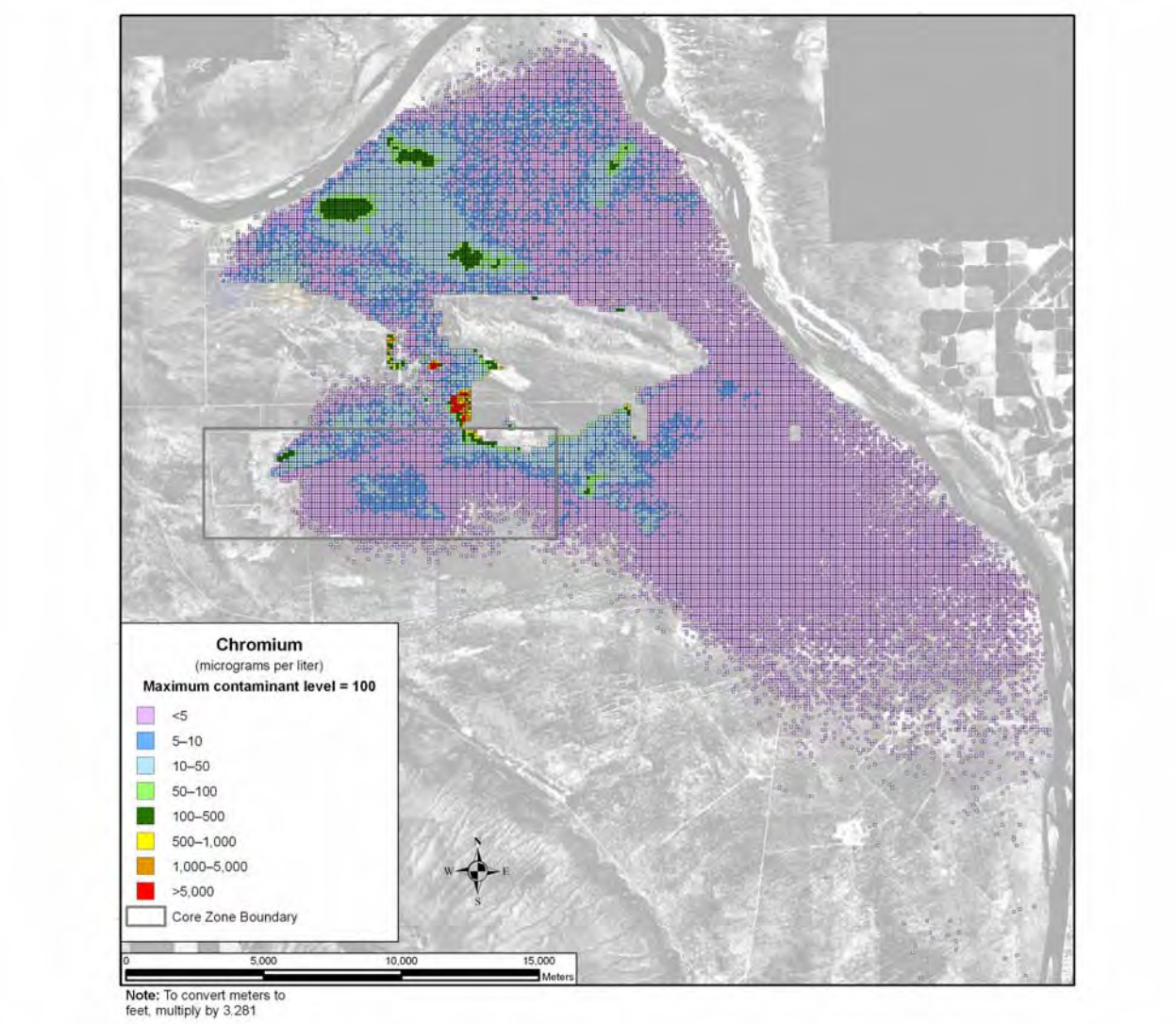


Figure 5–291. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2135

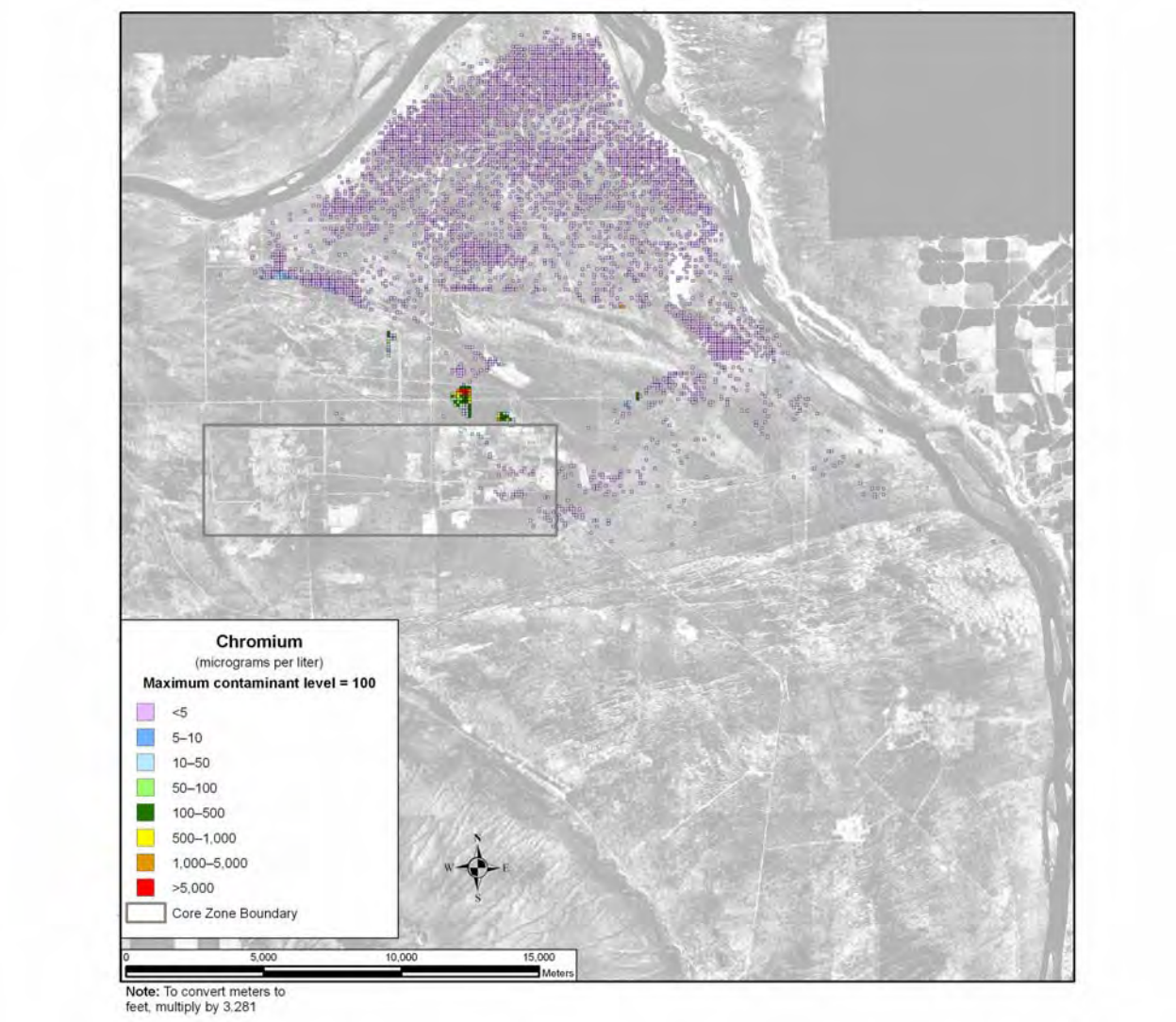


Figure 5–292. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

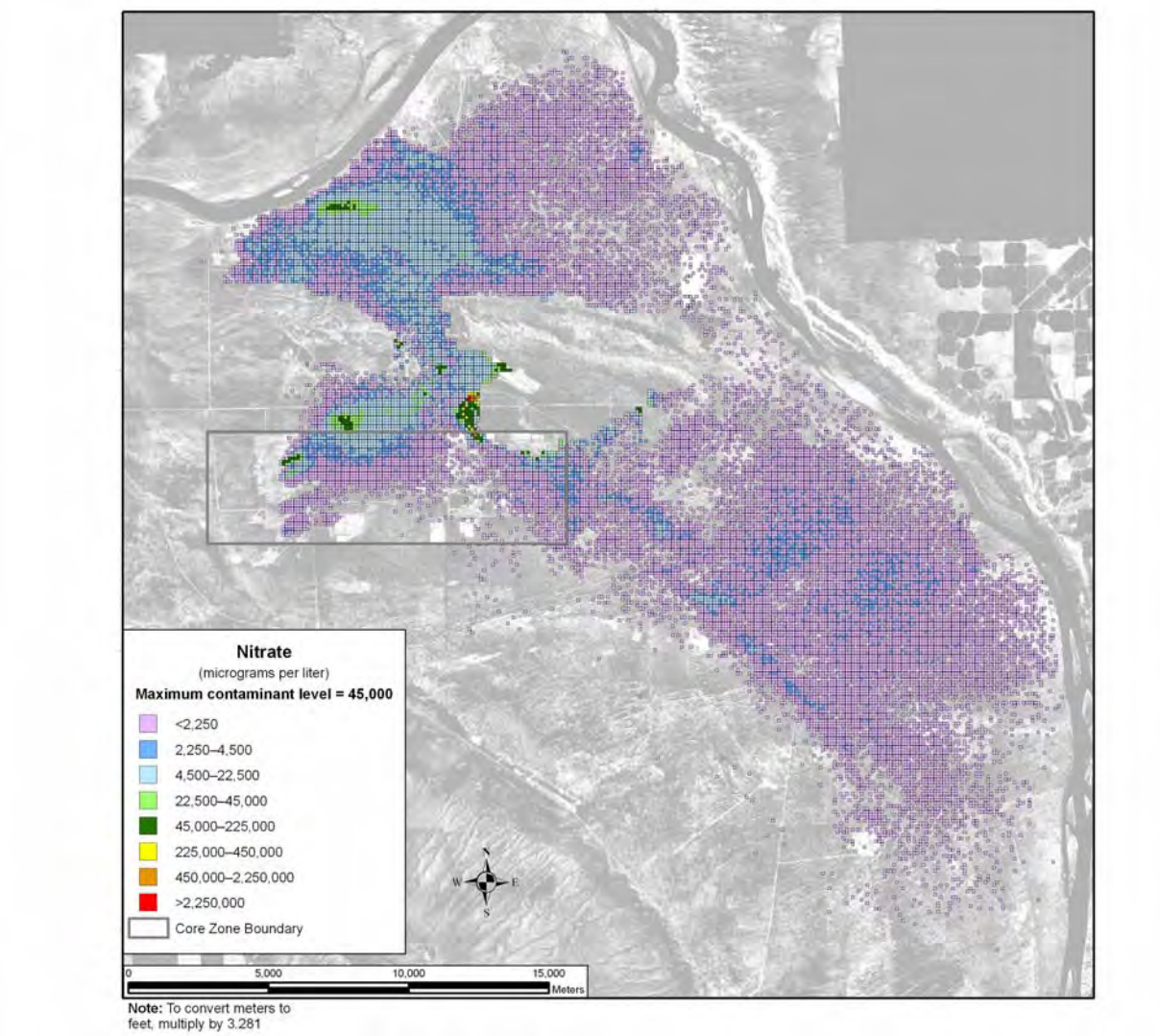


Figure 5–293. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

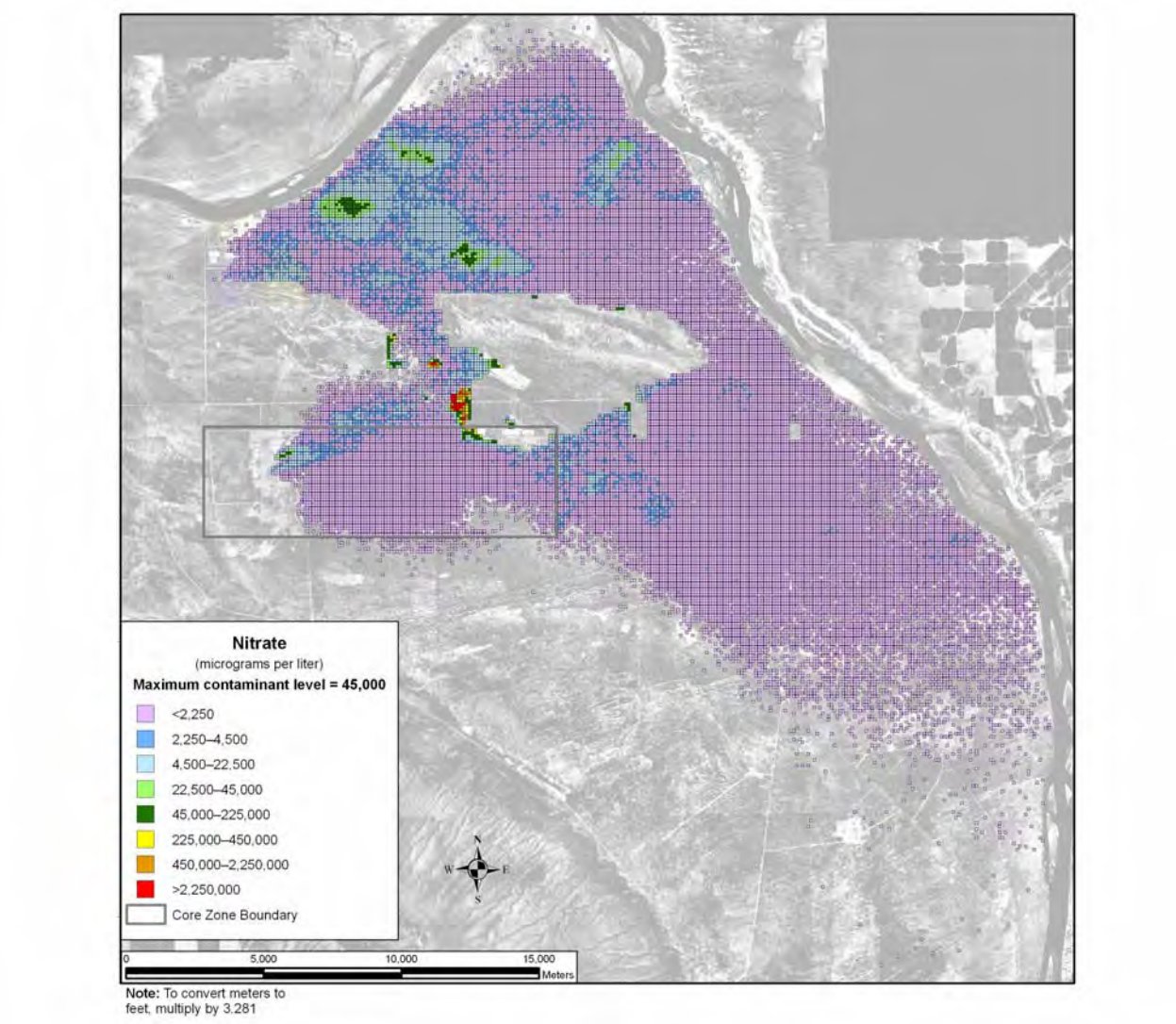


Figure 5–294. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2135

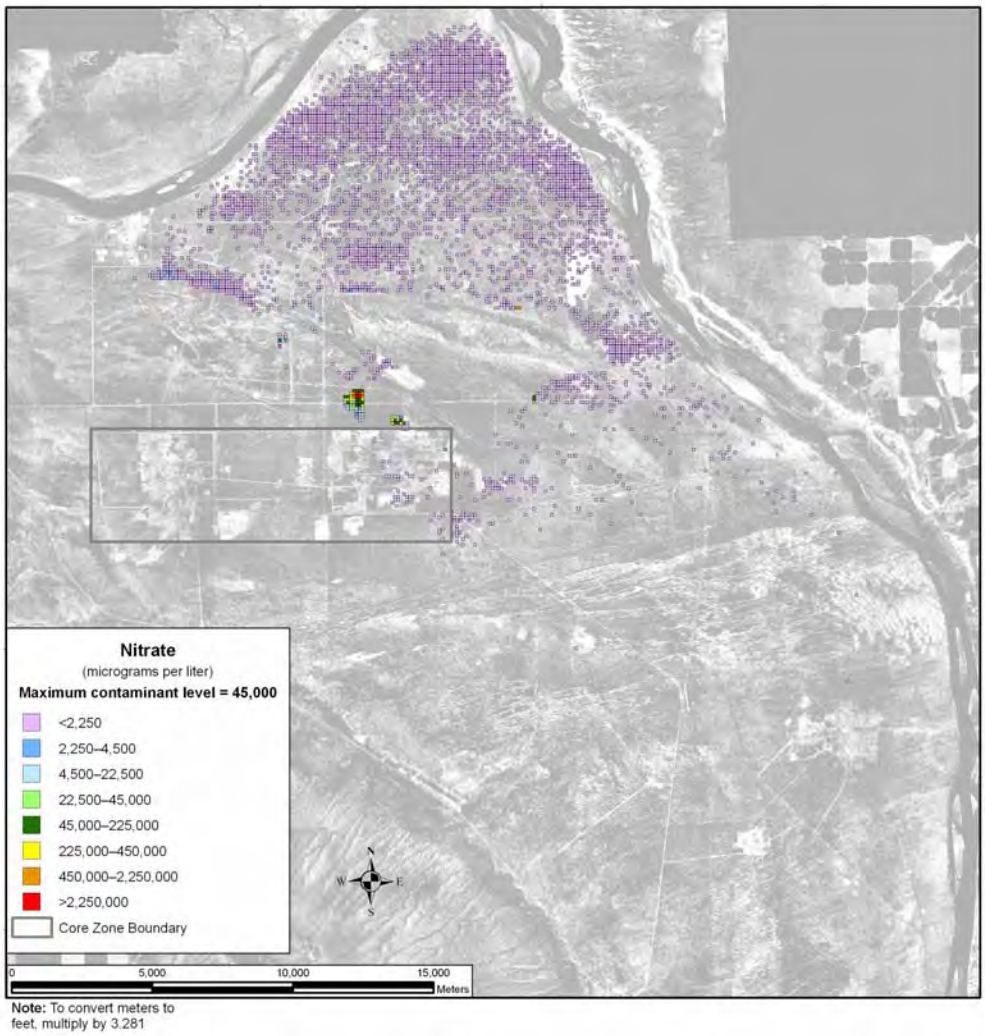


Figure 5–295. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

The spatial distribution of groundwater concentrations for the conservative tracers under the Option Case is essentially identical to that under the Base Case (see Figures 5–296 through 5–307).

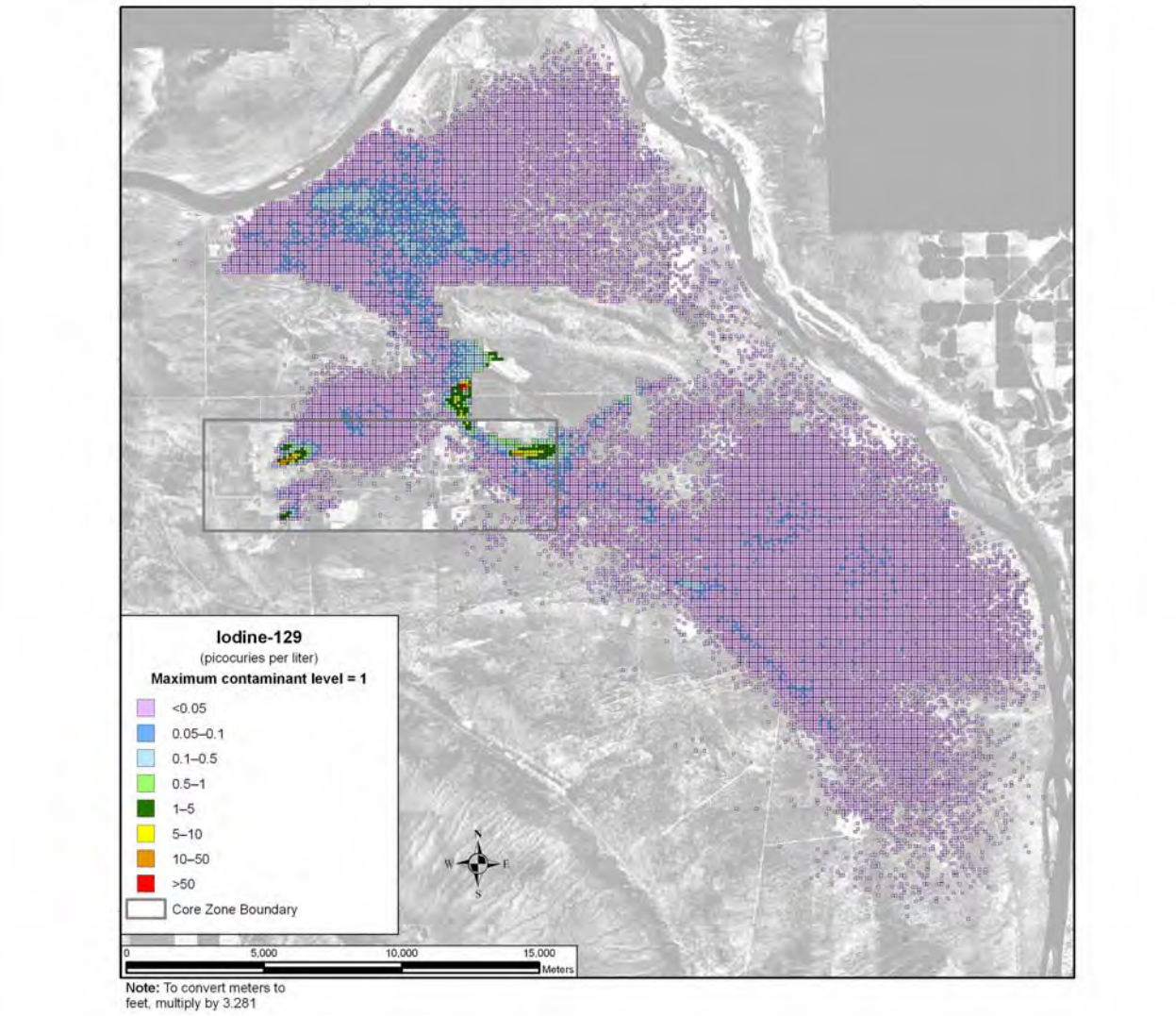


Figure 5–296. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

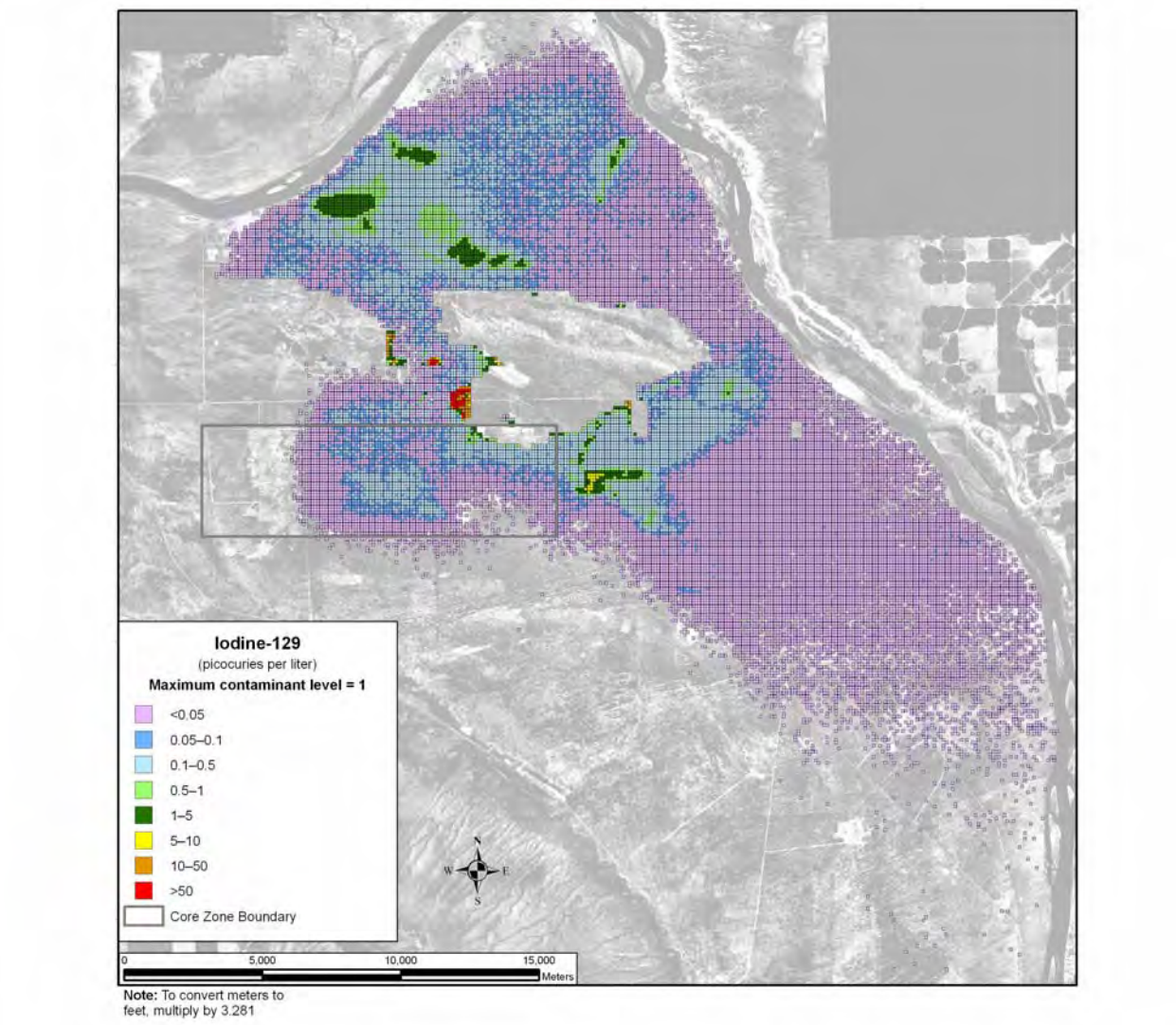


Figure 5–297. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2135

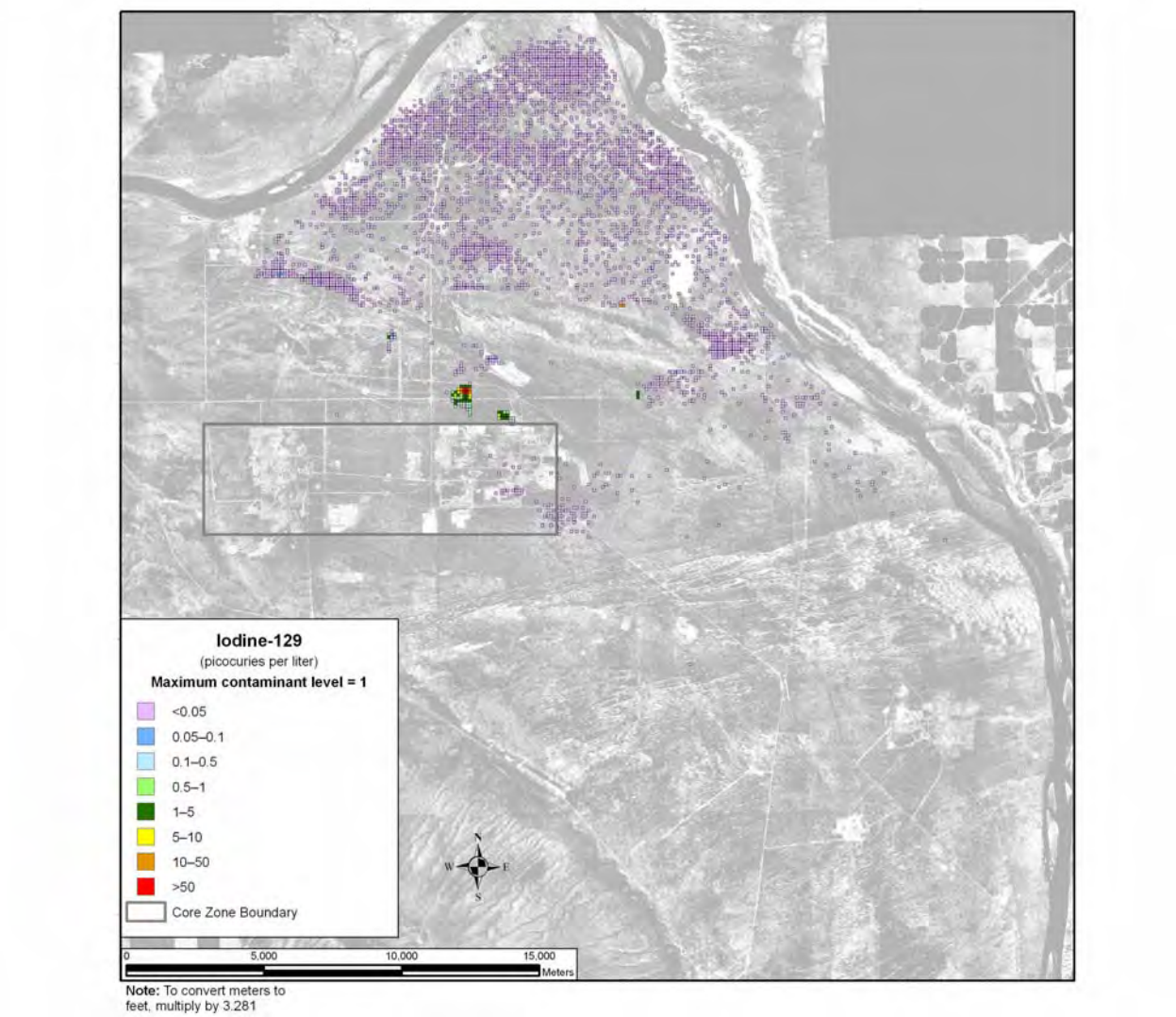


Figure 5–298. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

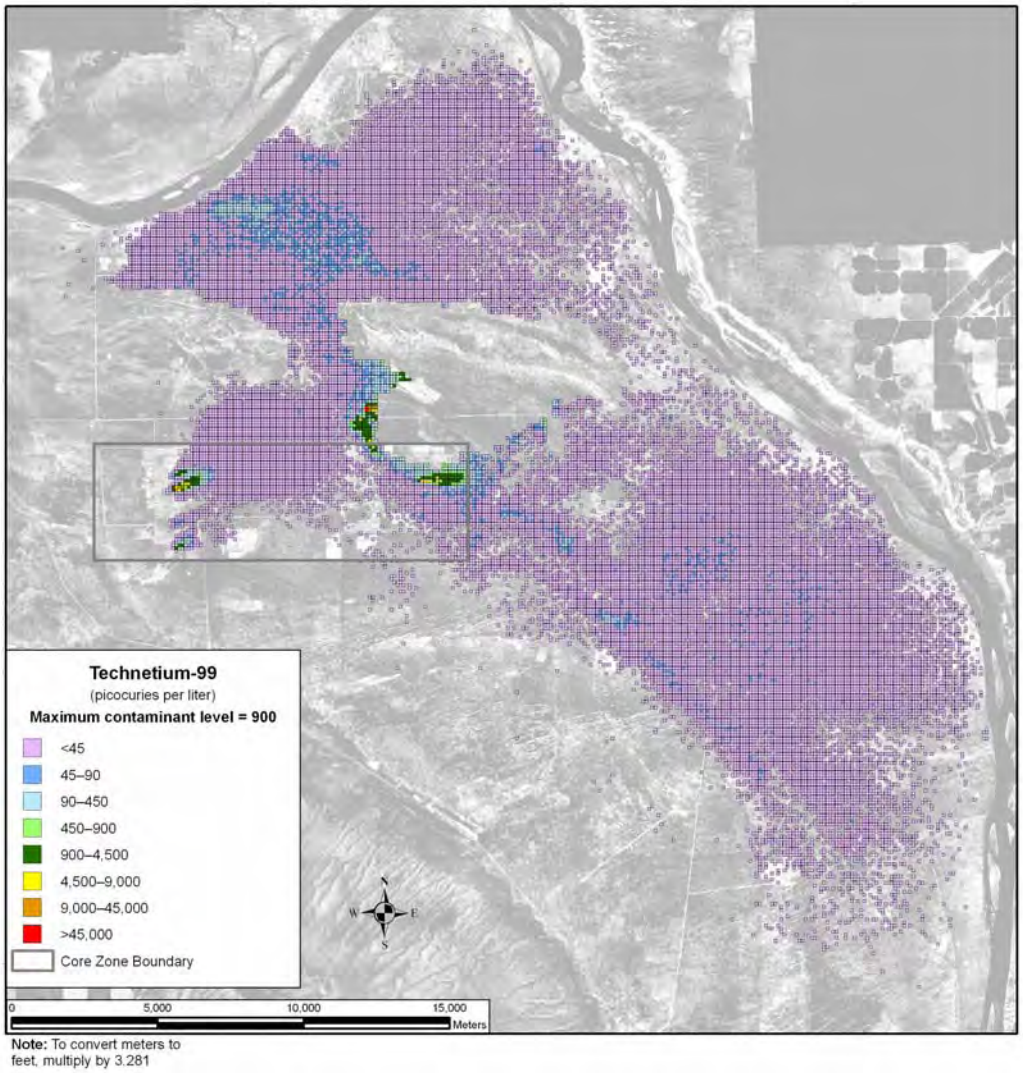


Figure 5–299. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

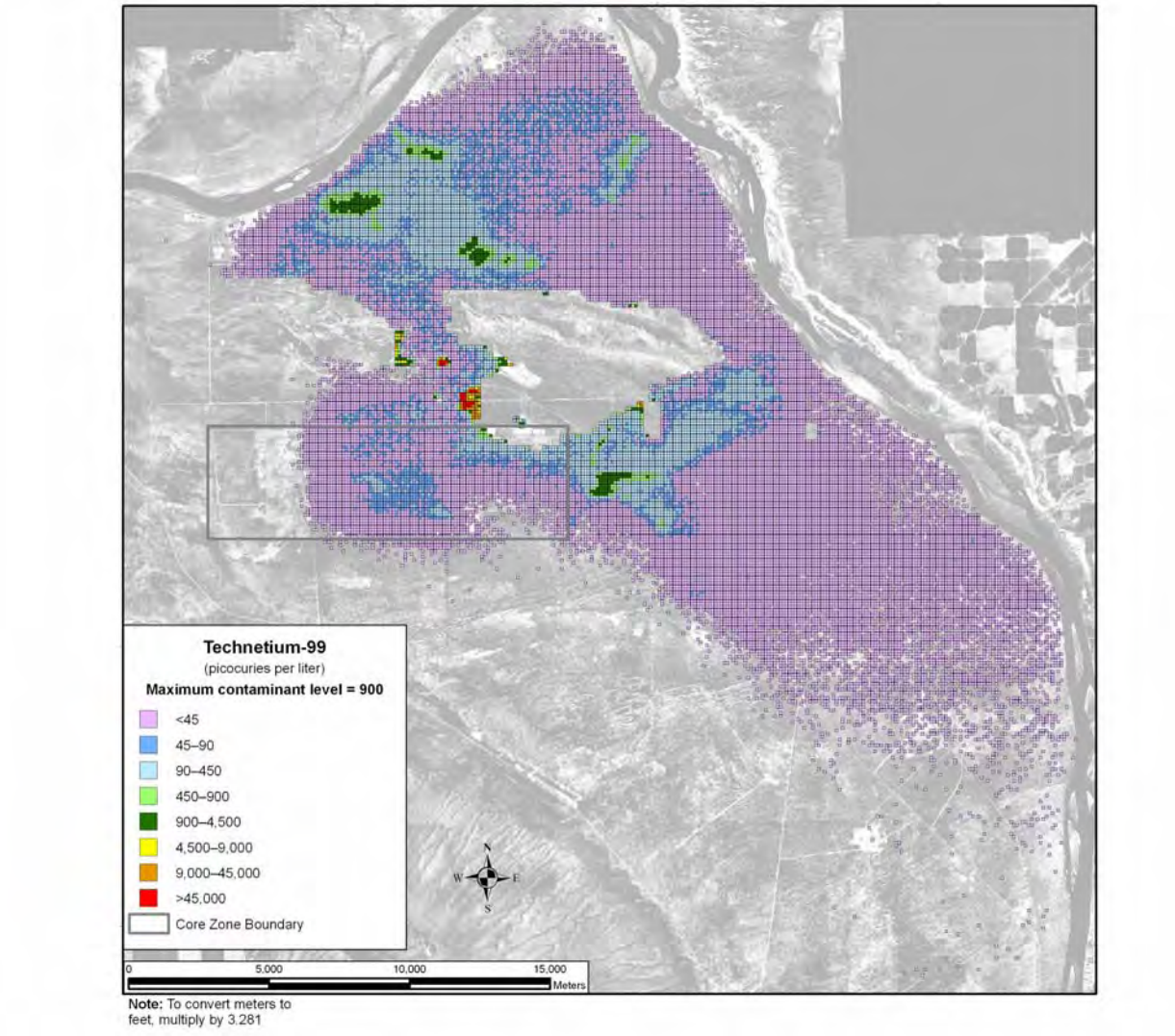


Figure 5–300. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2135

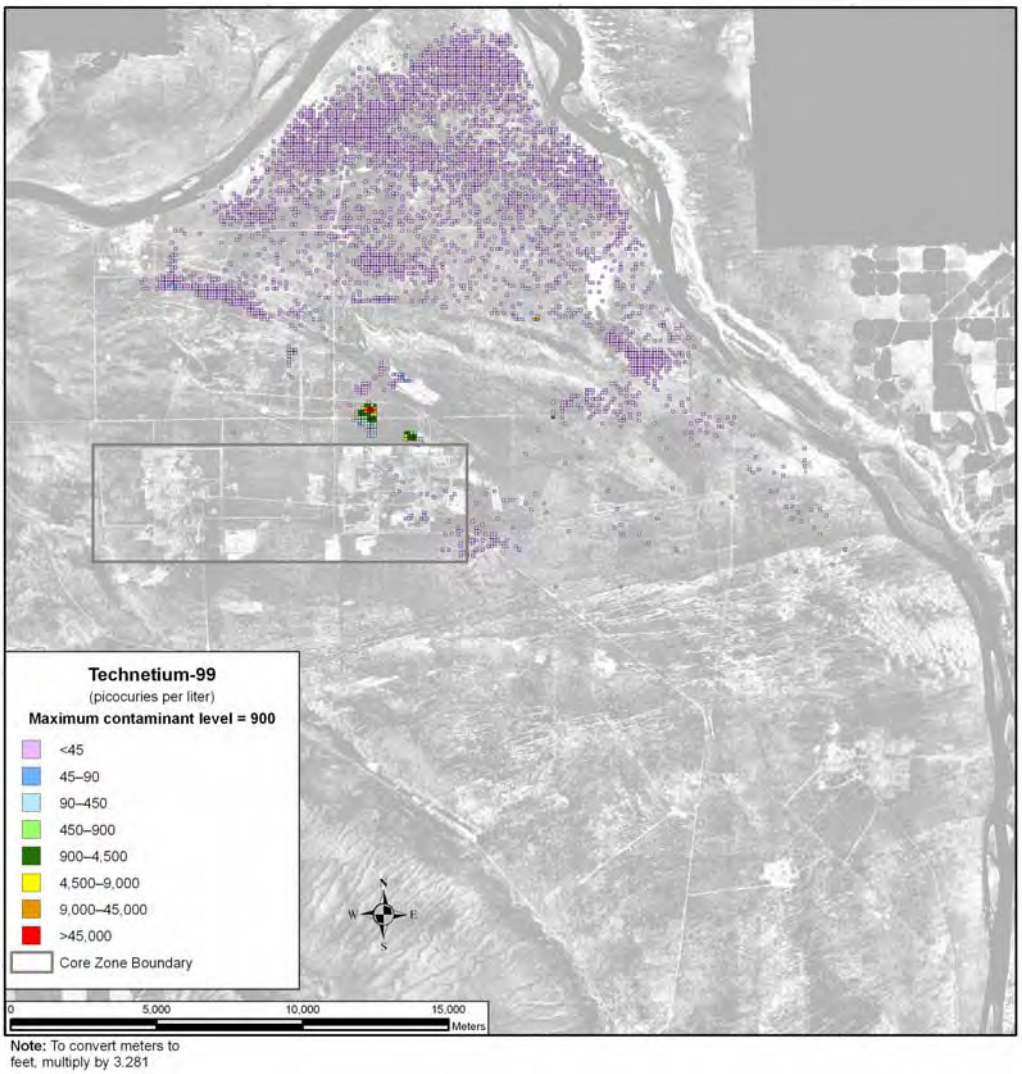


Figure 5–301. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

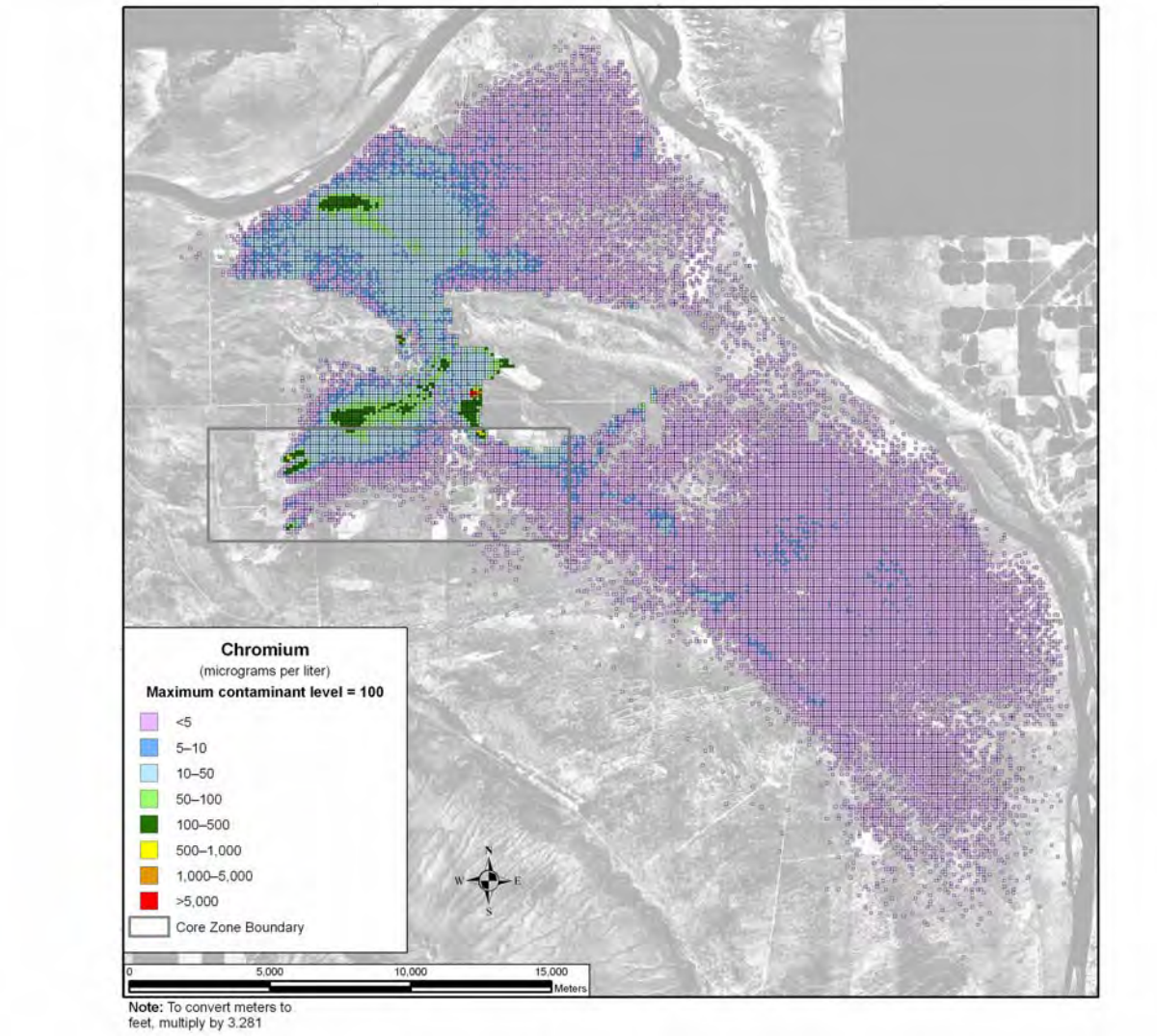


Figure 5–302. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

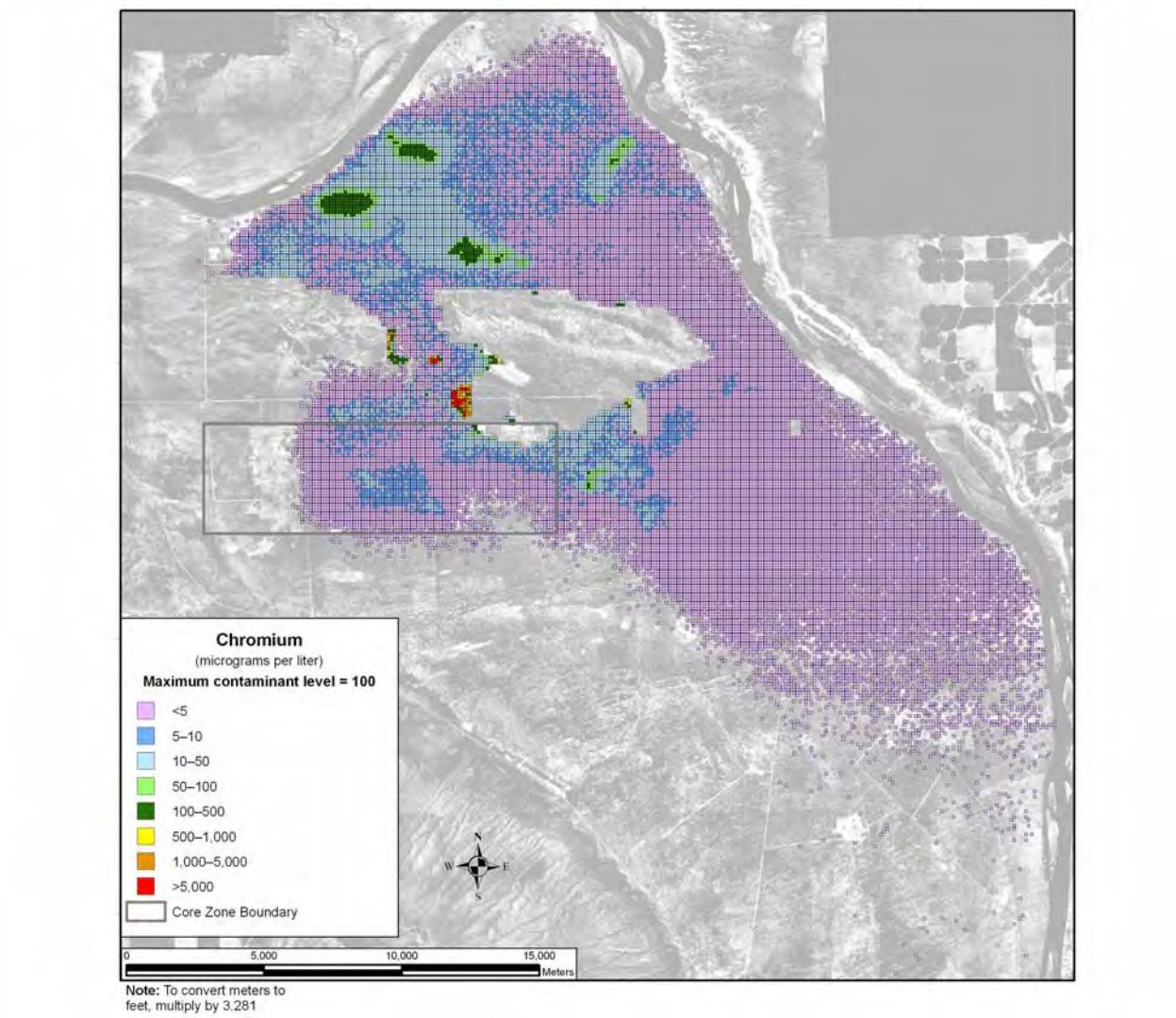


Figure 5–303. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2135

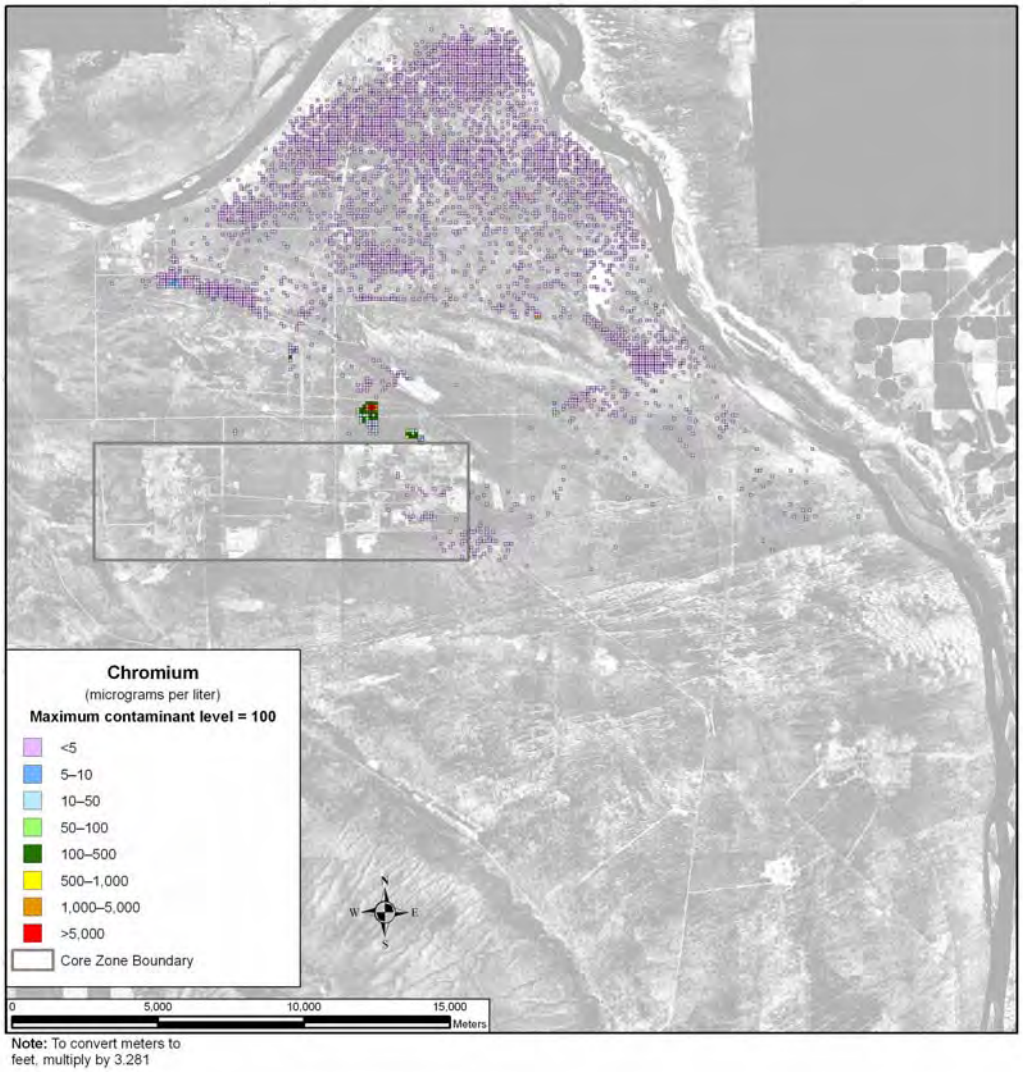


Figure 5–304. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

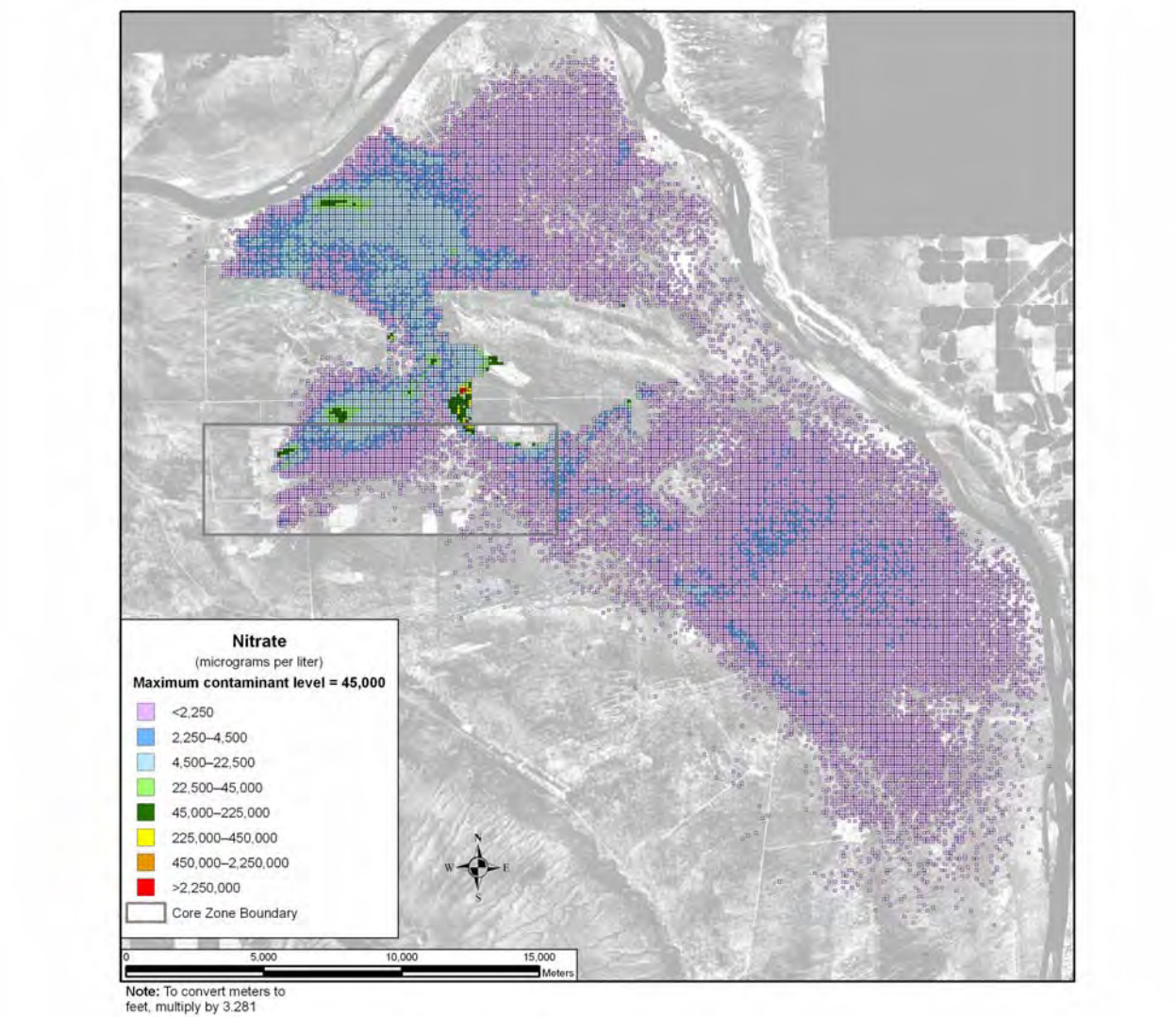


Figure 5–305. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

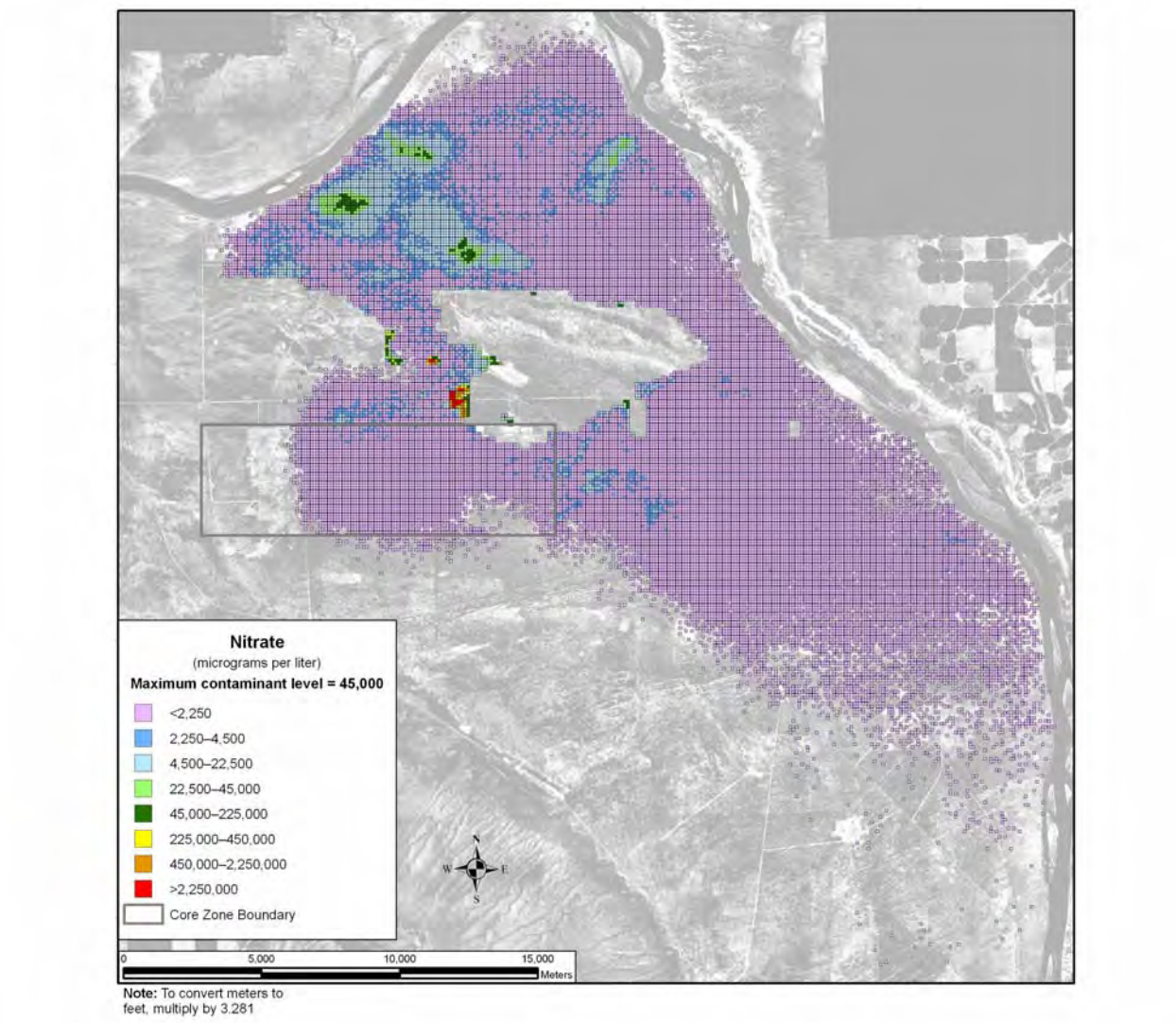


Figure 5–306. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2135

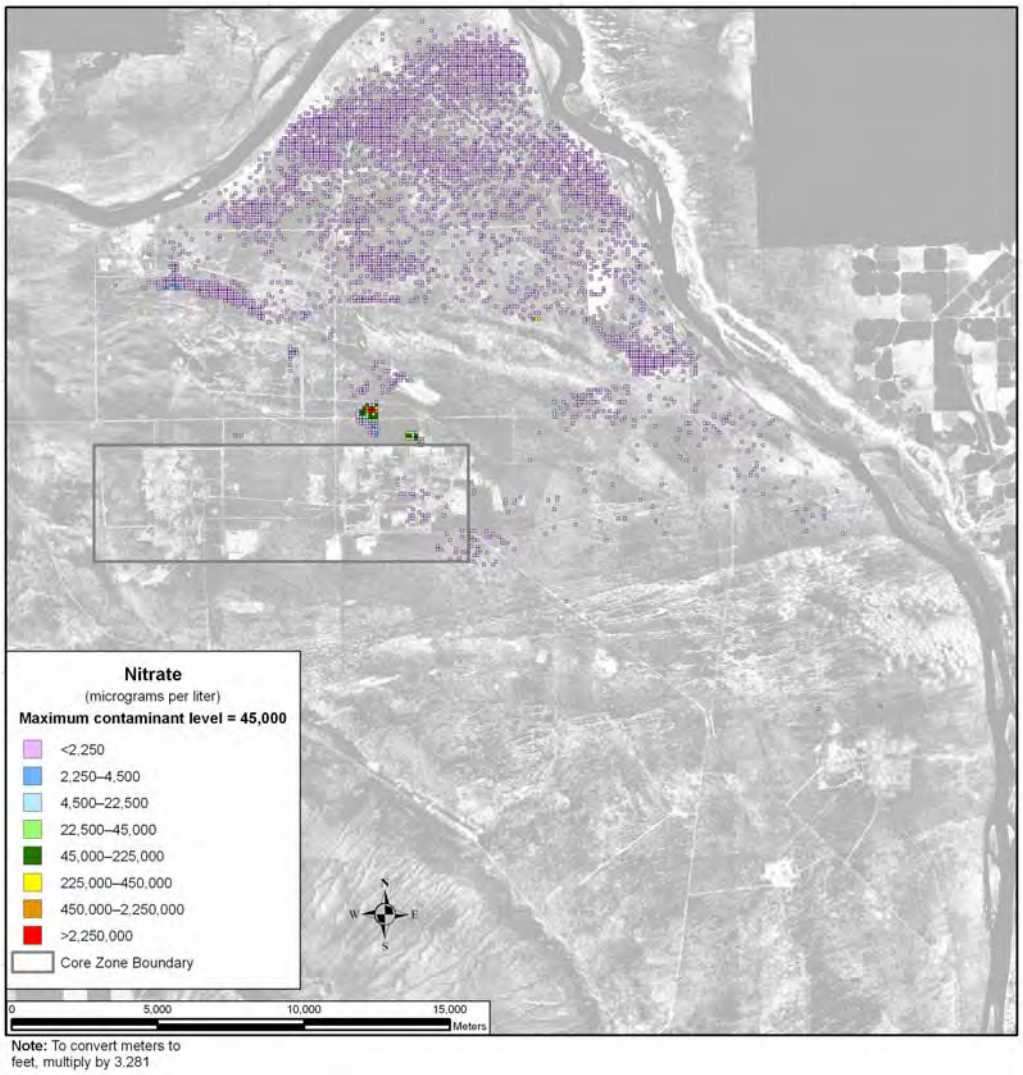


Figure 5–307. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium under the Base Case are not as mobile as those COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–308 shows the distribution of uranium-238 during CY 2005. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration and is contained within the Core Zone Boundary. By CY 7140, the area of the plume has grown and extended to the Columbia River (see Figure 5–309). Most of the plume is significantly below the benchmark except for a small pocket with high concentrations in the southern region of Gable Gap extending north from the B Barrier. At CY 11,885, the greatest development of the plume during the analysis period is seen (see Figure 5–310). The only area with a significant level of contaminant concentration is the area in the southern region of Gable Gap that originates from the B Barrier. Figures 5–311 through 5–313 show similar results for total uranium.

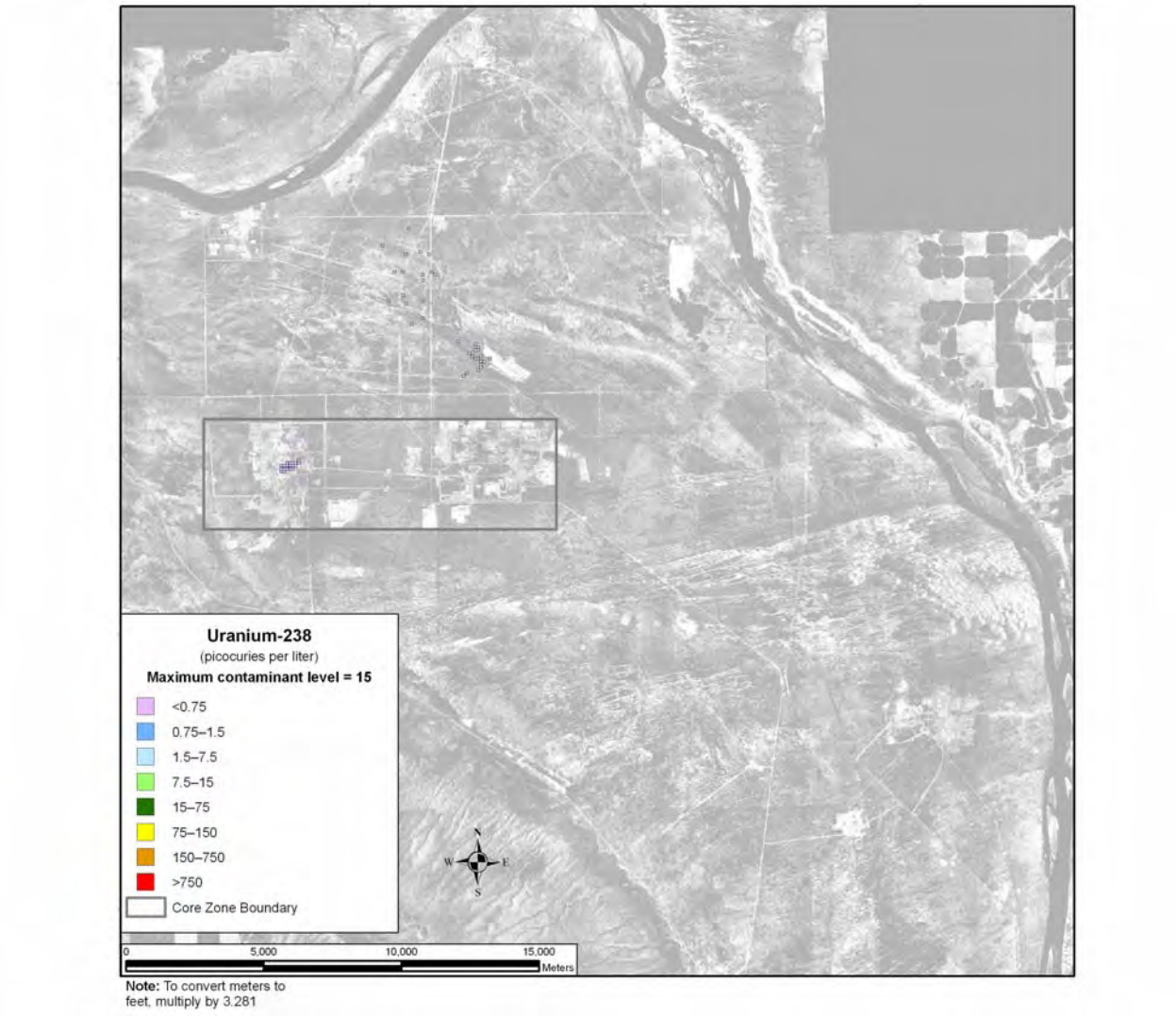


Figure 5–308. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

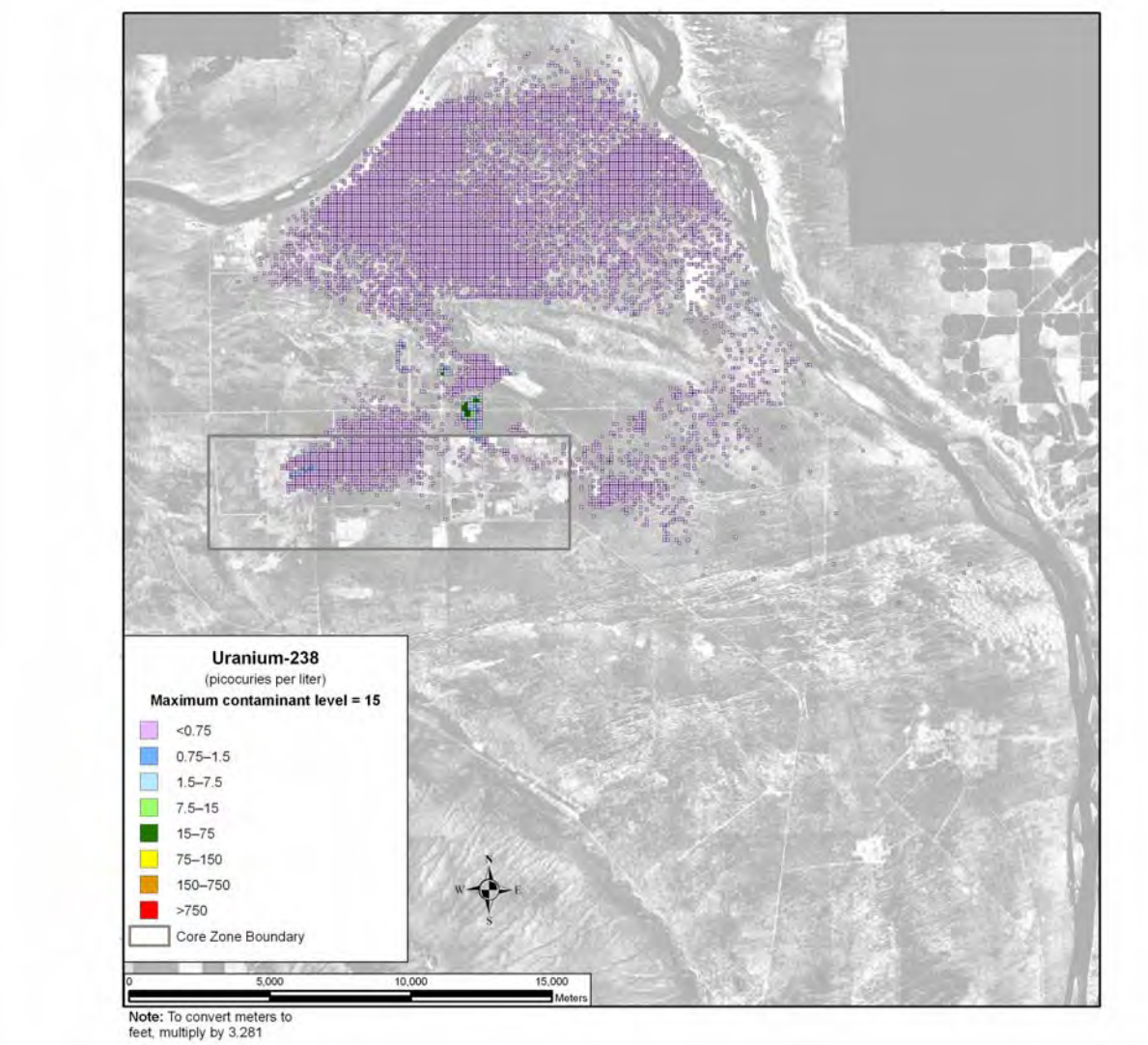


Figure 5–309. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 7140

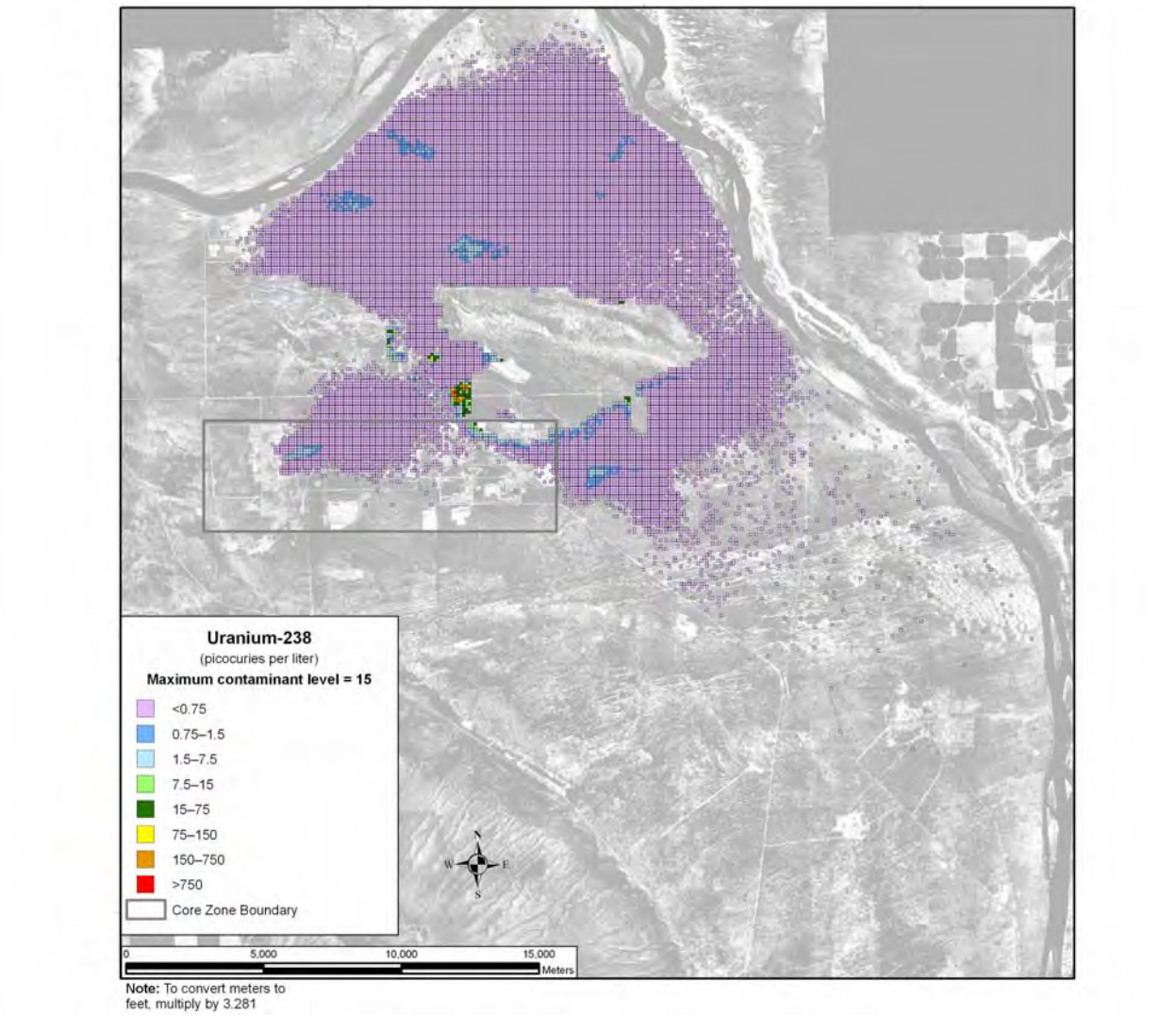


Figure 5–310. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

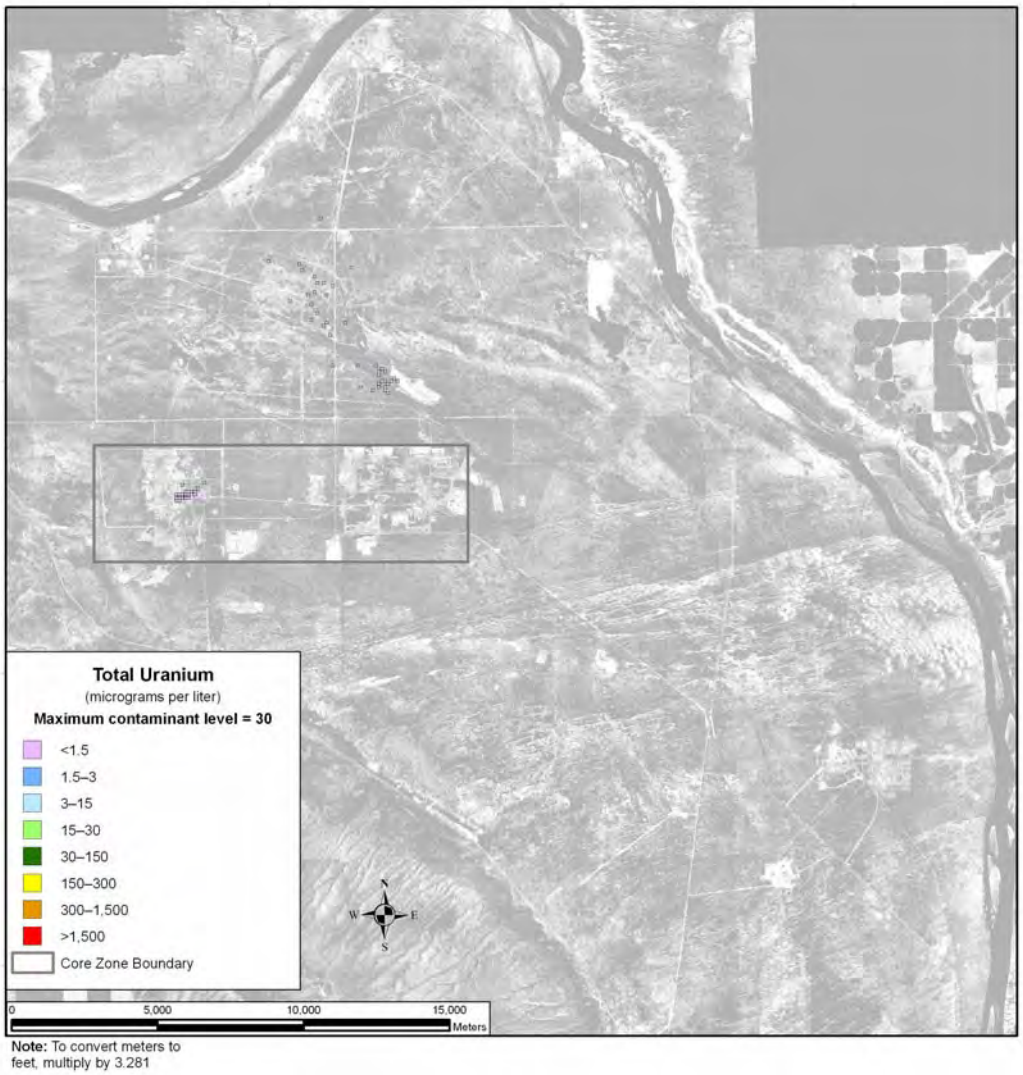


Figure 5–311. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

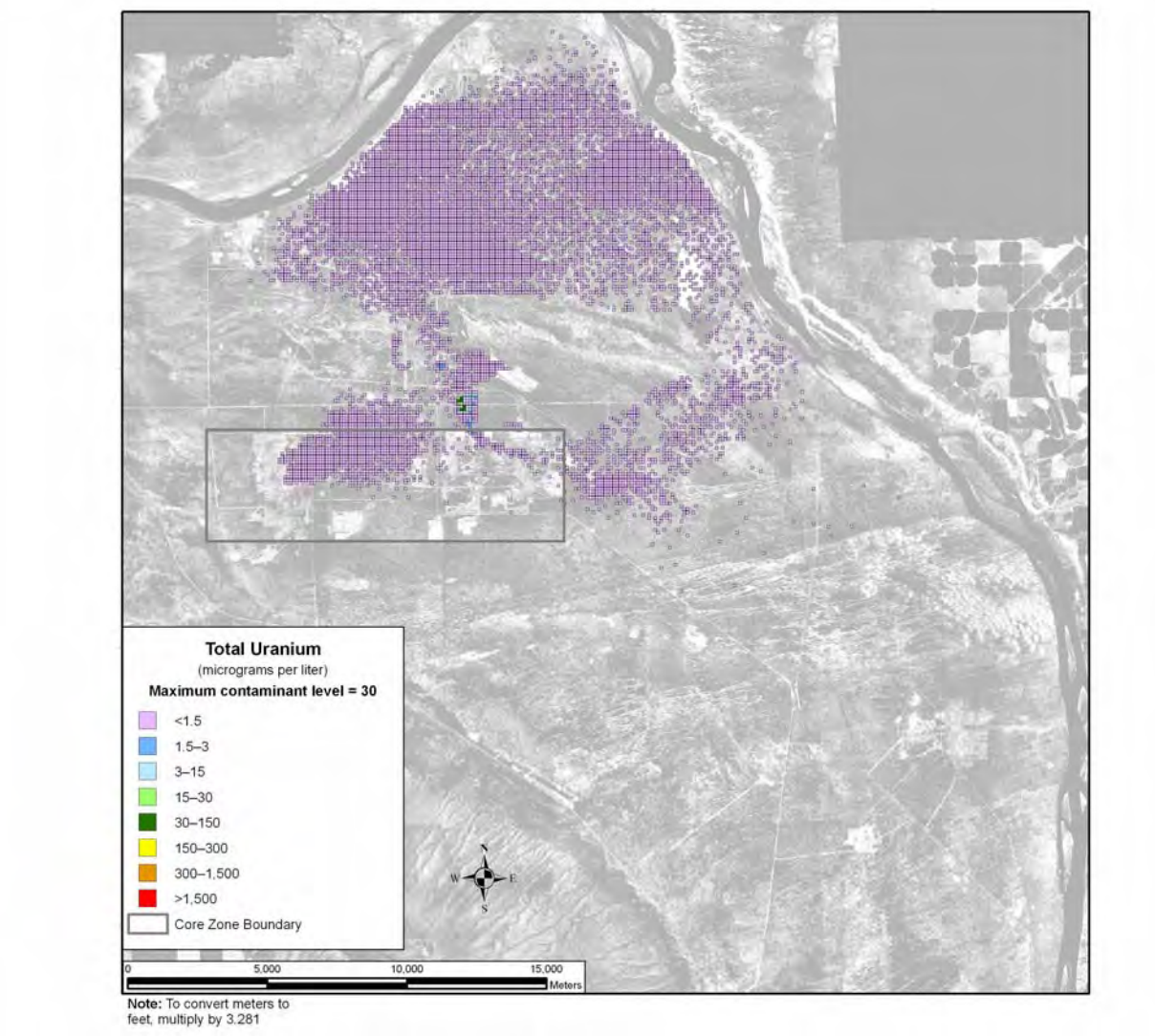


Figure 5–312. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 7140

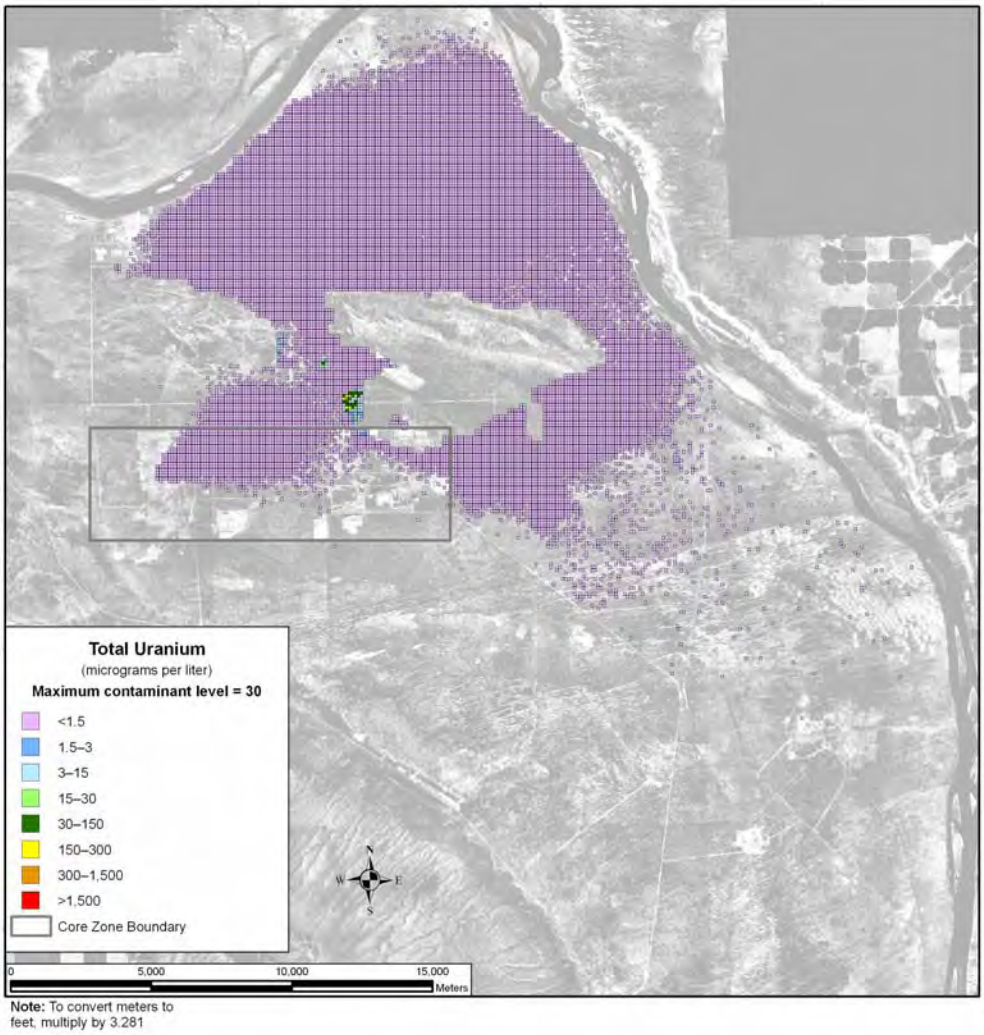


Figure 5–313. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

Figure 5–314 shows the distribution of uranium-238 during CY 2005 under the Option Case. There are two plumes associated with this case, one originating from the T Barrier and the other from the B Barrier. Although there are no significant contaminant concentrations, the plumes under the Option Case are much larger than those under the Base Case. By CY 2135, the contaminant plume has grown and reached the Columbia River, but there are still no significant peaks in concentration levels (see Figure 5–315). By CY 11,885, while the greatest development of the plume occurred under the Base Case, the contaminant plume under the Option Case has begun to recede (see Figure 5–316). This recession is due to the removal of the six sets of cribs and trenches (ditches) and the remediation of their contaminant plumes. Figures 5–317 through 5–319 show similar results for total uranium.

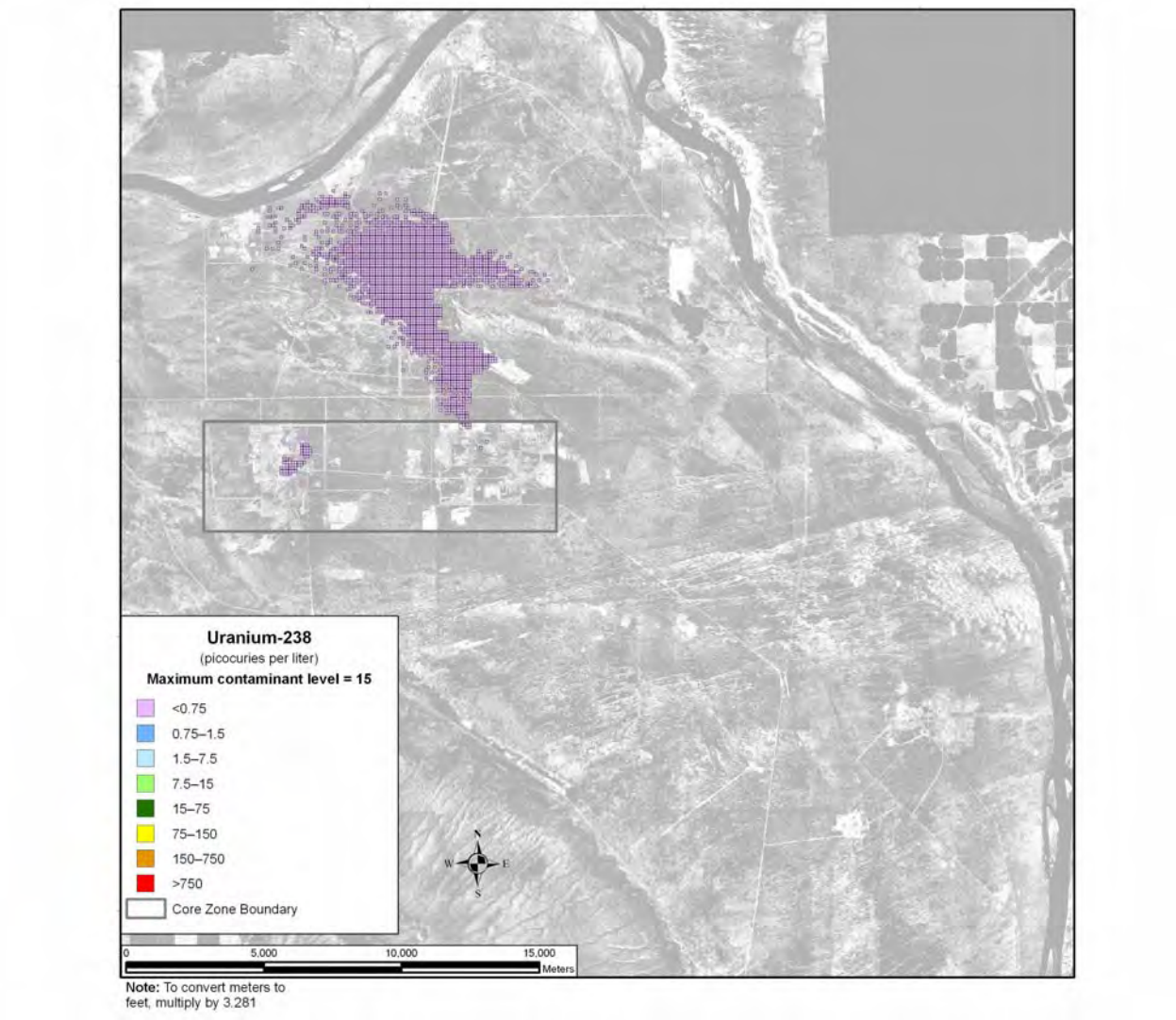


Figure 5–314. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2005

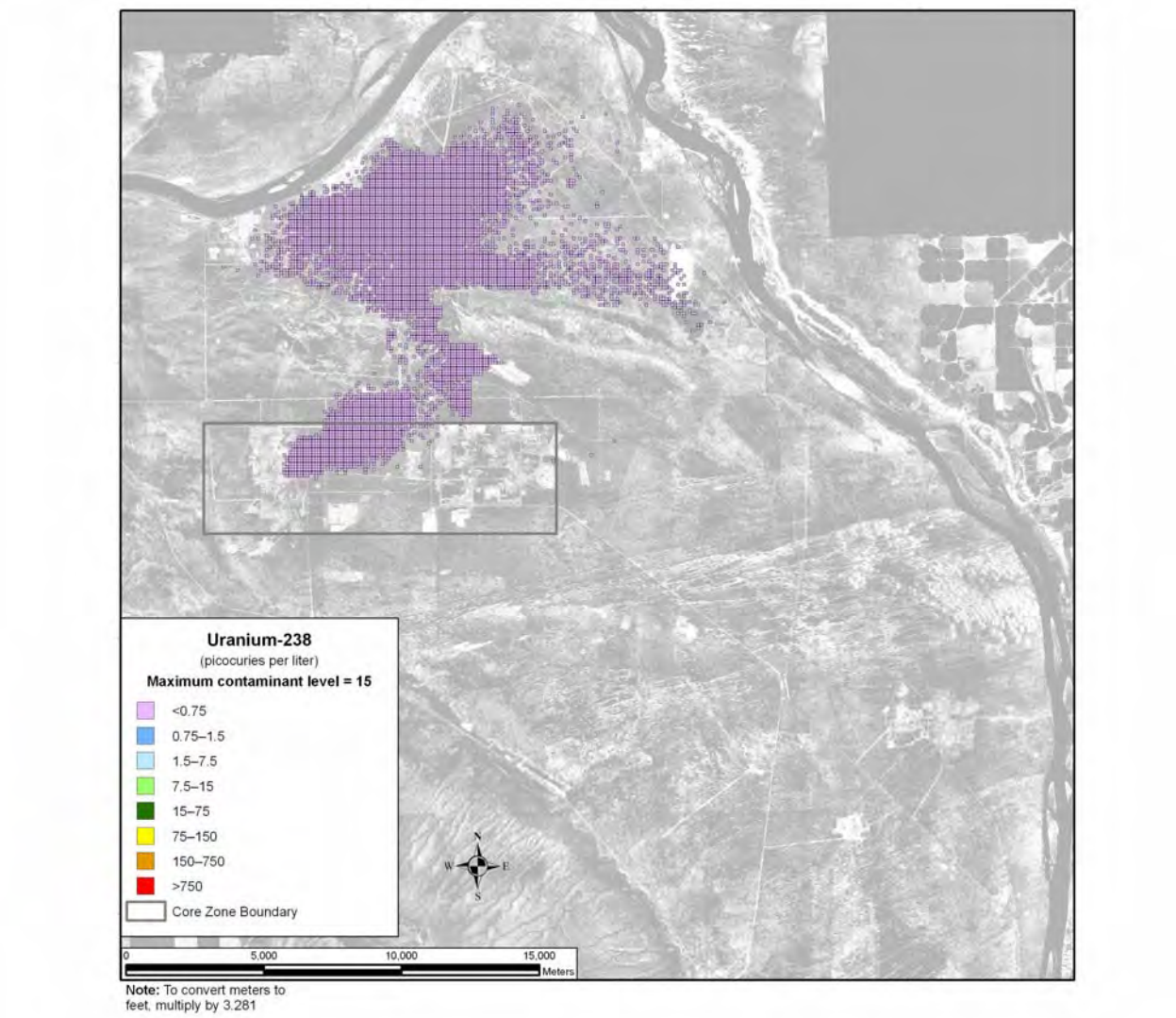


Figure 5–315. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135

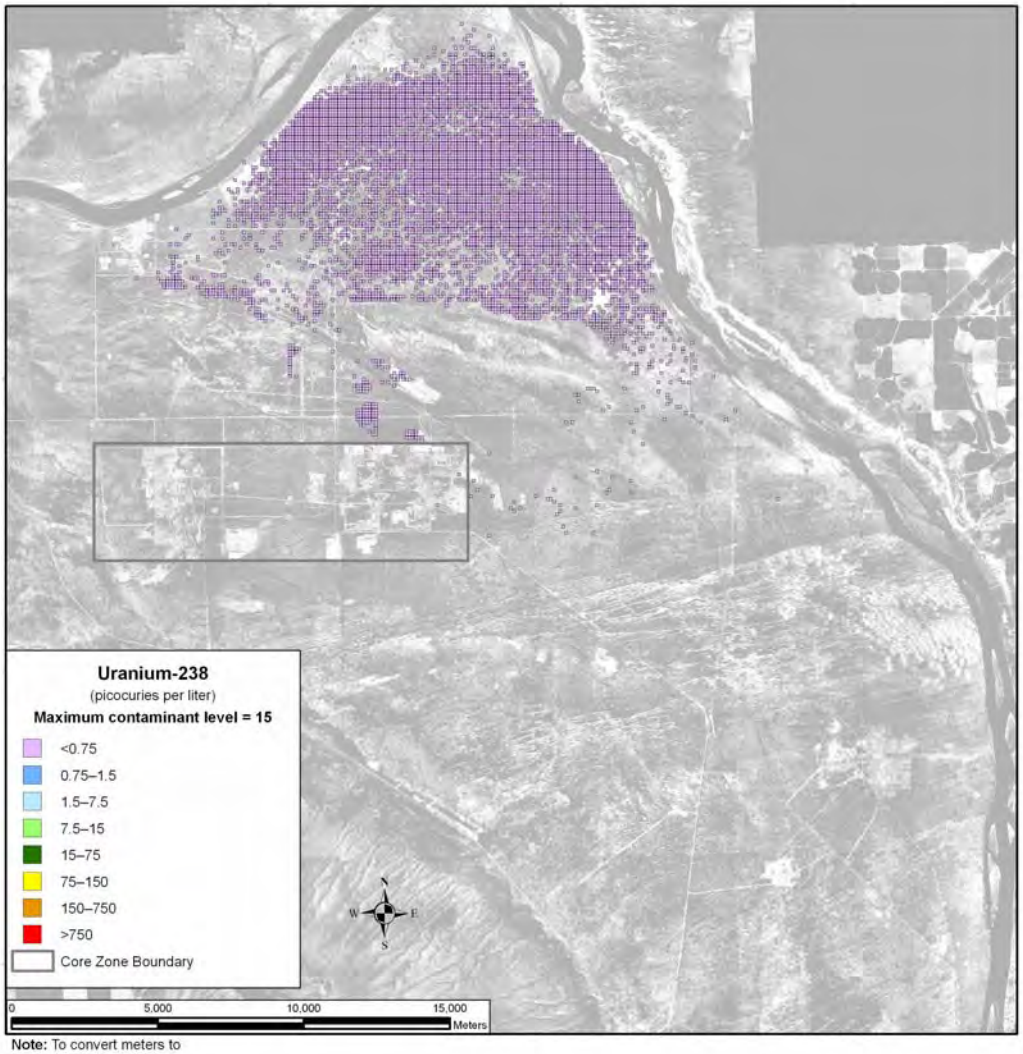


Figure 5–316. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

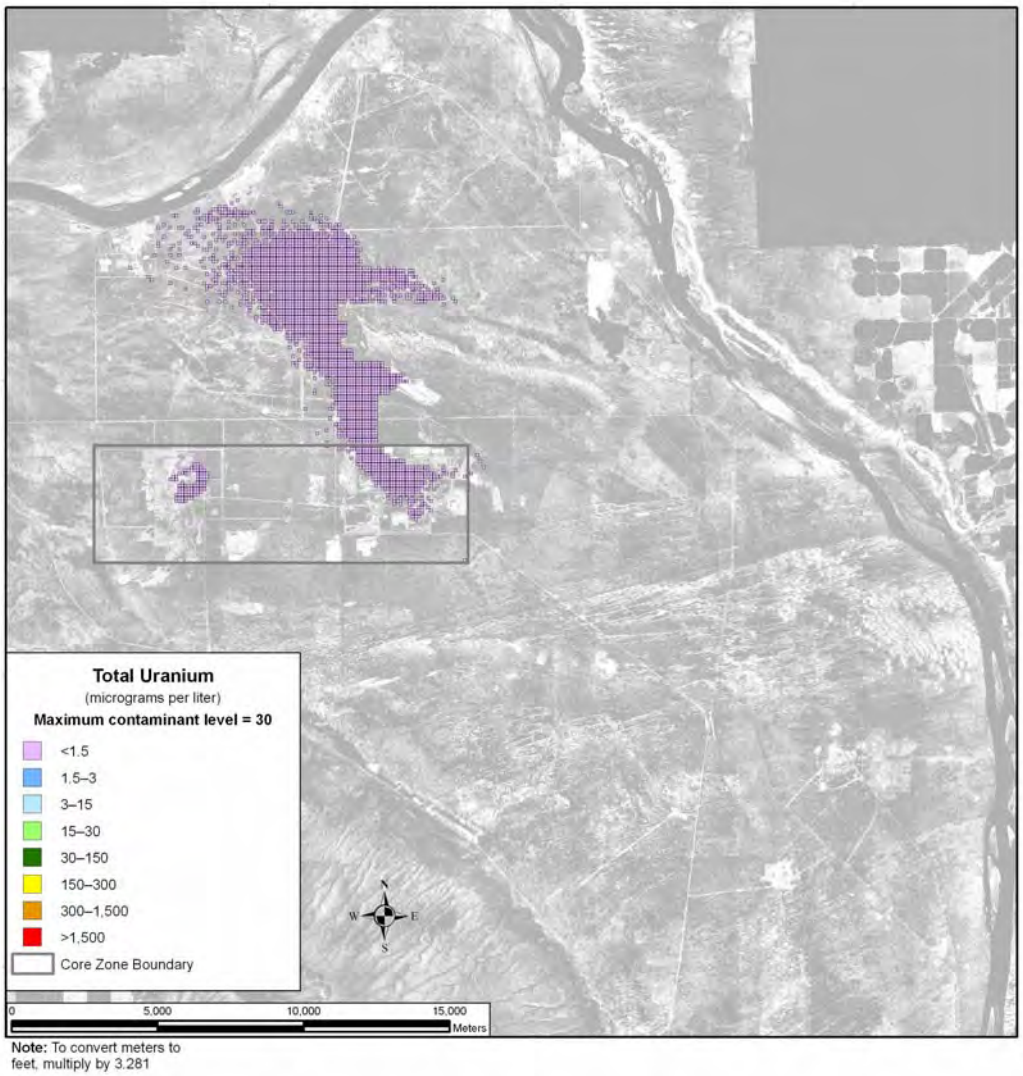


Figure 5–317. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2005

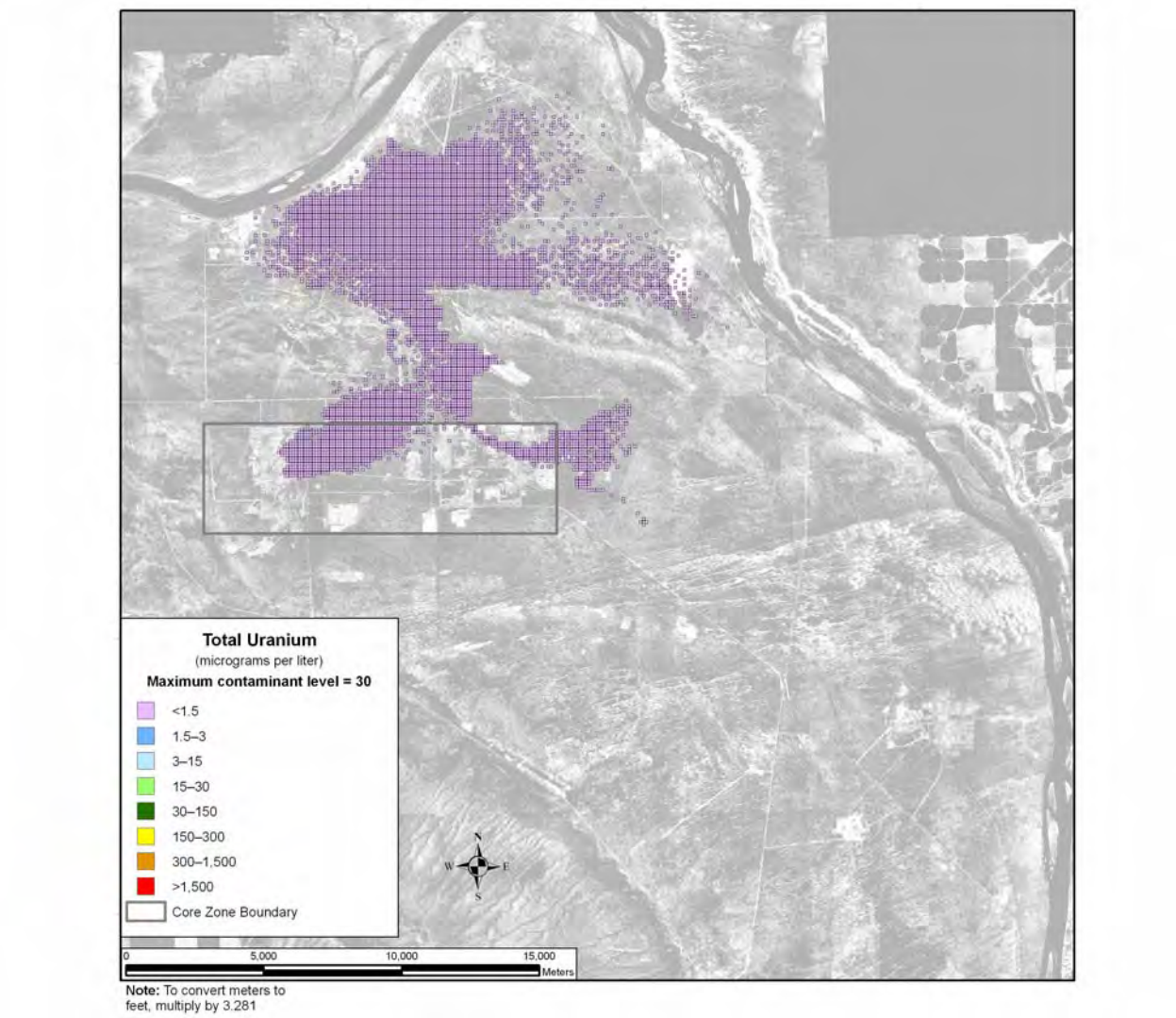


Figure 5–318. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135

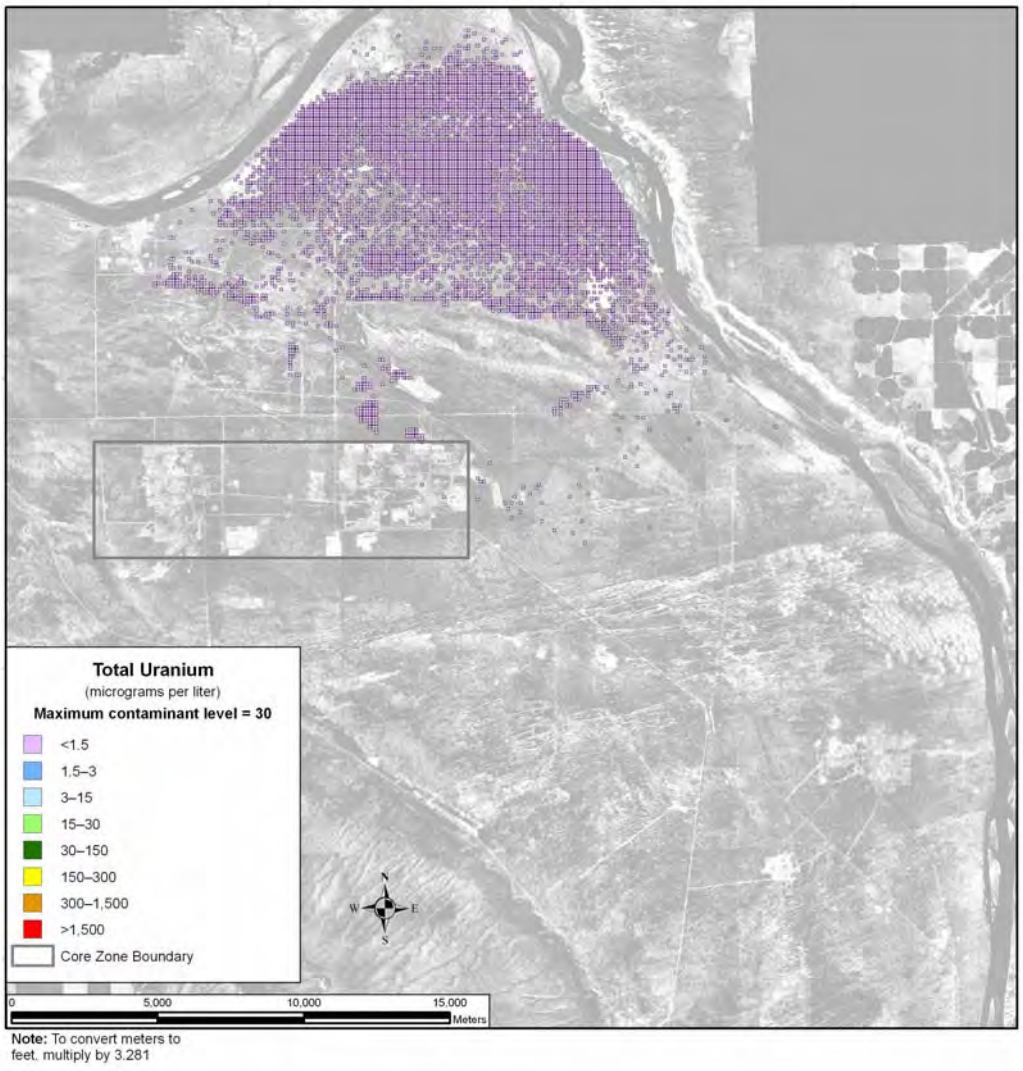


Figure 5–319. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

Figure 5–320 shows the area in square kilometers in which groundwater concentrations of technetium-99 exceed the benchmark concentration in the analysis as a function of time under the Base Case. A peak of almost 4.0 square kilometers (1.7 square miles) occurs around CY 2135, followed by a fairly sharp decrease. By about CY 4000, the area with a concentration above the benchmark begins to level out around 0.5 square kilometers (0.19 square miles). Iodine-129 shows a similar pattern (see Figure 5–321), as both constituents are conservative tracers.

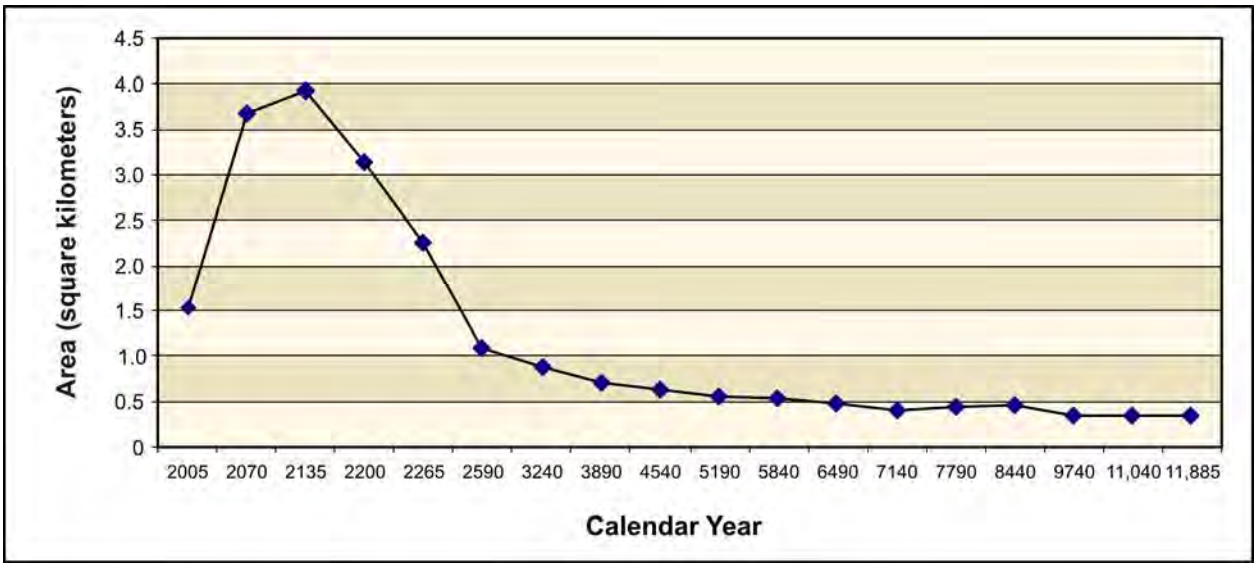


Figure 5–320. Tank Closure Alternative 6B, Base Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

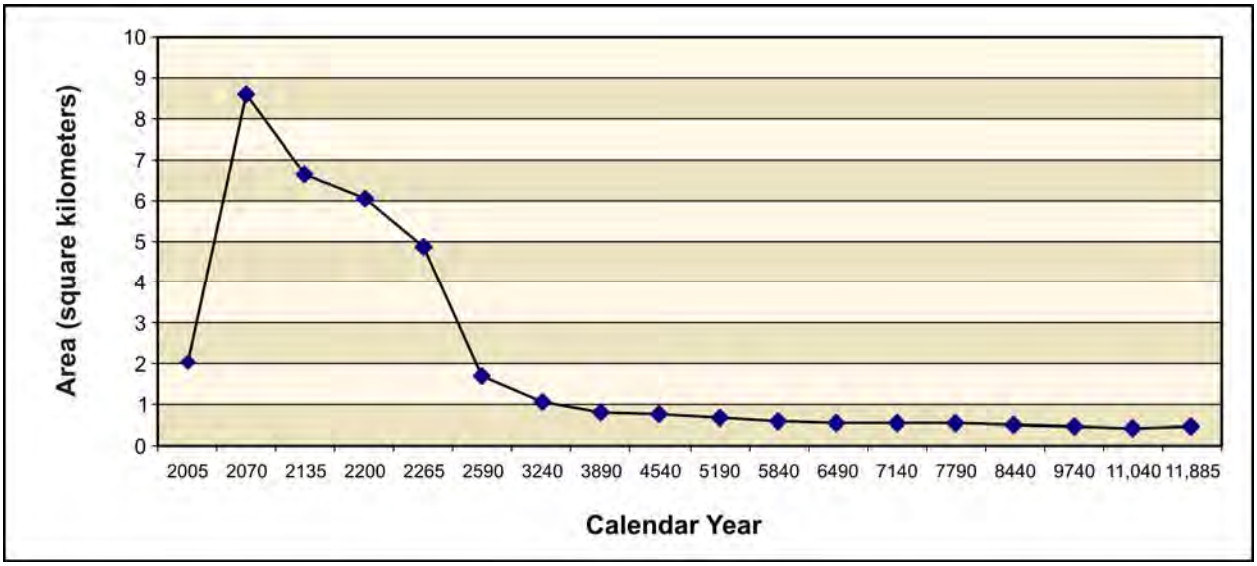


Figure 5–321. Tank Closure Alternative 6B, Base Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Option Case, the areas with concentrations of technetium-99 and iodine-129 above the benchmarks are essentially identical to those under the Base Case (see Figures 5–322 and 5–323).

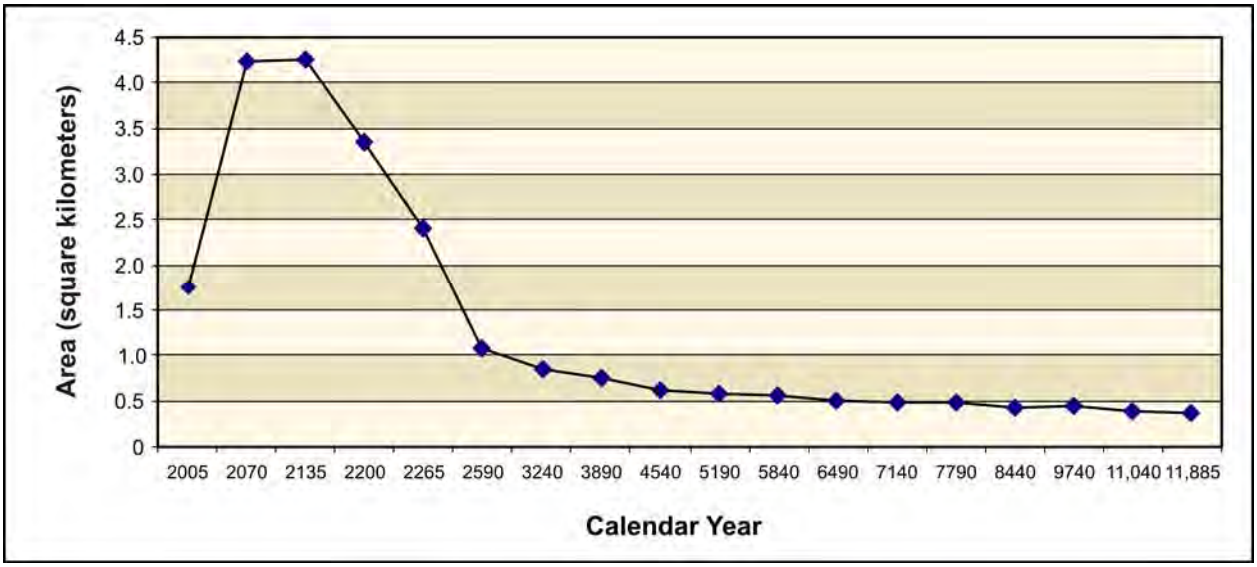


Figure 5–322. Tank Closure Alternative 6B, Option Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

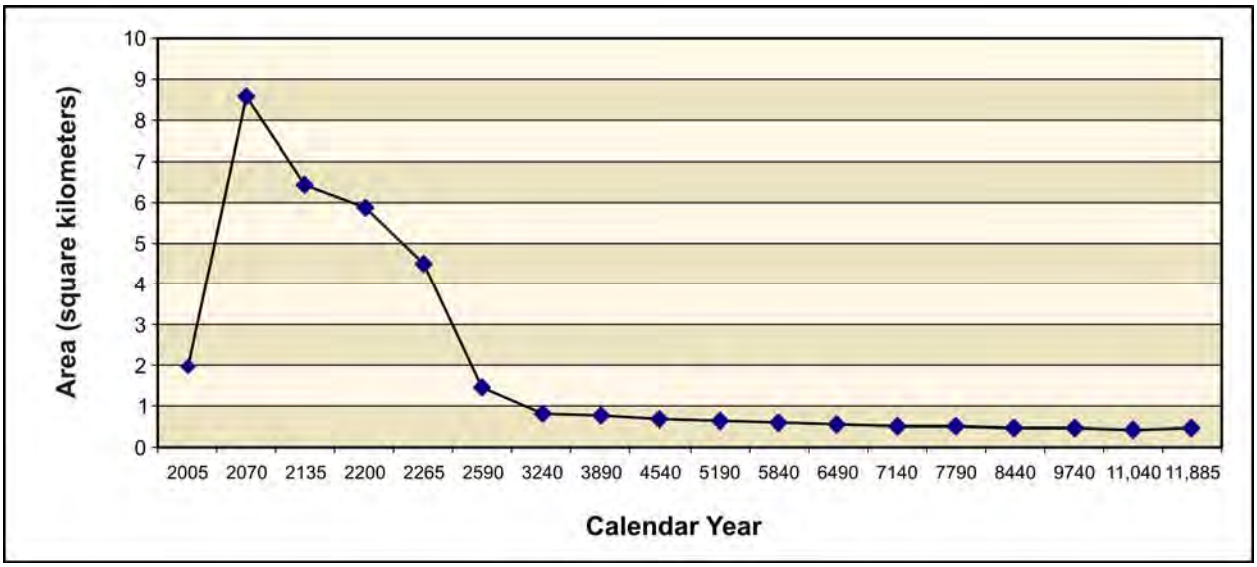


Figure 5–323. Tank Closure Alternative 6B, Option Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Base Case, uranium-238 did not register above the benchmark in any area until after CY 5840 (see Figure 5–324). A sharp increase in area with concentrations above the maximum contaminant level is seen after CY 5840 and continues to rise through the end of the period of analysis (CY 11,940). It is expected that the majority of the uranium-238 would continue to migrate through the vadose zone after the period of analysis is over.

Under the Option Case, uranium-238 did not register above the benchmark in any area during the period of analysis. This is a result of the high retardation rate and the removal and remediation of the cribs and trenches (ditches).

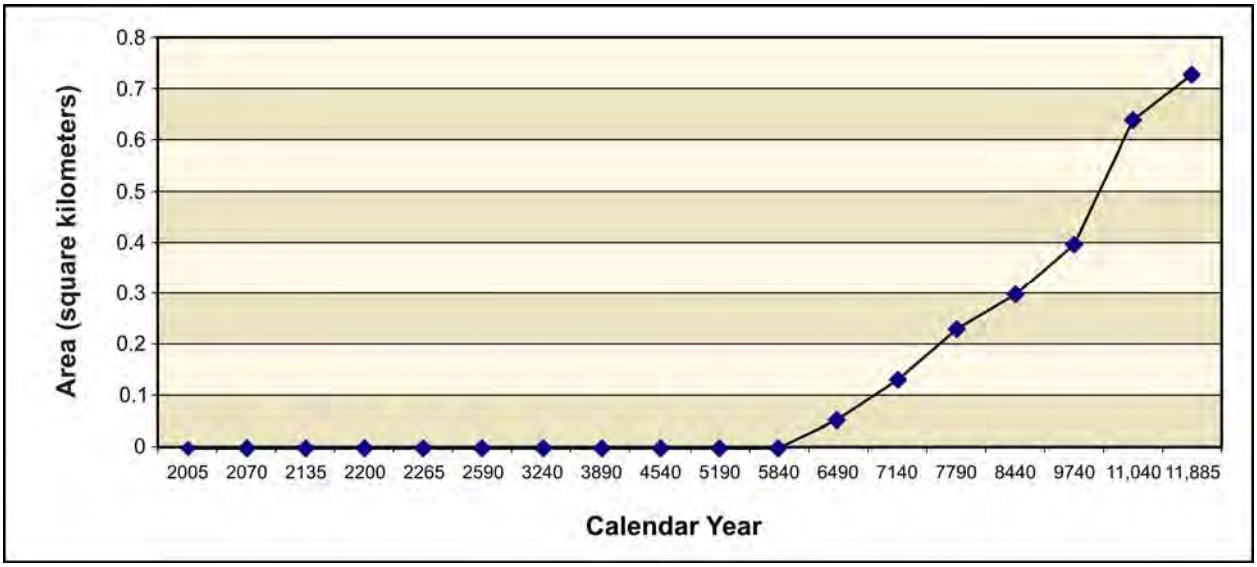


Figure 5–324. Tank Closure Alternative 6B, Base Case, Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.10.6 Summary of Impacts

For the conservative tracers under the Base Case, concentrations at the Core Zone Boundary exceeded the benchmark standards by about two orders of magnitude during the early part of the period of analysis, around CY 1956. Columbia River nearshore concentrations never reached the benchmark concentration and peaked at about one-half to one order of magnitude below it. The intensities and areas of these groundwater plumes peaked around CY 1956.

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Option Case are essentially identical to those under the Base Case.

For tritium under the Base Case, concentrations at the Core Zone Boundary exceeded the benchmark by about two orders of magnitude for a short period of time during the early part of the period of analysis, around CY 1956. During the same period of time, the Columbia River nearshore concentrations peaked at about one order of magnitude below the benchmark. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium.

The concentrations of tritium under the Option Case are essentially identical to those under the Base Case.

For uranium-238 and total uranium under the Base Case, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species began to approach the benchmark at the Core Zone Boundary toward the latter part of the period of analysis but never reached it. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never came to within about two orders of magnitude below the benchmark. The intensity and area of the contaminant plumes peaked at the end of the period of analysis.

Under the Option Case, uranium-238 concentrations at the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark concentration, except for a short spike at the Core Zone Boundary to about one order of magnitude below the benchmark at the beginning of the period of analysis. The Columbia River nearshore concentrations stayed fairly constant at about four orders of magnitude below the benchmark. Total uranium concentrations at the Core Zone Boundary generally stayed about three to four orders of magnitude below the benchmark. The Columbia River nearshore

concentrations remained fairly constant at around four and a half orders of magnitude below the benchmark.

5.1.1.11 Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

Activities under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would be similar in scope and timing. Tank waste would be retrieved to a volume corresponding to 99 percent retrieval, and residual material in tanks would be stabilized in place. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. From the long-term groundwater impact perspective, the results from the analyses of these alternatives are identical. Refer to Section 5.1.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.1 Actions and Timeframes Influencing Groundwater Impacts

Refer to Section 5.1.1.3.1 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.2 COPC Drivers

Refer to Section 5.1.1.3.2 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.3 Analysis of Release and Mass Balance

Refer to Section 5.1.1.3.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.4 Analysis of Concentration Versus Time

Refer to Section 5.1.1.3.4 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.5 Analysis of Spatial Distribution of Concentration

Refer to Section 5.1.1.3.5 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.6 Summary of Impacts

Refer to Section 5.1.1.3.6 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, which are identical to those for Tank Closure Alternative 6C.

5.1.2 Human Health Impacts

Potential human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer. For long-term performance assessment, radiological dose and risk are estimated consistent with the recommendations of *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (Eckerman et al. 1999), including use of radionuclide-specific dose factors and risk coefficients. Potential human health effects due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as Hazard Index, the sum of the Hazard Quotients of a group of chemicals. Further information on the nature of human health effects in response to exposure to radiological and chemical constituents is provided in Appendix K. Screening analysis identified 14 radionuclide and 26 chemical constituents as contributing the greatest risk of adverse impacts. Appendix Q provides more information on the screening analysis, including time of occurrence of peak impacts and constituent- and location-specific impacts under each Tank Closure, FFTF Decommissioning, and Waste Management alternative.

Four measures of human health impacts are considered in this analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radiological constituents, and Hazard Index from chemical constituents. These measures are calculated for each year for 10,000 years for receptors at eight specific locations (i.e., A, B, S, T, and U Barriers, Core Zone Boundary, Columbia River nearshore, and Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts as dose, and the observation that peak risk and peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose.

Three types of release are considered under the Tank Closure alternatives. The first type of release is the past practice of direct discharge of liquid to cribs and trenches (ditches). The second type of release is due to past leaks from damaged tanks. The third type of release identified in the following text and figures as “other tank farm sources” is due to future activities and includes leaks during retrieval of waste from the tanks, as well as long-term leaching of waste material in tanks and ancillary equipment.

Onsite locations are the boundaries of the tank farms, Core Zone Boundary, and Columbia River nearshore. Offsite locations are access points to Columbia River surface water near the site and at population centers downstream of the site. Estimates of concentration of constituents in the Columbia River surface water are used to calculate impacts for both the offsite location points of analysis. Total offsite population is 5 million people. Four types of receptor are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking-water consumption and consumes both wild plant materials, which use groundwater, and game animals, which use surface water. In Appendix Q, estimates of impacts are presented in two sets of tables, one set for receptors using groundwater and one set for users of surface water. To facilitate presentation, estimates of impacts on the American Indian hunter-gatherer are presented in the set of tables for surface water users in Appendix Q. However, in this section and in subsequent sections, the

impacts on the American Indian hunter-gatherer are presented under the Columbia River nearshore location.

The significance of dose impacts is evaluated by comparison with the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. The level of protection provided for the drinking-water pathway is evaluated by comparison with applicable drinking-water standards presented in Section 5.1.1. Population doses are compared with the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The significance of noncarcinogenic chemical impacts is evaluated by comparison with a guideline value of unity for Hazard Index.

5.1.2.1 Tank Closure Alternative 1: No Action

Under Tank Closure Alternative 1, the tank farms would be maintained in the current condition indefinitely but, for the purpose of analysis, the structural integrity of the tanks is assumed to fail after an administrative control period of 100 years. The salt cake in the SSTs is assumed available at this time for leaching into the vadose zone, and the liquid contents of the DSTs are assumed to be discharged directly to the vadose zone. Potential human health impacts under Tank Closure Alternative 1 are detailed in Appendix Q and summarized in Tables 5–10 through 5–15; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–10 and 5–11; to past leaks after CY 1940 in Tables 5–12 and 5–13; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–14 and 5–15.

Due to the large magnitude of the liquid release in the analysis, transport through the vadose zone is rapid, and impacts exceeding dose standards are estimated for onsite locations. The largest contributors are the cribs and trenches (ditches) and the presence of tritium, technetium-99, iodine-129, uranium-238, chromium, nitrates, and total uranium. Due to large dilution in the Columbia River, offsite impacts on individuals are small. The population dose was estimated as 3.39 person-rem per year for the year of maximum impact. This corresponds to 1.85×10^{-4} percent of the annual population dose due to background exposure.

Table 5–10. Tank Closure Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.39×10^{2}	7.88×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	8.86×10^{2}	3.48×10^{-2}	1.98×10^{-7}	3.48×10^{-2}
T Barrier	1.44×10^{3}	1.23×10^{2}	1.37×10^{-2}	0.00	1.37×10^{-2}	2.30×10^{3}	1.35×10^{2}	2.40×10^{-2}	3.54×10^{-8}	2.40×10^{-2}
Core Zone Boundary	6.39×10^{2}	5.12×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.88×10^{2}	3.48×10^{-2}	1.13×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.51×10^{-1}	4.57×10^{-1}	4.89×10^{-6}	0.00	4.89×10^{-6}	4.40×10^{-1}	5.04×10^{-1}	1.58×10^{-5}	1.28×10^{-10}	1.58×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.93×10^{-4}	1.60×10^{-4}	5.88×10^{-9}	3.39×10^{-14}	5.88×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–11. Tank Closure Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.37×10^{3}	1.50×10^{3}	7.43×10^{-2}	9.10×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.22×10^{3}	2.22×10^{2}	4.79×10^{-2}	1.62×10^{-3}	4.79×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.37×10^{3}	1.02×10^{3}	7.43×10^{-2}	5.17×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	8.29×10^{-1}	8.33×10^{-1}	3.44×10^{-5}	5.86×10^{-6}	3.44×10^{-5}	5.44×10^{-1}	8.17×10^{-1}	6.69×10^{-6}	2.93×10^{-6}	7.94×10^{-6}
Off Site										
Columbia River	5.59×10^{-4}	2.10×10^{-1}	1.80×10^{-8}	1.56×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–12. Tank Closure Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.87×10^{1}	6.34×10^{-1}	8.23×10^{-4}	0.00	8.23×10^{-4}	6.39×10^{1}	6.58×10^{-1}	2.55×10^{-3}	2.30×10^{-10}	2.55×10^{-3}
B Barrier	2.05×10^{1}	1.26	6.00×10^{-4}	0.00	6.00×10^{-4}	4.62×10^{1}	1.35	1.87×10^{-3}	4.04×10^{-10}	1.87×10^{-3}
S Barrier	9.13	4.19	2.64×10^{-4}	0.00	2.64×10^{-4}	2.04×10^{1}	4.26	8.19×10^{-4}	1.65×10^{-9}	8.19×10^{-4}
T Barrier	5.36×10^{1}	5.81	1.54×10^{-3}	0.00	1.54×10^{-3}	1.19×10^{2}	6.03	4.76×10^{-3}	2.12×10^{-9}	4.76×10^{-3}
U Barrier	9.86×10^{-1}	1.39×10^{-1}	1.11×10^{-5}	0.00	1.11×10^{-5}	1.02	1.42×10^{-1}	3.14×10^{-5}	5.29×10^{-11}	3.14×10^{-5}
Core Zone Boundary	1.20×10^{1}	4.55	3.57×10^{-4}	0.00	3.57×10^{-4}	2.74×10^{1}	4.63	1.12×10^{-3}	1.76×10^{-9}	1.12×10^{-3}
Columbia River nearshore	3.14×10^{-1}	4.19×10^{-2}	9.45×10^{-6}	0.00	9.45×10^{-6}	7.24×10^{-1}	4.32×10^{-2}	2.97×10^{-5}	1.60×10^{-11}	2.97×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.27×10^{-5}	2.15×10^{-6}	1.32×10^{-9}	7.48×10^{-16}	1.32×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–13. Tank Closure Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.24×10^{2}	1.01	5.48×10^{-3}	1.05×10^{-5}	5.48×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	8.99×10^{1}	2.15	4.02×10^{-3}	1.85×10^{-5}	4.02×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.96×10^{1}	6.36	1.76×10^{-3}	7.55×10^{-5}	1.76×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.31×10^{2}	9.26	1.02×10^{-2}	9.70×10^{-5}	1.02×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.51	2.15×10^{-1}	6.76×10^{-5}	2.42×10^{-6}	6.76×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	5.36×10^{1}	6.95	2.41×10^{-3}	8.09×10^{-5}	2.41×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.42	6.56×10^{-2}	6.41×10^{-5}	7.34×10^{-7}	6.41×10^{-5}	7.64×10^{-3}	1.86×10^{-2}	9.87×10^{-8}	3.67×10^{-7}	4.44×10^{-7}
Off Site										
Columbia River	1.32×10^{-4}	1.05×10^{-3}	4.72×10^{-9}	3.43×10^{-11}	4.74×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–14. Tank Closure Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.43×10^{2}	4.13	4.45×10^{-3}	2.40×10^{-11}	4.45×10^{-3}	3.39×10^{2}	4.66	1.42×10^{-2}	1.12×10^{-9}	1.42×10^{-2}
B Barrier	3.69×10^{2}	6.95×10^{1}	1.13×10^{-2}	0.00	1.24×10^{-2}	8.60×10^{2}	7.94×10^{1}	3.56×10^{-2}	1.98×10^{-8}	3.56×10^{-2}
S Barrier	8.33×10^{1}	1.73×10^{1}	2.51×10^{-3}	1.36×10^{-11}	2.51×10^{-3}	1.92×10^{2}	1.78×10^{1}	7.89×10^{-3}	6.49×10^{-9}	7.89×10^{-3}
T Barrier	3.52×10^{1}	1.18×10^{1}	1.00×10^{-3}	0.00	1.37×10^{-2}	7.80×10^{1}	1.28×10^{1}	3.10×10^{-3}	3.58×10^{-9}	2.40×10^{-2}
U Barrier	3.43×10^{1}	3.42	9.87×10^{-4}	0.00	9.87×10^{-4}	7.63×10^{1}	3.59	3.06×10^{-3}	1.21×10^{-9}	3.06×10^{-3}
Core Zone Boundary	7.44×10^{2}	1.31×10^{2}	2.26×10^{-2}	2.99×10^{-11}	2.26×10^{-2}	1.73×10^{3}	1.35×10^{2}	7.12×10^{-2}	4.79×10^{-8}	7.12×10^{-2}
Columbia River nearshore	1.19×10^{1}	1.88	3.40×10^{-4}	6.19×10^{-13}	3.40×10^{-4}	2.62×10^{1}	1.98	1.07×10^{-3}	6.47×10^{-10}	1.07×10^{-3}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.77×10^{-4}	4.39×10^{-5}	2.76×10^{-8}	1.24×10^{-14}	2.76×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–15. Tank Closure Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	6.72×10^{2}	7.87	3.07×10^{-2}	5.12×10^{-5}	3.07×10^{-2}	N/A	N/A	N/A	N/A	N/A
B Barrier	1.70×10^{3}	1.37×10^{2}	7.70×10^{-2}	9.10×10^{-4}	7.70×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.77×10^{2}	2.71×10^{1}	1.70×10^{-2}	2.97×10^{-4}	1.70×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.51×10^{2}	2.08×10^{1}	6.66×10^{-3}	1.64×10^{-4}	4.79×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.48×10^{2}	5.59	6.57×10^{-3}	5.56×10^{-5}	6.57×10^{-3}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.40×10^{3}	2.08×10^{2}	1.54×10^{-1}	2.20×10^{-3}	1.54×10^{-1}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	5.11×10^{1}	3.10	2.30×10^{-3}	2.97×10^{-5}	2.30×10^{-3}	7.31×10^{-2}	1.14	3.49×10^{-6}	1.48×10^{-5}	1.77×10^{-5}
Off Site										
Columbia River	2.61×10^{-3}	3.94×10^{-2}	9.42×10^{-8}	5.68×10^{-10}	9.47×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

For releases from the cribs and trenches (ditches), peak impacts at the B and T Barriers are estimated to occur in the past, prior to CY 2000. For past leaks, peak impacts at the tank farm barriers are estimated to occur in the vicinity of, or prior to, CY 2050. As shown in Figure 5–325, peak impacts at the Core Zone Boundary due to all sources are the result primarily of assumed tank failure and occur as a narrow, early peak and as a broad pulse extending between CYs 2500 and 5000. An elevated level of risk due to tank failure extends over the entire period of analysis. At the Core Zone Boundary, peak risk due to tank failure is approximately a factor of 20 greater than peak risk due to cribs and trenches (ditches) and a factor of 100 greater than peak risk due to past leaks.

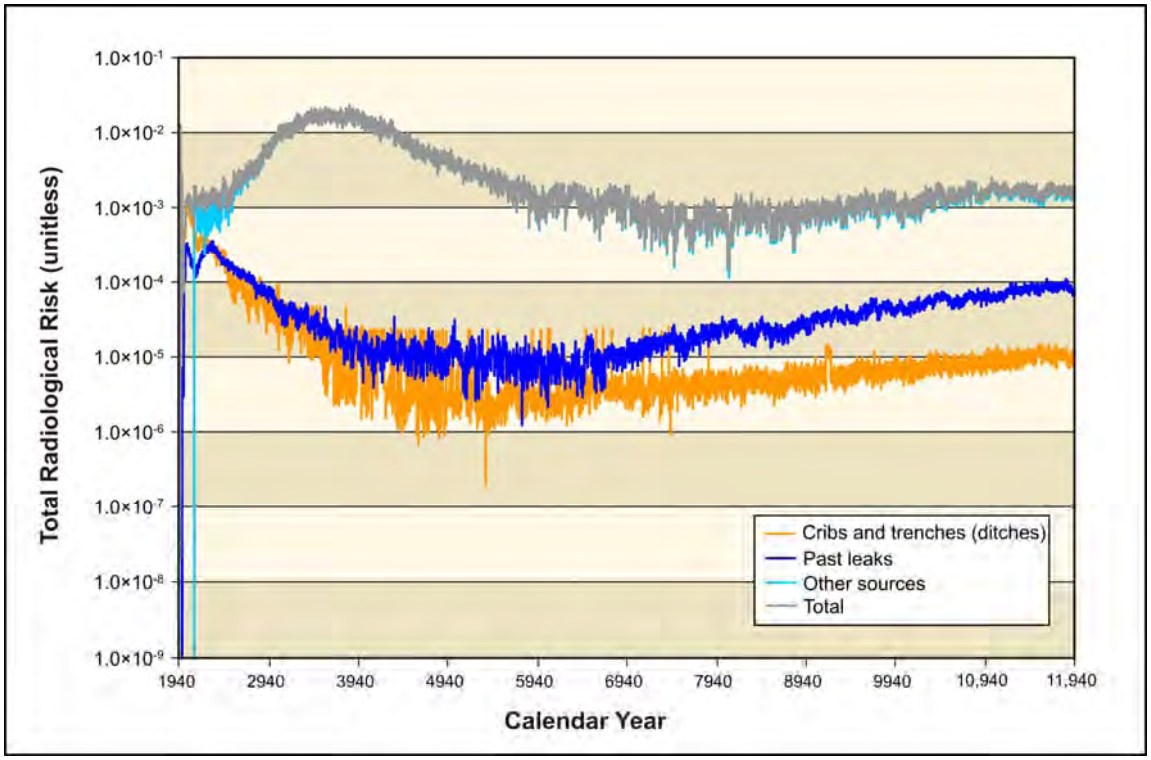


Figure 5–325. Tank Closure Alternative 1 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.2 Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure

Under Tank Closure Alternative 2A, tank waste would be retrieved to a volume corresponding to 99 percent retrieval, but the residual material in tanks would not be stabilized. After an administrative control period of 100 years, salt cake in the tanks was assumed available for dissolution in infiltrating water and the liquid contents of the DSTs are assumed to be discharged directly to the vadose zone. Potential human health impacts under Tank Closure Alternative 2A are detailed in Appendix Q and summarized in Tables 5–16 through 5–21; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–16 and 5–17; to past leaks after CY 1940 in Tables 5–18 and 5–19; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–20 and 5–21.

The dose standard would be exceeded at the B Barrier, T Barrier, and Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer due to the presence of tritium, technetium-99, and iodine-129 released from the cribs and trenches (ditches), but would not be exceeded at the other locations. For the drinking-water well user, resident farmer, and American Indian resident farmer, the Hazard Index guideline would be exceeded at the B Barrier, T Barrier, and Core Zone Boundary due primarily to release of chromium and nitrate from the cribs and trenches (ditches).

Table 5–16. Tank Closure Alternative 2A Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.61×10^{2}	7.60×10^{2}	1.29×10^{-2}	0.00	1.29×10^{-2}	1.28×10^{3}	8.63×10^{2}	3.59×10^{-2}	1.80×10^{-7}	3.59×10^{-2}
T Barrier	1.43×10^{3}	1.25×10^{2}	1.36×10^{-2}	0.00	1.36×10^{-2}	2.28×10^{3}	1.37×10^{2}	2.39×10^{-2}	3.58×10^{-8}	2.39×10^{-2}
Core Zone Boundary	6.61×10^{2}	5.00×10^{2}	1.29×10^{-2}	0.00	1.29×10^{-2}	1.28×10^{3}	5.76×10^{2}	3.59×10^{-2}	1.07×10^{-7}	3.59×10^{-2}
Columbia River nearshore	2.16×10^{-1}	3.97×10^{-1}	4.24×10^{-6}	0.00	4.24×10^{-6}	3.83×10^{-1}	4.39×10^{-1}	1.35×10^{-5}	1.15×10^{-10}	1.35×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.88×10^{-4}	1.60×10^{-4}	5.67×10^{-9}	3.49×10^{-14}	5.67×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–17. Tank Closure Alternative 2A American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.45×10^{3}	1.47×10^{3}	7.67×10^{-2}	8.27×10^{-3}	7.67×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.19×10^{3}	2.25×10^{2}	4.76×10^{-2}	1.64×10^{-3}	4.76×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.45×10^{3}	1.00×10^{3}	7.67×10^{-2}	4.89×10^{-3}	7.67×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	7.20×10^{-1}	7.27×10^{-1}	2.92×10^{-5}	5.29×10^{-6}	2.92×10^{-5}	4.37×10^{-1}	6.78×10^{-1}	5.38×10^{-6}	2.65×10^{-6}	6.85×10^{-6}
Off Site										
Columbia River	5.55×10^{-4}	2.09×10^{-1}	1.77×10^{-8}	1.60×10^{-9}	1.85×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–18. Tank Closure Alternative 2A Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.79×10^{1}	6.31×10^{-1}	7.95×10^{-4}	0.00	7.95×10^{-4}	6.18×10^{1}	6.55×10^{-1}	2.46×10^{-3}	2.30×10^{-10}	2.46×10^{-3}
B Barrier	2.07×10^{1}	1.55	6.17×10^{-4}	0.00	6.17×10^{-4}	4.74×10^{1}	1.57	1.93×10^{-3}	3.75×10^{-10}	1.93×10^{-3}
S Barrier	9.08	4.08	2.62×10^{-4}	0.00	2.62×10^{-4}	2.03×10^{1}	4.15	8.12×10^{-4}	1.60×10^{-9}	8.12×10^{-4}
T Barrier	5.30×10^{1}	5.73	1.52×10^{-3}	0.00	1.52×10^{-3}	1.18×10^{2}	5.95	4.70×10^{-3}	2.08×10^{-9}	4.70×10^{-3}
U Barrier	1.24	1.44×10^{-1}	1.40×10^{-5}	0.00	1.40×10^{-5}	1.29	1.48×10^{-1}	3.14×10^{-5}	5.48×10^{-11}	3.14×10^{-5}
Core Zone Boundary	1.37×10^{1}	4.95	3.30×10^{-4}	0.00	3.30×10^{-4}	2.54×10^{1}	5.03	1.03×10^{-3}	1.95×10^{-9}	1.03×10^{-3}
Columbia River nearshore	3.08×10^{-1}	4.11×10^{-2}	9.27×10^{-6}	0.00	9.27×10^{-6}	7.10×10^{-1}	4.23×10^{-2}	2.92×10^{-5}	1.61×10^{-11}	2.92×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.29×10^{-5}	2.26×10^{-6}	1.32×10^{-9}	7.74×10^{-16}	1.32×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–19. Tank Closure Alternative 2A American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.20×10^{2}	1.01	5.28×10^{-3}	1.05×10^{-5}	5.28×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	9.27×10^{1}	2.16	4.17×10^{-3}	1.72×10^{-5}	4.17×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.93×10^{1}	6.20	1.75×10^{-3}	7.33×10^{-5}	1.75×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.28×10^{2}	9.15	1.01×10^{-2}	9.53×10^{-5}	1.01×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.51	2.25×10^{-1}	6.77×10^{-5}	2.51×10^{-6}	6.77×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.95×10^{1}	7.49	2.22×10^{-3}	8.95×10^{-5}	2.22×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.39	6.43×10^{-2}	6.30×10^{-5}	7.39×10^{-7}	6.30×10^{-5}	1.06×10^{-2}	1.71×10^{-2}	1.38×10^{-7}	3.70×10^{-7}	4.28×10^{-7}
Off Site										
Columbia River	1.35×10^{-4}	1.08×10^{-3}	4.78×10^{-9}	3.55×10^{-11}	4.81×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–20. Tank Closure Alternative 2A Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	3.60	3.16×10^{-1}	1.05×10^{-4}	1.16×10^{-13}	7.95×10^{-4}	8.09	3.80×10^{-1}	3.26×10^{-4}	4.73×10^{-11}	2.46×10^{-3}
B Barrier	6.83×10^{1}	6.89×10^{1}	2.05×10^{-3}	0.00	1.29×10^{-2}	1.57×10^{2}	7.78×10^{1}	6.45×10^{-3}	1.67×10^{-8}	3.59×10^{-2}
S Barrier	6.31	2.94	1.85×10^{-4}	0.00	2.62×10^{-4}	1.43×10^{1}	2.99	5.78×10^{-4}	1.14×10^{-9}	8.12×10^{-4}
T Barrier	3.53×10^{1}	9.90	1.01×10^{-3}	0.00	1.36×10^{-2}	7.82×10^{1}	1.06×10^{1}	3.11×10^{-3}	3.14×10^{-9}	2.39×10^{-2}
U Barrier	1.33	2.60×10^{-1}	3.57×10^{-5}	0.00	3.57×10^{-5}	2.74	2.93×10^{-1}	1.12×10^{-4}	6.66×10^{-11}	1.12×10^{-4}
Core Zone Boundary	5.92×10^{1}	3.78×10^{1}	1.80×10^{-3}	4.67×10^{-14}	1.29×10^{-2}	1.37×10^{2}	4.38×10^{1}	5.66×10^{-3}	7.69×10^{-9}	3.59×10^{-2}
Columbia River nearshore	4.39×10^{-1}	4.36×10^{-1}	1.32×10^{-5}	1.53×10^{-15}	1.32×10^{-5}	1.01	4.80×10^{-1}	4.15×10^{-5}	1.26×10^{-10}	4.15×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.37×10^{-5}	2.00×10^{-5}	1.77×10^{-9}	3.91×10^{-15}	5.67×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–21. Tank Closure Alternative 2A American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.57×10^{1}	6.87×10^{-1}	7.02×10^{-4}	2.17×10^{-6}	5.28×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.08×10^{2}	1.32×10^{2}	1.39×10^{-2}	7.68×10^{-4}	7.67×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.78×10^{1}	4.49	1.25×10^{-3}	5.23×10^{-5}	1.75×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.51×10^{2}	1.70×10^{1}	6.68×10^{-3}	1.44×10^{-4}	4.76×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	5.36	4.96×10^{-1}	2.41×10^{-4}	3.05×10^{-6}	2.41×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.70×10^{2}	7.67×10^{1}	1.22×10^{-2}	3.53×10^{-4}	7.67×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.98	7.91×10^{-1}	8.96×10^{-5}	5.78×10^{-6}	8.96×10^{-5}	4.36×10^{-2}	3.99×10^{-1}	5.66×10^{-7}	2.89×10^{-6}	6.85×10^{-6}
Off Site										
Columbia River	1.72×10^{-4}	2.93×10^{-2}	6.19×10^{-9}	1.79×10^{-10}	1.85×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

The dose standard would be exceeded at the A Barrier for the American Indian resident farmer and at the T Barrier for the resident farmer and American Indian resident farmer due to the presence of tritium, technetium-99, and iodine-129 released in past leaks. The Hazard Index guideline would be exceeded for the drinking-water well user, resident farmer, and American Indian resident farmer at the B Barrier, S Barrier, T Barrier, and the Core Zone Boundary primarily due to release of chromium and nitrate from past leaks. The Hazard Index guideline would also be exceeded for the resident farmer at the A Barrier primarily due to chromium and nitrate. The Hazard Index guideline would be exceeded for the American Indian resident farmer at the T Barrier primarily due to release of nitrate from past leaks. After CY 2050, the dose standard would be exceeded at the B Barrier and Core Zone Boundary for the resident farmer and American Indian resident farmer due to the presence of tritium, technetium-99, and iodine-129, and the dose standard would be exceeded at the T Barrier for the American Indian resident farmer due to the presence of tritium, technetium-99, iodine-129, and uranium-238. The Hazard Index guideline would be exceeded at the B Barrier, S Barrier, T Barrier, and Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer primarily due to chromium, nitrate, and total uranium. The population dose was estimated as 2.18×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.20×10^{-5} percent of the annual population dose due to background exposure.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternative 1. As shown in Figure 5–326, peak impacts at the Core Zone Boundary due to tank salt cake or liquid release are reduced by approximately a factor of 100 due to tank retrieval activity. A substantial peak due to tank failure remains centered on CY 3200, but the major contributor for long-term impacts shifts to past leaks under Tank Closure Alternative 2A.

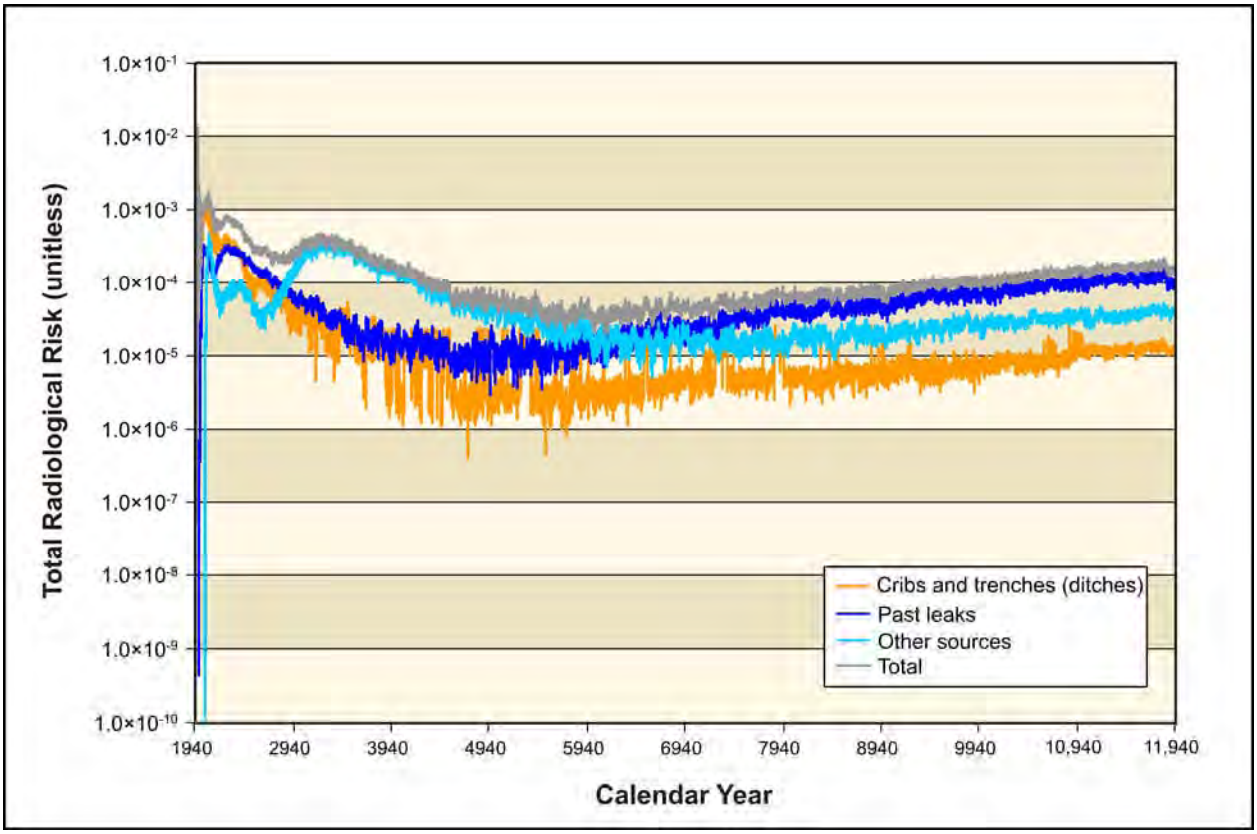


Figure 5–326. Tank Closure Alternative 2A Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Activities under Tank Closure Alternative 2B would be similar to those under Tank Closure Alternative 2A, except that residual material in tanks would be stabilized in place. Soil would be removed down to 4.6 meters (15 feet) for the BX and SX tank farms and replaced with clean soils from onsite sources. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Potential human health impacts under Tank Closure Alternative 2B are detailed in Appendix Q and summarized in Tables 5–22 through 5–27; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–22 and 5–23; to past leaks after CY 1940 in Tables 5–24 and 5–25; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–26 and 5–27.

The risk and hazard drivers are tritium, technetium-99, iodine-129, uranium-238, chromium, nitrate, and total uranium. Impacts would be slightly less than those under Tank Closure Alternative 2A, and standards would be exceeded, as under Alternative 2A. The population dose was estimated as 1.95×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.07×10^{-5} percent of the annual population dose due to background exposure.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternatives 1 and 2A. As shown in Figure 5–327, radiological risks at the Core Zone Boundary due to cribs and trenches (ditches) and past leaks prior to CY 3000 are nearly identical to those under Tank Closure Alternative 2A, while long-term risks are reduced slightly due to placement of caps under Tank Closure Alternative 2B. As in the case of Tank Closure Alternative 2A, peak impacts are due to releases from cribs and trenches (ditches) for the early time period, to leaching from other tank farm sources for the intermediate time period, and to past leaks for the long-term time period.

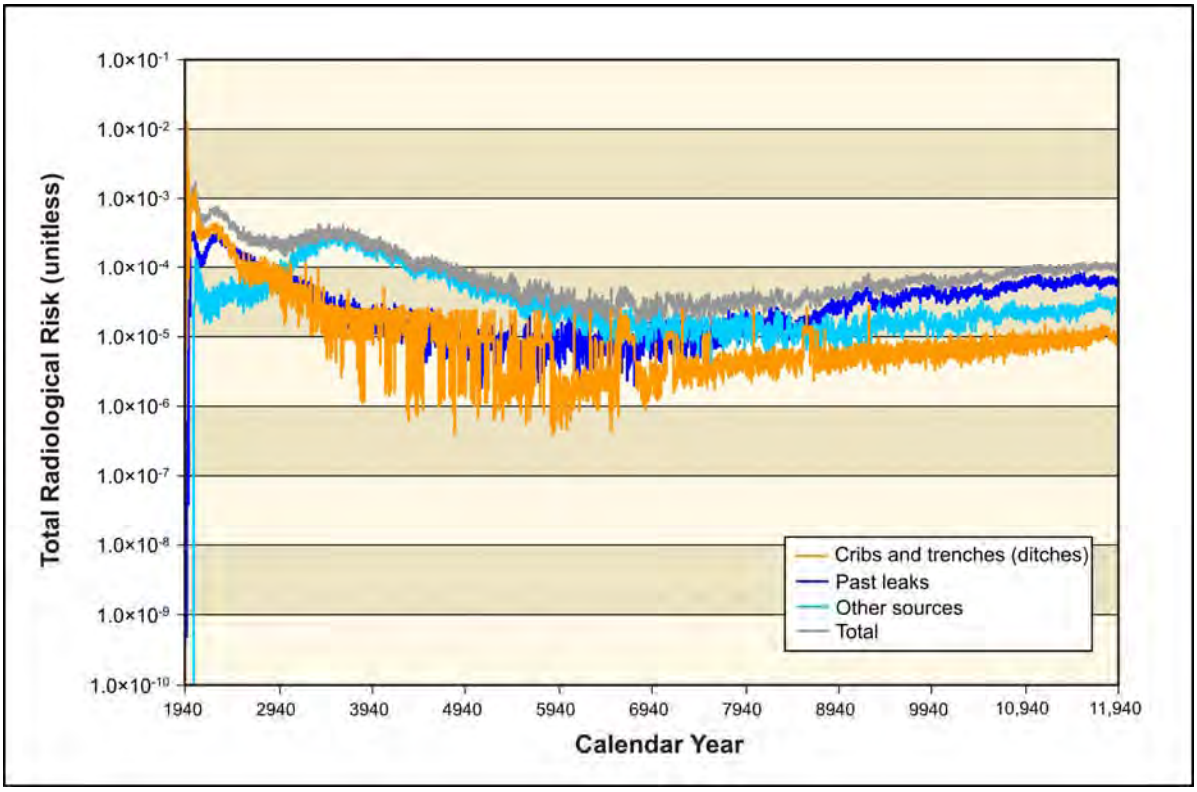


Figure 5–327. Tank Closure Alternative 2B Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

Table 5–22. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.36×10^{2}	7.95×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	8.94×10^{2}	3.48×10^{-2}	2.00×10^{-7}	3.48×10^{-2}
T Barrier	1.46×10^{3}	1.27×10^{2}	1.39×10^{-2}	0.00	1.39×10^{-2}	2.32×10^{3}	1.39×10^{2}	2.43×10^{-2}	3.66×10^{-8}	2.43×10^{-2}
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.08×10^{-1}	4.02×10^{-1}	5.89×10^{-6}	0.00	5.89×10^{-6}	4.79×10^{-1}	4.35×10^{-1}	1.85×10^{-5}	1.23×10^{-10}	1.85×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–23. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.36×10^{3}	1.51×10^{3}	7.43×10^{-2}	9.16×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.27×10^{3}	2.27×10^{2}	4.85×10^{-2}	1.68×10^{-3}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.53×10^{-1}	7.03×10^{-1}	4.01×10^{-5}	5.66×10^{-6}	4.01×10^{-5}	4.04×10^{-1}	7.14×10^{-1}	4.97×10^{-6}	2.83×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–24. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.75×10^{1}	6.52×10^{-1}	7.79×10^{-4}	0.00	7.79×10^{-4}	6.07×10^{1}	6.76×10^{-1}	2.40×10^{-3}	2.38×10^{-10}	2.40×10^{-3}
B Barrier	1.92×10^{1}	1.22	5.57×10^{-4}	0.00	5.57×10^{-4}	4.30×10^{1}	1.32	1.73×10^{-3}	3.76×10^{-10}	1.73×10^{-3}
S Barrier	9.42	4.15	2.72×10^{-4}	0.00	2.72×10^{-4}	2.10×10^{1}	4.22	8.44×10^{-4}	1.62×10^{-9}	8.44×10^{-4}
T Barrier	5.27×10^{1}	5.75	1.51×10^{-3}	0.00	1.51×10^{-3}	1.17×10^{2}	5.98	4.67×10^{-3}	2.07×10^{-9}	4.67×10^{-3}
U Barrier	9.90×10^{-1}	1.40×10^{-1}	1.12×10^{-5}	0.00	1.12×10^{-5}	1.03	1.43×10^{-1}	2.97×10^{-5}	5.31×10^{-11}	2.97×10^{-5}
Core Zone Boundary	1.10×10^{1}	4.03	3.21×10^{-4}	0.00	3.21×10^{-4}	2.48×10^{1}	4.10	9.99×10^{-4}	1.58×10^{-9}	9.99×10^{-4}
Columbia River nearshore	2.83×10^{-1}	4.21×10^{-2}	8.87×10^{-6}	0.00	8.87×10^{-6}	6.74×10^{-1}	4.34×10^{-2}	2.83×10^{-5}	1.57×10^{-11}	2.83×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.15×10^{-5}	2.07×10^{-6}	1.28×10^{-9}	7.23×10^{-16}	1.28×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–25. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.17×10^{2}	1.04	5.16×10^{-3}	1.09×10^{-5}	5.16×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	8.35×10^{1}	2.14	3.72×10^{-3}	1.72×10^{-5}	3.72×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	4.08×10^{1}	6.31	1.82×10^{-3}	7.44×10^{-5}	1.82×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.26×10^{2}	9.21	1.00×10^{-2}	9.52×10^{-5}	1.00×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.44	2.16×10^{-1}	6.38×10^{-5}	2.44×10^{-6}	6.38×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.82×10^{1}	6.12	2.15×10^{-3}	7.26×10^{-5}	2.15×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.34	6.61×10^{-2}	6.13×10^{-5}	7.21×10^{-7}	6.13×10^{-5}	6.74×10^{-3}	1.89×10^{-2}	9.01×10^{-8}	3.61×10^{-7}	4.20×10^{-7}
Off Site										
Columbia River	1.25×10^{-4}	1.02×10^{-3}	4.48×10^{-9}	3.32×10^{-11}	4.51×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–26. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	3.27	1.84×10^{-1}	9.56×10^{-5}	8.57×10^{-14}	7.79×10^{-4}	7.37	2.16×10^{-1}	2.97×10^{-4}	3.43×10^{-11}	2.40×10^{-3}
B Barrier	6.31×10^{1}	5.79×10^{1}	1.93×10^{-3}	0.00	1.24×10^{-2}	1.47×10^{2}	6.67×10^{1}	6.08×10^{-3}	1.27×10^{-8}	3.48×10^{-2}
S Barrier	6.09	2.74	1.77×10^{-4}	0.00	2.72×10^{-4}	1.36×10^{1}	2.80	5.48×10^{-4}	1.07×10^{-9}	8.44×10^{-4}
T Barrier	3.55×10^{1}	9.63	1.02×10^{-3}	0.00	1.39×10^{-2}	7.89×10^{1}	1.04×10^{1}	3.14×10^{-3}	3.02×10^{-9}	2.43×10^{-2}
U Barrier	1.04	1.18×10^{-1}	1.79×10^{-5}	0.00	1.79×10^{-5}	1.36	1.19×10^{-1}	5.72×10^{-5}	3.91×10^{-11}	5.72×10^{-5}
Core Zone Boundary	5.42×10^{1}	3.39×10^{1}	1.66×10^{-3}	3.26×10^{-14}	1.24×10^{-2}	1.27×10^{2}	3.96×10^{1}	5.25×10^{-3}	6.55×10^{-9}	3.48×10^{-2}
Columbia River nearshore	4.28×10^{-1}	4.35×10^{-1}	1.30×10^{-5}	1.07×10^{-15}	1.30×10^{-5}	9.93×10^{-1}	4.70×10^{-1}	4.14×10^{-5}	1.35×10^{-10}	4.14×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.89×10^{-5}	1.91×10^{-5}	1.57×10^{-9}	3.96×10^{-15}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–27. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.43×10^{1}	3.82×10^{-1}	6.40×10^{-4}	1.57×10^{-6}	5.16×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.90×10^{2}	1.16×10^{2}	1.31×10^{-2}	5.82×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.64×10^{1}	4.19	1.18×10^{-3}	4.89×10^{-5}	1.82×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.53×10^{2}	1.67×10^{1}	6.76×10^{-3}	1.38×10^{-4}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	2.71	1.84×10^{-1}	1.24×10^{-4}	1.79×10^{-6}	1.24×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.50×10^{2}	6.98×10^{1}	1.14×10^{-2}	3.00×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.96	7.58×10^{-1}	8.95×10^{-5}	6.17×10^{-6}	8.95×10^{-5}	5.69×10^{-2}	3.84×10^{-1}	7.24×10^{-7}	3.09×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	1.54×10^{-4}	2.77×10^{-2}	5.55×10^{-9}	1.82×10^{-10}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.4 Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Activities under Tank Closure Alternative 3A would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percent of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.2.5 Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Activities under Tank Closure Alternative 3B would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percent of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.2.6 Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Activities under Tank Closure Alternative 3C would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percent of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.2.7 Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Under Tank Closure Alternative 4, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval. Except for the BX and SX tank farms, residual material in tanks would be stabilized in place and the tank farms and adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. The BX and SX tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. Potential human health impacts under Tank Closure Alternative 4 are detailed in Appendix Q and summarized in Tables 5–28 through 5–33; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–28 and 5–29; to past leaks after CY 1940 in Tables 5–30 and 5–31; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–32 and 5–33.

Table 5–28. Tank Closure Alternative 4 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.36×10^{2}	7.95×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	8.94×10^{2}	3.48×10^{-2}	2.00×10^{-7}	3.48×10^{-2}
T Barrier	1.46×10^{3}	1.27×10^{2}	1.39×10^{-2}	0.00	1.39×10^{-2}	2.32×10^{3}	1.39×10^{2}	2.43×10^{-2}	3.66×10^{-8}	2.43×10^{-2}
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.08×10^{-1}	4.02×10^{-1}	5.89×10^{-6}	0.00	5.89×10^{-6}	4.79×10^{-1}	4.35×10^{-1}	1.85×10^{-5}	1.23×10^{-10}	1.85×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–29. Tank Closure Alternative 4 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.36×10^{3}	1.51×10^{3}	7.43×10^{-2}	9.16×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.27×10^{3}	2.27×10^{2}	4.85×10^{-2}	1.68×10^{-3}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.53×10^{-1}	7.03×10^{-1}	4.01×10^{-5}	5.66×10^{-6}	4.01×10^{-5}	4.04×10^{-1}	7.14×10^{-1}	4.97×10^{-6}	2.83×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–30. Tank Closure Alternative 4 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.75×10^{1}	6.52×10^{-1}	7.79×10^{-4}	0.00	7.79×10^{-4}	6.07×10^{1}	6.76×10^{-1}	2.40×10^{-3}	2.38×10^{-10}	2.40×10^{-3}
B Barrier	1.74×10^{1}	1.09	5.07×10^{-4}	0.00	5.07×10^{-4}	3.91×10^{1}	1.18	1.57×10^{-3}	3.39×10^{-10}	1.57×10^{-3}
S Barrier	8.92	3.99	2.55×10^{-4}	0.00	2.55×10^{-4}	1.98×10^{1}	4.06	7.90×10^{-4}	1.56×10^{-9}	7.90×10^{-4}
T Barrier	5.27×10^{1}	5.75	1.51×10^{-3}	0.00	1.51×10^{-3}	1.17×10^{2}	5.98	4.67×10^{-3}	2.07×10^{-9}	4.67×10^{-3}
U Barrier	9.90×10^{-1}	1.40×10^{-1}	1.12×10^{-5}	0.00	1.12×10^{-5}	1.03	1.43×10^{-1}	2.97×10^{-5}	5.31×10^{-11}	2.97×10^{-5}
Core Zone Boundary	1.12×10^{1}	2.56	3.26×10^{-4}	0.00	3.26×10^{-4}	2.52×10^{1}	2.61	1.02×10^{-3}	1.00×10^{-9}	1.02×10^{-3}
Columbia River nearshore	2.79×10^{-1}	3.45×10^{-2}	8.42×10^{-6}	0.00	8.42×10^{-6}	6.45×10^{-1}	3.55×10^{-2}	2.68×10^{-5}	1.30×10^{-11}	2.68×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.08×10^{-5}	1.85×10^{-6}	1.25×10^{-9}	6.26×10^{-16}	1.25×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–31. Tank Closure Alternative 4 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.17×10^{2}	1.04	5.16×10^{-3}	1.09×10^{-5}	5.16×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	7.60×10^{1}	1.92	3.39×10^{-3}	1.55×10^{-5}	3.39×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.83×10^{1}	6.08	1.70×10^{-3}	7.15×10^{-5}	1.70×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.26×10^{2}	9.21	1.00×10^{-2}	9.52×10^{-5}	1.00×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.44	2.16×10^{-1}	6.38×10^{-5}	2.44×10^{-6}	6.38×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.90×10^{1}	3.90	2.19×10^{-3}	4.59×10^{-5}	2.19×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.27	5.38×10^{-2}	5.81×10^{-5}	5.97×10^{-7}	5.81×10^{-5}	6.17×10^{-3}	1.56×10^{-2}	8.89×10^{-8}	2.99×10^{-7}	3.54×10^{-7}
Off Site										
Columbia River	1.23×10^{-4}	9.79×10^{-4}	4.41×10^{-9}	2.87×10^{-11}	4.43×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–32. Tank Closure Alternative 4 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	3.28	1.79×10^{-1}	9.61×10^{-5}	0.00	7.79×10^{-4}	7.40	2.09×10^{-1}	2.99×10^{-4}	3.47×10^{-11}	2.40×10^{-3}
B Barrier	5.92×10^{1}	5.77×10^{1}	1.81×10^{-3}	0.00	1.24×10^{-2}	1.38×10^{2}	6.64×10^{1}	5.71×10^{-3}	1.26×10^{-8}	3.48×10^{-2}
S Barrier	4.77×10^{-1}	3.61×10^{-1}	1.40×10^{-5}	0.00	2.55×10^{-4}	1.08	3.68×10^{-1}	4.38×10^{-5}	1.40×10^{-10}	7.90×10^{-4}
T Barrier	3.55×10^{1}	9.63	1.02×10^{-3}	0.00	1.39×10^{-2}	7.90×10^{1}	1.04×10^{1}	3.15×10^{-3}	3.02×10^{-9}	2.43×10^{-2}
U Barrier	1.02	1.15×10^{-1}	1.18×10^{-5}	0.00	1.18×10^{-5}	1.06	1.18×10^{-1}	3.68×10^{-5}	3.87×10^{-11}	3.68×10^{-5}
Core Zone Boundary	5.02×10^{1}	3.36×10^{1}	1.54×10^{-3}	0.00	1.24×10^{-2}	1.18×10^{2}	3.93×10^{1}	4.88×10^{-3}	6.47×10^{-9}	3.48×10^{-2}
Columbia River nearshore	3.91×10^{-1}	4.31×10^{-1}	1.21×10^{-5}	0.00	1.21×10^{-5}	9.24×10^{-1}	4.65×10^{-1}	3.85×10^{-5}	1.33×10^{-10}	3.85×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.85×10^{-5}	1.91×10^{-5}	1.55×10^{-9}	3.96×10^{-15}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–33. Tank Closure Alternative 4 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.44×10^{1}	3.70×10^{-1}	6.44×10^{-4}	1.59×10^{-6}	5.16×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.72×10^{2}	1.15×10^{2}	1.24×10^{-2}	5.80×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.10	5.52×10^{-1}	9.43×10^{-5}	6.41×10^{-6}	1.70×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.53×10^{2}	1.67×10^{1}	6.77×10^{-3}	1.38×10^{-4}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.77	1.85×10^{-1}	7.93×10^{-5}	1.78×10^{-6}	7.93×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.32×10^{2}	6.93×10^{1}	1.05×10^{-2}	2.97×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.83	7.51×10^{-1}	8.34×10^{-5}	6.10×10^{-6}	8.34×10^{-5}	5.69×10^{-2}	3.79×10^{-1}	7.24×10^{-7}	3.05×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	1.52×10^{-4}	2.77×10^{-2}	5.49×10^{-9}	1.81×10^{-10}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Similar to Alternatives 2A, 2B, 3A, 3B, and 3C, the risk and hazard drivers are tritium, technetium-99, iodine-129, uranium-238, chromium, nitrate, and total uranium. The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Alternatives 2A, 2B, 3A, 3B, and 3C for releases from cribs and trenches (ditches). The dose standard would be exceeded at the same locations and for the same receptors as under Alternatives 2A, 2B, 3A, 3B, and 3C for releases from past leaks, with slightly less impacts at the B Barrier, S Barrier, and Core Zone Boundary as a result of clean closure at the two tank farms located within the B and S Barriers. Impacts would be slightly less than those under Alternatives 2B, 3A, 3B, 3C, and 6C as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources, with the exception of the S Barrier, where no exceedances were identified. Overall, the population dose was estimated as 1.92×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.05×10^{-5} percent of the annual population dose due to background exposure.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternative 2B. The time series of radiological risk at the Core Zone Boundary for Tank Closure Alternative 4 is presented in Figure 5–328. Comparison of the time series of risk for other tank farm sources under Tank Closure Alternative 4 with the time series of risk under Tank Closure Alternative 2B (see Figure 5–327) identifies three points of interest. First, for the time period prior to CY 2500, the estimated risks under the two alternatives, presumably due to retrieval leaks, are nearly identical. Second, for the intermediate time between CYs 3000 and 4000, the broad peak is reduced by a factor of approximately 5 under Tank Closure Alternative 4 relative to that under Tank Closure Alternative 2B. Third, for the long-term period extending out to CY 11,940, risk is reduced by a factor of 10 under Tank Closure Alternative 4 relative to that under Tank Closure Alternative 2B. The reduction in risk estimate is due to clean closure of the BX and SX tank farms and greater retrieval of tank waste under Tank Closure Alternative 4 relative to that under Tank Closure Alternative 2B.

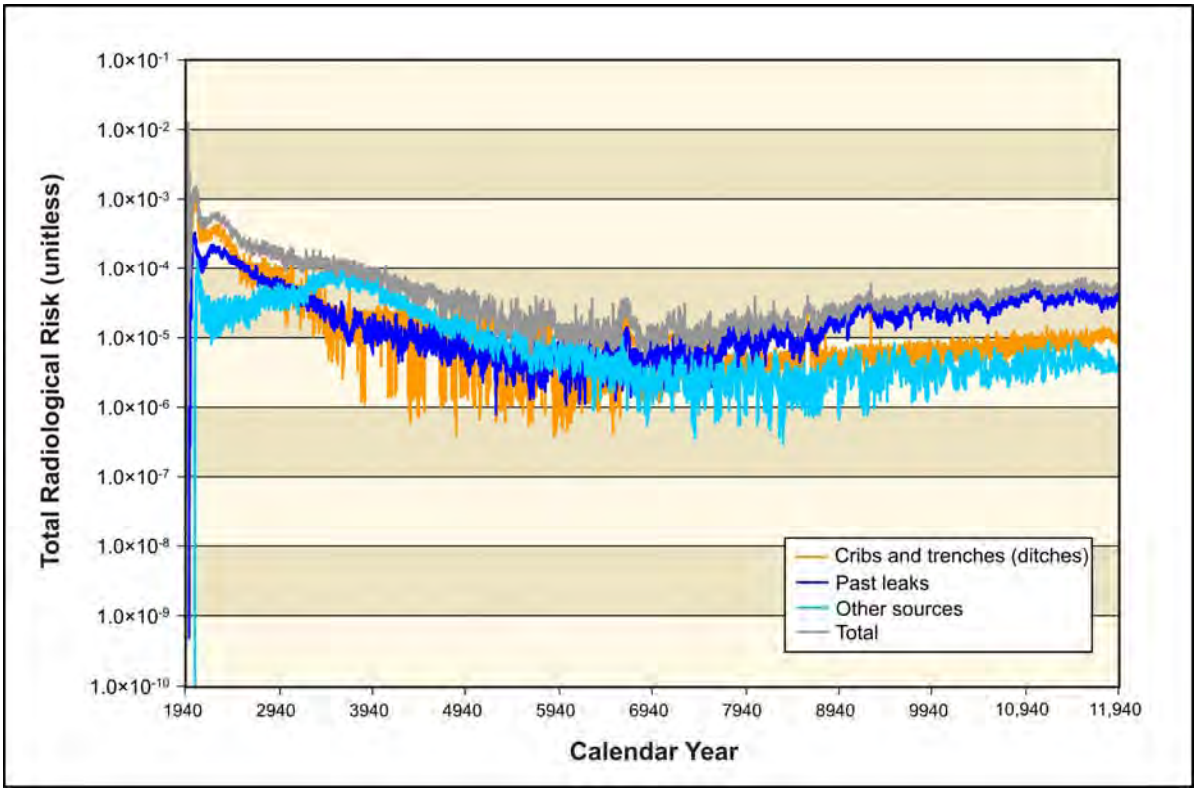


Figure 5–328. Tank Closure Alternative 4 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.8 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Under Tank Closure Alternative 5, tank waste would be retrieved to a volume corresponding to 90 percent retrieval, residual material in tanks would be stabilized in place, and the tank farms and adjacent cribs and trenches (ditches) would be covered with a Hanford barrier. Potential human health impacts under Tank Closure Alternative 5 are detailed in Appendix Q and summarized in Tables 5–34 through 5–39; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–34 and 5–35; to past leaks after CY 1940 in Tables 5–36 and 5–37; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–38 and 5–39.

The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, and 4 for releases from cribs and trenches (ditches). The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, and 3C for releases from past leaks, but would be slightly higher than under these alternatives. Impacts would occur at a later date than under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C for onsite locations as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources. This may be due to the Hanford barrier. However, exceedances at the offsite locations are would be higher. The population dose was estimated as 3.39×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.86×10^{-5} percent of the annual population dose due to background exposure.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternative 2B. The time series of radiological risk at the Core Zone Boundary under Tank Closure Alternative 5 is presented in Figure 5–329. Comparison of the time series of risk for other tank farm sources under Tank Closure Alternative 5 with the time series of risk under Tank Closure Alternative 2B (see Figure 5–327) identifies three points of interest. First, for the time period prior to CY 2500, the estimated risks under the two alternatives, presumably due to retrieval leaks, are nearly identical. Second, for the intermediate time between CYs 3000 and 4000, the broad peak is increased by a factor of approximately five under Tank Closure Alternative 5 relative to that under Tank Closure Alternative 2B. Third, for the long-term period extending out to CY 11,940, risk is increased by a factor of three under Tank Closure Alternative 5 relative to that under Tank Closure Alternative 2B. The increase in risk estimate is due to less retrieval of tank waste under Tank Closure Alternative 5 relative to that under Tank Closure Alternative 2B.

Table 5–34. Tank Closure Alternative 5 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.36×10^{2}	7.95×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	8.94×10^{2}	3.48×10^{-2}	2.00×10^{-7}	3.48×10^{-2}
T Barrier	1.46×10^{3}	1.27×10^{2}	1.39×10^{-2}	0.00	1.39×10^{-2}	2.32×10^{3}	1.39×10^{2}	2.43×10^{-2}	3.66×10^{-8}	2.43×10^{-2}
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.08×10^{-1}	4.02×10^{-1}	5.89×10^{-6}	0.00	5.89×10^{-6}	4.79×10^{-1}	4.35×10^{-1}	1.85×10^{-5}	1.23×10^{-10}	1.85×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–35. Tank Closure Alternative 5 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.36×10^{3}	1.51×10^{3}	7.43×10^{-2}	9.16×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.27×10^{3}	2.27×10^{2}	4.85×10^{-2}	1.68×10^{-3}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.53×10^{-1}	7.03×10^{-1}	4.01×10^{-5}	5.66×10^{-6}	4.01×10^{-5}	4.04×10^{-1}	7.14×10^{-1}	4.97×10^{-6}	2.83×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–36. Tank Closure Alternative 5 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.87×10^{1}	6.67×10^{-1}	8.23×10^{-4}	0.00	8.23×10^{-4}	6.39×10^{1}	6.92×10^{-1}	2.55×10^{-3}	2.45×10^{-10}	2.55×10^{-3}
B Barrier	7.95	1.23	1.73×10^{-4}	0.00	1.73×10^{-4}	1.43×10^{1}	1.34	4.71×10^{-4}	3.81×10^{-10}	4.71×10^{-4}
S Barrier	9.29	4.20	2.69×10^{-4}	0.00	2.69×10^{-4}	2.08×10^{1}	4.26	8.34×10^{-4}	1.65×10^{-9}	8.34×10^{-4}
T Barrier	4.76×10^{1}	5.74	1.49×10^{-3}	0.00	1.49×10^{-3}	1.14×10^{2}	5.97	4.76×10^{-3}	2.07×10^{-9}	4.76×10^{-3}
U Barrier	9.89×10^{-1}	1.42×10^{-1}	1.12×10^{-5}	0.00	1.12×10^{-5}	1.03	1.45×10^{-1}	3.00×10^{-5}	5.40×10^{-11}	3.00×10^{-5}
Core Zone Boundary	1.11×10^{1}	4.49	3.28×10^{-4}	0.00	3.28×10^{-4}	2.51×10^{1}	4.56	1.03×10^{-3}	1.77×10^{-9}	1.03×10^{-3}
Columbia River nearshore	2.57×10^{-1}	4.62×10^{-2}	7.81×10^{-6}	0.00	7.81×10^{-6}	5.97×10^{-1}	4.73×10^{-2}	2.46×10^{-5}	1.77×10^{-11}	2.46×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.25×10^{-5}	2.04×10^{-6}	1.32×10^{-9}	7.17×10^{-16}	1.32×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–37. Tank Closure Alternative 5 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.24×10^{2}	1.06	5.48×10^{-3}	1.12×10^{-5}	5.48×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.50×10^{1}	2.18	9.78×10^{-4}	1.75×10^{-5}	9.78×10^{-4}	N/A	N/A	N/A	N/A	N/A
S Barrier	4.03×10^{1}	6.36	1.80×10^{-3}	7.59×10^{-5}	1.80×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.26×10^{2}	9.20	1.03×10^{-2}	9.49×10^{-5}	1.03×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.45	2.19×10^{-1}	6.47×10^{-5}	2.48×10^{-6}	6.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.93×10^{1}	6.79	2.23×10^{-3}	8.14×10^{-5}	2.23×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.18	7.12×10^{-2}	5.33×10^{-5}	8.13×10^{-7}	5.33×10^{-5}	6.35×10^{-3}	1.89×10^{-2}	8.75×10^{-8}	4.06×10^{-7}	4.62×10^{-7}
Off Site										
Columbia River	1.28×10^{-4}	1.02×10^{-3}	4.62×10^{-9}	3.29×10^{-11}	4.65×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–38. Tank Closure Alternative 5 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	5.46	4.06×10^{-1}	1.84×10^{-4}	4.90×10^{-13}	8.23×10^{-4}	1.38×10^{1}	4.45×10^{-1}	6.02×10^{-4}	1.14×10^{-10}	2.55×10^{-3}
B Barrier	4.96×10^{1}	5.79×10^{1}	1.47×10^{-3}	0.00	1.24×10^{-2}	1.13×10^{2}	6.66×10^{1}	4.61×10^{-3}	1.26×10^{-8}	3.48×10^{-2}
S Barrier	6.04	2.91	2.03×10^{-4}	3.37×10^{-13}	2.69×10^{-4}	1.52×10^{1}	2.96	6.62×10^{-4}	1.14×10^{-9}	8.34×10^{-4}
T Barrier	3.26×10^{1}	9.77	9.86×10^{-4}	0.00	1.39×10^{-2}	7.56×10^{1}	1.05×10^{1}	3.11×10^{-3}	3.07×10^{-9}	2.43×10^{-2}
U Barrier	3.24	4.01×10^{-1}	1.08×10^{-4}	0.00	1.08×10^{-4}	8.13	4.23×10^{-1}	3.53×10^{-4}	1.41×10^{-10}	3.53×10^{-4}
Core Zone Boundary	6.50×10^{1}	3.38×10^{1}	2.18×10^{-3}	4.72×10^{-13}	1.24×10^{-2}	1.64×10^{2}	3.95×10^{1}	7.10×10^{-3}	6.79×10^{-9}	3.48×10^{-2}
Columbia River nearshore	1.37	4.43×10^{-1}	4.47×10^{-5}	7.09×10^{-15}	4.47×10^{-5}	3.37	4.79×10^{-1}	1.45×10^{-4}	1.37×10^{-10}	1.45×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.78×10^{-5}	1.92×10^{-5}	2.94×10^{-9}	3.97×10^{-15}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–39. Tank Closure Alternative 5 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.80×10^{1}	7.28×10^{-1}	1.31×10^{-3}	5.23×10^{-6}	5.48×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.21×10^{2}	1.16×10^{2}	9.93×10^{-3}	5.77×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.09×10^{1}	4.43	1.44×10^{-3}	5.21×10^{-5}	1.80×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.49×10^{2}	1.69×10^{1}	6.73×10^{-3}	1.41×10^{-4}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.65×10^{1}	6.64×10^{-1}	7.68×10^{-4}	6.45×10^{-6}	7.68×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.31×10^{2}	6.96×10^{1}	1.55×10^{-2}	3.11×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	6.78	7.74×10^{-1}	3.14×10^{-4}	6.26×10^{-6}	3.14×10^{-4}	5.68×10^{-2}	3.94×10^{-1}	7.20×10^{-7}	3.13×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	1.72×10^{-4}	2.77×10^{-2}	7.73×10^{-9}	1.82×10^{-10}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

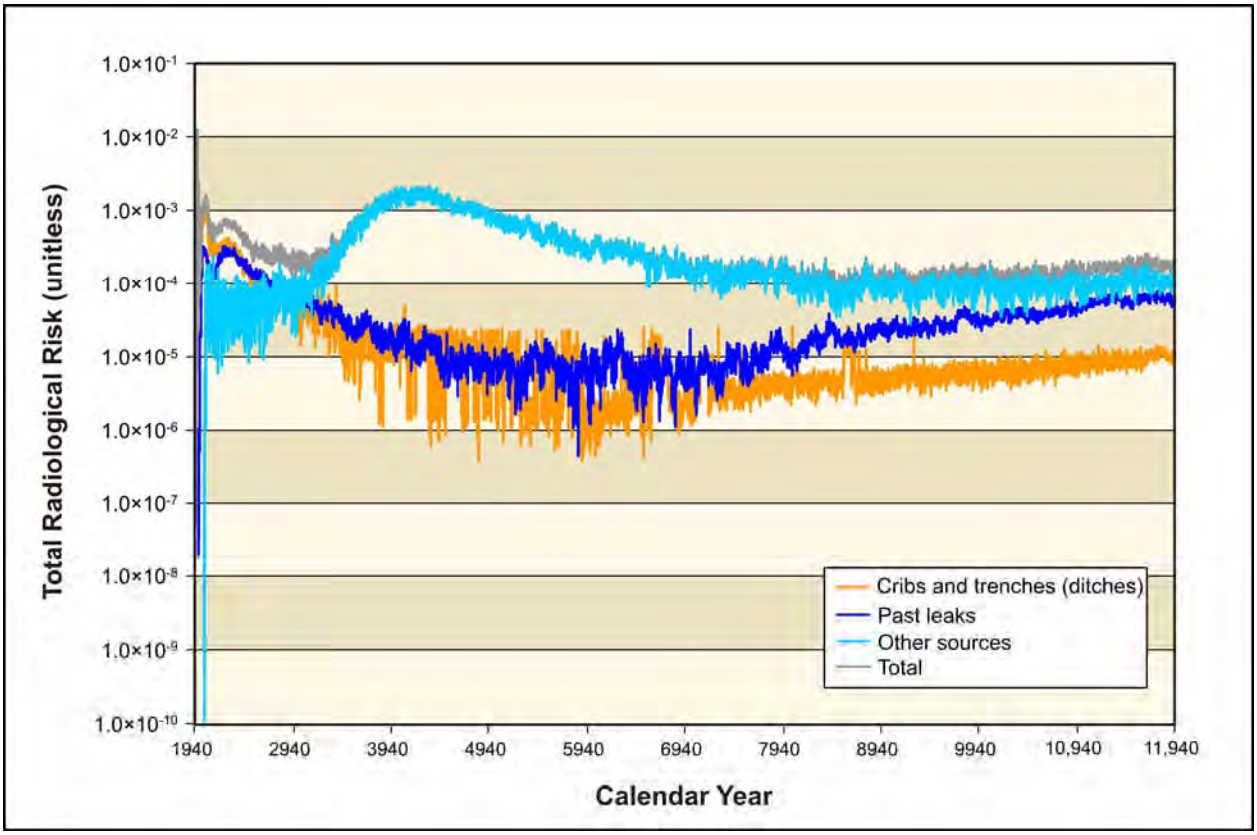


Figure 5–329. Tank Closure Alternative 5 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.9 Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure

5.1.2.9.1 Base Case

Under Tank Closure Alternative 6A, Base Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval and all tank farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Potential human health impacts under Tank Closure Alternative 6A, Base Case, are detailed in Appendix Q and summarized in Tables 5–40 through 5–45; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–40 and 5–41; to past leaks after CY 1940 in Tables 5–42 and 5–43; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–44 and 5–45.

Table 5–40. Tank Closure Alternative 6A, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.36×10^{2}	7.95×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	8.94×10^{2}	3.48×10^{-2}	2.00×10^{-7}	3.48×10^{-2}
T Barrier	1.46×10^{3}	1.27×10^{2}	1.39×10^{-2}	0.00	1.39×10^{-2}	2.32×10^{3}	1.39×10^{2}	2.43×10^{-2}	3.66×10^{-8}	2.43×10^{-2}
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.08×10^{-1}	4.02×10^{-1}	5.89×10^{-6}	0.00	5.89×10^{-6}	4.79×10^{-1}	4.35×10^{-1}	1.85×10^{-5}	1.23×10^{-10}	1.85×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–41. Tank Closure Alternative 6A, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.36×10^{3}	1.51×10^{3}	7.43×10^{-2}	9.16×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.27×10^{3}	2.27×10^{2}	4.85×10^{-2}	1.68×10^{-3}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.53×10^{-1}	7.03×10^{-1}	4.01×10^{-5}	5.66×10^{-6}	4.01×10^{-5}	4.04×10^{-1}	7.14×10^{-1}	4.97×10^{-6}	2.83×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–42. Tank Closure Alternative 6A, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.80×10^{1}	6.57×10^{-1}	7.99×10^{-4}	0.00	7.99×10^{-4}	6.21×10^{1}	6.82×10^{-1}	2.47×10^{-3}	2.39×10^{-10}	2.47×10^{-3}
B Barrier	1.94×10^{1}	1.18	5.56×10^{-4}	0.00	5.56×10^{-4}	4.30×10^{1}	1.28	1.72×10^{-3}	3.64×10^{-10}	1.72×10^{-3}
S Barrier	9.24	3.99	2.65×10^{-4}	0.00	2.65×10^{-4}	2.05×10^{1}	4.05	8.18×10^{-4}	1.56×10^{-9}	8.18×10^{-4}
T Barrier	5.25×10^{1}	5.78	1.51×10^{-3}	0.00	1.51×10^{-3}	1.17×10^{2}	6.00	4.69×10^{-3}	2.09×10^{-9}	4.69×10^{-3}
U Barrier	3.39×10^{-1}	1.36×10^{-1}	9.91×10^{-6}	0.00	9.91×10^{-6}	7.64×10^{-1}	1.40×10^{-1}	3.09×10^{-5}	5.15×10^{-11}	3.09×10^{-5}
Core Zone Boundary	1.10×10^{1}	4.04	3.21×10^{-4}	0.00	3.21×10^{-4}	2.46×10^{1}	4.11	1.00×10^{-3}	1.58×10^{-9}	1.00×10^{-3}
Columbia River nearshore	3.04×10^{-1}	4.17×10^{-2}	9.37×10^{-6}	0.00	9.37×10^{-6}	7.15×10^{-1}	4.28×10^{-2}	2.97×10^{-5}	1.59×10^{-11}	2.97×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.39×10^{-5}	2.22×10^{-6}	1.37×10^{-9}	7.68×10^{-16}	1.37×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–43. Tank Closure Alternative 6A, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.20×10^{2}	1.05	5.31×10^{-3}	1.10×10^{-5}	5.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	8.32×10^{1}	2.08	3.69×10^{-3}	1.67×10^{-5}	3.69×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.97×10^{1}	6.05	1.76×10^{-3}	7.16×10^{-5}	1.76×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.27×10^{2}	9.24	1.01×10^{-2}	9.59×10^{-5}	1.01×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.49	2.13×10^{-1}	6.64×10^{-5}	2.36×10^{-6}	6.64×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.82×10^{1}	6.15	2.17×10^{-3}	7.23×10^{-5}	2.17×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.41	6.47×10^{-2}	6.43×10^{-5}	7.27×10^{-7}	6.43×10^{-5}	1.89×10^{-3}	1.62×10^{-2}	9.48×10^{-8}	3.64×10^{-7}	4.11×10^{-7}
Off Site										
Columbia River	1.33×10^{-4}	1.06×10^{-3}	4.83×10^{-9}	3.52×10^{-11}	4.85×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–44. Tank Closure Alternative 6A, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	3.03	8.36×10^{-2}	8.88×10^{-5}	0.00	7.99×10^{-4}	6.85	8.63×10^{-2}	2.77×10^{-4}	3.11×10^{-11}	2.47×10^{-3}
B Barrier	6.15×10^{1}	5.77×10^{1}	1.87×10^{-3}	0.00	1.24×10^{-2}	1.43×10^{2}	6.65×10^{1}	5.90×10^{-3}	1.25×10^{-8}	3.48×10^{-2}
S Barrier	6.14	2.91	1.78×10^{-4}	0.00	2.65×10^{-4}	1.37×10^{1}	2.96	5.52×10^{-4}	1.14×10^{-9}	8.18×10^{-4}
T Barrier	3.53×10^{1}	9.56	1.01×10^{-3}	0.00	1.39×10^{-2}	7.87×10^{1}	1.03×10^{1}	3.14×10^{-3}	2.99×10^{-9}	2.43×10^{-2}
U Barrier	3.39×10^{-1}	1.03×10^{-1}	9.91×10^{-6}	0.00	9.91×10^{-6}	7.64×10^{-1}	1.07×10^{-1}	3.09×10^{-5}	3.78×10^{-11}	3.09×10^{-5}
Core Zone Boundary	5.14×10^{1}	3.38×10^{1}	1.58×10^{-3}	0.00	1.24×10^{-2}	1.21×10^{2}	3.95×10^{1}	5.00×10^{-3}	6.52×10^{-9}	3.48×10^{-2}
Columbia River nearshore	3.55×10^{-1}	4.20×10^{-1}	1.07×10^{-5}	0.00	1.07×10^{-5}	8.16×10^{-1}	4.54×10^{-1}	3.41×10^{-5}	1.30×10^{-10}	3.41×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.14×10^{-5}	1.92×10^{-5}	1.67×10^{-9}	3.96×10^{-15}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–45. Tank Closure Alternative 6A, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.33×10^{1}	1.32×10^{-1}	5.97×10^{-4}	1.43×10^{-6}	5.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.81×10^{2}	1.15×10^{2}	1.28×10^{-2}	5.72×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.66×10^{1}	4.42	1.19×10^{-3}	5.21×10^{-5}	1.76×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.53×10^{2}	1.66×10^{1}	6.75×10^{-3}	1.37×10^{-4}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.49	1.63×10^{-1}	6.64×10^{-5}	1.73×10^{-6}	6.64×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.38×10^{2}	6.97×10^{1}	1.08×10^{-2}	2.99×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.62	7.33×10^{-1}	7.39×10^{-5}	5.97×10^{-6}	7.39×10^{-5}	5.68×10^{-2}	3.76×10^{-1}	7.22×10^{-7}	2.98×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	1.60×10^{-4}	2.77×10^{-2}	5.82×10^{-9}	1.82×10^{-10}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5 for releases from cribs and trenches (ditches). The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 4 for releases from past leaks. Impacts would be slightly higher than those under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C for onsite locations as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources. However, after the year 2940, the impacts drop significantly as a result of tank farm removal and clean closure activities. The population dose was estimated as 2.07×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.13×10^{-5} percent of the annual population dose due to background exposure.

The time series of radiological risk under Tank Closure Alternative 6A, Base Case, is presented in Figure 5–330. Because of removal operations, impacts due to retrieval leaks and leaching from other tank farm sources do not occur. For cribs and trenches (ditches), estimated risk is similar to that estimated for Tank Closure Alternative 2B. For past leaks, risk estimated for the period prior to CY 3000 is similar to that estimated for Tank Closure Alternative 2B, while risk estimated for the long-term period is reduced by a factor of 10 relative to that estimated for Tank Closure Alternative 2B.

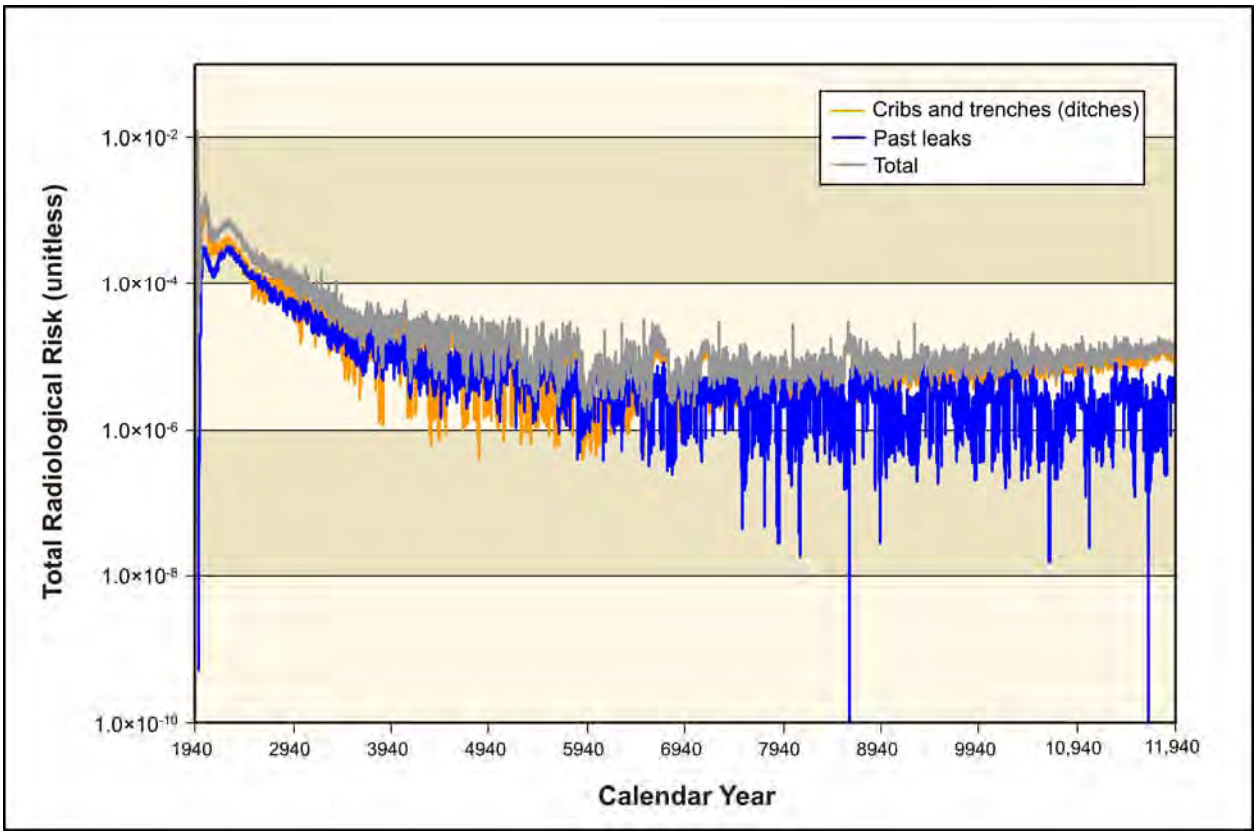


Figure 5–330. Tank Closure Alternative 6A, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.9.2 Option Case

Under Tank Closure Alternative 6A, Option Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval, and all tanks farms would be clean-closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. In addition, the adjacent cribs and trenches (ditches) would be clean-closed. Potential human health impacts

under Tank Closure Alternative 6A, Option Case, are detailed in Appendix Q and summarized in Tables 5–46 and 5–51; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–46 and 5–47; to past leaks after CY 1940 in Tables 5–48 and 5–49; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–50 and 5–51.

The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, 5, and 6A, Base Case, for releases from cribs and trenches (ditches). Similar to Tank Closure Alternative 6A, Base Case, the dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, and 3C, but would be slightly higher than under these alternatives. Impacts would be slightly higher than under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C for onsite locations as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources. However, after the year 2940, the impacts drop significantly as a result of tank farm removal. The population dose was estimated as 2.05×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.12×10^{-5} percent of the annual population dose due to background exposure.

The time series of radiological risk under Tank Closure Alternative 6A, Option Case, is presented in Figure 5–331. Because of removal operations, impacts due to retrieval leaks and leaching from other tank farm sources do not occur. For cribs and trenches (ditches), estimated risk is similar to that estimated for Tank Closure Alternative 6A, Base Case, prior to CY 5000, but is reduced by a factor of 1,000 for the long-term period. For past leaks, estimates of risk are similar to those estimated for Tank Closure Alternative 6A, Base Case.

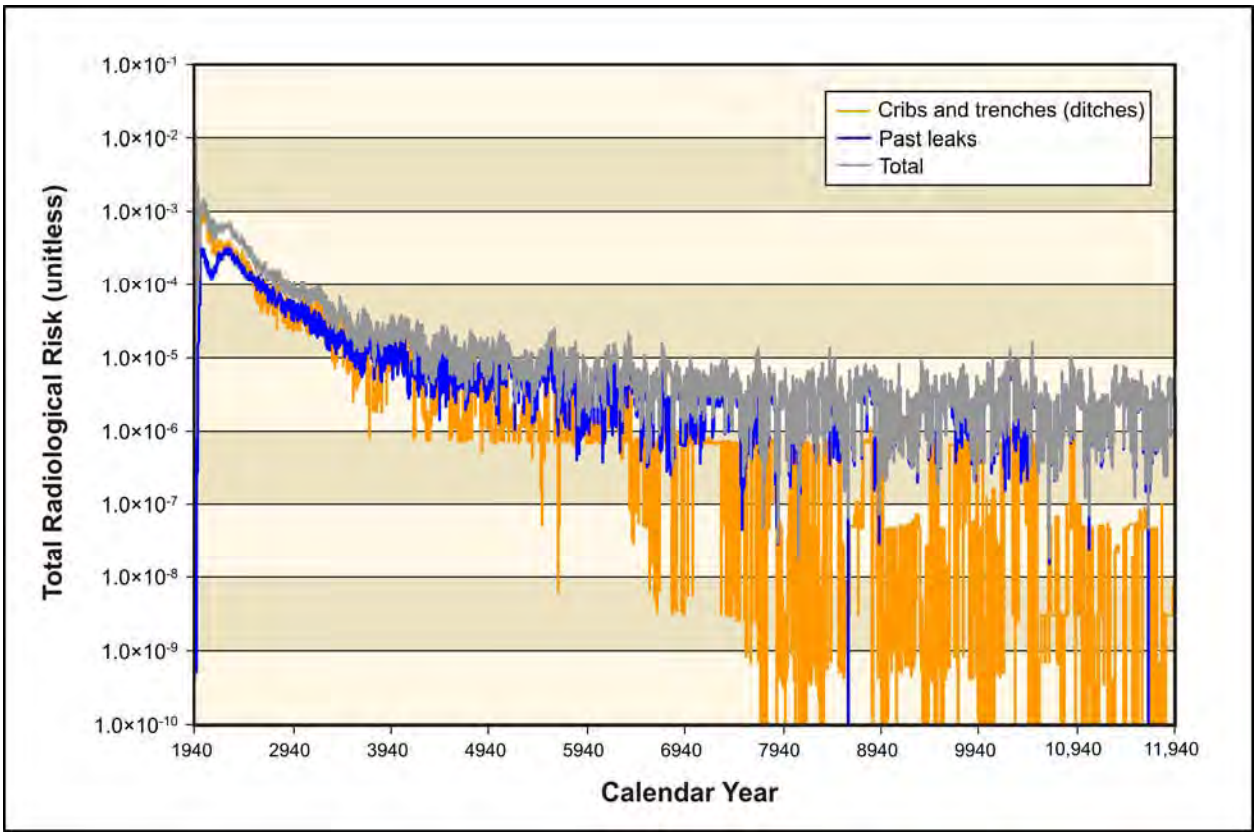


Figure 5–331. Tank Closure Alternative 6A, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

Table 5–46. Tank Closure Alternative 6A, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.38×10^{2}	7.95×10^{2}	1.25×10^{-2}	0.00	1.25×10^{-2}	1.24×10^{3}	8.93×10^{2}	3.49×10^{-2}	2.00×10^{-7}	3.49×10^{-2}
T Barrier	1.44×10^{3}	1.22×10^{2}	1.37×10^{-2}	0.00	1.37×10^{-2}	2.30×10^{3}	1.34×10^{2}	2.40×10^{-2}	3.48×10^{-8}	2.40×10^{-2}
Core Zone Boundary	6.38×10^{2}	5.09×10^{2}	1.25×10^{-2}	0.00	1.25×10^{-2}	1.24×10^{3}	5.85×10^{2}	3.49×10^{-2}	1.11×10^{-7}	3.49×10^{-2}
Columbia River nearshore	1.99×10^{-1}	3.66×10^{-1}	4.76×10^{-6}	0.00	4.76×10^{-6}	4.20×10^{-1}	4.08×10^{-1}	1.44×10^{-5}	1.02×10^{-10}	1.44×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.89×10^{-4}	1.59×10^{-4}	5.75×10^{-9}	3.41×10^{-14}	5.75×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–47. Tank Closure Alternative 6A, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.37×10^{3}	1.51×10^{3}	7.45×10^{-2}	9.18×10^{-3}	7.45×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.22×10^{3}	2.20×10^{2}	4.79×10^{-2}	1.60×10^{-3}	4.79×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.37×10^{3}	1.01×10^{3}	7.45×10^{-2}	5.11×10^{-3}	7.45×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	8.26×10^{-1}	6.84×10^{-1}	3.10×10^{-5}	4.69×10^{-6}	3.10×10^{-5}	4.00×10^{-1}	6.69×10^{-1}	4.92×10^{-6}	2.34×10^{-6}	5.77×10^{-6}
Off Site										
Columbia River	5.54×10^{-4}	2.13×10^{-1}	1.78×10^{-8}	1.56×10^{-9}	1.86×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–48. Tank Closure Alternative 6A, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.80×10^{1}	6.57×10^{-1}	7.99×10^{-4}	0.00	7.99×10^{-4}	6.21×10^{1}	6.82×10^{-1}	2.47×10^{-3}	2.39×10^{-10}	2.47×10^{-3}
B Barrier	1.94×10^{1}	1.18	5.56×10^{-4}	0.00	5.56×10^{-4}	4.30×10^{1}	1.28	1.72×10^{-3}	3.64×10^{-10}	1.72×10^{-3}
S Barrier	9.24	3.99	2.65×10^{-4}	0.00	2.65×10^{-4}	2.05×10^{1}	4.05	8.18×10^{-4}	1.56×10^{-9}	8.18×10^{-4}
T Barrier	5.25×10^{1}	5.78	1.51×10^{-3}	0.00	1.51×10^{-3}	1.17×10^{2}	6.00	4.69×10^{-3}	2.09×10^{-9}	4.69×10^{-3}
U Barrier	3.39×10^{-1}	1.36×10^{-1}	9.91×10^{-6}	0.00	9.91×10^{-6}	7.64×10^{-1}	1.40×10^{-1}	3.09×10^{-5}	5.15×10^{-11}	3.09×10^{-5}
Core Zone Boundary	1.10×10^{1}	4.04	3.21×10^{-4}	0.00	3.21×10^{-4}	2.46×10^{1}	4.11×10	1.00×10^{-3}	1.58×10^{-9}	1.00×10^{-3}
Columbia River nearshore	3.04×10^{-1}	4.17×10^{-2}	9.37×10^{-6}	0.00	9.37×10^{-6}	7.15×10^{-1}	4.28×10^{-2}	2.97×10^{-5}	1.59×10^{-11}	2.97×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.39×10^{-5}	2.22×10^{-6}	1.37×10^{-9}	7.68×10^{-16}	1.37×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–49. Tank Closure Alternative 6A, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.20×10^{2}	1.05	5.31×10^{-3}	1.10×10^{-5}	5.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	8.32×10^{1}	2.08	3.69×10^{-3}	1.67×10^{-5}	3.69×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.97×10^{1}	6.05	1.76×10^{-3}	7.16×10^{-5}	1.76×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.27×10^{2}	9.24	1.01×10^{-2}	9.59×10^{-5}	1.01×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.49	2.13×10^{-1}	6.64×10^{-5}	2.36×10^{-6}	6.64×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.82×10^{1}	6.15	2.17×10^{-3}	7.23×10^{-5}	2.17×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.41	6.47×10^{-2}	6.43×10^{-5}	7.27×10^{-7}	6.43×10^{-5}	1.89×10^{-3}	1.62×10^{-2}	9.48×10^{-8}	3.64×10^{-7}	4.11×10^{-7}
Off Site										
Columbia River	1.33×10^{-4}	1.06×10^{-3}	4.83×10^{-9}	3.52×10^{-11}	4.85×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–50. Tank Closure Alternative 6A, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	3.03	8.36×10^{-2}	8.88×10^{-5}	0.00	7.99×10^{-4}	6.85	8.63×10^{-2}	2.77×10^{-4}	3.11×10^{-11}	2.47×10^{-3}
B Barrier	5.61×10^{1}	6.46×10^{1}	1.64×10^{-3}	0.00	1.25×10^{-2}	1.26×10^{2}	7.38×10^{1}	5.09×10^{-3}	1.49×10^{-8}	3.49×10^{-2}
S Barrier	6.14	2.91	1.78×10^{-4}	0.00	2.65×10^{-4}	1.37×10^{1}	2.96	5.52×10^{-4}	1.14×10^{-9}	8.18×10^{-4}
T Barrier	3.54×10^{1}	9.64	1.01×10^{-3}	0.00	1.37×10^{-2}	7.79×10^{1}	1.04×10^{1}	3.13×10^{-3}	3.03×10^{-9}	2.40×10^{-2}
U Barrier	3.39×10^{-1}	1.03×10^{-1}	9.91×10^{-6}	0.00	9.91×10^{-6}	7.64×10^{-1}	1.07×10^{-1}	3.09×10^{-5}	3.78×10^{-11}	3.09×10^{-5}
Core Zone Boundary	4.51×10^{1}	3.67×10^{1}	1.35×10^{-3}	0.00	1.25×10^{-2}	1.04×10^{2}	4.34×10^{1}	4.27×10^{-3}	6.53×10^{-9}	3.49×10^{-2}
Columbia River nearshore	3.73×10^{-1}	3.91×10^{-1}	1.15×10^{-5}	0.00	1.15×10^{-5}	8.80×10^{-1}	4.34×10^{-1}	3.67×10^{-5}	1.13×10^{-10}	3.67×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.09×10^{-5}	2.00×10^{-5}	1.66×10^{-9}	4.17×10^{-15}	5.75×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–51. Tank Closure Alternative 6A, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.33×10^{1}	1.32×10^{-1}	5.97×10^{-4}	1.43×10^{-6}	5.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.45×10^{2}	1.27×10^{2}	1.10×10^{-2}	6.82×10^{-4}	7.45×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.66×10^{1}	4.42	1.19×10^{-3}	5.21×10^{-5}	1.76×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.51×10^{2}	1.67×10^{1}	6.73×10^{-3}	1.39×10^{-4}	4.79×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.49	1.63×10^{-1}	6.64×10^{-5}	1.73×10^{-6}	6.64×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.04×10^{2}	7.74×10^{1}	9.21×10^{-3}	3.00×10^{-4}	7.45×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.74	7.23×10^{-1}	7.94×10^{-5}	5.19×10^{-6}	7.94×10^{-5}	5.42×10^{-2}	3.52×10^{-1}	6.89×10^{-7}	2.60×10^{-6}	5.77×10^{-6}
Off Site										
Columbia River	1.59×10^{-4}	2.70×10^{-2}	5.78×10^{-9}	1.91×10^{-10}	1.86×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.10 Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure

5.1.2.10.1 Base Case

Tank Closure Alternative 6B, Base Case, resembles Tank Closure Alternative 6A, Base Case, except that waste retrieval and processing would proceed at a faster rate and closure would occur at an earlier date. All tank farms would be clean-closed, and the adjacent crib and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Potential human health impacts under Tank Closure Alternative 6B, Base Case, are detailed in Appendix Q and summarized in Tables 5–52 through 5–57; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–52 and 5–53; to past leaks after CY 1940 in Tables 5–54 and 5–55; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–56 and 5–57.

Impacts would be similar to those under Tank Closure Alternative 6A, Base Case, and standards would be exceeded, as under Tank Closure Alternative 6A, Base Case. The population dose was estimated as 2.04×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.12×10^{-5} percent of the annual population dose due to background exposure.

Table 5–52. Tank Closure Alternative 6B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.36×10^{2}	7.95×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	8.94×10^{2}	3.48×10^{-2}	2.00×10^{-7}	3.48×10^{-2}
T Barrier	1.46×10^{3}	1.27×10^{2}	1.39×10^{-2}	0.00	1.39×10^{-2}	2.32×10^{3}	1.39×10^{2}	2.43×10^{-2}	3.66×10^{-8}	2.43×10^{-2}
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.08×10^{-1}	4.02×10^{-1}	5.89×10^{-6}	0.00	5.89×10^{-6}	4.79×10^{-1}	4.35×10^{-1}	1.85×10^{-5}	1.23×10^{-10}	1.85×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–53. Tank Closure Alternative 6B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.36×10^{3}	1.51×10^{3}	7.43×10^{-2}	9.16×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.27×10^{3}	2.27×10^{2}	4.85×10^{-2}	1.68×10^{-3}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.53×10^{-1}	7.03×10^{-1}	4.01×10^{-5}	5.66×10^{-6}	4.01×10^{-5}	4.04×10^{-1}	7.14×10^{-1}	4.97×10^{-6}	2.83×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–54. Tank Closure Alternative 6B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.89×10^{1}	6.75×10^{-1}	8.27×10^{-4}	0.00	8.27×10^{-4}	6.42×10^{1}	7.00×10^{-1}	2.56×10^{-3}	2.48×10^{-10}	2.56×10^{-3}
B Barrier	1.96×10^{1}	1.18	5.68×10^{-4}	0.00	5.68×10^{-4}	4.38×10^{1}	1.28	1.76×10^{-3}	3.57×10^{-10}	1.76×10^{-3}
S Barrier	9.02	4.08	2.60×10^{-4}	0.00	2.60×10^{-4}	2.01×10^{1}	4.14	8.04×10^{-4}	1.60×10^{-9}	8.04×10^{-4}
T Barrier	5.40×10^{1}	5.75	1.56×10^{-3}	0.00	1.56×10^{-3}	1.21×10^{2}	5.97	4.83×10^{-3}	2.09×10^{-9}	4.83×10^{-3}
U Barrier	3.24×10^{-1}	1.40×10^{-1}	9.40×10^{-6}	0.00	9.40×10^{-6}	7.25×10^{-1}	1.44×10^{-1}	2.92×10^{-5}	5.31×10^{-11}	2.92×10^{-5}
Core Zone Boundary	1.03×10^{1}	4.14	3.02×10^{-4}	0.00	3.02×10^{-4}	2.32×10^{1}	4.20	9.41×10^{-4}	1.64×10^{-9}	9.41×10^{-4}
Columbia River nearshore	2.79×10^{-1}	3.64×10^{-2}	8.88×10^{-6}	0.00	8.88×10^{-6}	6.73×10^{-1}	3.73×10^{-2}	2.84×10^{-5}	1.38×10^{-11}	2.84×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.33×10^{-5}	2.07×10^{-6}	1.34×10^{-9}	7.12×10^{-16}	1.34×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–55. Tank Closure Alternative 6B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.24×10^{2}	1.07	5.50×10^{-3}	1.14×10^{-5}	5.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	8.50×10^{1}	2.08	3.79×10^{-3}	1.64×10^{-5}	3.79×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.89×10^{1}	6.19	1.73×10^{-3}	7.33×10^{-5}	1.73×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.34×10^{2}	9.19	1.04×10^{-2}	9.59×10^{-5}	1.04×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.41	2.17×10^{-1}	6.29×10^{-5}	2.44×10^{-6}	6.29×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.53×10^{1}	6.25	2.03×10^{-3}	7.51×10^{-5}	2.03×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.34	5.64×10^{-2}	6.17×10^{-5}	6.35×10^{-7}	6.17×10^{-5}	1.90×10^{-3}	1.57×10^{-2}	9.41×10^{-8}	3.18×10^{-7}	3.72×10^{-7}
Off Site										
Columbia River	1.31×10^{-4}	1.00×10^{-3}	4.75×10^{-9}	3.26×10^{-11}	4.77×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–56. Tank Closure Alternative 6B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	3.21	7.68×10^{-2}	9.24×10^{-5}	0.00	8.27×10^{-4}	7.15	7.94×10^{-2}	2.86×10^{-4}	2.84×10^{-11}	2.56×10^{-3}
B Barrier	6.17×10^{1}	5.78×10^{1}	1.88×10^{-3}	0.00	1.24×10^{-2}	1.44×10^{2}	6.65×10^{1}	5.94×10^{-3}	1.25×10^{-8}	3.48×10^{-2}
S Barrier	5.86	2.85	1.70×10^{-4}	0.00	2.60×10^{-4}	1.31×10^{1}	2.90	5.27×10^{-4}	1.11×10^{-9}	8.04×10^{-4}
T Barrier	3.61×10^{1}	9.65	1.03×10^{-3}	0.00	1.39×10^{-2}	8.04×10^{1}	1.04×10^{1}	3.20×10^{-3}	3.03×10^{-9}	2.43×10^{-2}
U Barrier	3.23×10^{-1}	9.89×10^{-2}	9.33×10^{-6}	0.00	9.40×10^{-6}	7.22×10^{-1}	1.02×10^{-1}	2.89×10^{-5}	3.63×10^{-11}	2.92×10^{-5}
Core Zone Boundary	5.16×10^{1}	3.38×10^{1}	1.59×10^{-3}	0.00	1.24×10^{-2}	1.21×10^{2}	3.95×10^{1}	5.02×10^{-3}	6.50×10^{-9}	3.48×10^{-2}
Columbia River nearshore	3.38×10^{-1}	4.22×10^{-1}	1.06×10^{-5}	0.00	1.06×10^{-5}	8.07×10^{-1}	4.56×10^{-1}	3.39×10^{-5}	1.31×10^{-10}	3.39×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.09×10^{-5}	1.91×10^{-5}	1.66×10^{-9}	3.98×10^{-15}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–57. Tank Closure Alternative 6B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.38×10^{1}	1.21×10^{-1}	6.15×10^{-4}	1.30×10^{-6}	5.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.83×10^{2}	1.15×10^{2}	1.28×10^{-2}	5.72×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.55×10^{1}	4.35	1.13×10^{-3}	5.10×10^{-5}	1.73×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.56×10^{2}	1.67×10^{1}	6.89×10^{-3}	1.39×10^{-4}	4.85×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.40	1.57×10^{-1}	6.22×10^{-5}	1.67×10^{-6}	6.29×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.39×10^{2}	6.96×10^{1}	1.09×10^{-2}	2.98×10^{-4}	7.43×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.60	7.35×10^{-1}	7.34×10^{-5}	6.00×10^{-6}	7.34×10^{-5}	5.68×10^{-2}	3.77×10^{-1}	7.22×10^{-7}	3.00×10^{-6}	6.40×10^{-6}
Off Site										
Columbia River	1.57×10^{-4}	2.76×10^{-2}	5.73×10^{-9}	1.82×10^{-10}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.10.2 Option Case

Tank Closure Alternative 6B, Option Case, resembles Tank Closure Alternative 6A, Option Case, except that waste retrieval and processing would proceed at a faster rate and closure would occur at an earlier date. All tank farms would be clean-closed, and the adjacent crib and trenches (ditches) would be clean-closed. Potential human health impacts under Tank Closure Alternative 6B, Option Case, are detailed in Appendix Q and summarized in Tables 5–58 through 5–63; those related to cribs and trenches (ditches) after CY 1940 are in Tables 5–58 and 5–59; to past leaks after CY 1940 in Tables 5–60 and 5–61; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050 in Tables 5–62 and 5–63.

Impacts would be slightly less than those under Tank Closure Alternative 6B, Base Case, and standards would be exceeded, as under Tank Closure Alternative 6B, Base Case. The population dose was estimated as 2.00×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.09×10^{-5} percent of the annual population dose due to background exposure.

Table 5–58. Tank Closure Alternative 6B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	6.37×10^{2}	8.06×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	9.07×10^{2}	3.48×10^{-2}	2.01×10^{-7}	3.48×10^{-2}
T Barrier	1.45×10^{3}	1.25×10^{2}	1.38×10^{-2}	0.00	1.38×10^{-2}	2.31×10^{3}	1.37×10^{2}	2.42×10^{-2}	3.59×10^{-8}	2.42×10^{-2}
Core Zone Boundary	6.37×10^{2}	5.15×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.92×10^{2}	3.48×10^{-2}	1.11×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.13×10^{-1}	3.56×10^{-1}	4.14×10^{-6}	0.00	4.14×10^{-6}	3.54×10^{-1}	3.92×10^{-1}	1.26×10^{-5}	1.01×10^{-10}	1.26×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.92×10^{-4}	1.60×10^{-4}	5.86×10^{-9}	3.50×10^{-14}	5.86×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–59. Tank Closure Alternative 6B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
B Barrier	2.37×10^{3}	1.54×10^{3}	7.42×10^{-2}	9.23×10^{-3}	7.42×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	4.25×10^{3}	2.26×10^{2}	4.83×10^{-2}	1.65×10^{-3}	4.83×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.37×10^{3}	1.03×10^{3}	7.42×10^{-2}	5.10×10^{-3}	7.42×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	6.85×10^{-1}	6.46×10^{-1}	2.71×10^{-5}	4.63×10^{-6}	2.71×10^{-5}	5.07×10^{-1}	6.93×10^{-1}	6.23×10^{-6}	2.31×10^{-6}	7.31×10^{-6}
Off Site										
Columbia River	5.59×10^{-4}	2.06×10^{-1}	1.80×10^{-8}	1.60×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–60. Tank Closure Alternative 6B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	2.89×10^{1}	6.75×10^{-1}	8.27×10^{-4}	0.00	8.27×10^{-4}	6.42×10^{1}	7.00×10^{-1}	2.56×10^{-3}	2.48×10^{-10}	2.56×10^{-3}
B Barrier	1.96×10^{1}	1.18	5.68×10^{-4}	0.00	5.68×10^{-4}	4.38×10^{1}	1.28	1.76×10^{-3}	3.57×10^{-10}	1.76×10^{-3}
S Barrier	9.02	4.08	2.60×10^{-4}	0.00	2.60×10^{-4}	2.01×10^{1}	4.14	8.04×10^{-4}	1.60×10^{-9}	8.04×10^{-4}
T Barrier	5.40×10^{1}	5.75	1.56×10^{-3}	0.00	1.56×10^{-3}	1.21×10^{2}	5.97	4.83×10^{-3}	2.09×10^{-9}	4.83×10^{-3}
U Barrier	3.24×10^{-1}	1.40×10^{-1}	9.40×10^{-6}	0.00	9.40×10^{-6}	7.25×10^{-1}	1.44×10^{-1}	2.92×10^{-5}	5.31×10^{-11}	2.92×10^{-5}
Core Zone Boundary	1.03×10^{1}	4.14	3.02×10^{-4}	0.00	3.02×10^{-4}	2.32×10^{1}	4.20	9.41×10^{-4}	1.64×10^{-9}	9.41×10^{-4}
Columbia River nearshore	2.79×10^{-1}	3.64×10^{-2}	8.88×10^{-6}	0.00	8.88×10^{-6}	6.73×10^{-1}	3.73×10^{-2}	2.84×10^{-5}	1.38×10^{-11}	2.84×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.33×10^{-5}	2.07×10^{-6}	1.34×10^{-9}	7.12×10^{-16}	1.34×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–61. Tank Closure Alternative 6B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.24×10^{2}	1.07	5.50×10^{-3}	1.14×10^{-5}	5.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	8.50×10^{1}	2.08	3.79×10^{-3}	1.64×10^{-5}	3.79×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.89×10^{1}	6.19	1.73×10^{-3}	7.33×10^{-5}	1.73×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.34×10^{2}	9.19	1.04×10^{-2}	9.59×10^{-5}	1.04×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.41	2.17×10^{-1}	6.29×10^{-5}	2.44×10^{-6}	6.29×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.53×10^{1}	6.25	2.03×10^{-3}	7.51×10^{-5}	2.03×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.34	5.64×10^{-2}	6.17×10^{-5}	6.35×10^{-7}	6.17×10^{-5}	1.90×10^{-3}	1.57×10^{-2}	9.41×10^{-8}	3.18×10^{-7}	3.72×10^{-7}
Off Site										
Columbia River	1.31×10^{-4}	1.00×10^{-3}	4.75×10^{-9}	3.26×10^{-11}	4.77×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–62. Tank Closure Alternative 6B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	3.21	7.68×10^{-2}	9.24×10^{-5}	0.00	8.27×10^{-4}	7.15	7.94×10^{-2}	2.86×10^{-4}	2.84×10^{-11}	2.56×10^{-3}
B Barrier	5.79×10^{1}	6.37×10^{1}	1.75×10^{-3}	0.00	1.24×10^{-2}	1.34×10^{2}	7.25×10^{1}	5.50×10^{-3}	1.48×10^{-8}	3.48×10^{-2}
S Barrier	5.86	2.85	1.70×10^{-4}	0.00	2.60×10^{-4}	1.31×10^{1}	2.90	5.27×10^{-4}	1.11×10^{-9}	8.04×10^{-4}
T Barrier	3.61×10^{1}	9.58	1.04×10^{-3}	0.00	1.38×10^{-2}	8.05×10^{1}	1.03×10^{1}	3.20×10^{-3}	3.05×10^{-9}	2.42×10^{-2}
U Barrier	3.23×10^{-1}	9.89×10^{-2}	9.33×10^{-6}	0.00	9.40×10^{-6}	7.22×10^{-1}	1.02×10^{-1}	2.89×10^{-5}	3.63×10^{-11}	2.92×10^{-5}
Core Zone Boundary	4.79×10^{1}	3.52×10^{1}	1.46×10^{-3}	0.00	1.24×10^{-2}	1.12×10^{2}	4.21×10^{1}	4.61×10^{-3}	6.92×10^{-9}	3.48×10^{-2}
Columbia River nearshore	3.38×10^{-1}	3.79×10^{-1}	1.04×10^{-5}	0.00	1.04×10^{-5}	7.91×10^{-1}	4.16×10^{-1}	3.28×10^{-5}	1.09×10^{-10}	3.28×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.99×10^{-5}	1.93×10^{-5}	1.62×10^{-9}	4.02×10^{-15}	5.86×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–63. Tank Closure Alternative 6B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
A Barrier	1.38×10^{1}	1.21×10^{-1}	6.15×10^{-4}	1.30×10^{-6}	5.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.63×10^{2}	1.24×10^{2}	1.19×10^{-2}	6.79×10^{-4}	7.42×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.55×10^{1}	4.35	1.13×10^{-3}	5.10×10^{-5}	1.73×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.56×10^{2}	1.65×10^{1}	6.89×10^{-3}	1.40×10^{-4}	4.83×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.40	1.57×10^{-1}	6.22×10^{-5}	1.67×10^{-6}	6.29×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.20×10^{2}	7.60×10^{1}	9.96×10^{-3}	3.17×10^{-4}	7.42×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.56	6.83×10^{-1}	7.09×10^{-5}	5.01×10^{-6}	7.09×10^{-5}	5.53×10^{-2}	3.45×10^{-1}	7.10×10^{-7}	2.51×10^{-6}	7.32×10^{-6}
Off Site										
Columbia River	1.54×10^{-4}	2.69×10^{-2}	5.62×10^{-9}	1.84×10^{-10}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.11 Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

Activities under Tank Closure Alternative 6C would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percent of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.3 Ecological Risk

This section presents the results of the evaluation of long-term impacts on ecological resources of releases to air and groundwater under Tank Closure alternatives. Risk indices—Hazard Quotient or Hazard Index—were calculated by comparing predicted dose to benchmark dose (see Appendix P of this EIS). Risk indices could not be calculated for some chemical COPCs and some receptors. For each receptor, calculated risk indices are presented for the COPC with the highest Hazard Quotients or Hazard Indices.

Releases to air and groundwater are expected under all Tank Closure alternatives. The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources of releases to groundwater were evaluated at the Columbia River.

5.1.3.1 Tank Closure Alternative 1: No Action

Predicted emissions of COPCs in air under Tank Closure Alternative 1, No Action, are unlikely to pose a hazard to ecological receptors. Under Tank Closure Alternative 1, the largest Hazard Quotient (1.16) for any COPC was calculated for the mouse exposed to xylene deposited to soil at the onsite maximum-exposure location (see Table 5–64). Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk, but there is uncertainty in the calculated value. The mouse Hazard Quotient for xylene is within the margin of error of the uncertainties in the estimated exposure and toxicity of chemical COPCs and does not indicate that small omnivorous mammals are likely to be adversely impacted (see Appendix P). The largest Hazard Index (0.0098) for radiological COPCs released to air under Tank Closure Alternative 1 (see Appendix P, Table P–3) is predicted for the mourning dove at the onsite maximum-exposure location. This indicates no risk from radiological COPCs released to air under Tank Closure Alternative 1.

Long-term impacts on ecological resources as a result of releases to groundwater from past leaks, residuals, ancillary equipment, and cribs and trenches (ditches) were evaluated at the Columbia River (see Appendix P). The largest risk index (Hazard Quotient is 21) for groundwater releases under Tank Closure Alternative 1 (see Table 5–65) is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River. The uncertainty about the risk it poses to aquatic biota from chromium in groundwater releases under *TC & WM EIS* alternatives is discussed in Appendix P (see Section P.3.2). The next-largest Hazard Quotient (0.82) for any chemical COPC was calculated for the spotted sandpiper exposed to chromium deposited to sediment and taken up by its benthic invertebrate prey. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.02) for radiological COPCs released to groundwater under Tank Closure Alternative 1 (see Appendix P, Table P–12) is predicted for benthic invertebrates. This indicates no risk from radiological COPCs under Tank Closure Alternative 1.

Table 5–64. Tank Closure Alternatives – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

Tank Closure Alternative	Hazard Quotient of Worst-Case Chemical COPC by Receptor								
	Plants	Soil-Dwelling Invertebrate	Side-Blotched Lizard	Great Basin Pocket Mouse	Coyote	Mule Deer	Meadow Lark	Mourning Dove	Burrowing Owl
	Mercury	Mercury	Mercury	Xylene	Xylene	Formaldehyde	Mercury	Mercury	Mercury
1	0.00	0.00	0.00	**1.16**	1.48×10^{-1}	1.63×10^{-1}	0.00	0.00	0.00
2A	6.46	9.02×10^{-1}	**1.52×10^{2}**	1.21×10^{2}	1.54×10^{1}	1.29×10^{1}	9.12×10^{1}	7.53	6.35
2B	7.05	9.85×10^{-1}	**1.66×10^{2}**	9.79×10^{1}	1.24×10^{1}	1.24×10^{1}	9.95×10^{1}	8.22	6.92
3A	1.67×10^{1}	2.33	**3.92×10^{2}**	1.02×10^{2}	1.30×10^{1}	1.24×10^{1}	2.35×10^{2}	1.94×10^{1}	1.64×10^{1}
3B	4.80	6.70×10^{-1}	1.13×10^{2}	**1.23×10^{2}**	1.57×10^{1}	1.39×10^{1}	6.77×10^{1}	5.59	4.71
3C	1.67×10^{1}	2.33	**3.92×10^{2}**	1.07×10^{2}	1.35×10^{1}	1.26×10^{1}	2.35×10^{2}	1.94×10^{1}	1.64×10^{1}
4	6.67	9.31×10^{-1}	**1.57×10^{2}**	9.06×10^{1}	1.15×10^{1}	1.35×10^{1}	9.41×10^{1}	7.77	6.54
5	6.34	8.85×10^{-1}	**1.49×10^{2}**	**1.49×10^{2}**	1.90×10^{1}	1.79×10^{1}	8.94×10^{1}	7.38	6.22
6A, Base	6.56	9.16×10^{-1}	1.54×10^{2}	**2.70×10^{2}**	3.43×10^{1}	3.49×10^{1}	9.25×10^{1}	7.64	6.44
6A, Option	6.51	9.09×10^{-1}	1.53×10^{2}	**2.74×10^{2}**	3.48×10^{1}	4.26×10^{1}	9.18×10^{1}	7.58	6.39
6B, Base	7.33	1.02	**1.72×10^{2}**	1.51×10^{2}	1.92×10^{1}	2.32×10^{1}	1.03×10^{2}	8.54	7.20
6B, Option	7.30	1.02	**1.71×10^{2}**	1.56×10^{2}	1.98×10^{1}	3.09×10^{1}	1.03×10^{2}	8.50	7.16
6C	7.30	1.02	**1.71×10^{2}**	9.70×10^{1}	1.23×10^{1}	1.04×10^{1}	1.03×10^{2}	8.50	7.16

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.
Key: Base=Base Case; COPC=constituent of potential concern; Option=Option Case.

Table 5–65. Tank Closure Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Resources at the Columbia River

Tank Closure Alternative	Hazard Quotient or Hazard Index of Worst-Case Chemical or Radiological COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Chromium	Chromium	Chromium	Uranium	Nitrate	Chromium	Chromium
1	1.20×10^{-1}	4.71×10^{-3}	8.16×10^{-1}	2.95×10^{-1}	6.31×10^{-1}	2.08×10^{-2}	**2.14×10^{1}**
2A	2.35×10^{-2}	9.17×10^{-4}	1.59×10^{-1}	4.11×10^{-2}	6.25×10^{-1}	1.49×10^{-2}	**2.20×10^{1}**
2B, 3A, 3B, 3C, 6C	2.50×10^{-2}	9.79×10^{-4}	1.70×10^{-1}	2.88×10^{-2}	6.30×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
4	2.47×10^{-2}	9.67×10^{-4}	1.68×10^{-1}	2.32×10^{-2}	6.30×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
5	2.54×10^{-2}	9.93×10^{-4}	1.72×10^{-1}	4.12×10^{-2}	6.30×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
6A, Base	2.42×10^{-2}	9.46×10^{-4}	1.64×10^{-1}	2.72×10^{-3}	6.30×10^{-1}	1.50×10^{-2}	**2.22×10^{1}**
6A, Option	2.11×10^{-2}	8.24×10^{-4}	1.43×10^{-1}	1.01×10^{-4}	6.36×10^{-1}	1.44×10^{-2}	**2.15×10^{1}**
6B, Base	2.43×10^{-2}	9.52×10^{-4}	1.65×10^{-1}	2.72×10^{-3}	6.30×10^{-1}	1.50×10^{-2}	**2.22×10^{1}**
6B, Option	2.03×10^{-2}	7.95×10^{-4}	1.38×10^{-1}	7.41×10^{-5}	6.16×10^{-1}	1.47×10^{-2}	**2.21×10^{1}**

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.

Key: Base=Base Case; COPC=constituent of potential concern; Option=Option Case.

5.1.3.2 Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 2A pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 2A. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 121) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 152) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under Tank Closure Alternative 2A. The largest Hazard Index (0.0167) for radiological COPCs released to air under Tank Closure Alternative 2A (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from COPC releases to air under Tank Closure Alternative 2A at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 2A is that calculated for exposure to hexavalent chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.0049) for radiological COPCs released to groundwater under Tank Closure Alternative 2A (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 4 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 2A.

5.1.3.3 Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 2B pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location, only slightly larger than under Tank Closure Alternative 2A (see Table 5–64). Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 2B. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 98) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 166) at the onsite maximum-exposure location. There would be no risk from radiological COPCs under Tank Closure Alternative 2B. The largest Hazard Index (0.0091) for radiological COPCs released to air under Tank Closure Alternative 2B (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 2B at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 2B is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.003) for radiological COPCs released to groundwater under Tank Closure Alternative 2B (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 7 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 2B.

5.1.3.4 Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 3A pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Tank Closure

Alternative 3A (and Tank Closure Alternative 3C) poses the highest risk of all alternatives for soil-dwelling invertebrates and the side-blotched lizard, meadow lark, mourning dove, and owl at the onsite maximum-exposure location (see Table 5–64). Hazard Quotients calculated for plants are between 1 and 20 for toluene and mercury under Tank Closure Alternative 3A. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 102) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 392) at the onsite maximum-exposure location. There would be no risk from radiological COPCs under Tank Closure Alternative 3A. The largest Hazard Index (0.0137) for radiological COPCs released to air under Tank Closure Alternative 3A (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Tank Closure Alternative 3A at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 3A is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.003) for radiological COPCs released to groundwater under Tank Closure Alternative 3A (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 7 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 3A.

5.1.3.5 Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 3B pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location (see Table 5–64). Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 3B. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 123) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 113) at the onsite maximum-exposure location. There would be no risk from radiological COPCs under Tank Closure Alternative 3B. The largest Hazard Index (0.0086) for radiological COPCs released to air under Tank Closure Alternative 3B (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Tank Closure Alternative 3B at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 3B is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.003) for radiological COPCs released to groundwater under Tank Closure Alternative 3B (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 7 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 3B.

5.1.3.6 Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 3C pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Tank Closure Alternative 3C risk indices are similar to those under Tank Closure Alternative 3A, posing the highest

risk of all alternatives for soil-dwelling invertebrates and the side-blotched lizard, meadow lark, mourning dove, and owl at the onsite maximum-exposure location (see Table 5–64). Hazard Quotients calculated for plants are between 1 and 20 for toluene and mercury under Tank Closure Alternative 3C. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 107) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 392) at the onsite maximum-exposure location. There would be no risk from radiological COPCs under Tank Closure Alternative 3C. The largest Hazard Index (0.0137) for radiological COPCs released to air under Tank Closure Alternative 3C (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Tank Closure Alternative 3C at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 3C is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.003) for radiological COPCs released to groundwater under Tank Closure Alternative 3C (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 7 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 3C.

5.1.3.7 Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 4 pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 4. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 91) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 157) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under Tank Closure Alternative 4. The largest Hazard Index (0.01) for radiological COPCs released to air under Tank Closure Alternative 4 (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 4 at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 4 is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.0027) for radiological COPCs released to groundwater under Tank Closure Alternative 4 (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 7.5 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 4.

5.1.3.8 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 5 pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 5. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the

mammals (mouse Hazard Quotient is 149) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 149) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under Tank Closure Alternative 5. The largest Hazard Index (0.0098) for radiological COPCs released to air under Tank Closure Alternative 5 (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 5 at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 5 is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.003) for radiological COPCs released to groundwater under Tank Closure Alternative 5 (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 7 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 5.

5.1.3.9 Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure

5.1.3.9.1 Base Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6A, Base Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6A, Base Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 270) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 154) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under Tank Closure Alternative 6A, Base Case. The largest Hazard Index (0.022) for radiological COPCs released to air under Tank Closure Alternative 6A, Base Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 6A, Base Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 6A, Base Case, is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.0014) for radiological COPCs released to groundwater under Tank Closure Alternative 6A, Base Case (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 15 less than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 6A, Base Case.

5.1.3.9.2 Option Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6A, Option Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6A, Option Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 274) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 153) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under

Tank Closure Alternative 6A, Option Case. The largest Hazard Index (0.024) for radiological COPCs released to air under Tank Closure Alternative 6A, Option Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 6A, Option Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 21.5) for groundwater releases under Tank Closure Alternative 6A, Option Case, is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.0003) for radiological COPCs released to groundwater under Tank Closure Alternative 6A, Option Case (see Appendix P, Table P–12) is predicted for the least weasel, a factor of almost 6 less than that under Tank Closure Alternative 1 (Hazard Index is 0.002) and a factor of 65 less than the maximum Hazard Index under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 6A, Option Case.

5.1.3.10 Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure

5.1.3.10.1 Base Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6B, Base Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6B, Base Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 151) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 172) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under Tank Closure Alternative 6B, Base Case. The largest Hazard Index (0.022) for radiological COPCs released to air under Tank Closure Alternative 6B, Base Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 6B, Base Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 6B, Base Case, is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.0014) for radiological COPCs released to groundwater under Tank Closure Alternative 6B, Base Case (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 15 less than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 6B, Base Case.

5.1.3.10.2 Option Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6B, Option Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6B, Option Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 156) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 171) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under

Tank Closure Alternative 6B, Option Case. The largest Hazard Index (0.023) for radiological COPCs released to air under Tank Closure Alternative 6B, Option Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 6B, Option Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 6B, Option Case, is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.0003) for radiological COPCs released to groundwater under Tank Closure Alternative 6B, Option Case (see Appendix P, Table P–12) is predicted for the least weasel, a factor of almost 6 less than under Tank Closure Alternative 1 (Hazard Index is 0.002) and a factor of 65 less than the maximum Hazard Index under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 6B, Option Case.

5.1.3.11 Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 6C pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6C. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for the mammals (mouse Hazard Quotient is 97) and mercury for the soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 171) at the onsite maximum-exposure location (see Table 5–64). There would be no risk from radiological COPCs under Tank Closure Alternative 6C. The largest Hazard Index (0.0091) for radiological COPCs released to air under Tank Closure Alternative 6C (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under Tank Closure Alternative 6C at the offsite maximum-exposure location (Columbia River).

The largest risk index (Hazard Quotient is 22) for groundwater releases under Tank Closure Alternative 6C is that calculated for exposure to chromium for aquatic biota, including salmonids, at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–65). No other Hazard Quotients exceed 1.0. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.003) for radiological COPCs released to groundwater under Tank Closure Alternative 6C (see Appendix P, Table P–12) is predicted for benthic invertebrates, a factor of 7 smaller than that under Tank Closure Alternative 1. This indicates no risk from radiological COPCs released to groundwater under Tank Closure Alternative 6C.

5.1.4 Environmental Justice

Sections 5.1.1 and 5.1.2 evaluate groundwater impacts and associated potential long-term human health effects under the Tank Closure alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs

from that of the American Indian resident farmer. The American Indian hunter-gatherer does not cultivate crops but gathers food from indigenous plants, harvests fish from the Columbia River, and is exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Appendix Q, Section Q.2.1. Long-term human health impacts of tank closure actions would be greatest under Tank Closure Alternative 1. Radiological releases under this alternative would result in the doses at the A and B Barriers and the Core Zone Boundary exceeding regulatory limits for the resident farmer, American Indian resident farmer, and American Indian hunter-gatherer; the dose at the S Barrier would exceed regulatory limits for the American Indian resident farmer and American Indian hunter-gatherer; at the T Barrier, for the American Indian hunter-gatherer. None of the hypothetical receptors at the Columbia River nearshore or surface-water locations would be exposed to a dose in excess of regulatory limits. Nonradiological releases under this alternative would result in exceedance of the Hazard Index for chromium and nitrate at all onsite locations analyzed for the resident farmer, American Indian resident farmer, and American Indian hunter-gatherer. The analysis determined that the greatest impact of any alternative on long-term human health could result in radiological doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the A, B, S, T, or U Barriers, Core Zone Boundary, or Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected for the foreseeable future because the Core Zone is designated for Industrial-Exclusive land use, the Columbia River nearshore is designated for Preservation (Hanford Reach National Monument), and the area between them is designated for Conservation (Mining) (DOE 1999). It is unlikely, therefore, that any of the Tank Closure alternatives would pose a disproportionately high and adverse long-term human health risk to the offsite American Indian population. The greatest risk would be to the American Indian resident farmer at the Core Zone Boundary. During the year of peak dose, this receptor would receive a radiological dose of 3.4 rem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent.

5.2 FFTF DECOMMISSIONING ALTERNATIVES

This section describes the potential long-term environmental and human health impacts associated with the implementation of alternatives considered to decommission the Fast Flux Test Facility (FFTF) and auxiliary facilities at Hanford; manage waste from the decommissioning process, including waste designated as remote-handled special components (RH-SCs); and disposition the Hanford inventory of radioactively contaminated bulk sodium from FFTF, as well as other facilities on site. Three FFTF Decommissioning alternatives are considered and analyzed: (1) FFTF Decommissioning Alternative 1, No Action, in which only certain deactivation activities at FFTF would be conducted, consistent with previous DOE National Environmental Policy Act actions and two action alternatives; (2) FFTF Decommissioning Alternative 2, Entombment; and (3) FFTF Decommissioning Alternative 3, Removal. FFTF Decommissioning Alternative 2 would involve removing all aboveground structures within the 400 Area Property Protected Area (PPA), with minimal removal of below-grade structures, equipment, and materials as necessary to comply with regulatory standards. The FFTF reactor vessel and other equipment below grade would remain. FFTF Decommissioning Alternative 3 would consist of removing all above-grade structures within the 400 Area PPA and the additional removal of contaminated below-grade structures, including the FFTF reactor vessel, equipment, and materials. Associated construction, operations, deactivation, closure, and decommissioning activities are assessed, as applicable, for each alternative.

For each action alternative (i.e., FFTF Decommissioning Alternatives 2 and 3), two options (Hanford and Idaho Options) are evaluated for disposition of RH-SCs and two (Hanford Reuse and Idaho Reuse Options) for disposition of bulk sodium. For RH-SCs, the Hanford Option would involve treating the waste in a new, onsite treatment facility, followed by disposal of the treated components and residuals along with other Hanford waste in the 200 Areas. Under the Idaho Option, RH-SCs would be shipped to the proposed Remote Treatment Project (RTP) at the Idaho National Laboratory (INL) Materials and Fuels Complex (MFC). Following treatment at the RTP, the FFTF components and residuals would be disposed of with other INL waste at an offsite facility or returned to Hanford for disposal. For disposition of bulk sodium under the Hanford Reuse Option, the bulk sodium would be stored in its current locations until it is shipped to a new onsite facility for processing. The caustic would then be transferred to the WTP for reuse. Under the Idaho Reuse Option, the bulk sodium would be stored in its current locations until it is shipped to the INL MFC for processing in the existing Sodium Processing Facility (SPF). Following processing, the caustic would be returned to Hanford for use in the WTP. These alternatives and options are described further in Chapter 2, Section 2.5.

5.2.1 Groundwater

The focus is on the impacts of FFTF disposition (sodium processing and remote-handled treatment should not have a groundwater impact); the waste removed from FFTF or resulting from removal will be discussed under the Waste Management alternatives.

5.2.1.1 FFTF Decommissioning Alternative 1: No Action

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 1: No Action, including long-term groundwater impacts of contaminant sources within the FFTF Barrier (for analysis purposes, the FFTF Barrier is represented by a rectangle surrounding FFTF). Impacts of sources removed from within the FFTF Barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.1.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 1, after a period of administrative control, no further actions would be taken to remove radionuclides or chemicals from within the FFTF Barrier. Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, two major periods were identified for FFTF Decommissioning Alternative 1, as follows:

- The administrative control period was assumed to start in 2008 and end in CY 2107 (100-year duration). It was assumed that during this administrative control period, corrective action or emergency response measures would preclude releases of contaminants from FFTF to the environment.

- The post–administrative control period was assumed to start in CY 2108 and continue through the 10,000-year period of analysis until CY 11,940. During this post–administrative control period, all remaining constituents at FFTF would be available for release to the environment.

5.2.1.1.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 1. Complete results for all 40 COPCs are provided in Appendices M, N, and O. The discussion in this section of long-term impacts associated with FFTF Decommissioning Alternative 1 is focused on the following COPC drivers:

- Radiological risk drivers: tritium and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: none

The COPC drivers for FFTF Decommissioning Alternative 1 were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the FFTF Barrier during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers account for essentially all of the radiological risk. The peak chemical hazard to a drinking-water well user at the FFTF Barrier is essentially negligible.

The COPC drivers that are discussed in detail in this section fall into two categories. Technetium-99 is mobile (i.e., moves with groundwater) and long-lived (relative to the 10,000-year period of analysis). It is essentially a conservative tracer. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. The other COPCs that were analyzed do not significantly contribute to drinking water risk or hazard at the FFTF Barrier during the period of analysis because of low inventories, low release rates, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.2.1.1.3 Analysis of Release and Mass Balance

This section presents the impacts of FFTF Decommissioning Alternative 1 in terms of total amount of radiological COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies (see Figures 5–332 through 5–334). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude.

Figure 5–332 shows the estimated release to the vadose zone for the radiological risk drivers. The total release to the vadose zone is controlled only by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). About 2 curies of tritium and about 27 curies of technetium-99 were released to the vadose zone in the analysis. Figure 5–333 shows the release to groundwater for the radiological risk drivers. In addition to the inventory considerations, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For technetium-99, the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, the amount released to groundwater is strongly attenuated by radioactive decay. Less than 1 percent of the tritium that was released in the analysis into the vadose zone reached the groundwater. Figure 5–334 shows the release to the Columbia River for the radiological risk drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is strongly attenuated by radioactive decay. Overall, only about 6 percent of the tritium released to groundwater reaches the Columbia River in the analysis.

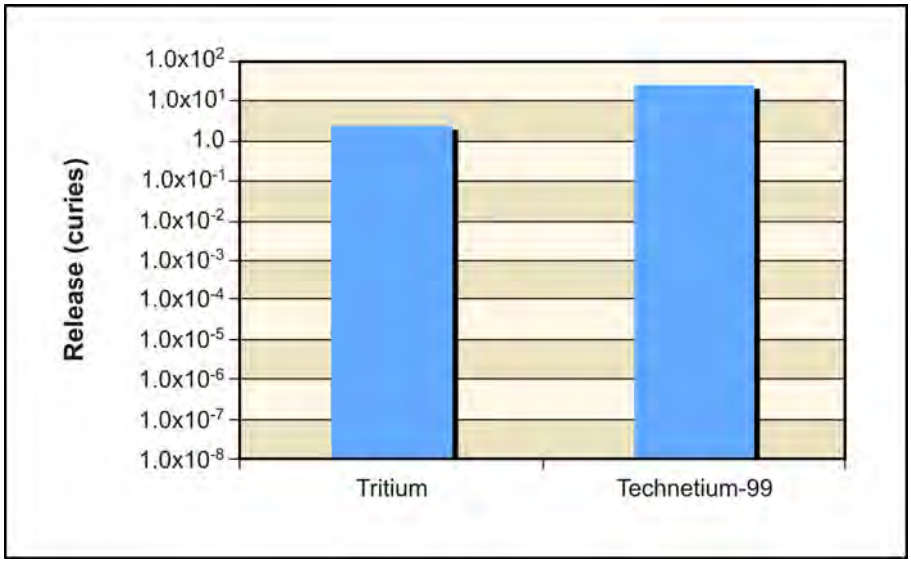


Figure 5–332. FFTF Decommissioning Alternative 1 Releases of Radiological Constituent of Potential Concern to Vadose Zone from Sources Inside the Fast Flux Test Facility Barrier

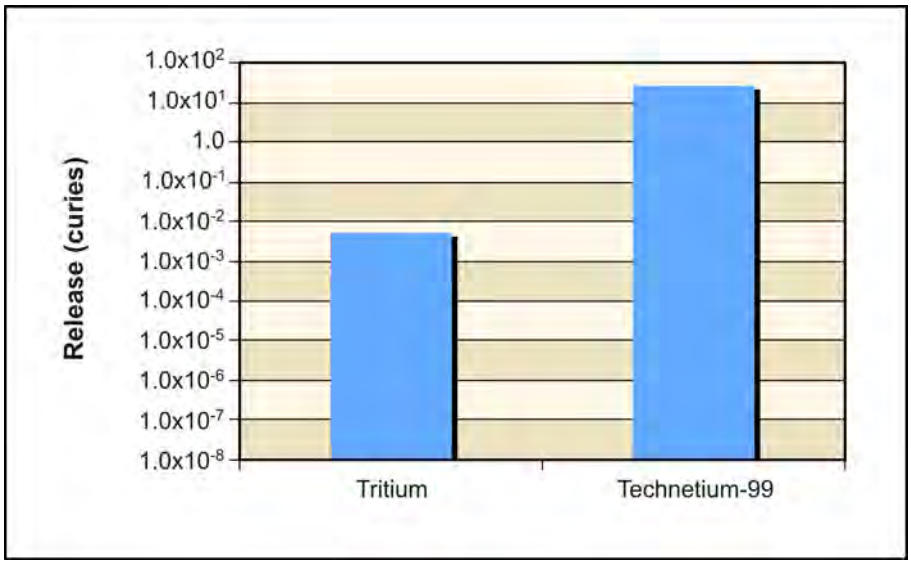


Figure 5–333. FFTF Decommissioning Alternative 1 Releases of Radiological Constituent of Potential Concern to Groundwater from Sources Inside the Fast Flux Test Facility Barrier

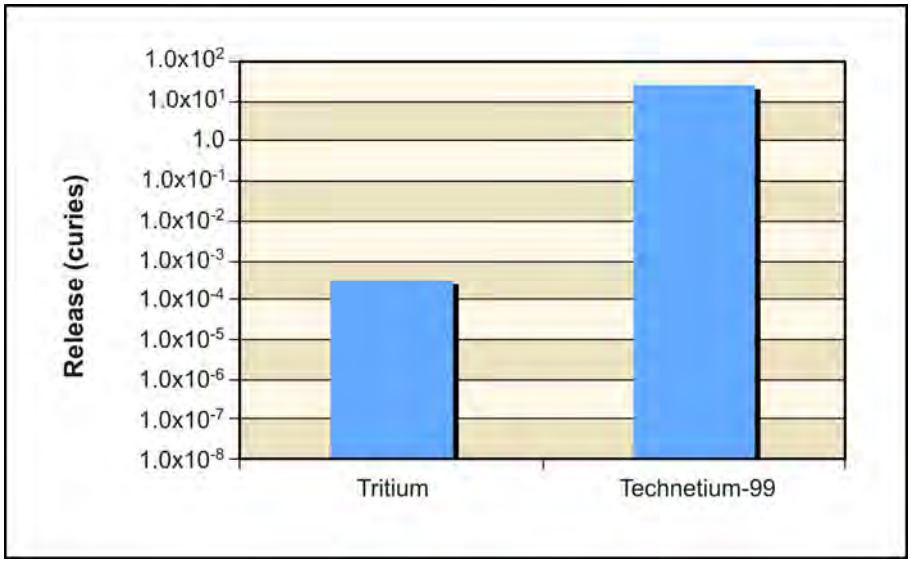


Figure 5–334. FFTF Decommissioning Alternative 1 Releases of Radiological Constituent of Potential Concern to Columbia River from Sources Inside the Fast Flux Test Facility Barrier

5.2.1.1.4 Analysis of Concentration Versus Time

This section presents the analysis of FFTF Decommissioning Alternative 1 impacts in terms of groundwater concentration versus time at the FFTF Barrier and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter (see Figures 5–335 and 5–336). The benchmark concentration for each radionuclide is also shown (900 and 20,000 picocuries per liter for technetium-99 and tritium, respectively). Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over two orders of magnitude.

Figure 5–335 shows concentration versus time for technetium-99. The concentration of technetium-99 at the FFTF Barrier peaks at about 40 percent of the benchmark around CY 2550. During this time, groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration. Technetium-99 is essentially not a factor at times later than CY 5800.

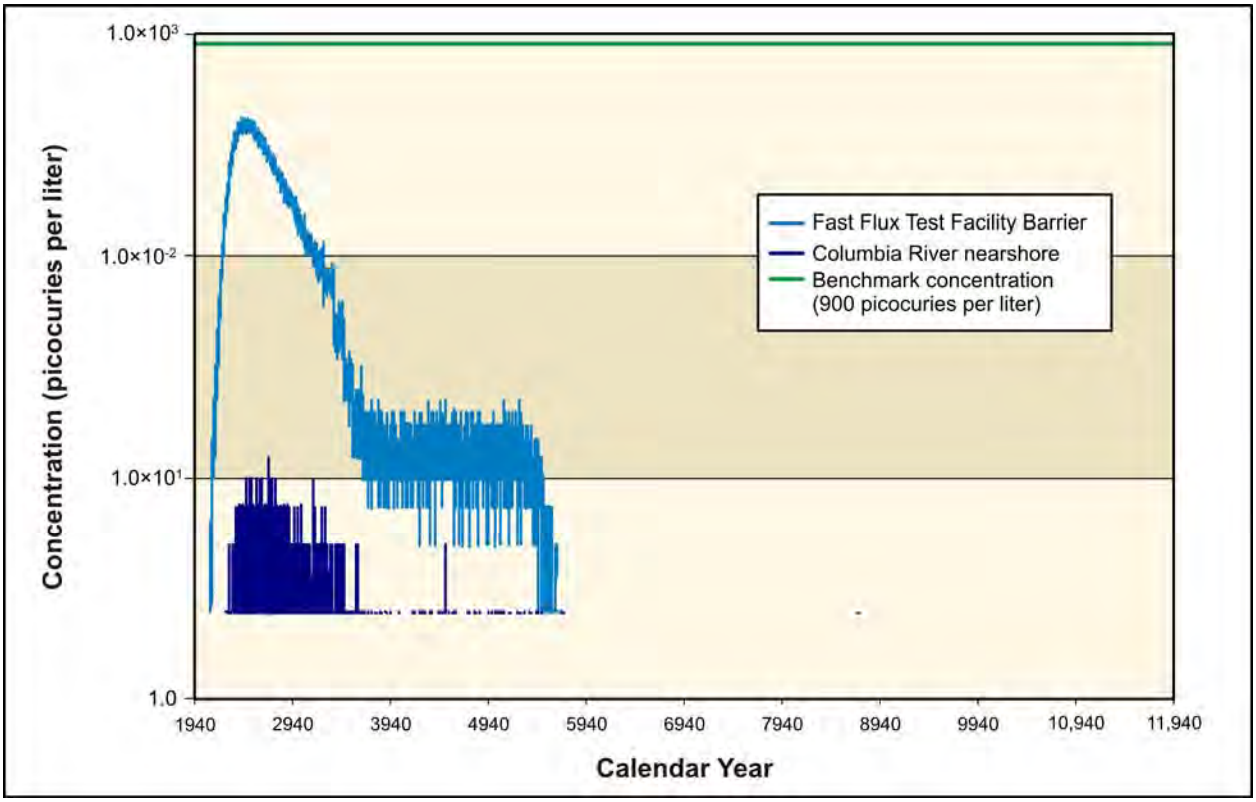


Figure 5–335. FFTF Decommissioning Alternative 1 Technetium-99 Concentration Versus Time

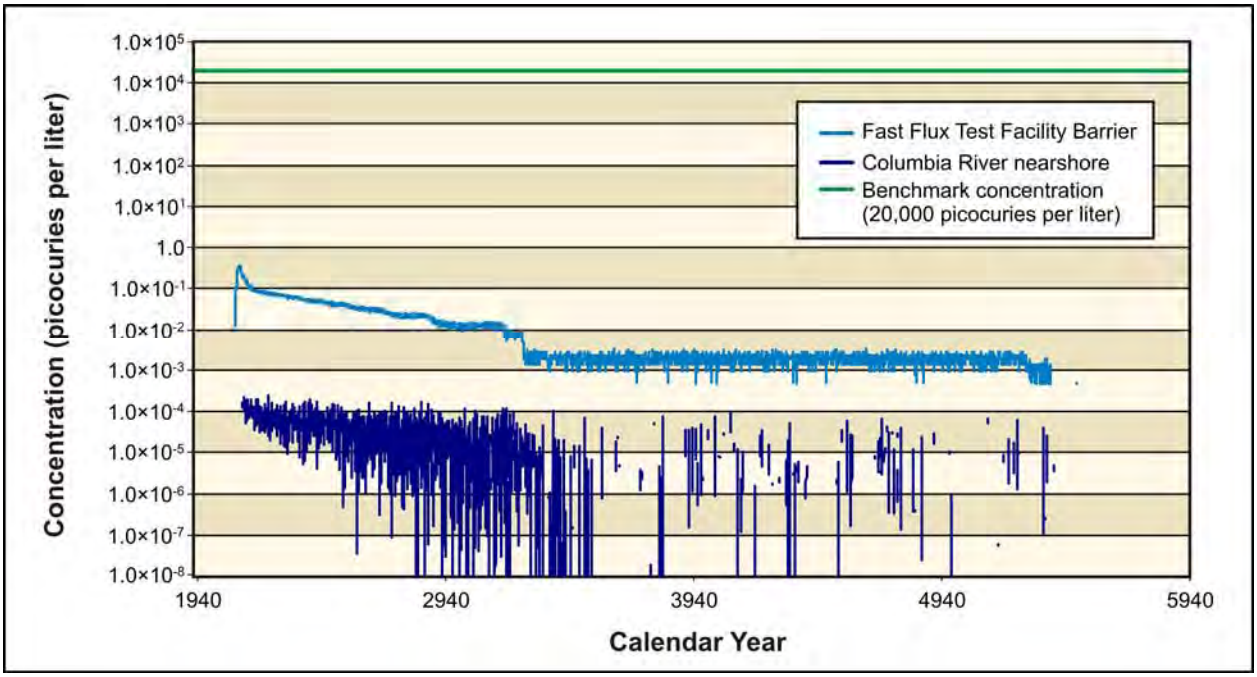


Figure 5–336. FFTF Decommissioning Alternative 1 Hydrogen-3 (Tritium) Concentration Versus Time

Figure 5–336 shows concentration versus time for tritium. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration. Releases from FFTF did not cause groundwater concentrations to exceed the benchmark throughout the period of analysis. The concentrations at the FFTF Barrier peak at about five orders of magnitude below the benchmark. During this time, groundwater concentrations at the Columbia River nearshore peak at about eight orders of magnitude below the benchmark. Table 5–66 lists the estimated maximum concentrations of tritium and technetium-99 in the peak year at the FFTF Barrier and the Columbia River nearshore.

Table 5–66. FFTF Decommissioning Alternative 1 Maximum COPC Concentrations in the Peak Year at the FFTF Barrier and Columbia River Nearshore

Contaminant	FFTF Barrier	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter			
Hydrogen-3 (tritium)	0.36	0.00024	20,000
	(2122)	(2243)	
Technetium-99	416	12	900
	(2425)	(2702)	

Note: Corresponding calendar years shown in parentheses.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

5.2.1.1.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of FFTF Decommissioning Alternative 1 in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter (see Figures 5–337 and 5–338). Concentrations for each radionuclide are indicated by a color scale that is relative to the benchmark concentration (900 and 20,000 picocuries per liter for technetium-99 and tritium, respectively). Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–337 shows the spatial distribution of groundwater concentration for technetium-99 during CY 2590, roughly the time of greatest development of the groundwater plume. Analysis releases from FFTF result in a groundwater concentration plume that extends easterly from the facility to the Columbia River nearshore. Peak concentrations in this plume are less than a tenth of the benchmark during CY 2590.

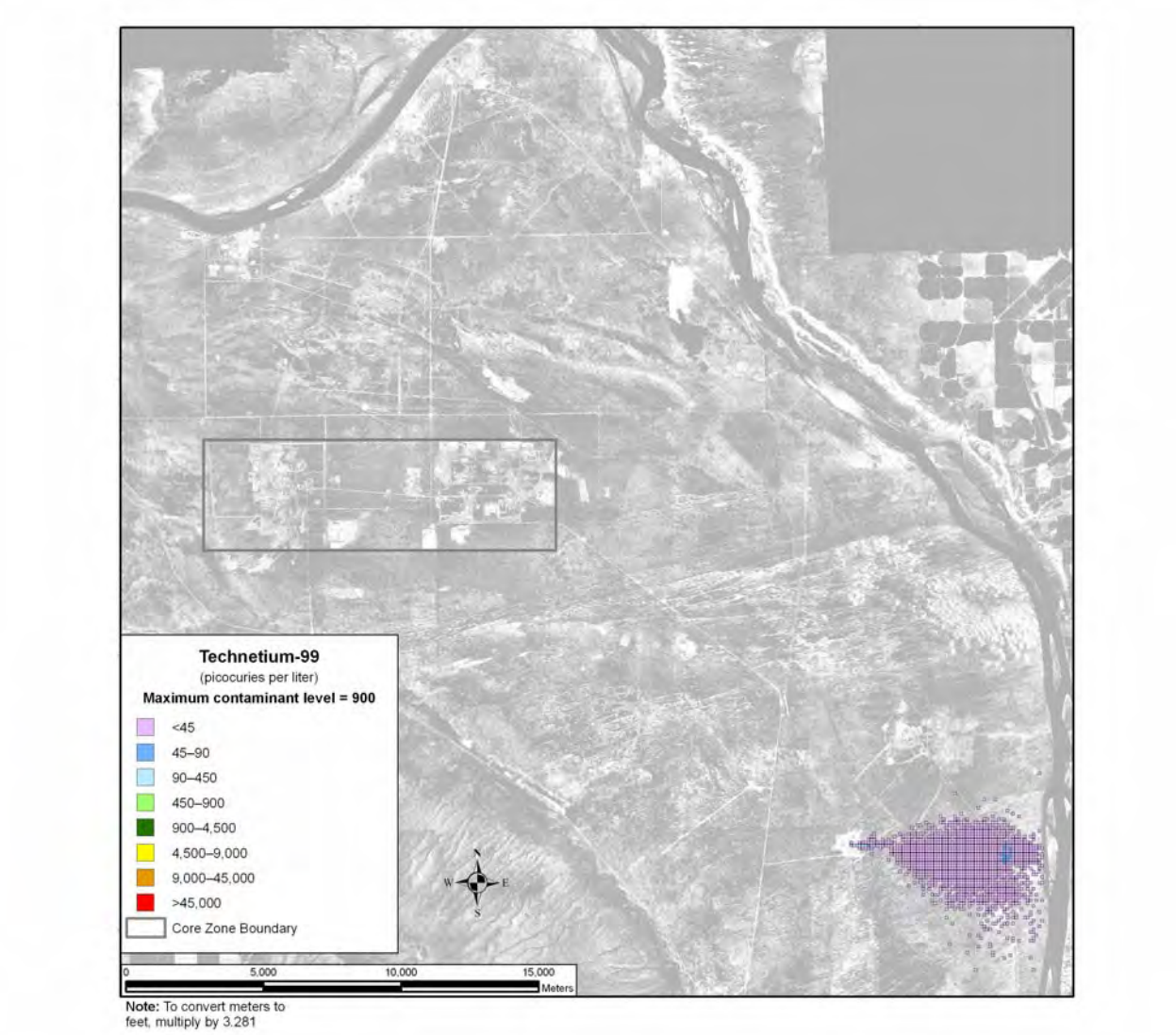


Figure 5–337. FFTF Decommissioning Alternatives 1 and 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2590

Figure 5–338 shows the spatial distribution of groundwater concentration for tritium during CY 2135. Analysis releases from FFTF result in a groundwater concentration plume that extends from the facility easterly to the Columbia River nearshore. Peak concentrations in this plume are about 20 times less than the benchmark.

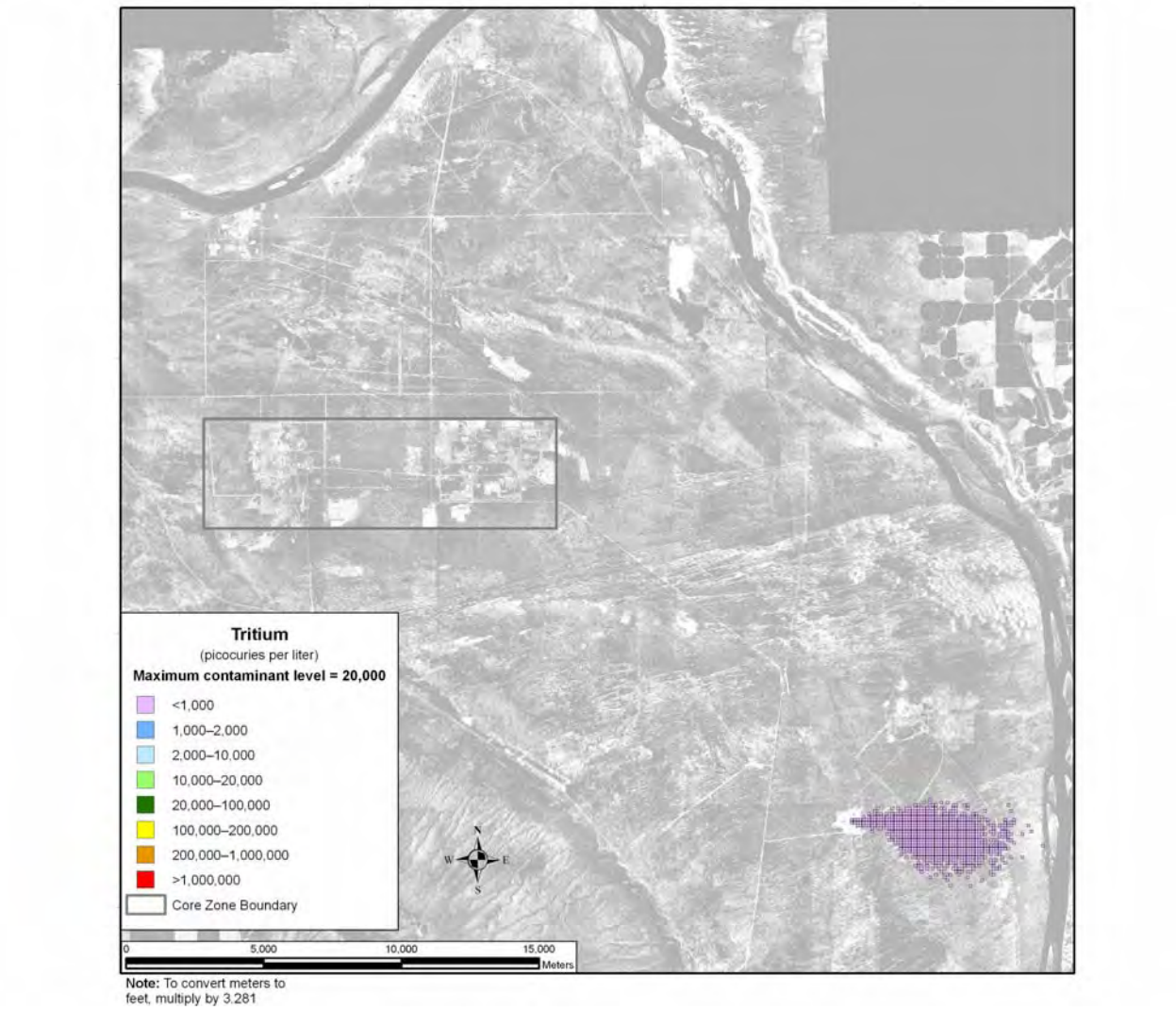


Figure 5–338. FFTF Decommissioning Alternative 1 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2135

5.2.1.1.6 Summary of Impacts

Under FFTF Decommissioning Alternative 1, technetium-99 and tritium are the COPC drivers in the analysis. Neither COPC exceeds benchmark standards at the FFTF Barrier or the Columbia River nearshore during the 10,000-year period of analysis. Tritium concentrations are strongly attenuated by radioactive decay, and the impacts are dominated by technetium-99. The impacts are greatest around CY 2500.

5.2.1.2 FFTF Decommissioning Alternative 2: Entombment

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 2, Entombment, including long-term groundwater impacts of contaminant sources within the FFTF Barrier. Impacts of sources removed from within the FFTF Barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.2.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 2, all aboveground structures and minimal below-grade structures, equipment, and materials would be removed. An RCRA-compliant barrier would be constructed over the Reactor Containment Building and any other remaining below-grade structures (including the reactor vessel). Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, two major periods were identified for FFTF Decommissioning Alternative 2, as follows:

- The entombment period was assumed to start in CY 2013 when decommissioning activities begin and to end in CY 2121, following the completion of decommissioning and entombment activities and a 100-year postclosure period. It was assumed that during this entombment period, there would be no releases from FFTF.

- The post-entombment period was assumed to start in CY 2122 and continue through the 10,000-year period of analysis until CY 11,940. During this post-entombment period, all remaining constituents at FFTF would be available for release to the environment.

5.2.1.2.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 2. Complete results for all 40 COPCs are provided in Appendices M, N, and O. The discussion in this section of long-term impacts associated with FFTF Decommissioning Alternative 2 is focused on the following COPC drivers:

- Radiological risk drivers: technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: none

The COPC drivers for FFTF Decommissioning Alternative 2 were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the FFTF Barrier during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers account for essentially all of the radiological risk. The peak chemical hazard to a drinking-water well user at the FFTF Barrier is essentially negligible.

The COPC driver that is discussed in detail in this section is technetium-99. Technetium-99 is mobile (i.e., moves with groundwater) and long-lived (relative to the 10,000-year period of analysis). It is essentially a conservative tracer. The other COPCs that were analyzed do not significantly contribute to drinking water risk or hazard at the FFTF Barrier during the period of analysis because of low inventories, low release rates, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.2.1.2.3 Analysis of Release and Mass Balance

This section presents the impacts of FFTF Decommissioning Alternative 2 in terms of total amount of radiological COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies (see Figures 5–339 through 5–341). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over seven orders of magnitude.

Figure 5–339 shows the estimated release to the vadose zone for technetium-99, about 27 curies. Figure 5–340 shows the release to groundwater, which is essentially the same as that released to the vadose zone. This is due to technetium-99's lack of retardation and long half-life. Figure 5–341 shows the release to the Columbia River for technetium-99, which also is about 27 curies.

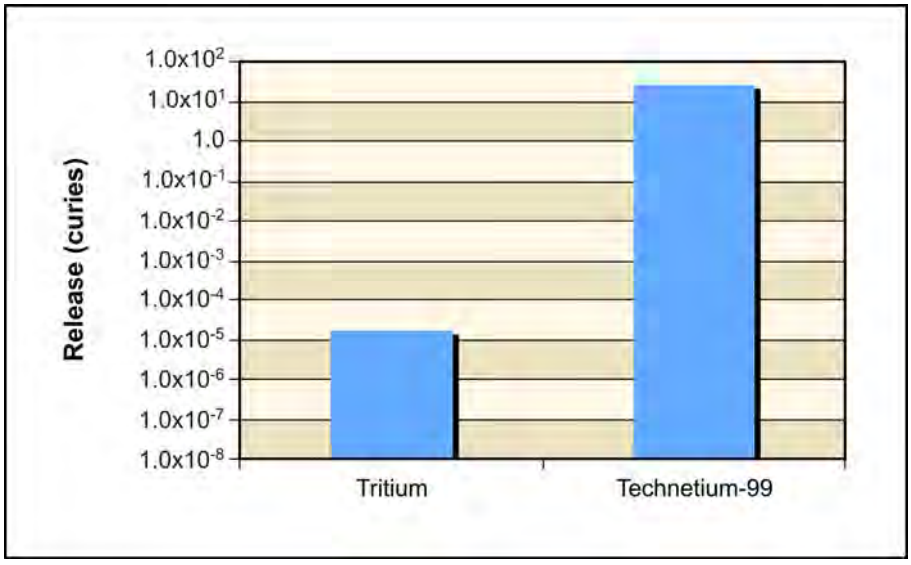


Figure 5–339. FFTF Decommissioning Alternative 2 Releases of Radiological Constituent of Potential Concern to Vadose Zone from Sources Inside the Fast Flux Test Facility Barrier

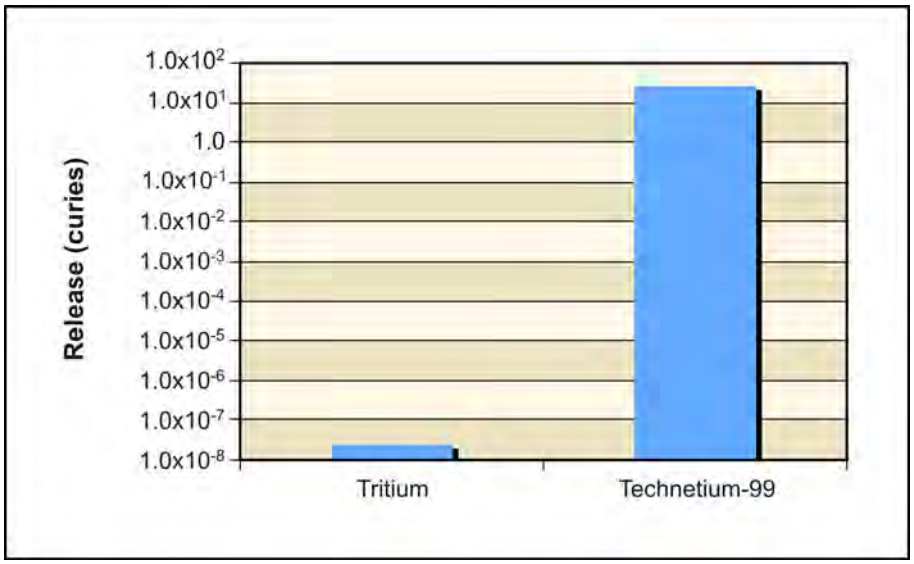


Figure 5–340. FFTF Decommissioning Alternative 2 Releases of Radiological Constituent of Potential Concern to Groundwater from Sources Inside the Fast Flux Test Facility Barrier

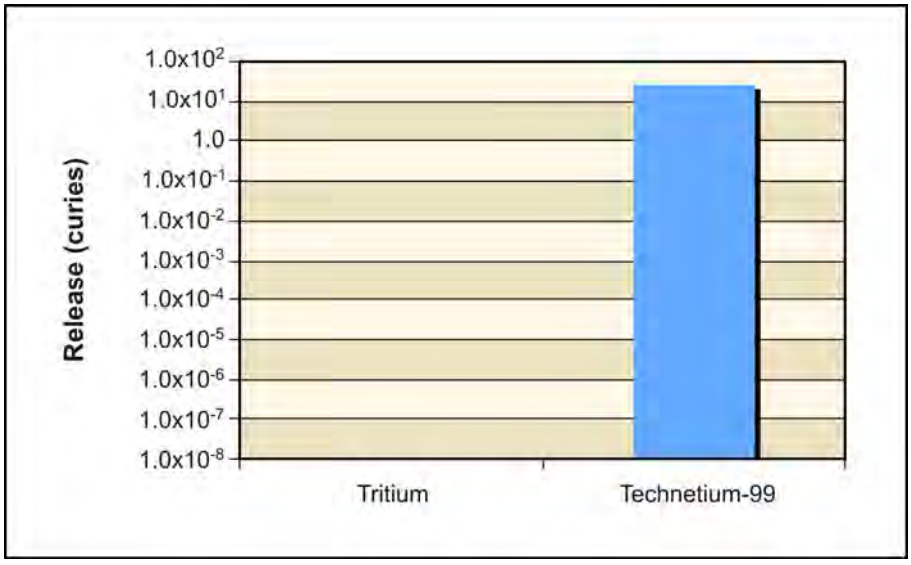


Figure 5–341. FFTF Decommissioning Alternative 2 Releases of Radiological Constituent of Potential Concern to Columbia River from Sources Inside the Fast Flux Test Facility Barrier

5.2.1.2.4 Analysis of Concentration Versus Time

This section presents the impacts of FFTF Decommissioning Alternative 2 in terms of groundwater concentration versus time at the FFTF Barrier and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter (see Figure 5–342). The benchmark concentration for technetium-99 is also shown (900 picocuries per liter). Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over two to three orders of magnitude.

Figure 5–342 shows concentration versus time for technetium-99. The concentration of technetium-99 at the FFTF Barrier peaks at about 40 percent of the benchmark around CY 2550. During this time, groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration. Technetium-99 is essentially not a factor at times later than CY 5800. Table 5–67 lists the estimated maximum concentrations of technetium-99 in the peak year at the FFTF Barrier and the Columbia River nearshore.

Table 5–67. FFTF Decommissioning Alternative 2 Maximum COPC Concentrations in the Peak Year at the FFTF Barrier and Columbia River Nearshore

Contaminant	FFTF Barrier	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter			
Hydrogen-3 (tritium)	0	0	20,000
	N/A	N/A	
Technetium-99	407	12	900
	(2819)	(2965)	

Note: Corresponding calendar years shown in parentheses.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility; N/A=not applicable.

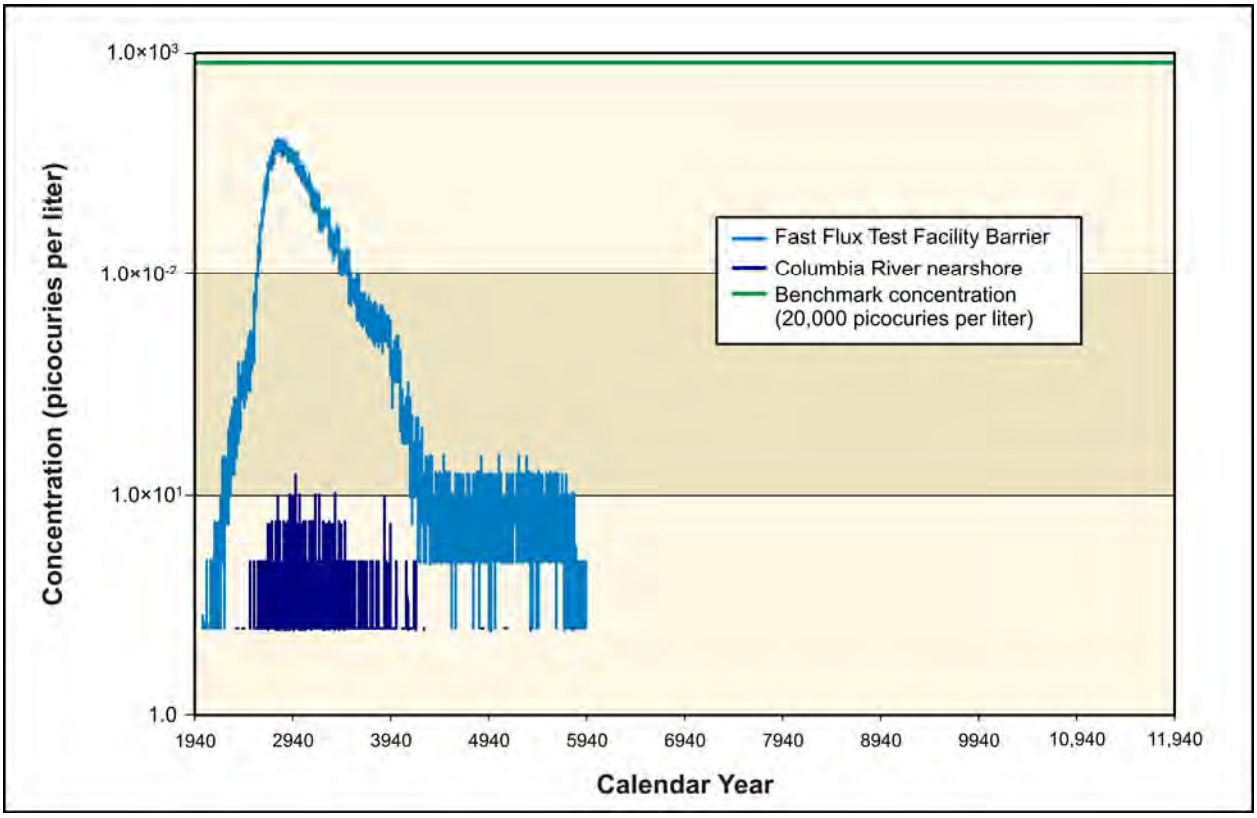


Figure 5–342. FFTF Decommissioning Alternative 2 Technetium-99 Concentration Versus Time

5.2.1.2.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of FFTF Decommissioning Alternative 2 in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter (see Figure 5–337). Concentrations of technetium-99 are indicated by a color scale that is relative to the benchmark concentration (900 picocuries per liter). Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

The results of the analyses of release and mass balance and of concentration versus time show that the plume development for technetium-99 is identical under FFTF Decommissioning Alternatives 1 and 2. Figure 5–337 shows the spatial distribution of the technetium plume during CY 2590, roughly the time of greatest development of the groundwater plume. Analysis releases from FFTF result in a groundwater concentration plume that extends easterly from the facility to the Columbia River nearshore. Peak concentrations in this plume are less than a tenth of the benchmark during CY 2590.

5.2.1.2.6 Summary of Impacts

Under FFTF Decommissioning Alternative 2, technetium-99 is the COPC driver in the analysis. Groundwater impacts of technetium-99 are similar to those under FFTF Decommissioning Alternative 1. Technetium-99 concentrations do not exceed benchmark standards at the FFTF Barrier or the Columbia River nearshore during the 10,000-year period of analysis. The impacts are greatest around CY 2500.

5.2.1.3 FFTF Decommissioning Alternative 3: Removal

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 3, Removal, including long-term groundwater impacts of contaminant sources within the FFTF Barrier. Impacts of sources removed from within the FFTF Barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.3.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 3, all above-grade structures within the 400 Area PPA would be removed; additionally, contaminated below-grade structures, equipment, and materials would be removed. Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, two major periods were identified for FFTF Decommissioning Alternative 3, as follows:

- The removal period was assumed to start in CY 2013 when decommissioning activities begin and to end in CY 2121, following the completion of decommissioning and removal activities and a 100-year postclosure period. It was assumed that during this removal period, there would be no releases from FFTF.

- The post-removal period was assumed to start in CY 2122 and continue through the 10,000-year period of analysis until CY 11,940. During this post-removal period, all remaining constituents at FFTF would be available for release to the environment.

5.2.1.3.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 3. These COPCs become available for release to the environment at the end of the post-removal period in 2121. The total amount of each COPC released to the aquifer is limited first by the inventory remaining after removal. The removal activities limit the residual inventories to a much greater extent under FFTF Decommissioning Alternative 3 than under FFTF Decommissioning Alternatives 1 and 2. The maximum residual inventory calculated under FFTF Decommissioning Alternative 3 is for carbon-14, which is approximately 4×10^{-4} curies. The second factor that limits release to the aquifer is attenuation by retardation and/or radioactive decay. Accounting for both factors, the calculated maximum total release to the aquifer of all COPCs is for technetium-99, which is 4×10^{-6} curies. For all COPCs, the calculated peak rate of release to the aquifer is less than 10^{-8} curies per year, the threshold for evaluating long-term groundwater impacts (see Appendix O). Thus, the analysis predicts no long-term groundwater impacts associated with FFTF Decommissioning Alternative 3 above *de minimis* values.

5.2.2 Human Health Impacts

Potential human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer. For long-term performance assessment, radiological dose and risk are estimated consistent with the recommendations of *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (Eckerman et al. 1999), including use of radionuclide-specific dose factors and risk coefficients. Potential human health effects due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects were estimated as a Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as a Hazard Index, the sum of the Hazard Quotients of a group of chemicals. Further information on the nature of human health effects in response to exposure to radiological and chemical constituents is provided in Appendix K. Screening analysis identified 14 radionuclide and 26 chemical constituents as contributing the greatest risk of adverse impacts. Appendix Q provides more

information on the screening analysis, including time of occurrence of peak impacts and constituent- and location-specific impacts under each Tank Closure, FFTF Decommissioning, and Waste Management alternative.

Four measures of human health impacts were considered in this analysis: lifetime risks of developing cancer from both radiological and chemical constituents, dose from radiological constituents, and Hazard Index from chemical constituents. These measures were calculated for each year for 10,000 years for each receptor at three locations: the FFTF Barrier, Columbia River nearshore, and surface water of the Columbia River. This large amount of information must be summarized to allow an interpretation of results. The method chosen was to present the dose for the year of maximum dose, the risk for the year of maximum risk, and the Hazard Index for the year of maximum Hazard Index. This choice was based on regulation of radiological impacts as dose and observations from the analysis results that (1) risk due to exposure to chemical constituents would be small relative to risk due to exposure to radiological constituents and (2) peak noncarcinogenic impacts expressed as a Hazard Index may occur at times other than that of peak dose.

Impacts on human health over the long period following decommissioning of the FFTF would be due primarily to the materials left in place following no action, entombment, or removal. Onsite analysis locations included the FFTF boundary and the Columbia River nearshore. Offsite analysis locations included access points to Columbia River surface water near the site and at population centers downstream of the site. Estimates of constituent concentrations in Columbia River surface water were used to calculate the impacts for both offsite location points of analysis. The total offsite population is 5 million people. Four types of receptor were considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield were assumed to be adequate to produce approximately 25 percent of average requirements for crops and animal products. The third type, an American Indian resident farmer, also uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield were assumed to be adequate to produce the entirety of average requirements for crops and animal products. The fourth type, an American Indian hunter-gatherer, uses both groundwater and surface water because surface water is used for drinking-water consumption and both wild plant materials, which use groundwater, and game, which use surface water, are consumed.

The significance of the dose impacts was evaluated by comparison with the 100-millirem-per-year all-exposure modes standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. The level of protection provided for the drinking-water pathway was evaluated by comparison with the applicable drinking-water standards presented in Section 5.2.1. The population doses were compared with the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The significance of noncarcinogenic chemical impacts was evaluated by comparison with a guideline value of unity for Hazard Index.

5.2.2.1 FFTF Decommissioning Alternative 1: No Action

This section contains the results for FFTF Decommissioning Alternative 1, No Action. The section includes analysis of long-term human health impacts from sources within the FFTF Barrier. Impacts from sources removed from the FFTF Barrier and disposed of in an IDF are discussed in Section 5.3, which deals with waste management issues.

Under FFTF Decommissioning Alternative 1, only those actions consistent with previous DOE National Environmental Policy Act actions would be completed. Final decommissioning of FFTF would not occur. For analysis purposes, the remaining waste would be available for release to the environment after an institutional control period of 100 years.

The potential human health impacts of this alternative are summarized in Tables 5–68 and 5–69 and are detailed in Appendix Q. The key constituent contributors to human health risk would be tritium and technetium-99 for radionuclides. The chemical risk and hazard drivers were essentially negligible. Neither the dose standards nor the Hazard Index guideline would be exceeded at any location. The population dose was estimated as 9.80×10^{-3} person-rem per year for the year of peak dose. This corresponds to 5.27×10^{-7} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the FFTF Barrier is presented in Figure 5–343.

Table 5–68. FFTF Decommissioning Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Fast Flux Test Facility	7.29×10^{-1}	3.19×10^{-6}	2.51×10^{-5}	0.00	2.51×10^{-5}	1.87	3.22×10^{-6}	8.23×10^{-5}	3.48×10^{-16}	8.23×10^{-5}
Columbia River nearshore	2.16×10^{-2}	1.01×10^{-7}	7.42×10^{-7}	0.00	7.42×10^{-7}	5.54×10^{-2}	1.02×10^{-7}	2.43×10^{-6}	1.02×10^{-17}	2.43×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.96×10^{-6}	8.56×10^{-13}	8.60×10^{-11}	3.49×10^{-22}	8.60×10^{-11}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–69. FFTF Decommissioning Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Fast Flux Test Facility	3.82	3.33×10^{-6}	1.79×10^{-4}	1.60×10^{-11}	1.79×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.13×10^{-1}	1.06×10^{-7}	5.31×10^{-6}	4.67×10^{-13}	5.31×10^{-6}	1.36×10^{-4}	5.74×10^{-9}	7.43×10^{-9}	2.34×10^{-13}	7.43×10^{-9}
Off Site										
Columbia River	4.53×10^{-6}	1.37×10^{-12}	2.14×10^{-10}	1.60×10^{-17}	2.14×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

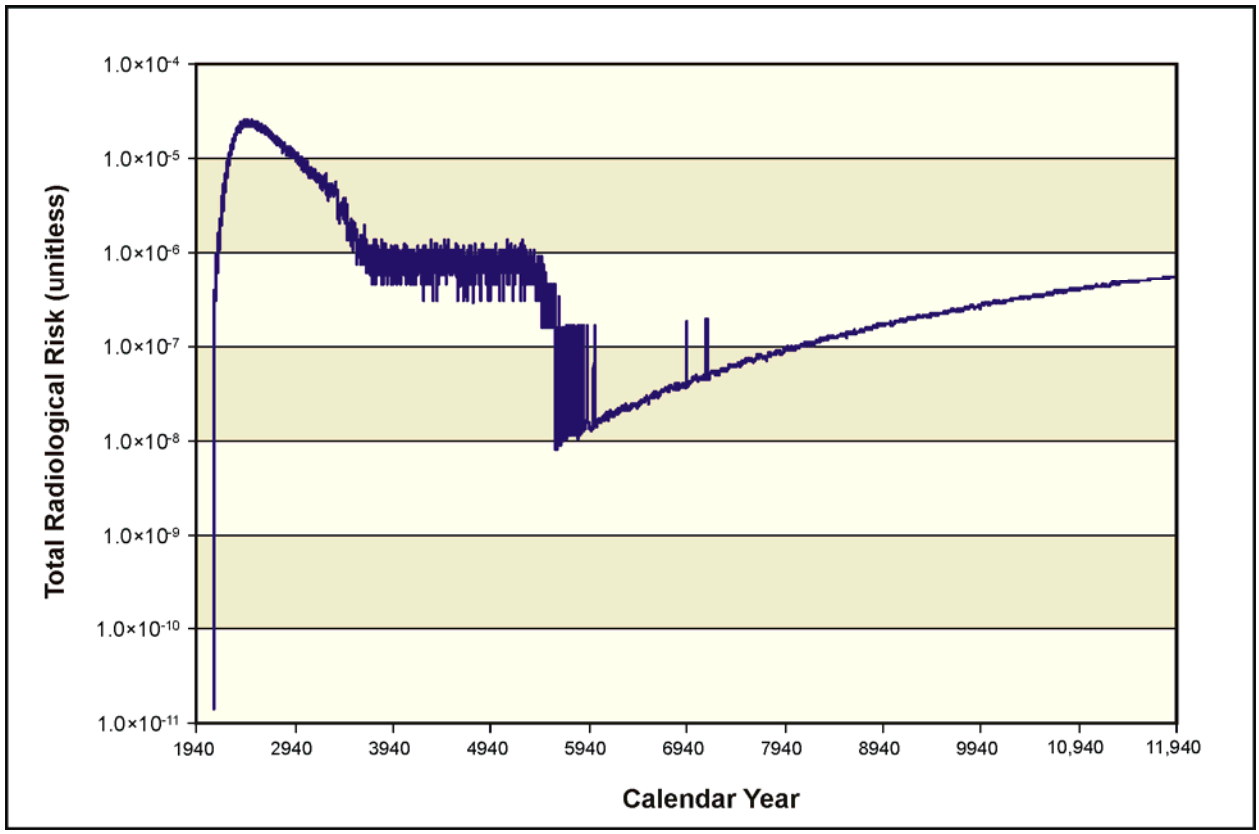


Figure 5–343. FFTF Decommissioning Alternative 1 Total Radiological Risk for Fast Flux Test Facility Barrier Drinking-Water Well User Versus Time

5.2.2.2 FFTF Decommissioning Alternative 2: Entombment

Under FFTF Decommissioning Alternative 2, Entombment, all aboveground structures and minimal below-grade structures, equipment, and materials would be removed. An RCRA-compliant barrier would be constructed over the Reactor Containment Building and any other remaining below-grade structures, including the reactor vessel. Impacts from sources removed from the FFTF Barrier and disposed of in an IDF are discussed in Section 5.3, which discusses waste management issues.

The potential human health impacts of this alternative are summarized in Tables 5–70 and 5–71 and are detailed in Appendix Q. The key constituent contributor to human health risk would be technetium-99 for radionuclides. The chemical risk and hazard drivers would be essentially negligible. Neither dose standards nor the Hazard Index guideline would be exceeded at any location. The population dose was estimated as 8.90×10^{-3} person-rem per year for the year of peak dose. This corresponds to 4.87×10^{-7} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the FFTF Barrier is presented in Figure 5–344.

Table 5–70. FFTF Decommissioning Alternative 2 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Fast Flux Test Facility	7.13×10^{-1}	0.00	2.45×10^{-5}	0.00	2.45×10^{-5}	1.83	0.00	8.04×10^{-5}	0.00	8.04×10^{-5}
Columbia River nearshore	2.16×10^{-2}	0.00	7.42×10^{-7}	0.00	7.42×10^{-7}	5.55×10^{-2}	0.00	2.44×10^{-6}	0.00	2.44×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.78×10^{-6}	0.00	7.81×10^{-11}	0.00	7.81×10^{-11}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–71. FFTF Decommissioning Alternative 2 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad. Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Fast Flux Test Facility	3.73	0.00	1.75×10^{-4}	0.00	1.75×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.13×10^{-1}	0.00	5.31×10^{-6}	0.00	5.31×10^{-6}	1.36×10^{-4}	0.00	7.46×10^{-9}	0.00	7.46×10^{-9}
Off Site										
Columbia River	4.11×10^{-6}	0.00	1.95×10^{-10}	0.00	1.95×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

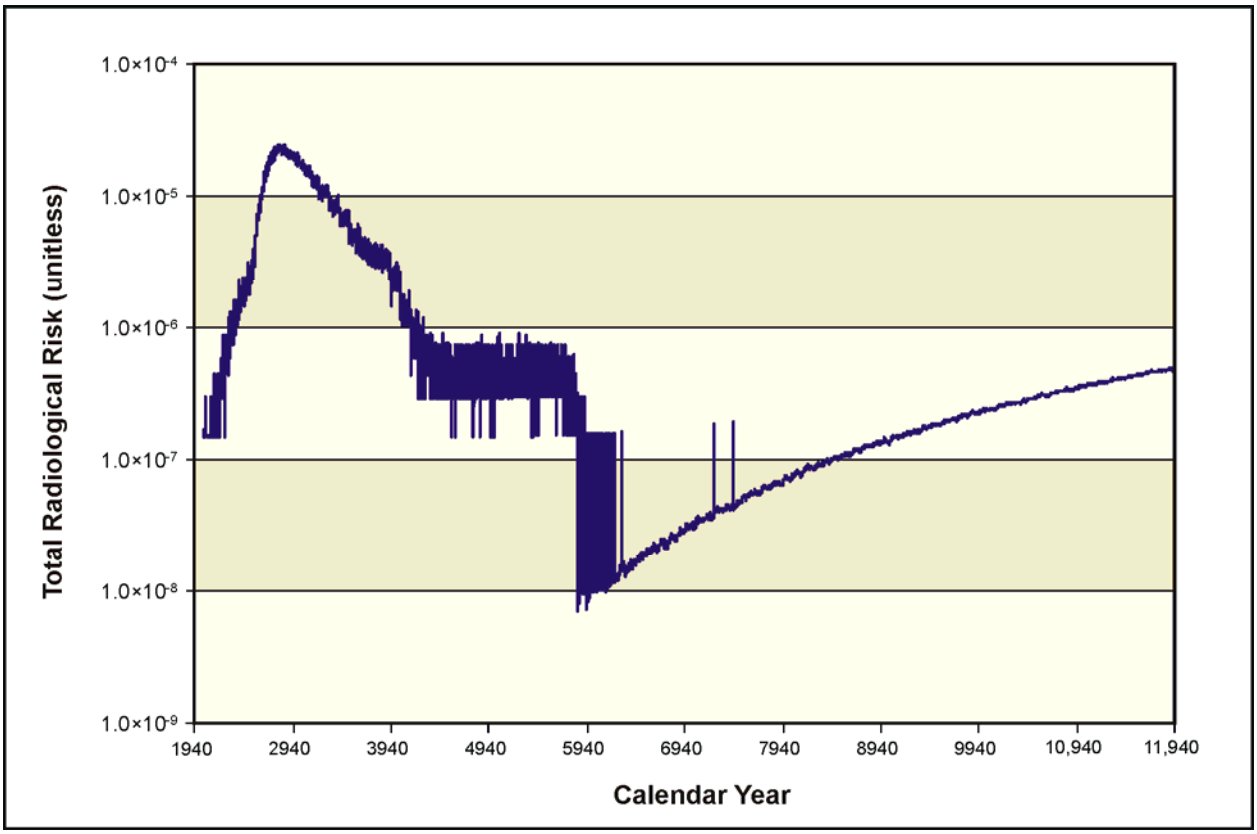


Figure 5–344. FFTF Decommissioning Alternative 2 Total Radiological Risk for Fast Flux Test Facility Barrier Drinking-Water Well User Versus Time

5.2.2.3 FFTF Decommissioning Alternative 3: Removal

Under FFTF Decommissioning Alternative 3, all aboveground structures, as well as contaminated below-grade structures, equipment, and materials would be removed. As a result of the removal of all contaminated material, there would be no impacts on groundwater, surface water, or human health.

5.2.3 Ecological Risk

This section presents the results of the evaluation of long-term impacts on ecological resources of releases to air and groundwater under the FFTF Decommissioning alternatives. Risk indices—Hazard Quotient or Hazard Index—were calculated by comparing predicted dose to benchmark dose (see Appendix P). Risk indices could not be calculated for lizards, toads, or birds for COPCs (organic compounds only) released under the FFTF Decommissioning alternatives because there are no toxicity reference values for such receptors for these COPCs. Risk indices for air emissions were calculated for the three FFTF Decommissioning alternatives and the Hanford and Idaho Options and Reuse Options for FFTF Decommissioning Alternatives 2 and 3. Separate risk indices for air releases were not calculated for the three components of each alternative: disposition of facilities, RH-SCs, and bulk sodium. Calculated risk indices for the COPC with the highest Hazard Quotient or Hazard Index are presented for each receptor.

Releases to air are expected for Environmental Assessment-associated activities under the No Action Alternative (FFTF Decommissioning Alternative 1) and facility disposition under FFTF Decommissioning Alternatives 2 and 3. Releases to air associated with the disposition of RH-SCs and bulk sodium are expected under all FFTF Decommissioning alternatives at Hanford under the Hanford Option and Hanford Reuse Option and, under FFTF Decommissioning Alternatives 2 and 3, at both Hanford and INL under the Idaho Option and Idaho Reuse Option. The impacts on ecological resources

of releases to air were evaluated together for the disposition of RH-SCs and bulk sodium. The estimated impacts are identical under FFTF Decommissioning Alternatives 2 and 3 because the options for RH-SC disposition and bulk sodium disposition are identical under the two alternatives. There would be impacts of releases to groundwater associated with the FFTF Decommissioning Alternatives—No Action, Entombment, and Removal.

The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources of releases to groundwater were evaluated at the Columbia River.

5.2.3.1 FFTF Decommissioning Alternative 1: No Action

The FFTF Decommissioning No Action Alternative is not expected to result in releases of radionuclides to air. Releases of chemicals to air are expected due to activities associated with the Environmental Assessment (see Section 5.2 and Chapter 2, Section 2.3). The calculated risks to plants, the Great Basin pocket mouse, and the coyote from air releases under FFTF Decommissioning Alternative 1 are the highest of all Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Predicted emissions of COPCs in air under FFTF Decommissioning Alternative 1 pose a small risk to plants (Hazard Quotient is 47) and a moderate risk to mammals at the onsite maximum-exposure location (see Table 5–72). The chemical COPCs released to air with the largest calculated Hazard Quotients for the Great Basin pocket mouse are xylene (2120), toluene (338), formaldehyde (79), and benzene (17) at the onsite maximum-exposure location. The coyote has the next-largest calculated chemical COPC with the Hazard Quotient for xylene (269).

Table 5–72. FFTF Decommissioning Alternatives – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

FFTF Decommissioning Alternative	Hazard Quotient of Worst-Case Chemical COPC by Receptor			
	Plants	**Great Basin Pocket Mouse**	**Coyote**	**Mule Deer**
	Toluene	**Xylene**	**Xylene**	**Formaldehyde**
1	4.68×10^{1}	**2.12×10^{3}**	2.69×10^{2}	4.79×10^{1}
2	1.63×10^{-1}	**7.60**	9.65×10^{-1}	6.09×10^{-1}
3	1.64×10^{-1}	**7.65**	9.71×10^{-1}	5.79×10^{-1}

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text. Results are not available for other terrestrial receptors: side-blotched lizard, mourning dove, western meadowlark, and burrowing owl.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under FFTF Decommissioning Alternative 1 at the offsite maximum-exposure location (Columbia River). The only estimated Hazard Quotient exceeding 1 is xylene for the mouse (2.4). This value is well within the margin of error of the uncertainties in the estimated exposure and toxicity.

Predicted emissions of chemical and radiological COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (Hazard Index is 0.00001) for groundwater releases under FFTF Decommissioning Alternative 1 (see Table 5–73) is that calculated for total internal and external exposure to all radiological COPCs for birds eating benthic invertebrates (the spotted sandpiper) at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 1.

Table 5–73. FFTF Decommissioning Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Resources at the Columbia River

FFTF Decommissioning Alternative	Hazard Quotient or Hazard Index of Worst-Case Chemical or Radiological COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	All Rad. COPCs	All Rad. COPCs	All Rad. COPCs	All Rad. COPCs	All Rad. COPCs	All Rad. COPCs	All Rad. COPCs
1	1.05×10^{-6}	9.76×10^{-6}	1.07×10^{-5}	1.01×10^{-5}	5.60×10^{-6}	1.98×10^{-6}	9.42×10^{-7}
2	7.43×10^{-7}	6.69×10^{-6}	7.65×10^{-6}	7.06×10^{-6}	5.10×10^{-6}	1.80×10^{-6}	8.56×10^{-7}
3	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility; N/A=not applicable; Rad.=radiological.

5.2.3.2 FFTF Decommissioning Alternative 2: Entombment

Under FFTF Decommissioning Alternative 2, long-term impacts on ecological resources were evaluated for releases to air and groundwater at Hanford (Hanford and Hanford Reuse Options) and releases to air at Idaho (Idaho and Idaho Reuse Options) associated with the disposition of FFTF and associated facilities, RH-SCs, and bulk sodium.

Predicted emissions of COPCs in the air at Hanford under FFTF Decommissioning Alternative 2 (Hanford and Idaho Options) do not pose a risk to ecological receptors. The chemical COPC with the largest calculated Hazard Quotient for air releases is xylene for the mouse (7.6) at the onsite maximum-exposure location under the Hanford Option (see Table 5–72). This is within the margin of error of the uncertainties in the estimated exposure and toxicity of COPCs. Hazard Quotients calculated for chemical COPCs released to air under FFTF Decommissioning Alternative 2, Idaho Option, are about half as large as those under the Hanford Option. The largest Hazard Index (6.6×10^{-6}) for radiological COPCs released to air under FFTF Decommissioning Alternative 2, Hanford Option (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location, with tritium as the primary contributor. This Hazard Index, much smaller than 1, indicates no risk from radiological COPCs released to air at Hanford under FFTF Decommissioning Alternative 2, either Hanford or Idaho Option. Also, there would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under FFTF Decommissioning Alternative 2 at the offsite maximum-exposure location (Columbia River) under both Hanford and Idaho Options.

Although risk indices were not calculated for ecological receptors at INL, the relative magnitude of emissions there suggests little to no risk. For the disposition of RH-SCs and bulk sodium under FFTF Decommissioning Alternative 2, Idaho and Idaho Reuse Options, the predicted peak annual emissions of tritium (5.72 curies per year) and cesium-137 (3.3×10^{-4} curies per year) at INL are orders of magnitude smaller than the maximum emissions at Hanford under any *TC & WM EIS* alternative (1.22×10^{3} curies per year for tritium, 2.5×10^{2} curies per year for cesium-137). The emissions of COPCs at INL would be smaller than emissions at Hanford under at least one of the Tank Closure, FFTF Decommissioning, or Waste Management alternatives (see Table 5–74). There would be no releases of mercury at INL. Because predicted emissions of COPCs do not pose a risk to ecological receptors at Hanford, the smaller rates at INL are unlikely to pose a risk to similar ecological receptors with similar exposure pathways.

Predicted emissions of chemical and radiological COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (Hazard Index is 0.000008) for groundwater releases under FFTF Decommissioning Alternative 2 (Table 5–73) is that calculated for total internal and external exposure to all radiological COPCs for birds eating benthic invertebrates (the spotted sandpiper) at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 2.

5.2.3.3 FFTF Decommissioning Alternative 3: Removal

Under FFTF Decommissioning Alternative 3, long-term impacts on ecological resources were evaluated for releases to air and groundwater at Hanford (Hanford Option) and releases to air at Idaho (Idaho Option).

Predicted emissions of COPCs in air at Hanford under FFTF Decommissioning Alternative 3 (Hanford and Idaho Options) are similar to those under FFTF Decommissioning Alternative 2 and do not pose a risk to ecological receptors. The chemical COPC with the largest calculated Hazard Quotient (xylene, 7.65) is for the mouse at the onsite maximum-exposure location (see Table 5–72). Hazard Quotients calculated for chemical COPCs released to air under FFTF Decommissioning Alternative 3, Idaho Option, are about half as large as those under the Hanford Option. The largest Hazard Index (6.6×10^{-6}) for radiological COPCs released to air under FFTF Decommissioning Alternative 3, Hanford Option

(see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location, primarily from tritium. This indicates no risk from radiological COPCs released to air at Hanford under FFTF Decommissioning Alternative 3, either Hanford or Idaho Option. There also would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air under FFTF Decommissioning Alternative 3 at the offsite maximum-exposure location (Columbia River).

Although risk indices were not calculated for ecological receptors at INL, the relative magnitude of emissions there suggests little to no risk. For the disposition of RH-SCs and bulk sodium under FFTF Decommissioning Alternative 3, Idaho and Idaho Reuse Options, the predicted peak annual emissions of tritium (5.72 curies per year) and cesium-137 (3.30×10^{-4} curies per year) at INL are orders of magnitude smaller than the maximum emissions at Hanford under any *TC & WM EIS* alternative (1.22×10^{3} curies per year for tritium, 2.50×10^{2} curies per year for cesium-137). The emissions of COPCs at INL would be smaller than emissions at Hanford under at least one of the Tank Closure, FFTF Decommissioning, or Waste Management alternatives (see Table 5–74). There would be no releases of mercury at INL. Because predicted emissions of COPCs under FFTF Decommissioning Alternative 3 do not pose a risk to ecological receptors at Hanford, the smaller rates at INL are unlikely to pose a risk to similar ecological receptors with similar exposure pathways.

Table 5–74. Comparison of Peak Annual Emission Rates at INL Under FFTF Decommissioning Alternatives 2 and 3 and at the Hanford Site Under Tank Closure Alternatives

Constituent of Potential Concern	INL	Hanford	Alternative
Radionuclide (curies per year)			
Hydrogen-3 (tritium)	5.72	1.22×10^{3}	Tank Closure 2A
Carbon-14	0	N/A	N/A
Cobalt-60	0	N/A	N/A
Strontium-90	0	N/A	N/A
Technetium-99	0	N/A	N/A
Iodine-129	0	N/A	N/A
Cesium-137	3.30×10^{-4}	2.50×10^{2}	Tank Closure 6B
Uranium (all isotopes)	0	N/A	N/A
Plutonium-238	0	N/A	N/A
Plutonium-239, -240	0	N/A	N/A
Plutonium-241	0	N/A	N/A
Americium-241	0	N/A	N/A
Chemical (grams per year)			
Nitrogen dioxide	0	N/A	N/A
Sulfur dioxide	2.26×10^{3}	5.60×10^{7}	Tank Closure 2B
Ammonia	0	N/A	N/A
Benzene	0	N/A	N/A
Toluene	1.71×10^{4}	5.50×10^{6}	Tank Closure 5
Xylene	4.87×10^{3}	1.60×10^{6}	Tank Closure 5
1,3-Butadiene	1.55×10^{1}	2.58×10^{4}	Waste Management 3 (Disposal Group 2)
Mercury	0	N/A	N/A
Formaldehyde	0	N/A	N/A

Note: To convert grams to ounces, multiply by 0.03527.
Key: FFTF=Fast Flux Test Facility; INL=Idaho National Laboratory; N/A=not applicable because constituent not released at INL.

Under FFTF Decommissioning Alternative 3, all aboveground structures, as well as contaminated below grade structures, equipment, and materials would be removed. As a result of the removal of all contaminated material, there would be no impacts on ecological receptors resulting from releases to groundwater.

5.2.4 Environmental Justice

Sections 5.2.1 and 5.2.2 evaluate groundwater impacts and associated potential long-term human health effects under the FFTF Decommissioning alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differing from that of the American Indian resident farmer. The American Indian hunter gatherer does not cultivate crops but gathers food from indigenous plants, harvests fish from the Columbia River, and is exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Appendix Q, Section Q.2.1. Long-term human health impacts of FFTF decommissioning actions would be greatest under FFTF Decommissioning Alternative 1. Under this alternative, none of the hypothetical receptors at any of the assessment boundaries would be exposed to radiological doses in excess of regulatory limits or to chemicals with a Hazard Index greater than 1. The greatest risk would be to the American Indian resident farmer at the FFTF boundary. During the year of peak dose, this receptor would receive a radiological dose of 3.8 millirem, compared to the regulatory limit of 100 millirem from all sources. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index less than 1. Therefore, none of the FFTF Decommissioning alternatives would pose a disproportionately high and adverse long-term human health risk to the American Indian population at offsite locations.

5.3 WASTE MANAGEMENT ALTERNATIVES

This section describes the potential long-term environmental impacts associated with the implementation of alternatives for administering ongoing solid waste management operations and proposed disposal of low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) from Hanford and a limited volume of offsite LLW and MLLW in an IDF located at Hanford. Specifically, this includes the management and disposal of LLW and MLLW from tank closure activities as described in Chapter 4, Section 4.1.14, as well as other non–Comprehensive Environmental Response, Compensation, and Liability Act (non-CERCLA) LLW and MLLW from Hanford, including the waste from FFTF decommissioning described in Chapter 4, Section 4.2.14, and waste from other DOE sites (i.e., offsite waste). This section analyzes the impacts of expanding Hanford's waste disposal capacity to provide space for on- and offsite waste; this section also includes an analysis of associated storage, disposal, and closure activities, as well as facility-specific construction, operations, deactivation, and closure activities.

Three Waste Management alternatives are considered and analyzed, including (1) Waste Management Alternative 1: No Action; (2) Waste Management Alternative 2: Disposal in IDF, 200-East Area Only; and (3) Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas.

Waste Management Alternative 1 would include storing and disposing of LLW and MLLW in trenches 31 and 34 of existing low-level radioactive waste burial ground (LLBG) 218-W-5 and storing and disposing of transuranic (TRU) waste in the Waste Isolation Project Plant (WIPP) near Carlsbad, New Mexico. No offsite waste would be received; construction/use of the IDF located in the 200-East Area (IDF-East) would be discontinued; and IDF-East would be deactivated.

Waste Management Alternative 2 would include storing LLW, MLLW, and TRU waste in the Central Waste Complex (CWC) prior to disposal and processing waste prior to disposal at new facilities or existing-facility expansions at the CWC, Waste Receiving and Processing Facility, and the T Plant. A total volume of 62,000 cubic meters (2.2 million cubic feet) of LLW and 20,000 cubic meters (706,300 cubic feet) of MLLW from other DOE sites would be received for disposal under this alternative. Waste from tank closure and treatment operations, onsite non-CERCLA sources, FFTF decommissioning, and waste management, as well as offsite waste from other DOE sites would be disposed of in IDF-East. A new RPPDF would be constructed for disposal of lightly contaminated equipment and soils as a result of tank farm clean closure activities.

Waste Management Alternative 3 would involve the same waste storage and processing provisions as Waste Management Alternative 2 and the same volume of offsite waste accepted for disposal; a new RPPDF would also be constructed. However, an additional IDF would be constructed in the 200-West Area (IDF-West). Waste from tank closure and treatment operations would be disposed of in IDF-East, while onsite non-CERCLA waste, FFTF decommissioning waste, waste management, and offsite waste from other DOE sites would be disposed of in IDF-West.

In addition, under each Waste Management action alternative (i.e., Alternatives 2 and 3), three disposal groupings are analyzed: Disposal Groups 1, 2, and 3. These disposal groupings encompass the sizing requirements and associated construction, operations, and closure requirements for the IDF(s) and RPPDF necessary to accommodate the varying waste volumes considered under each disposal configuration. These alternatives and options are described further in Chapter 2, Section 2.5, of this EIS.

These disposal groupings are further divided into subgroupings for the consideration of the different types and volumes of waste generated from the 10 Tank Closure action alternatives and the 2 FFTF Decommissioning action alternatives to analyze the long-term impacts associated with disposal of the various waste types and volumes. These subgroupings are described in Table 5–75.

Table 5–75. Waste Management Action Alternative Subgroupings

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
1	N/A	LLBG, trenches 31 and 34	N/A	Non-CERCLA waste
2	Disposal Group 1, Subgroup 1-A	IDF-East	Tank Closure Alternative 2B • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 2B • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-B	IDF-East	Tank Closure Alternative 3A • ILAW glass • Bulk vitrification glass • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3A • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-C	IDF-East	Tank Closure Alternative 3B • ILAW glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3B • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-D	IDF-East	Tank Closure Alternative 3C • ILAW glass • Steam reforming waste • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3C • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-E	IDF-East	Tank Closure Alternative 4 • ILAW glass • Bulk vitrification glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 4 • Closure waste (LLW and MLLW)	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
2	Disposal Group 1, Subgroup 1-F	IDF-East	Tank Closure Alternative 5 • ILAW glass • Bulk vitrification glass • Cast stone waste • Sulfate grout • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A
2	Disposal Group 1, Subgroup 1-G	IDF-East	Tank Closure Alternative 6C • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6C • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 2, Subgroup 2-A	IDF-East	Tank Closure Alternative 2A • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A
2	Disposal Group 2, Subgroup 2-B	IDF-East	Tank Closure Alternative 6B, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6B, Base and Option Cases • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 3	IDF-East	Tank Closure Alternative 6A, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6A, Base and Option Cases • Closure waste (LLW and MLLW)	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
3	Disposal Group 1, Subgroup 1-A	IDF-East	Tank Closure Alternative 2B • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 2B • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-B	IDF-East	Tank Closure Alternative 3A • ILAW glass • Bulk vitrification glass • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3A • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-C	IDF-East	Tank Closure Alternative 3B • ILAW glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3B • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-D	IDF-East	Tank Closure Alternative 3C • ILAW glass • Steam reforming waste • LAW melters • Secondary Waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3C • Closure waste (LLW and MLLW)	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
3	Disposal Group 1, Subgroup 1-E	IDF-East	Tank Closure Alternative 4 • ILAW glass • Bulk vitrification glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 4 • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-F	IDF-East	Tank Closure Alternative 5 • ILAW glass • Bulk vitrification glass • Cast stone waste • Sulfate grout • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A
3	Disposal Group 1, Subgroup 1-G	IDF-East	Tank Closure Alternative 6C • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6C • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 2, Subgroup 2-A	IDF-East	Tank Closure Alternative 2A • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
3	Disposal Group 2, Subgroup 2-B	IDF-East	Tank Closure Alternative 6B, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6B, Base and Option Cases • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 3	IDF-East	Tank Closure Alternative 6A, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6A, Base and Option Cases • Closure waste (LLW and MLLW)	N/A

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; DOE= U.S. Department of Energy; FFTF=Fast Flux Test Facility; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLBG=low-level radioactive waste burial ground; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility.

5.3.1 Groundwater

5.3.1.1 Waste Management Alternative 1: No Action

This section describes the groundwater analysis results for Waste Management Alternative 1, including long-term groundwater impacts of contaminant sources within the Trenches 31 and 34 Barrier. Impacts of sources remaining within the tank farm barriers are presented in Section 5.1, which discusses tank closure impacts. Impacts of sources remaining within the FFTF Barrier are presented in Section 5.2, which discusses FFTF decommissioning impacts.

5.3.1.1.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Waste Management Alternative 1 are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 1, as follows:

- The disposal period was assumed to start with the onset of disposal operations in LLBG 218-W-5, trenches 31 and 34, in CY 2008 and continue through CY 2035, when the trenches would be operationally closed. During this time, these trenches have accepted, and would continue to

accept, onsite non-CERCLA LLW and MLLW. During the disposal period, the materials in this permitted, operational facility would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2036 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the trenches become available for release to the environment. Waste Management Alternative 1 does not include construction of barriers over trenches 31 and 34. However, the surrounding LLBG 218-W-5, which is included in the cumulative impact analysis, would have a barrier emplaced consistent with the cumulative impact analysis end-state methodology (see Appendix S). For the purpose of analyzing long-term groundwater impacts under Waste Management Alternative 1, trenches 31 and 34 are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

5.3.1.1.2 COPC Drivers

A total of 40 COPCs were analyzed for Waste Management Alternative 1. Complete results for all 40 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 1 is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 1 were selected by evaluating the risk or hazard associated with all 40 COPCs in the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 1.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

5.3.1.1.3 Analysis of Release and Mass Balance

This section presents the impacts of Waste Management Alternative 1 in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–345 through 5–350). Two subtotals are plotted representing releases from trenches 31 and 34. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over three orders of magnitude.

Figure 5–345 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–346, the chemical hazard drivers. For both sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Trenches 31 and 34 are equal sources for all COPCs.

Figure 5–347 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–348, the chemical hazard drivers. In addition to the inventory considerations discussed in the

previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All COPCs act as conservative tracers, and essentially all of the release to the vadose zone reached groundwater in the analysis.

Figure 5–349 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–350, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In all cases, nearly 100 percent of the amount released to groundwater reached the Columbia River in the analysis.

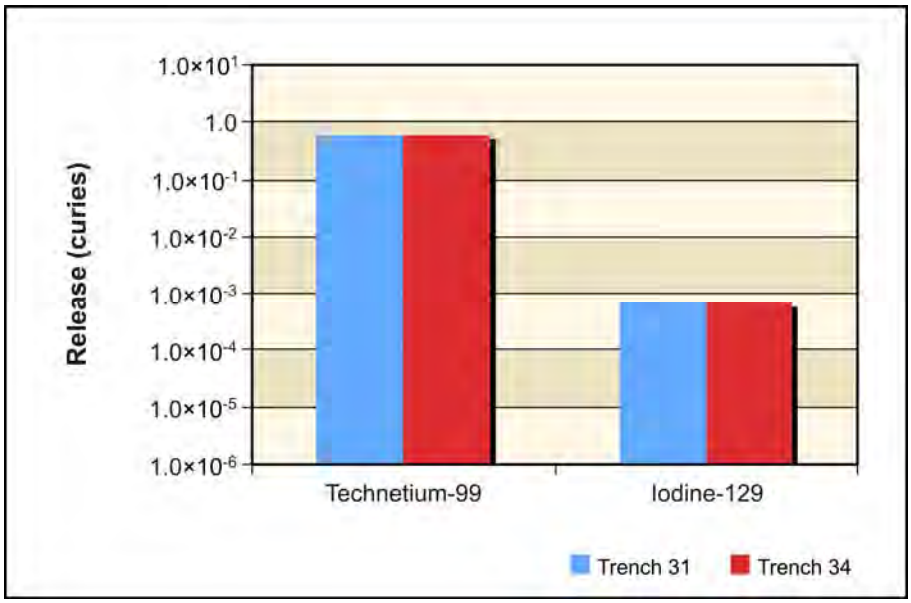


Figure 5–345. Waste Management Alternative 1, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

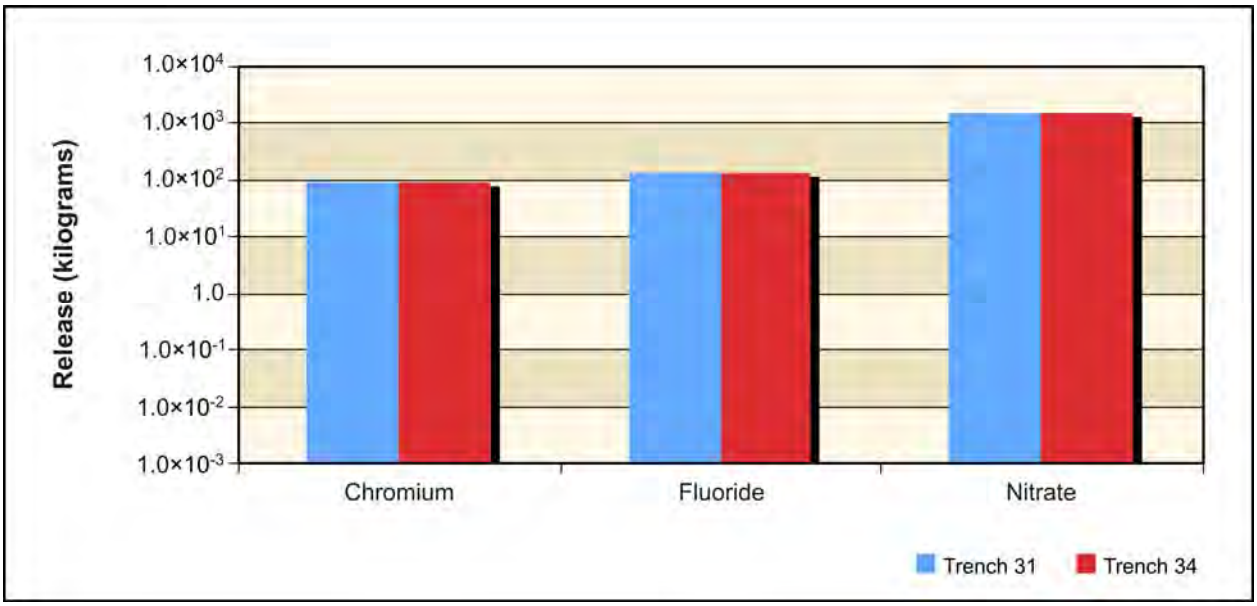


Figure 5–346. Waste Management Alternative 1, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

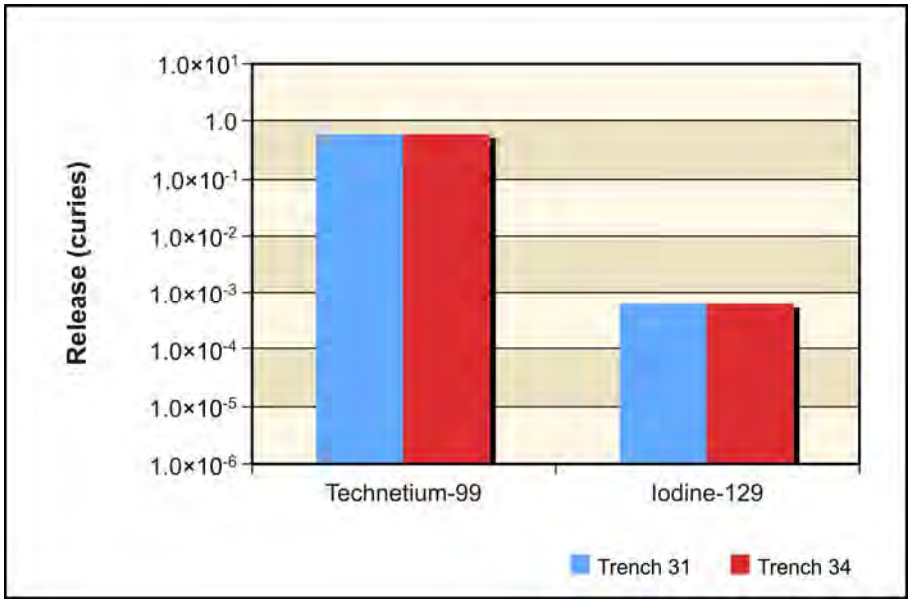


Figure 5–347. Waste Management Alternative 1, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

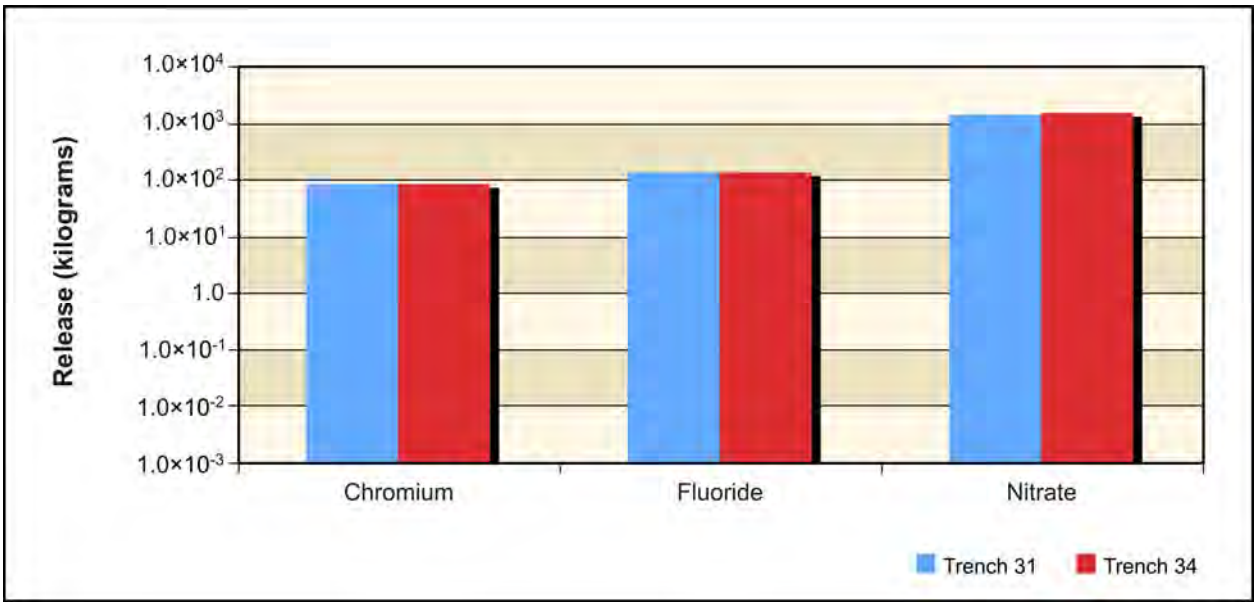


Figure 5–348. Waste Management Alternative 1, Chemical Releases at 200-East Area Integrated Disposal Facility Groundwater

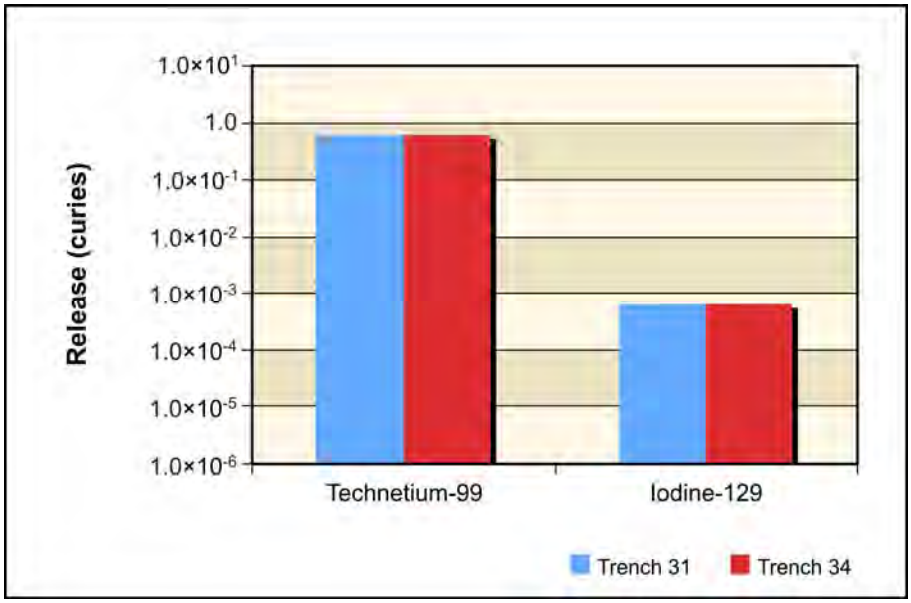


Figure 5–349. Waste Management Alternative 1, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

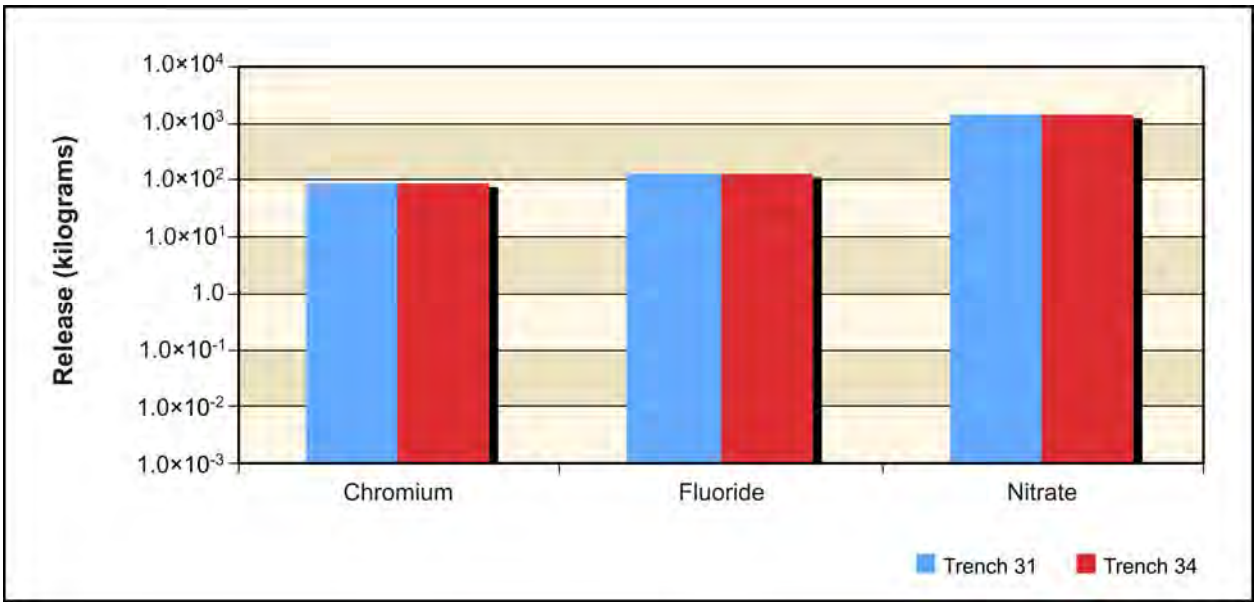


Figure 5–350. Waste Management Alternative 1, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

5.3.1.1.4 Analysis of Concentration Versus Time

This section presents the analysis of Waste Management Alternative 1 impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–351 through 5–356). The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude. Table 5–76 lists the maximum concentrations of the COPCs in the peak year at trenches 31 and 34 and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–351 through 5–354 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, concentrations at the Core Zone Boundary rise early in the simulation, reaching a peak of about two orders of magnitude below the benchmark between CYs 2940 and 3940. After the peak, concentrations decline for the remainder of the simulation. Iodine-129, chromium, and nitrate all follow similar patterns, although the peak concentration for nitrate at the Core Zone Boundary is over three orders of magnitude below the benchmark.

Figures 5–355 and 5–356 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of uranium, no contamination appears until CY 8940, when uranium-238 concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 remains over four orders of magnitude below the benchmark throughout the simulation. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation.

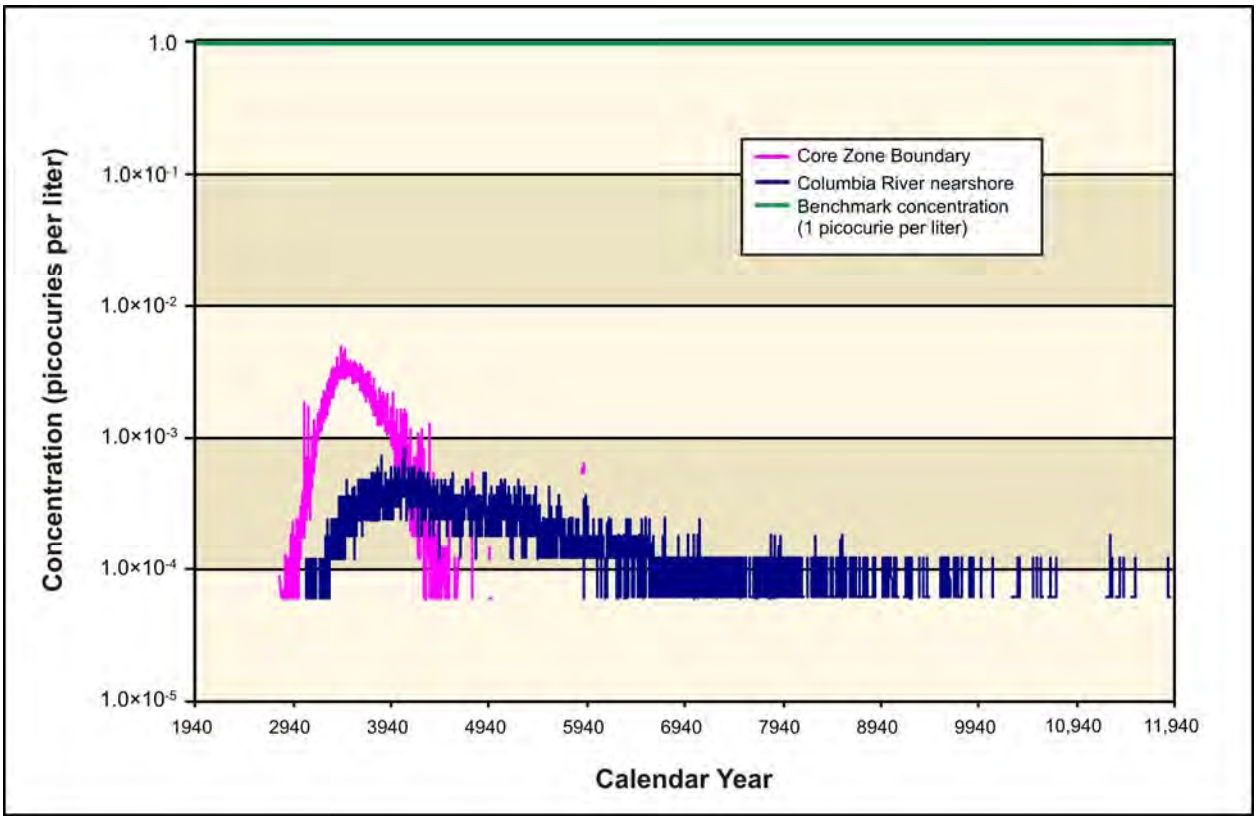


Figure 5–351. Waste Management Alternative 1, Iodine-129 Concentration Versus Time

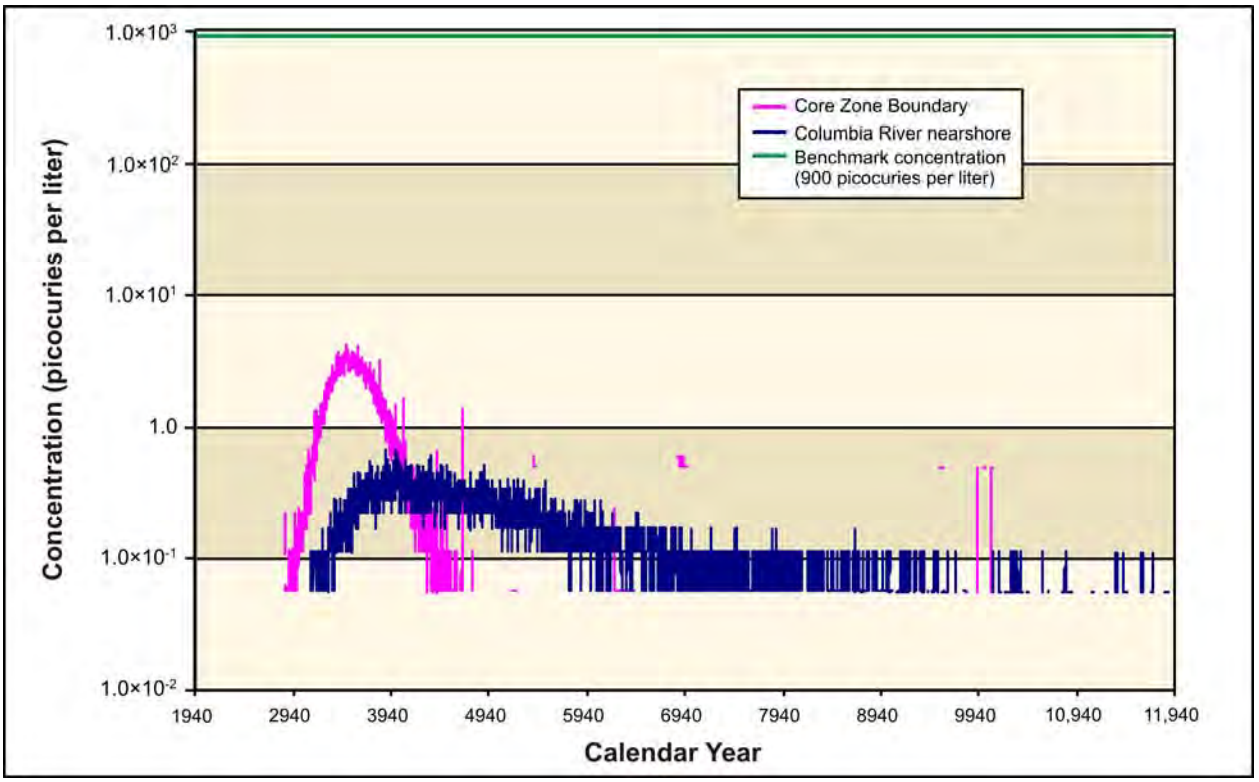


Figure 5–352. Waste Management Alternative 1, Technetium-99 Concentration Versus Time

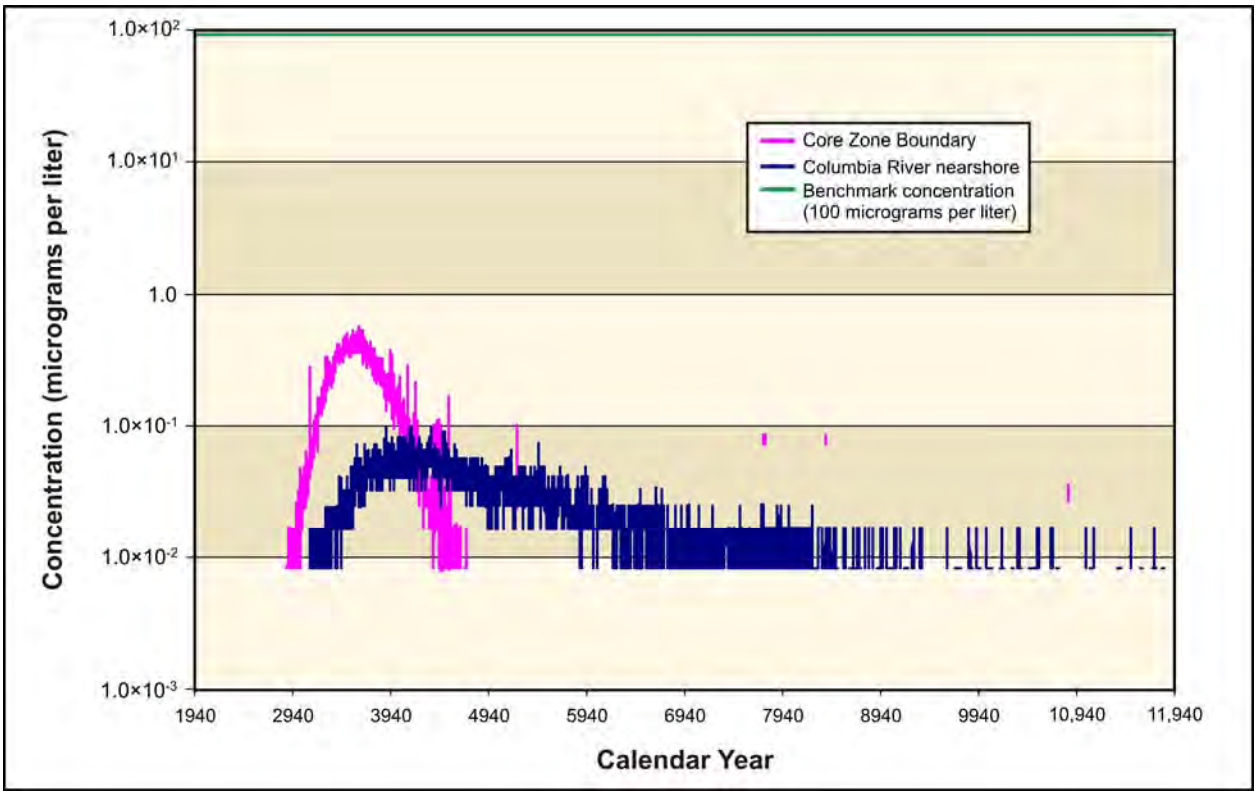


Figure 5–353. Waste Management Alternative 1, Chromium Concentration Versus Time

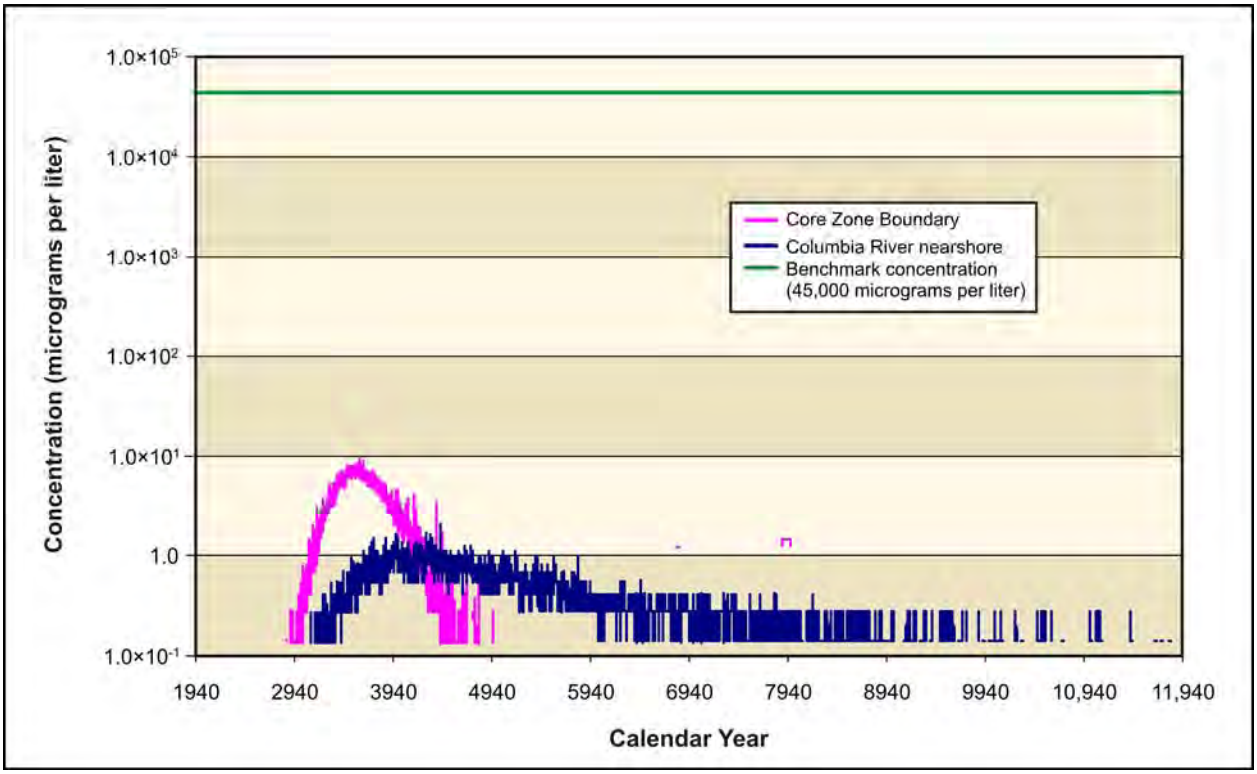


Figure 5–354. Waste Management Alternative 1, Nitrate Concentration Versus Time

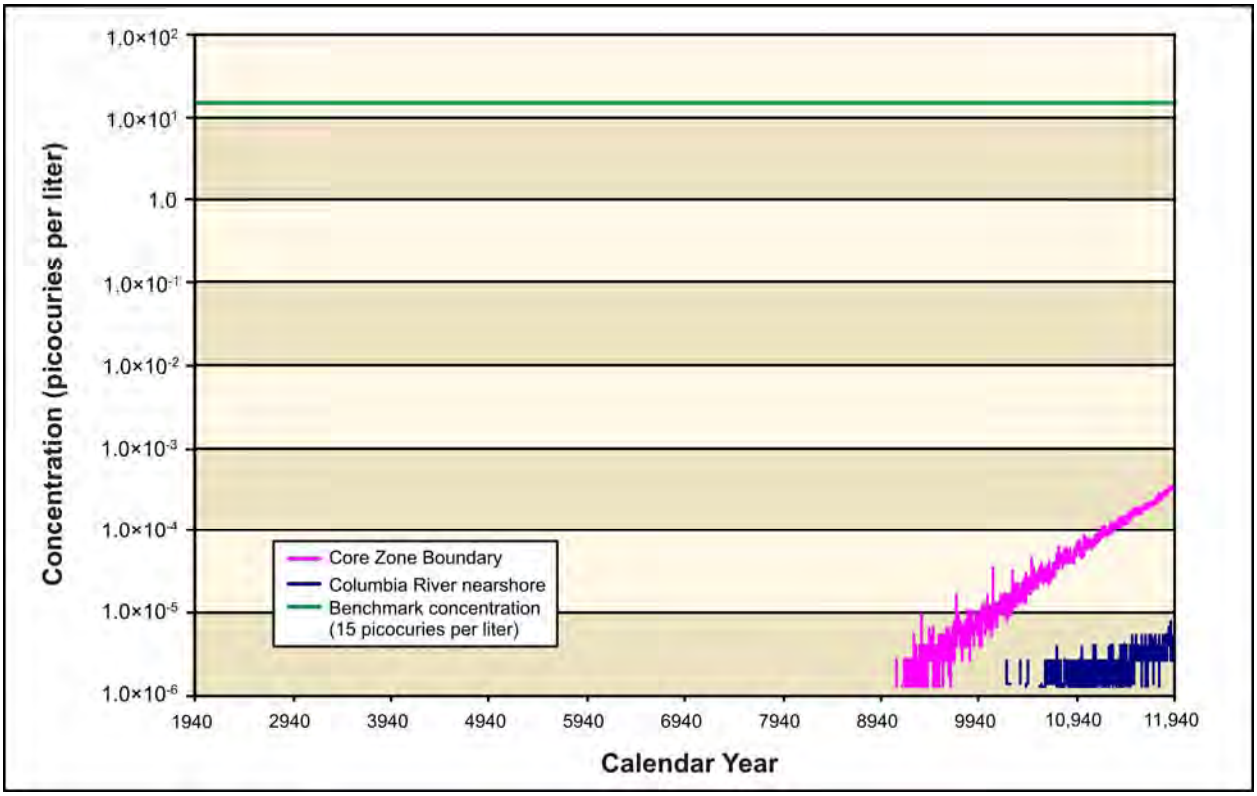


Figure 5–355. Waste Management Alternative 1, Uranium-238 Concentration Versus Time

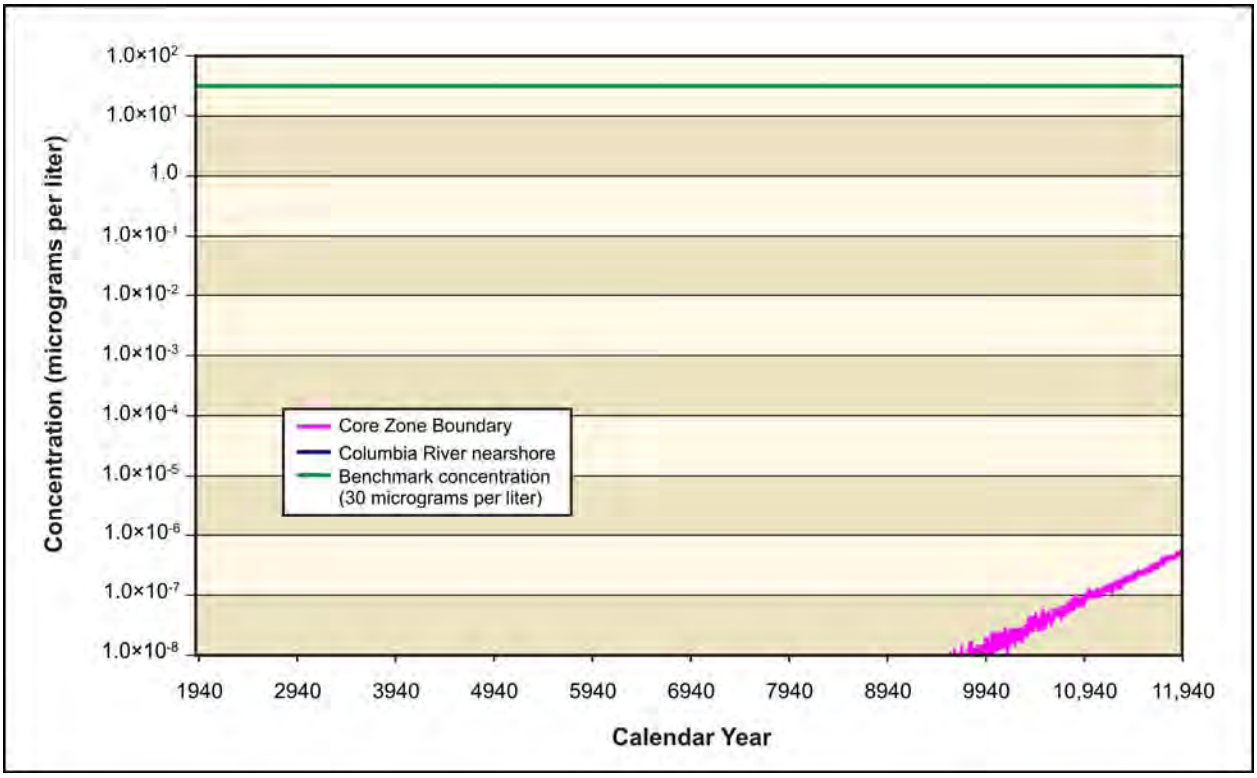


Figure 5–356. Waste Management Alternative 1, Total Uranium Concentration Versus Time

Table 5–76. Waste Management Alternative 1 Maximum COPC Concentrations in the Peak Year at Trenches 31 and 34, and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	Trenches 31 and 34	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	22 (3499)	N/A	4 (3474)	1 (3974)	900
Chemical in micrograms per liter					
Chromium	3 (3526)	N/A	1 (3615)	0 (4353)	100
Fluoride	4 (3545)	N/A	1 (3661)	0 (4592)	4,000
Nitrate	47 (3534)	N/A	9 (3600)	2 (4417)	45,000

Note: Corresponding calendar year shown in parentheses.
Key: COPC=constituent of potential concern; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

5.3.1.1.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Waste Management Alternative 1 in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Figures 5–357 through 5–366). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing

concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890 (see Figure 5–357), there is a very low-concentration plume of iodine-129 stretching northeast of trenches 31 and 34 and through Gable Gap. By CY 7140 (Figure 5–358), the plume has almost completely dissipated. Technetium-99 (see Figures 5–359 and 5–360), nitrate (see Figures 5–361 and 5–362), and chromium (see Figures 5–363 and 5–364) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium and uranium-238 show a different spatial distribution over time. They are not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, there are total uranium and uranium-238 plumes (see Figures 5–365 and 5–366, respectively) extending through Gable Gap from trenches 31 and 34. Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.

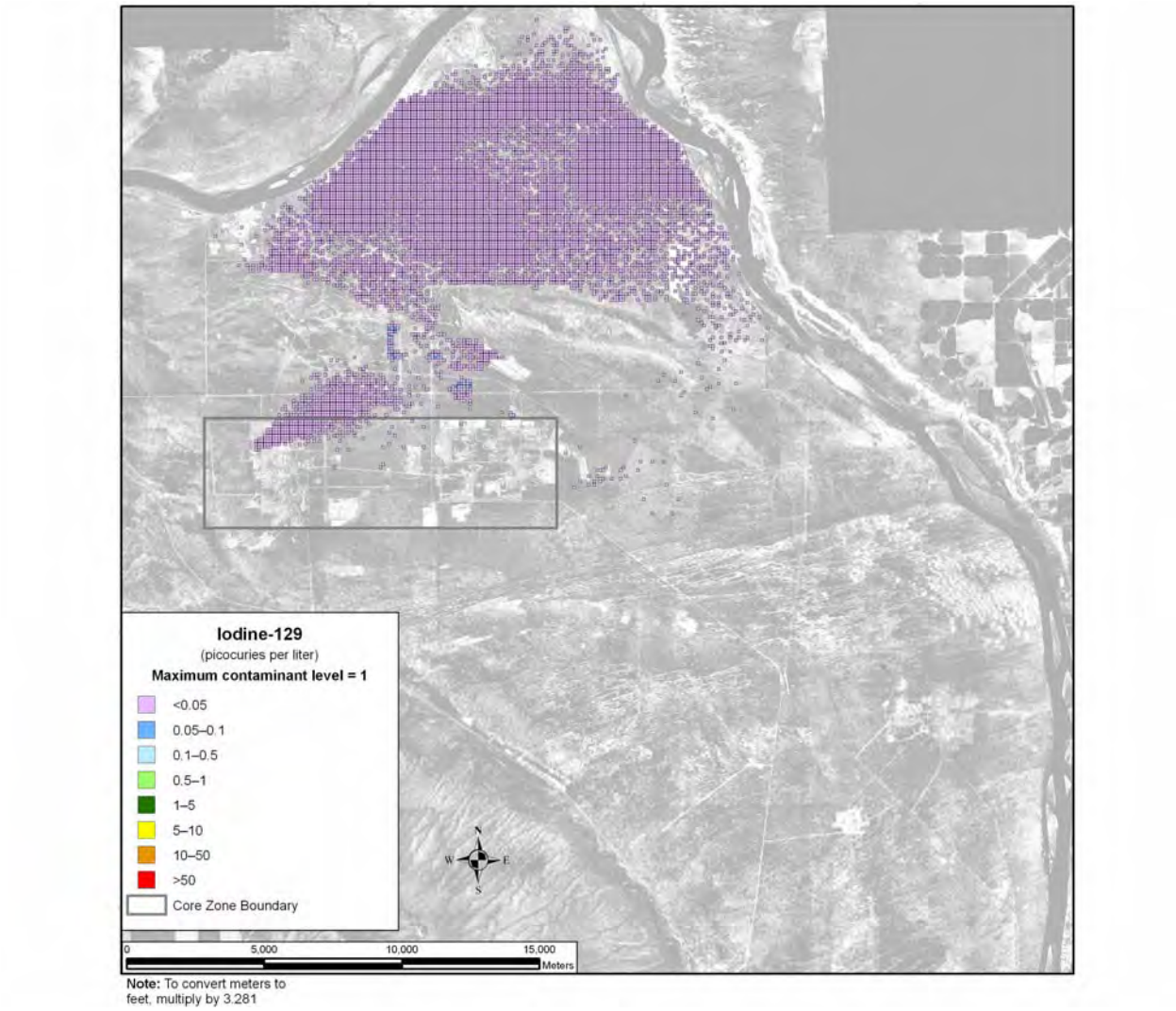


Figure 5–357. Waste Management Alternative 1, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

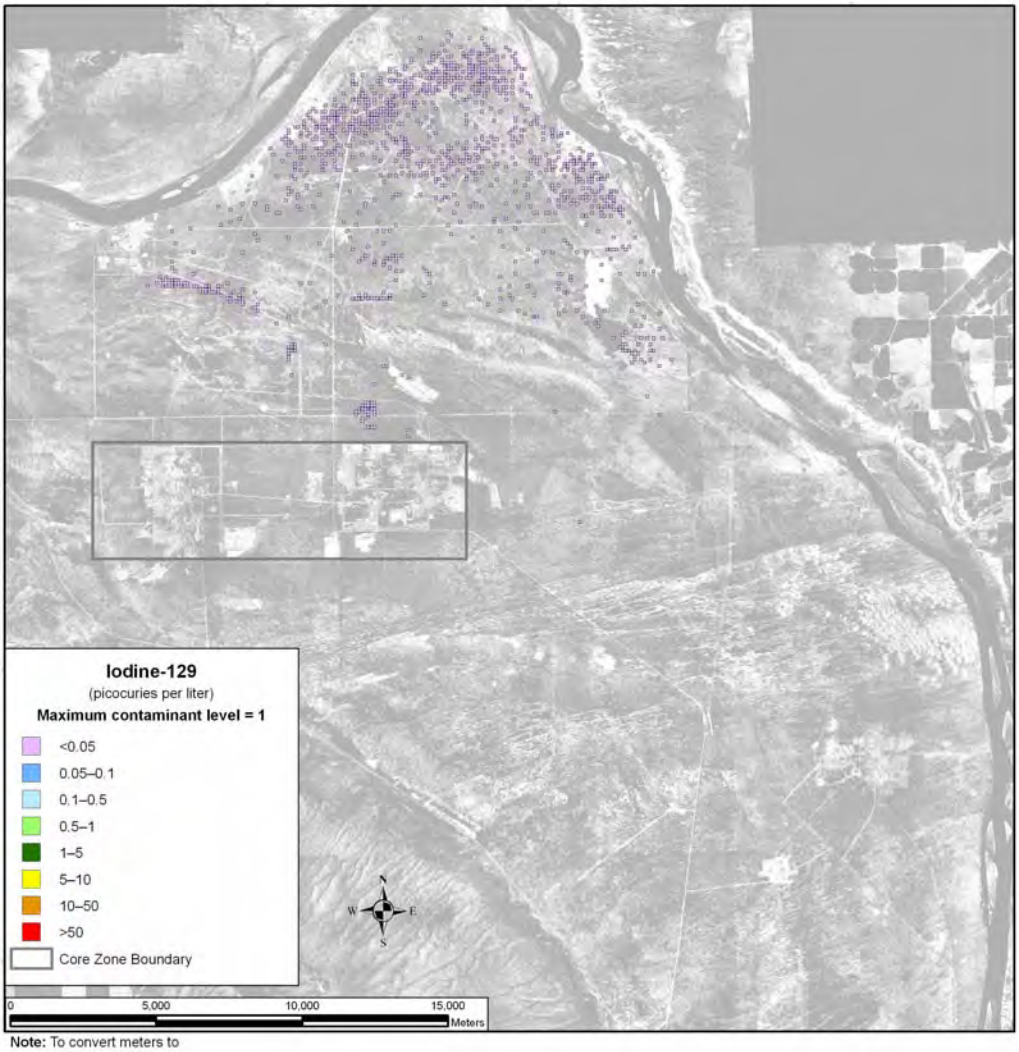


Figure 5–358. Waste Management Alternative 1, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

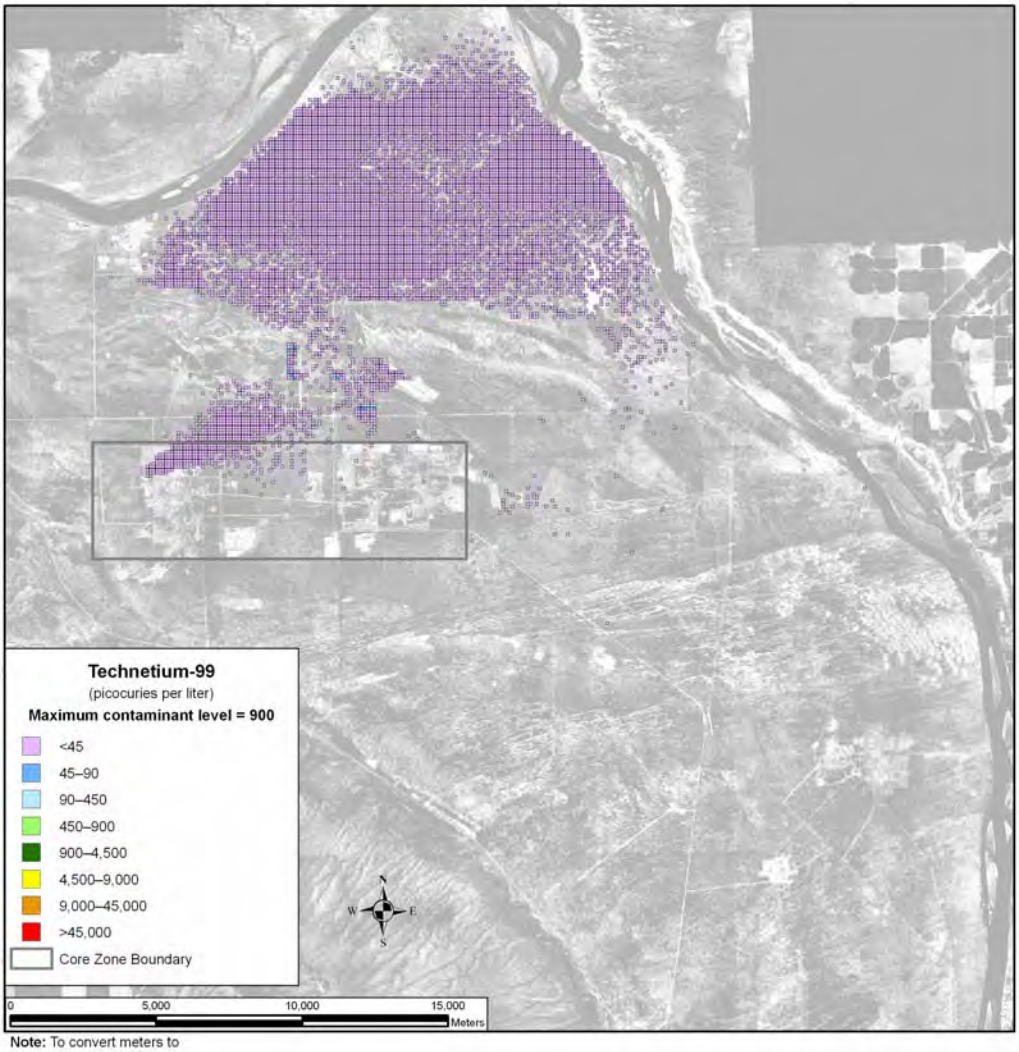


Figure 5–359. Waste Management Alternative 1, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

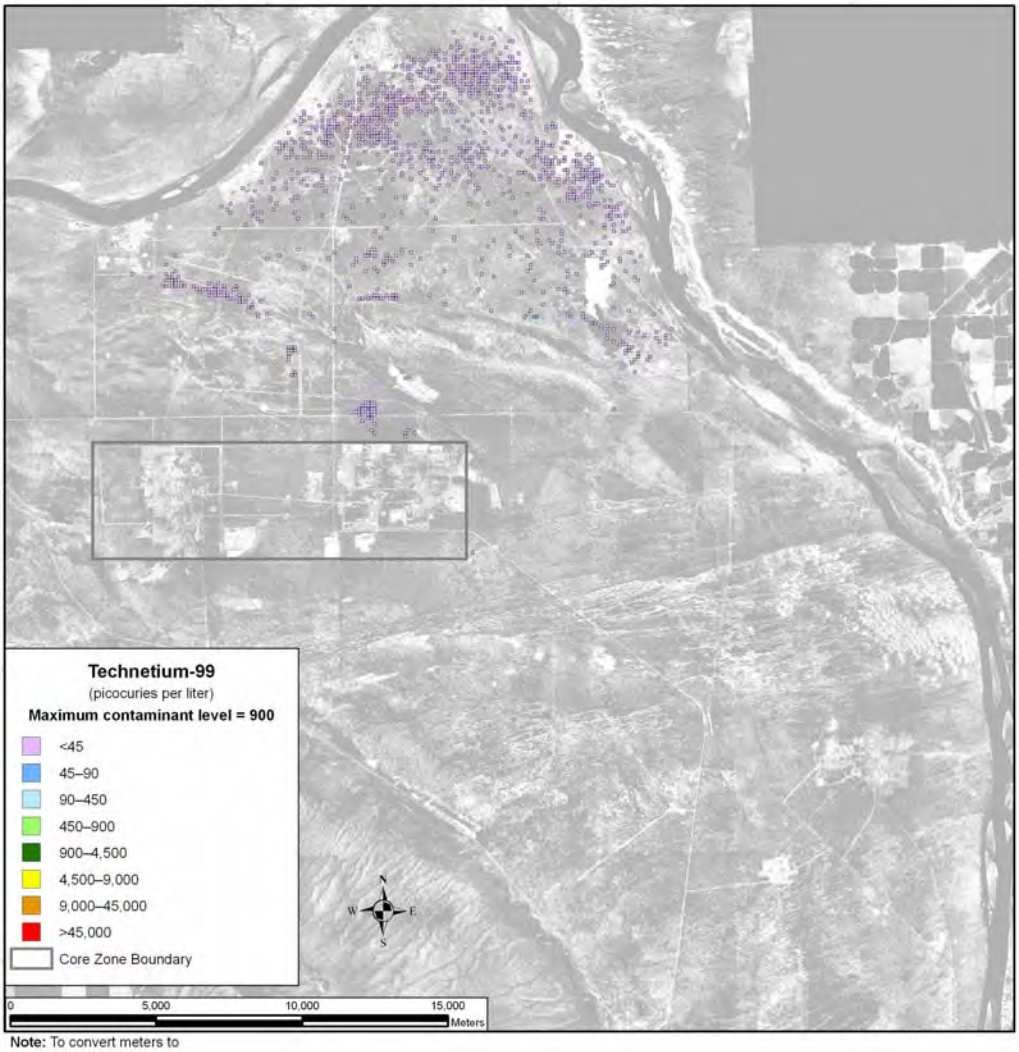


Figure 5–360. Waste Management Alternative 1, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

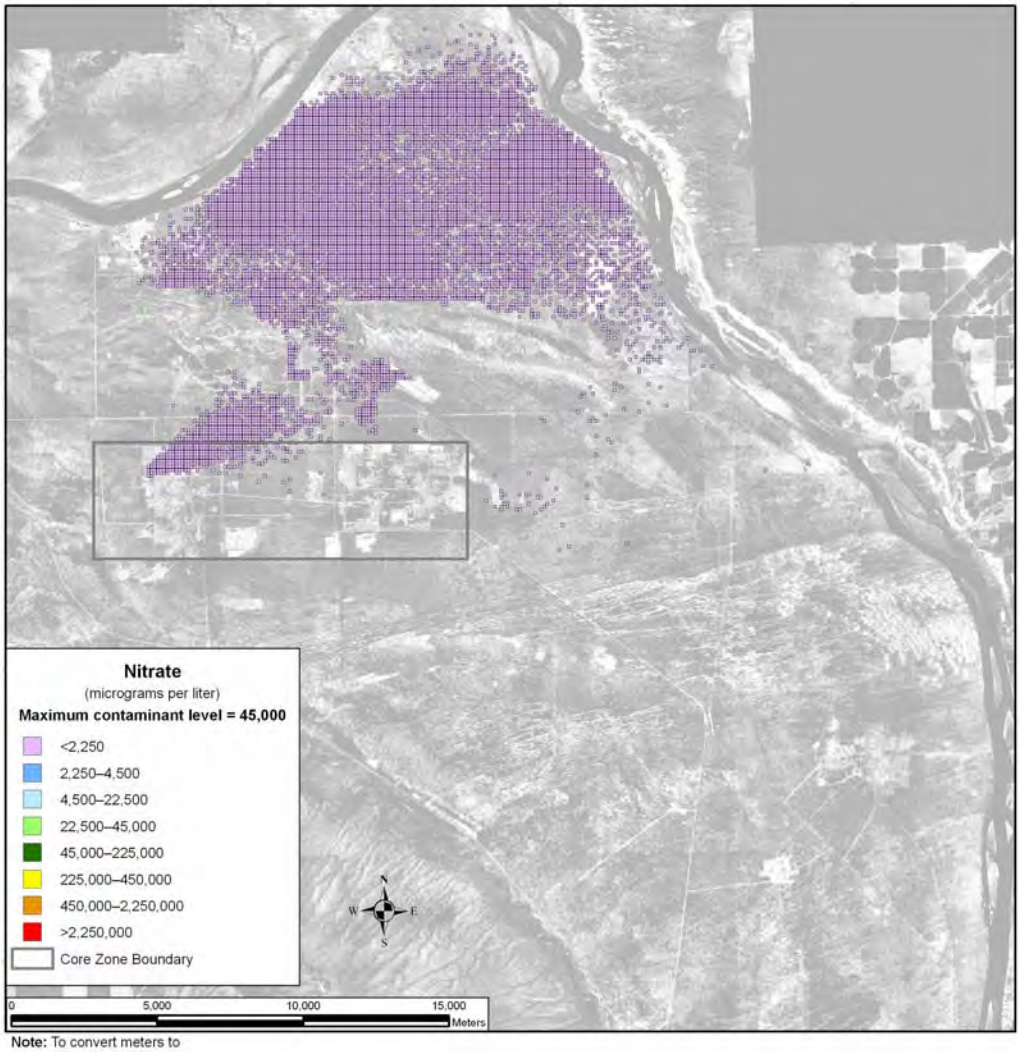


Figure 5–361. Waste Management Alternative 1, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

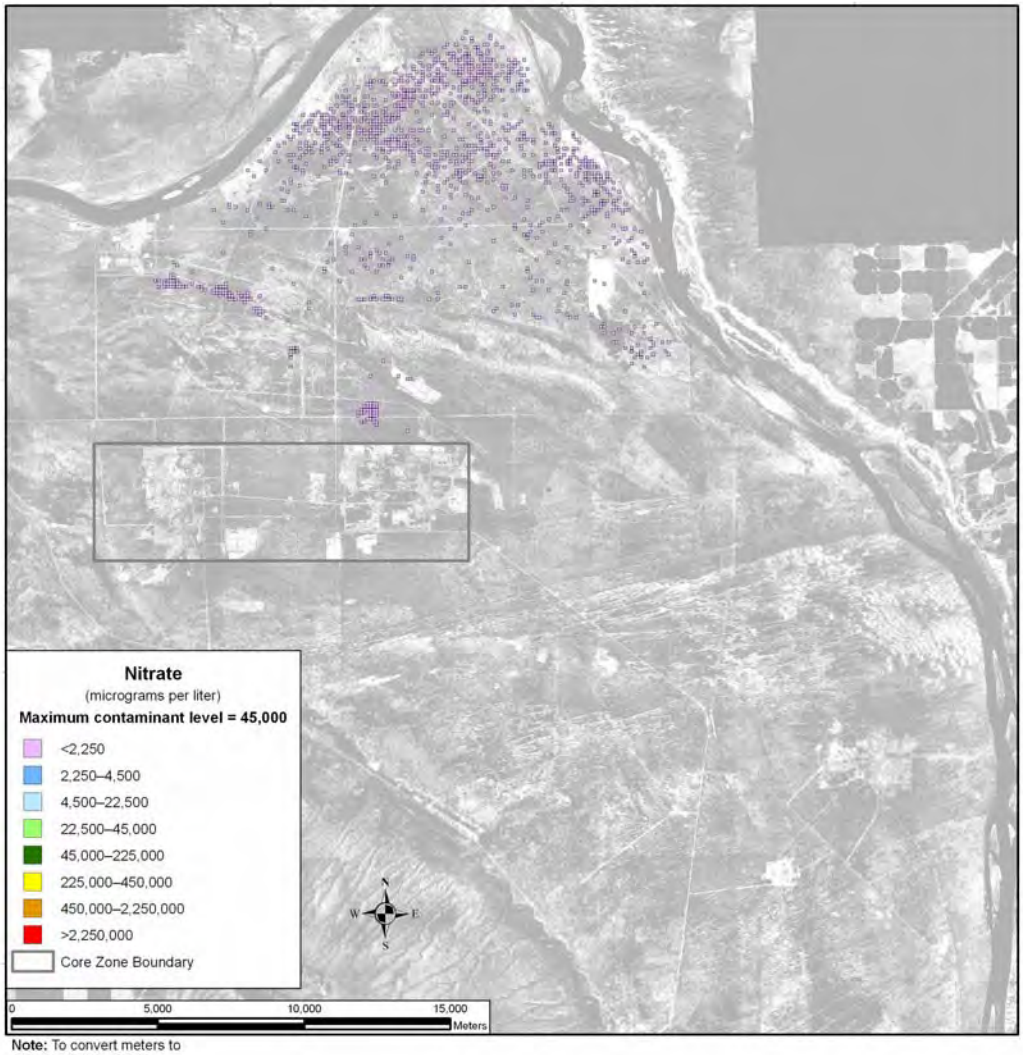
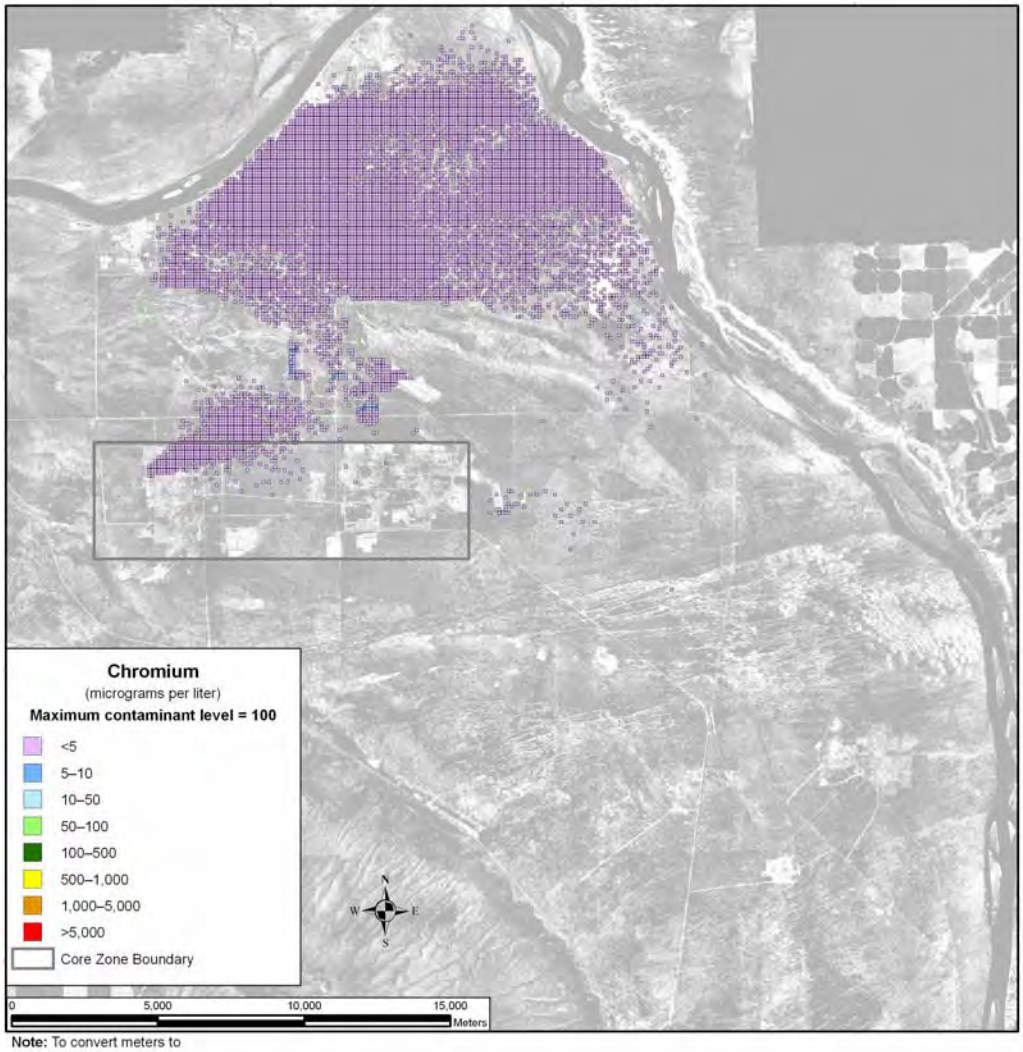


Figure 5–362. Waste Management Alternative 1, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–363. Waste Management Alternative 1, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

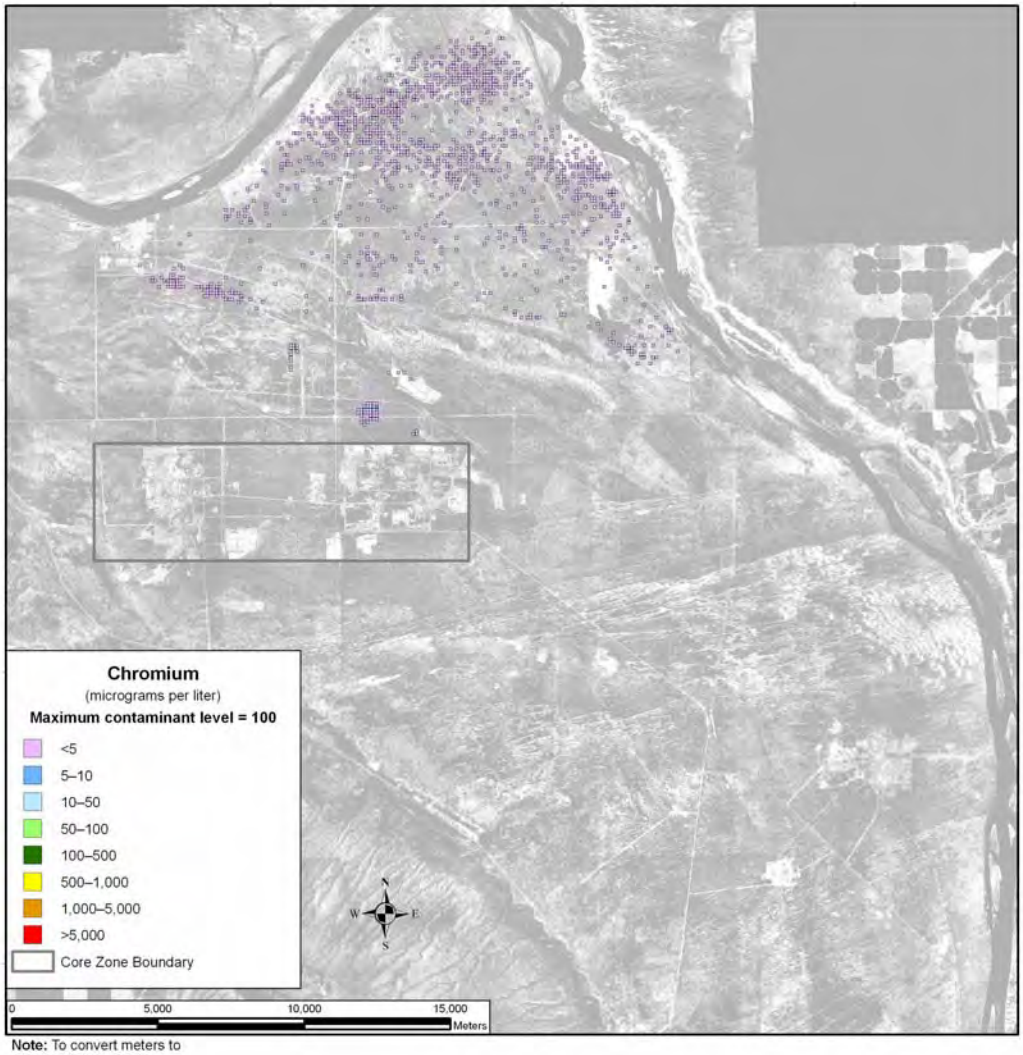


Figure 5–364. Waste Management Alternative 1, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

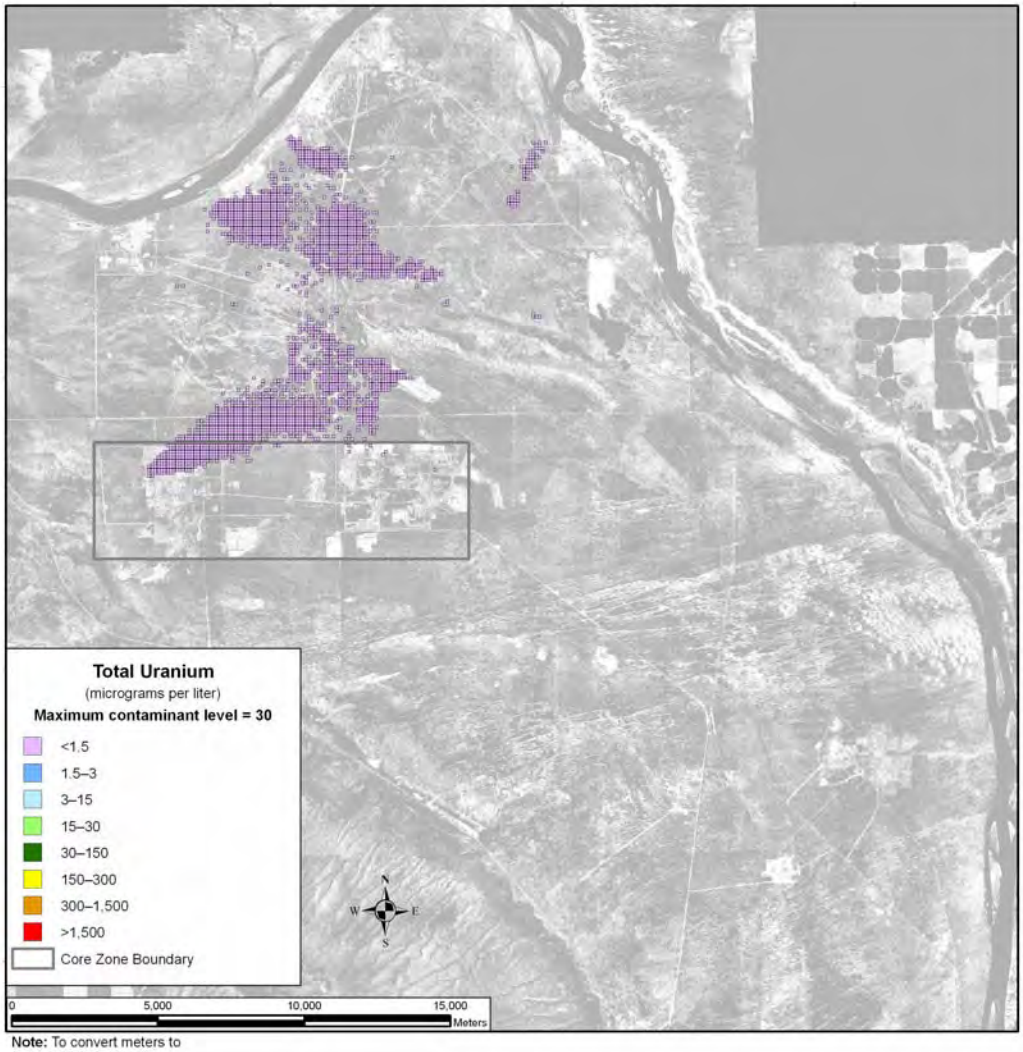


Figure 5–365. Waste Management Alternative 1, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

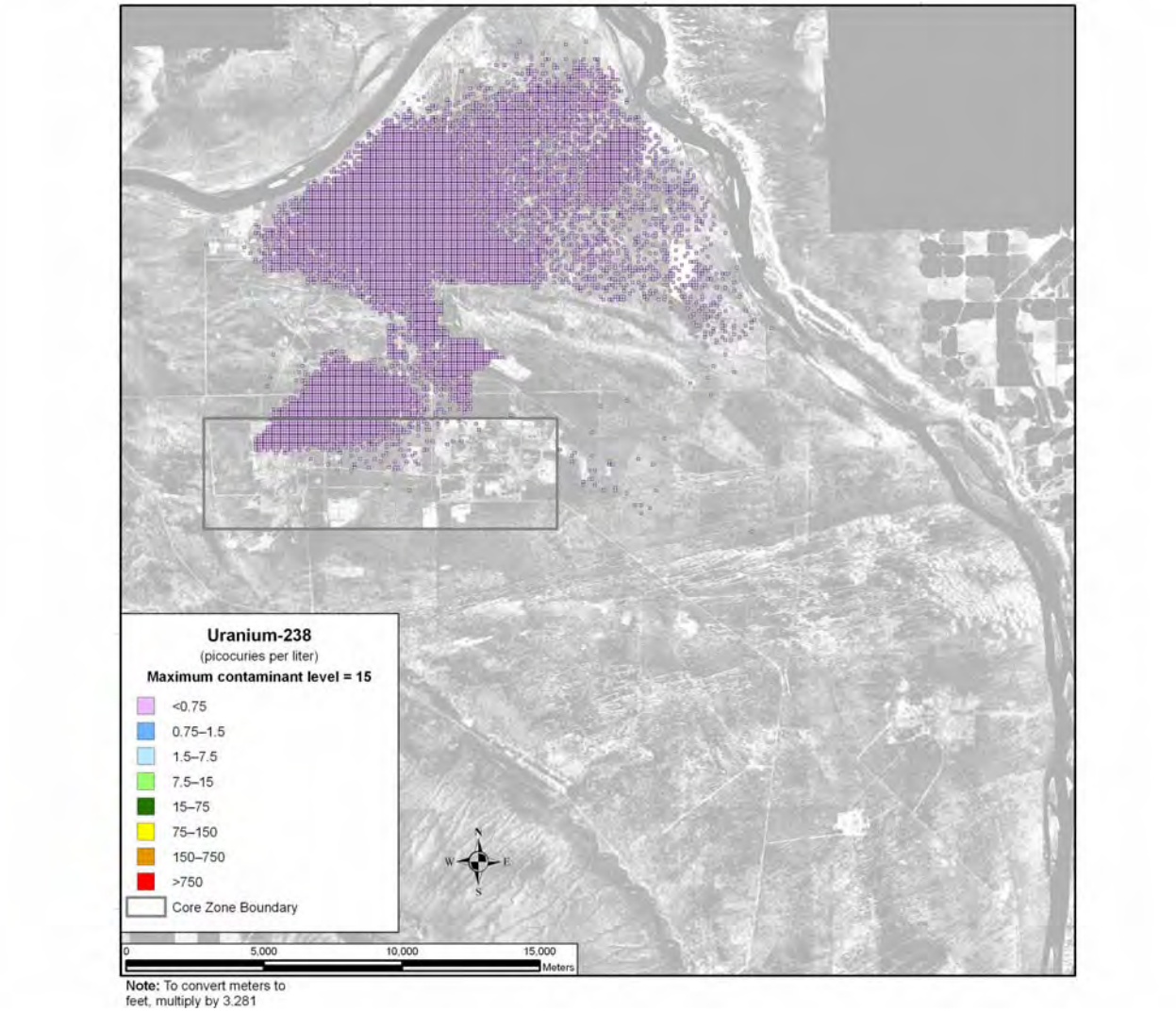


Figure 5–366. Waste Management Alternative 1, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

5.3.1.1.6 Summary of Impacts

Under Waste Management Alternative 1, all discharges originate in trenches 31 and 34.

No COPCs reached a concentration exceeding the benchmark concentration at the Core Zone Boundary or Columbia River during the course of the simulation.

5.3.1.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

This section describes the groundwater analysis results for Waste Management Alternative 2, including long-term groundwater impacts of contaminant sources within the IDF-East and RPPDF Barriers. Impacts of sources remaining within the tank farm barriers are presented in Section 5.1, which discusses tank closure impacts. Impacts of sources remaining within the FFTF Barrier are presented in Section 5.2, which discusses FFTF decommissioning impacts.

Summaries of the proposed actions and timelines for Waste Management Alternative 2 are provided in Chapter 2, Section 2.5. There are three disposal facilities, as follows:

- LLBG 218-W-5 trenches 31 and 34, which receive LLW and MLLW. For the purposes of this analysis, the waste inventories associated with these trenches are included with the IDF-East inventory.

- IDF-East, located in the south-central part of the 200-East Area, which receives tank waste, FFTF decommissioning waste, onsite-generated non-CERCLA waste, and offsite-received LLW and MLLW. The LLW and MLLW inventories for trenches 31 and 34 are also included at IDF-East in this analysis.

- The RPPDF, located in the Core Zone between the 200-East and 200-West Areas, which receives lightly contaminated equipment and soils resulting from tank farm closure activities.

Three disposal groups were analyzed. Each has a different configuration and timeline for IDF-East and the RPPDF. The three disposal groups are discussed in detail in the following subsections.

5.3.1.2.1 Disposal Group 1

Disposal Group 1 is characterized by an operational completion date of CY 2050 for both IDF-East and the RPPDF. Under Disposal Group 1, IDF-East has a large capacity (1,200,000 cubic meters [1,570,000 cubic yards]) and the RPPDF has a smaller capacity (1,030,000 cubic meters [1,350,000 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C; either FFTF Decommissioning Alternative 2 or 3; and waste management activities.

5.3.1.2.1.1 Disposal Group 1, Subgroup 1-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-A covers disposal of waste generated under Tank Closure Alternative 2B and either FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW and ILAW glass. IHLW would be stored on site, while ILAW glass would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2008 and continue through CY 2050, when these facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A (Tank Closure Alternative 2B, FFTF Decommissioning Alternative 3, and onsite- and offsite-generated waste), is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–367 through 5–378). Three subtotals are plotted, representing releases from the RPPDF and IDF-East, which include ILAW glass, Effluent Treatment Facility (ETF)-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over more than 10 orders of magnitude.

Figure 5–367 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers representing the individual waste form release and Figure 5–368, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period in the analysis). For the radiological COPCs (technetium-99 and iodine-129), the releases range over seven orders of magnitude, depending on the source. The chemical COPCs (boron, chromium, fluoride, and nitrate) in IDF-East all have releases associated with waste management secondary waste and onsite-generated waste. Other sources include 99 percent of the nitrate release from ETF-generated secondary waste and 81 percent of the chromium release from tank closure secondary waste; the other chromium releases are dispersed in the other waste forms.

Figure 5–369 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–370, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers

and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone. The exception to this is the release associated with retired melters, which decreases at groundwater for both technetium-99 and iodine-129 by more than 40 percent. These results suggest that melters as a source do not continue to release after the initial exposure.

Figure 5–371 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–372, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. The exception to this is the *de minimis* release associated with the retired melters.

Figure 5–373 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–374, the chemical hazard drivers. The release of technetium-99 is more than two orders of magnitude greater than the release of iodine-129 at the RPPDF. The chemical constituents show nitrate as the predominant COPC, about two orders of magnitude greater than the release of chromium at the RPPDF.

Figure 5–375 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–376, the chemical hazard drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

Figure 5–377 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–378, the chemical hazard drivers. Both figures show trends similar to those discussed in the previous paragraph for the release to the Columbia River for all COPC drivers at the RPPDF.

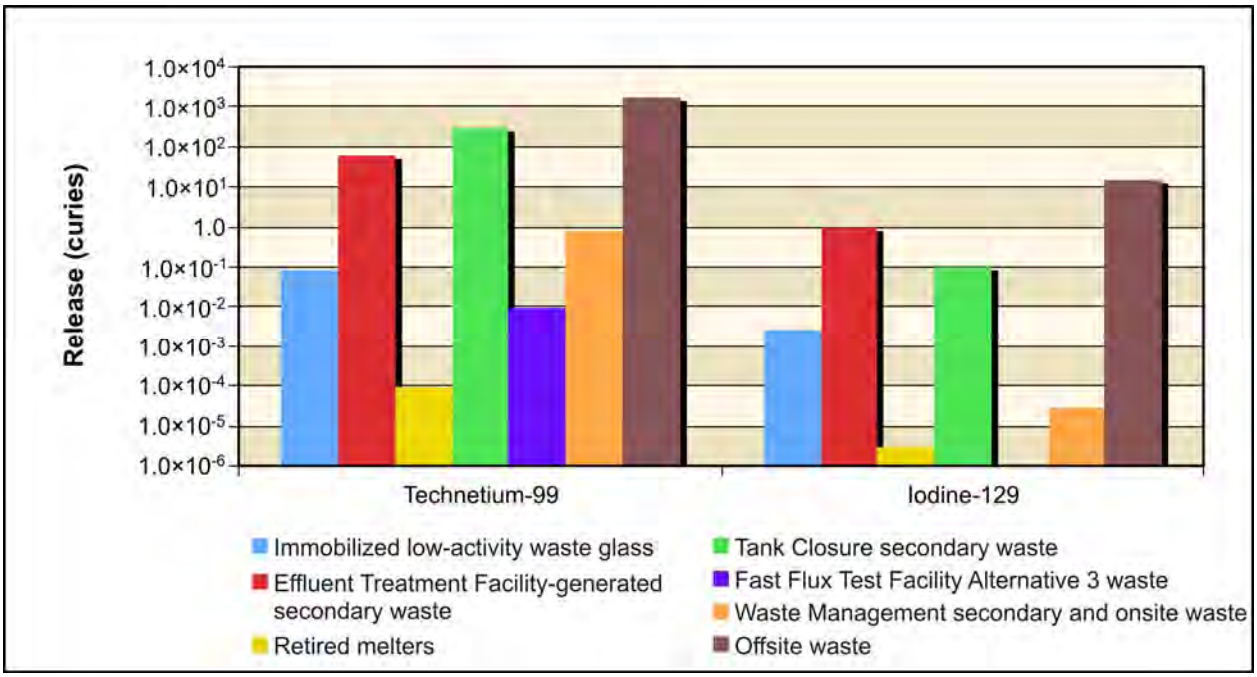


Figure 5–367. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

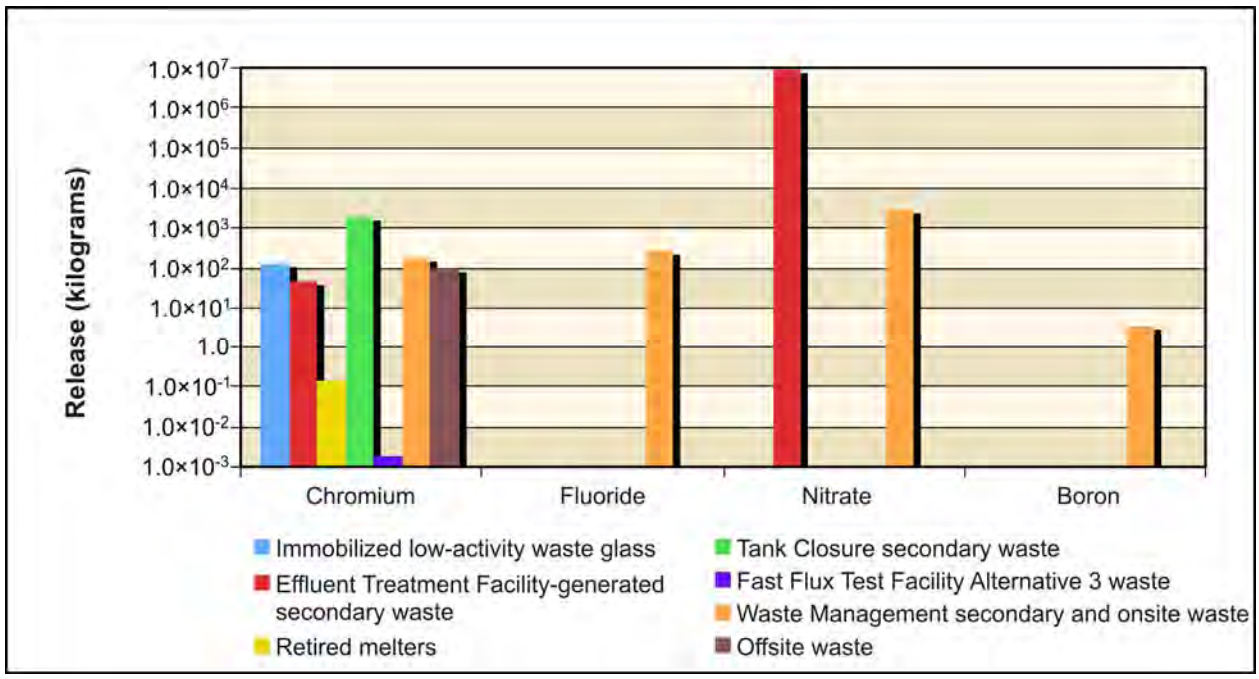


Figure 5–368. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

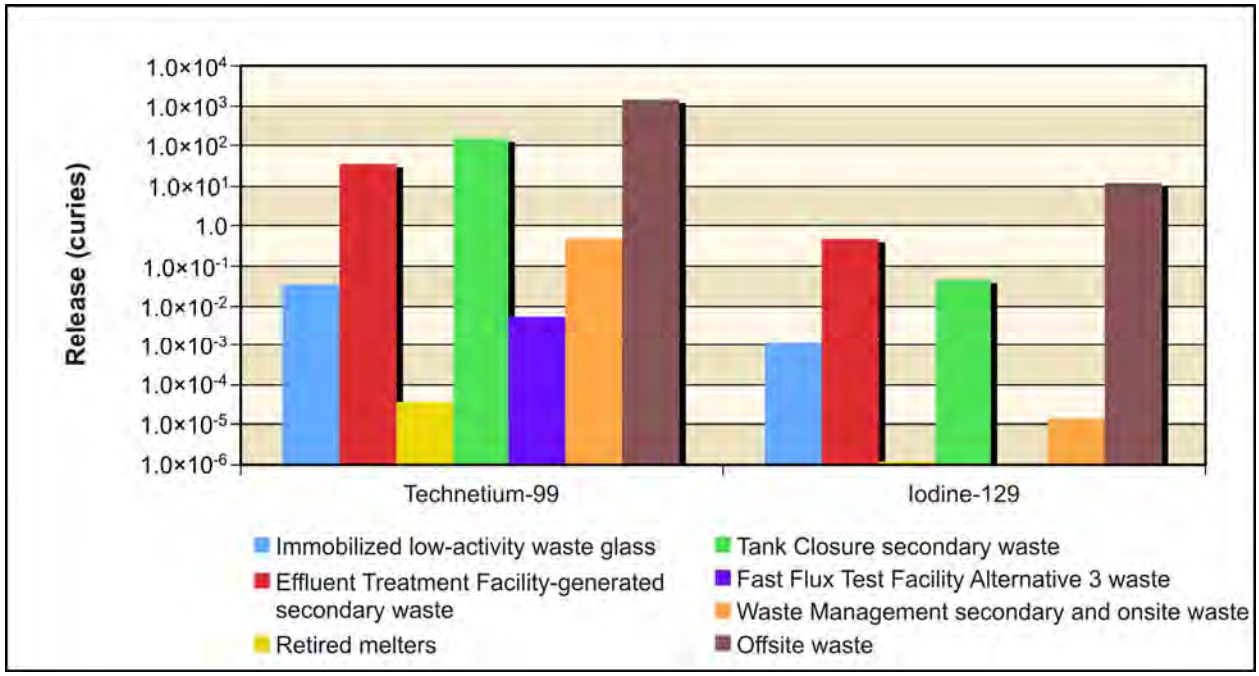


Figure 5–369. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

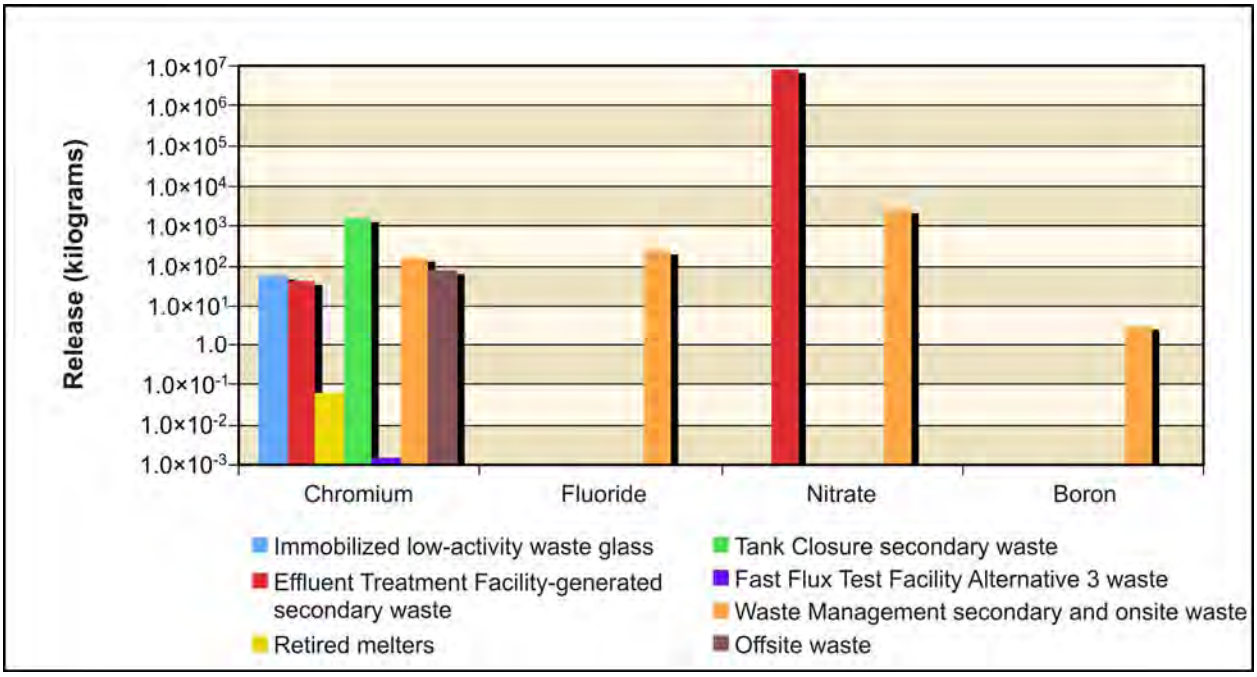


Figure 5–370. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

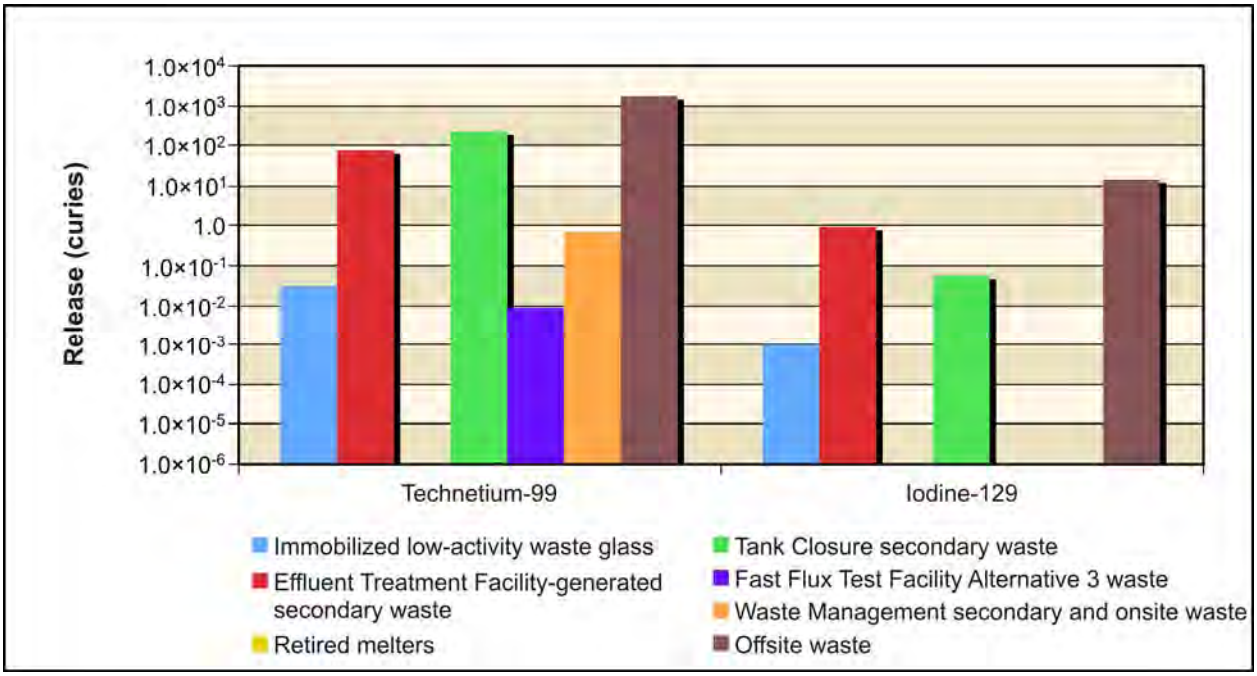


Figure 5–371. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

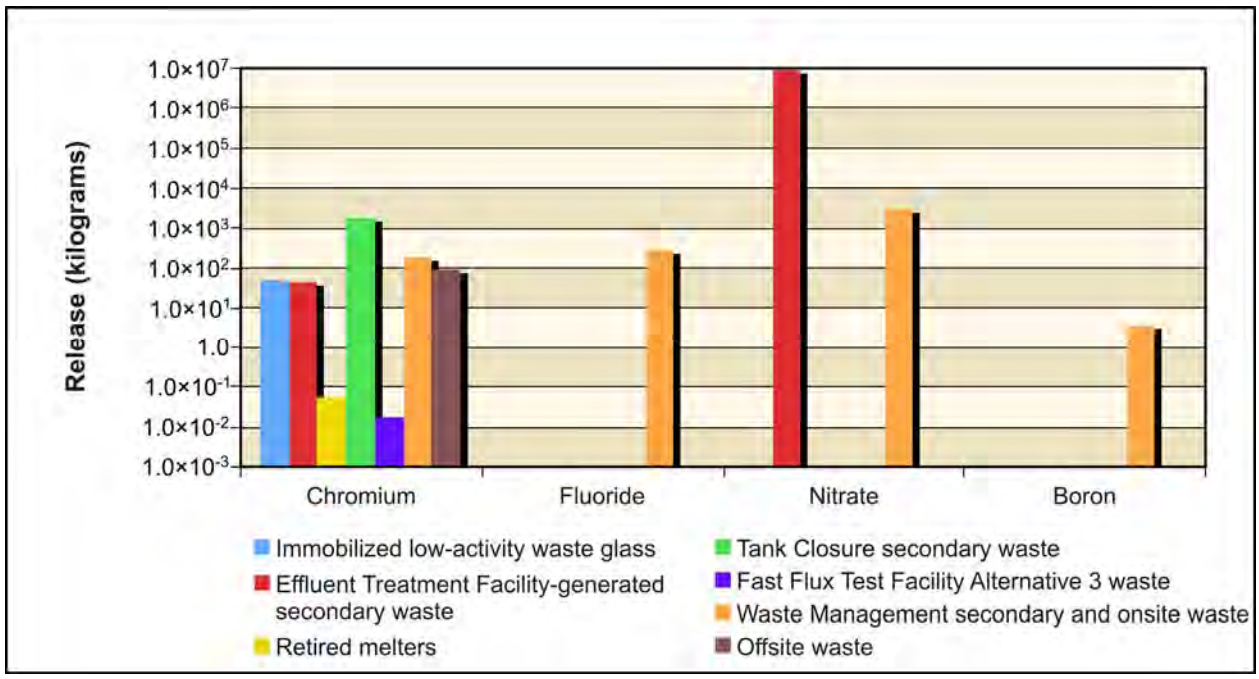


Figure 5–372. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

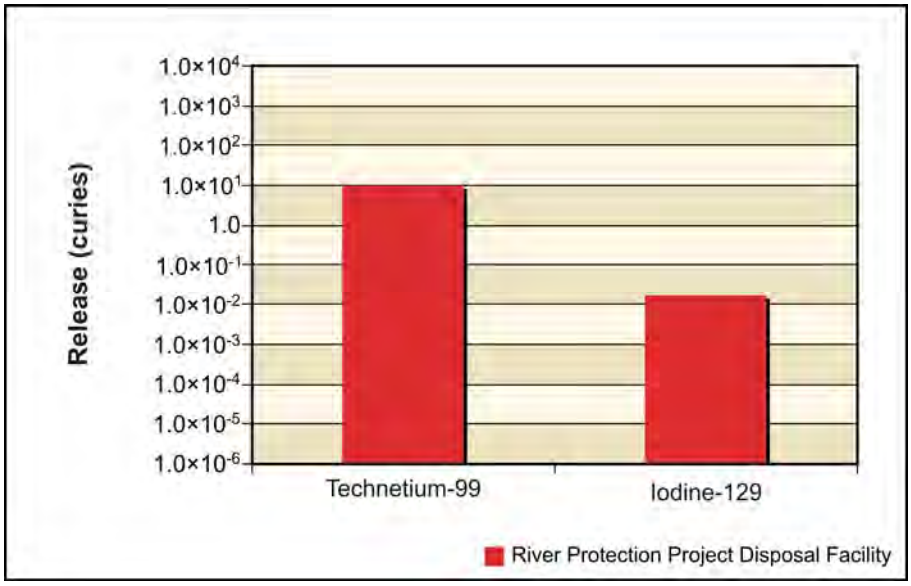


Figure 5–373. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

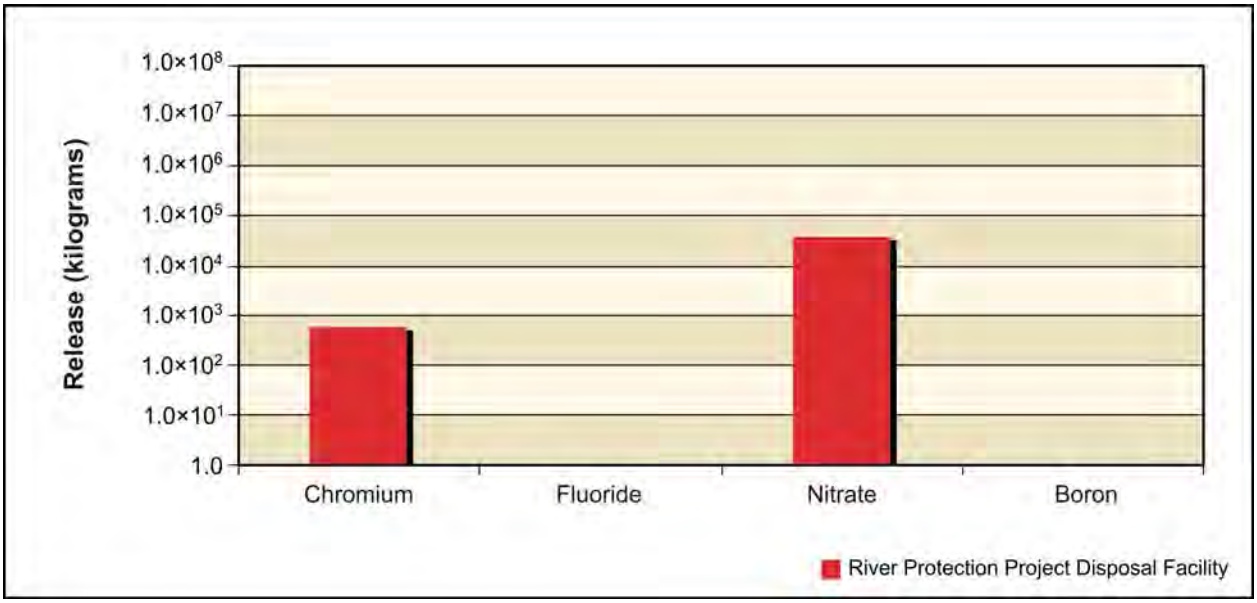


Figure 5–374. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

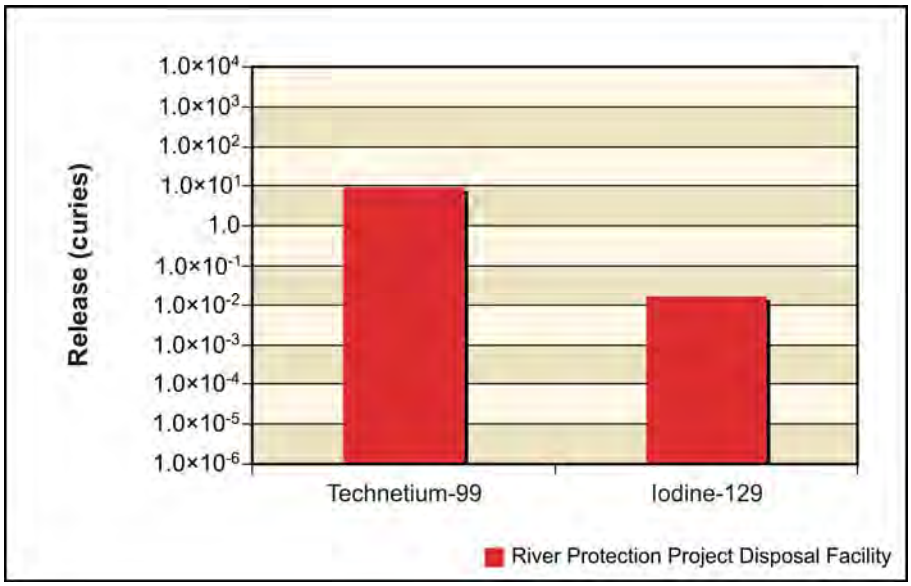


Figure 5–375. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Groundwater

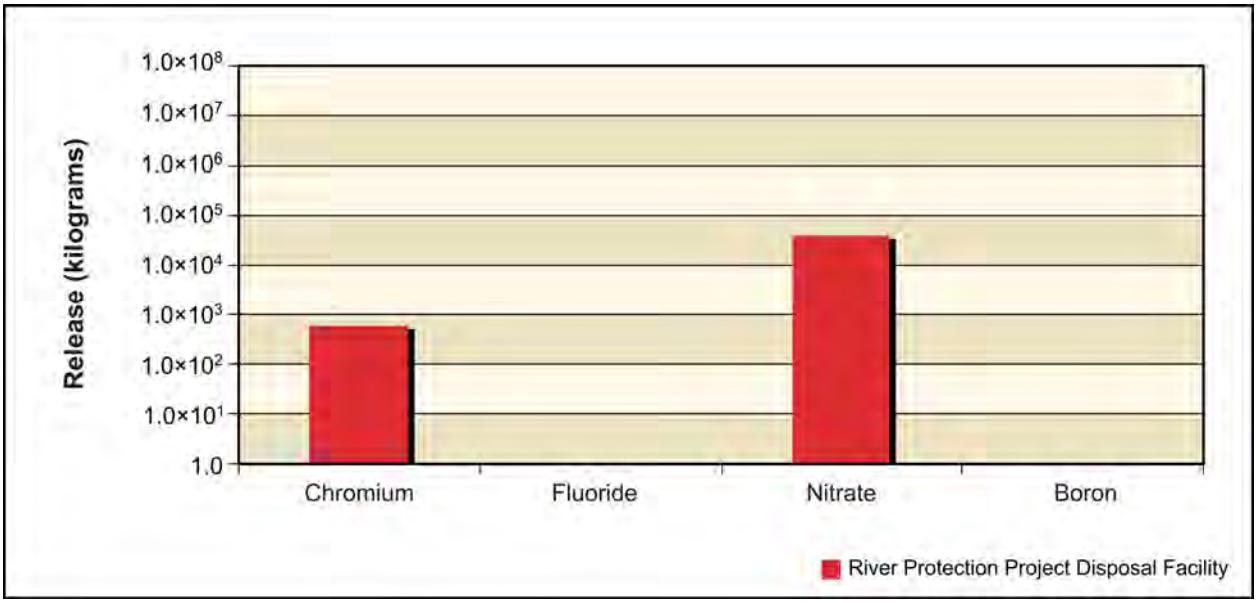


Figure 5–376. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Groundwater

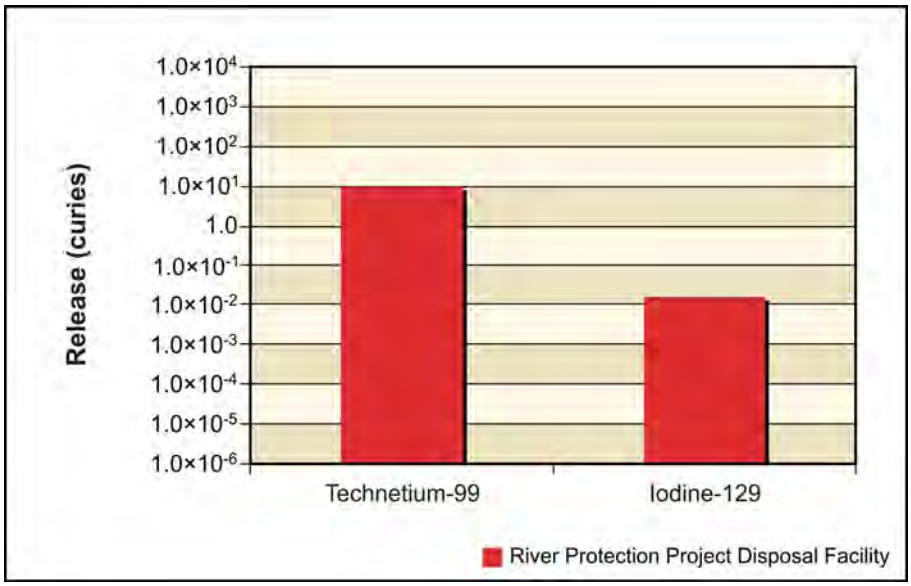


Figure 5–377. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Columbia River

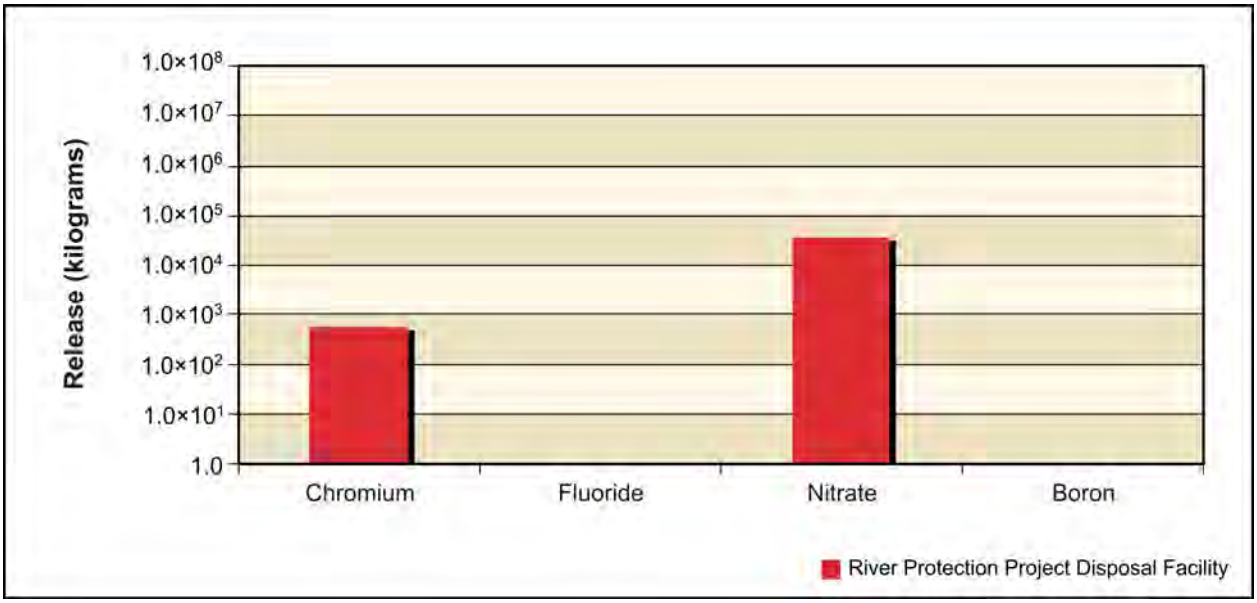


Figure 5–378. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Disposal Group 1, Subgroup 1-A, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–379 through 5–383). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–77 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–379 through 5–382 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from IDF-East and the RPPDF at the Core Zone Boundary cause groundwater concentrations to exceed the benchmark concentration for iodine-129 in CY 5500; using the confidence interval, the concentrations appear slightly below the benchmark for both the Core Zone Boundary and the Columbia River nearshore. The same trend is applicable to technetium-99 concentrations during the period of analysis. Chromium and nitrate measurements at the Core Zone Boundary and the Columbia River nearshore are below the benchmark concentrations by one to three orders of magnitude, showing a trend similar to iodine-129 and technetium-99.

Figure 5–383 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until CY 9800, when total uranium concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 does not surpass 1.0×10^{-8} picocuries per liter during the simulation, but total uranium continues to rise near the end of the

10,000-year period of analysis, still well below the benchmark for both the Core Zone Boundary and Columbia River nearshore by eight to nine orders of magnitude at the end of the period of analysis.

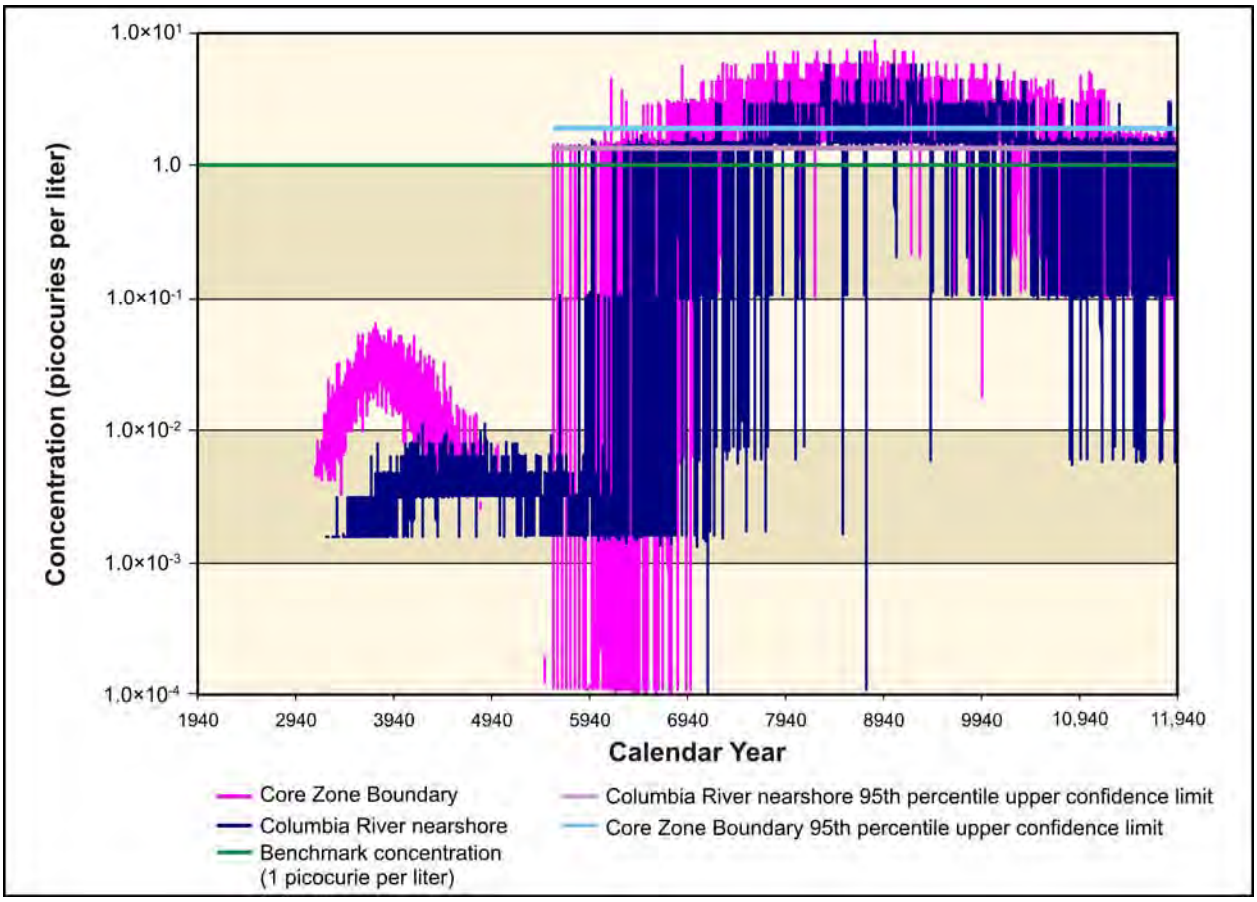


Figure 5–379. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time

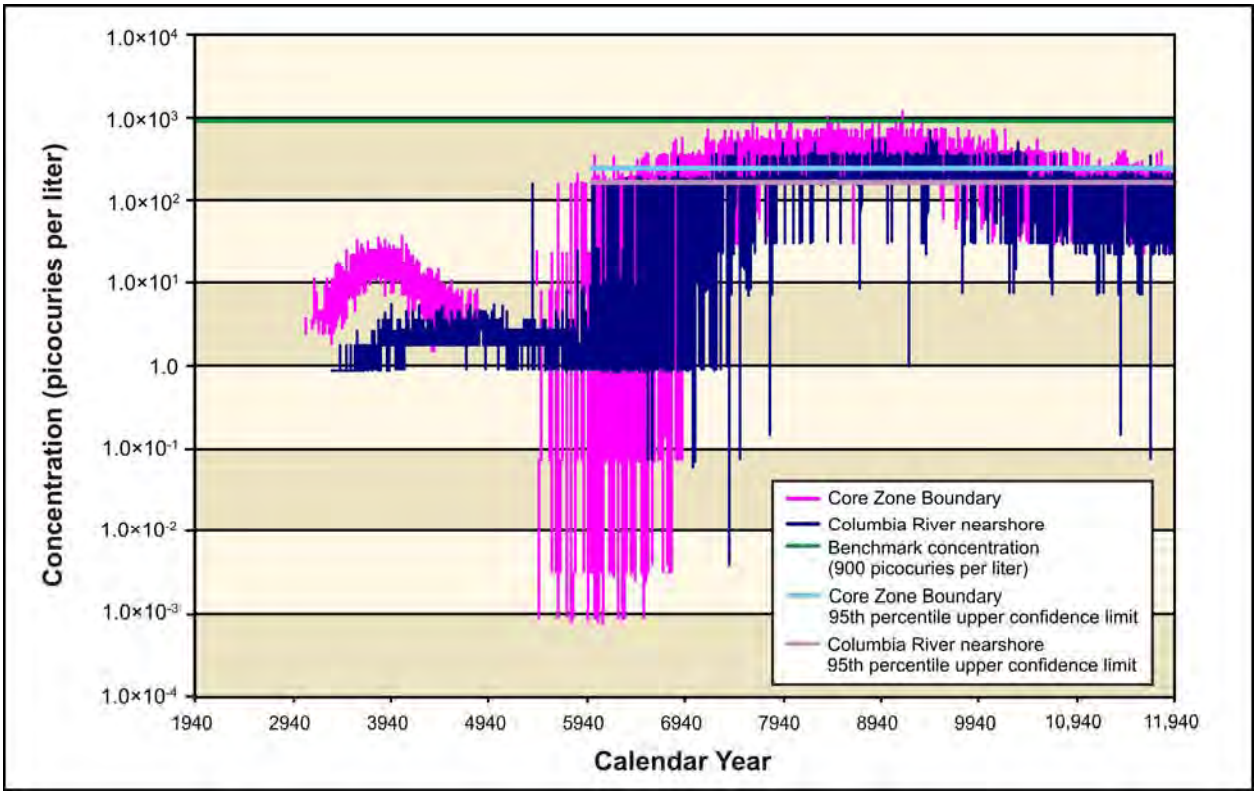


Figure 5–380. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time

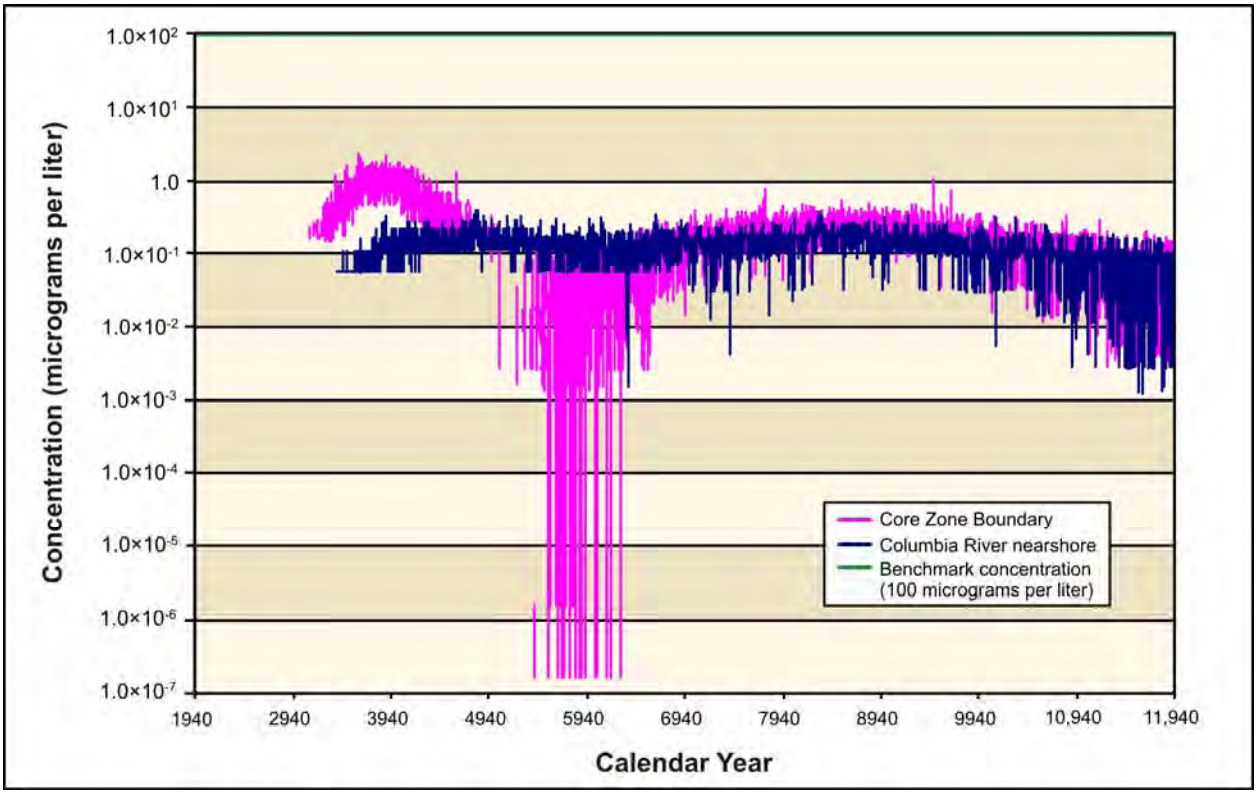


Figure 5–381. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chromium Concentration Versus Time

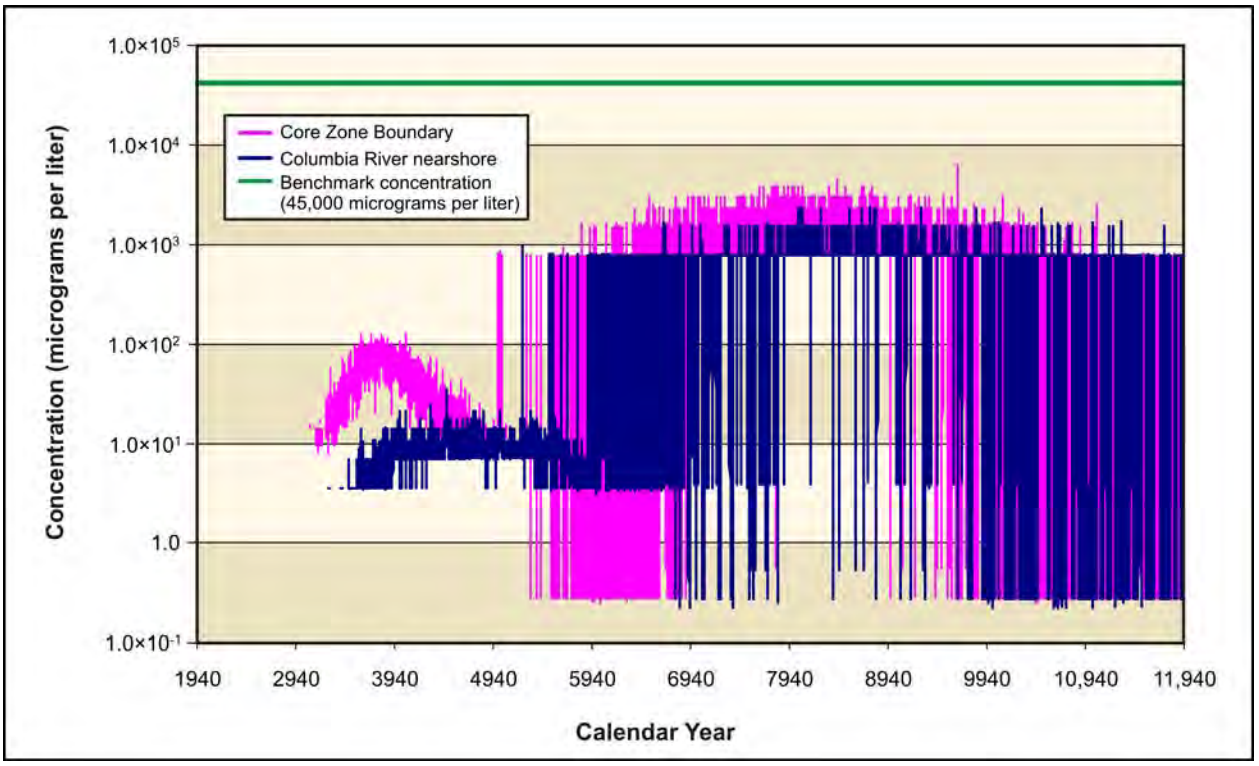


Figure 5–382. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Nitrate Concentration Versus Time

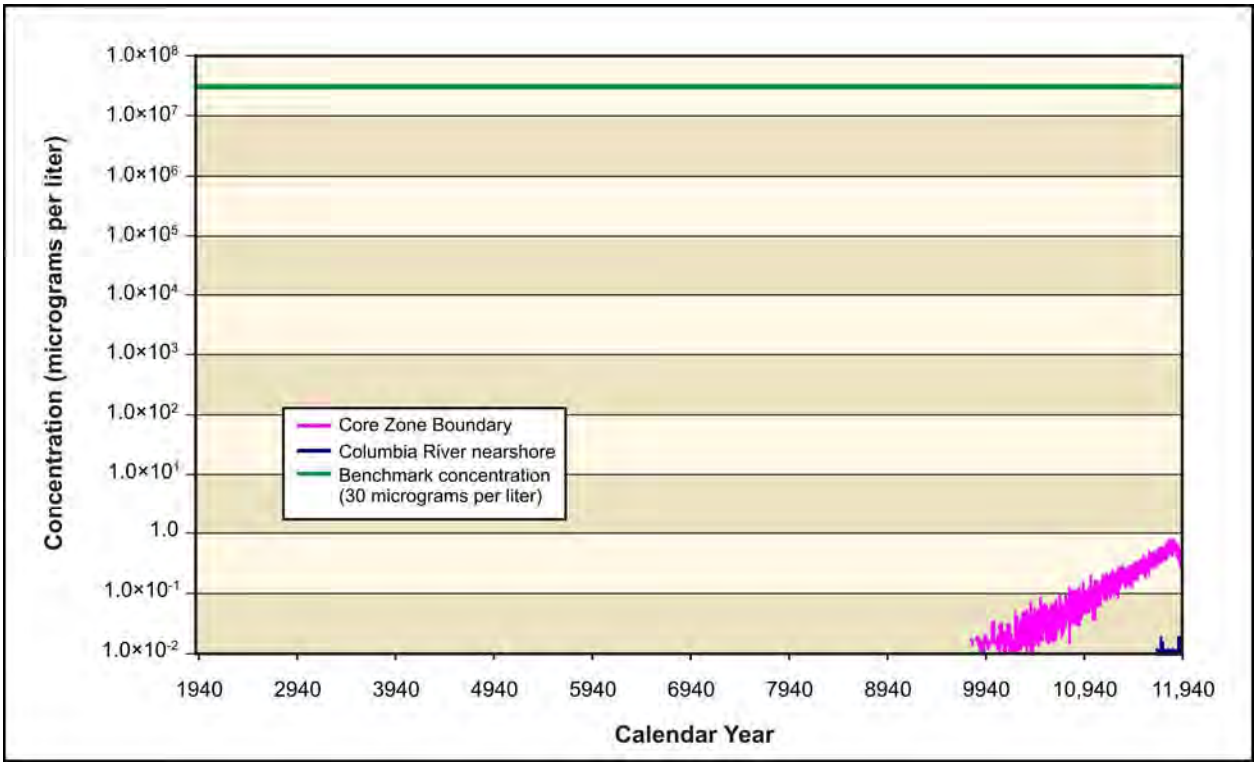


Figure 5–383. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Total Uranium Concentration Versus Time

Table 5–77. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,040**	33	**1,180**	675	900
	(9004)	(3825)	(9155)	(9451)	
Iodine-129	**19**	0.1	**9**	**7**	1
	(8739)	(3772)	(8858)	(8700)	
Chemical in micrograms per liter					
Chromium	4	2	2	1	100
	(8511)	(3856)	(3889)	(8898)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,200	149	5,630	2,440	45,000
	(8522)	(3811)	(9653)	(8827)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–384 through 5–396). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figures 5–384 through 5–386 show the spatial distribution of groundwater concentration for iodine-129. During CY 3890, there is a low-concentration plume that stretches north from the RPPDF and through Gable Gap. By CY 7140, the plume from the RPPDF is gone, but a new plume has formed, traveling east from IDF-East. The peak concentrations in this plume are greater than the benchmark. By CY 11,885, the plume continues to spread toward the river and the concentrations within remain relatively the same. Technetium-99 (see Figures 5–387 through 5–389), chromium (see Figures 5–390 through 5–392), and nitrate (see Figures 5–393 through 5–395) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

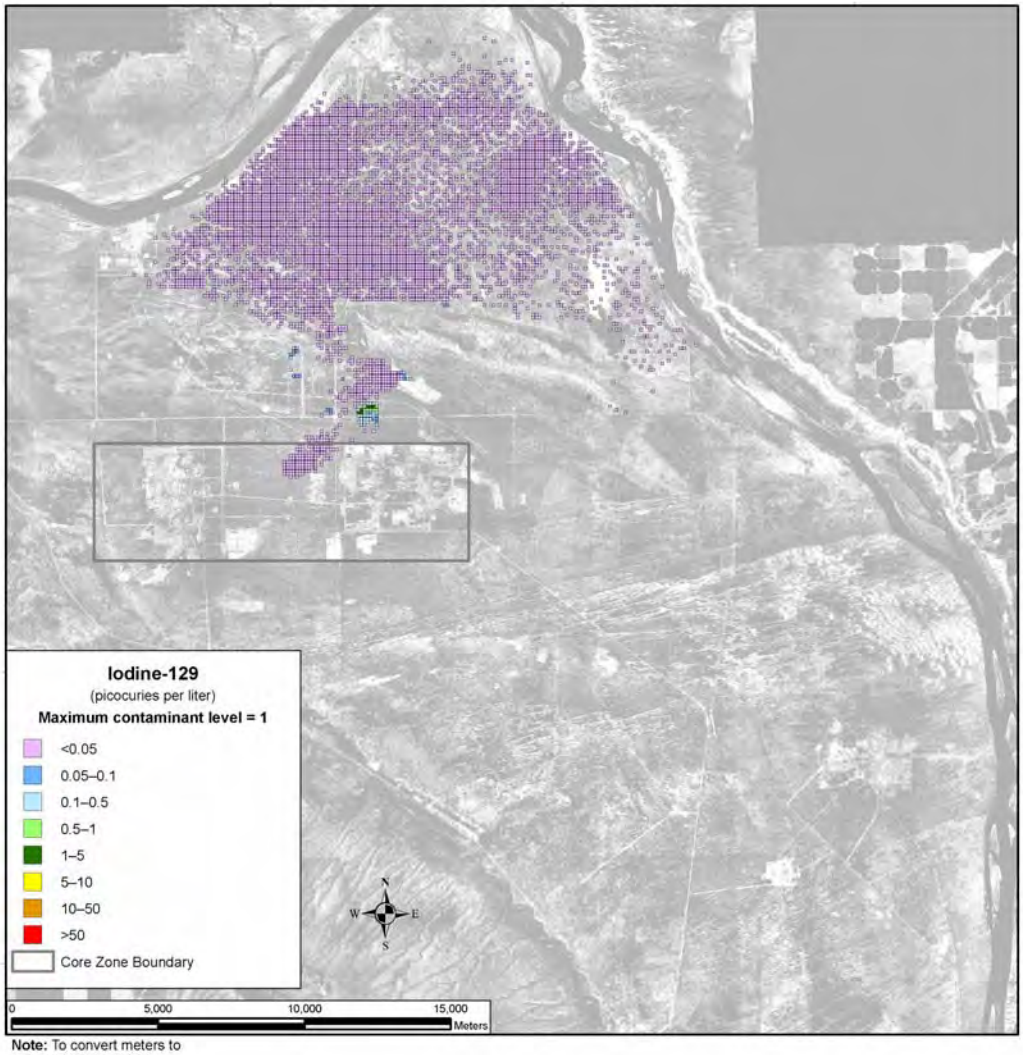


Figure 5–384. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

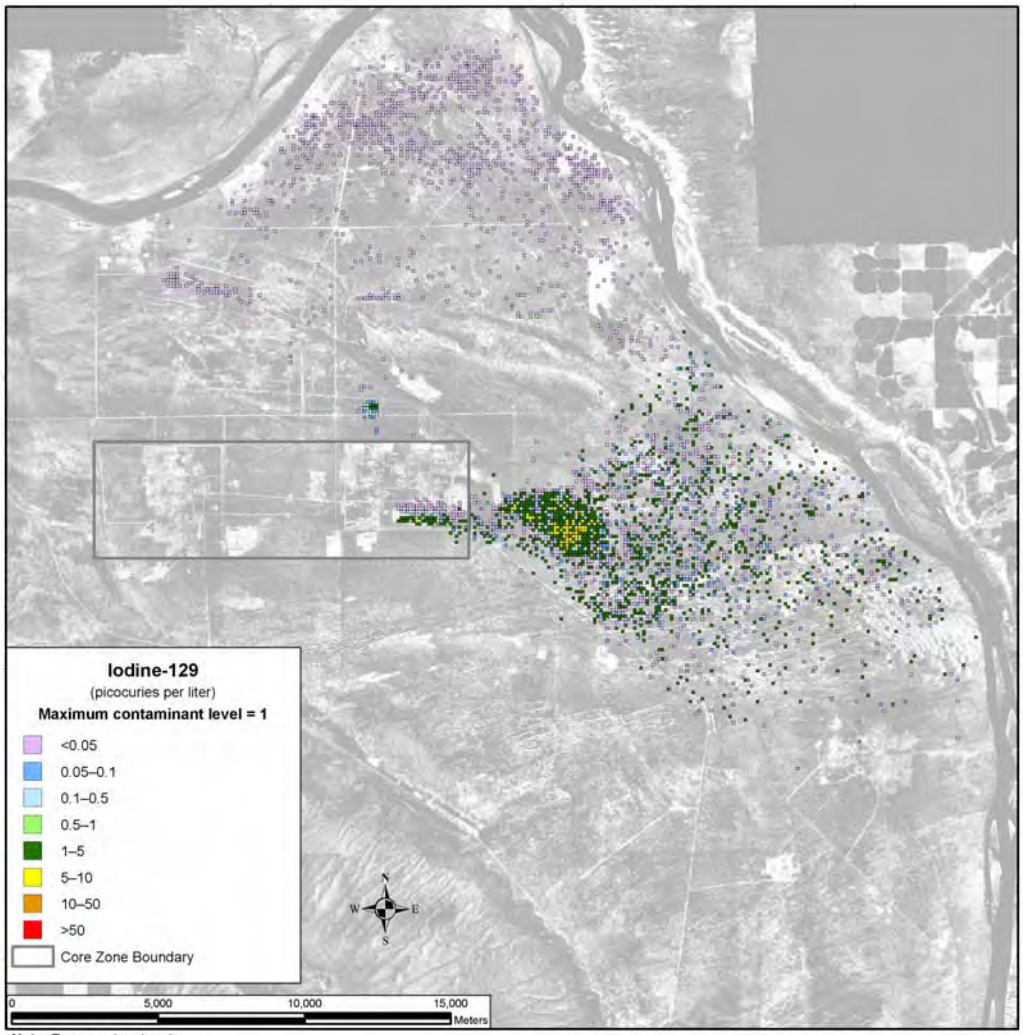
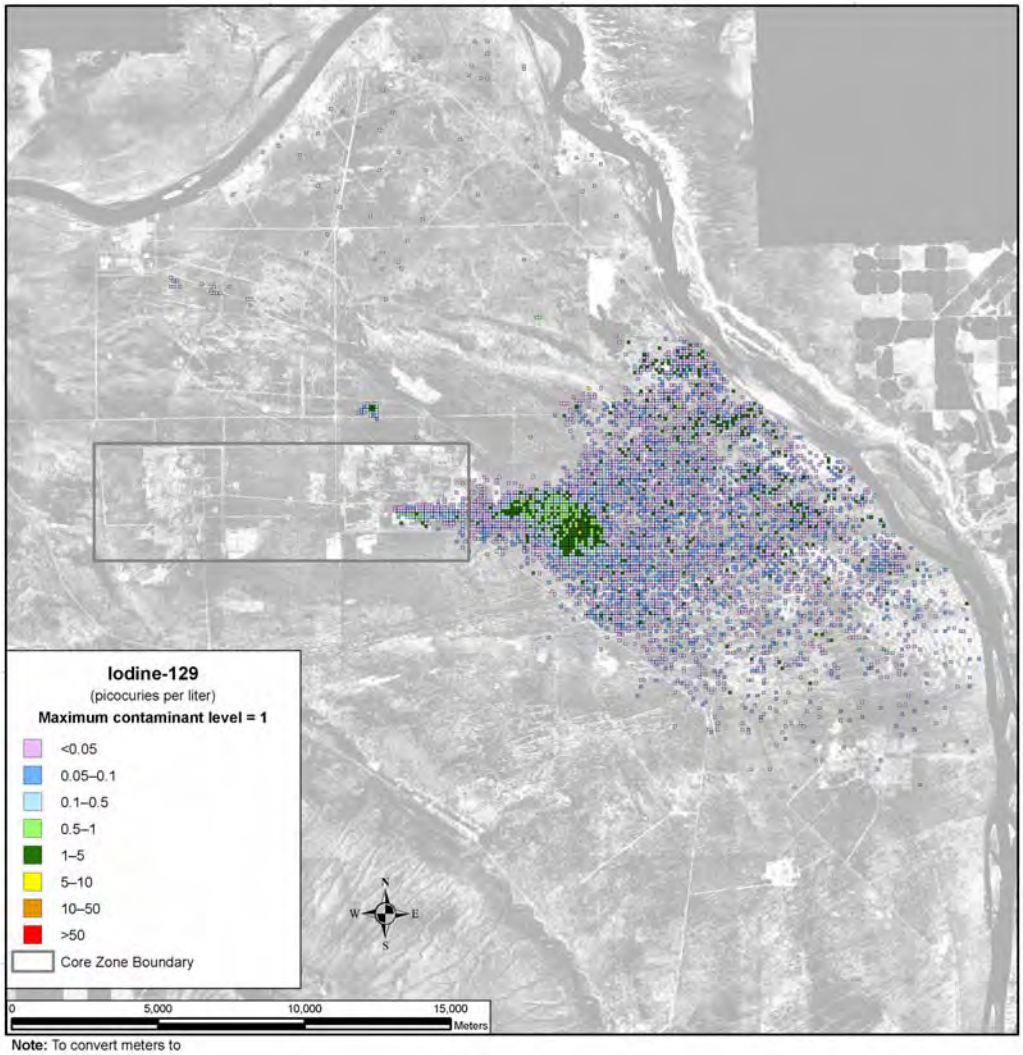


Figure 5–385. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–386. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

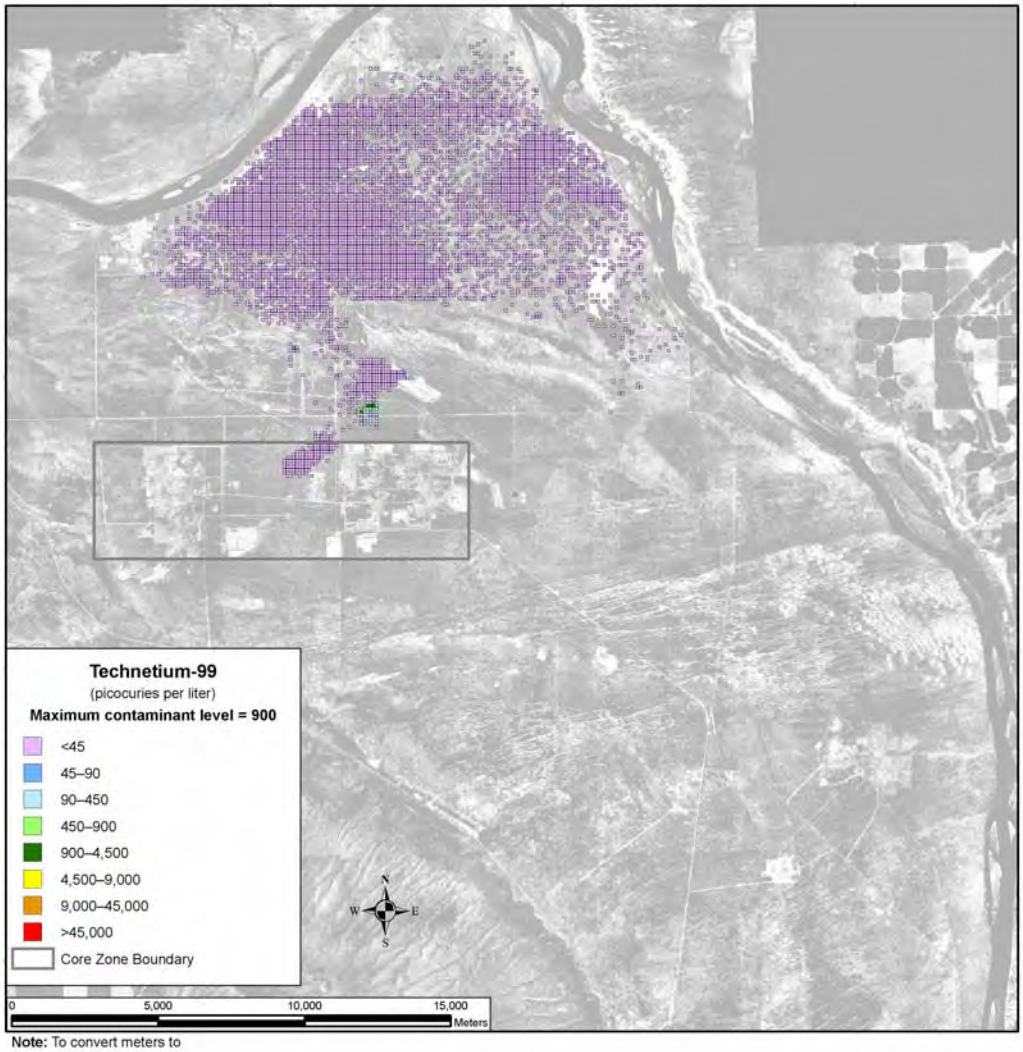


Figure 5–387. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

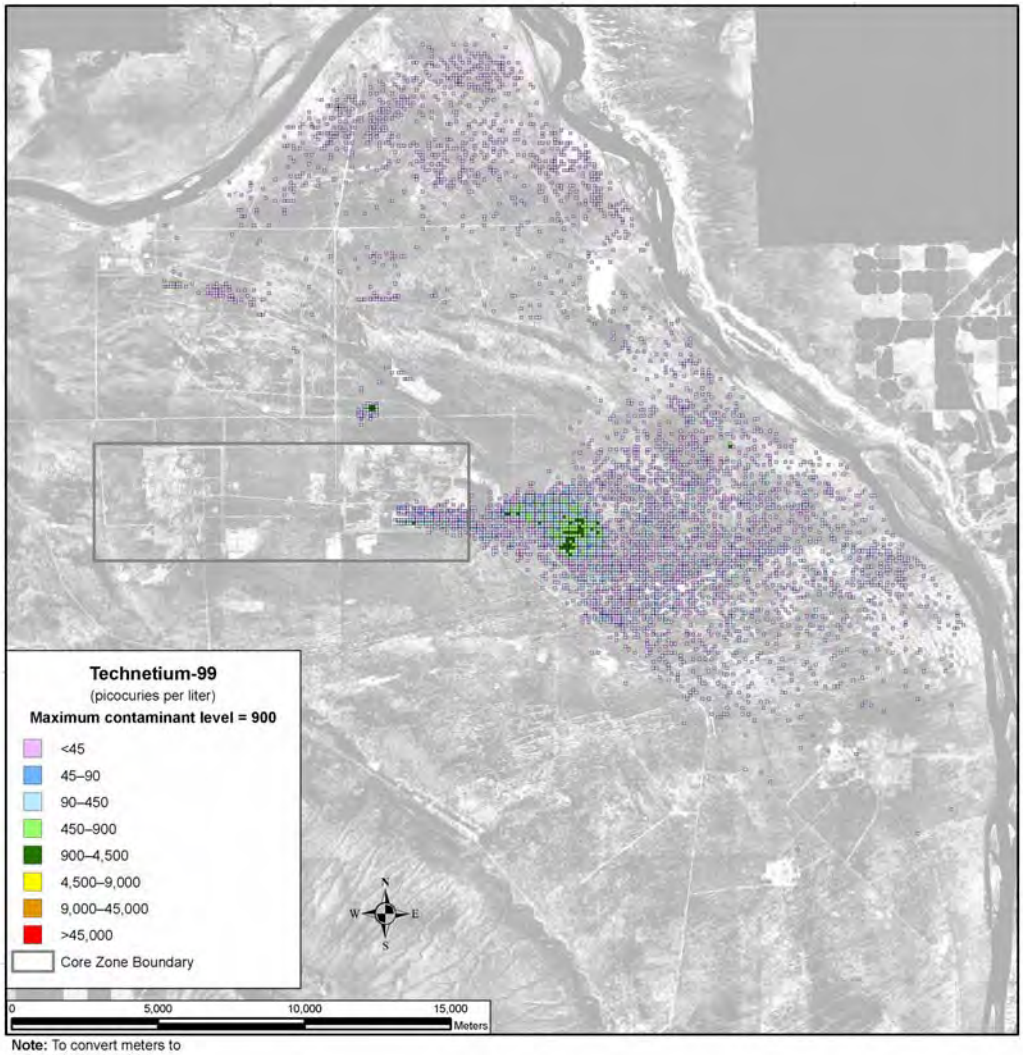


Figure 5–388. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

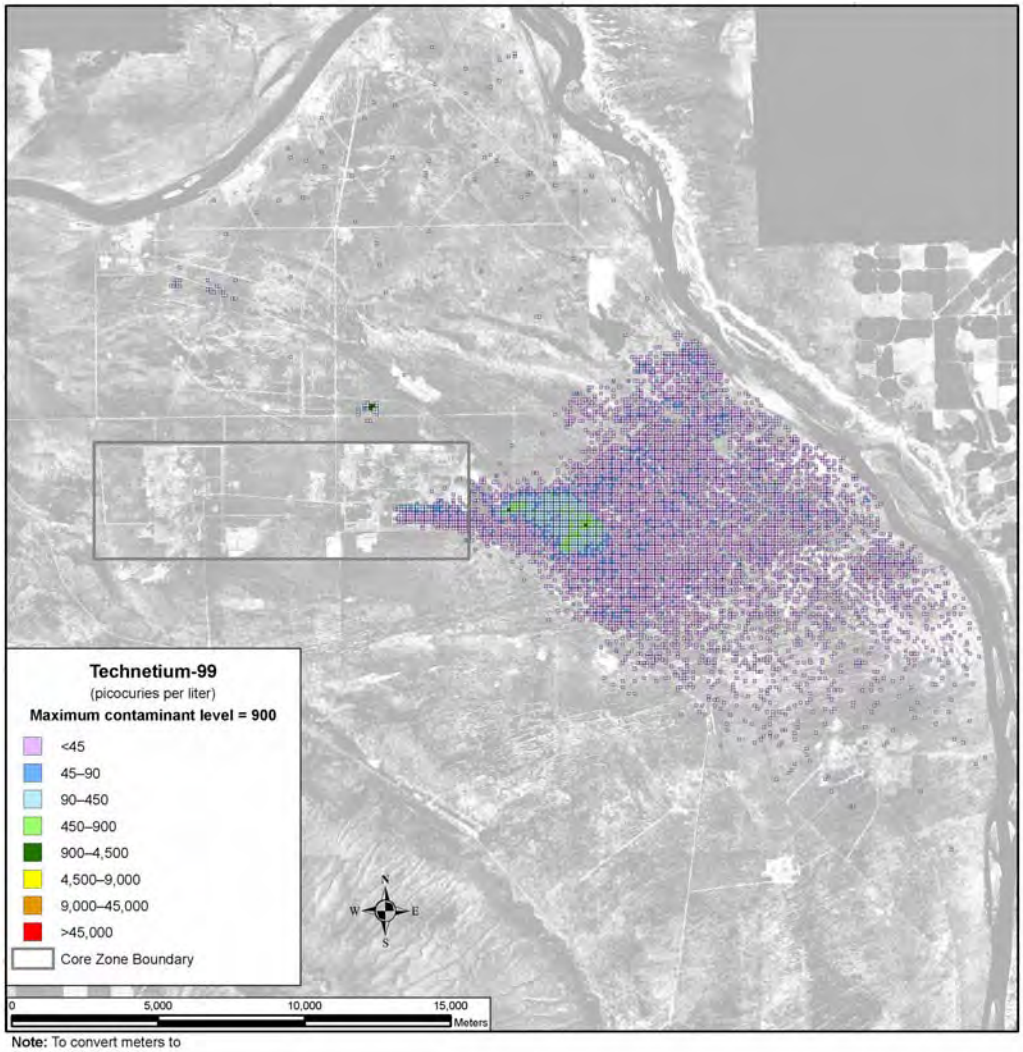


Figure 5–389. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

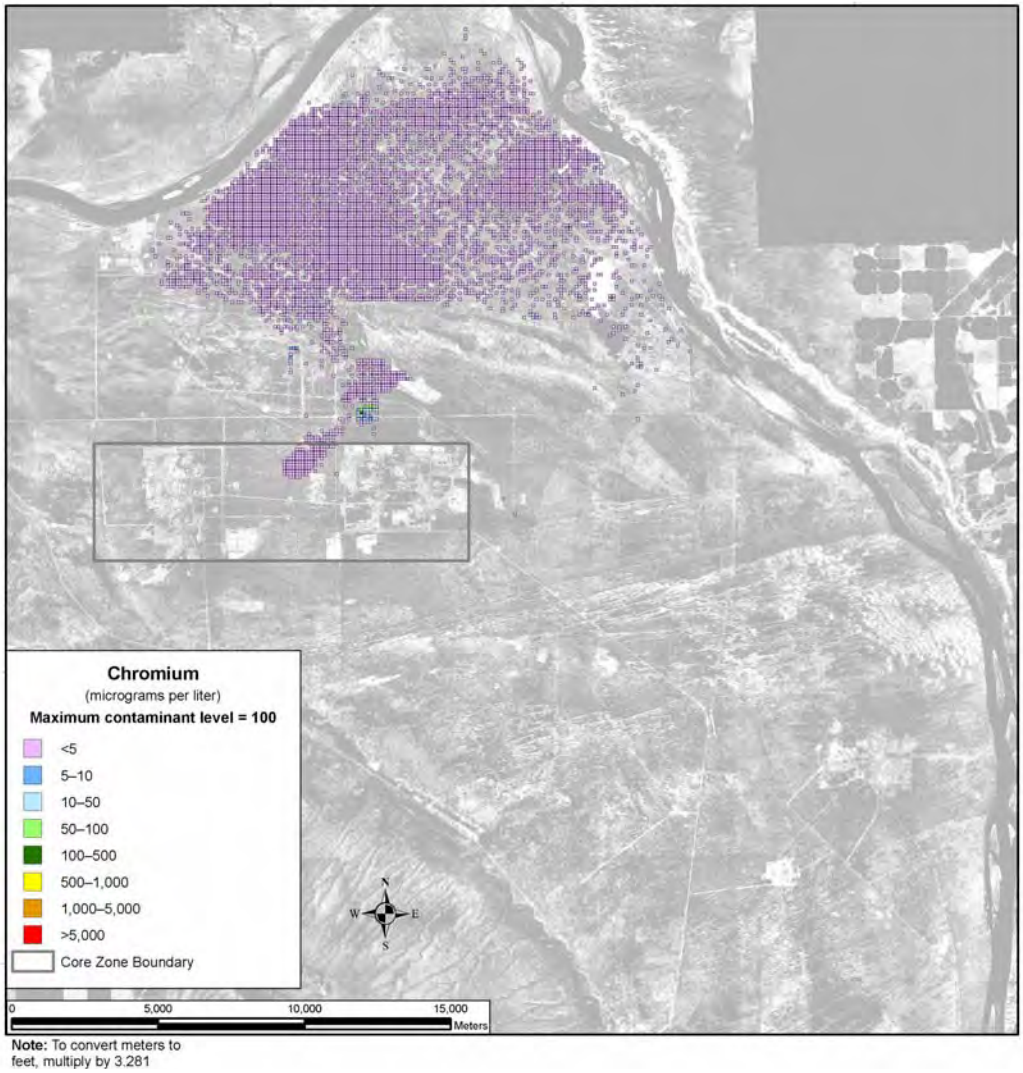


Figure 5–390. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

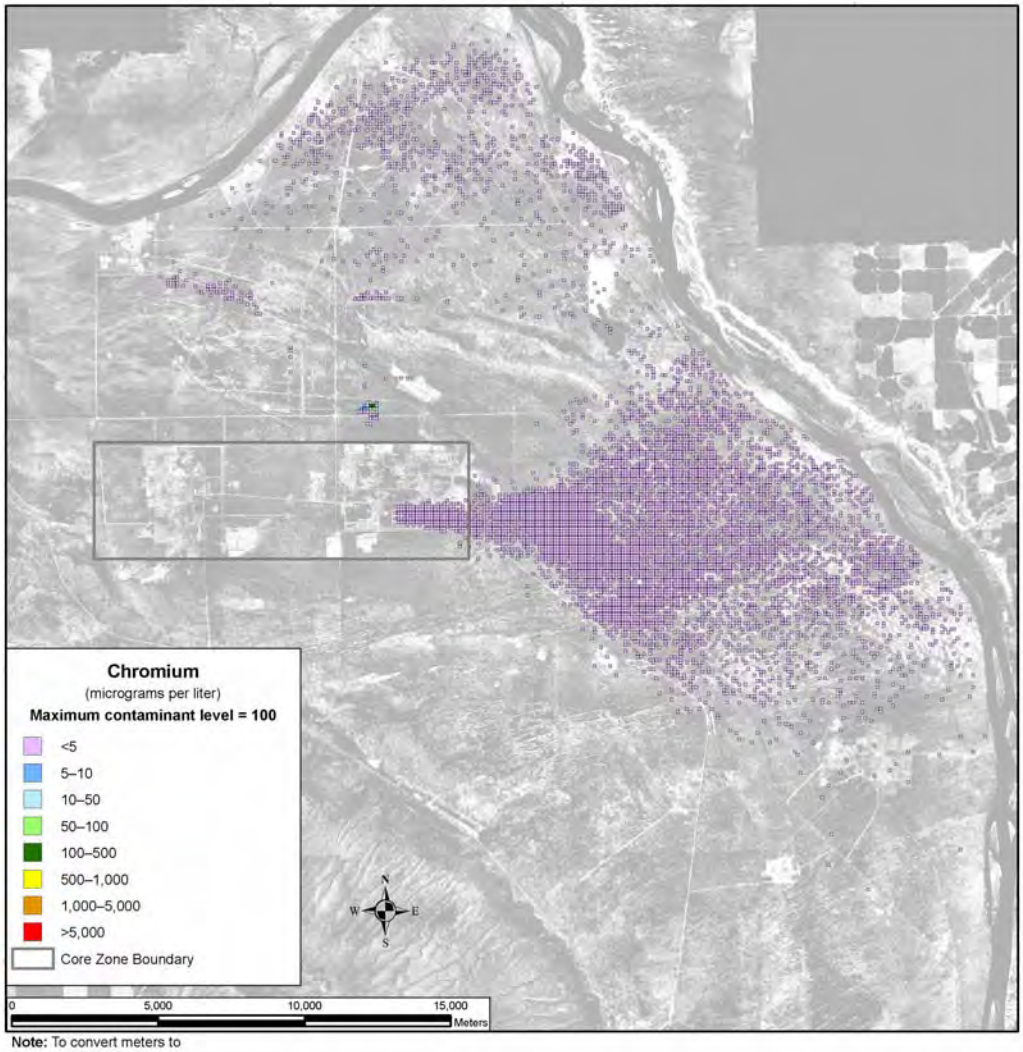


Figure 5–391. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

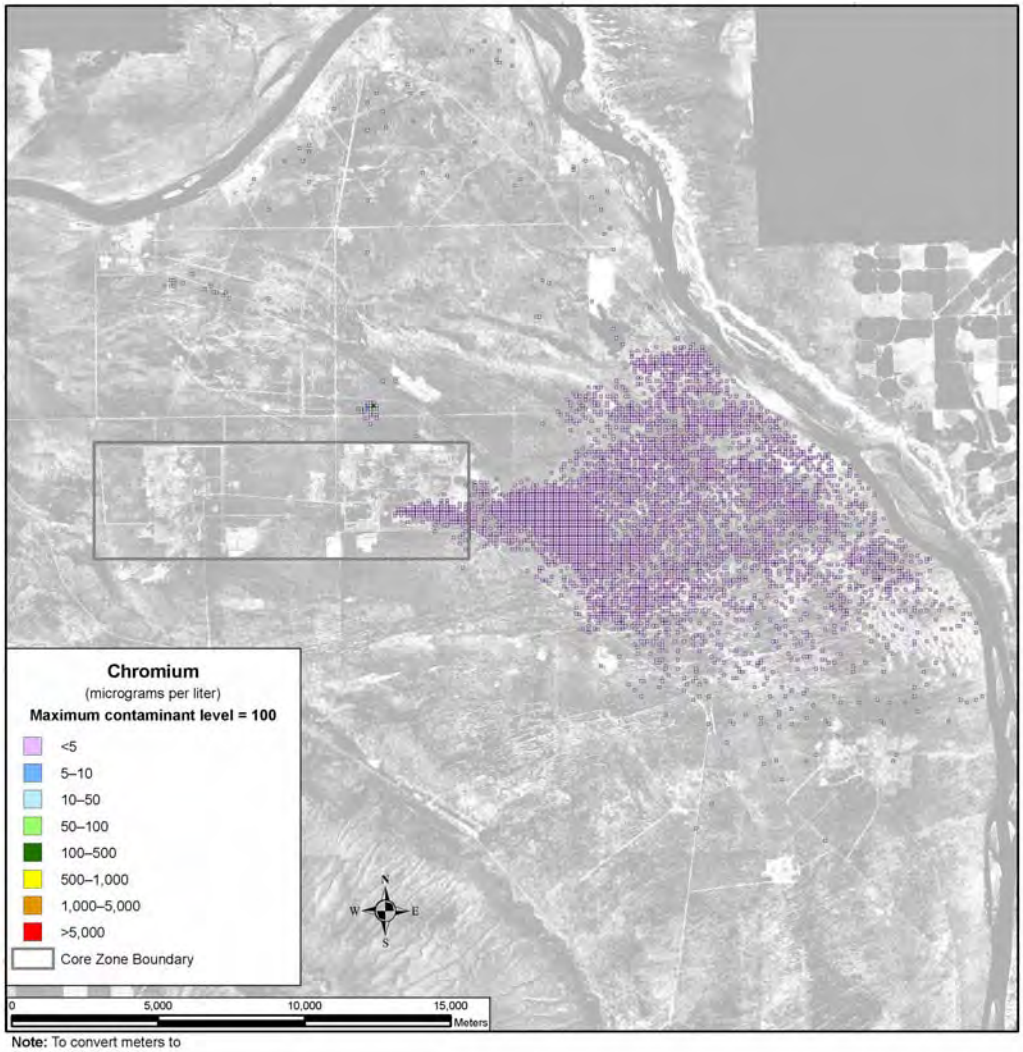


Figure 5–392. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

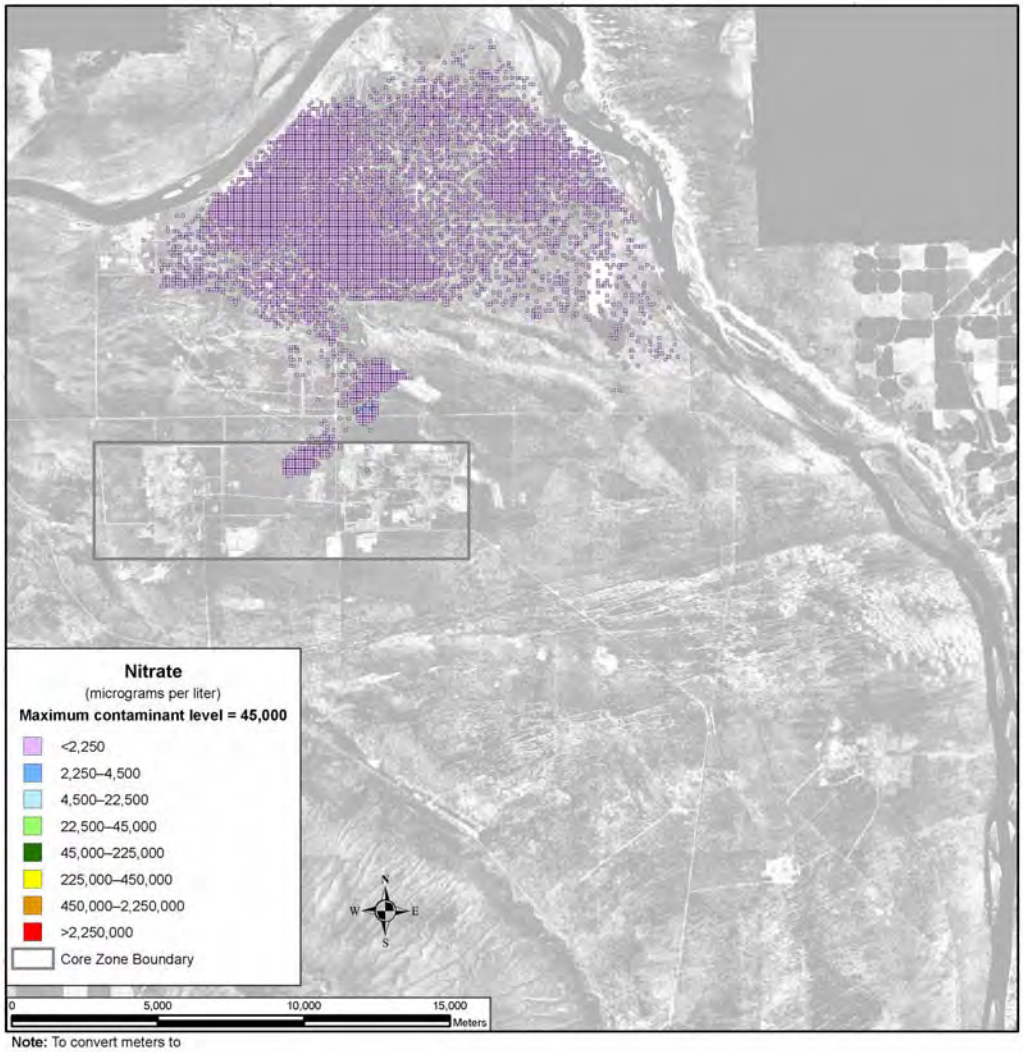


Figure 5–393. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

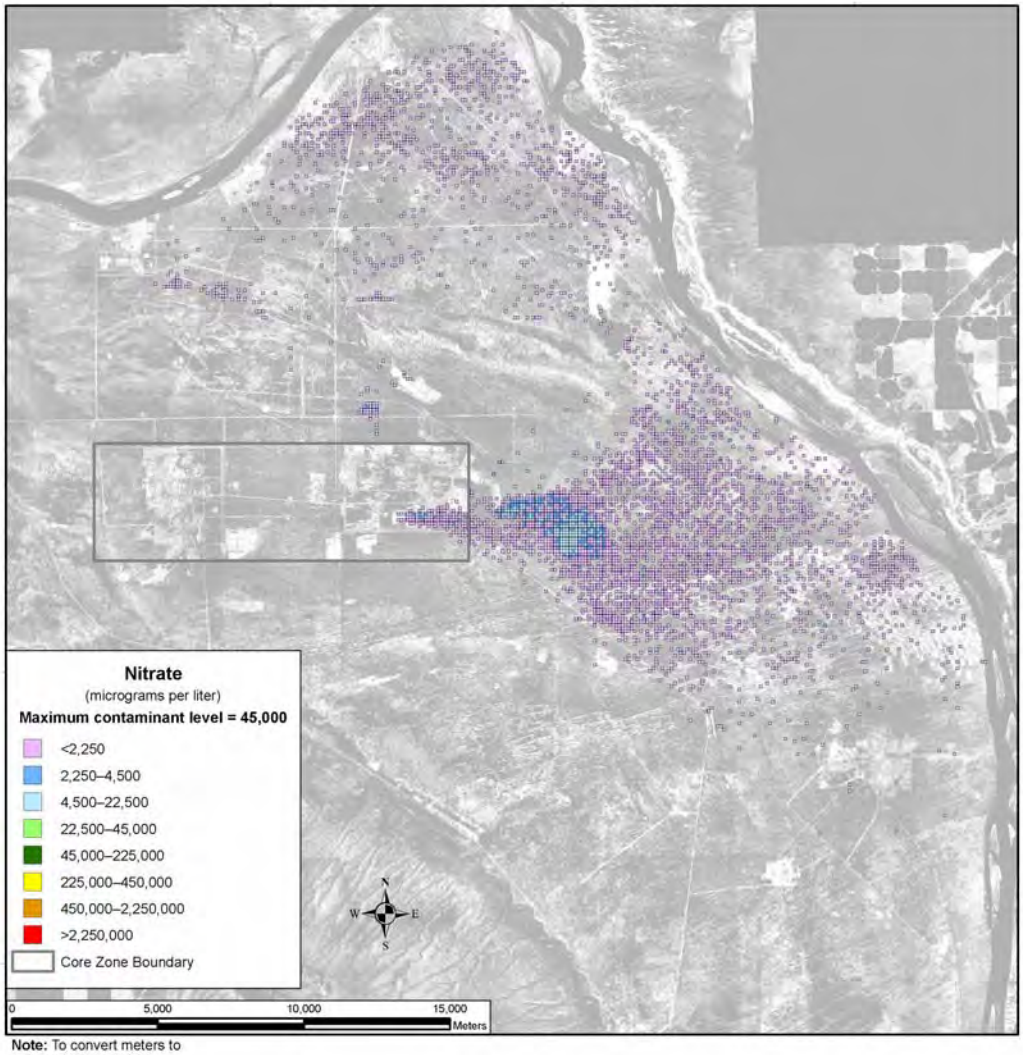


Figure 5–394. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

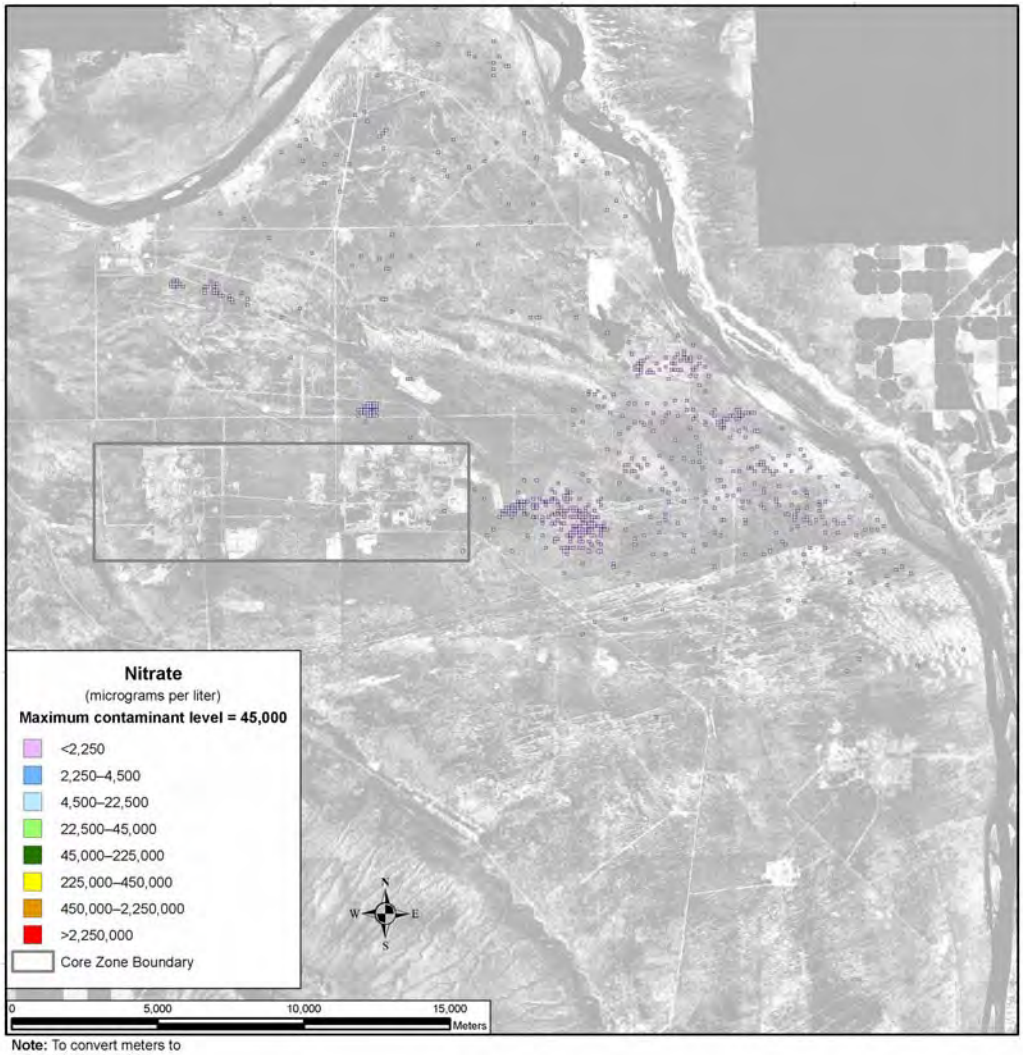


Figure 5–395. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–396 shows the distribution of total uranium at CY 11,885. There is a low-concentration plume that stretches north from the RPPDF and Gable Gap. Concentrations in all areas of the plume remain below one-tenth of the benchmark.

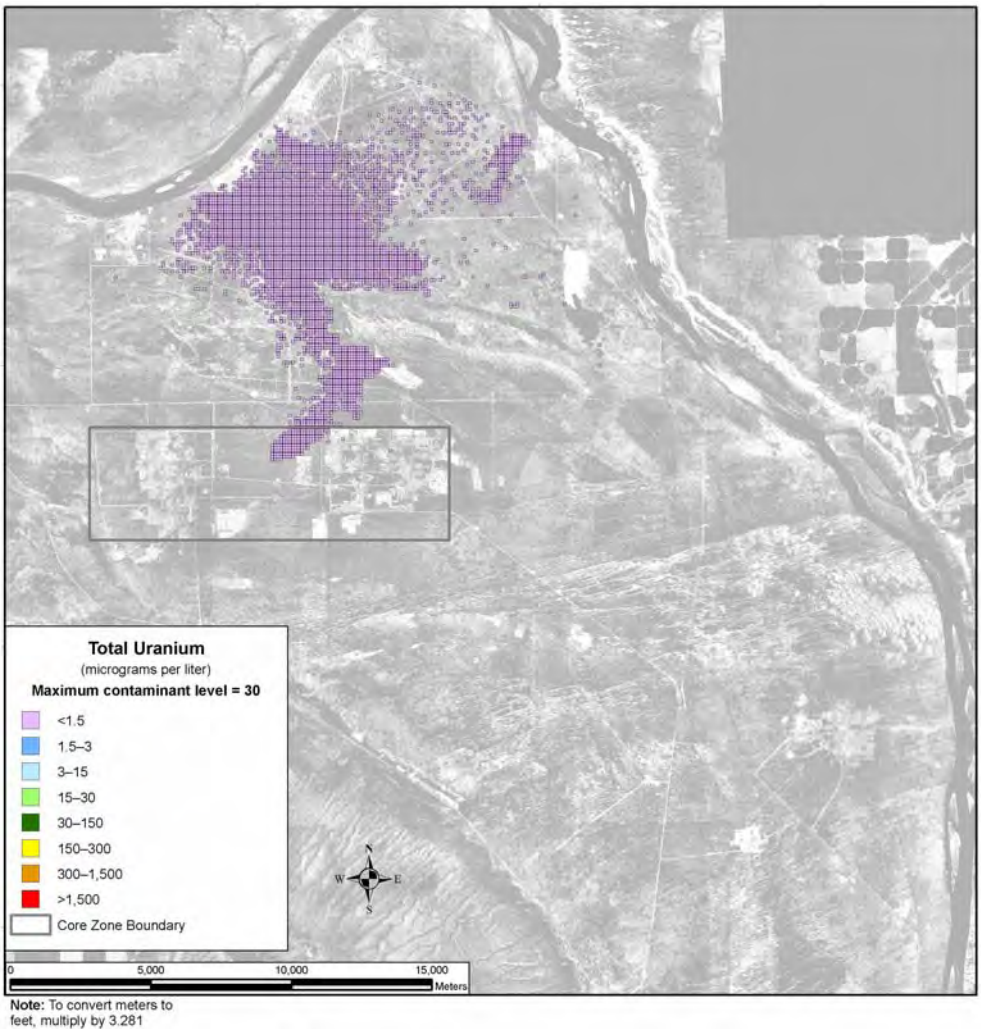


Figure 5–396. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, in general, the inventory remaining in IDF-East, available for release to the environment at the start of the post-disposal period, is the predominant contributor. The inventory available for release from the RPPDF during the post-disposal period is a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary approach or exceed benchmark standards by less than one order of magnitude during most of the period of analysis. Concentrations at the Columbia River nearshore are similar to or slightly lower than the concentrations at the Core Zone Boundary. The intensities and areas of these groundwater plumes peak between CYs 8000 and 9000.

For total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species are increasing, but are well below the benchmark at the Core Zone Boundary beyond CY 9940, and remain eight orders of magnitude below the benchmark at the Columbia River after CY 11,940. The peak intensity and area of the contamination plume are largest near the end of the period of analysis.

5.3.1.2.1.2 Disposal Group 1, Subgroup 1-B

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-B covers disposal of waste generated under Tank Closure Alternative 3A and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, and bulk vitrification glass. IHLW would be stored on site, while ILAW glass and bulk vitrification glass would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continue through CY 2050, when these facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.
- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2. Complete results for all 40 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 2 were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–397 through 5–408). Three subtotals are plotted representing releases from ILAW glass, bulk vitrification glass, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

Figure 5–397 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–398, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant sources of technetium-99 are bulk vitrification glass and offsite-generated waste; of iodine-129 is offsite-generated waste; and of boron is waste management secondary waste. The predominant sources for chromium are tank closure secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. The predominant sources for fluoride are waste management secondary waste and onsite-generated waste. The predominant source for nitrate is ETF-generated secondary waste.

Figure 5–399 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–400, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Nearly all of the technetium-99 and iodine-129 released to the vadose zone reached groundwater in the analysis, as well as nearly all of the chromium, fluoride, nitrate, and boron.

Figure 5–401 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–402, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99 and iodine-129, about 90 percent of the total amounts released from the vadose zone reached the Columbia River in the analysis; for chromium, about 93 percent; and for fluoride, nitrate, and boron, about 98 percent.

Figure 5–403 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–404, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e. 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF in the analysis (fluoride and boron are not).

Figure 5–405 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–406, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

Figure 5–407 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–408, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, and nitrate, approximately 100 percent of the total amounts released to the vadose zone at the RPPDF reached the Columbia River in the analysis.

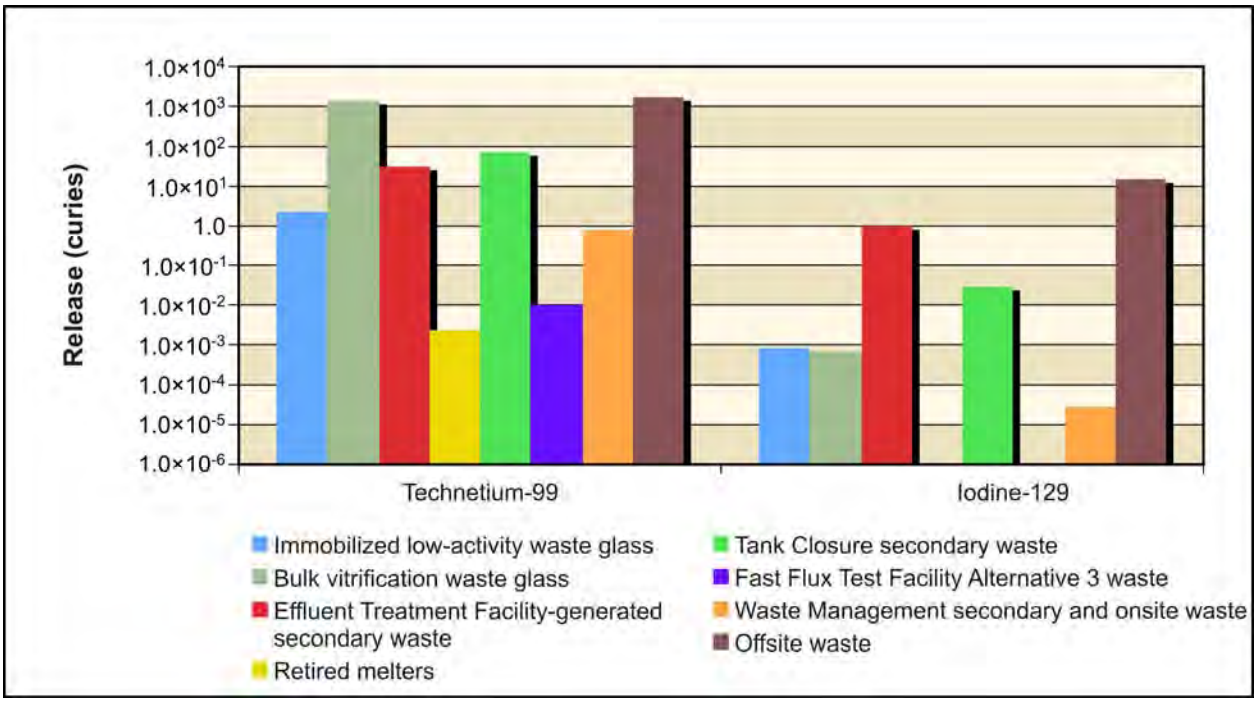


Figure 5–397. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

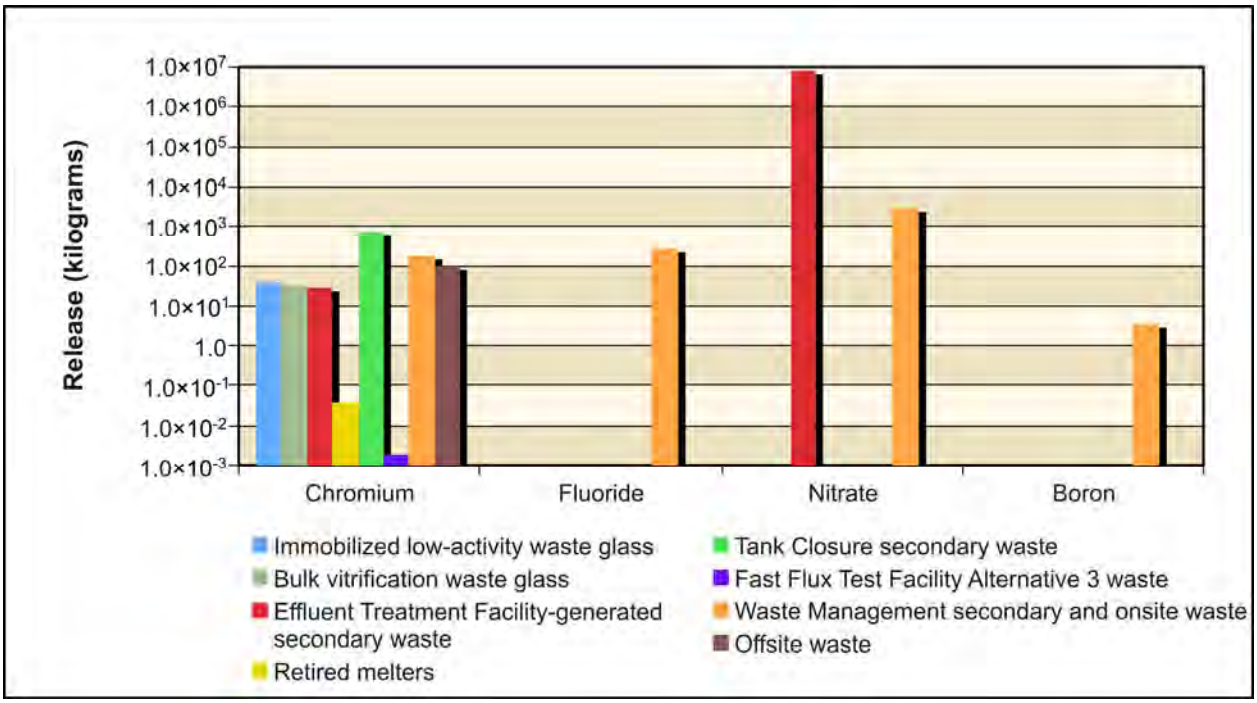


Figure 5–398. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

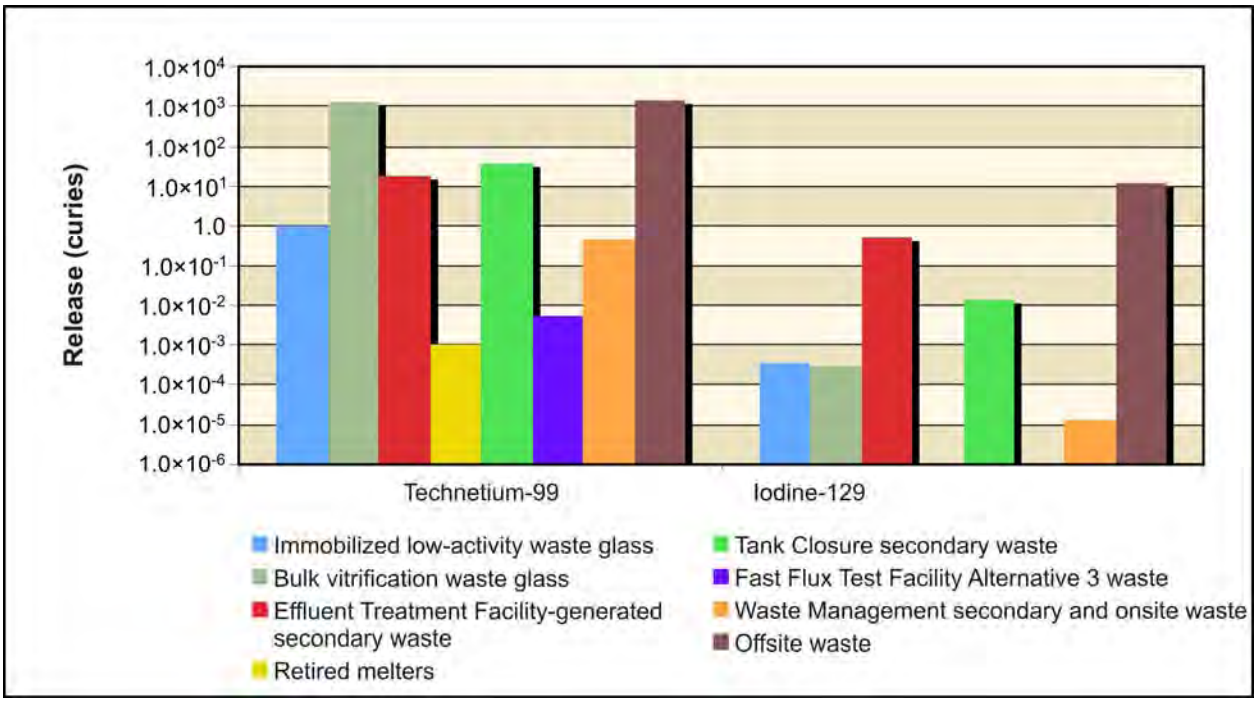


Figure 5–399. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

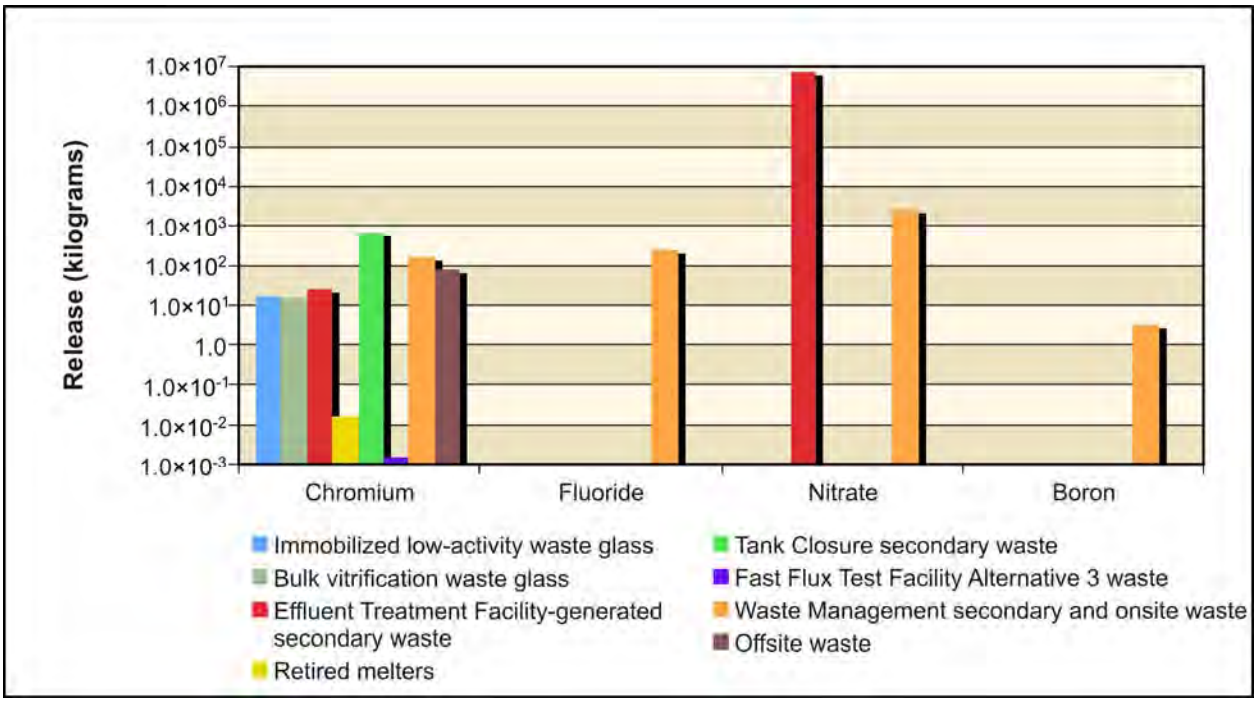


Figure 5–400. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

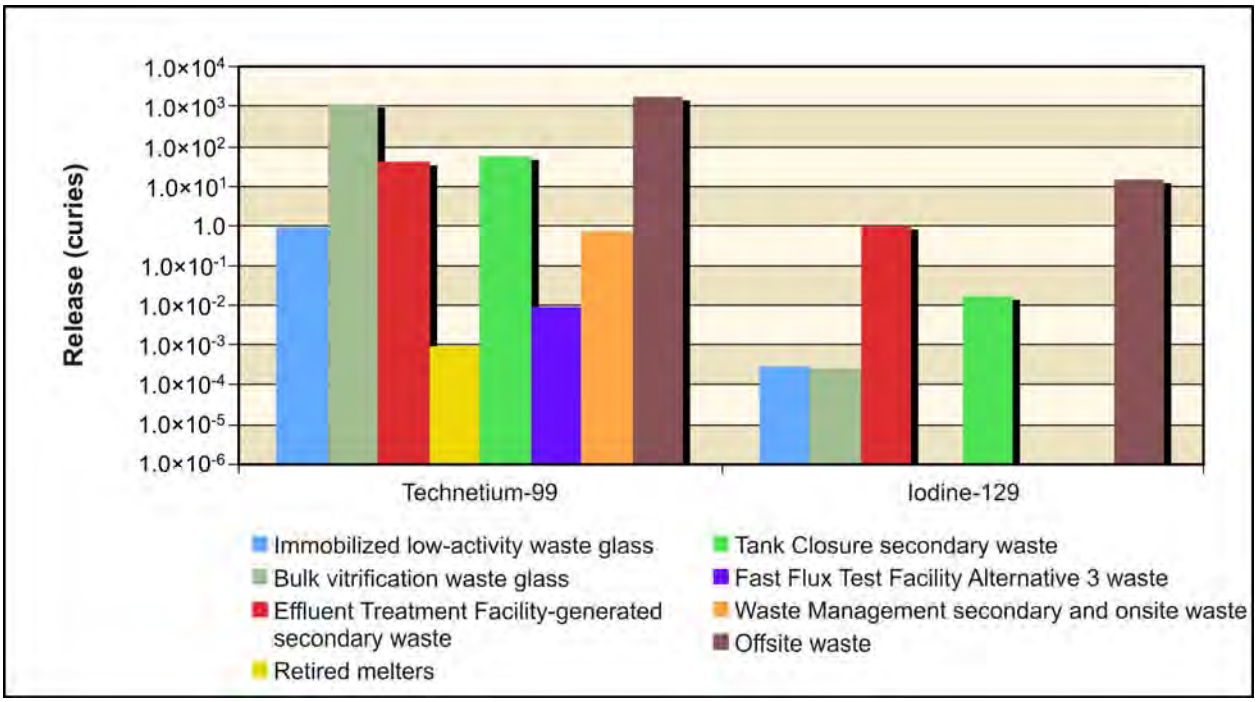


Figure 5–401. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

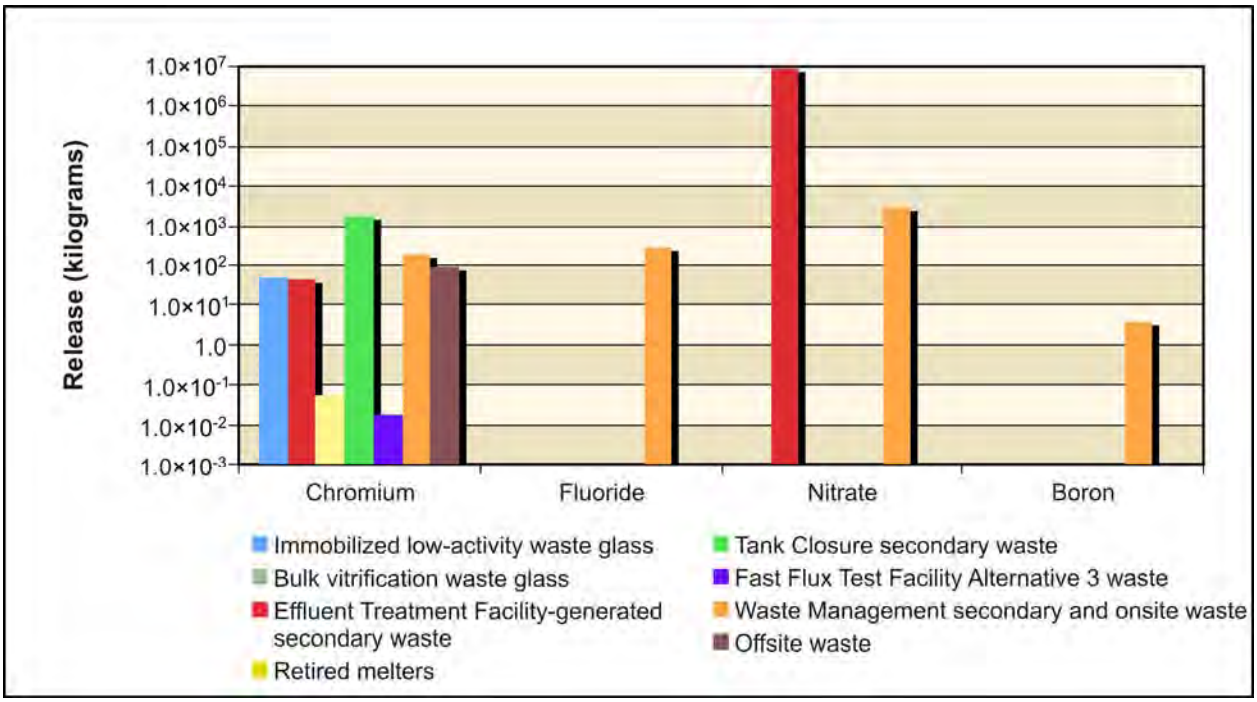


Figure 5–402. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

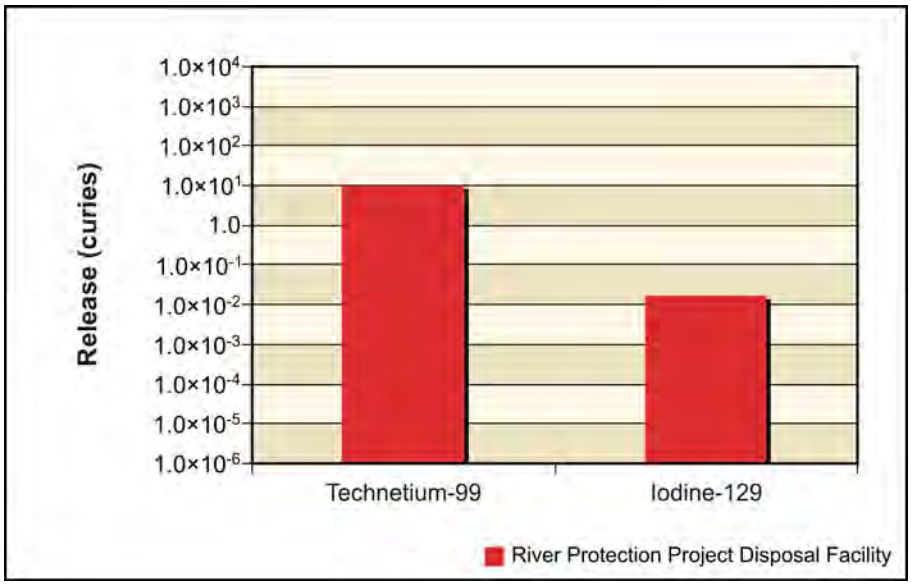


Figure 5–403. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

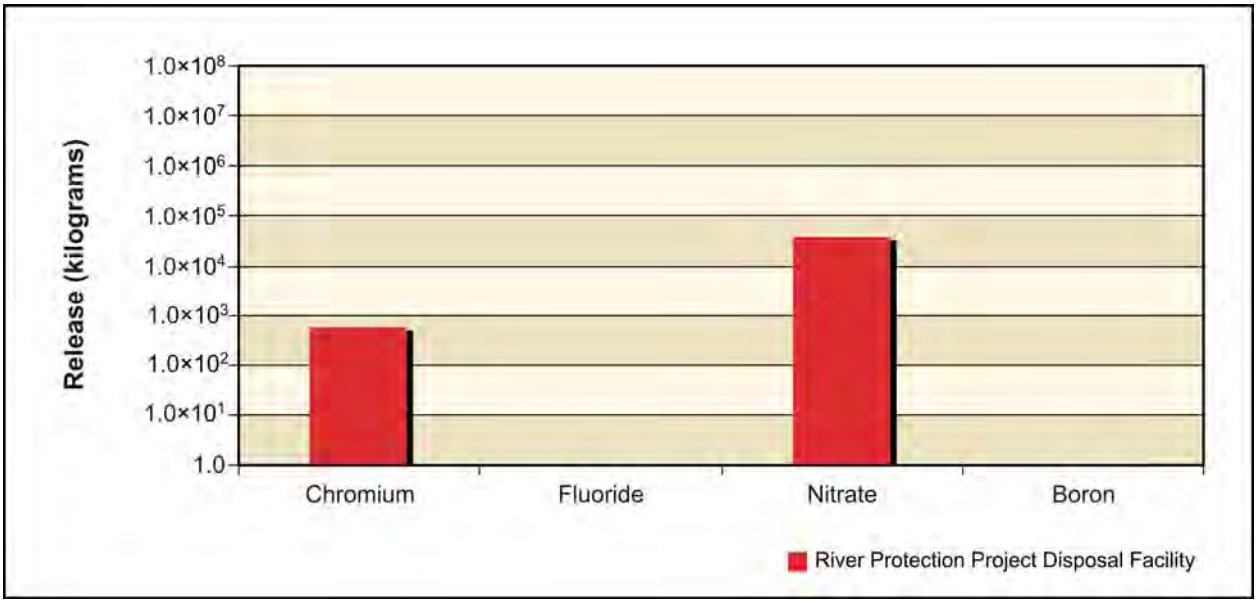


Figure 5–404. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

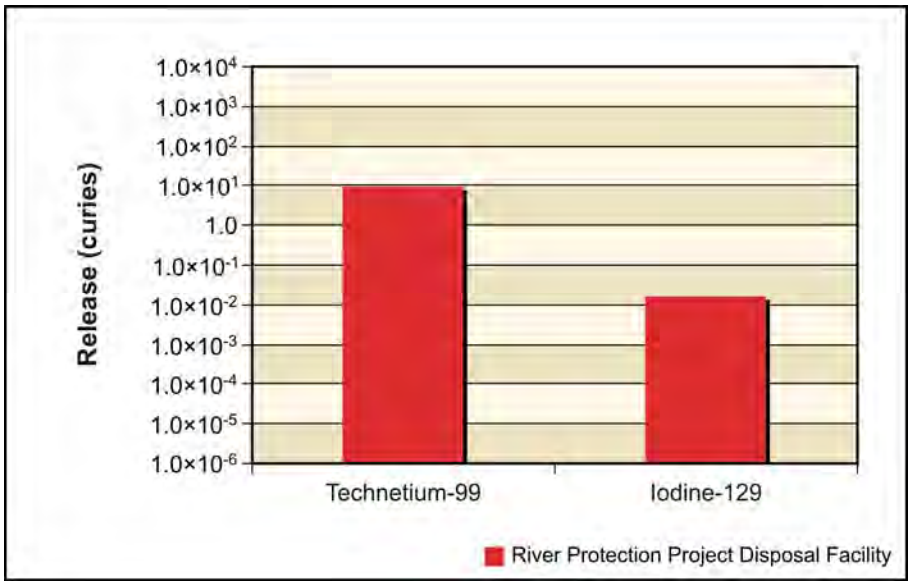


Figure 5–405. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Groundwater

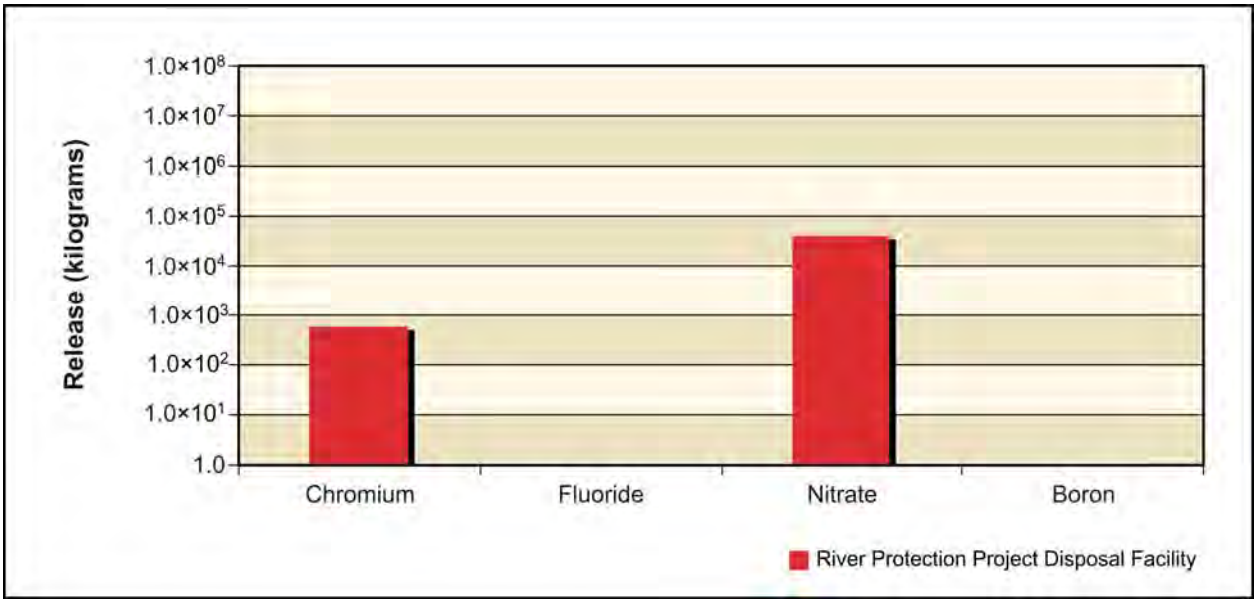


Figure 5–406. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Groundwater

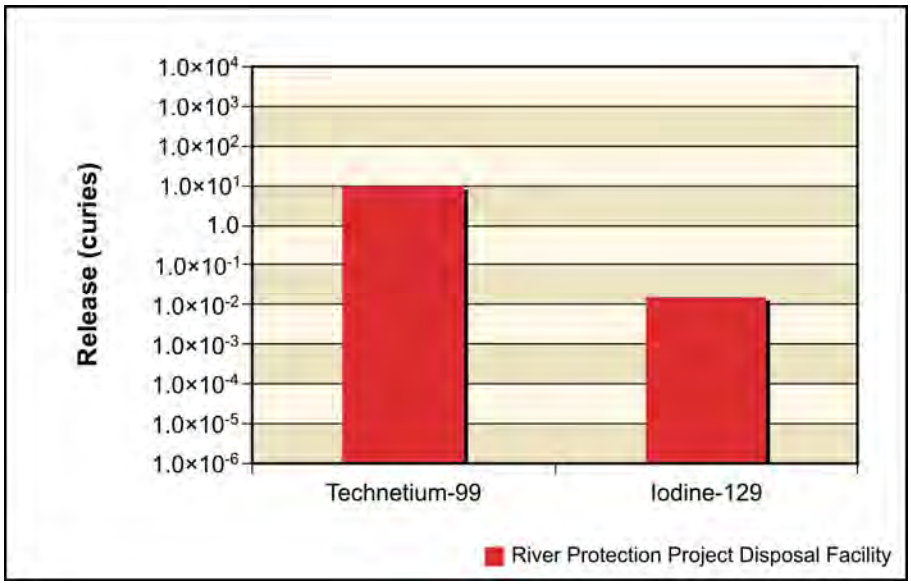


Figure 5–407. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Columbia River

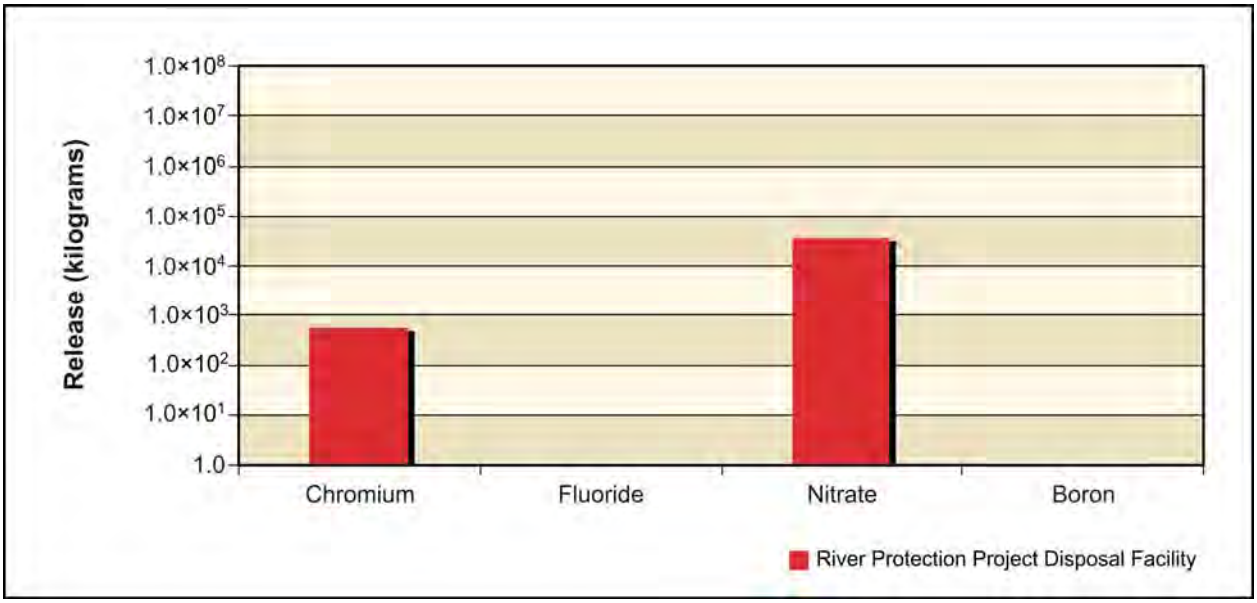


Figure 5–408. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter chemicals in micrograms per liter (see Figures 5–409 through 5–413). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude. Table 5–78 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–409 through 5–412 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, a small rise in concentration is evident in the early years, peaking around CY 3940, but remaining over an order of magnitude below the benchmark concentration. Beginning in CY 5400, concentrations at the Core Zone Boundary begin climbing again, reaching a level just below the benchmark concentration at CY 7940. Iodine-129 follows a similar pattern, reaching a concentration slightly above the benchmark, while chromium and nitrate peak over an order of magnitude below the benchmark.

Figure 5–413 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until CY 9940, when total uranium concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation. Uranium-238 does not surpass 1.0×10^{-8} picocuries per liter during the simulation.

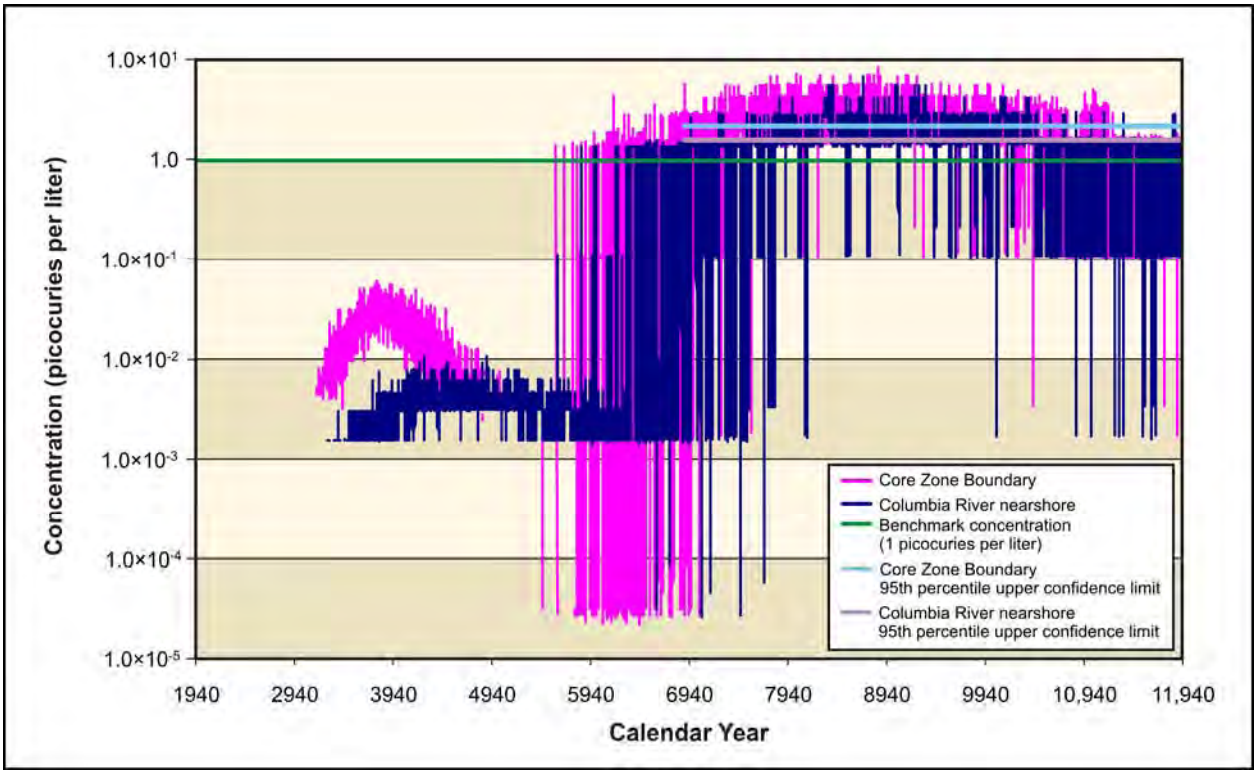


Figure 5–409. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Iodine-129 Concentration Versus Time

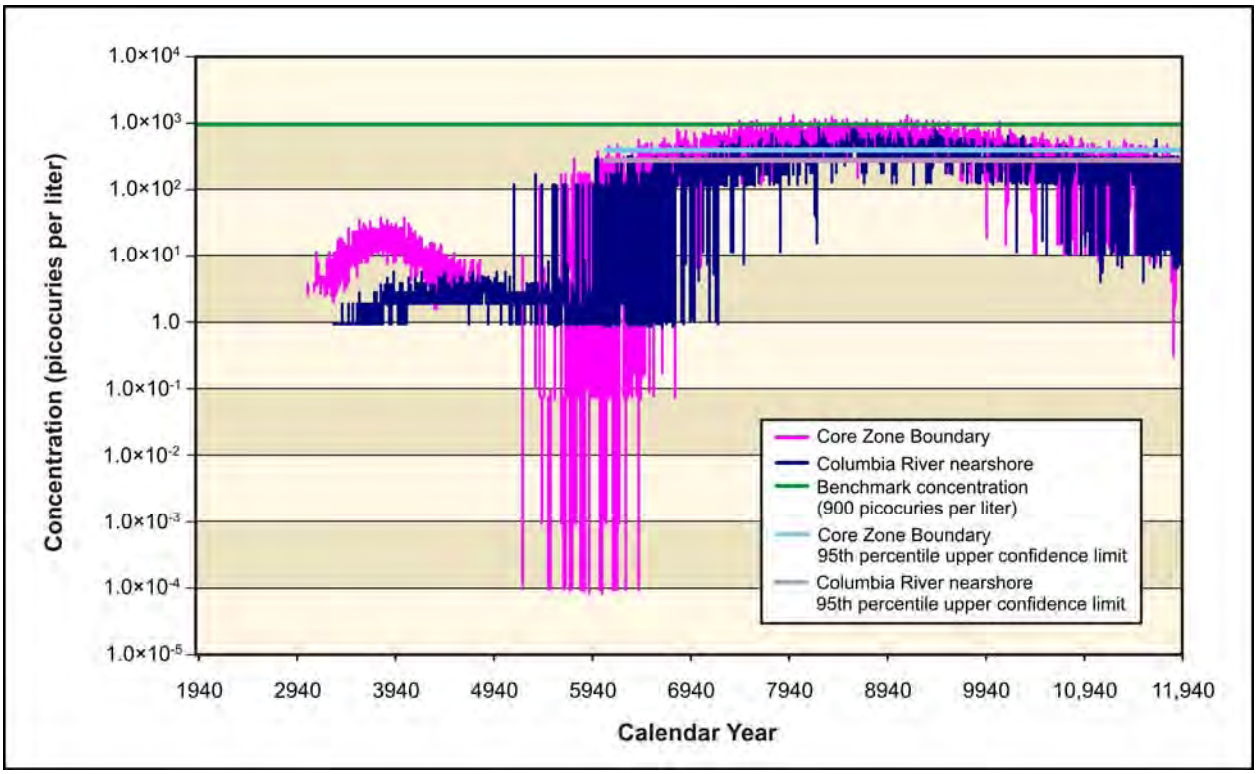


Figure 5–410. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Technetium-99 Concentration Versus Time

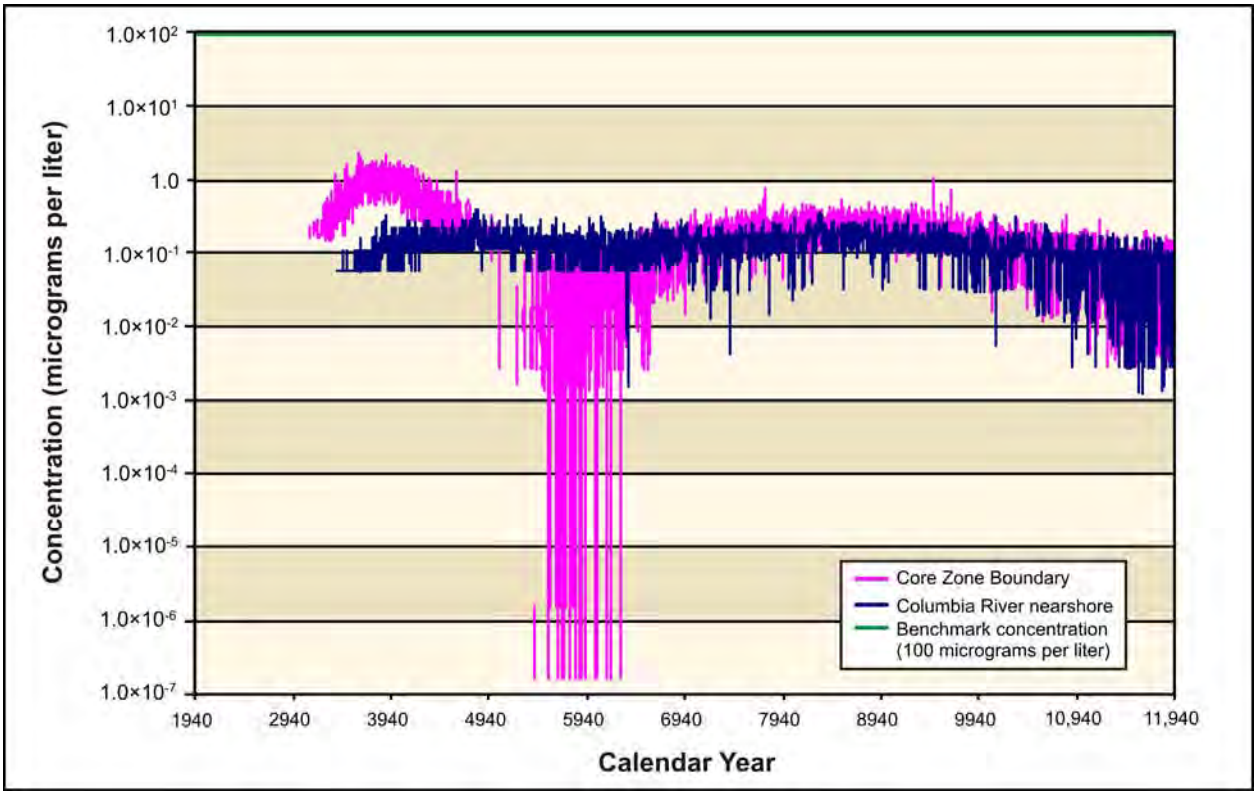


Figure 5–411. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chromium Concentration Versus Time

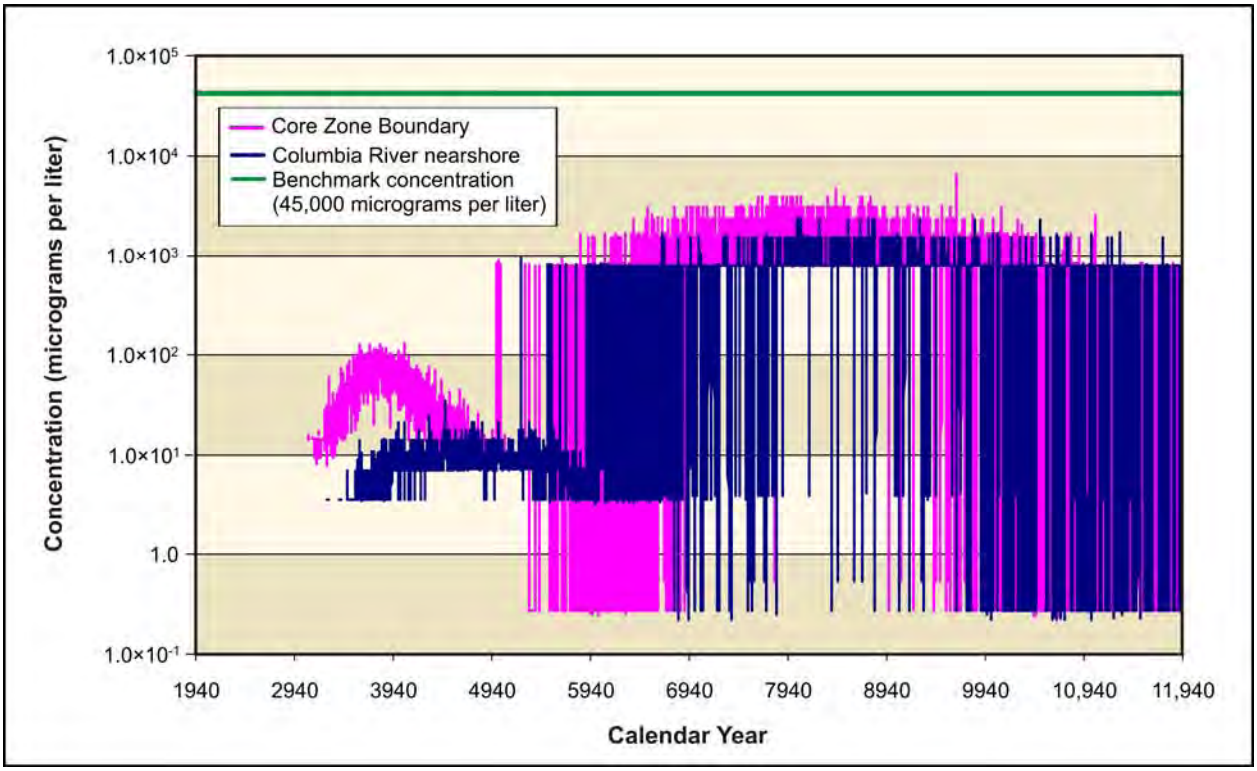


Figure 5–412. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Nitrate Concentration Versus Time

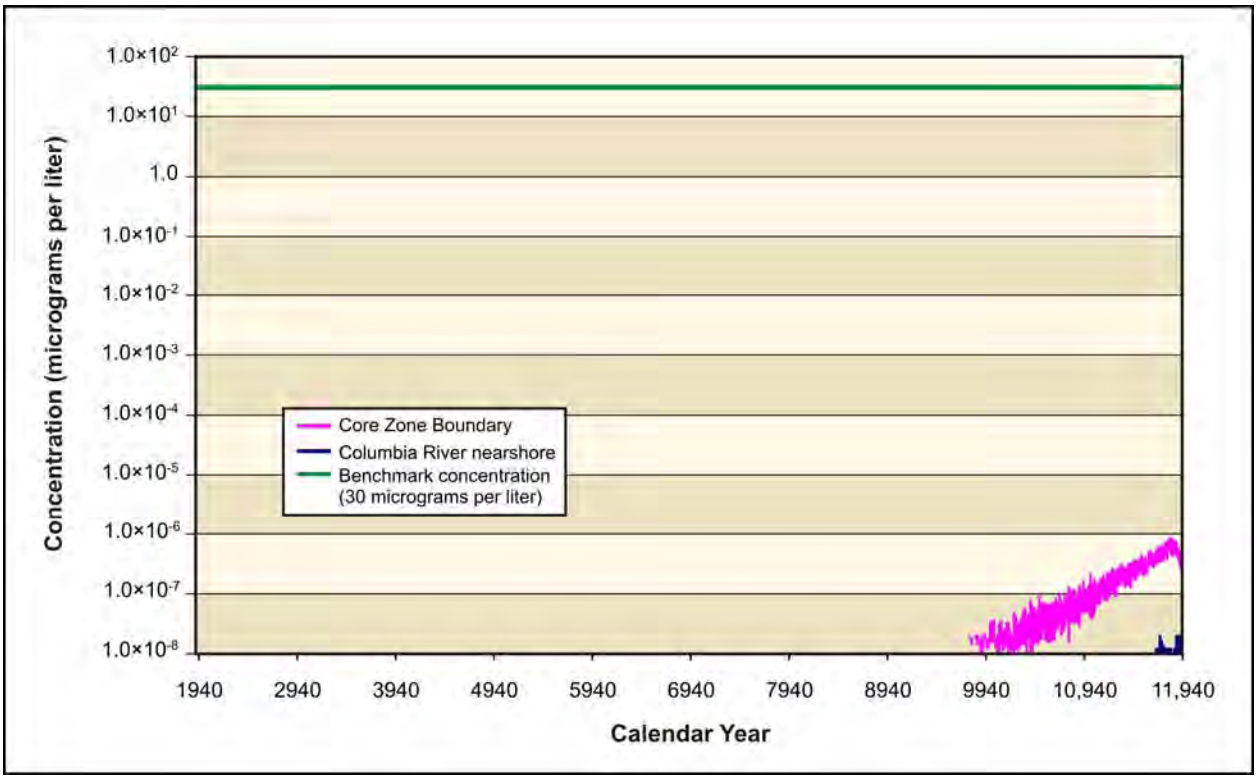


Figure 5–413. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Total Uranium Concentration Versus Time

Table 5–78. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,880**	33	**1,250**	815	900
	(8486)	(3825)	(7998)	(8273)	
Iodine-129	**18**	0.1	**8**	**7**	1
	(8195)	(3772)	(8858)	(8700)	
Chemical in micrograms per liter					
Chromium	2	2	2	0	100
	(8278)	(3856)	(3889)	(4826)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,400	149	5,860	3,680	45,000
	(7821)	(3811)	(8905)	(8144)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=an Integrated Disposal Facility in the 200-East Area of Hanford; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–414 through 5–426). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890 (see Figure 5–414), there is a low-concentration plume of iodine-129 that stretches north from the RPPDF and through Gable Gap. By CY 7140 (see Figure 5–415), the plume from the RPPDF is gone, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume reach a level over an order of magnitude above the benchmark. Figure 5–416 shows the iodine-129 concentration for CY 11,885. Technetium-99 (see Figures 5–417 through 5–419), chromium (see Figures 5–420 through 5–422), and nitrate (see Figures 5–423 through 5–425) show similar spatial distributions, with lower concentrations at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium shows a different spatial distribution over time. It is not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, there is a plume extending through Gable Gap from the RPPDF (see Figure 5–426). Concentrations in all areas of the plume remain below one-twentieth of the benchmark.

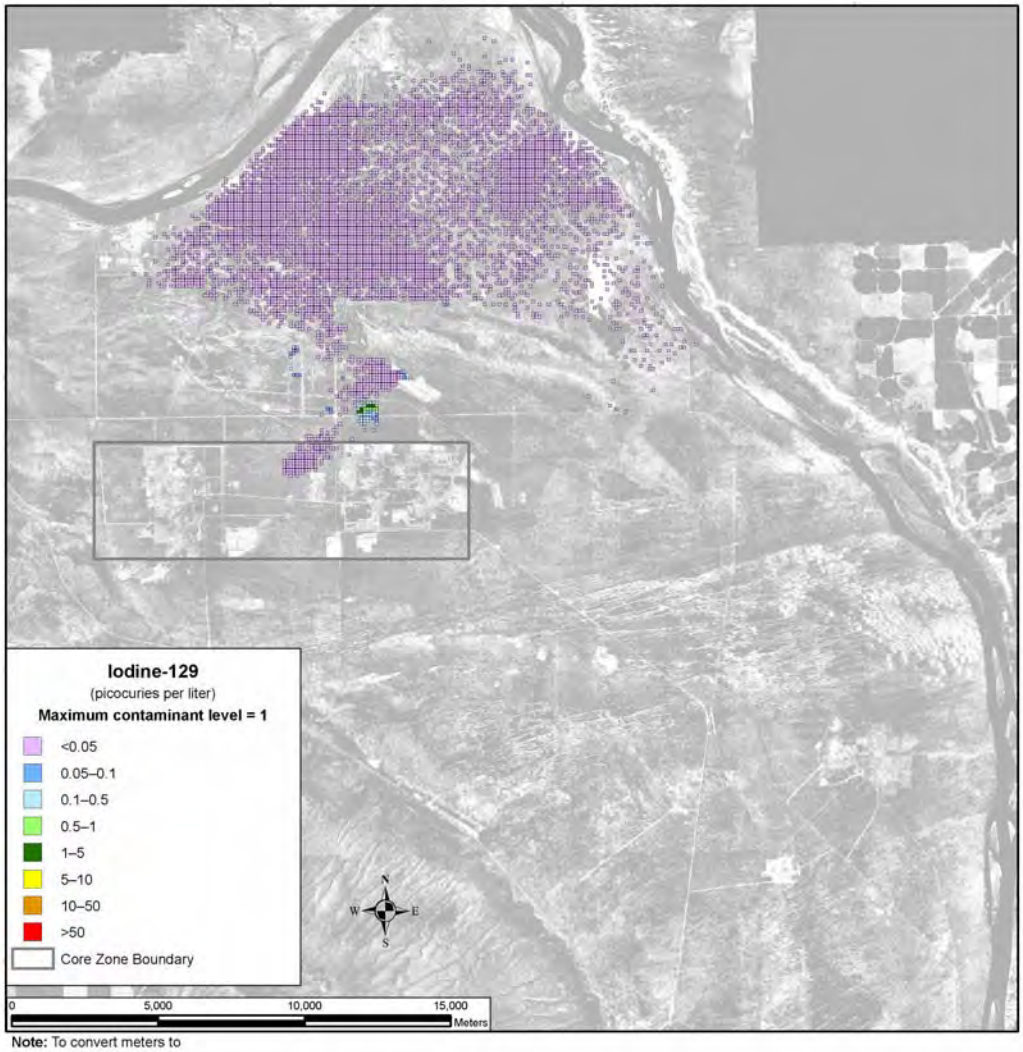


Figure 5–414. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

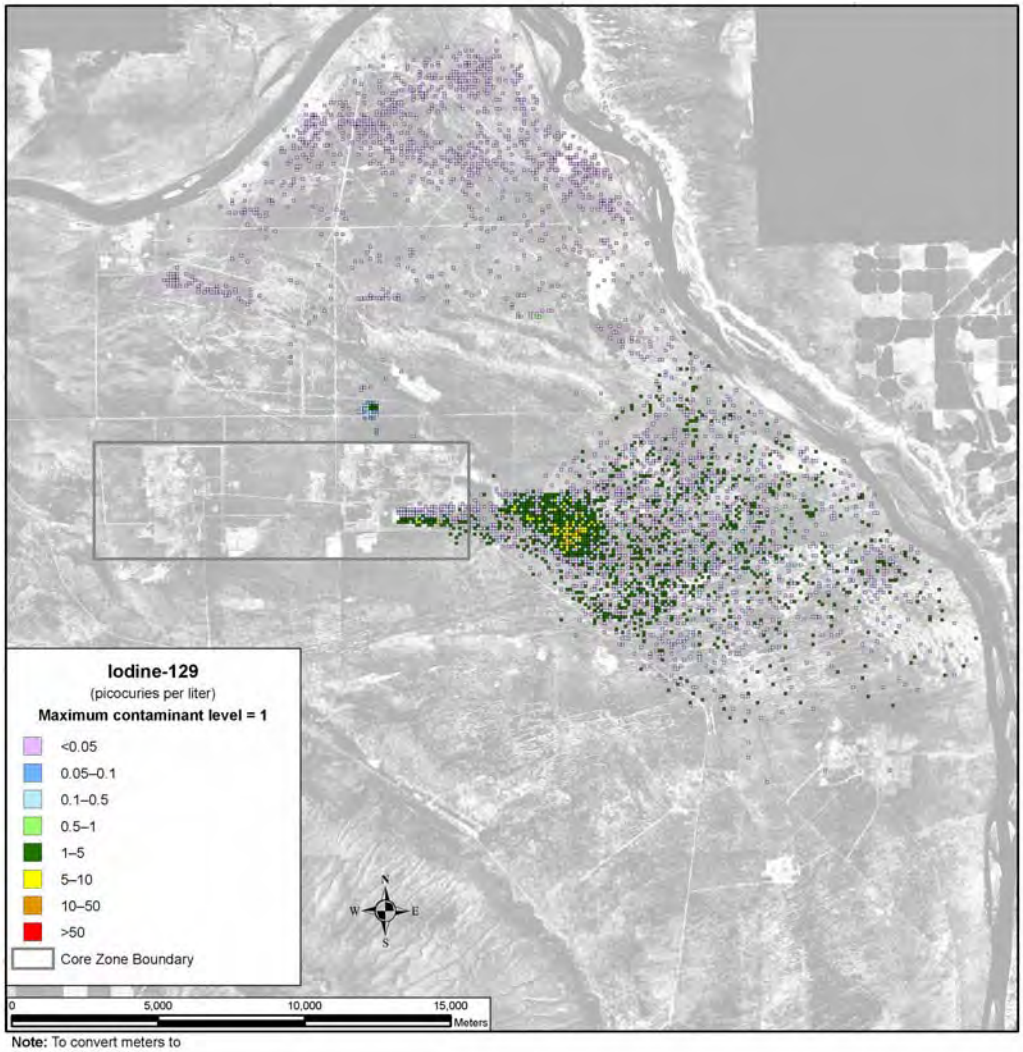


Figure 5–415. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

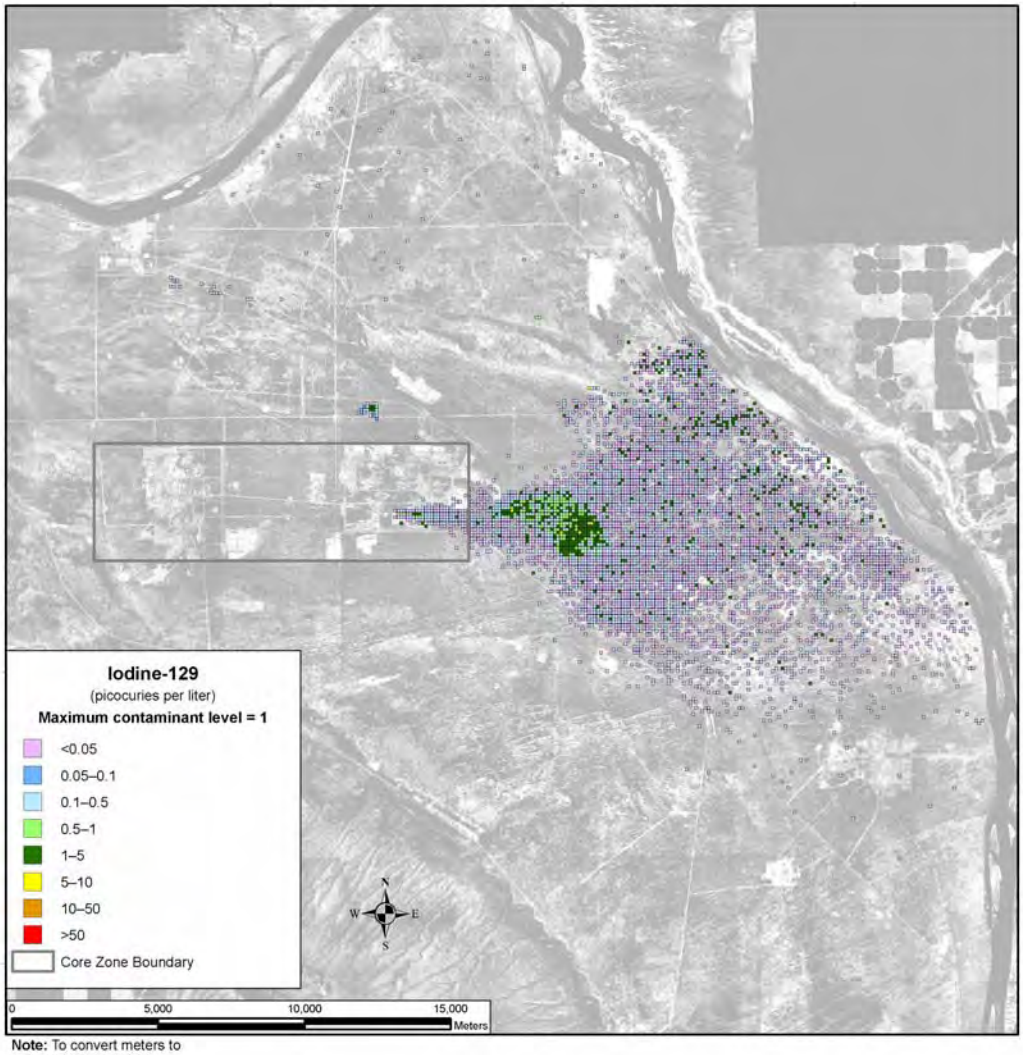


Figure 5–416. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

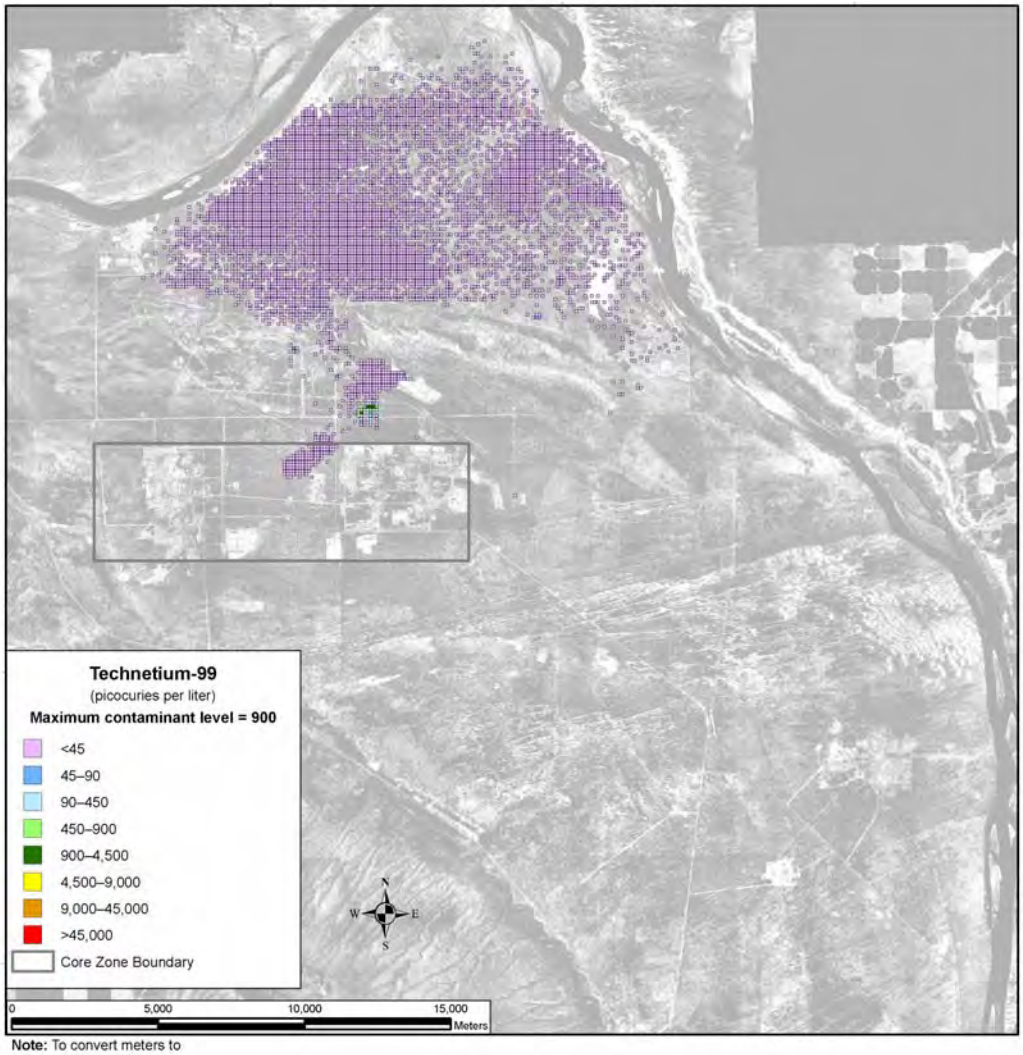


Figure 5–417. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

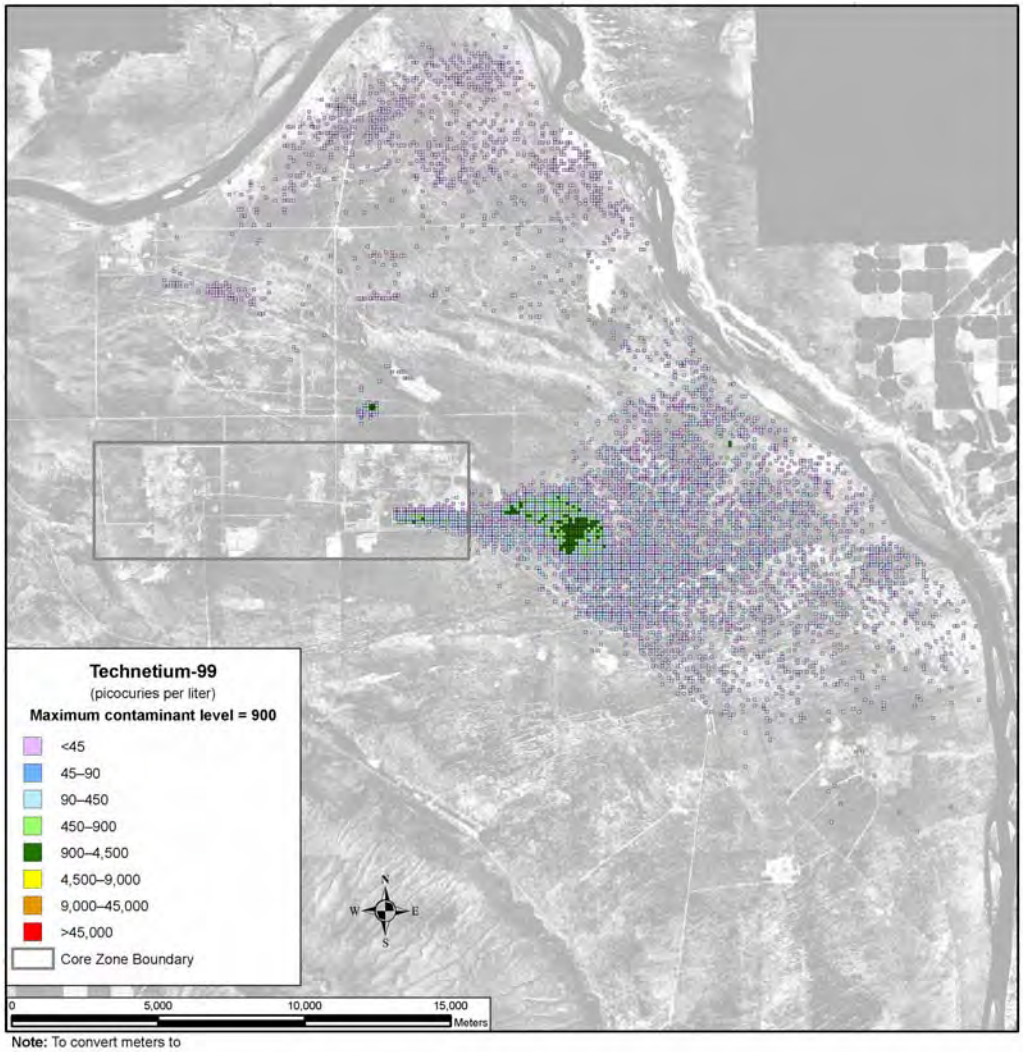


Figure 5–418. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

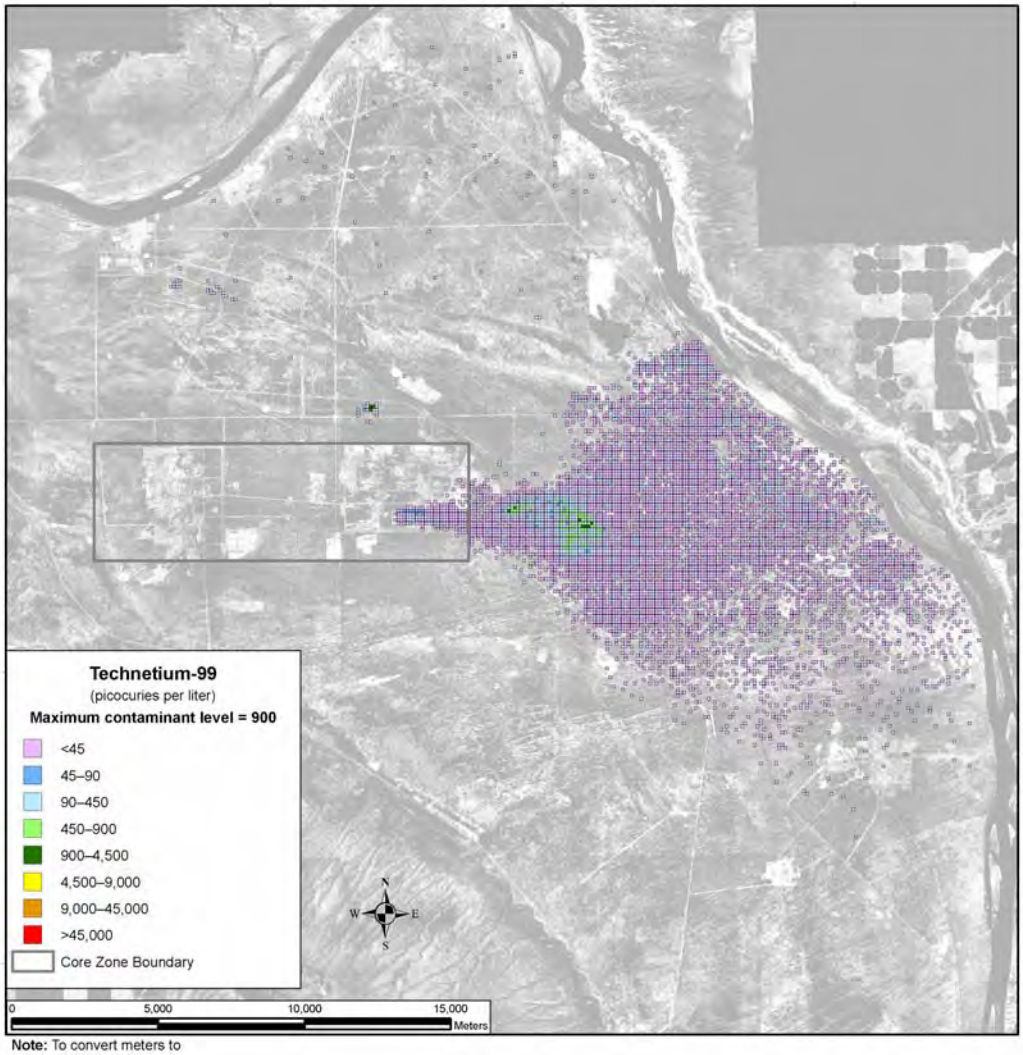


Figure 5–419. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

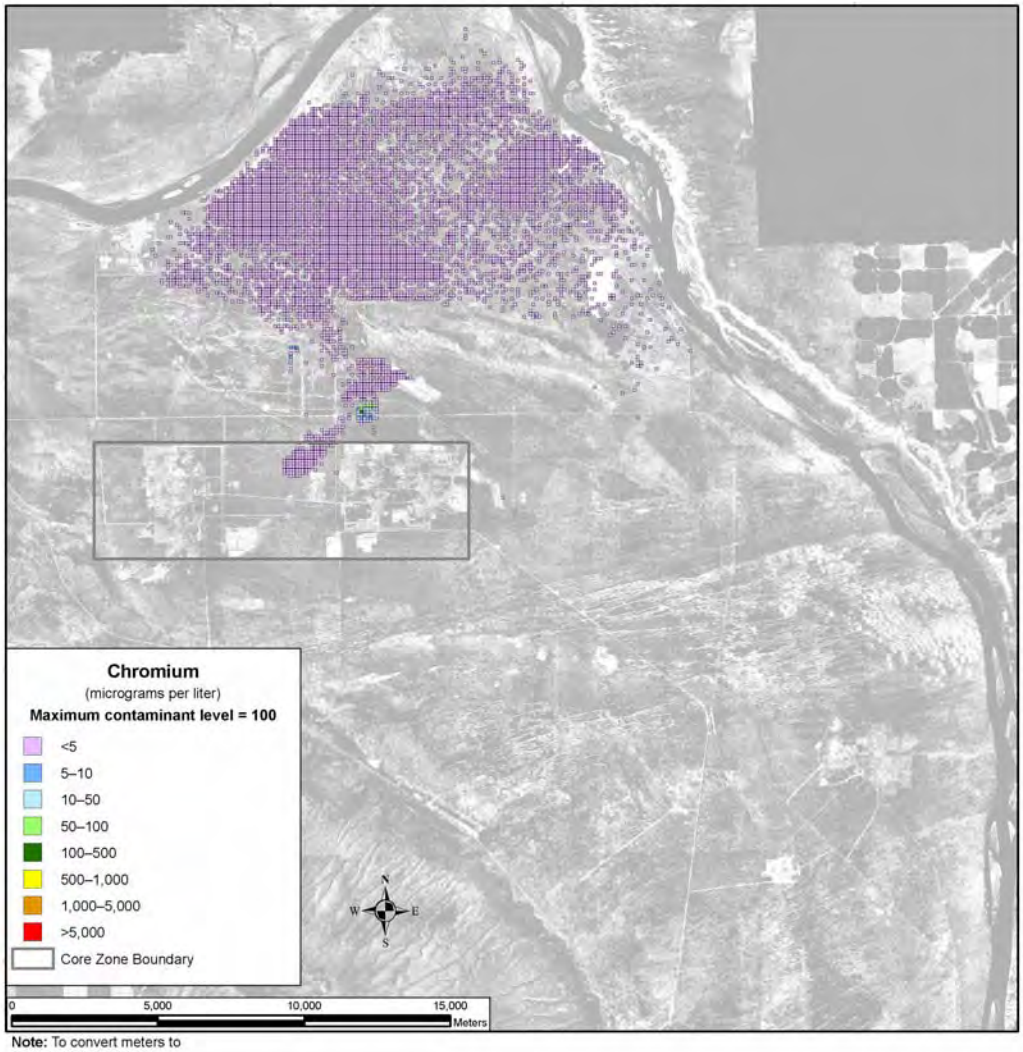


Figure 5–420. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

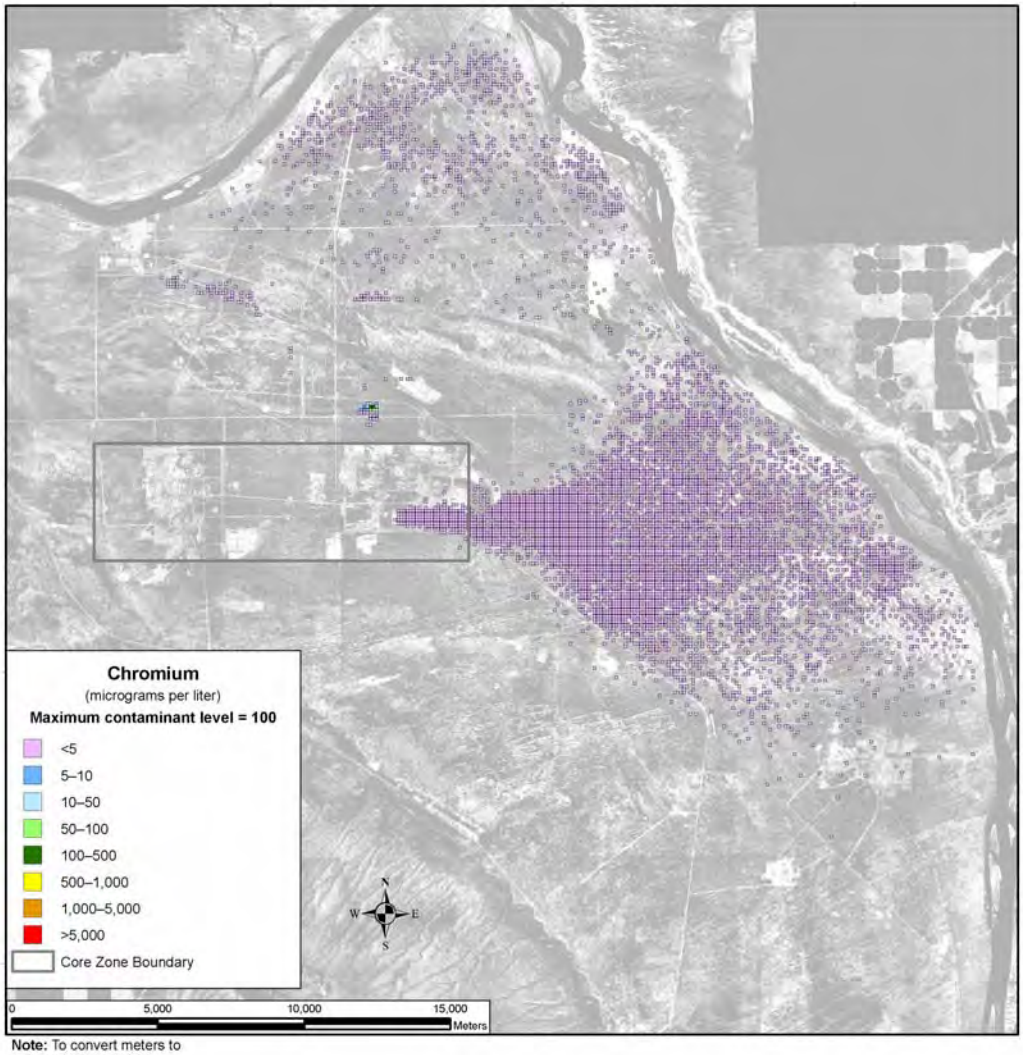


Figure 5–421. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

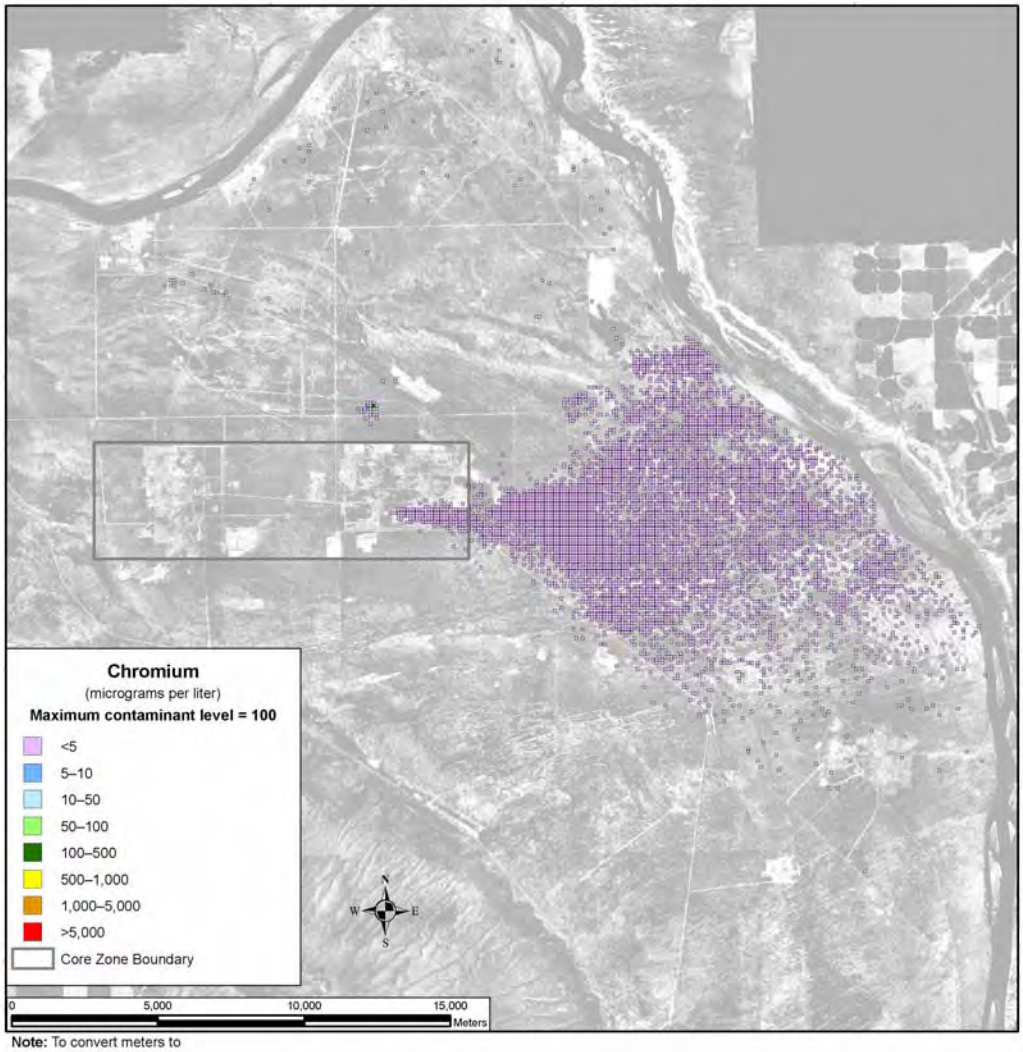


Figure 5–422. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

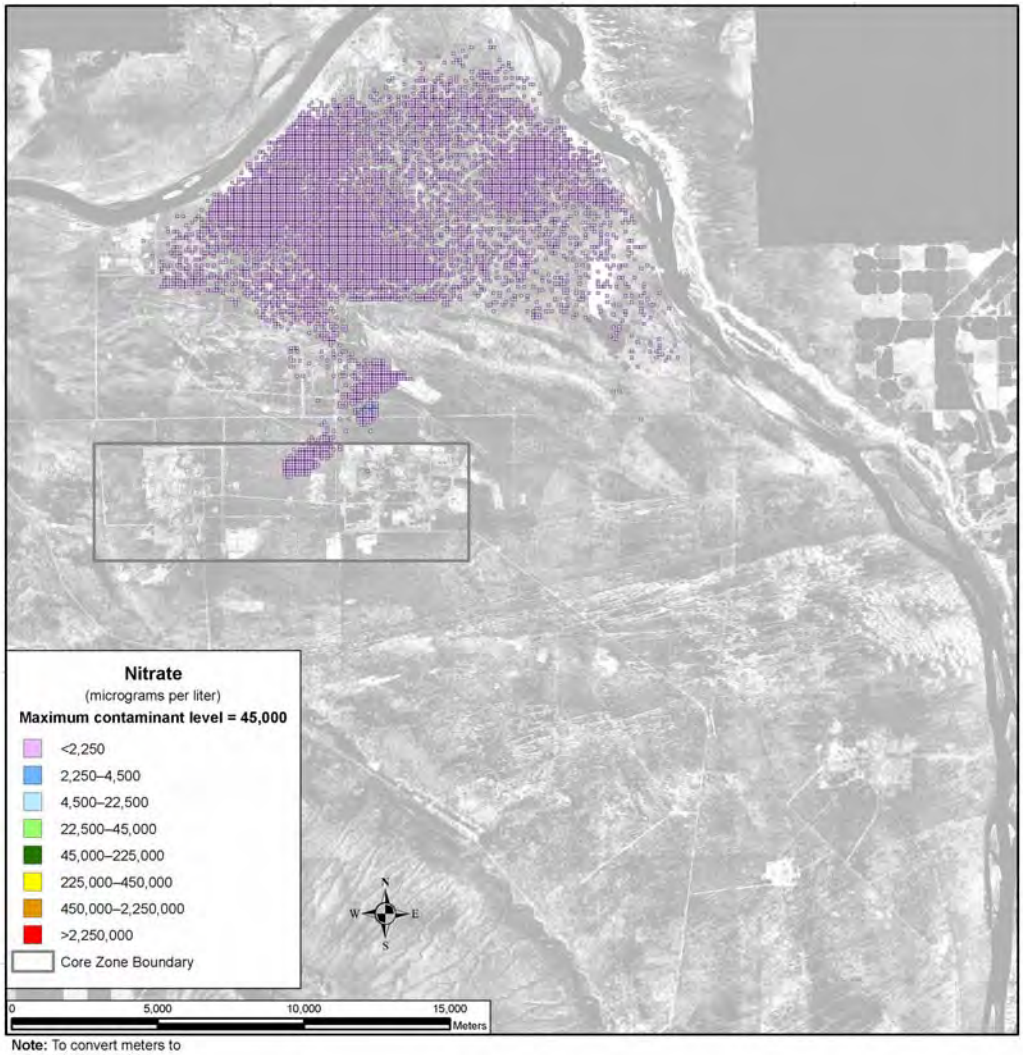


Figure 5–423. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

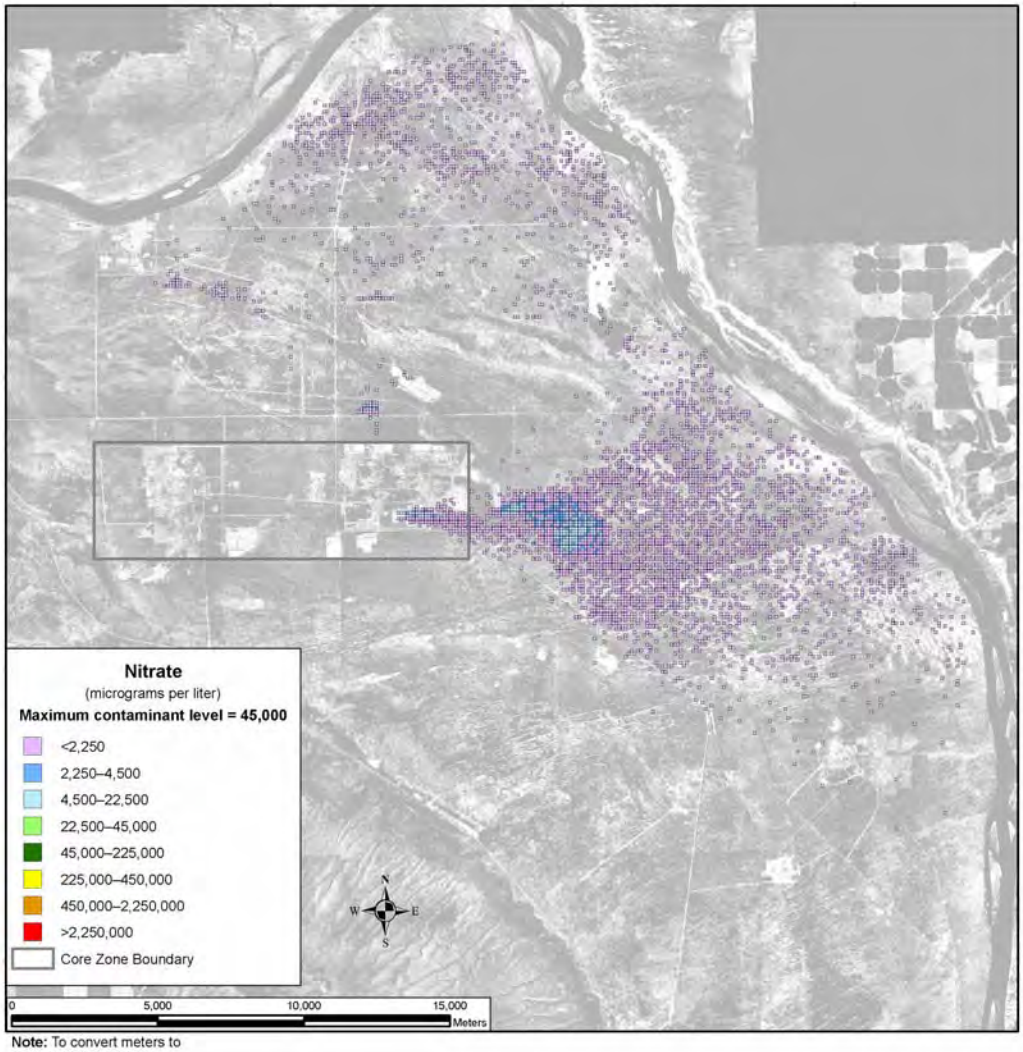


Figure 5–424. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

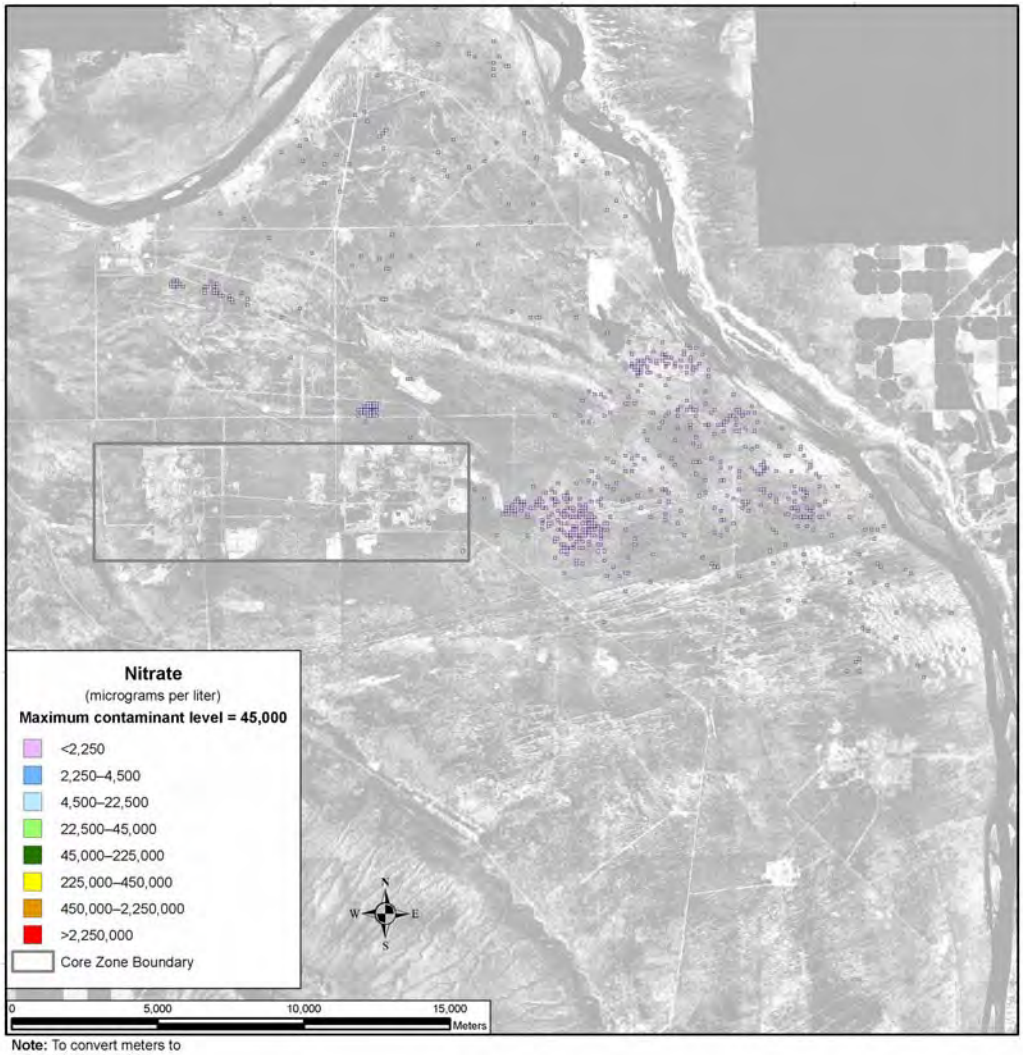


Figure 5–425. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

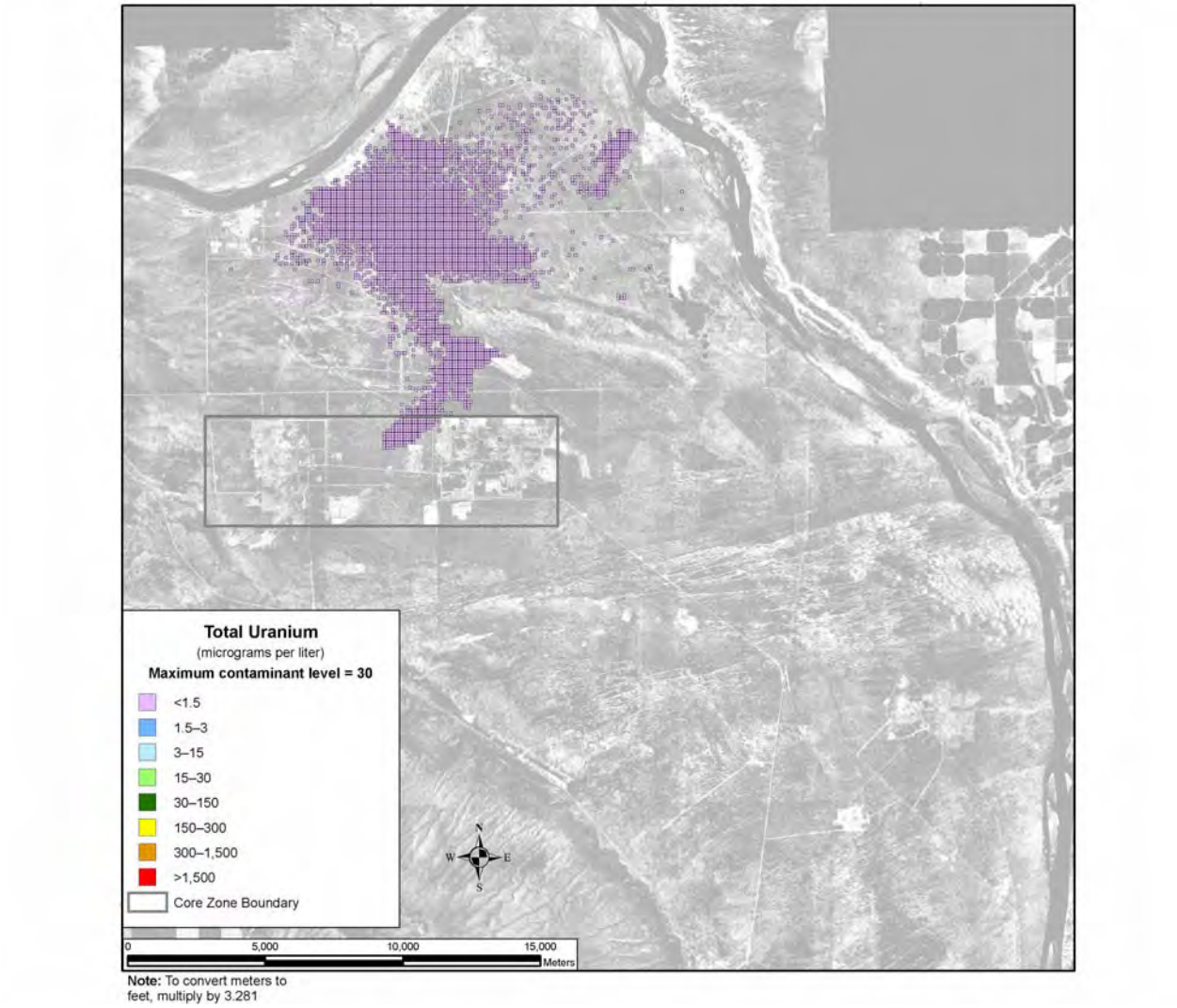


Figure 5–426. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, in general, discharges from IDF-East are the predominant contributors. The RPPDF is a secondary contributor.

For the conservative tracers, with the exception of chromium, concentrations at the Core Zone Boundary remain within an order of magnitude of the benchmark concentration during the last 5,000 years of the period of analysis. Concentrations at the Columbia River are slightly lower, but within an order of magnitude of the concentrations at the Core Zone Boundary. Chromium concentrations remain over two orders of magnitude below the benchmark at the Core Zone Boundary and the Columbia River.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the benchmark at the Core Zone Boundary and the Columbia River throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.1.2.1.3 Disposal Group 1, Subgroup 1-C

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-C covers disposal of waste generated under Tank Closure Alternative 3B and FFTF Decommissioning Alternative 2 or 3 as well as onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, and cast stone waste. IHLW would be stored on site, while ILAW glass and cast stone waste would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continue through CY 2050, when these facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C. Complete results for all 40 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, boron, chromium, fluoride, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for 100 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C.

The COPC drivers that are discussed in detail in this section fall into two categories. Iodine-129, technetium-99, acetonitrile, boron, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–427 through 5–438). Eight subtotals are plotted representing releases from ILAW glass, cast stone waste, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, onsite- and offsite-generated waste, and RPPDF waste. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

Figure 5–427 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–428, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant source of acetonitrile, chromium, nitrate, and technetium-99 is the cast stone waste; of iodine-129 is offsite-generated waste. Other sources of contamination include ILAW glass, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite-generated waste.

Figure 5–429 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–430, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. With the exception of offsite-generated waste, of which nearly all that was released to the vadose zone reached groundwater in the analysis, only 40 to 50 percent of the technetium-99 and iodine-129 released to the vadose zone reached groundwater. Chromium from ILAW glass and retired melters behaves similarly to technetium-99 and iodine-129. When released from other sources, nearly all the chromium that enters the vadose zone reaches groundwater. For nitrate, fluoride, boron, and acetonitrile, nearly everything released to the vadose zone reaches groundwater.

Figure 5–431 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–432, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In nearly all cases, between 90 and 100 percent of the amount released to groundwater reached the Columbia River in the analysis. The exceptions to this trend are the retired melters for both technetium-99 and iodine-129 and waste management secondary and onsite-generated waste for iodine-129. In these cases, nothing released to groundwater reached the Columbia River.

Figure 5–433 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–434, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF.

Figure 5–435 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–436, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

Figure 5–437 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–438, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially everything released to groundwater reached the Columbia River in the analysis for all COPC drivers present.

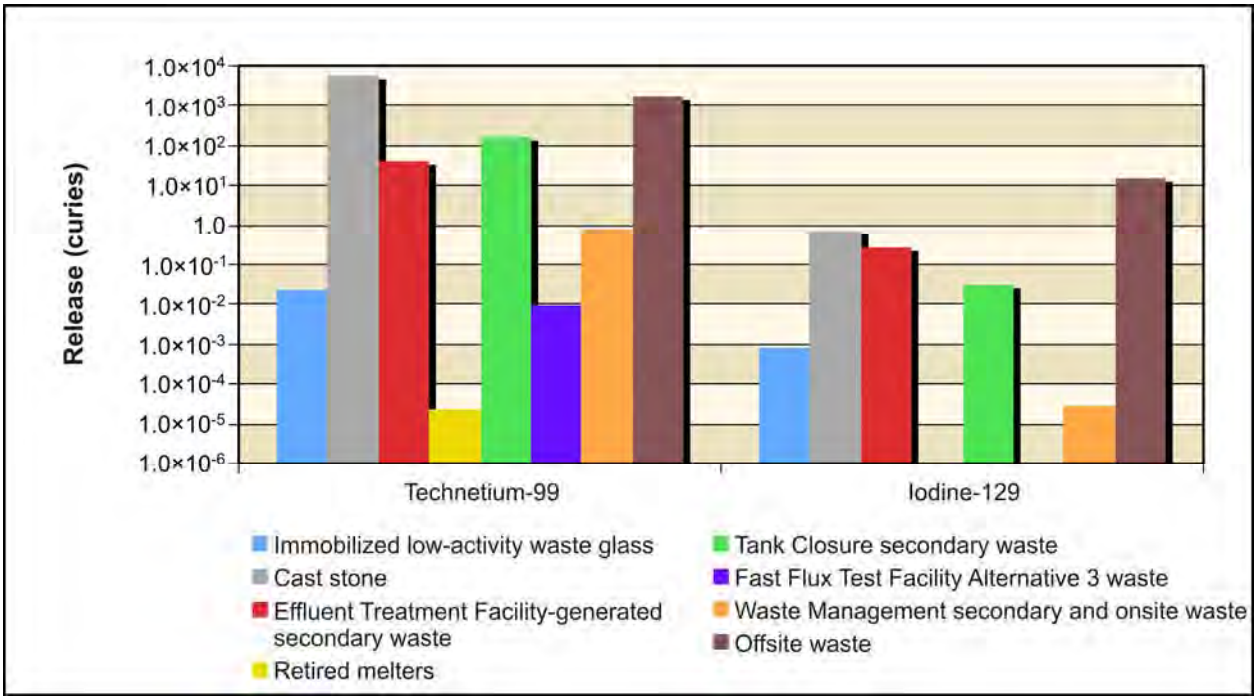


Figure 5–427. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

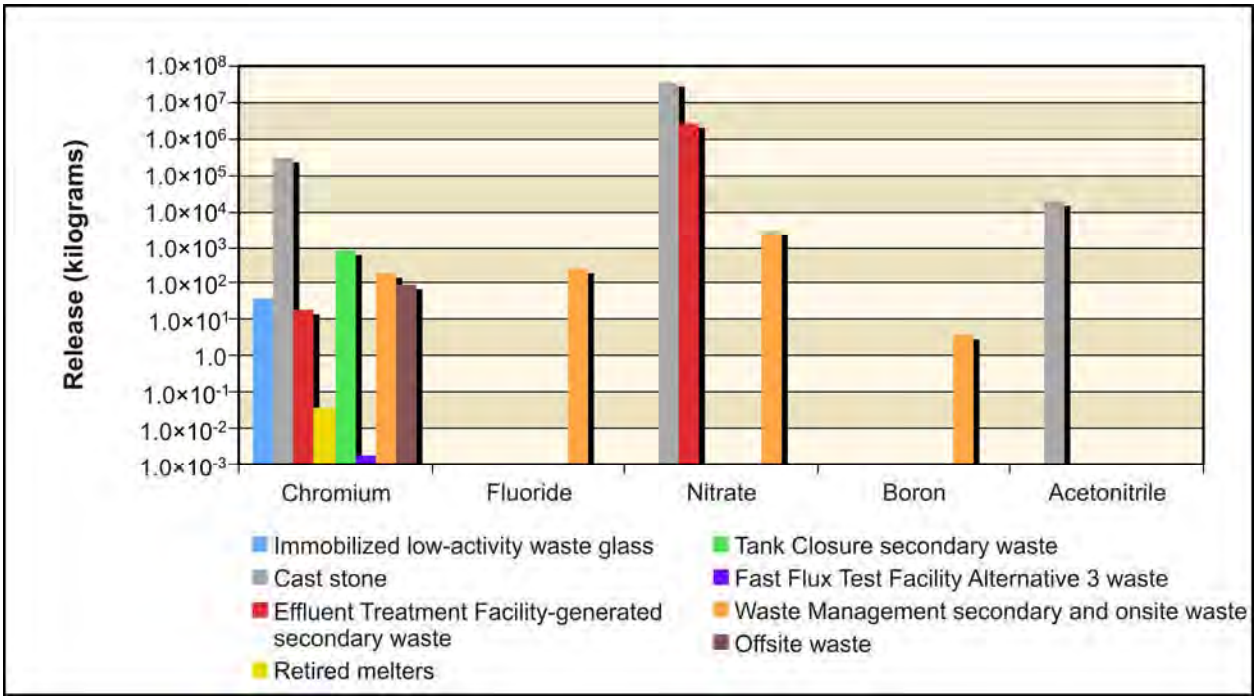


Figure 5–428. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

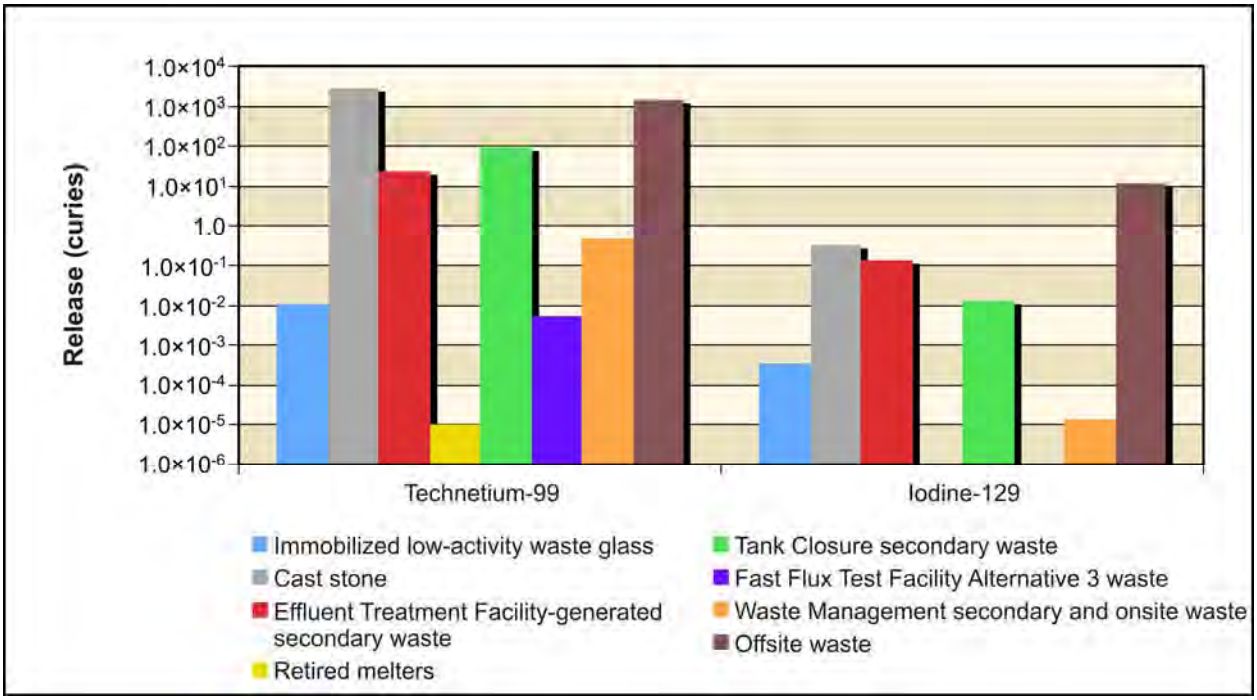


Figure 5–429. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

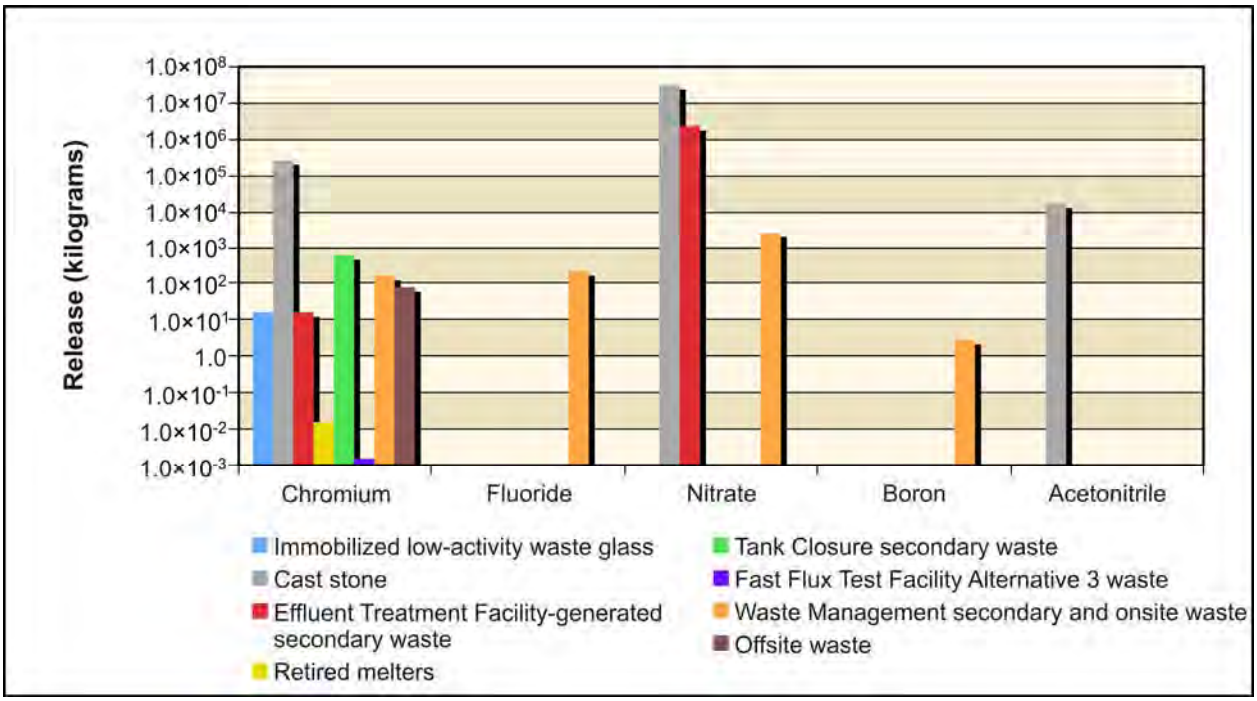


Figure 5–430. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

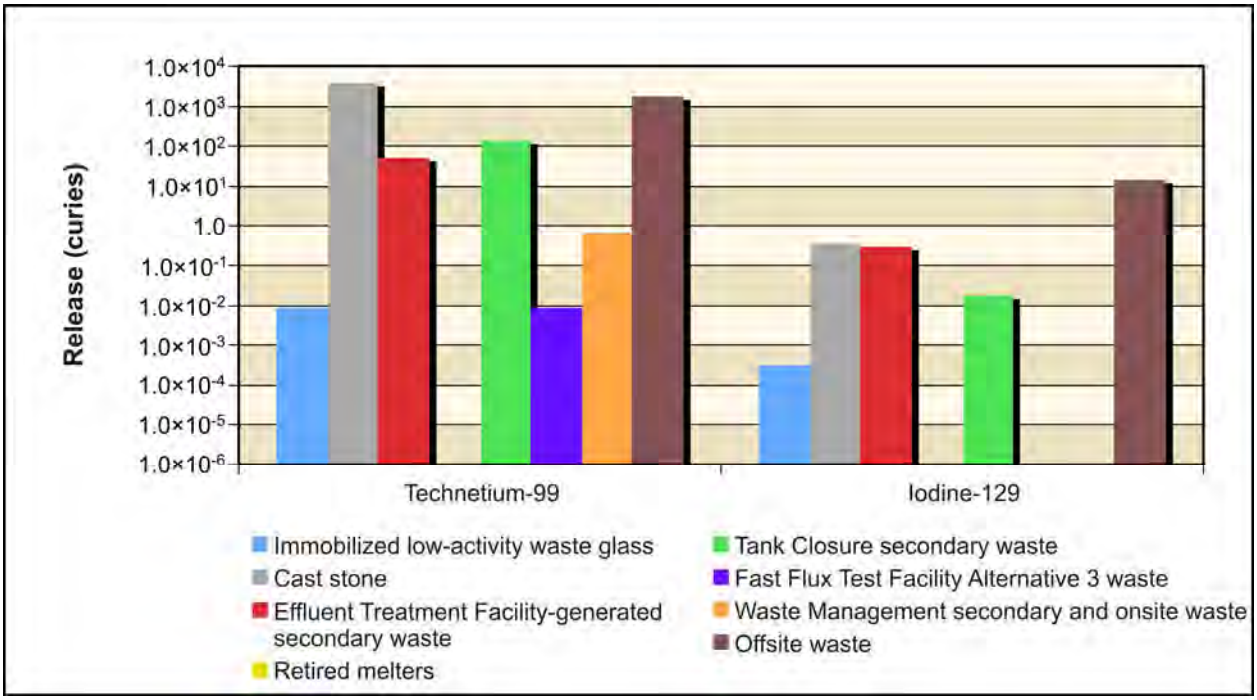


Figure 5–431. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

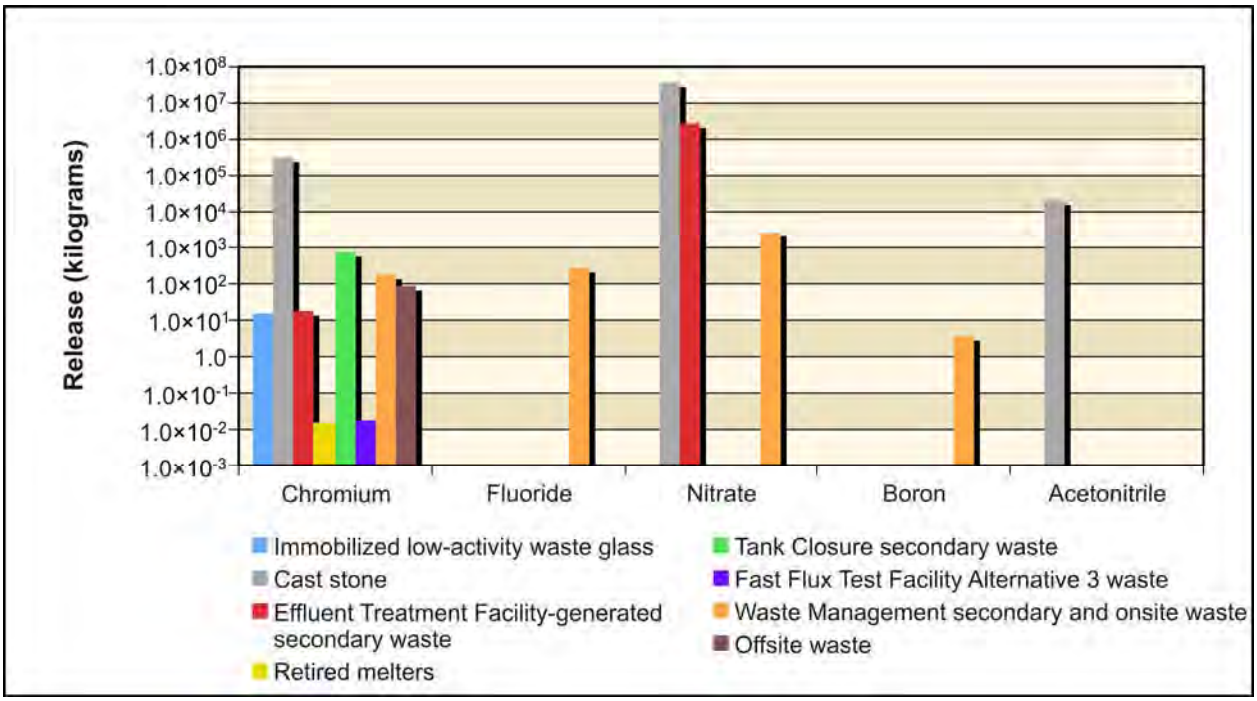


Figure 5–432. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

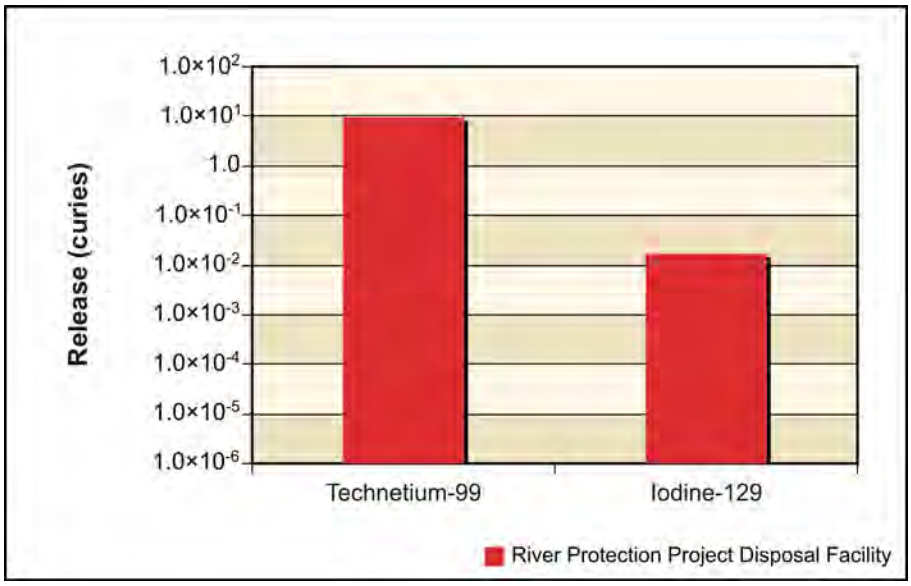


Figure 5–433. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

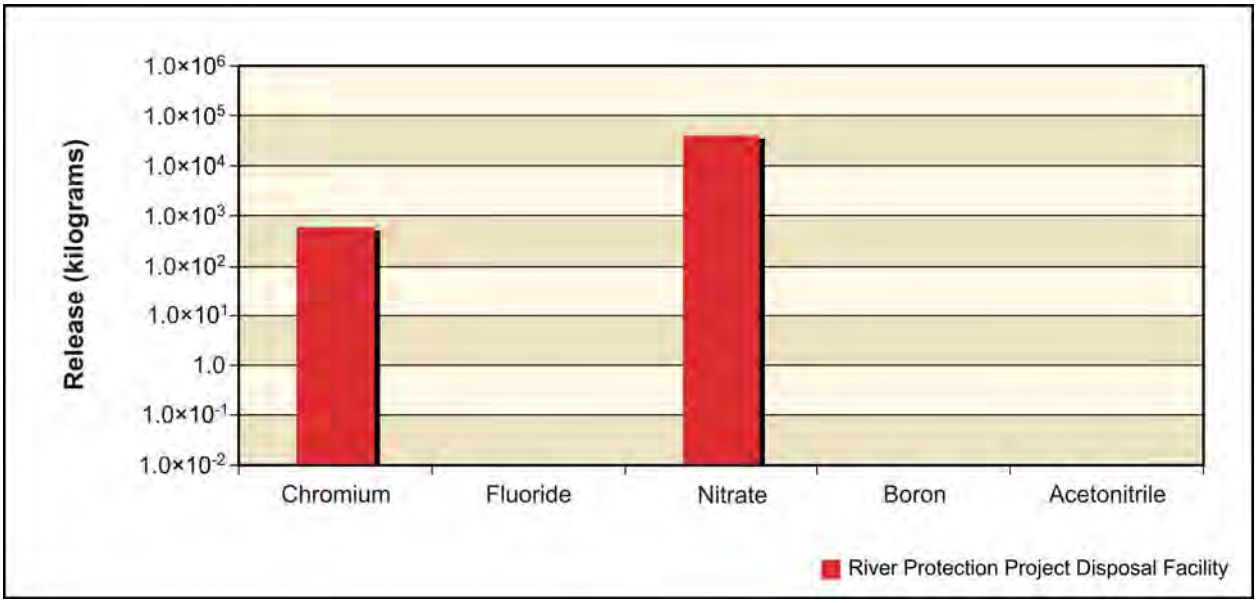


Figure 5–434. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

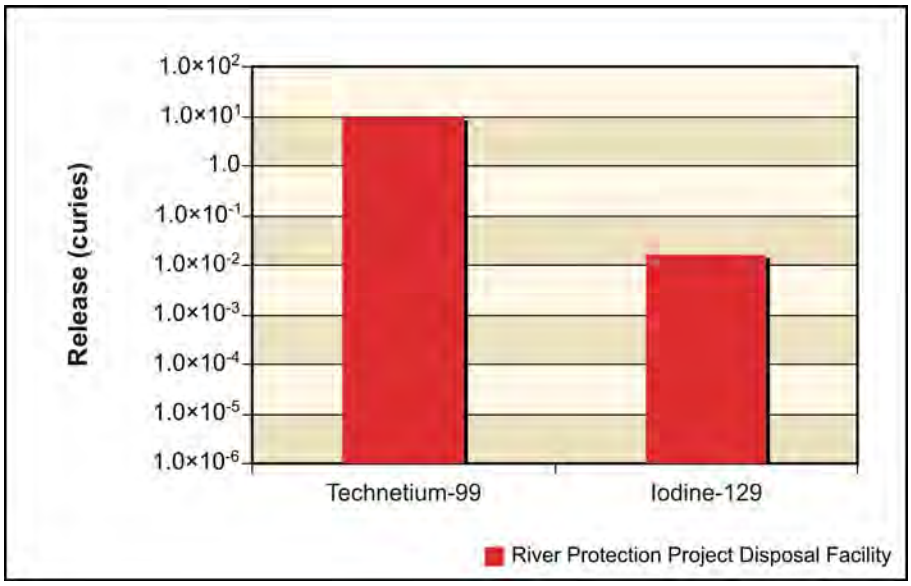


Figure 5–435. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Facility to Groundwater

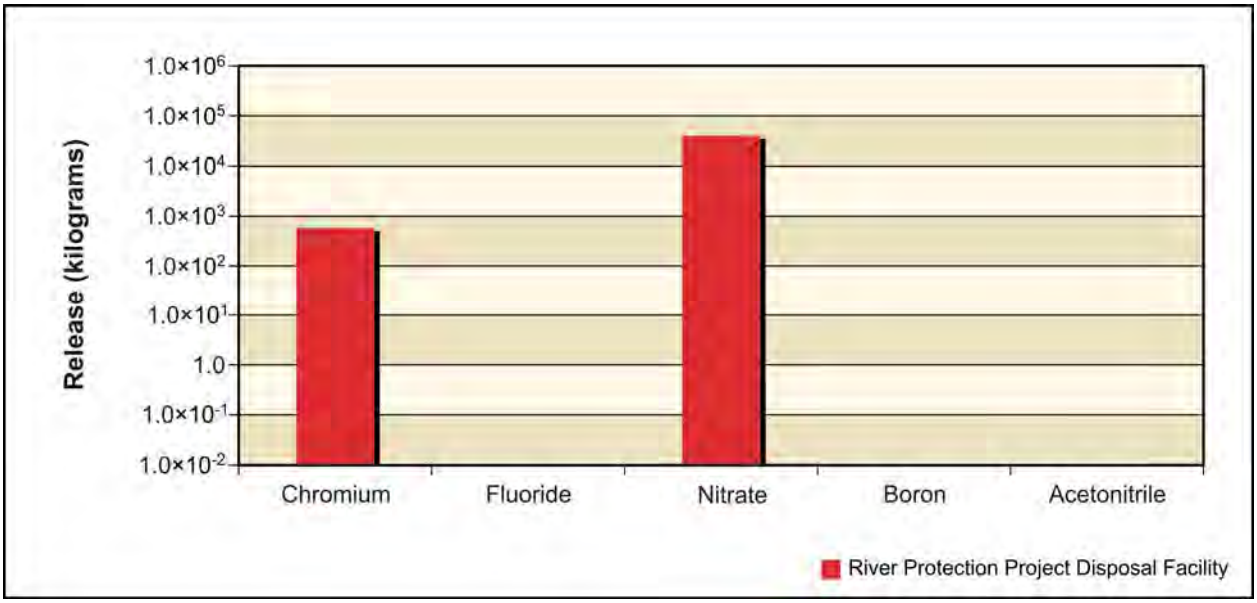


Figure 5–436. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Facility to Groundwater

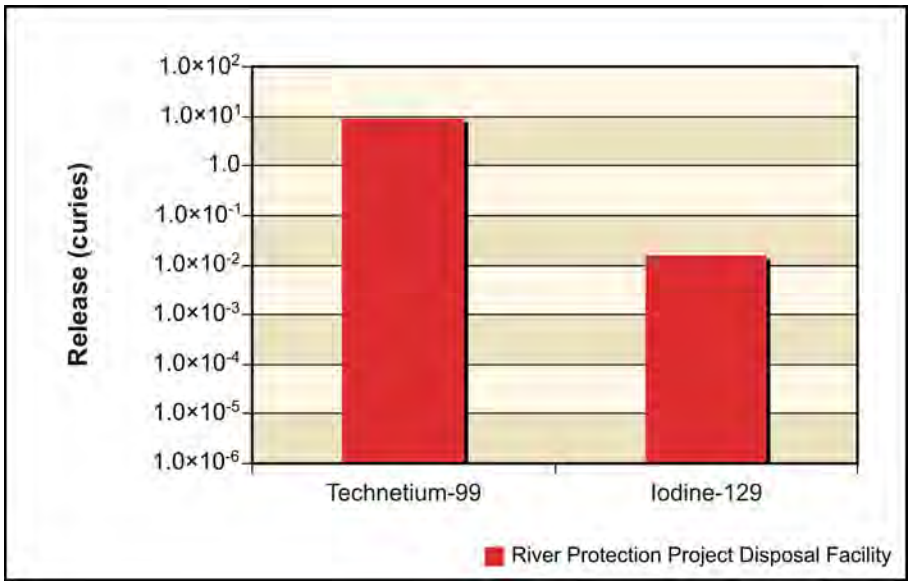


Figure 5–437. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Facility to Columbia River

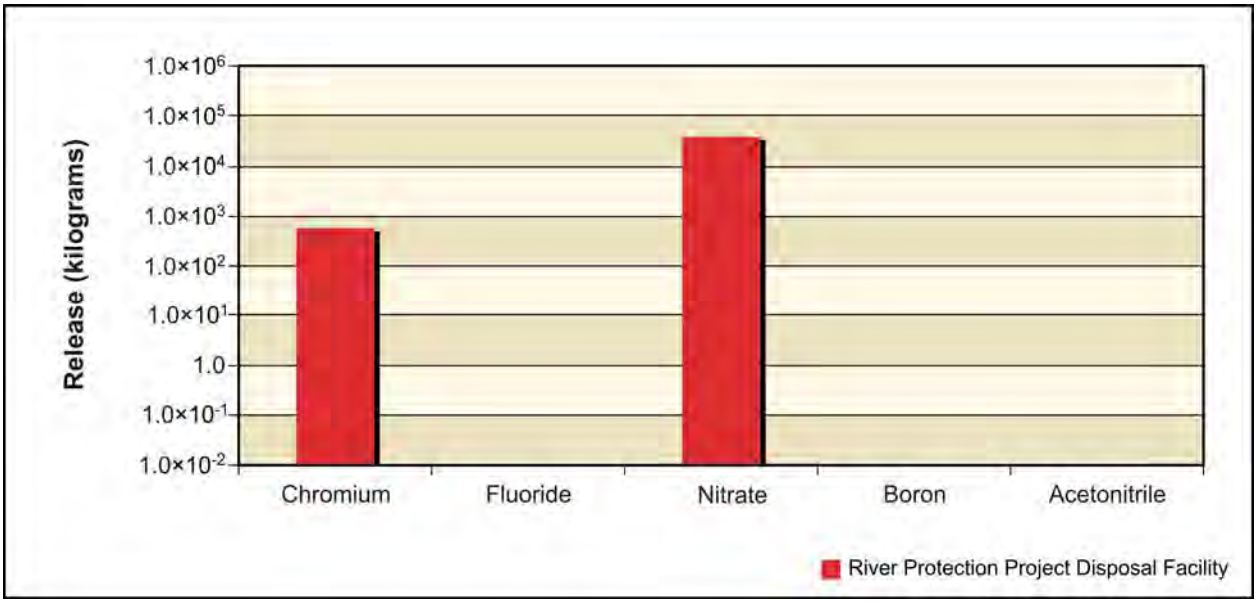


Figure 5–438. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–439 through 5–443). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is

basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–79 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–439 through 5–442 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, a small rise in concentration is evident in the early years, peaking around CY 3940 but remaining over an order of magnitude below the benchmark concentration. Beginning in CY 5400, concentrations at the Core Zone Boundary begin climbing again, stabilizing very near to the benchmark concentration at CY 7940. Iodine-129 follows a similar pattern, stabilizing slightly above the benchmark concentration, while chromium and nitrate peak below the benchmark.

Figure 5–443 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until CY 9940, when total uranium concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter.

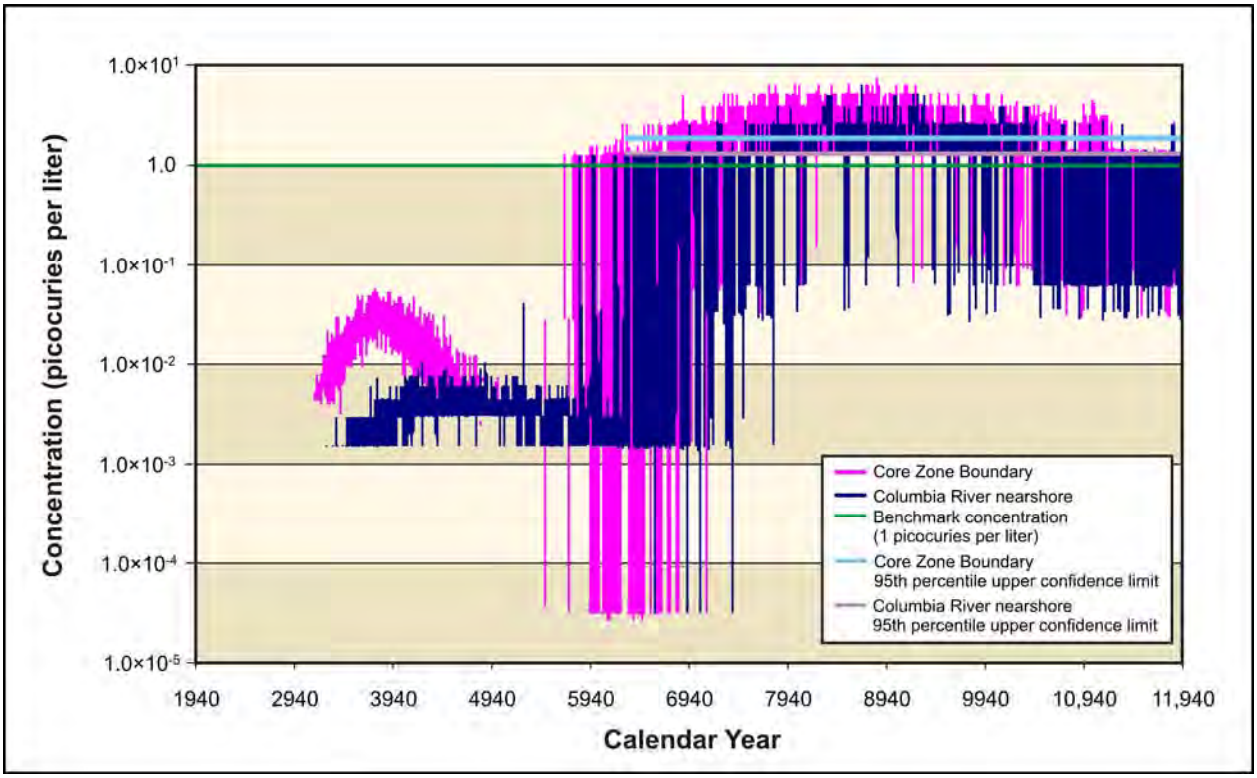


Figure 5–439. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Iodine-129 Concentration Versus Time

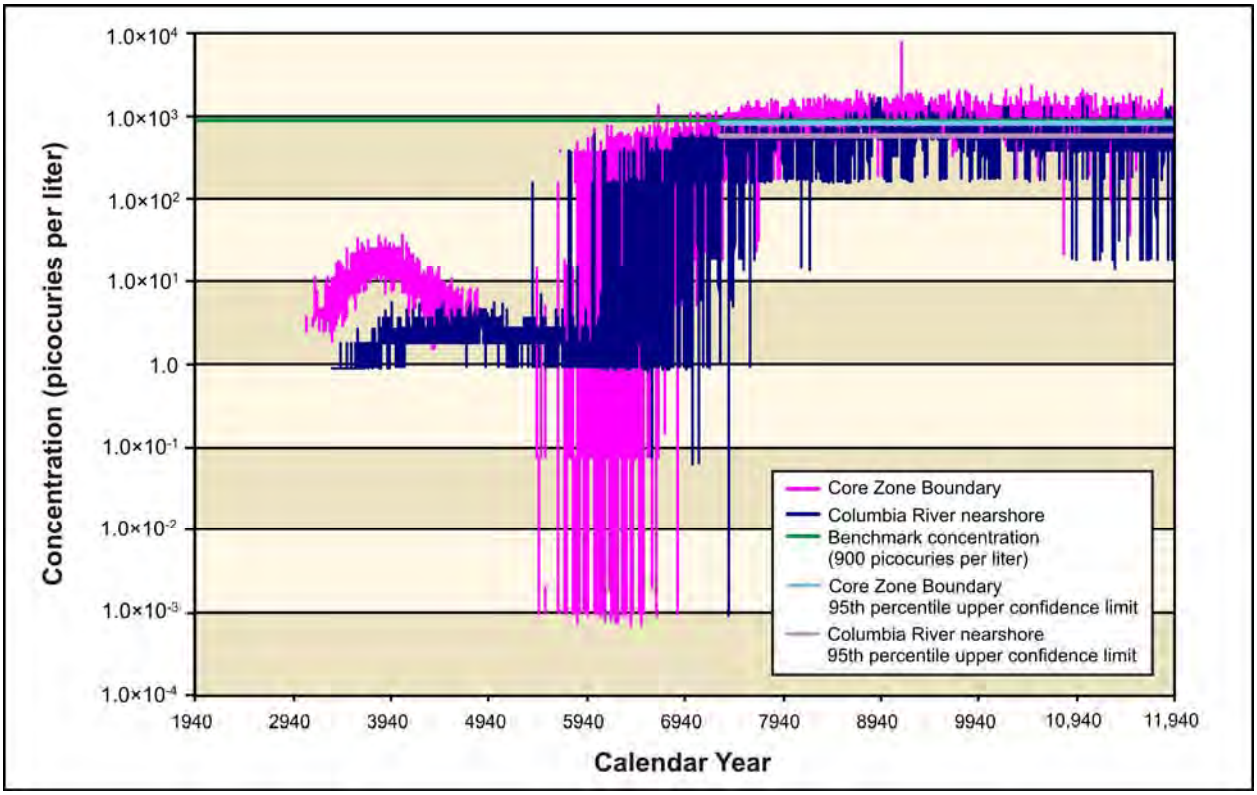


Figure 5–440. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Technetium-99 Concentration Versus Time

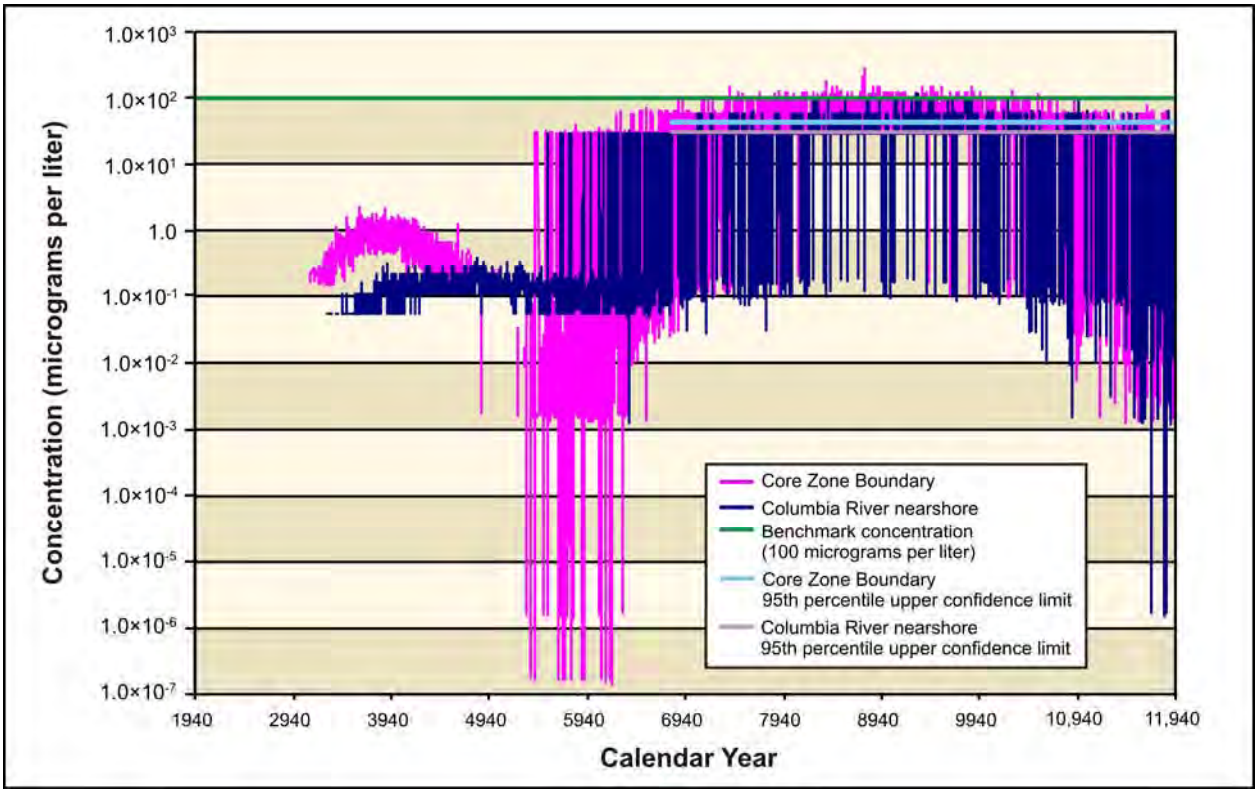


Figure 5–441. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chromium Concentration Versus Time

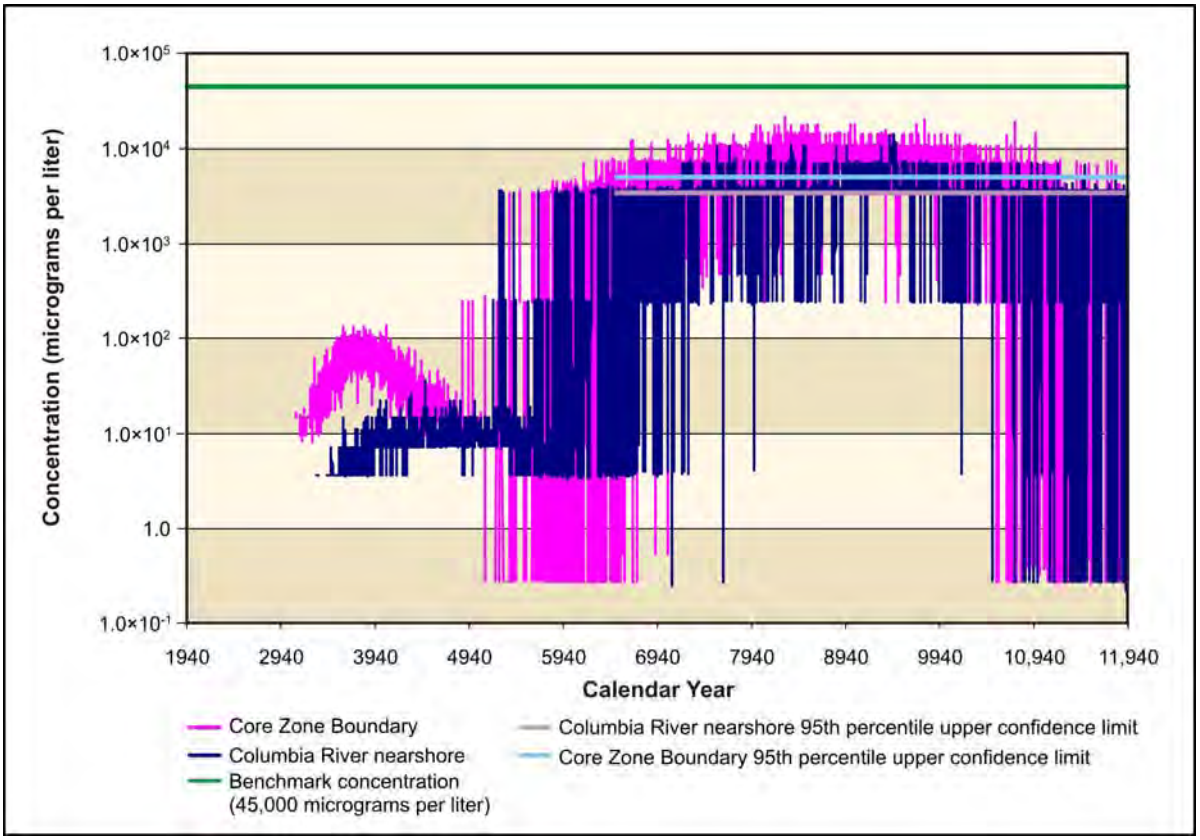


Figure 5–442. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Nitrate Concentration Versus Time

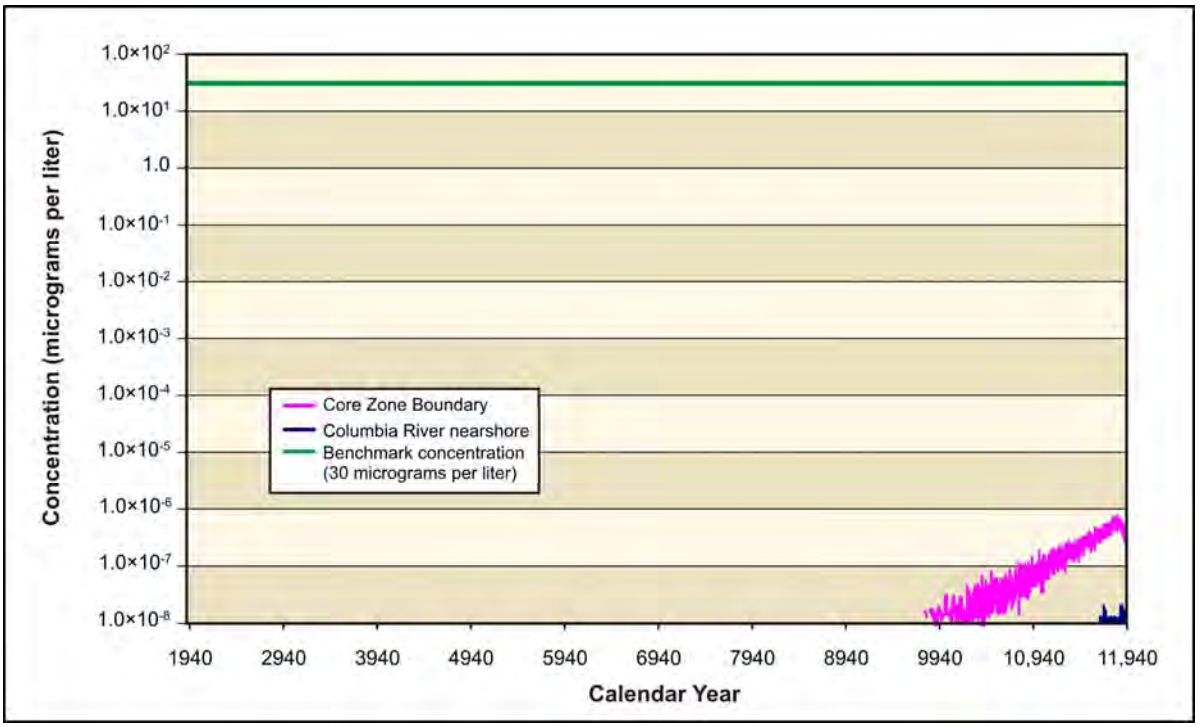


Figure 5–443. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Total Uranium Concentration Versus Time

Table 5–79. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore Groundwater

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**5,660** (9048)	33 (3825)	**8,160** (9163)	**1,690** (8927)	900
Iodine-129	**18** (8491)	0.1 (3772)	**8** (8858)	**7** (8700)	1
Chemical in micrograms per liter					
Acetonitrile	25 (8281)	0 (1940)	9 (8313)	7 (8973)	100
Chromium	**437** (8940)	2 (3856)	**265** (8760)	**116** (9311)	100
Fluoride	0 (8035)	0 (1940)	1 (7258)	0 (8913)	4,000
Nitrate	**50,200** (8665)	149 (3811)	21,200 (8290)	14,100 (9453)	45,000

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–444 through 5–456). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890, there is a low-concentration plume of iodine-129 (see Figure 5–444) that stretches north from the RPPDF and through Gable Gap. By CY 7140 (see Figure 5–445), the plume from the RPPDF is gone, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume are over an order of magnitude above the benchmark. Figure 5–446 shows the iodine-129 concentration for CY 11,885. Technetium-99 (see Figures 5–447 through 5–449), chromium (see Figures 5–450 through 5–452), and nitrate (see Figures 5–453 through 5–455) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium shows a different spatial distribution over time. It is not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, there is a plume extending through Gable Gap from the RPPDF (see Figure 5–456). Concentrations in all areas of the plume remain below one-twentieth of the benchmark.

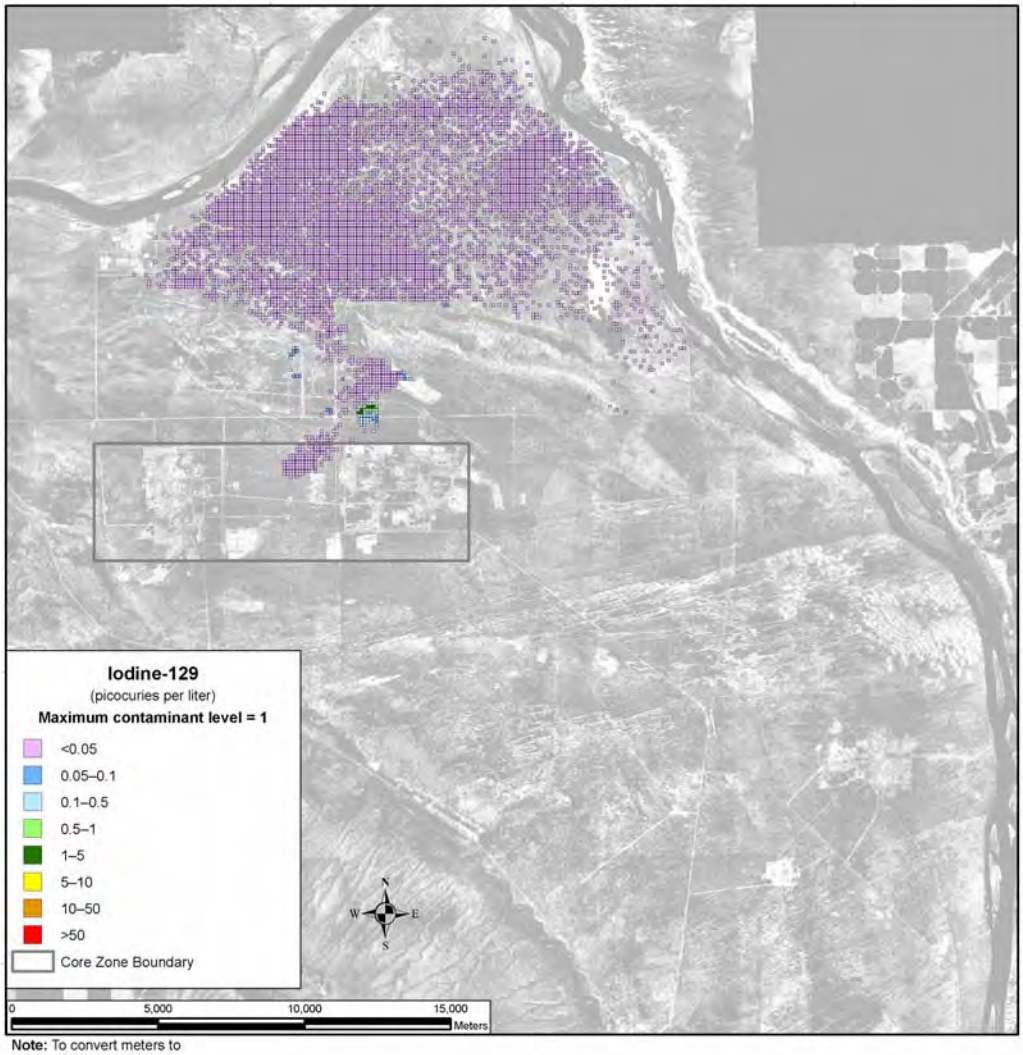


Figure 5–444. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

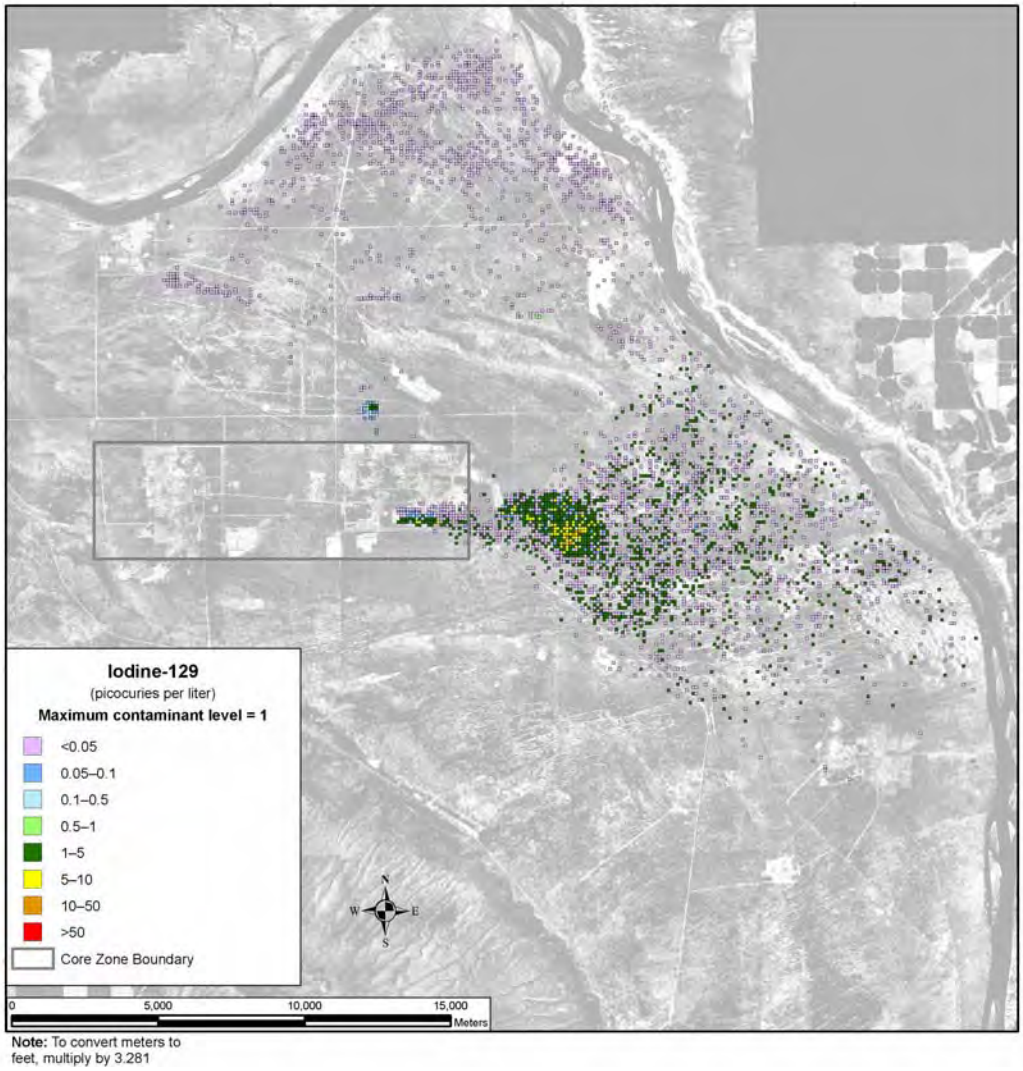


Figure 5–445. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

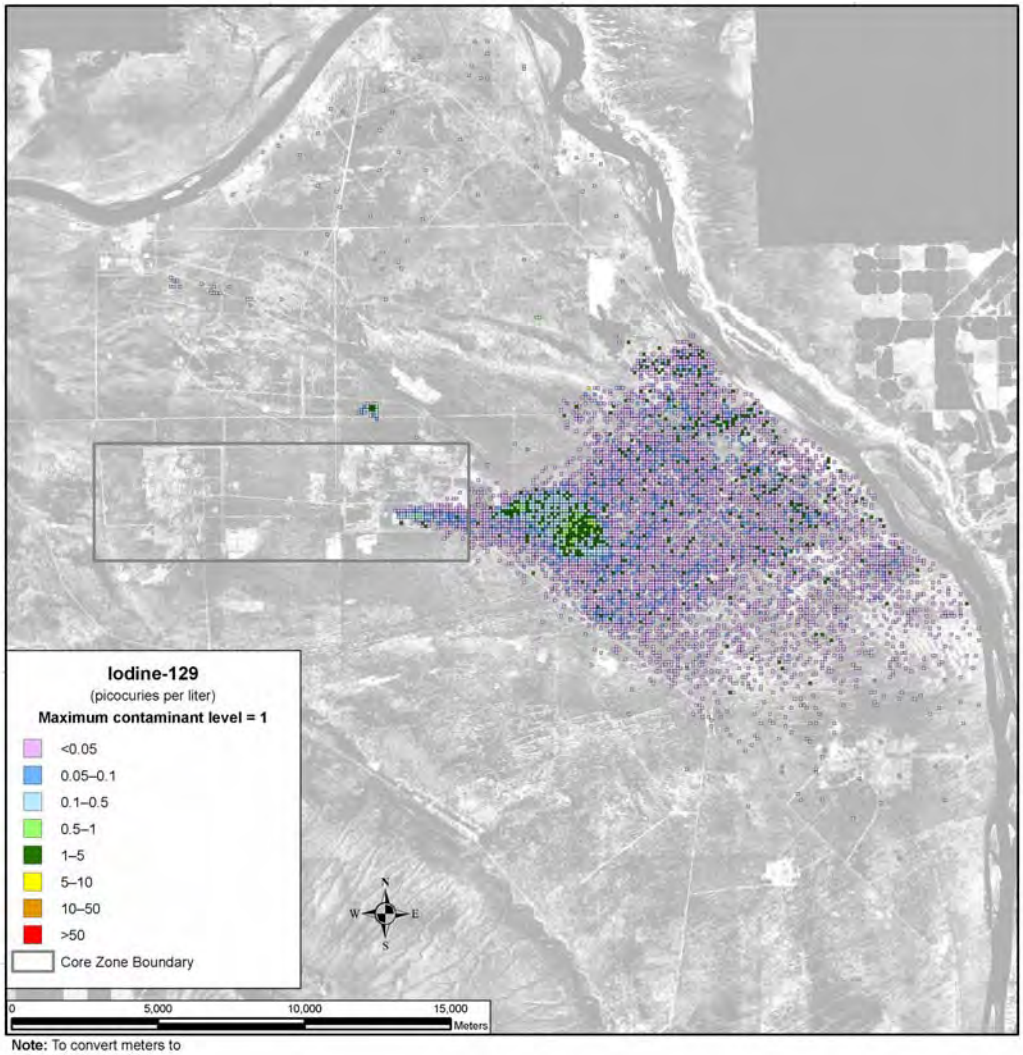


Figure 5–446. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

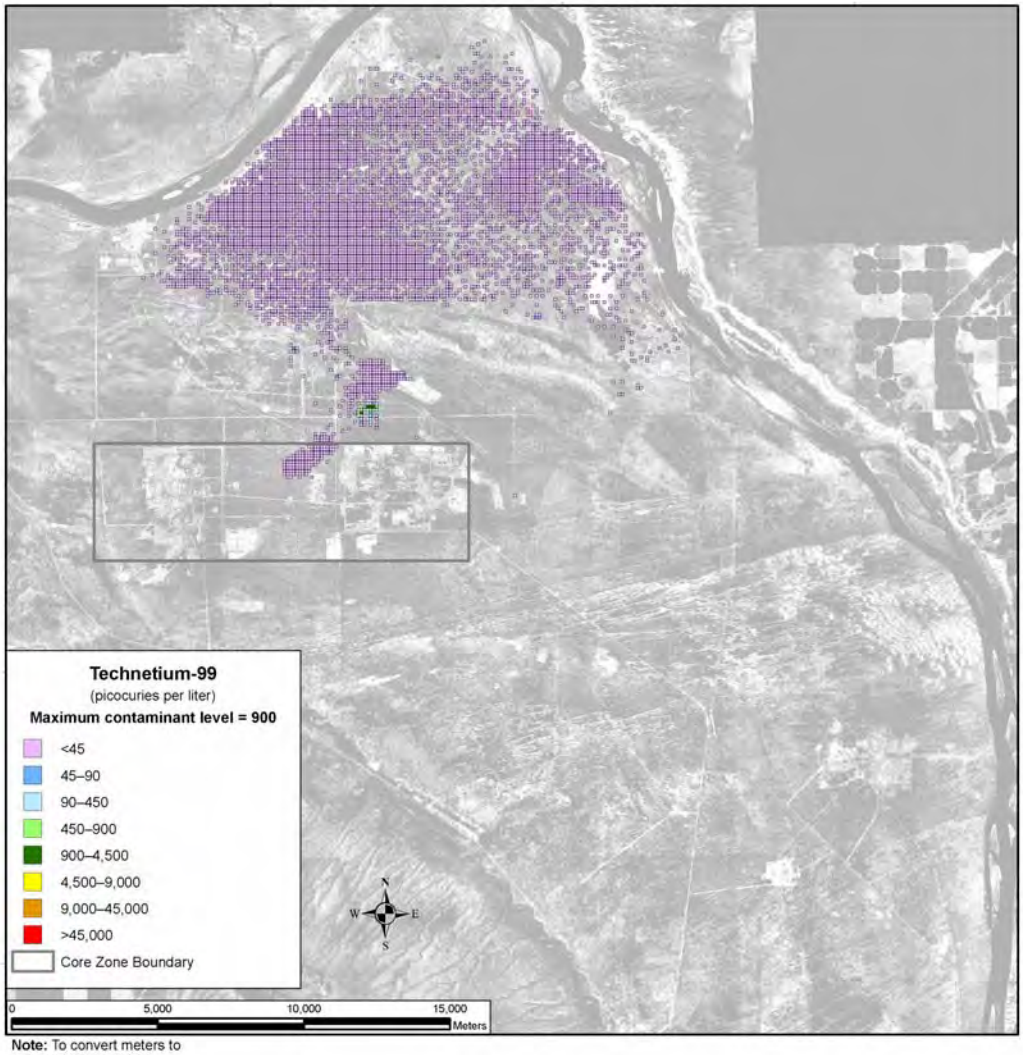


Figure 5–447. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

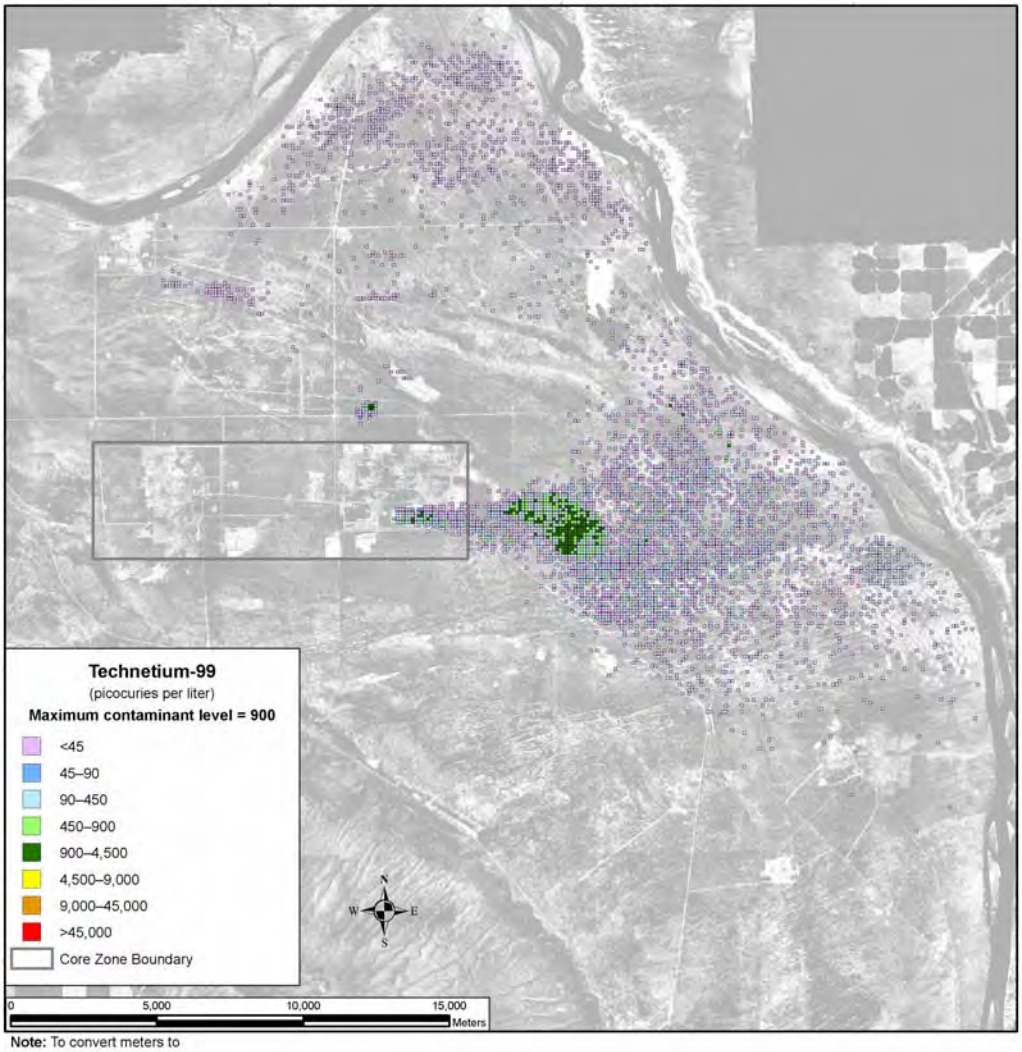


Figure 5–448. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

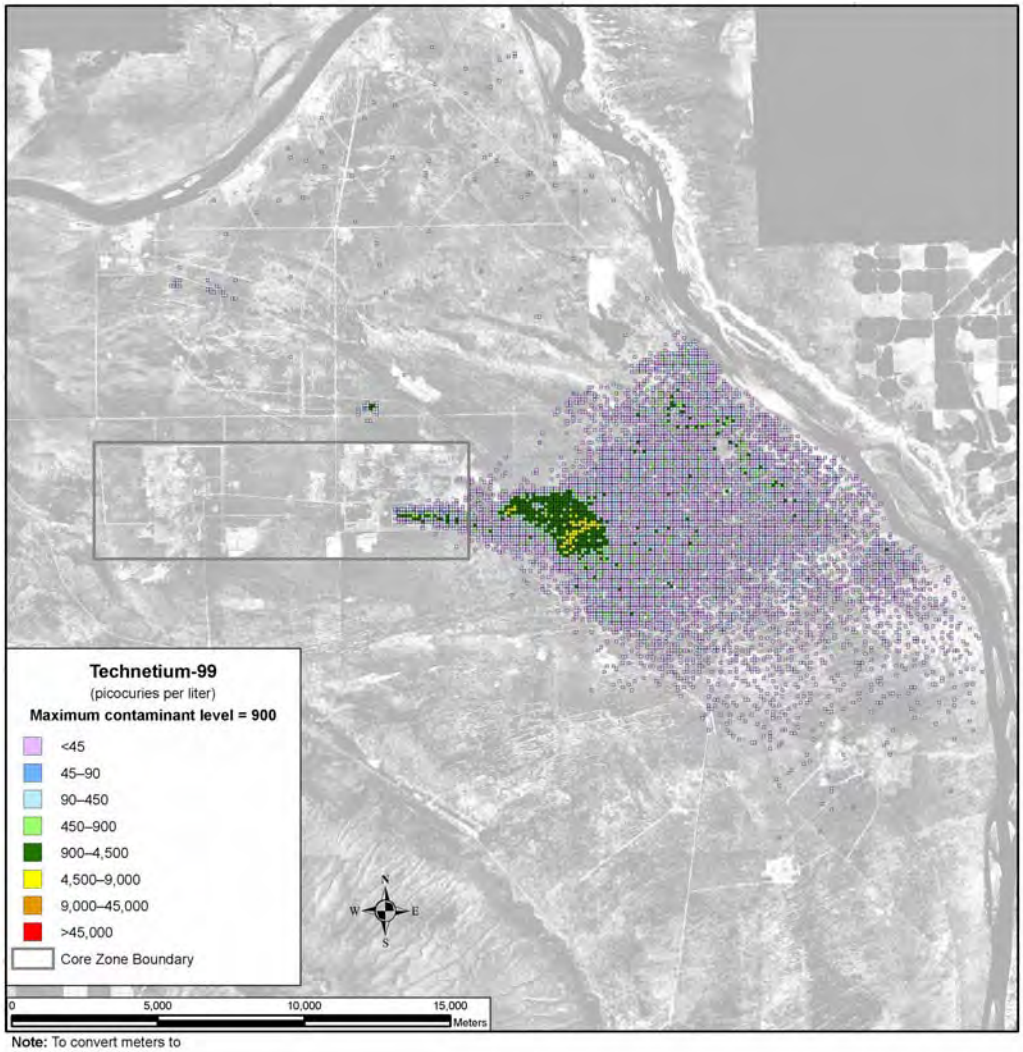


Figure 5–449. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

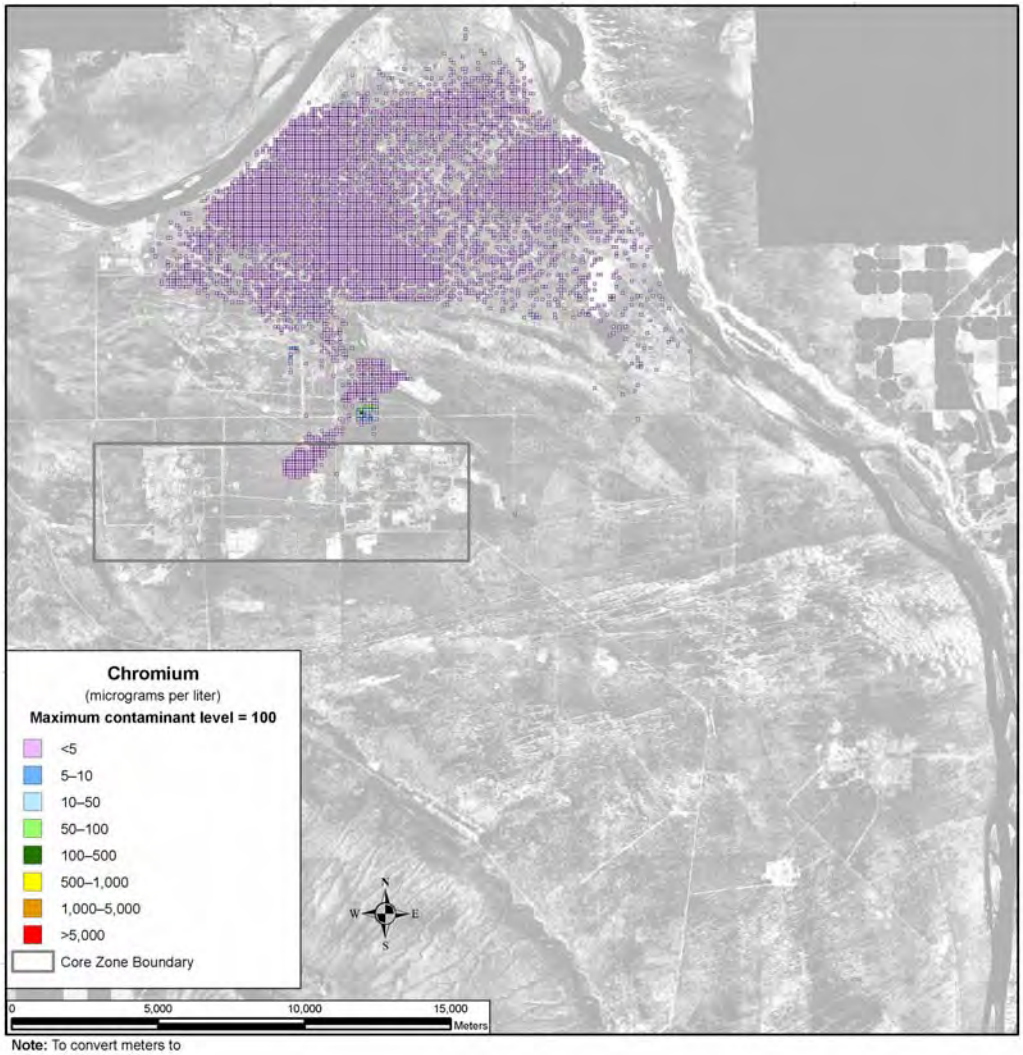


Figure 5–450. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

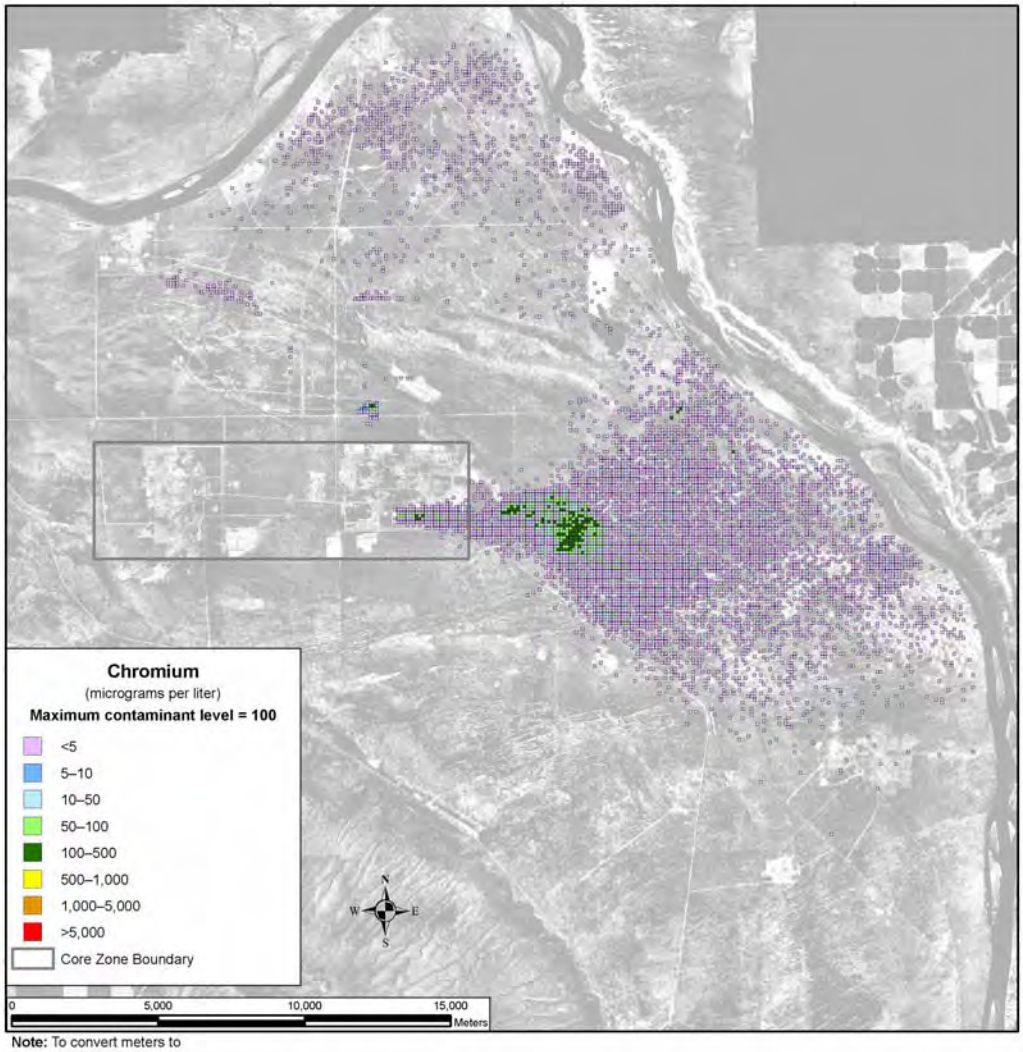


Figure 5–451. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

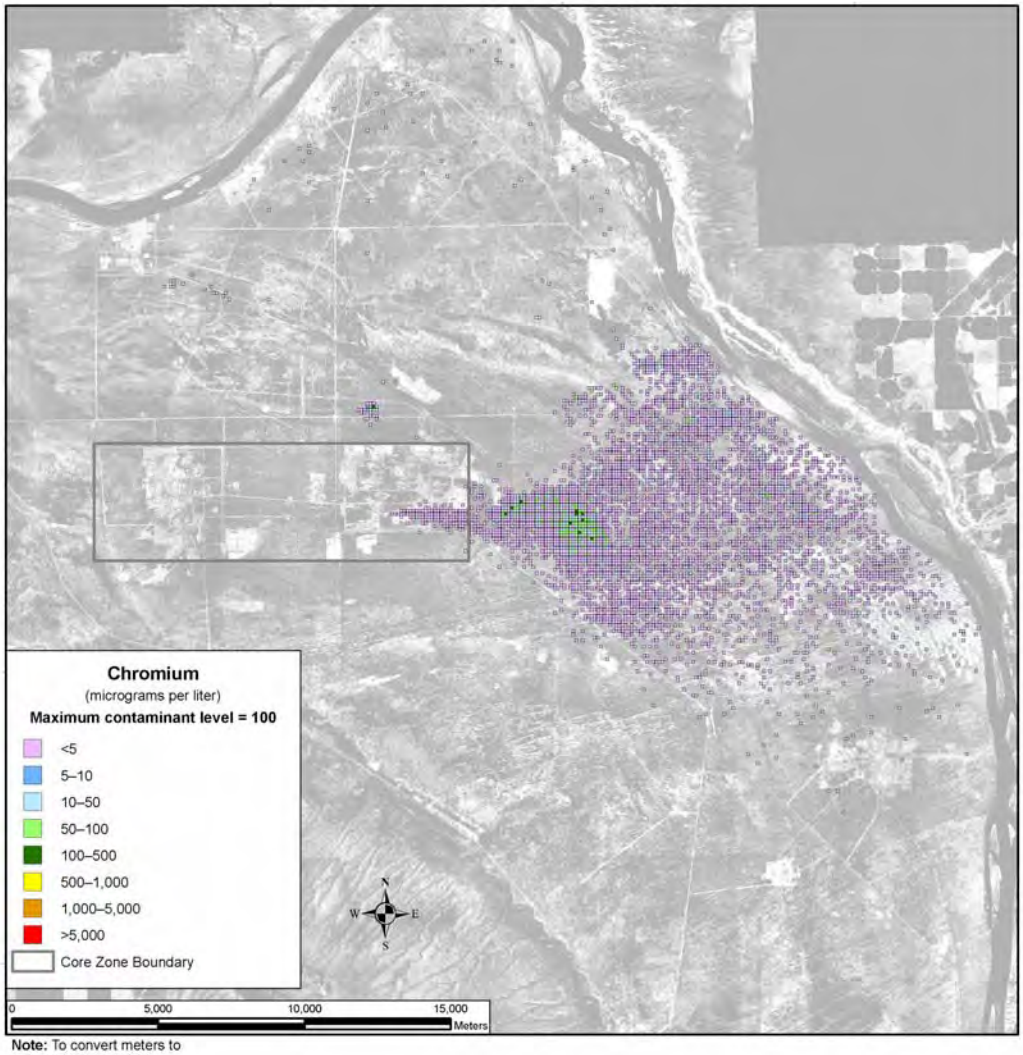


Figure 5–452. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

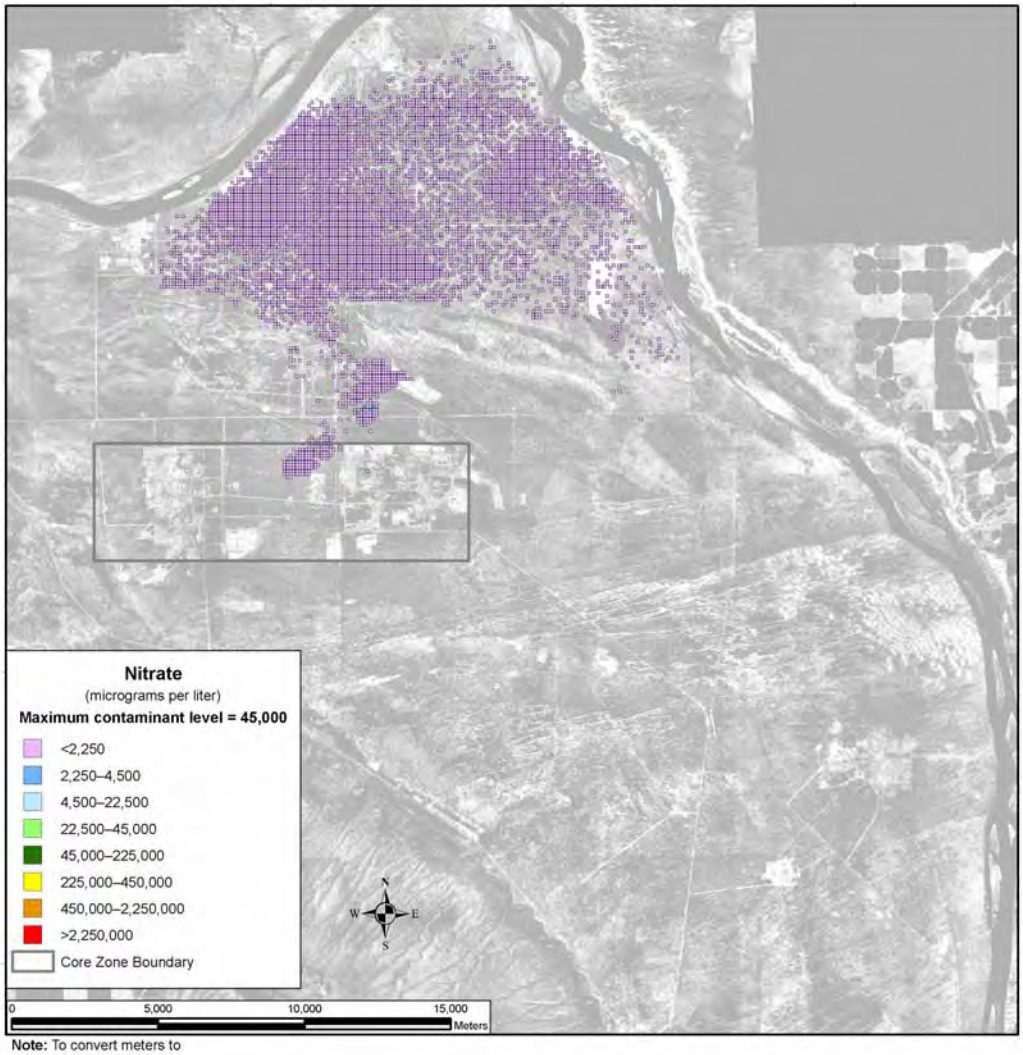


Figure 5–453. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

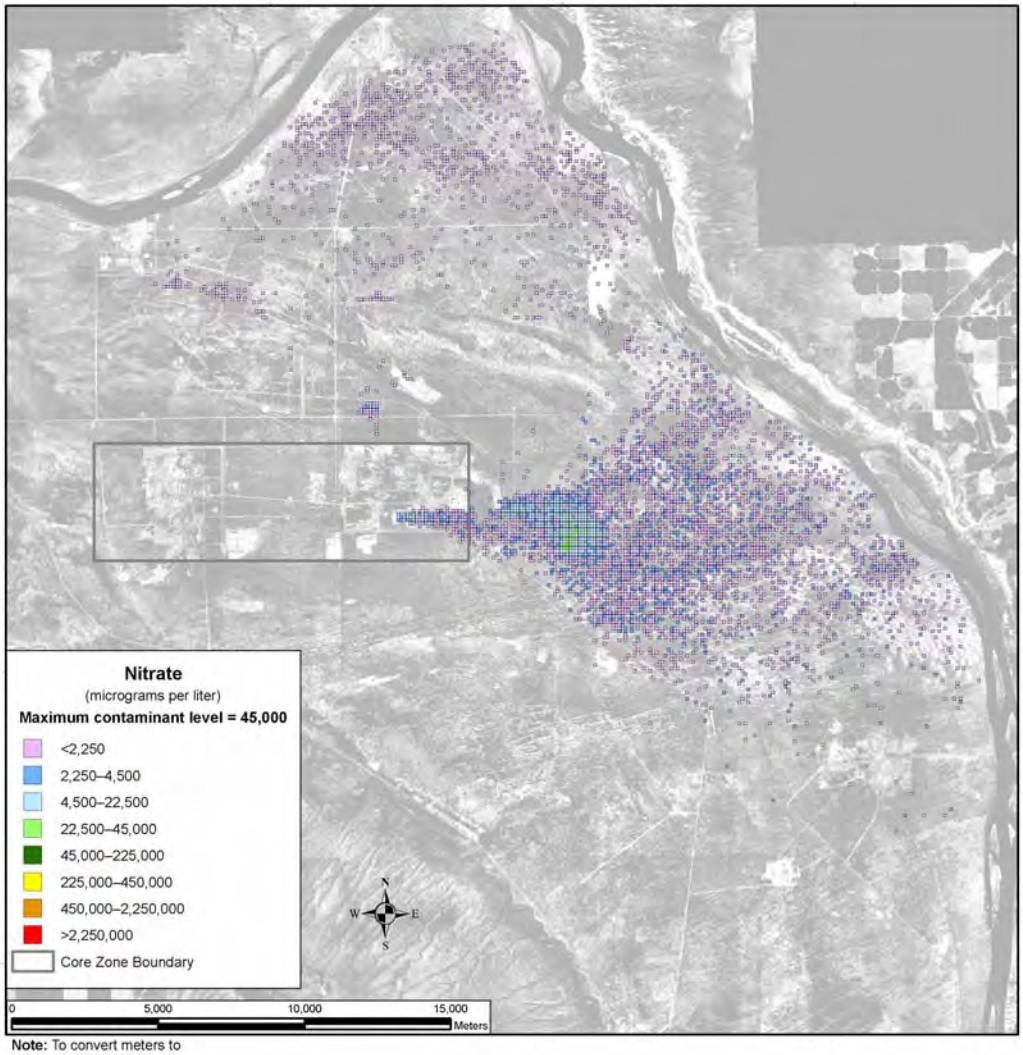


Figure 5–454. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

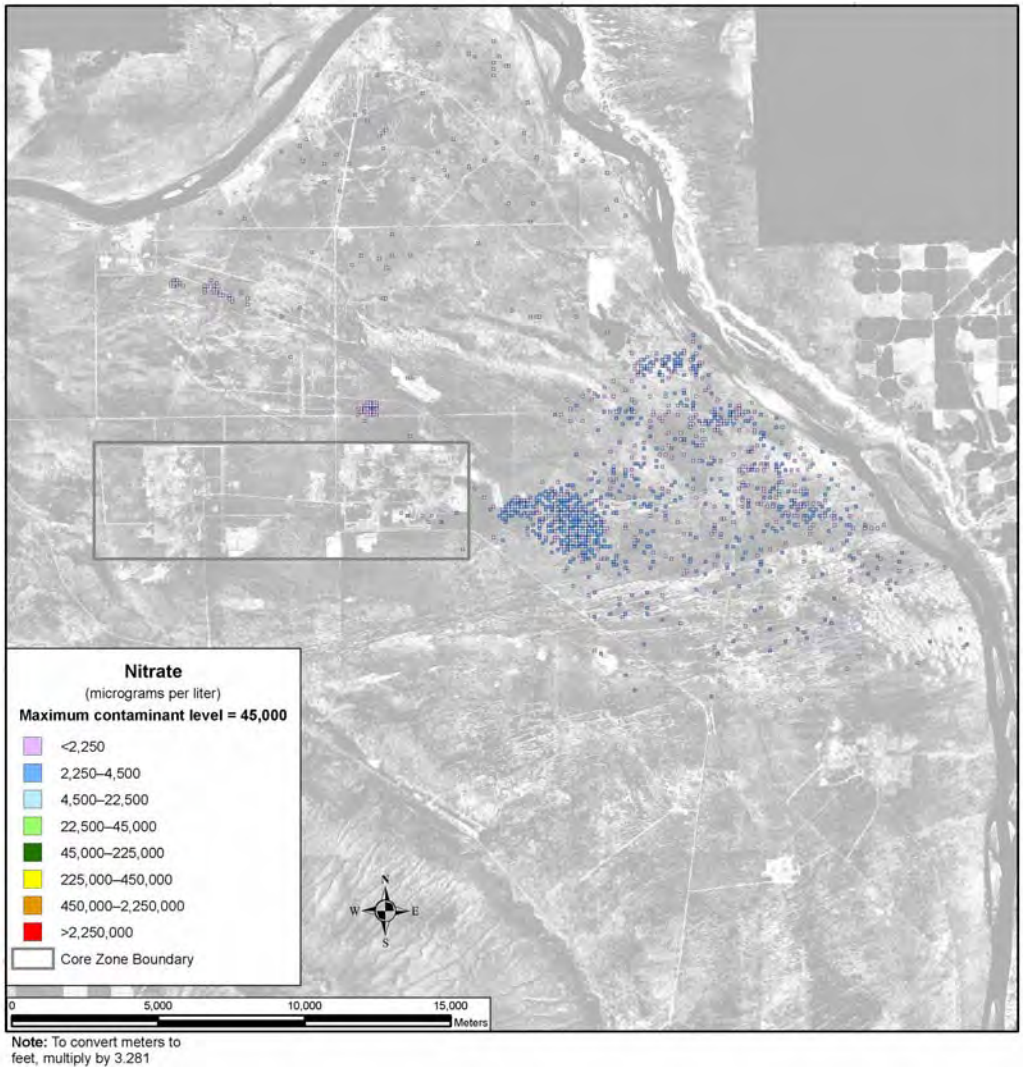


Figure 5–455. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

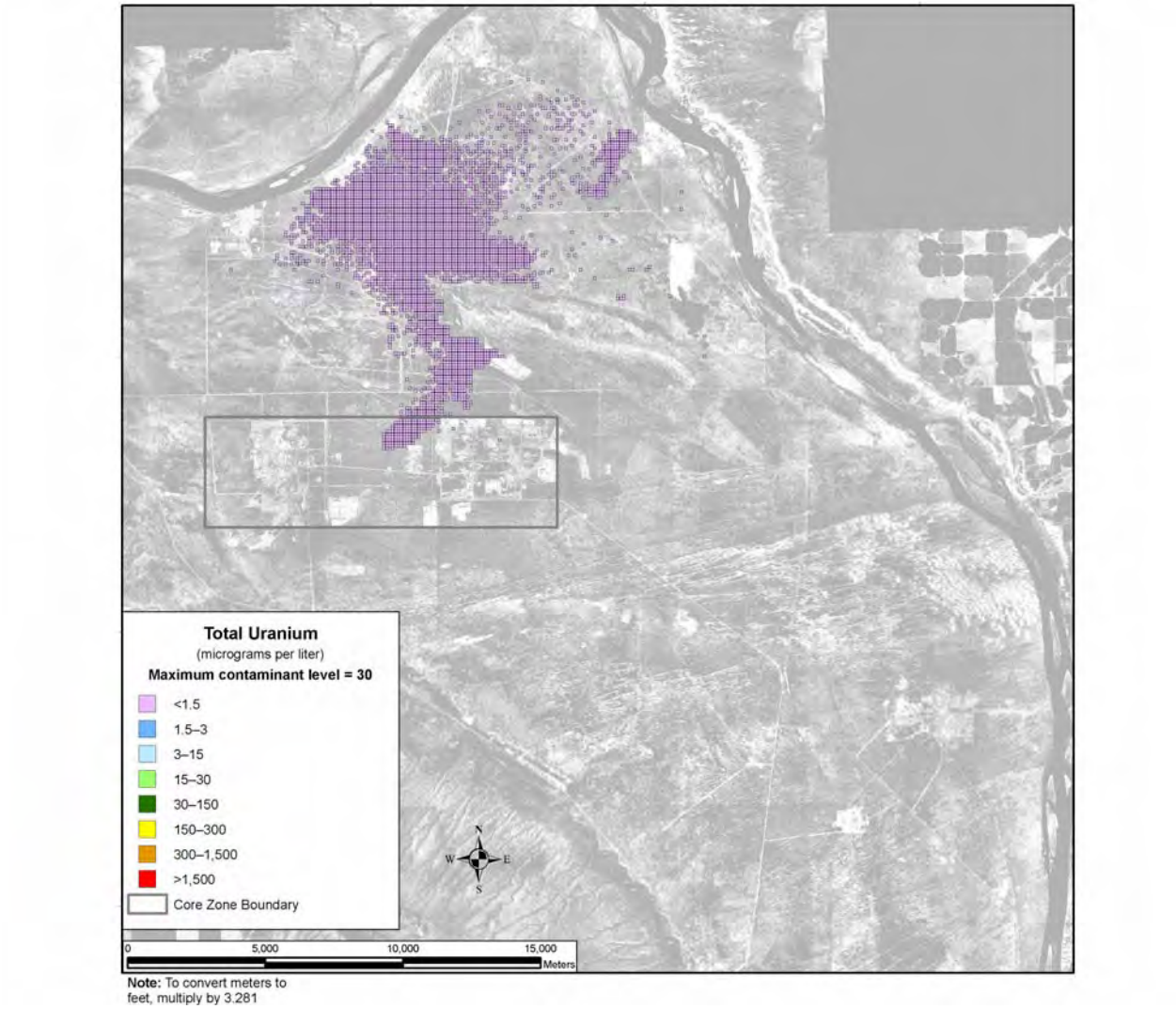


Figure 5–456. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, in general, discharges from IDF-East are the predominant contributors. The RPPDF is a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary remain within an order of magnitude of the benchmark concentration during the last 5,000 years of the period of analysis. Concentrations at the Columbia River are slightly lower, but within an order of magnitude of the concentrations at the Core Zone Boundary. The intensities and areas of these groundwater plumes stabilize around CY 6940.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the benchmark at the Core Zone Boundary and the Columbia River throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.1.2.1.4 Disposal Group 1, Subgroup 1-D

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-D covers disposal of waste generated under Tank Closure Alternative 3C and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, and steam reforming waste. IHLW would be stored on site, while ILAW glass and steam reforming waste would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continue through CY 2050, when these facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2 is focused on the following COPC drivers:

- Radiological risk drivers: technetium-99 and iodine-129
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, fluoride, boron, and total uranium

The COPC drivers for Waste Management Alternative 2 were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, chromium, fluoride, nitrate, and boron) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Total uranium was added to the list because it begins to appear toward the end of the period of analysis. Total uranium is long-lived, or stable, but is not as mobile as the other COPC drivers; it moves about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Disposal Group 1, Subgroup 1-D, in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–457 through 5–468). Eight subtotals are plotted for IDF-East representing releases from ILAW glass, ETF-generated secondary waste, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, onsite- and offsite-generated waste, steam reforming waste, retired melters, and waste management secondary waste. Release plots from the RPPDF are also included. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

Figure 5–457 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–458, the chemical hazard drivers. Technetium-99 is released to the vadose zone from each of the subtotaled sources, with steam reforming waste and offsite-generated waste contributing the most. Iodine-129 had releases in the analysis from six of the sources, with steam reforming waste and offsite-generated waste also contributing the most. Chromium had six sources, with steam reforming waste and tank closure secondary waste providing the most releases. Nitrate was released only from ETF-generated secondary waste, waste management secondary waste, and onsite-generated waste. Fluoride and boron both were released only from waste management secondary waste and onsite-generated waste.

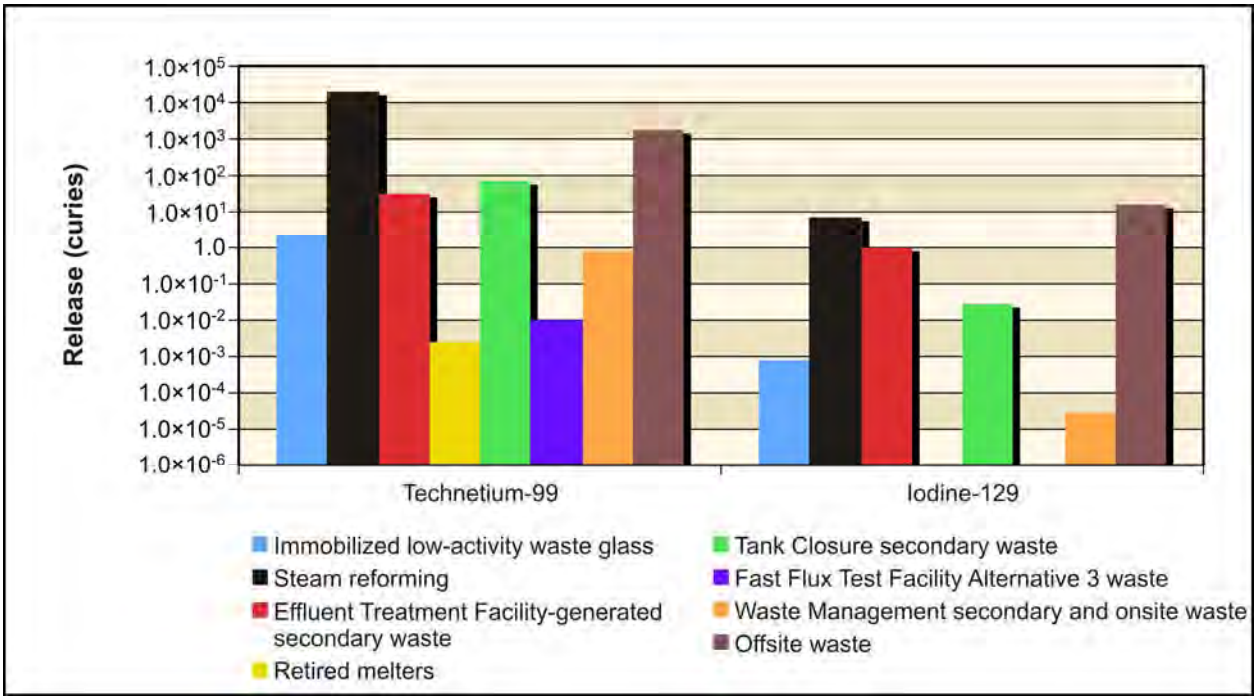


Figure 5–457. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

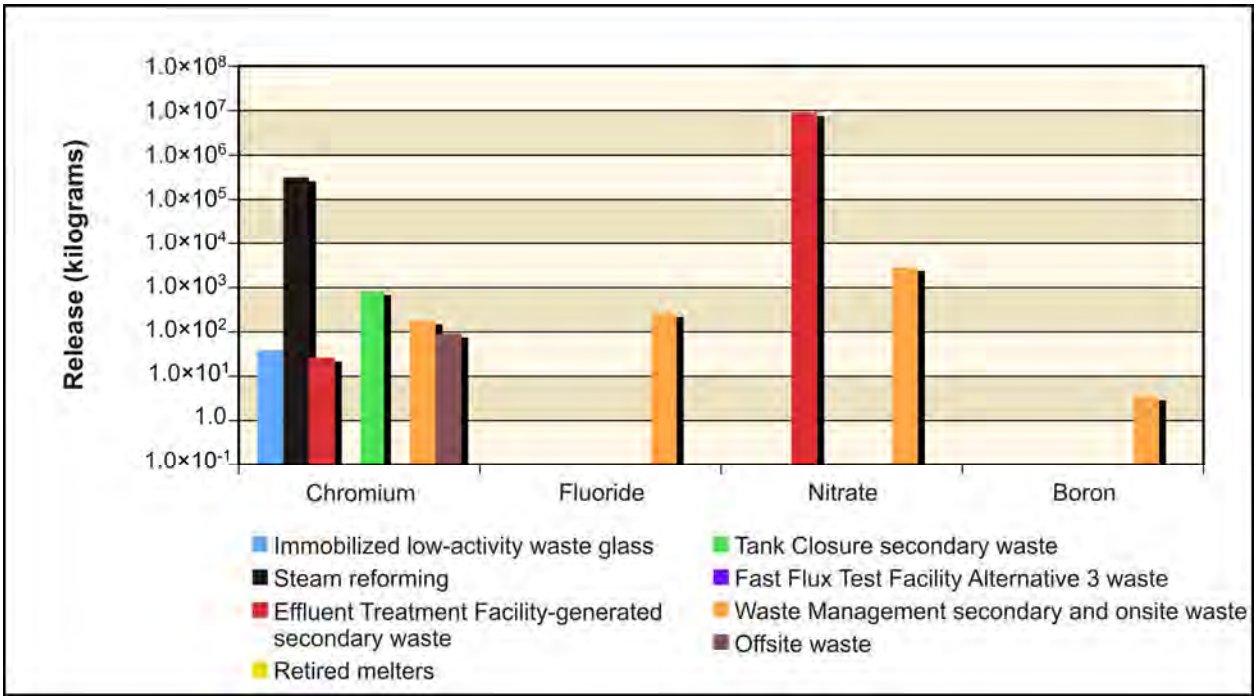


Figure 5–458. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–459 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–460, the chemical hazard drivers. Release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (technetium-99, iodine-129, chromium, nitrate, fluoride, and boron), the amount released to groundwater is typically equal to the amount released to the vadose zone. For technetium-99, the amount released to groundwater was essentially equal to that released to the vadose zone for steam reforming waste, ETF-generated secondary waste, and offsite-generated waste. For ILAW glass, retired melters, and tank closure secondary waste, about 45 to 50 percent of the technetium-99 released to the vadose zone was transferred to the groundwater. For FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite-generated waste, about 60 to 65 percent of the technetium-99 released to the vadose zone was transferred to the groundwater. For iodine-129, the amount released to groundwater was essentially equal to that released to the vadose zone for steam reforming waste and offsite-generated waste. For ILAW glass, ETF-generated secondary waste, tank closure secondary waste, waste management secondary waste, and onsite-generated waste, about 40 to 50 percent of the iodine-129 released to the vadose zone was transferred to the groundwater. For chromium, the amount released to groundwater was essentially equal to that released to the vadose zone for steam reforming waste, ETF-generated secondary waste, tank closure secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For ILAW glass, about 40 percent of the chromium released to the vadose zone was transferred to the groundwater. For nitrate, the amount released to groundwater was essentially equal to that released to the vadose zone for ETF-generated secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For fluoride, the amount released to groundwater was essentially equal to that released to the vadose zone for waste management secondary waste and onsite-generated waste. For boron, the amount released to groundwater was essentially equal to that released to the vadose zone for waste management secondary waste and onsite-generated waste.

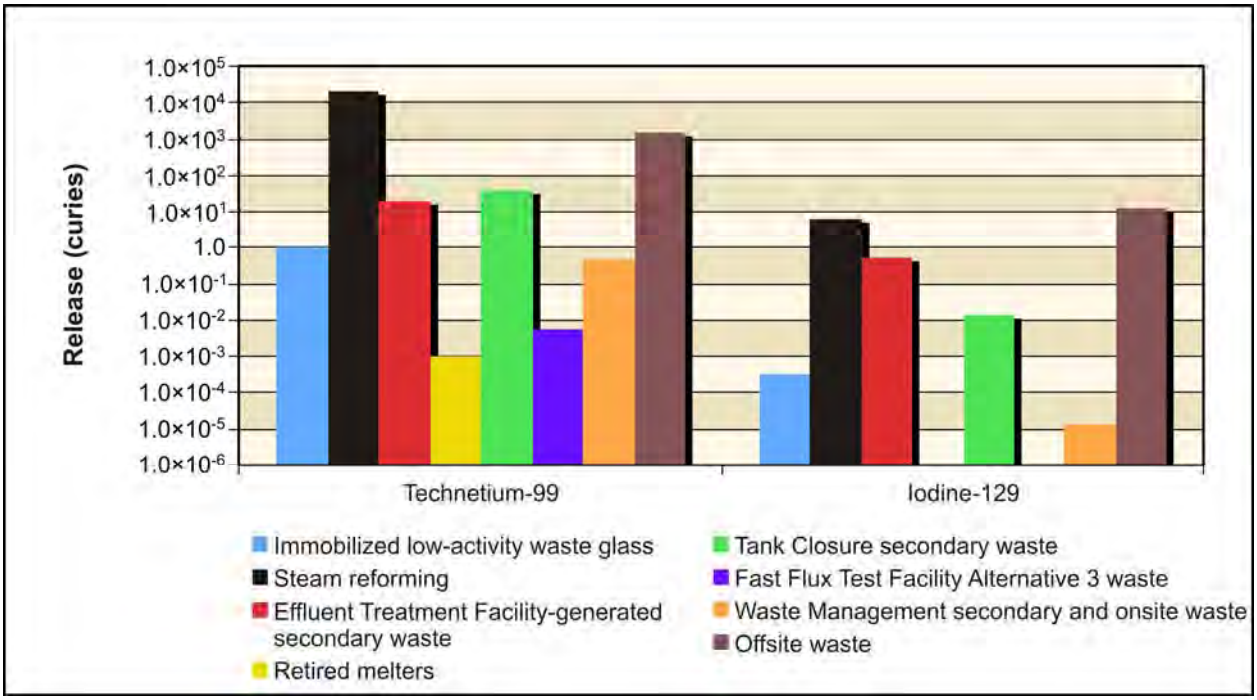


Figure 5–459. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

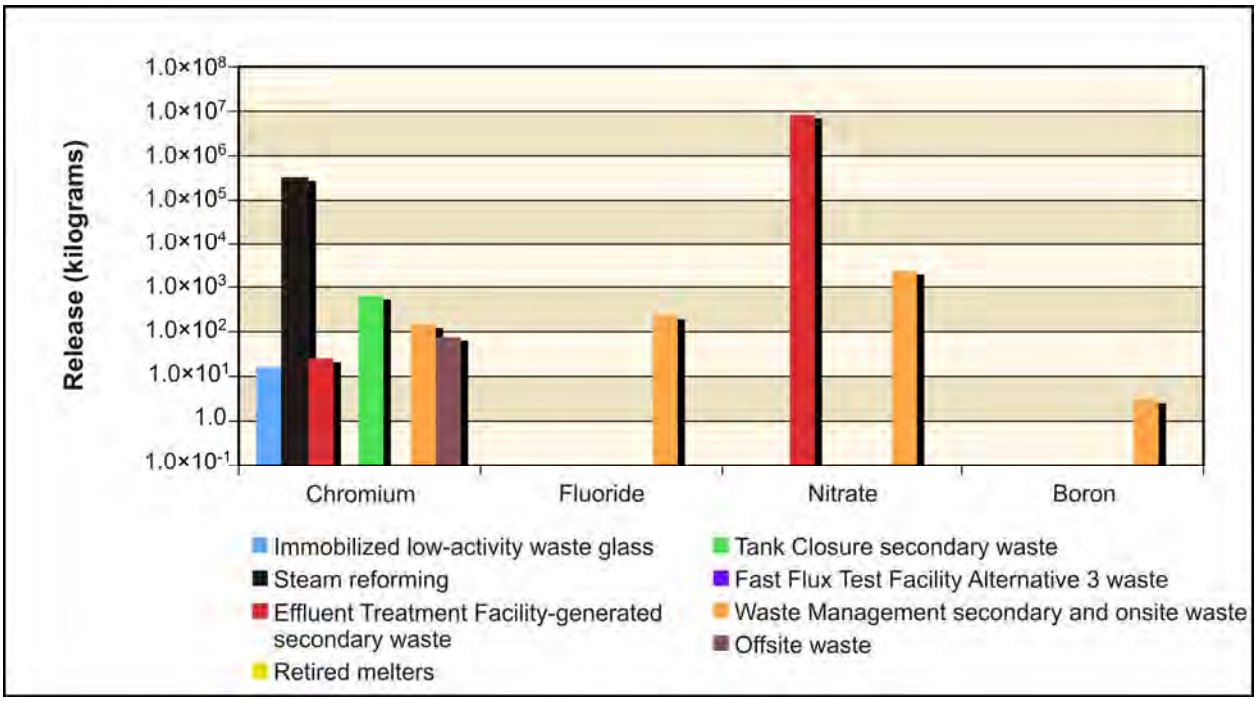


Figure 5–460. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–461 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–462, the chemical hazard drivers. For the conservative tracers (technetium-99, iodine-129, chromium, nitrate, fluoride, and boron), the amount released to the Columbia River is typically essentially equal to the amount released to the vadose zone. For technetium-99, the amount released to the Columbia River from the groundwater was about 90 to 98 percent for ILAW glass, steam reforming waste, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste. For iodine-129, the amount released to the Columbia River from the groundwater was about 90 to 100 percent for ILAW glass, stream reforming waste, ETF-generated secondary waste, tank closure secondary waste, and offsite-generated waste. Essentially none of the iodine-129 released from waste management secondary waste and onsite-generated waste from the groundwater was transferred to the Columbia River. For chromium, the amount released to the Columbia River from the groundwater was about 90 to 100 percent for ILAW glass, stream reforming waste, ETF-generated secondary waste, tank closure secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For nitrate, the amount released to the Columbia River was essentially equal to that released to the groundwater for ETF-generated secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For fluoride, the amount released to the Columbia River was essentially equal to that released to the groundwater for waste management secondary waste and onsite-generated waste. For boron, the amount released to the Columbia River was essentially equal to that released to the groundwater for waste management secondary waste and onsite-generated waste.

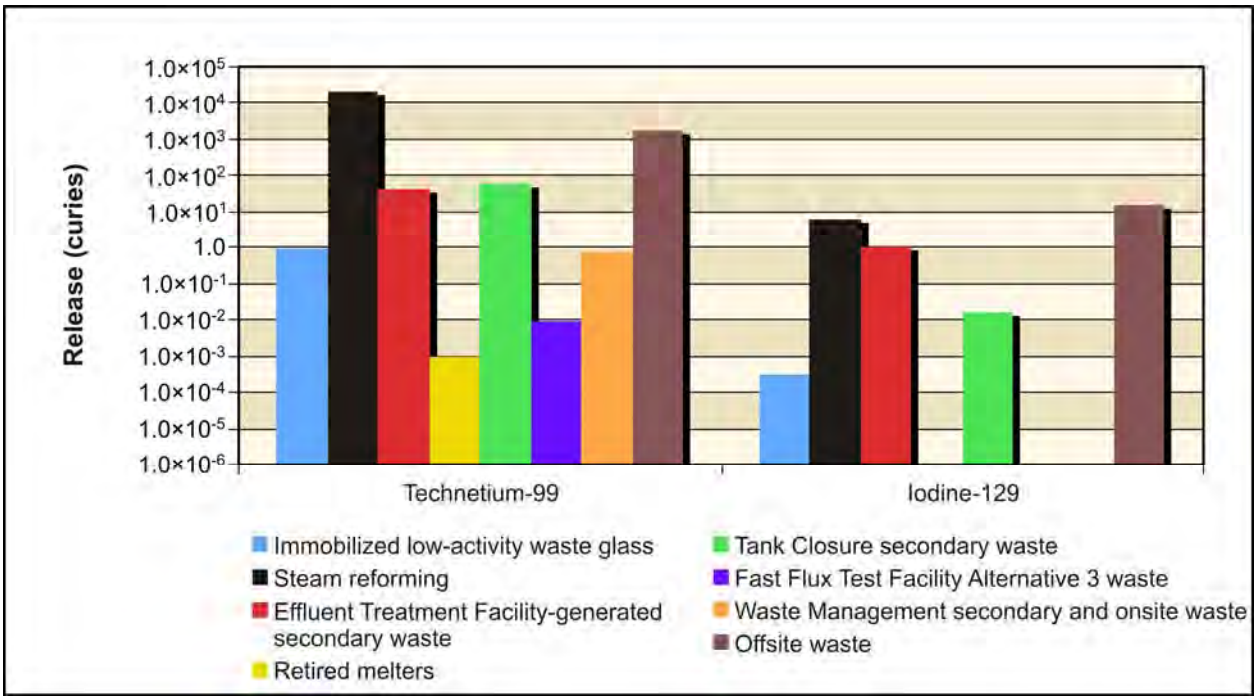


Figure 5–461. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

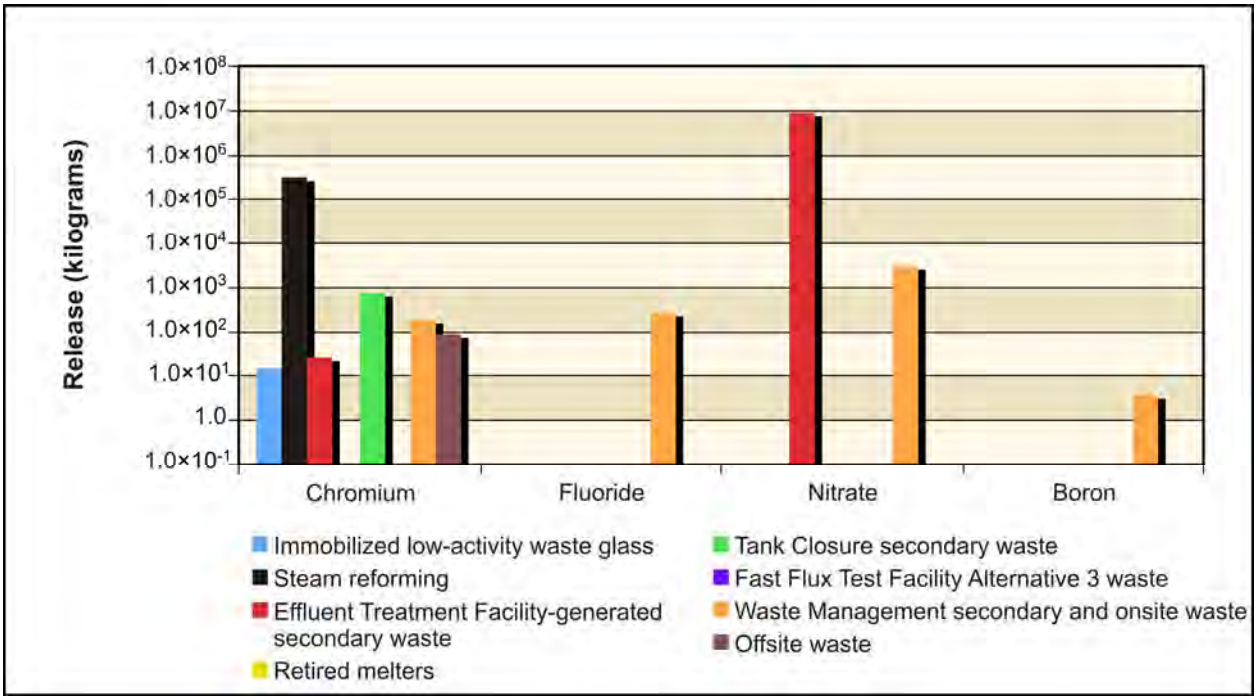


Figure 5–462. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Figure 5–463 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–464, the chemical hazard drivers. The only constituents released to the vadose zone from the RPPDF were technetium-99, iodine-129, chromium, and nitrate.

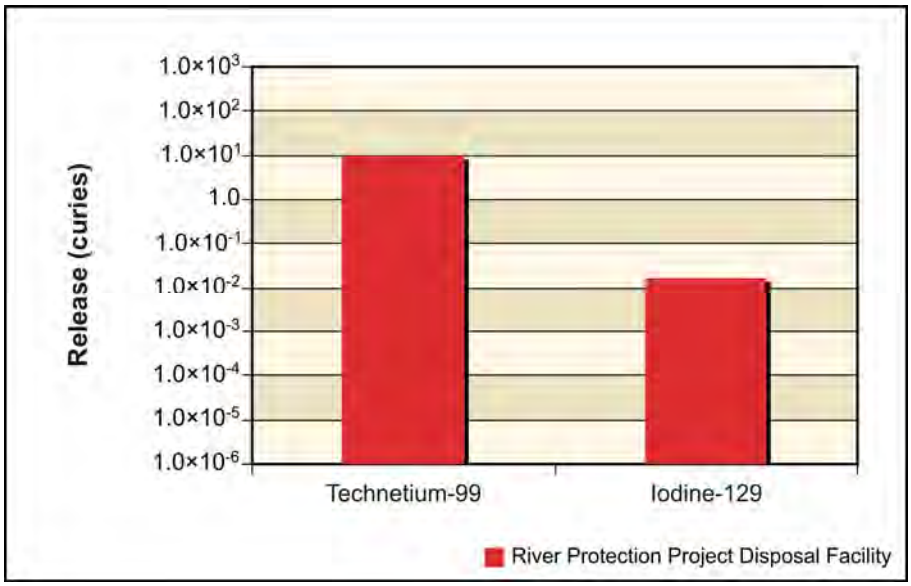


Figure 5–463. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

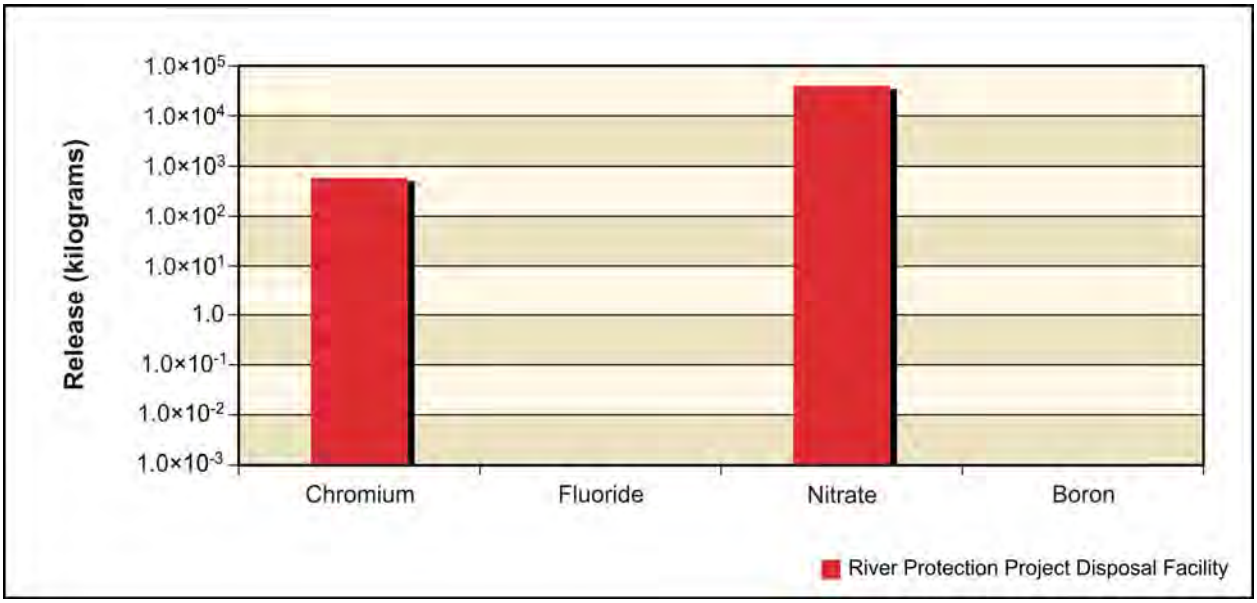


Figure 5–464. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–465 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–466, the chemical hazard drivers. For the RPPDF, the amount released to groundwater was essentially equal to that released to the vadose zone for technetium-99, iodine-129, chromium, and nitrate.

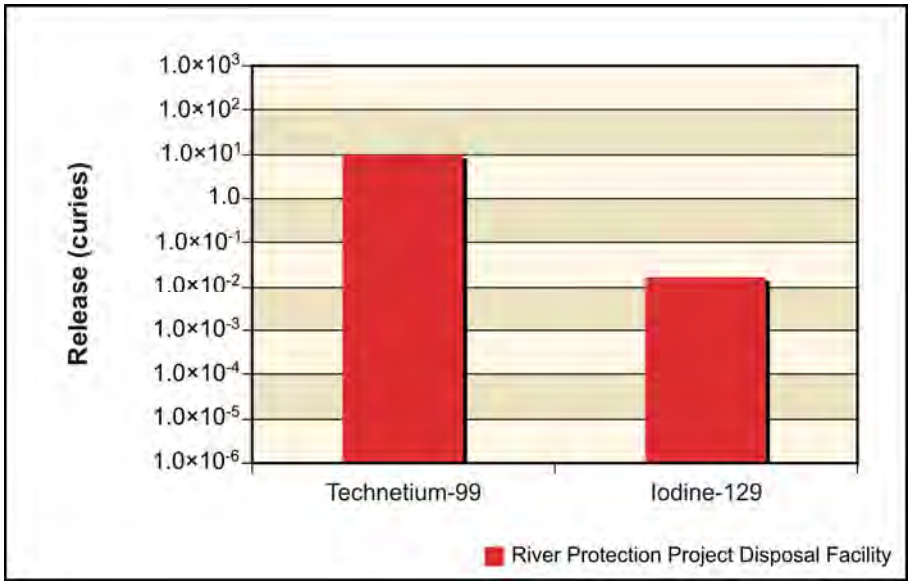


Figure 5–465. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Groundwater

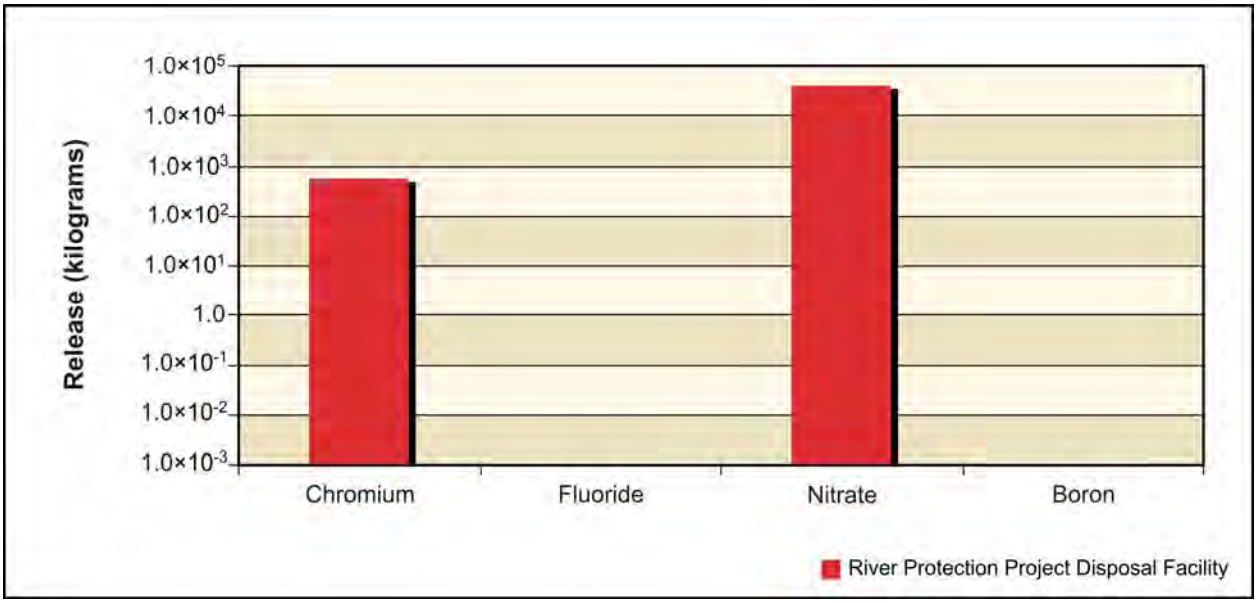


Figure 5–466. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–467 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–468, the chemical hazard drivers. For the RPPDF, about 95 percent of technetium-99, iodine-129, chromium, and nitrate released from the groundwater reached the Columbia River.

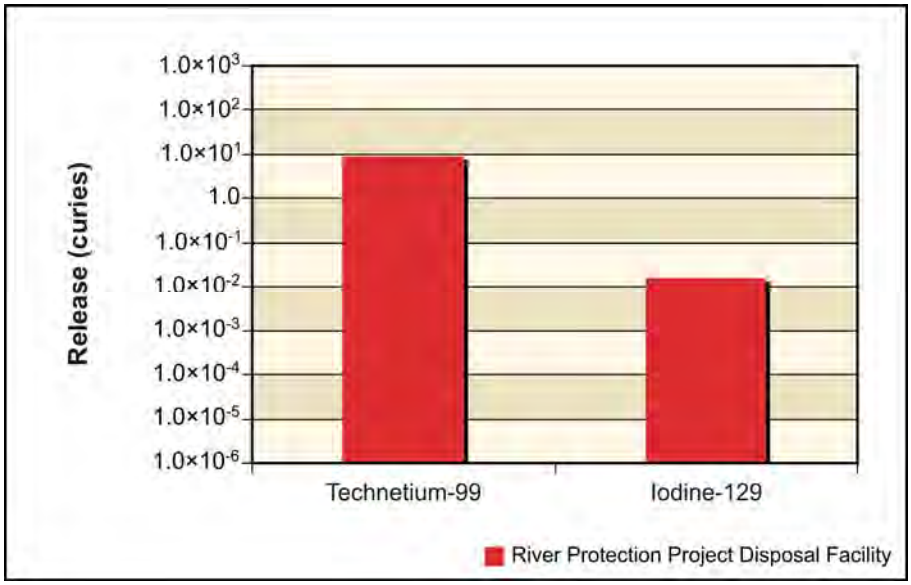


Figure 5–467. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Columbia River

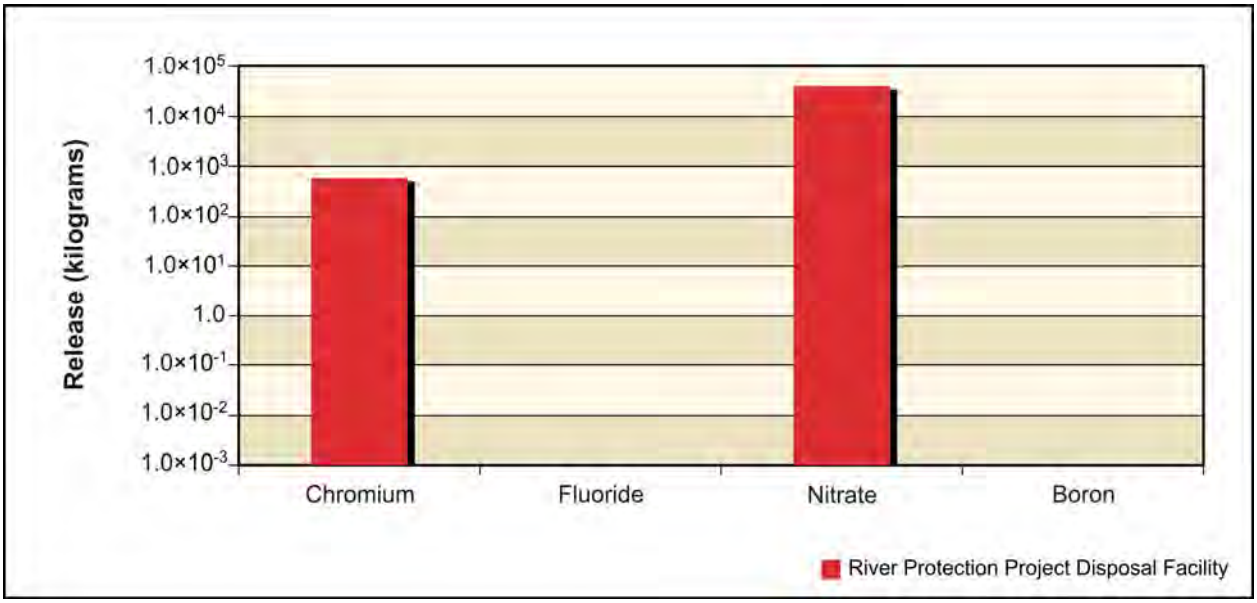


Figure 5–468. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–469 through 5–473). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–80 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figure 5–469 shows the concentration versus time plot for technetium-99. Releases cause the groundwater concentrations at the Core Zone Boundary and at the Columbia River nearshore to exceed the benchmark concentration by about one-half of an order of magnitude at around CY 6000. The concentrations at the Core Zone Boundary and the Columbia River nearshore remain above the benchmark concentration through the end of the period of analysis.

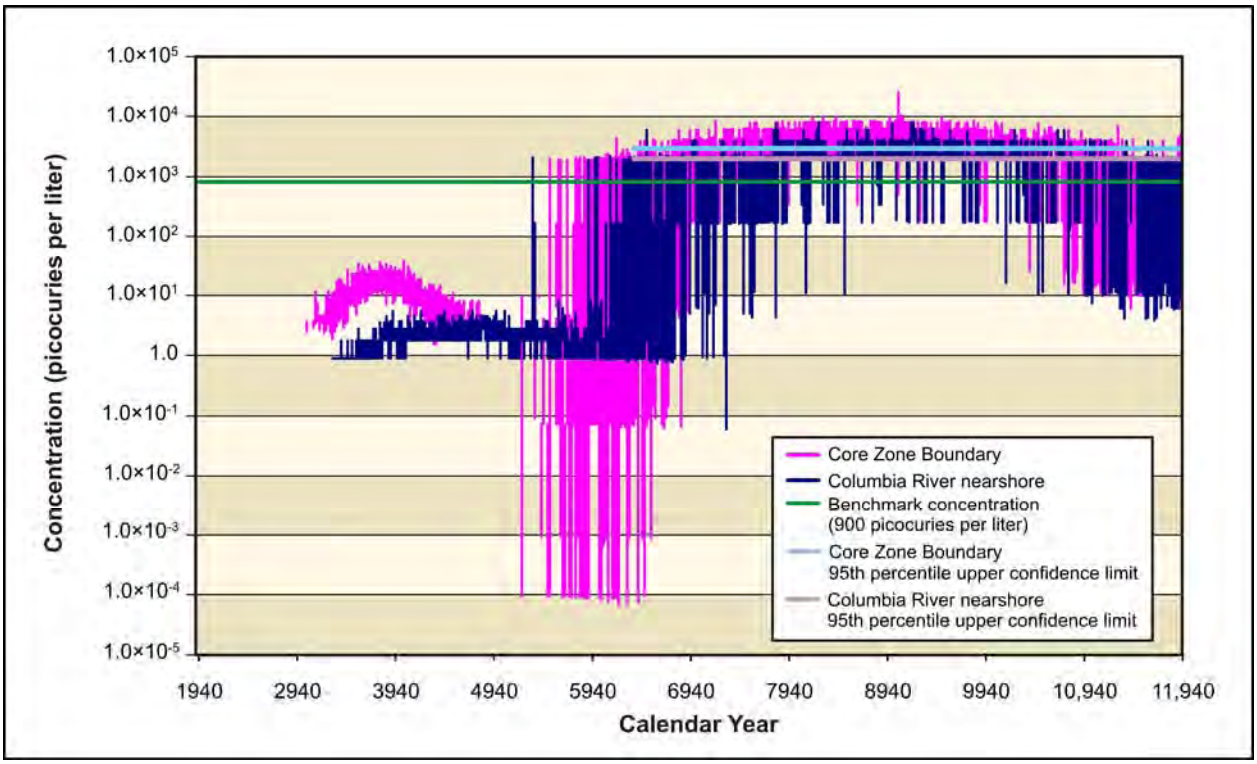


Figure 5–469. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Technetium-99 Concentration Versus Time

The plot of concentration of iodine-129 versus time shows a pattern similar to that of technetium-99 (see Figure 5–470).

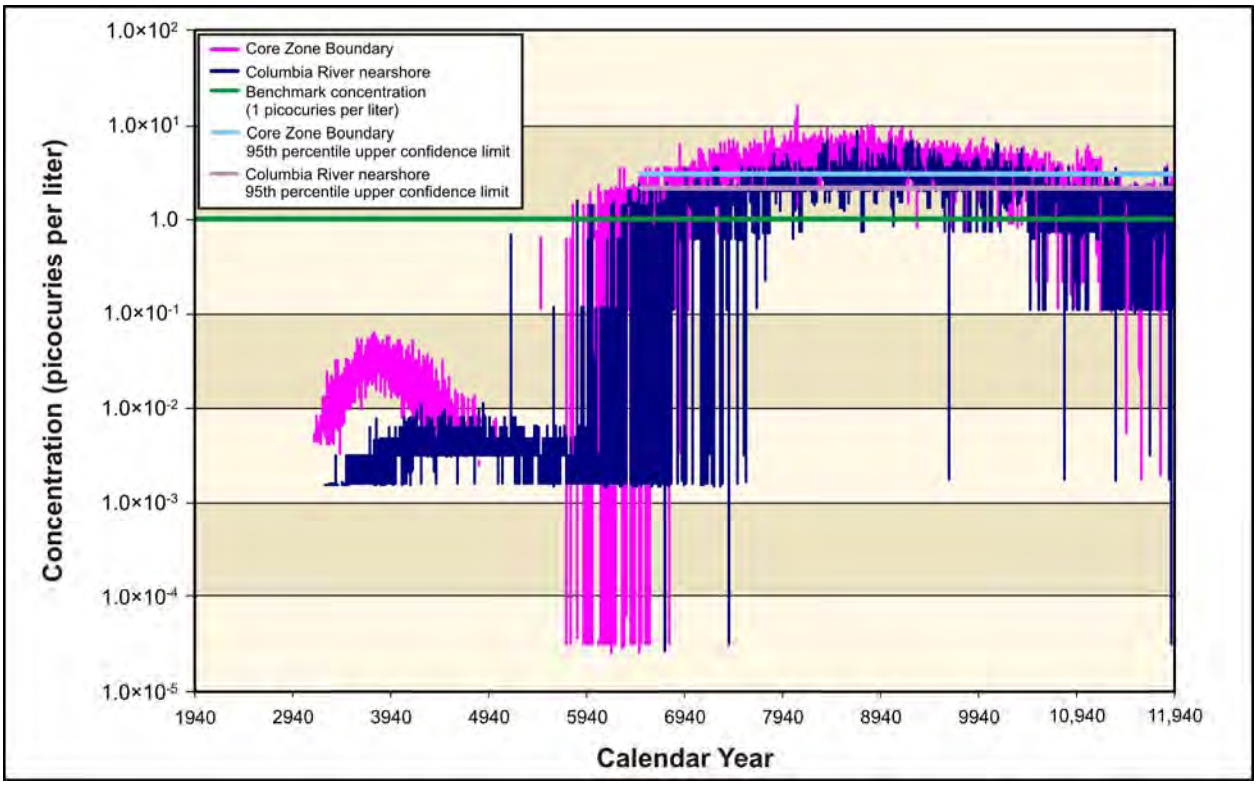


Figure 5–470. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Iodine-129 Concentration Versus Time

Figure 5–471 shows the concentration versus time plot for chromium. The concentrations at the Core Zone Boundary exceed the benchmark from about CY 7000 to 10,000. During the same time period, concentrations from the Columbia River nearshore approach the benchmark, but never reach it. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about one-half of an order of magnitude below the benchmark at the end of the period of analysis.

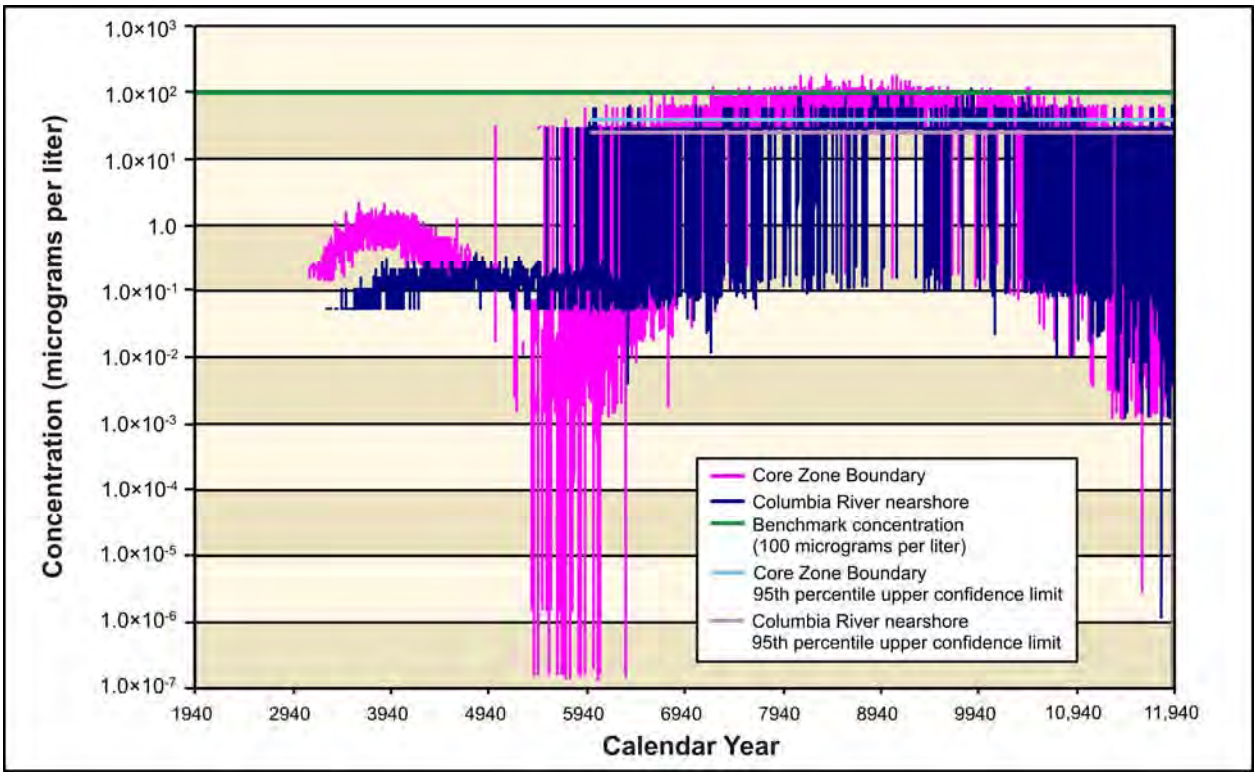


Figure 5–471. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chromium Concentration Versus Time

Figure 5–472 shows the concentration versus time plot for nitrate. The concentrations at the Core Zone Boundary and the Columbia River nearshore both peak at around CY 8000. Even at the concentration's peak, nitrate levels still remain about one to one and one-half orders of magnitude below the benchmark level.

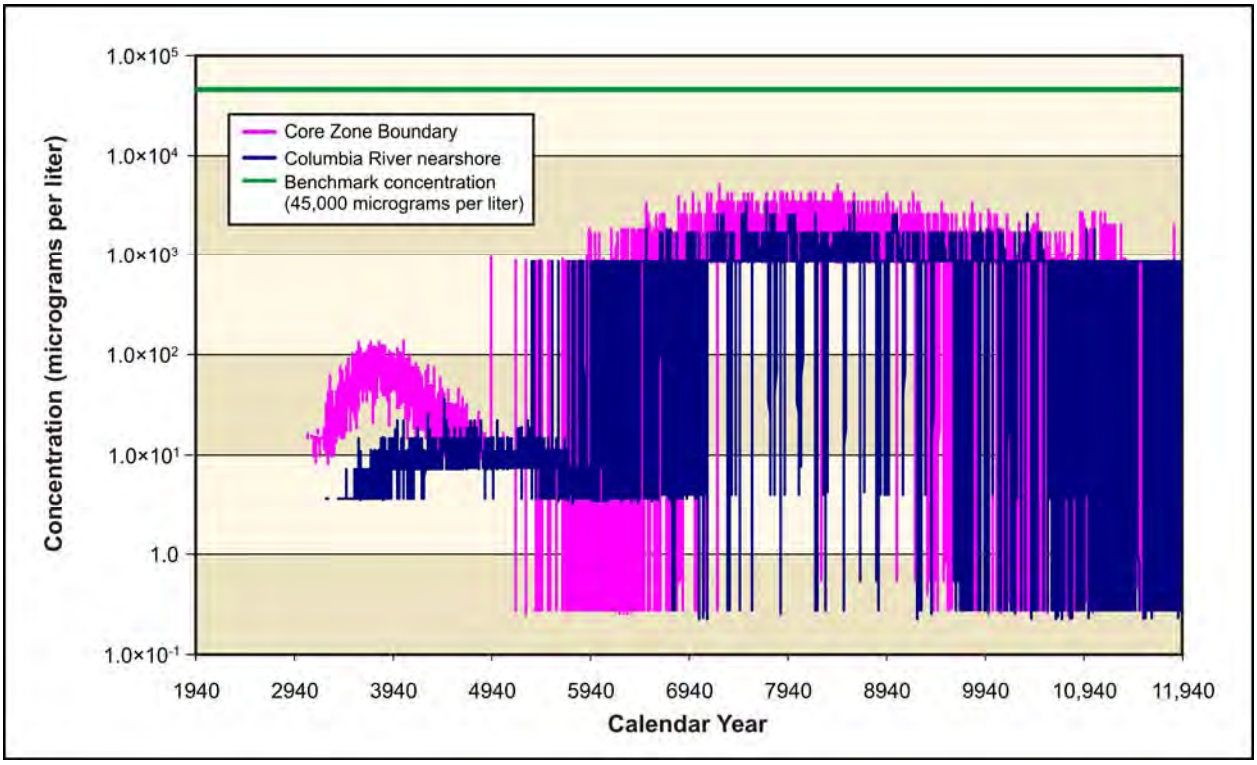


Figure 5–472. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Nitrate Concentration Versus Time

Figure 5–473 shows the concentration versus time plot for total uranium. It is not until around CY 9900 that concentrations begin to appear on the graph. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about eight to nine orders of magnitude below the benchmark level.

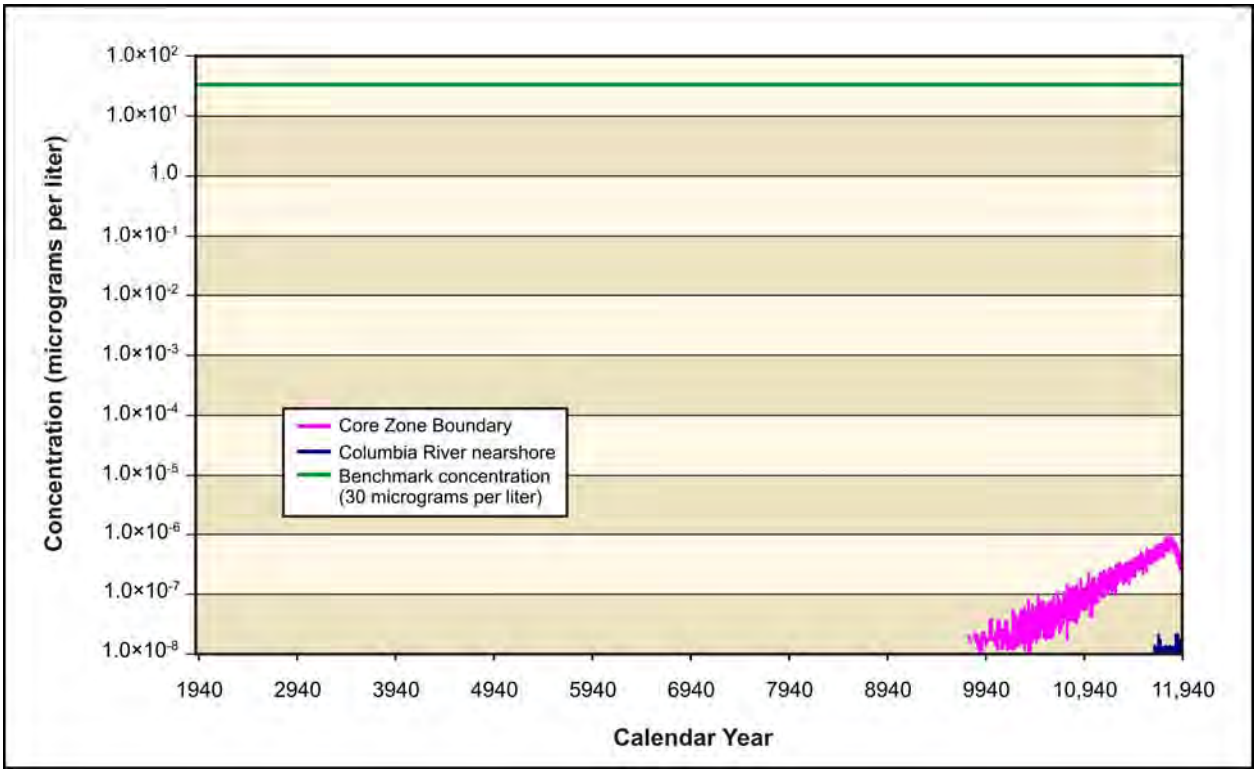


Figure 5–473. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Total Uranium Concentration Versus Time

Table 5–80. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**30,100**	33	**24,800**	**7,610**	900
	(9032)	(3825)	(9067)	(8274)	
Iodine-129	**24**	0.1	**16**	**8**	1
	(8195)	(3772)	(8082)	(8699)	
Chemical in micrograms per liter					
Chromium	**436**	2	**174**	**116**	100
	(9071)	(3856)	(8397)	(9878)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,500	149	4,970	3,320	45,000
	(7859)	(3811)	(7269)	(7744)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Disposal Group 1, Subgroup 1-D, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–474 shows the spatial distribution of groundwater concentration of iodine-129 during CY 3890. Releases from the RPPDF create a plume extending northerly through Gable Gap toward the Columbia River. Peak concentrations in this plume exceed the benchmark by about one to five times, although the majority of the plume has concentrations less than one-twentieth of the benchmark. By CY 7140, releases from IDF-East create a new plume extending easterly toward the Columbia River (see Figure 5–475). Peak concentrations in this plume exceed the benchmark by 10 to 50 times. By the end of the period of analysis (CY 11,885), the plume created by the RPPDF has mostly dissipated, while the IDF-East plume continues to persist, with small patches exceeding the benchmark by about 5 to 10 times (see Figure 5–476). Technetium-99 shows a similar spatial distribution over time (see Figure 5–477 through 5–479). Chromium and nitrate also show a similar spatial distribution over time, but with less-intense areas of peak concentration (see Figures 5–480 through 5–485).

Total uranium is not as mobile as those COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–486 shows the distribution of total uranium during CY 11,885. A plume that is less than one-twentieth of the benchmark was released from the RPPDF and is extending northerly through Gable Gap toward the Columbia River. Because of the slow nature of the pore water velocity, most of the uranium releases are expected to occur after the period of analysis is over.

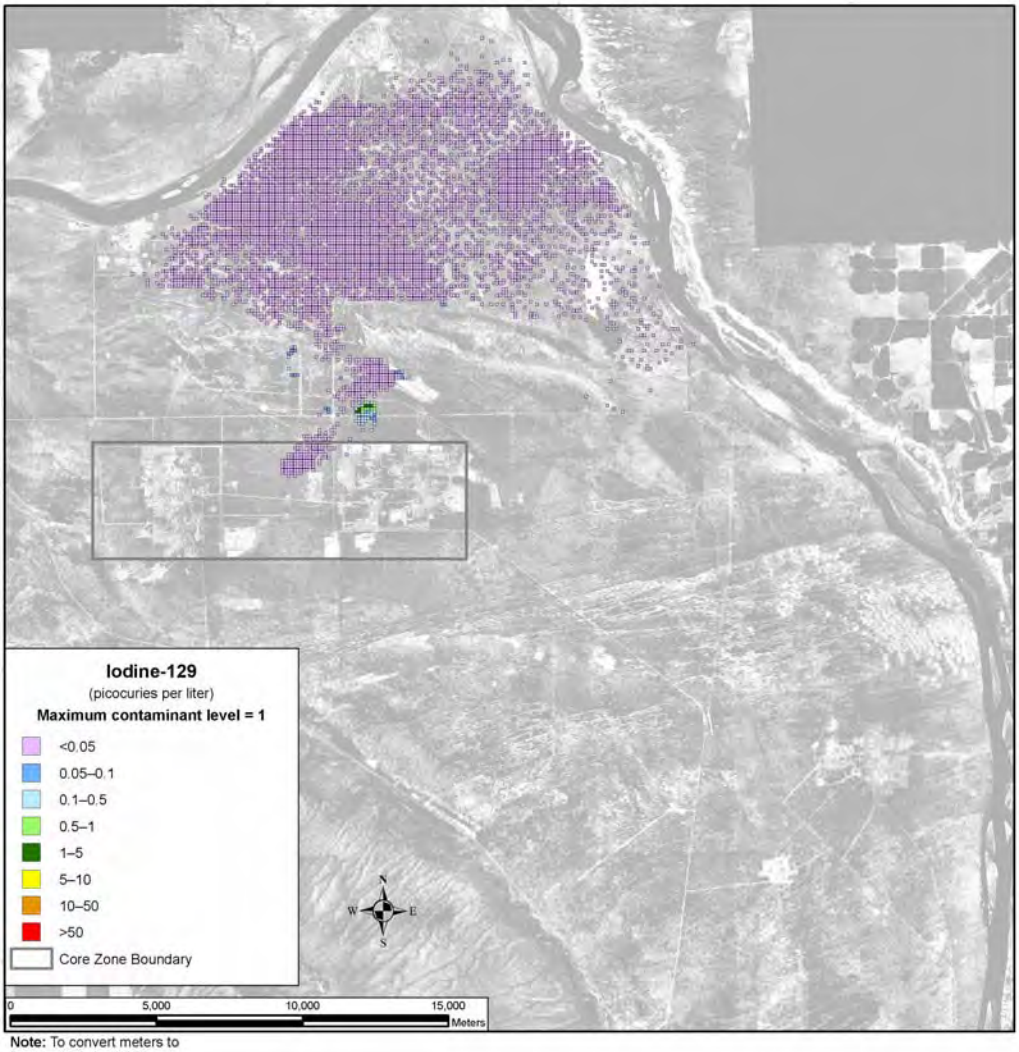


Figure 5–474. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

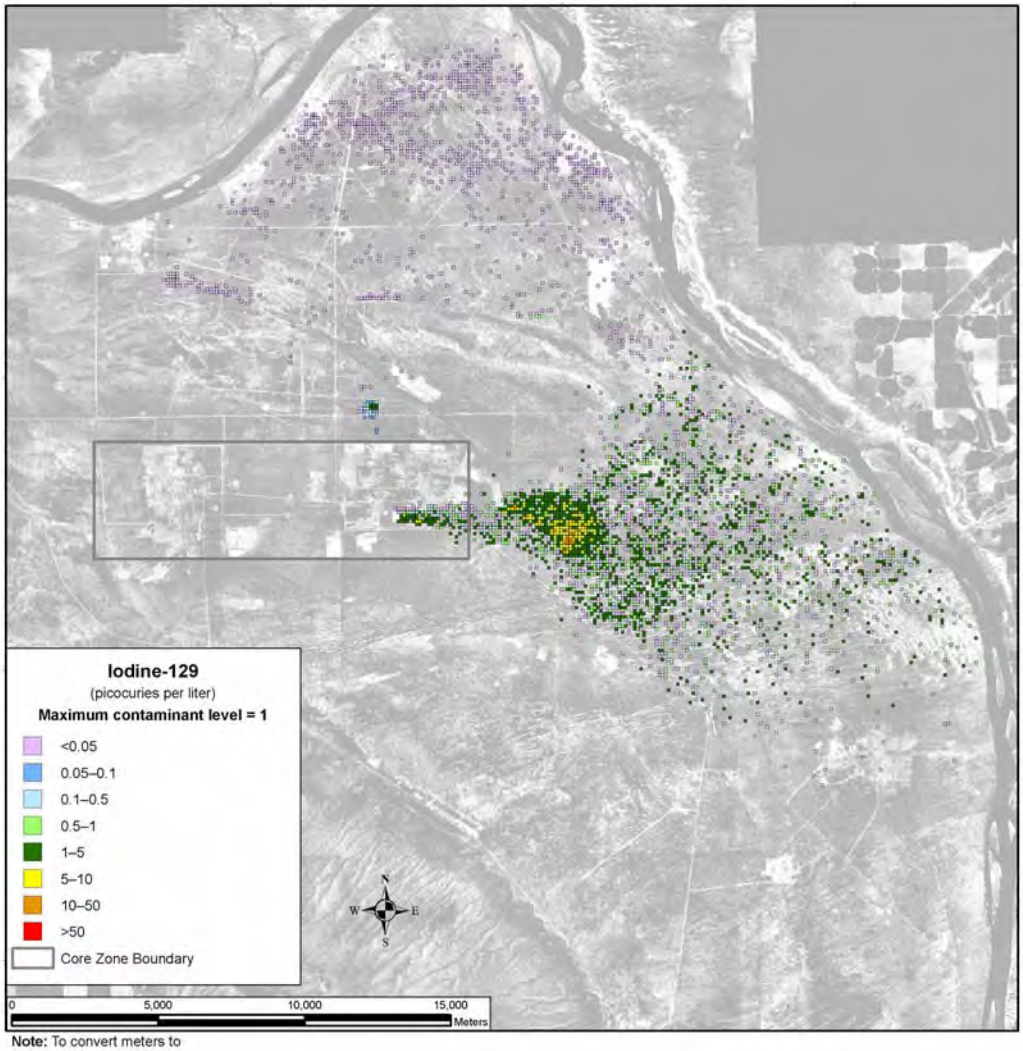


Figure 5–475. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

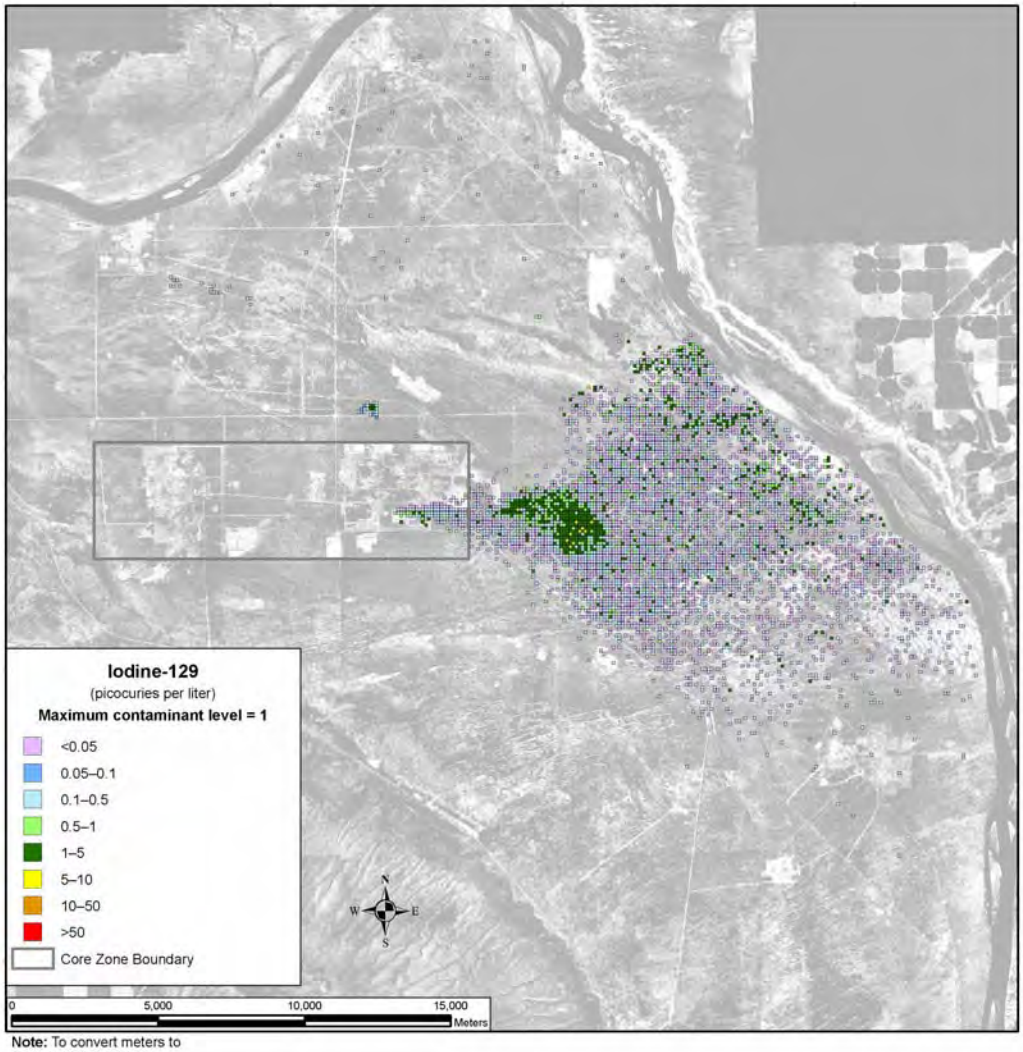


Figure 5–476. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

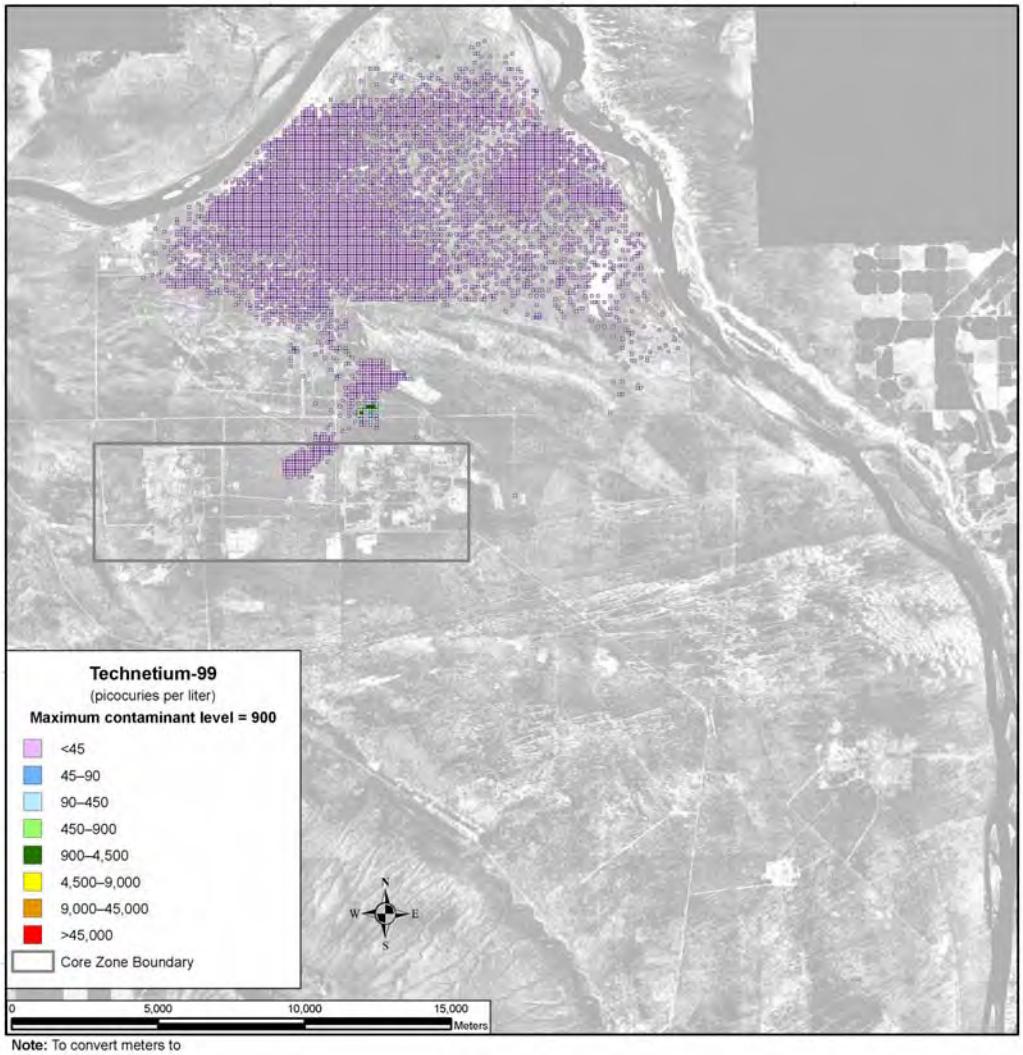


Figure 5–477. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

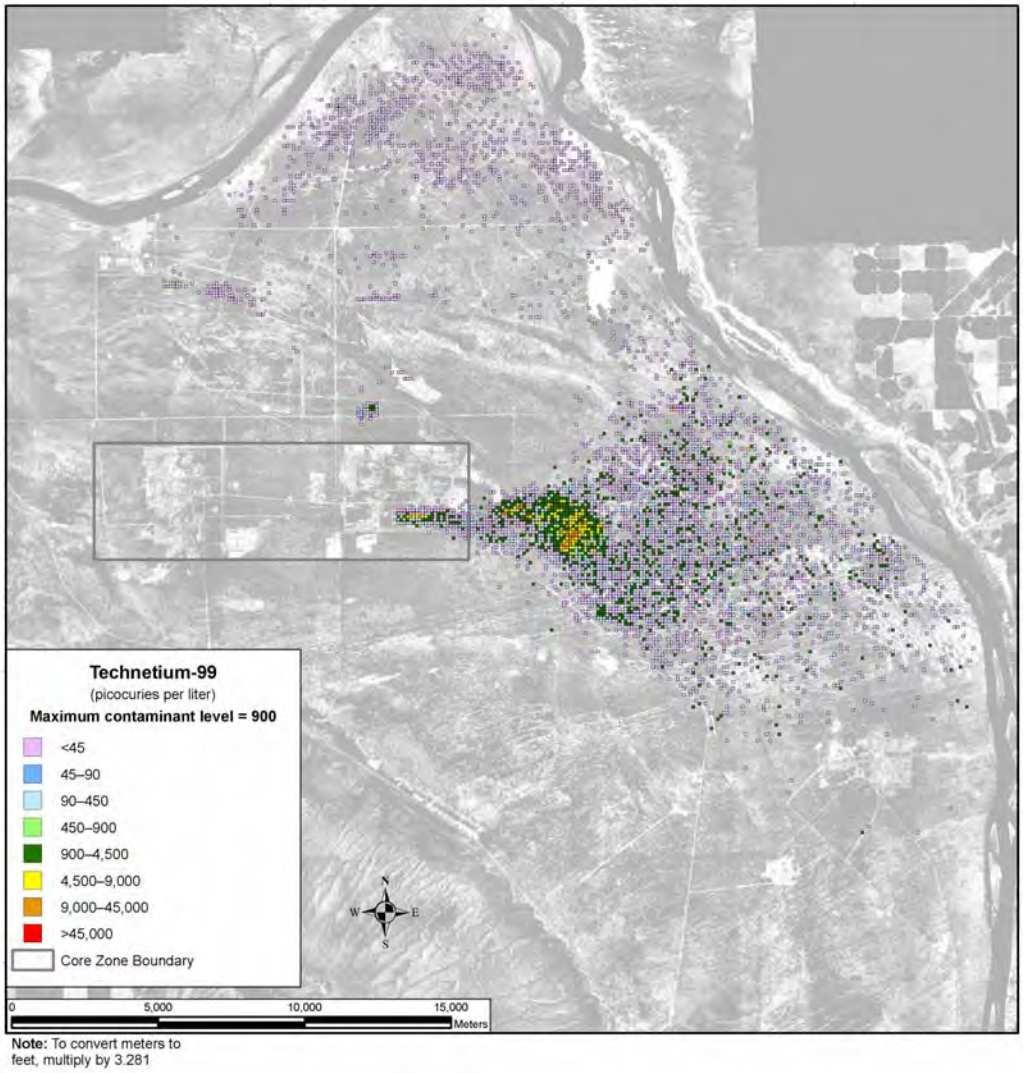


Figure 5–478. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

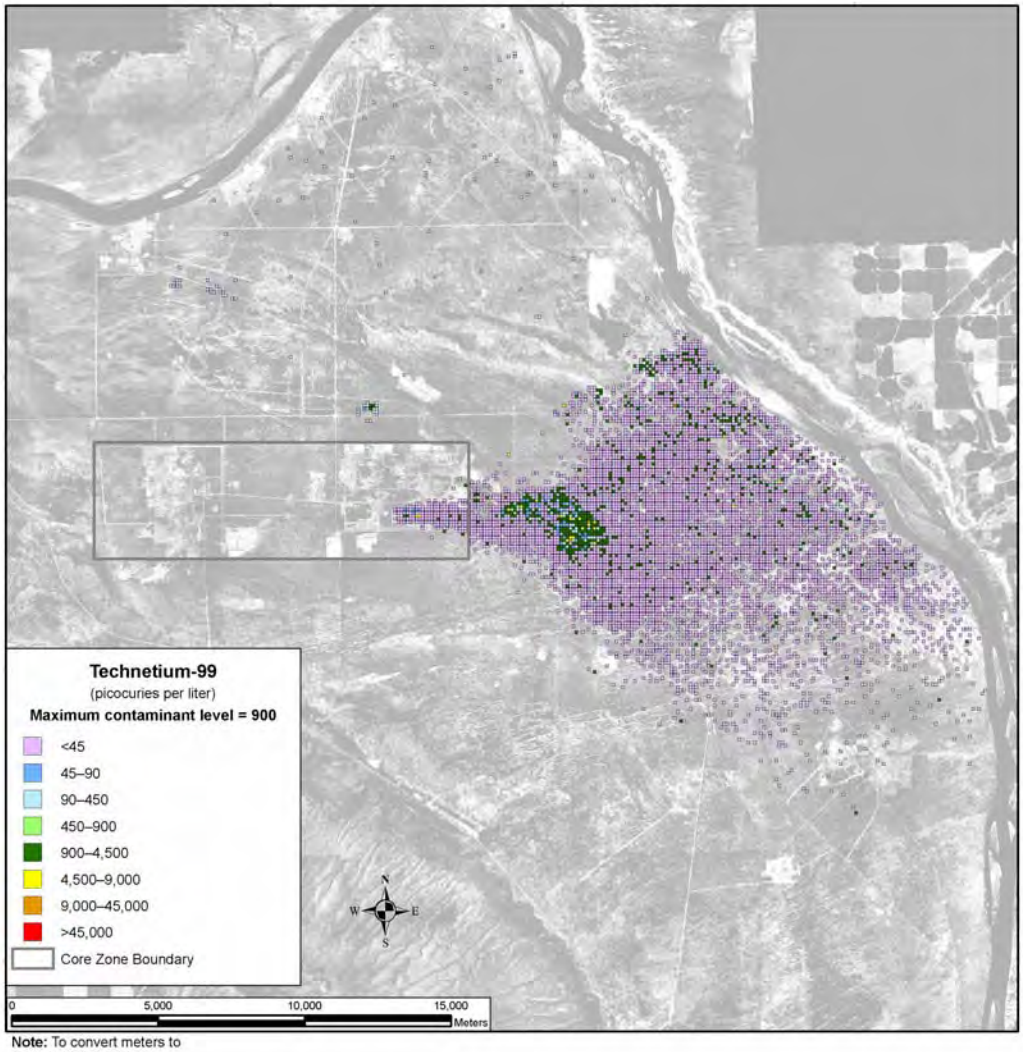


Figure 5–479. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

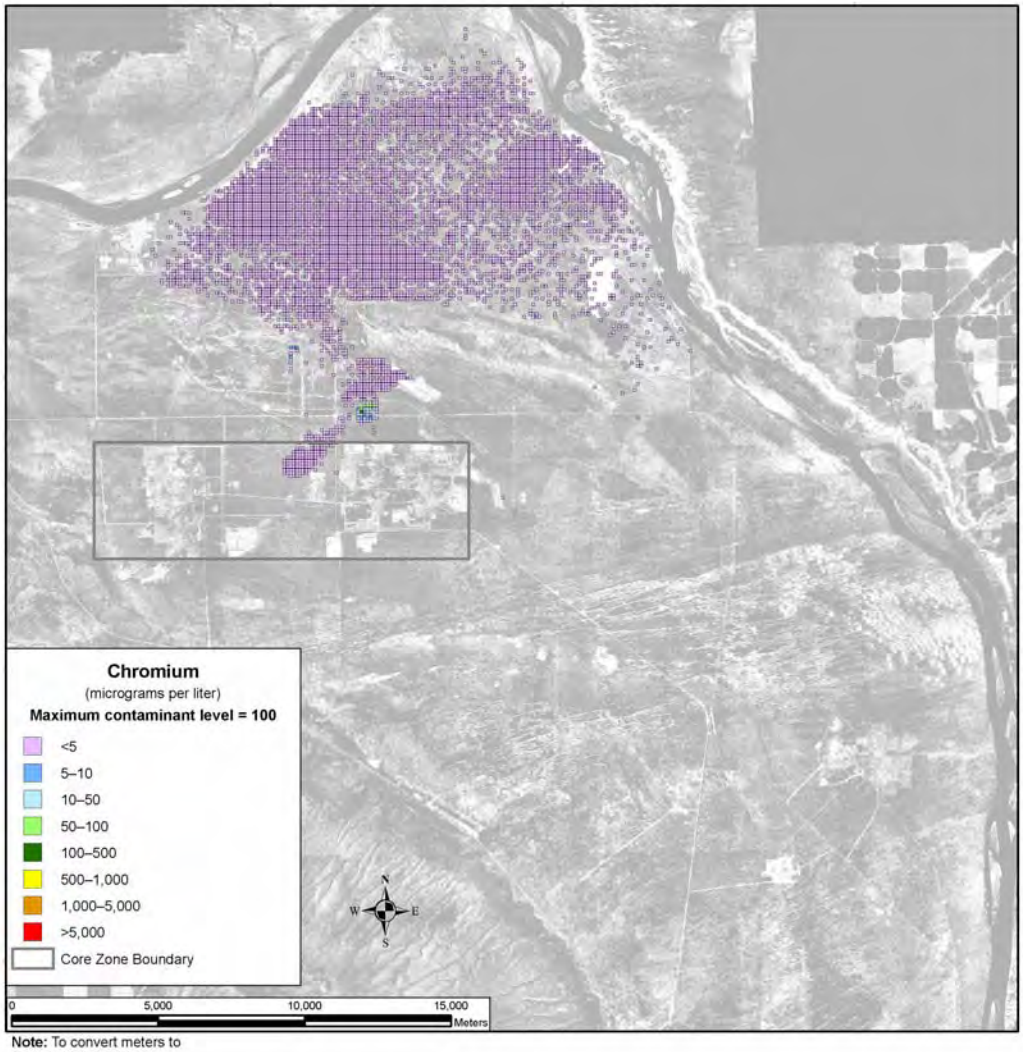


Figure 5–480. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

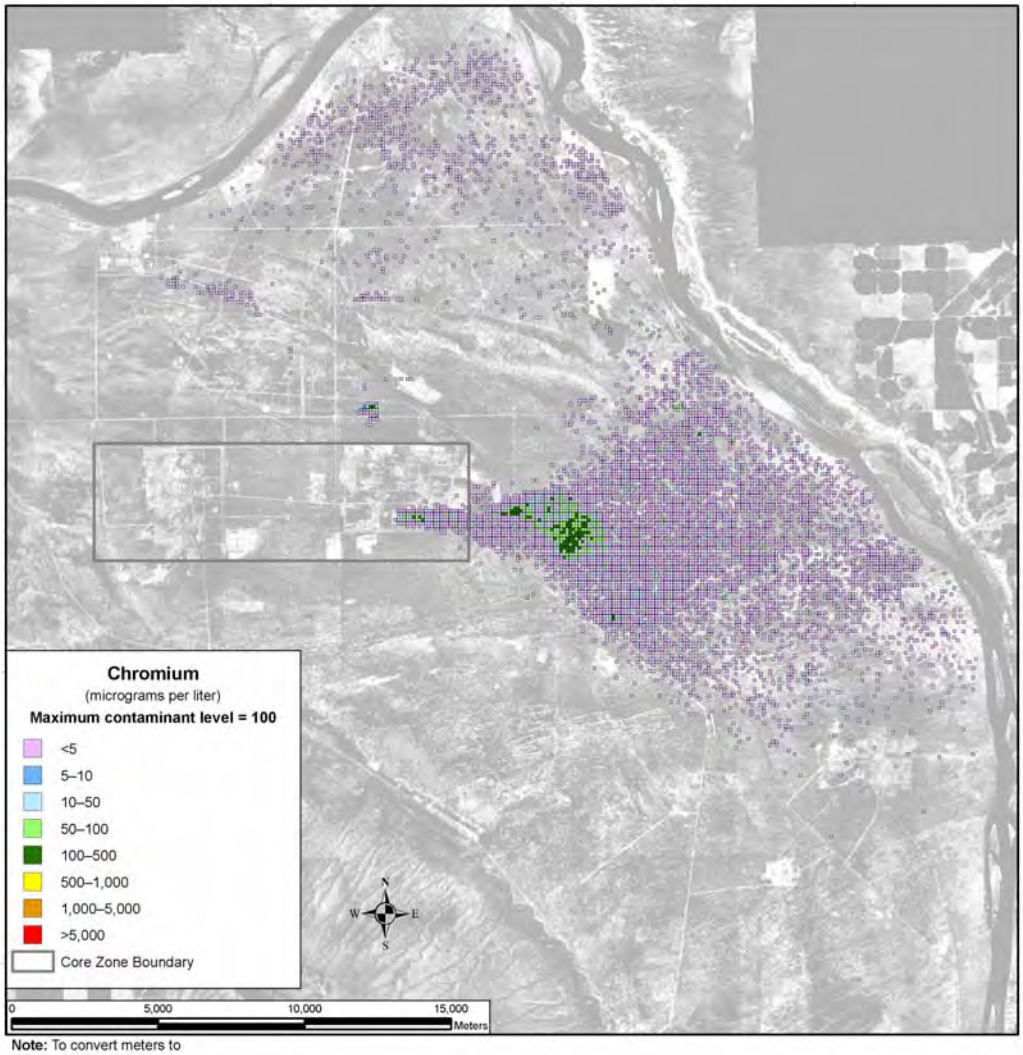


Figure 5–481. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

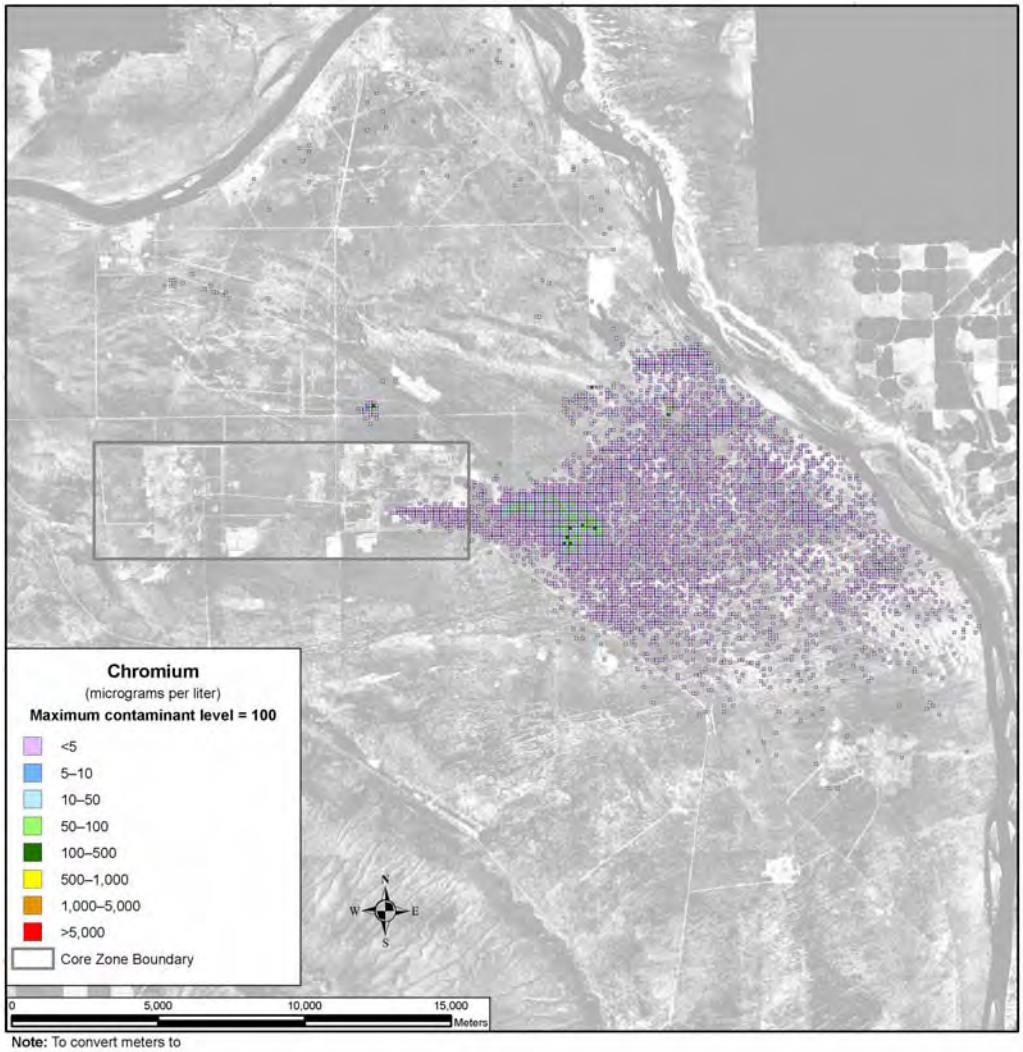


Figure 5–482. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

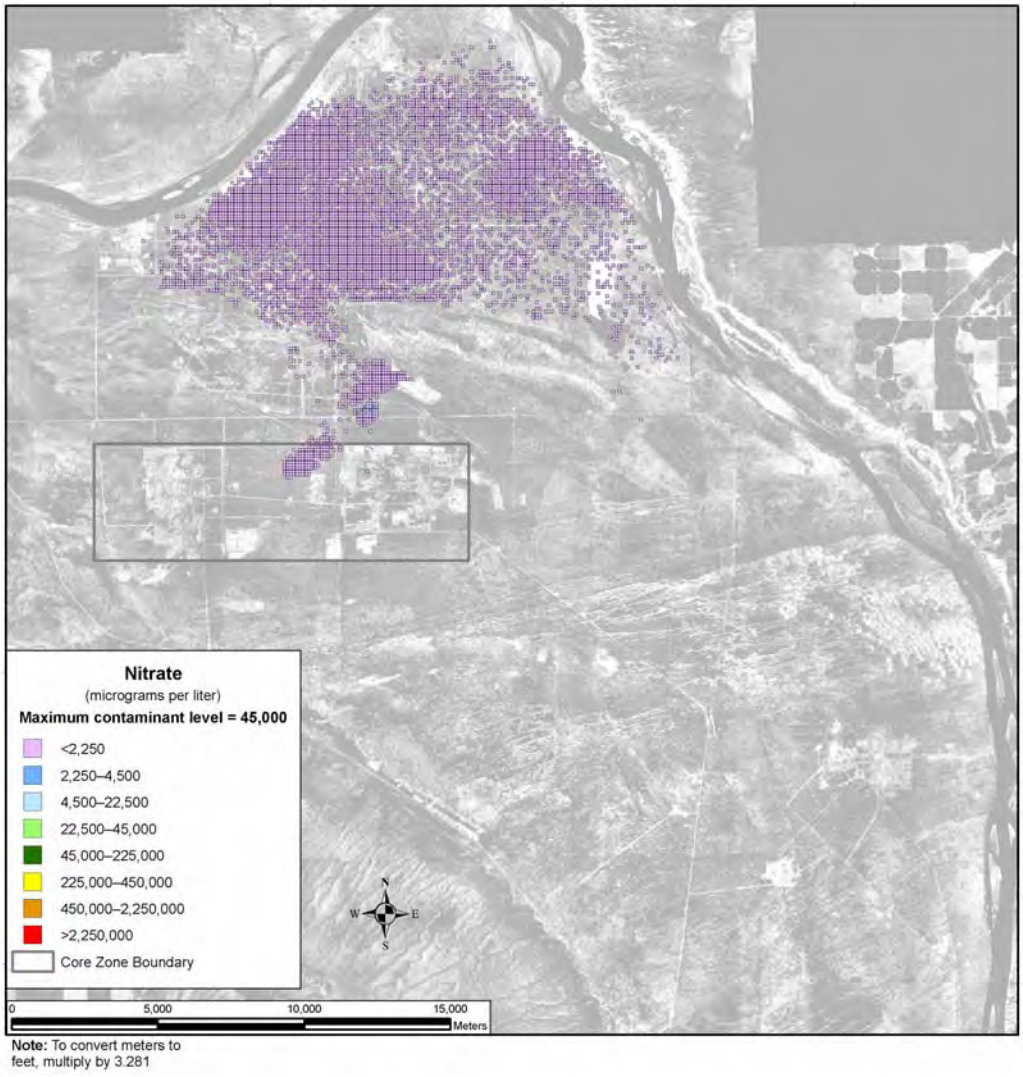


Figure 5–483. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

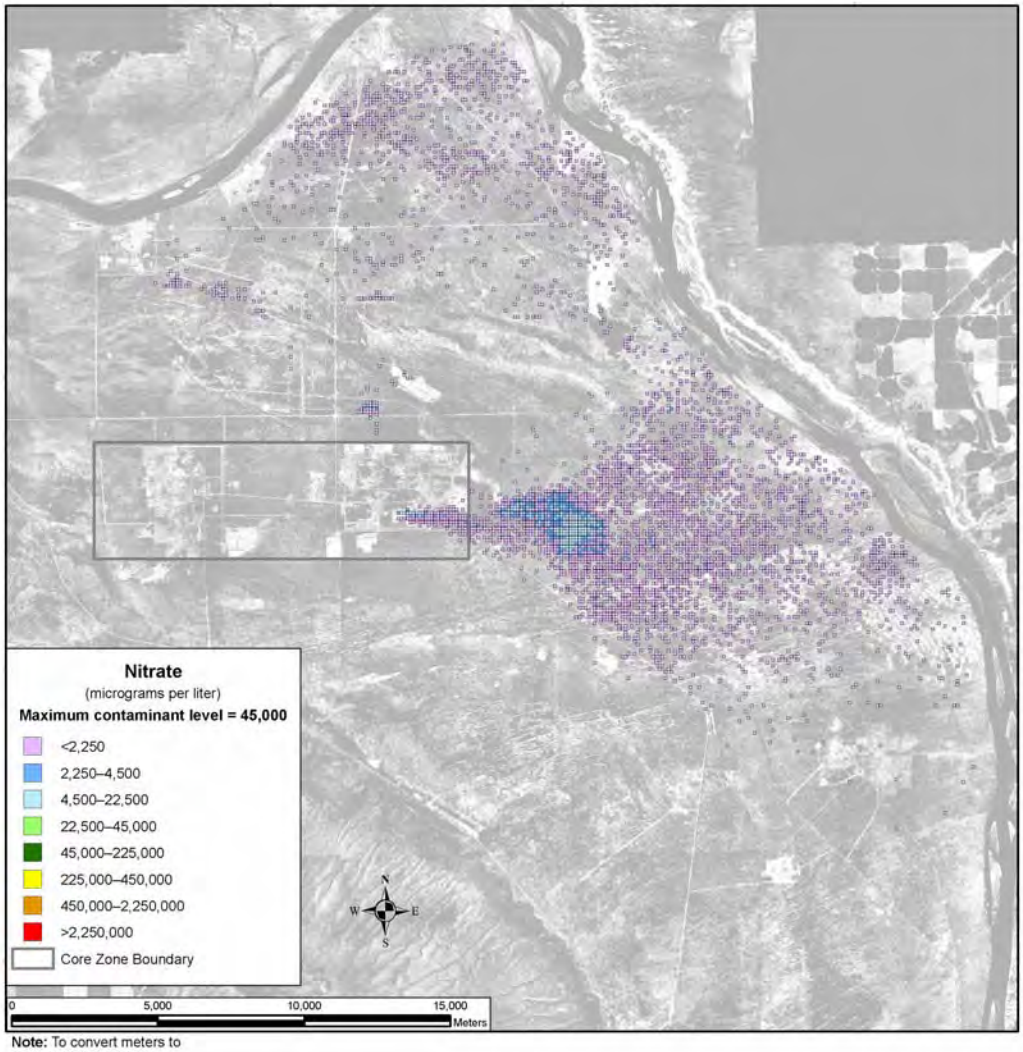


Figure 5–484. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

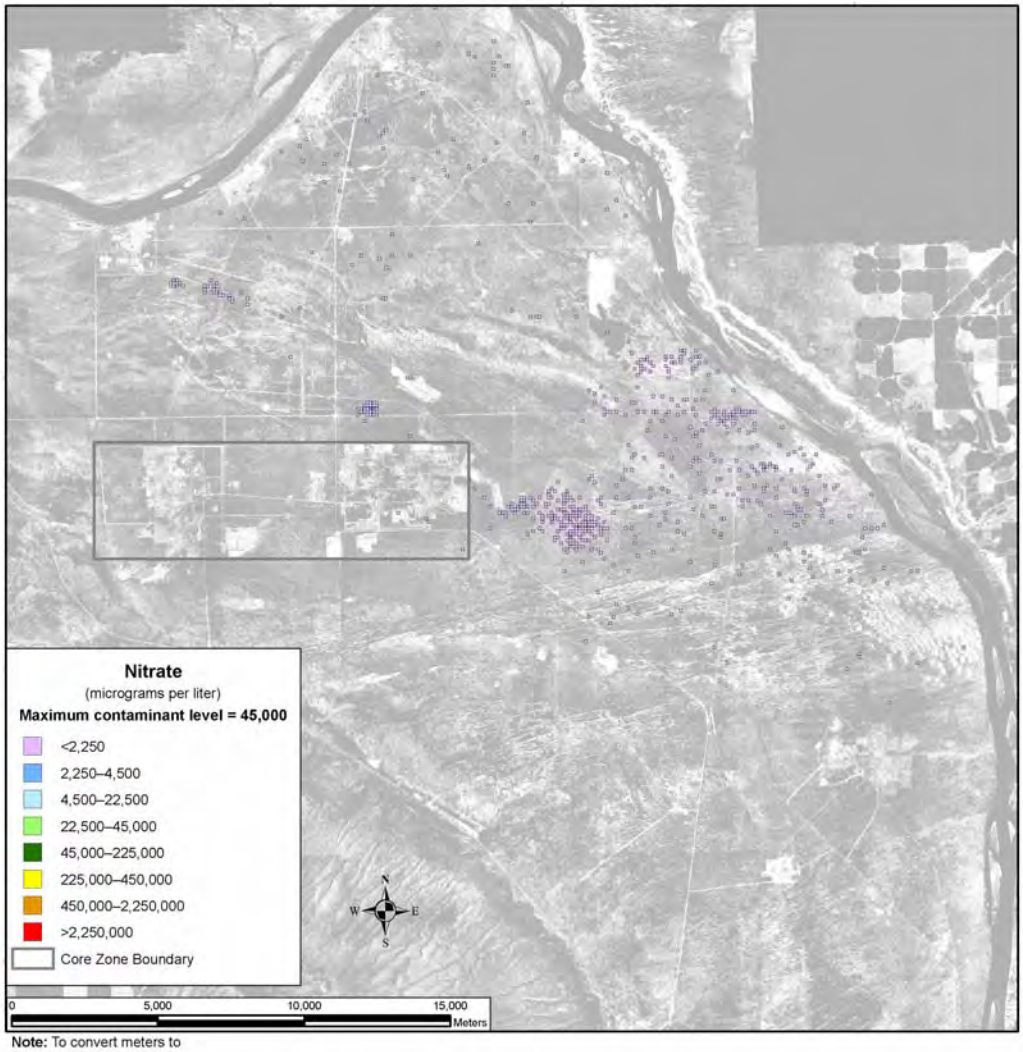


Figure 5–485. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

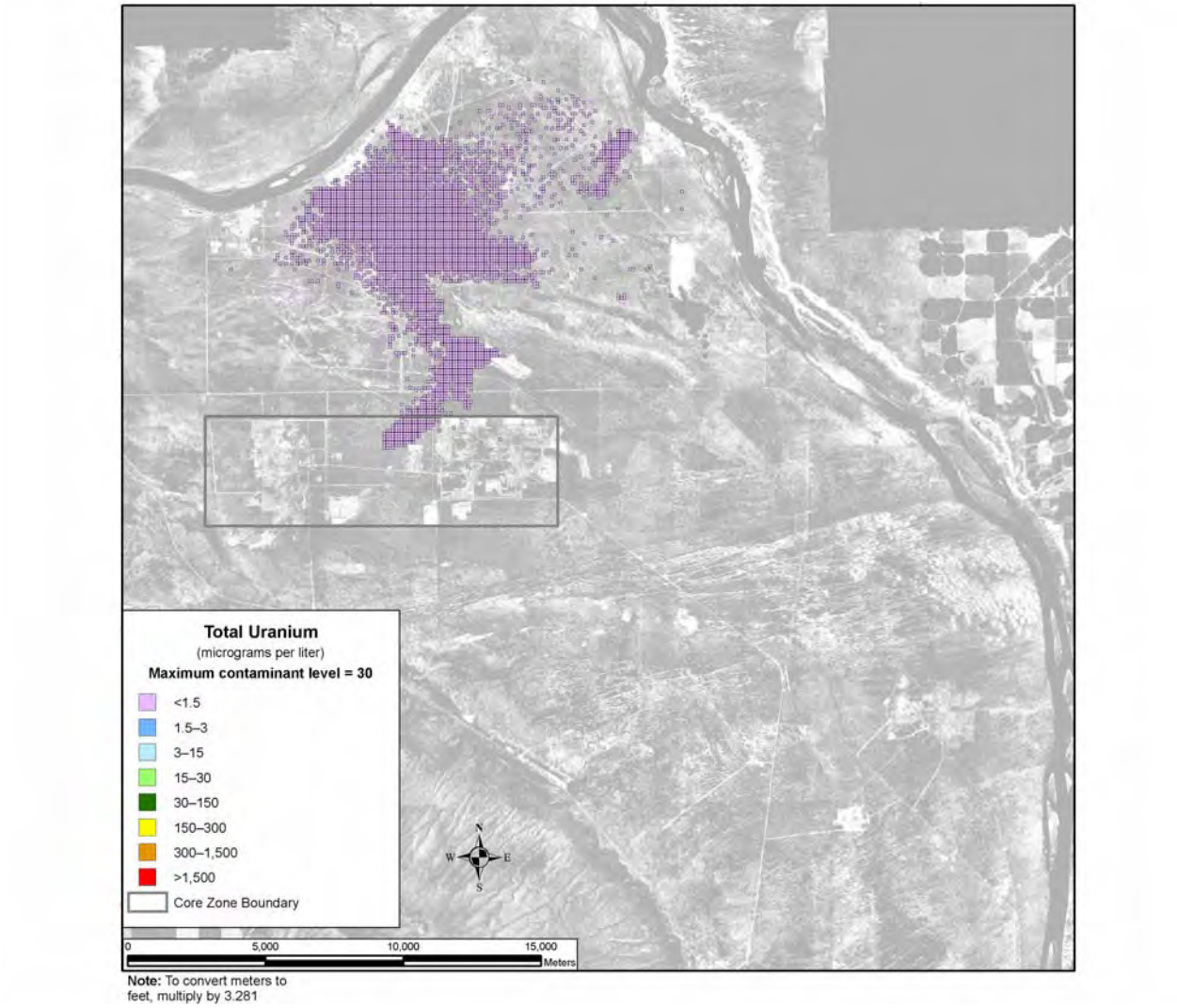


Figure 5–486. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For technetium-99, releases cause the groundwater concentrations at the Core Zone Boundary and at the Columbia River nearshore to exceed the benchmark concentration by about one-half of an order of magnitude at around CY 6000. The concentrations at the Core Zone Boundary and at the Columbia River nearshore remain above the benchmark concentration through the end of the period of analysis. Iodine-129 showed a pattern similar to that of technetium-99.

For chromium, the concentrations at the Core Zone Boundary exceed the benchmark from about CY 7000 to 10,000. During the same time period, concentrations from the Columbia River nearshore approach the benchmark, but never reach it. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about one-half of an order of magnitude below the benchmark at the end of the period of analysis.

Nitrate concentrations at the Core Zone Boundary and the Columbia River nearshore both peak at around CY 8000. Even at the concentration's peak, nitrate levels still remain about one to one and one-half orders of magnitude below the benchmark level.

It is not until around CY 9900 that total uranium concentrations begin to register on the graph. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain at about eight to nine orders of magnitude below the benchmark level.

5.3.1.2.1.5 Disposal Group 1, Subgroup 1-E

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-E covers disposal of waste generated under Tank Closure Alternative 4 and either FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, bulk vitrification glass, and cast stone waste. IHLW would be stored on site, while ILAW glass, bulk vitrification glass, and cast stone waste would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continue through CY 2050, when the facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, nitrate, and acetonitrile

The COPC drivers for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrate, acetonitrile) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The

other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E (IDF-East and the RPPDF releases), in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–487 through 5–498). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has nine subtotals plotted representing releases from ILAW glass, bulk vitrification glass, cast stone waste, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste.

Figure 5–487 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–488, the chemical hazard drivers. For all nine types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 is cast stone waste and of iodine-129 is offsite-generated waste. For chemicals, the predominant source of chromium, nitrate, and acetonitrile is cast stone waste. The predominant sources of fluoride and boron are waste management secondary waste and onsite-generated waste.

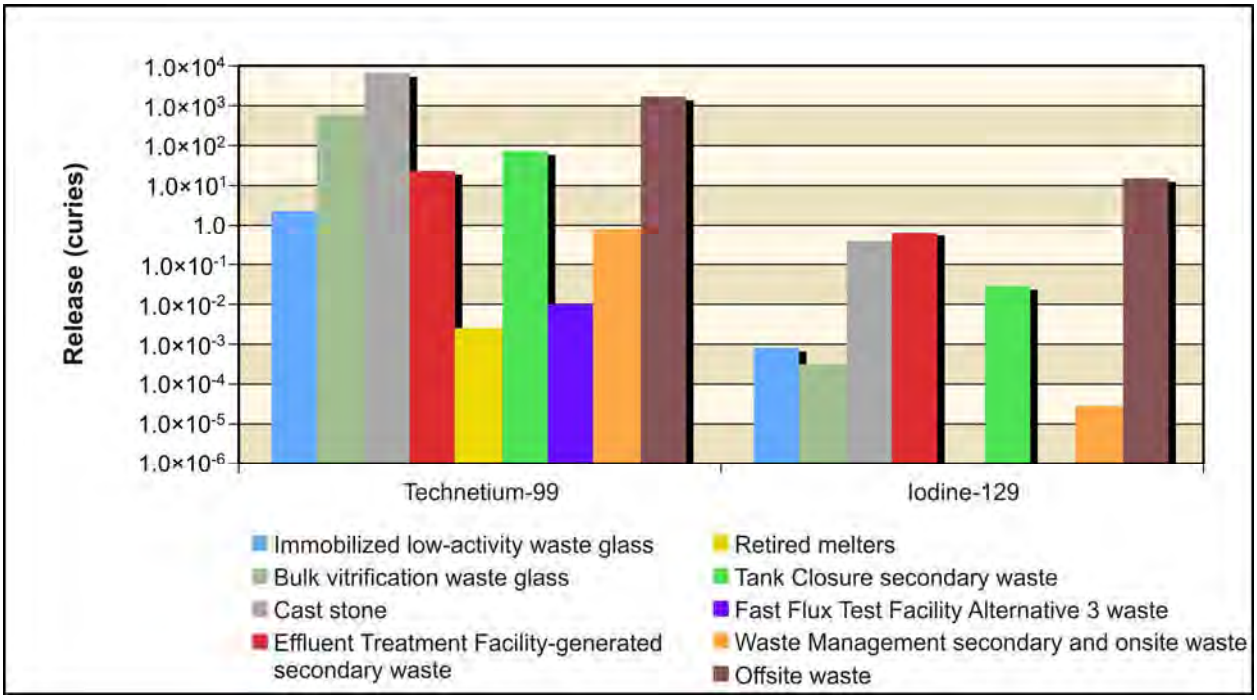


Figure 5–487. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at 200-East Area Integrated Disposal Facility to Vadose Zone

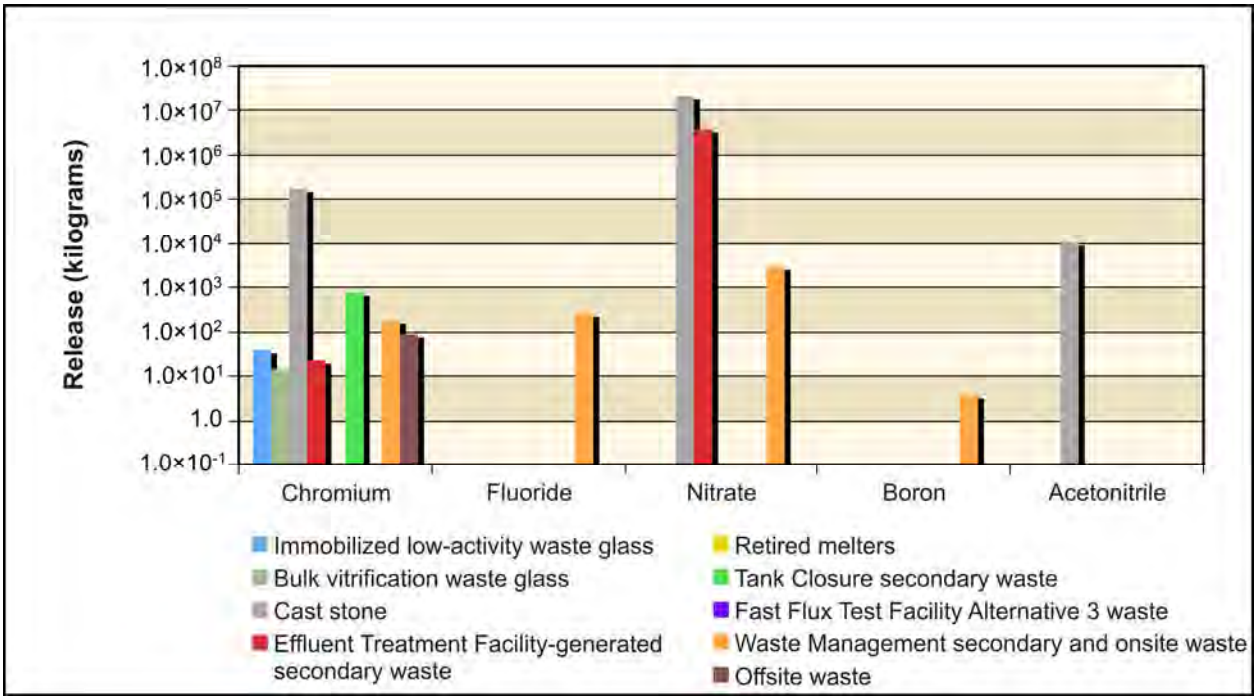


Figure 5–488. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–489 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–490, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, fluoride, boron, and acetonitrile, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 53 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 99 percent of the chemical quantity (kilograms) reached the groundwater.

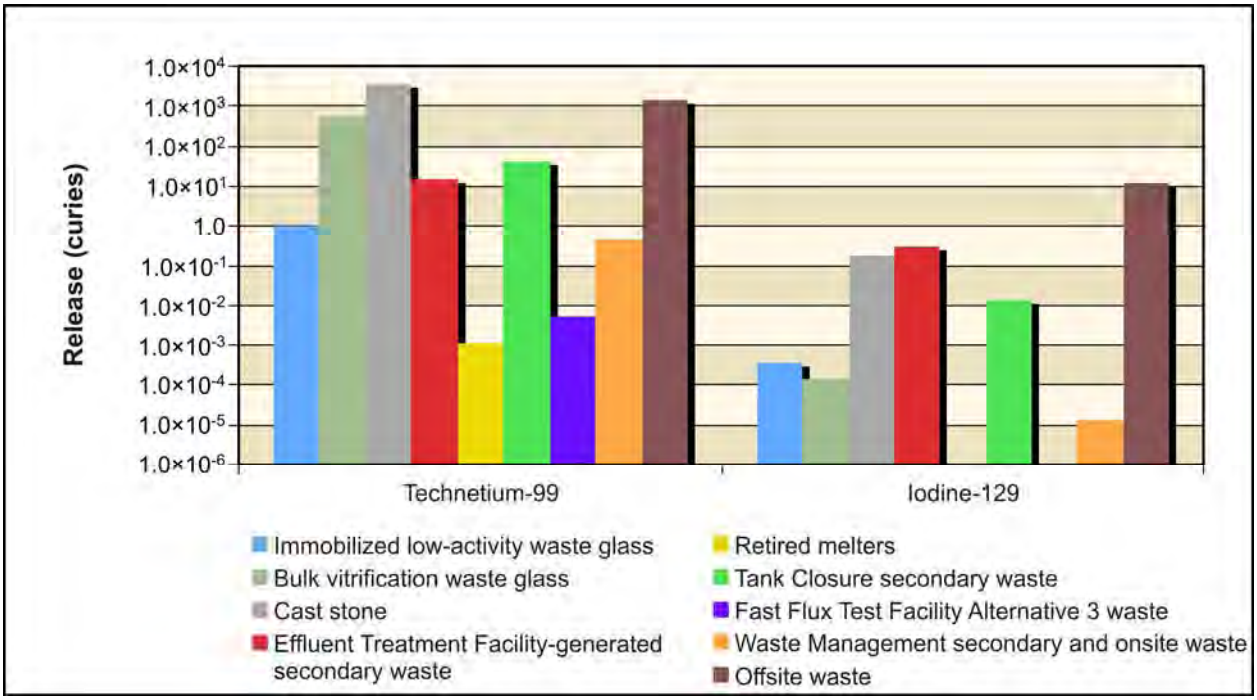


Figure 5–489. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at 200-East Area Integrated Disposal Facility to Groundwater

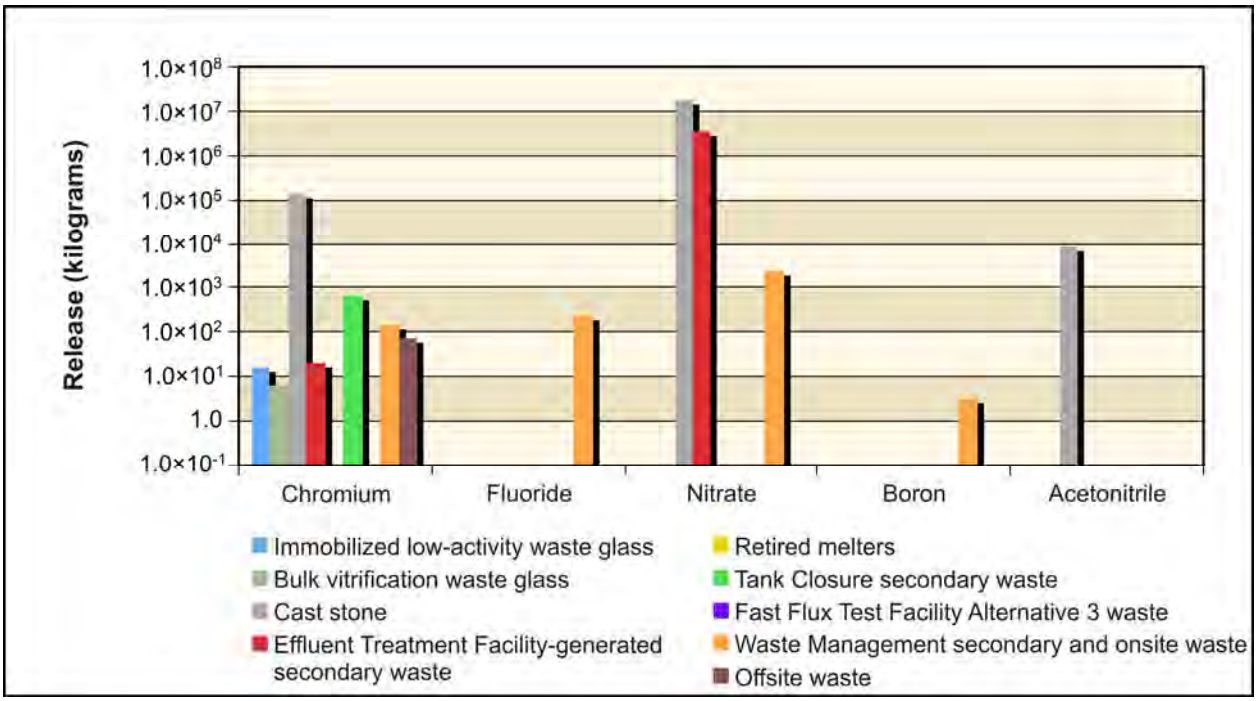


Figure 5–490. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–491 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–492, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, nitrate, fluoride, boron, and acetonitrile, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, about 75 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; approximately 98 percent of the chemical quantity (kilograms) reached the river.

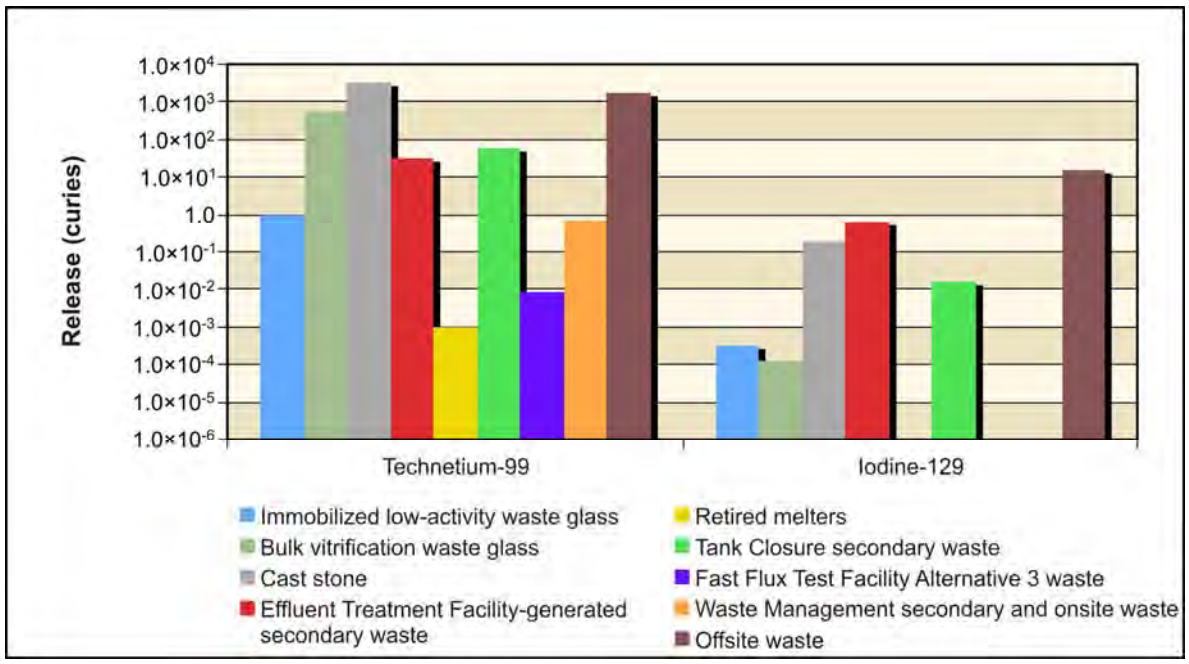


Figure 5–491. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at 200-East Area Integrated Disposal Facility to Columbia River

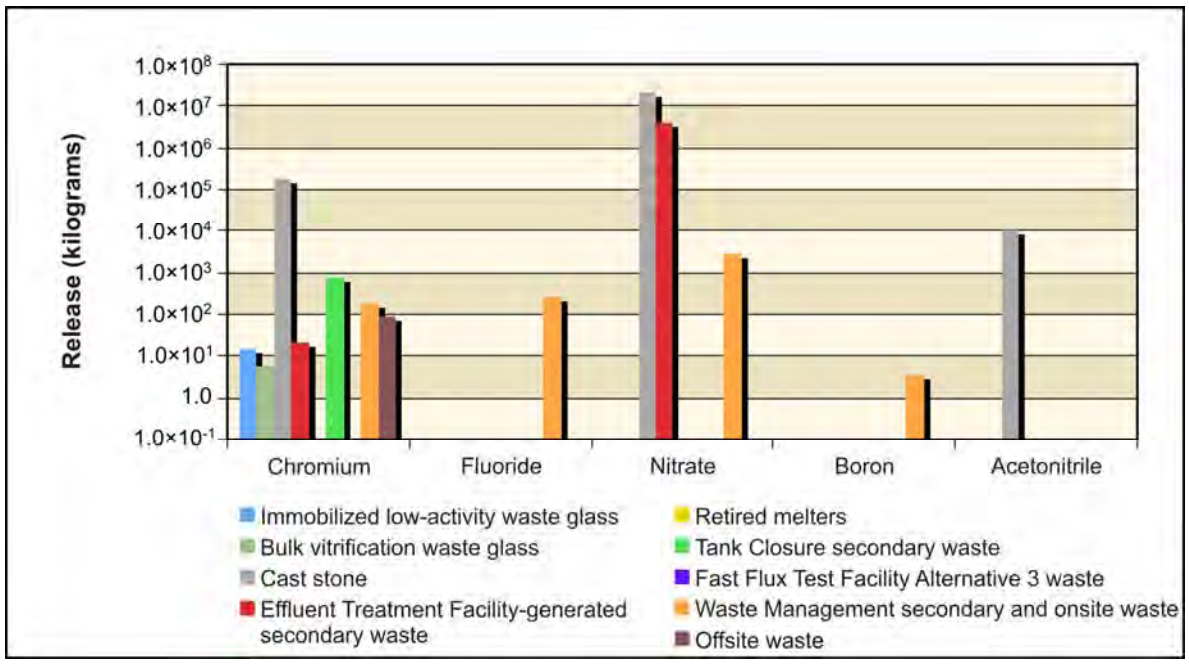


Figure 5–492. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–493 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–494, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium-99 (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). Fluoride, boron, and acetonitrile are not released from the RPPDF.

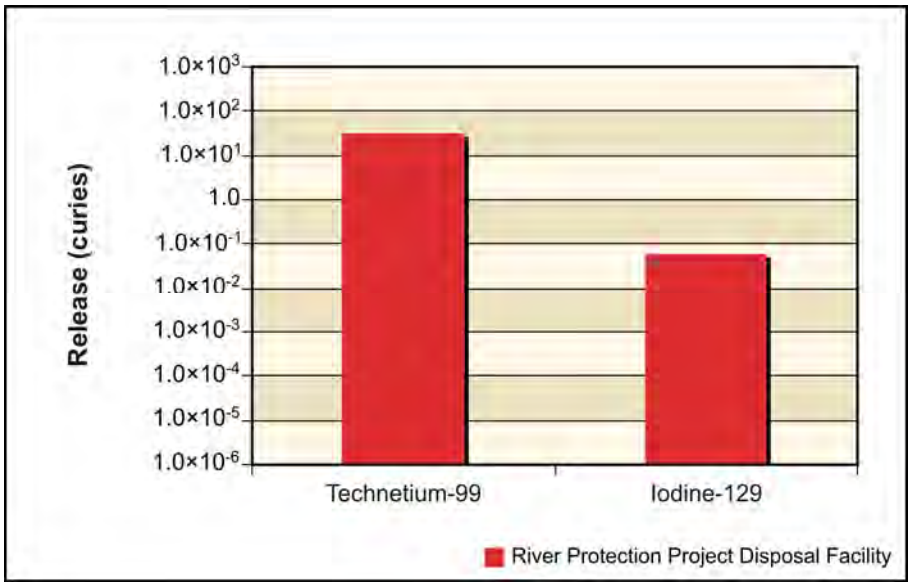


Figure 5–493. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at River Protection Project Disposal Facility to Vadose Zone

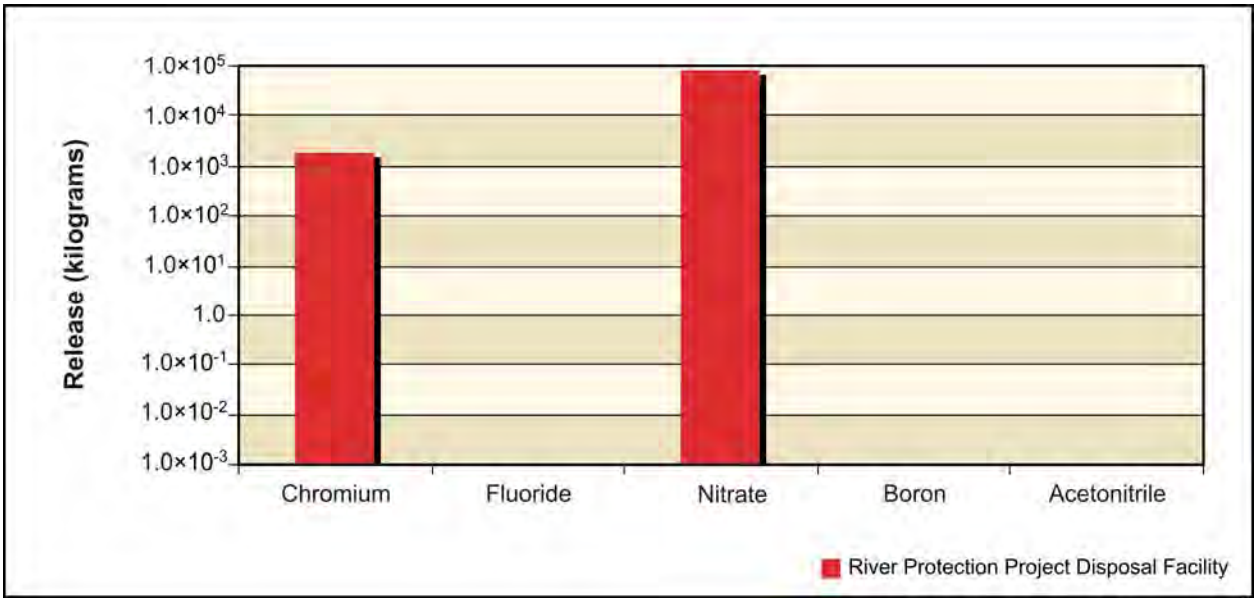


Figure 5–494. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at River Protection Project Disposal Facility to Vadose Zone

Figure 5–495 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–496, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

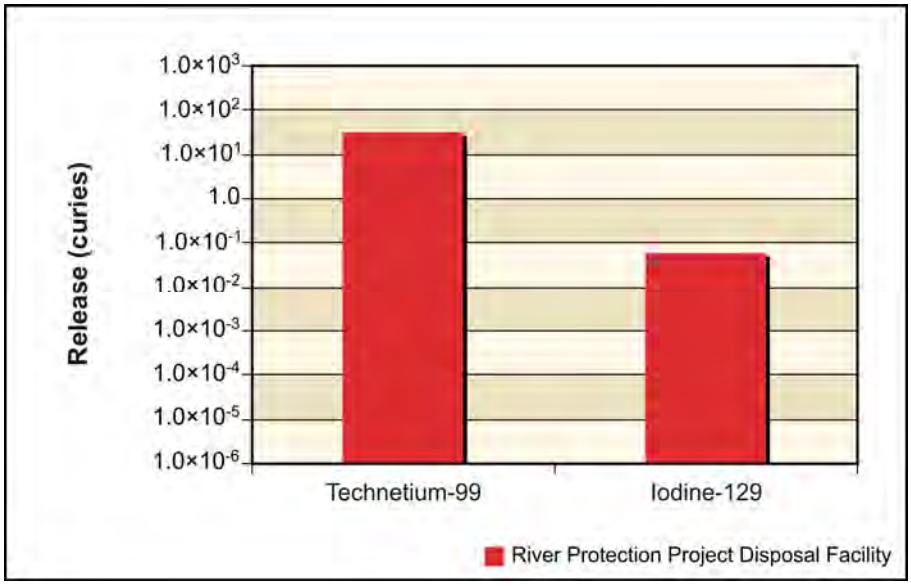


Figure 5–495. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at River Protection Project Disposal Facility to Groundwater

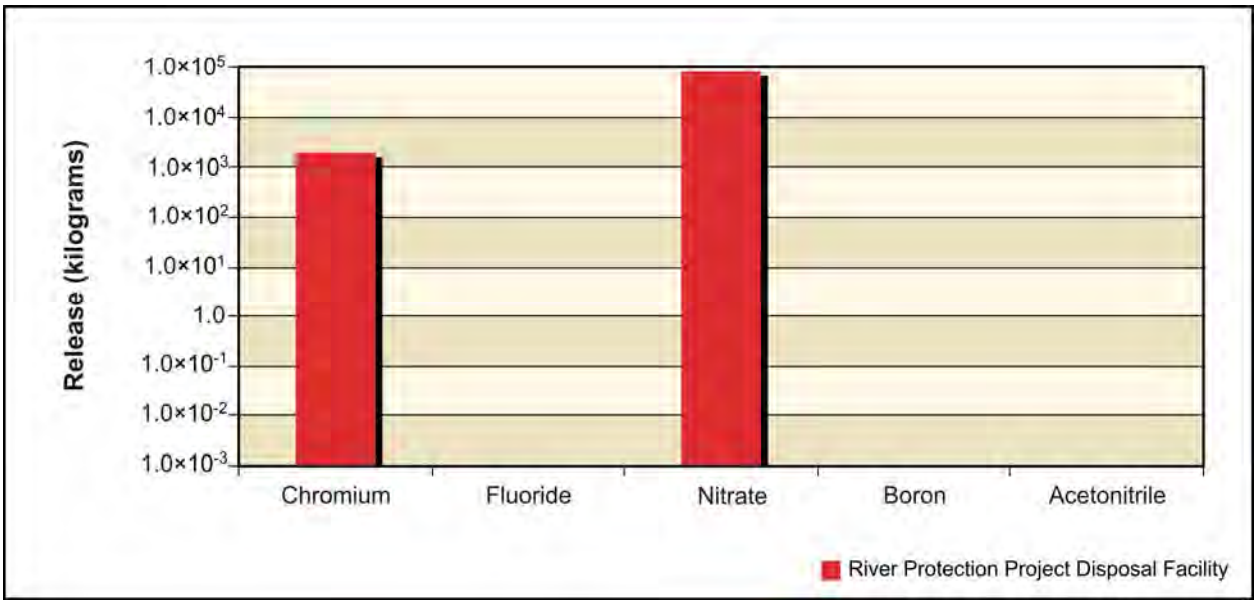


Figure 5–496. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at River Protection Project Disposal Facility to Groundwater

Figure 5–497 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–498, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 96 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; 96 percent of the chemical quantity (kilograms) reached the river.

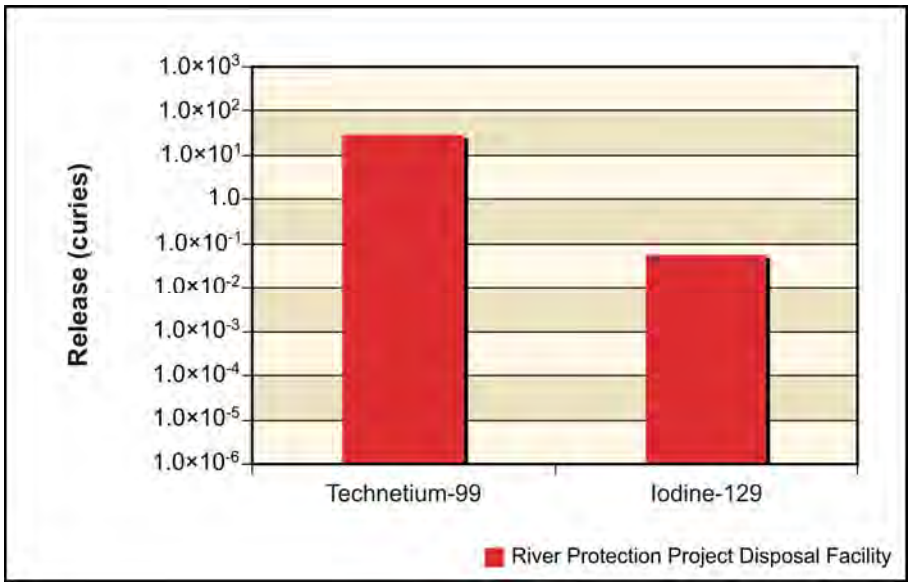


Figure 5–497. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at River Protection Project Disposal Facility to Columbia River

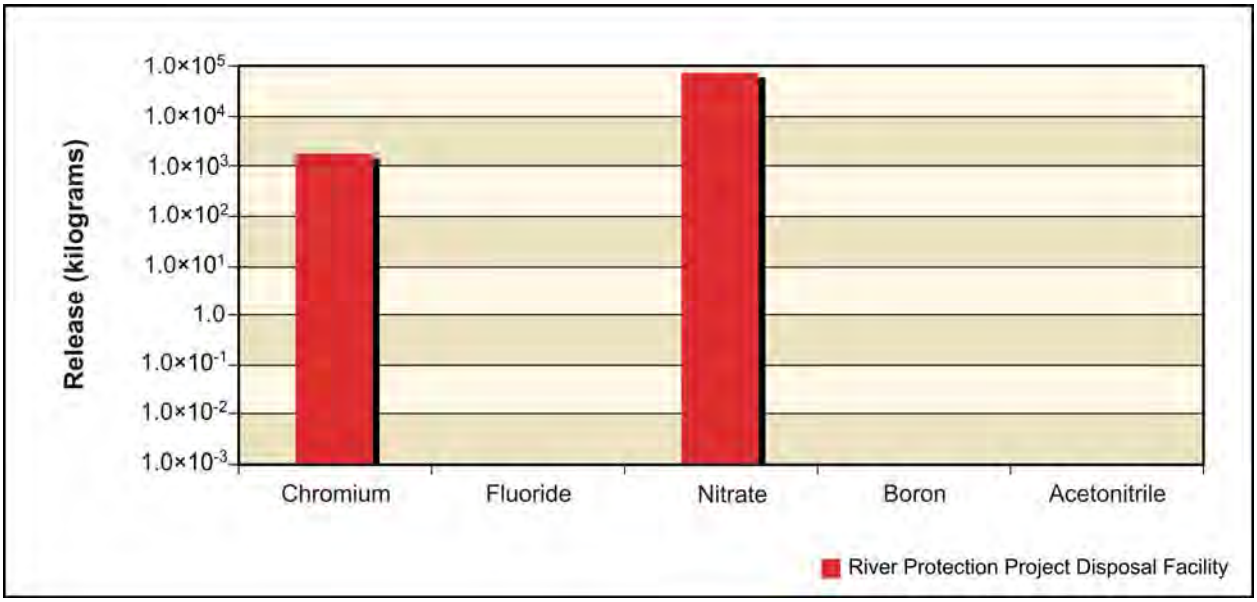


Figure 5–498. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter (see Figures 5–499 though 5–503). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–81 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–499 through 5–502 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East and the RPPDF cause technetium-99 and iodine-129 groundwater concentrations to exceed benchmark concentrations by less than one order of magnitude during the later part of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations. During this time, technetium-99 and iodine-129 groundwater concentrations at the Columbia River nearshore exceed the benchmark concentrations. Releases from IDF-East and the RPPDF cause groundwater concentrations to exceed benchmark concentrations by less than one order of magnitude during the middle and later parts of the period of analysis.

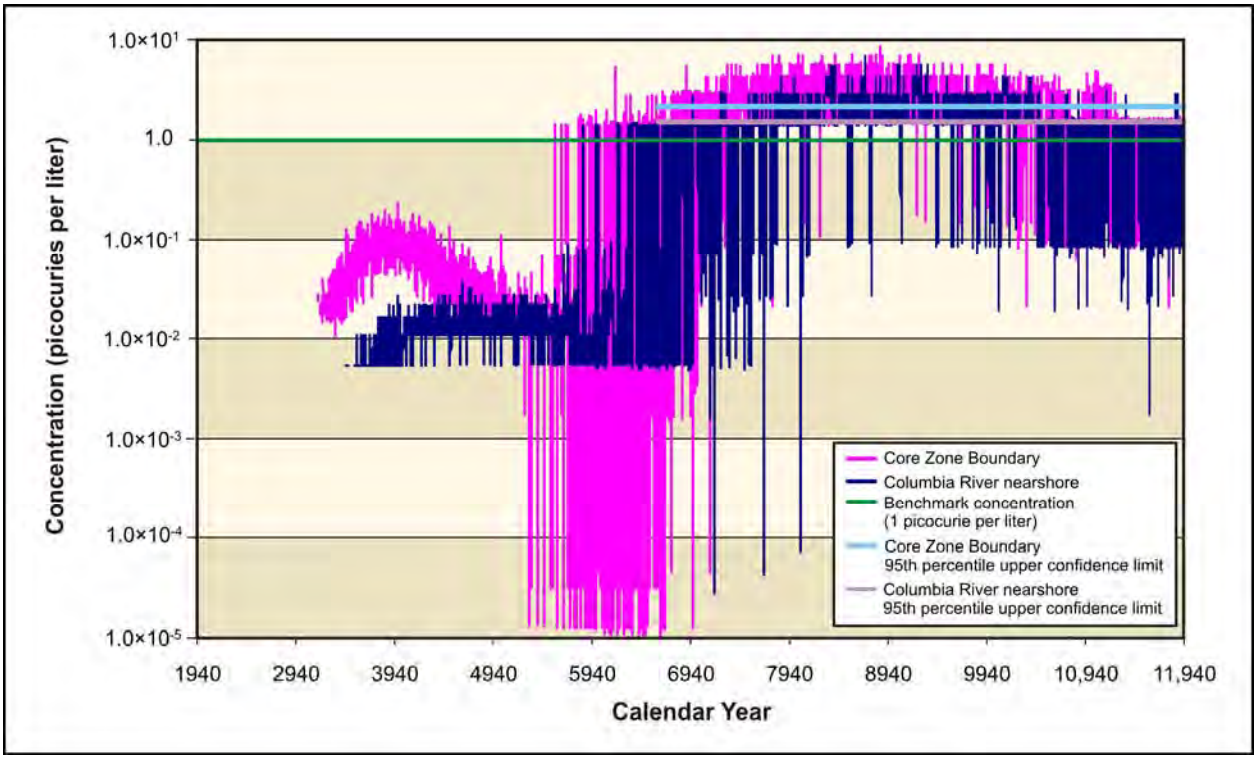


Figure 5–499. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Iodine-129 Concentration Versus Time

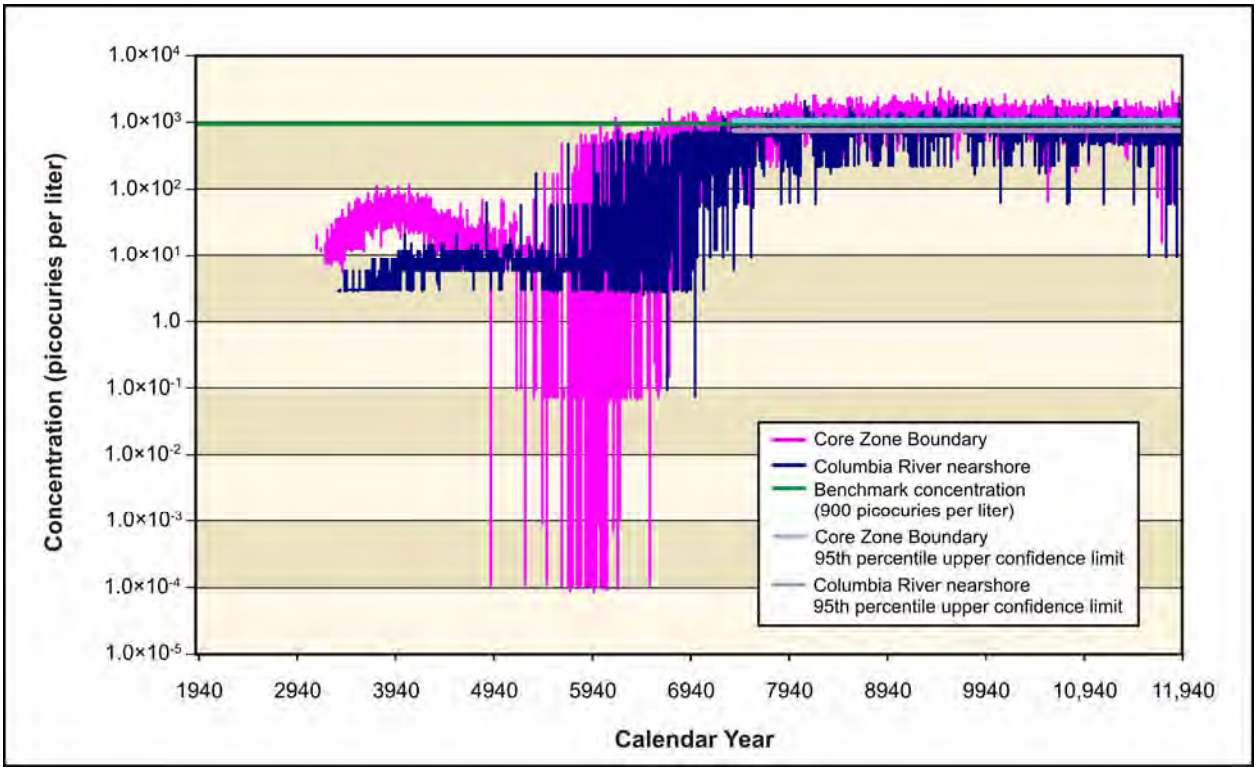


Figure 5–500. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Technetium-99 Concentration Versus Time

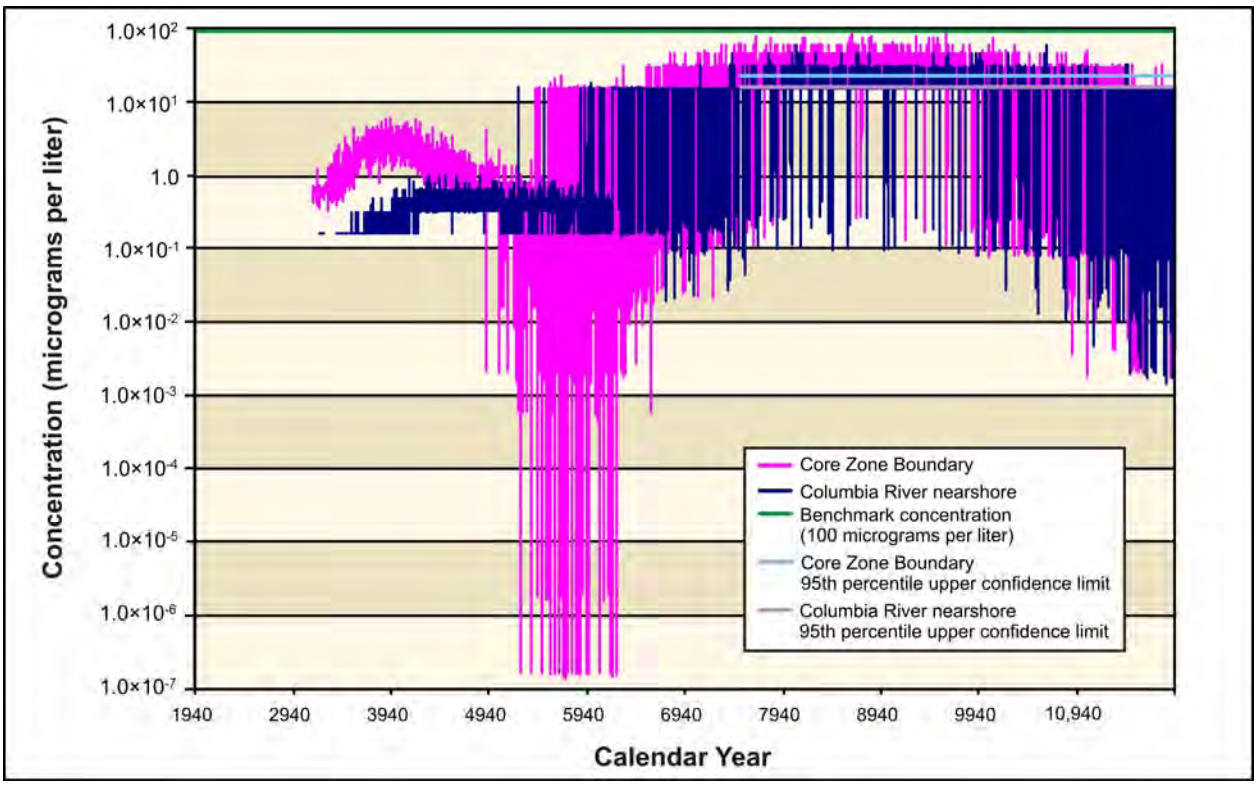


Figure 5–501. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chromium Concentration Versus Time

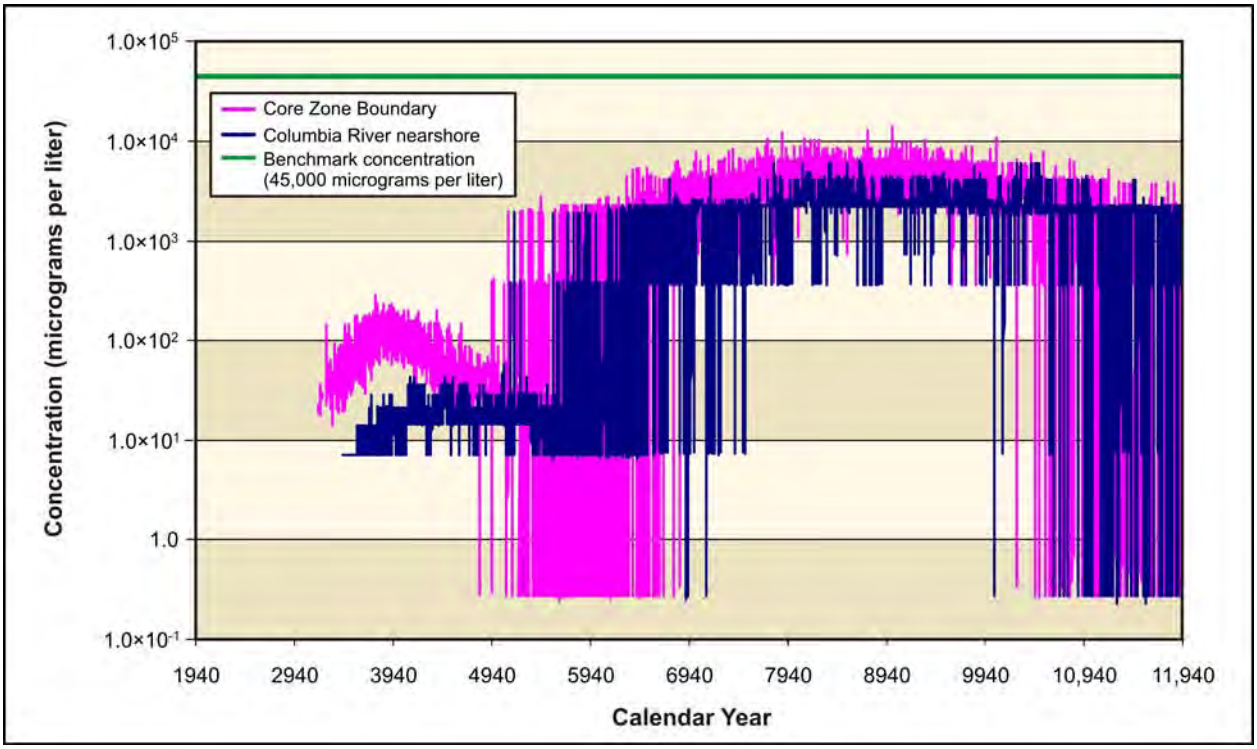


Figure 5–502. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Nitrate Concentration Versus Time

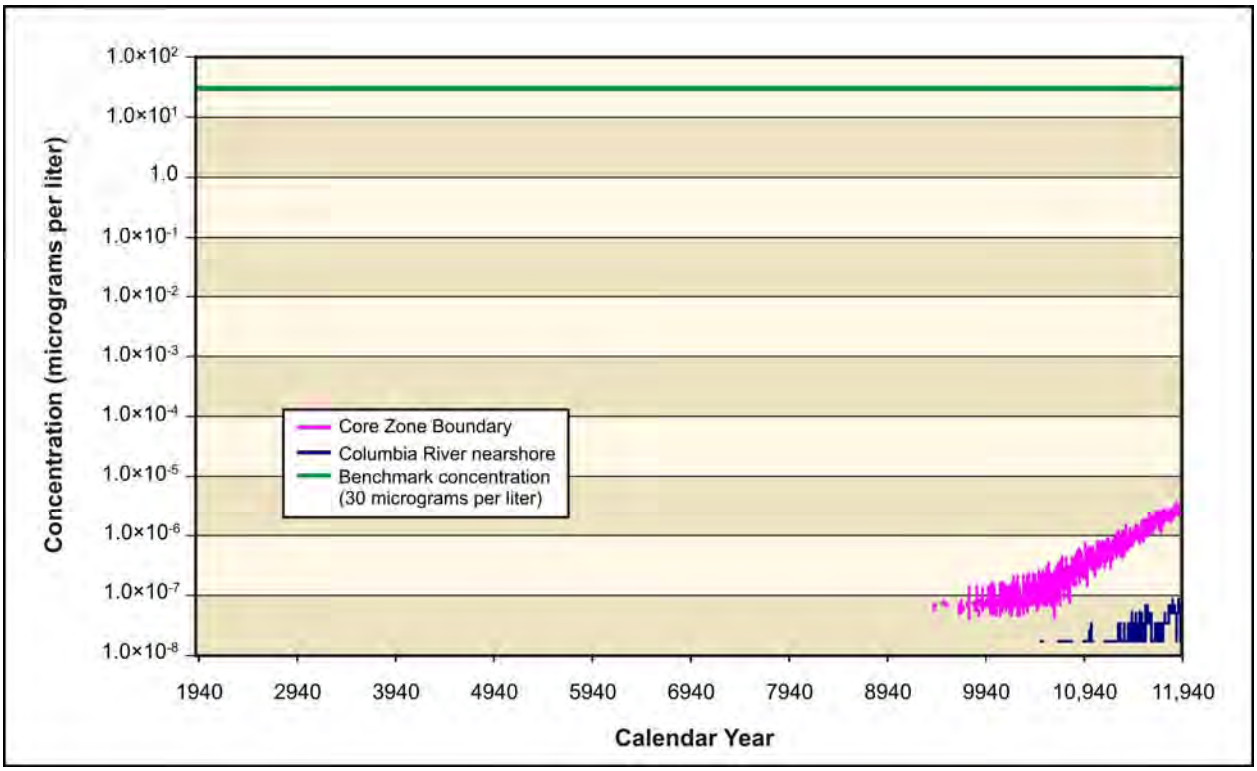


Figure 5–503. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Total Uranium Concentration Versus Time

Figure 5–503 shows concentration versus time for total uranium. Late releases from IDF-East and the RPPDF result in groundwater concentrations that are seven orders of magnitude lower than benchmark concentrations for total uranium. Total uranium concentrations, while very minimal, continue to rise throughout the duration of the period of analysis, but never exceed the benchmark concentrations by the end of the period of analysis.

Table 5–81. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**6,490**	103	**3,090**	**2,030**	900
	(9035)	(3822)	(9499)	(8117)	
Iodine-129	**18**	0.2	**8**	**7**	1
	(8491)	(3940)	(8858)	(8699)	
Chemical in micrograms per liter					
Acetonitrile	16	0	5	4	100
	(7959)	(1940)	(7381)	(6849)	
Chromium	**224**	6	96	64	100
	(9069)	(3804)	(8643)	(8079)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	29,000	229	13,900	6,380	45,000
	(9330)	(4042)	(8994)	(8673)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–504 through 5–516). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–504 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from the RPPDF result in groundwater concentration plumes that exceed the benchmark concentration north of the Core Zone Boundary. Peak concentrations in this plume are only slightly greater than the benchmark concentration and only in a very small area north of the Core Zone Boundary. During year 7140, releases from IDF-East create a plume exceeding the benchmark, extending from the 200-East Area moving eastward toward the Columbia River (see Figure 5–505). Also by CY 7140, most of the RPPDF plume continues to move north and reaches the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small, isolated pockets of high concentration exceeding the benchmark (see Figure 5–506). Technetium-99 (see Figures 5–507 through 5–509), chromium (see Figures 5–510 through 5–512), and nitrate

(see Figures 5–513 through 5–515) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–516 shows the distribution of total uranium during CY 11,885. Releases from the RPPDF result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.

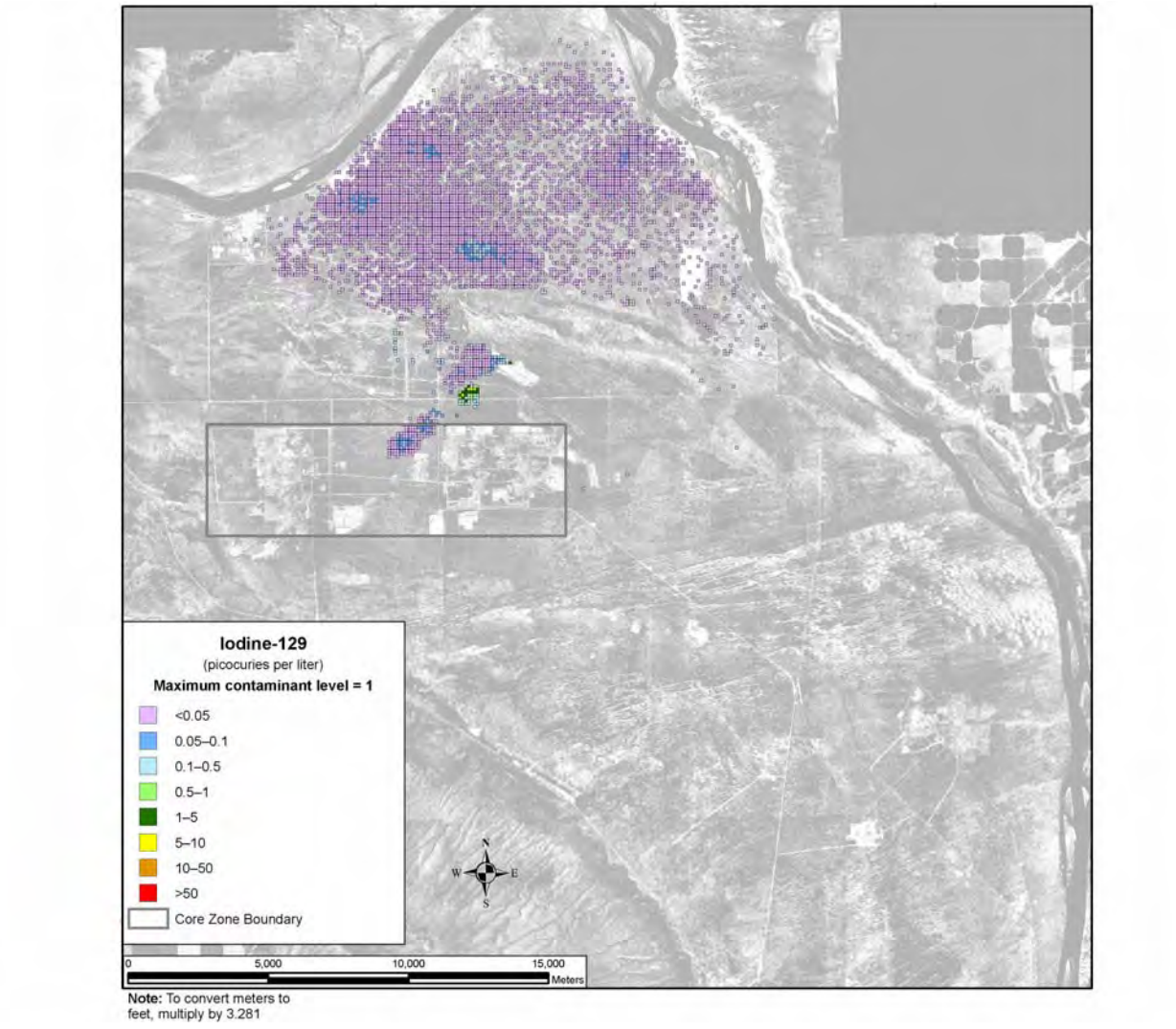


Figure 5–504. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

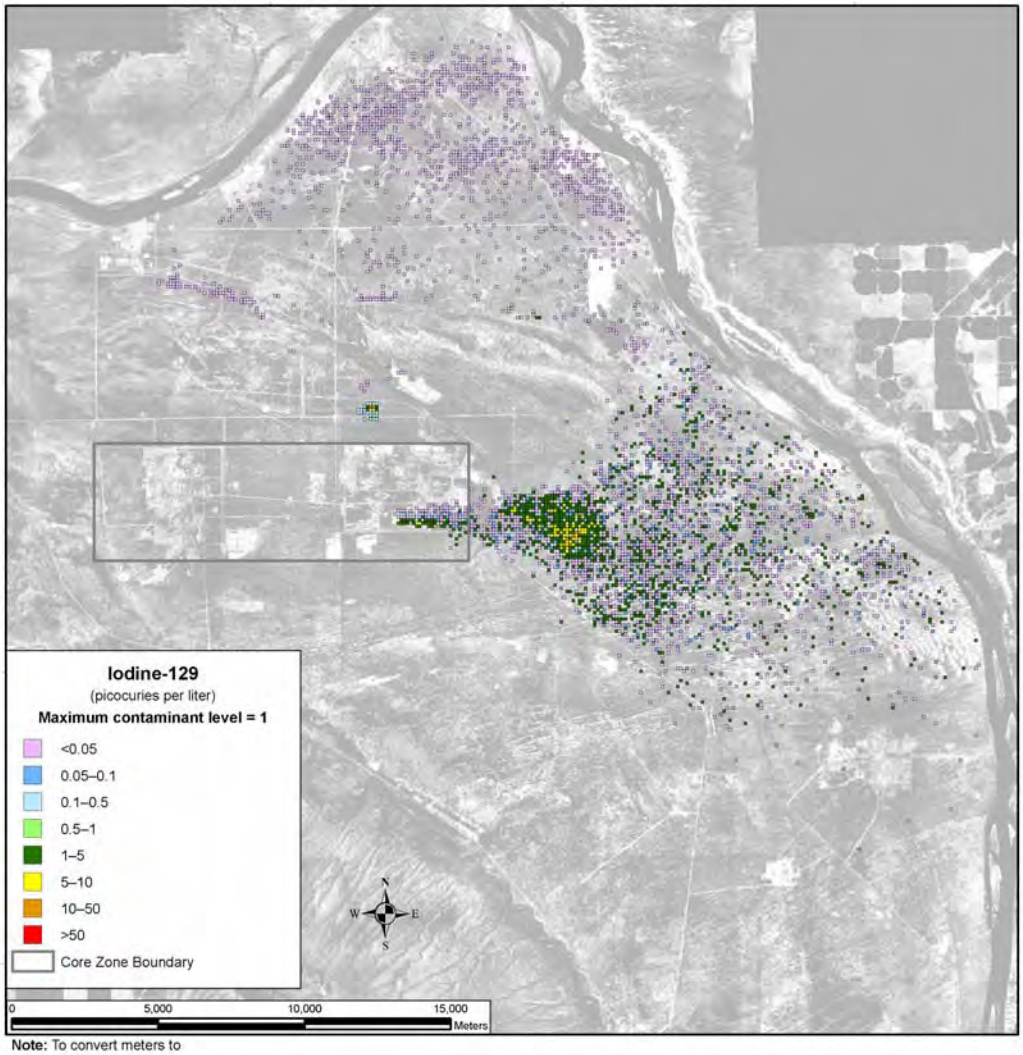


Figure 5–505. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

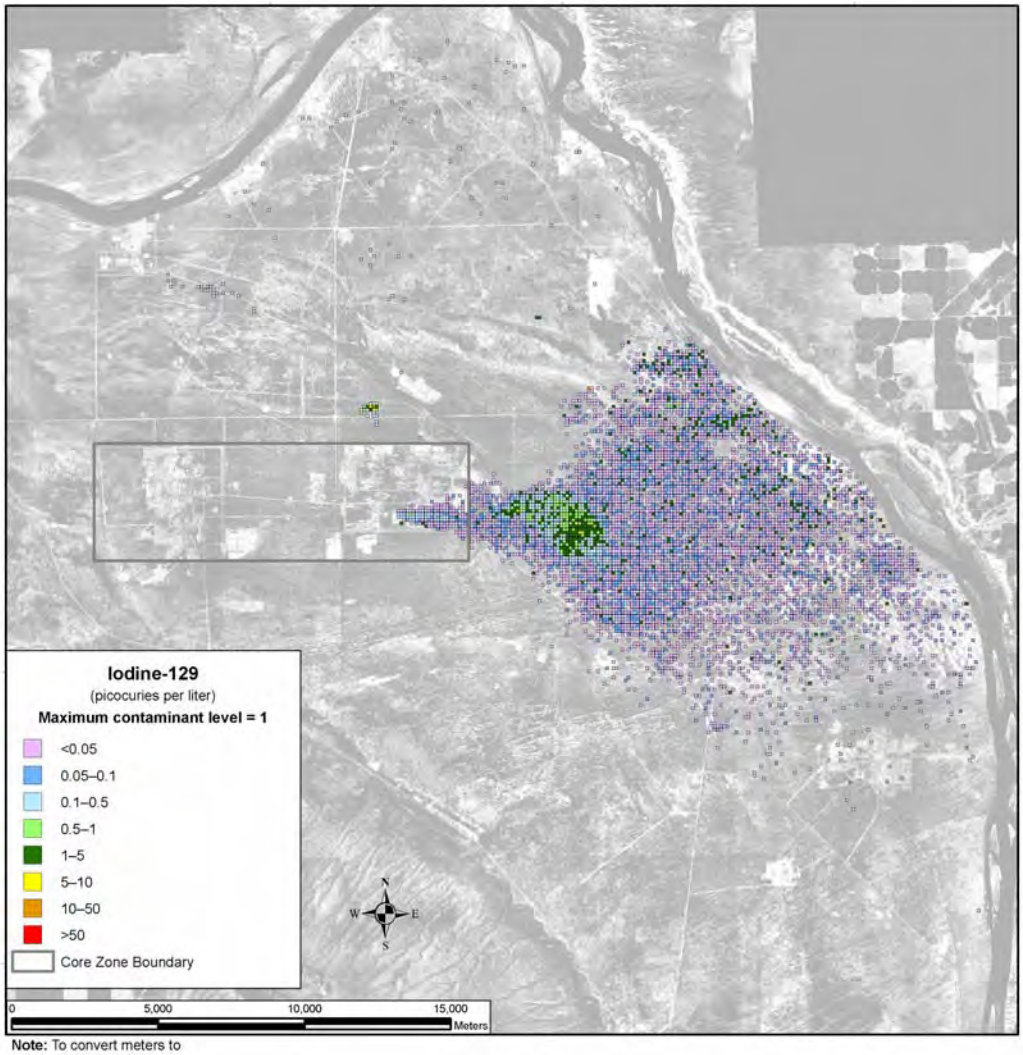


Figure 5–506. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

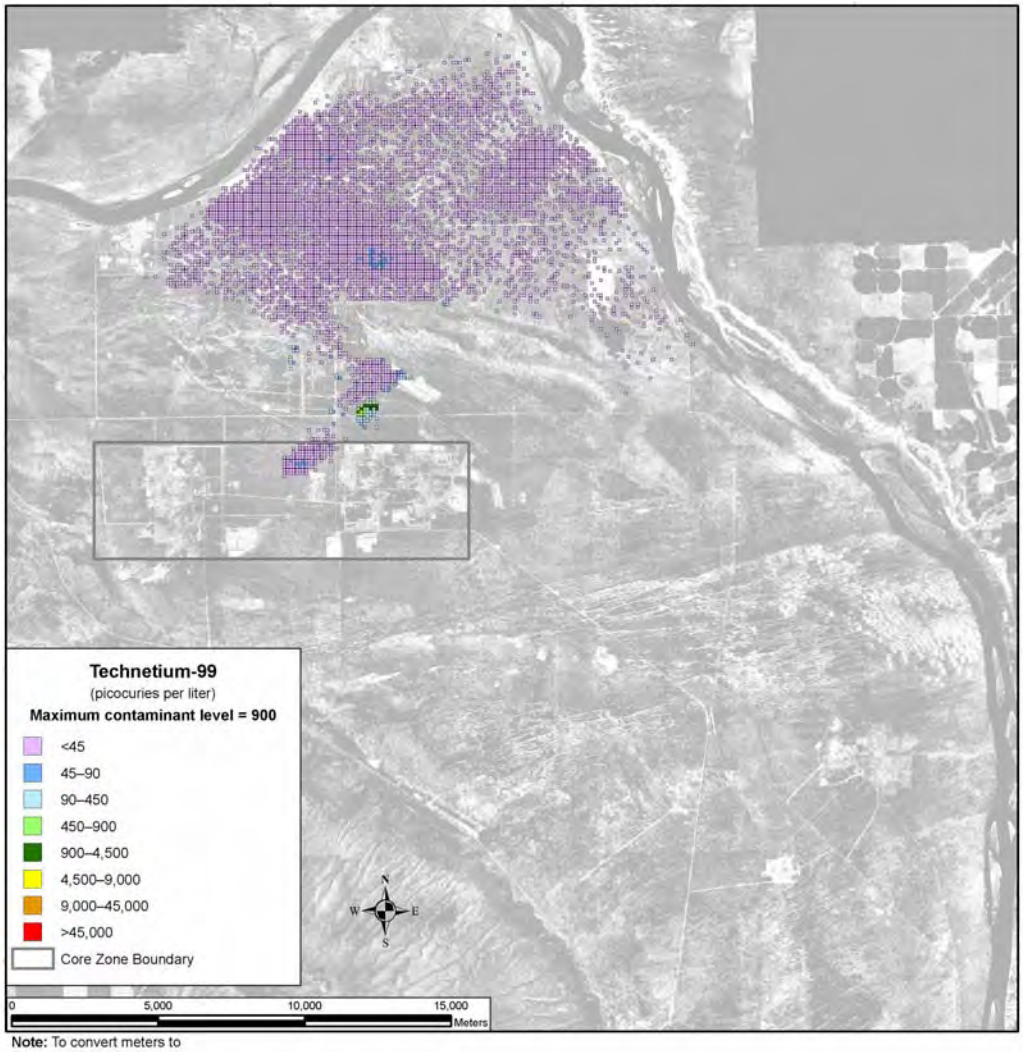


Figure 5–507. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

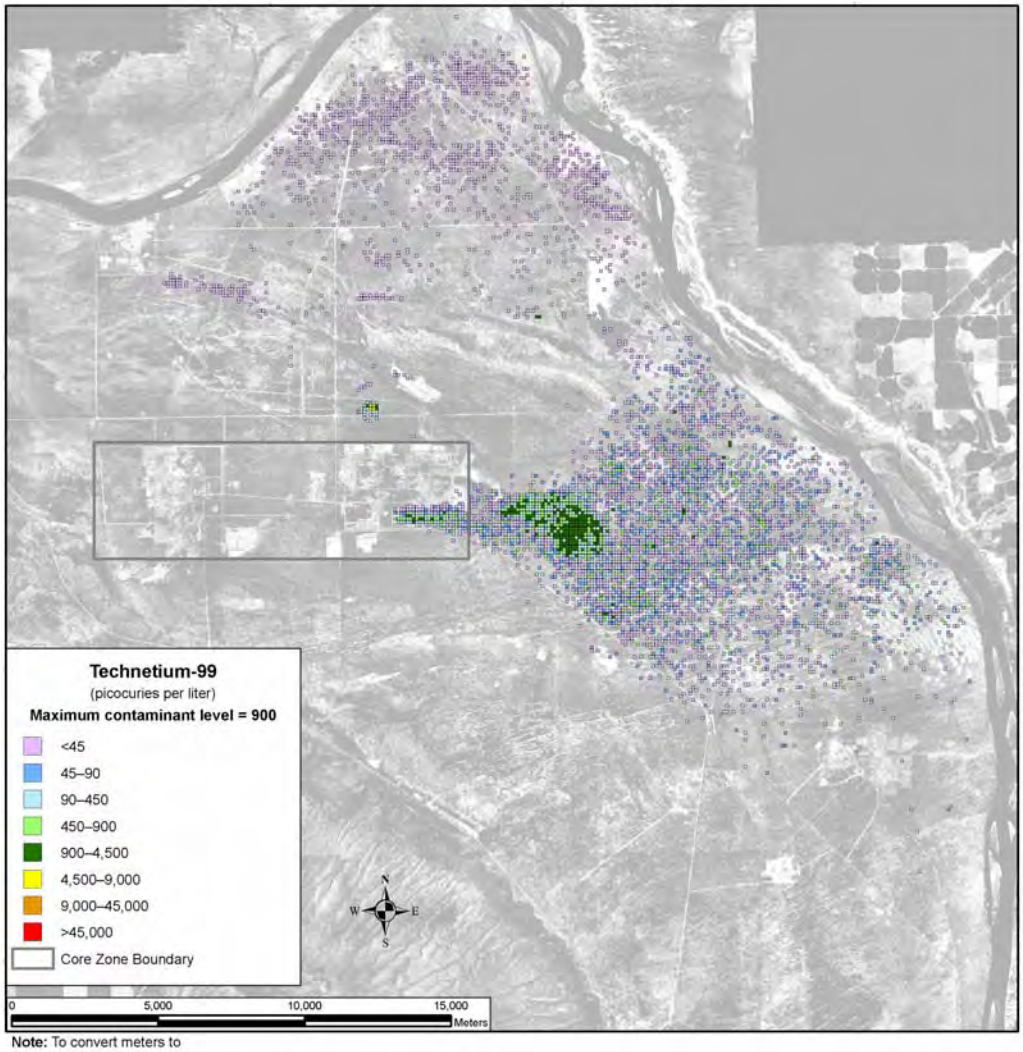


Figure 5–508. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

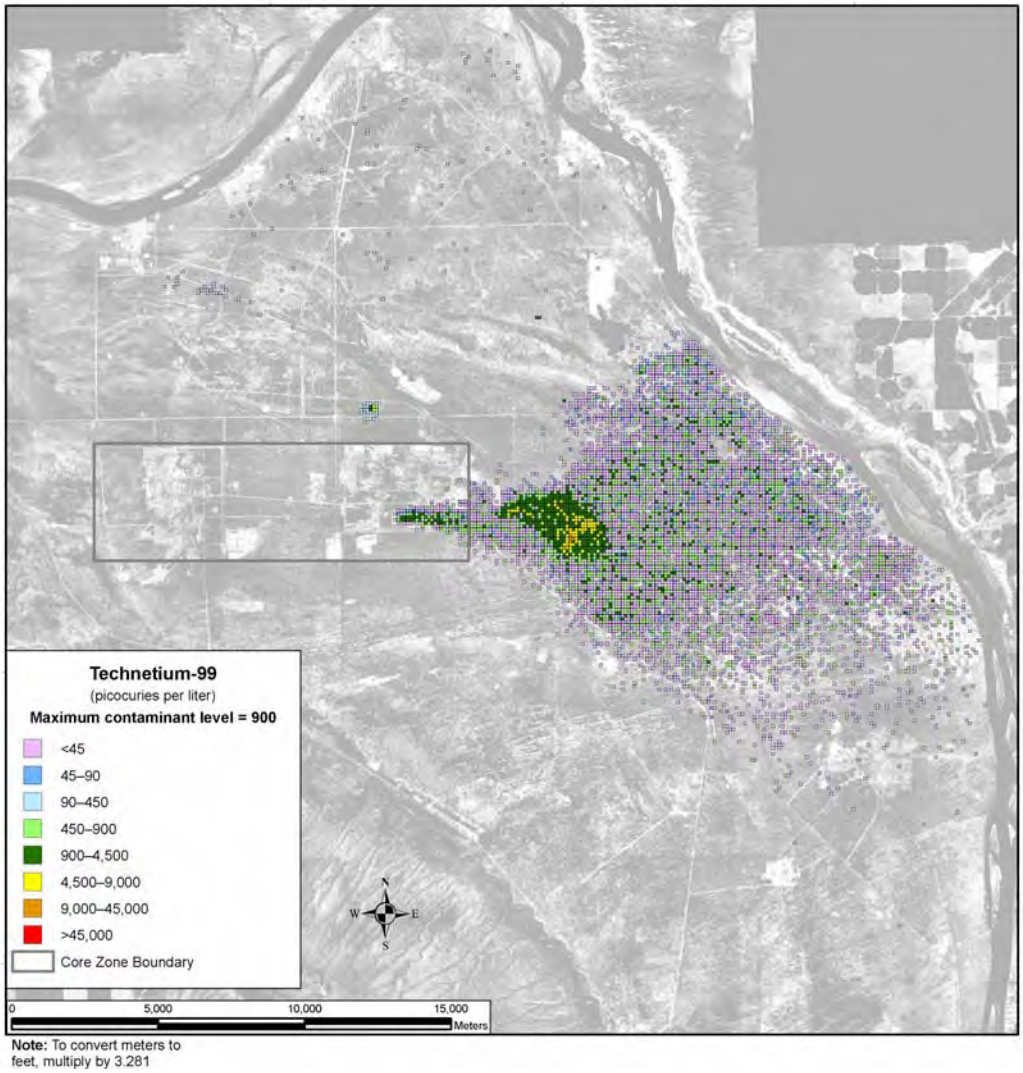


Figure 5–509. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

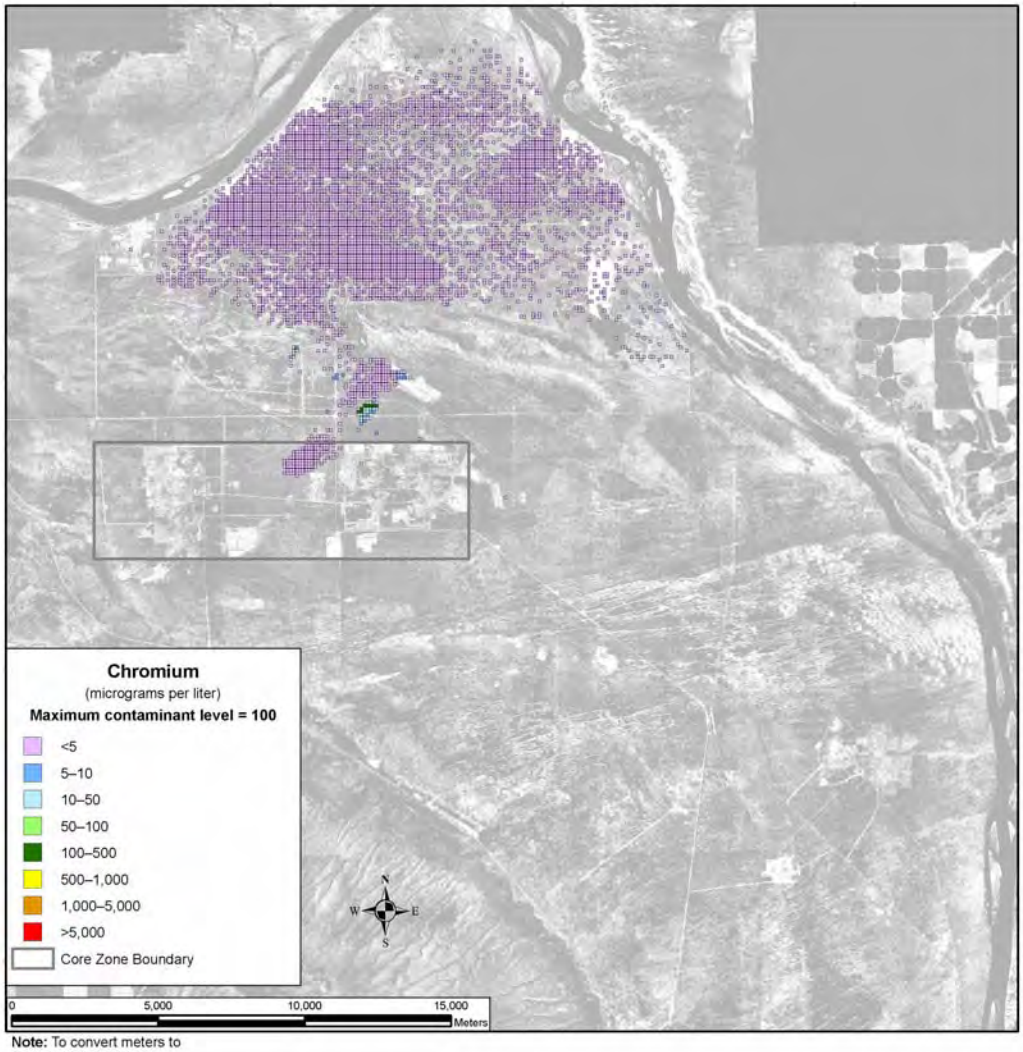


Figure 5–510. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

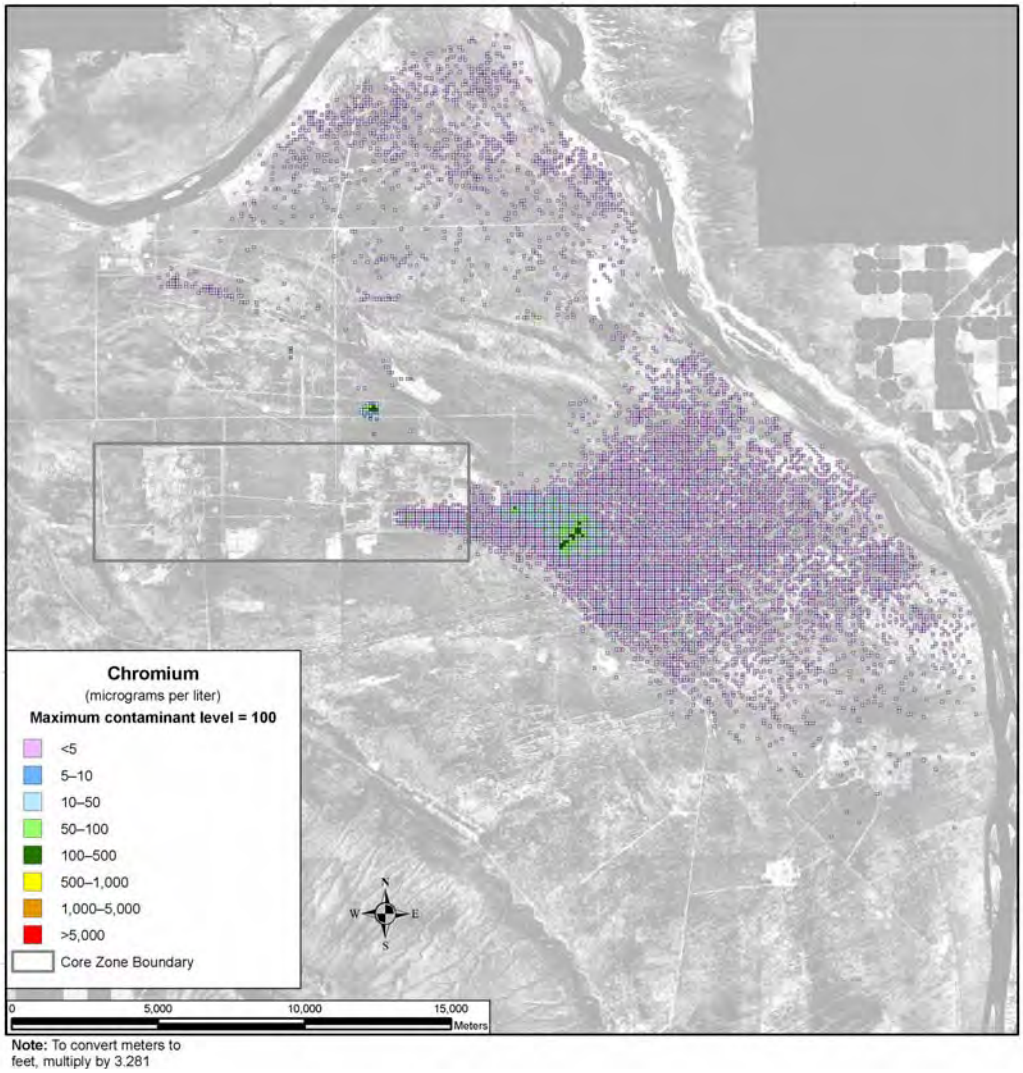


Figure 5–511. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

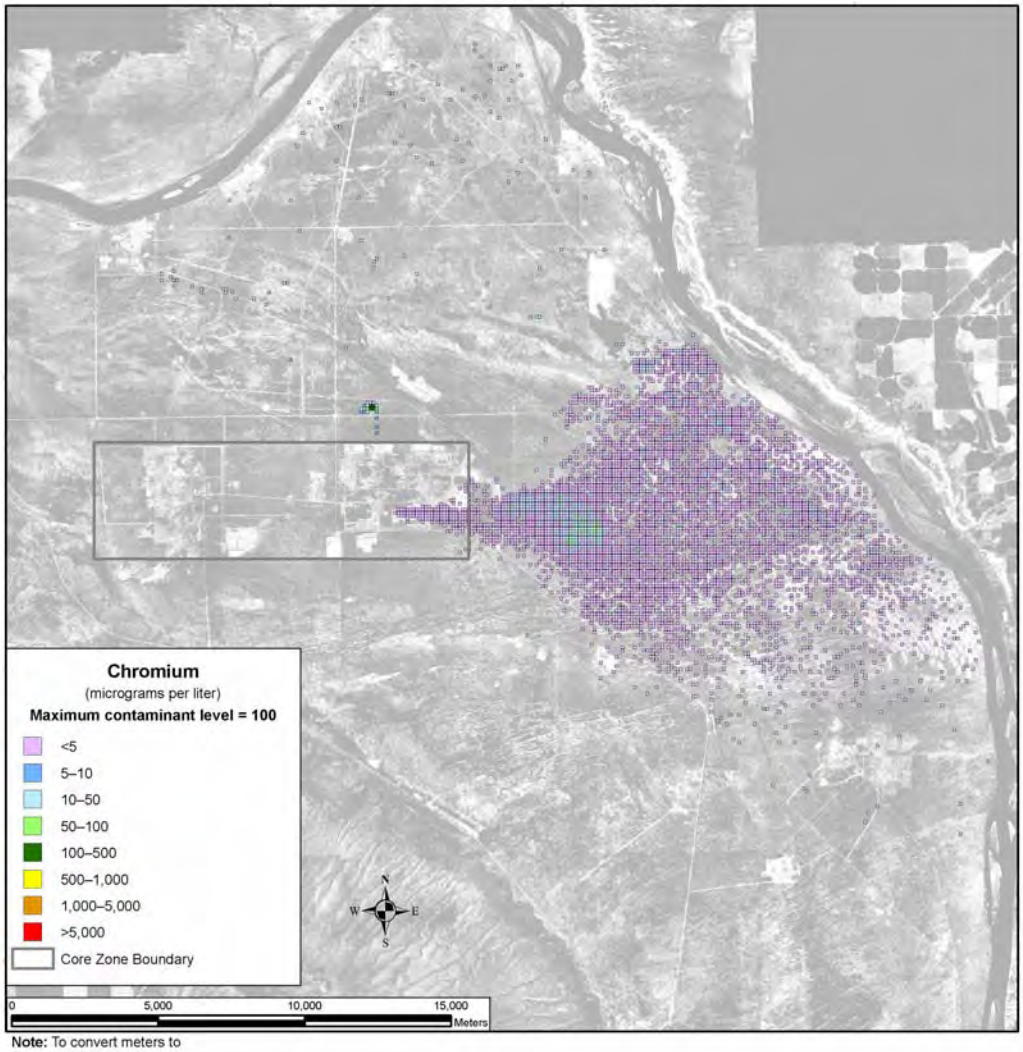


Figure 5–512. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

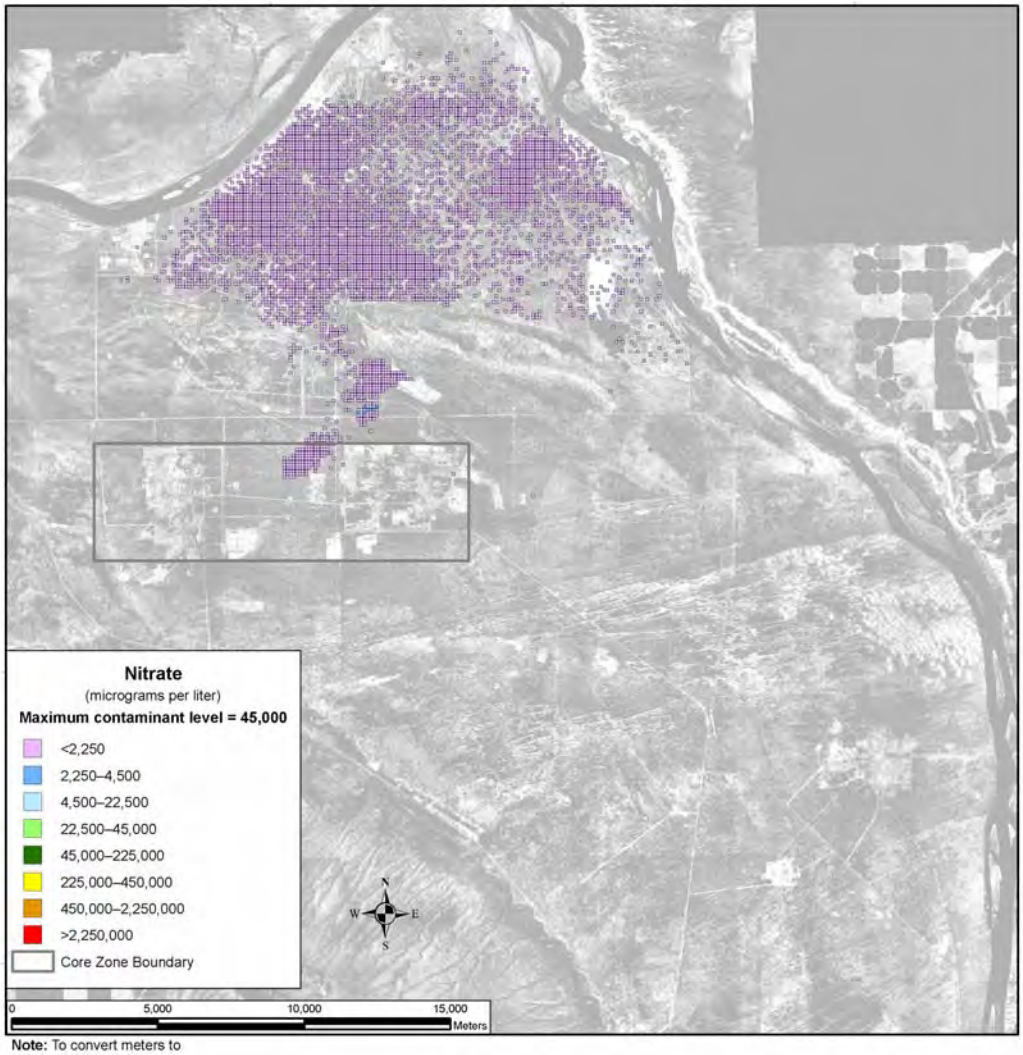


Figure 5–513. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

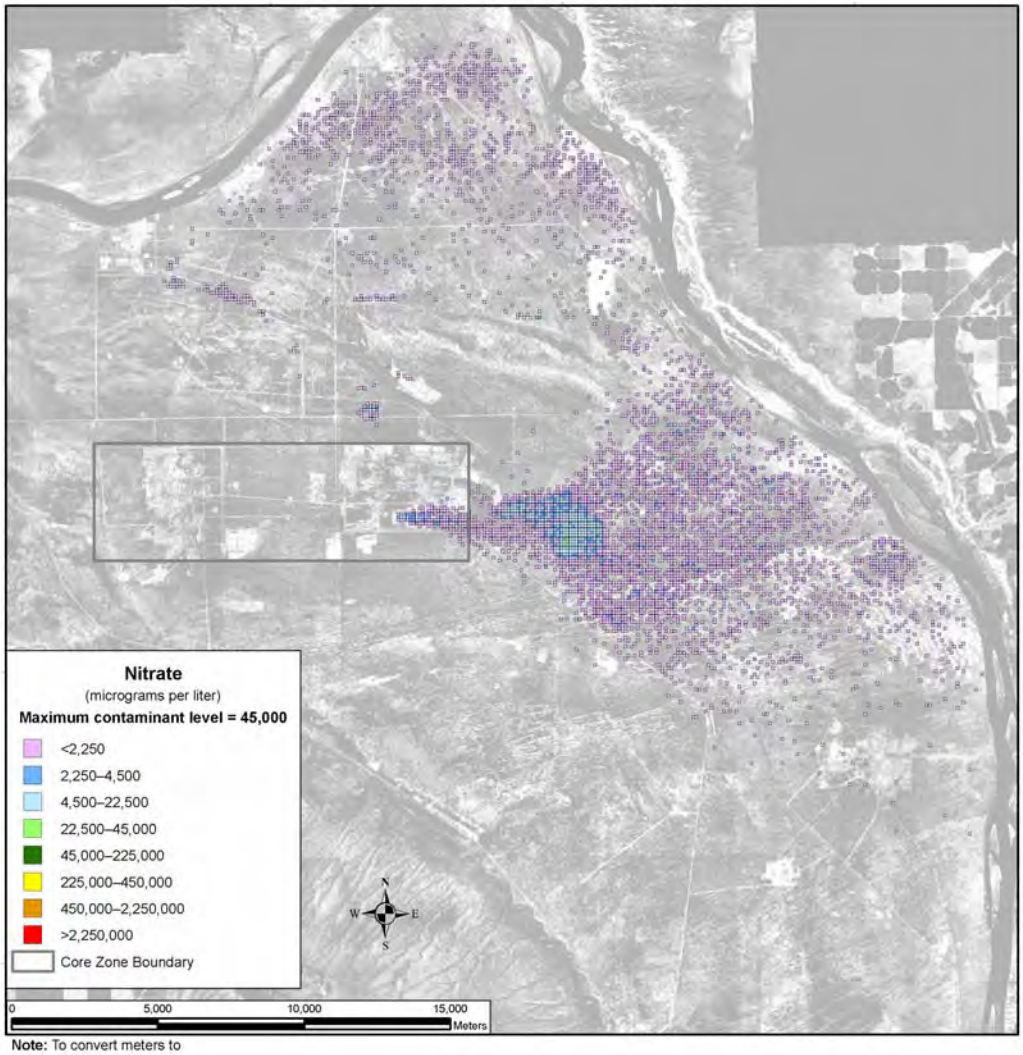


Figure 5–514. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

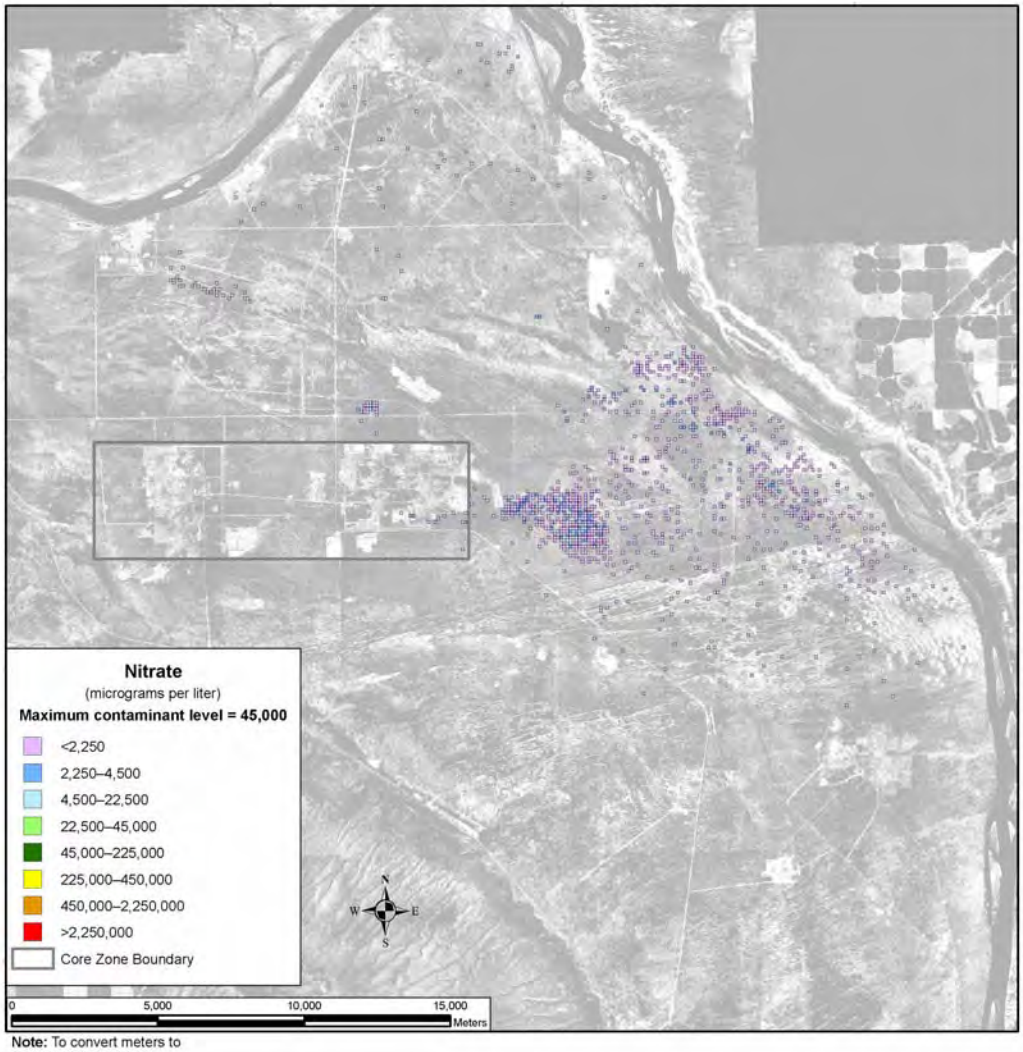


Figure 5–515. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

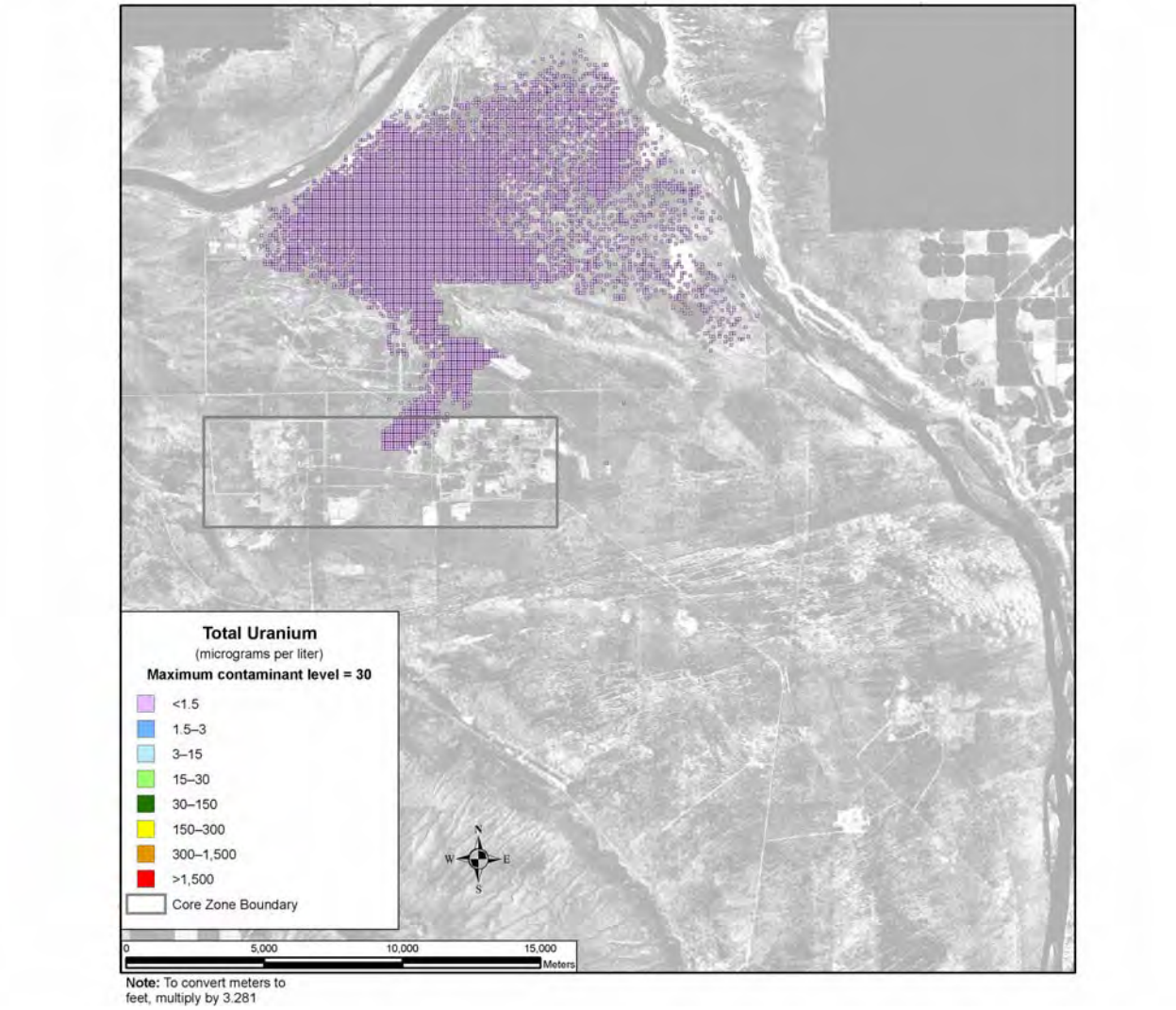


Figure 5–516. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group1, Subgroup 1-E, in general, the inventories remaining at both IDF-East and the RPPDF, which would be available for release to the environment at the start of the post-disposal period, are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one order of magnitude during most of the period of analysis. Concentrations at the Columbia River are about one order of magnitude smaller. The intensities and areas of these groundwater plumes peak between CYs 7140 and 11,885.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or Columbia River.

5.3.1.2.1.6 Disposal Group 1, Subgroup 1-F

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-F covers disposal of Tank Closure Alternative 5, FFTF Decommissioning Alternative 3, and onsite and offsite waste. Waste would be converted to IHLW, ILAW glass, bulk vitrification glass, and cast stone waste. IHLW would be stored on site, while ILAW glass, bulk vitrification glass, and cast stone waste would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, as follows:

- The disposal period was assumed to start with the onset of disposal operations for IDF-East in CY 2009 and continue through CY 2050, when the disposal facility would be operationally closed and postclosure care would cease. During the disposal period the materials in this permitted, operational facility is not available for release to the environment. The RPPDF is not constructed and operated for this subgroup.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East become available for release to the environment, and modified RCRA Subtitle C barrier would be emplaced over IDF-East to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F. Complete results for all 40 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, nitrate, and acetonitrile.

The COPC drivers for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, acetonitrile, boron, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, in terms of the total amounts of radionuclide and chemical COPCs released to the vadose zone,

groundwater, and Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–517 through 5–522). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

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Figure 5–517 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–518, the chemical hazard drivers. The COPC inventories in the waste forms are a major factor in the release quantities of a COPC to the vadose zone. The predominant source of technetium-99 is cast stone waste (60 percent), followed by offsite-generated waste (28 percent) and bulk vitrification glass (9 percent). Most of the iodine-129 (87 percent) is released from offsite-generated waste, followed by ETF-generated secondary waste (12 percent). All of the fluoride and boron are released by waste management secondary waste and onsite-generated waste. All of the acetonitrile is released by cast stone waste. The predominant source for chromium (78 percent) is sulfate grout, with some from cast stone waste (22 percent). The sources of nitrate are ETF-generated secondary waste (57 percent) and cast stone waste (43 percent).

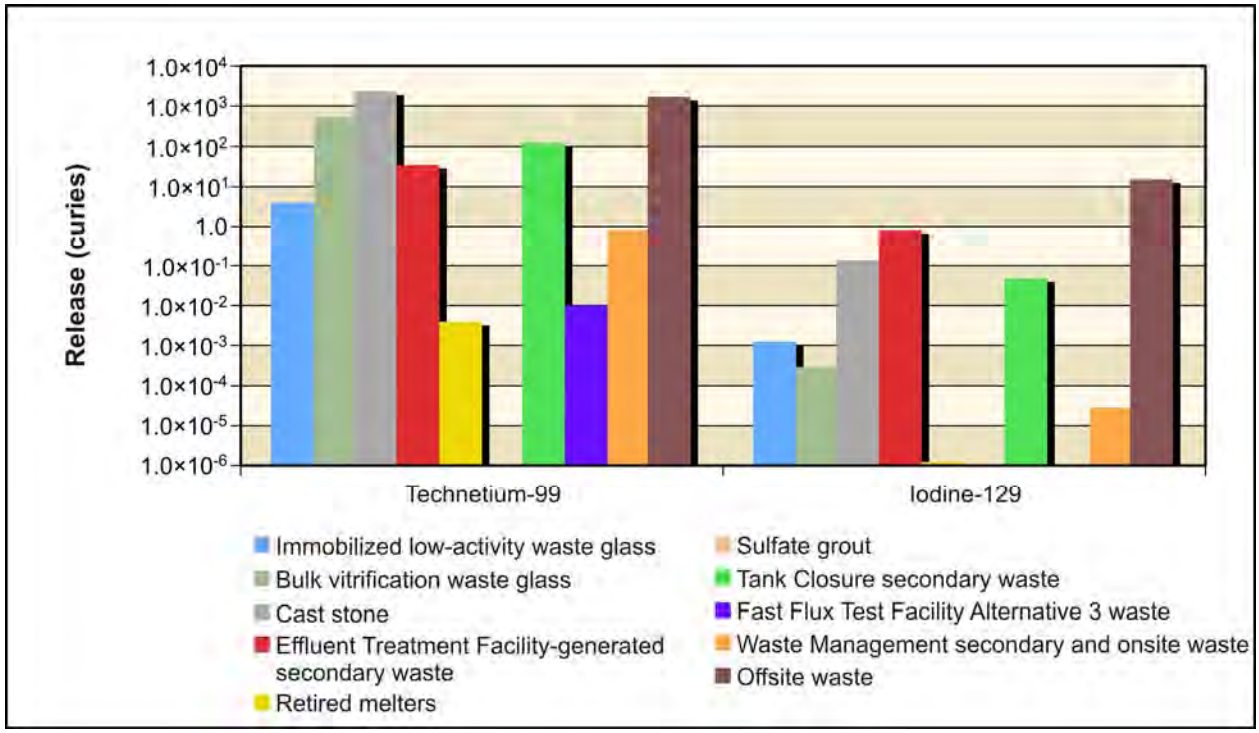


Figure 5–517. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

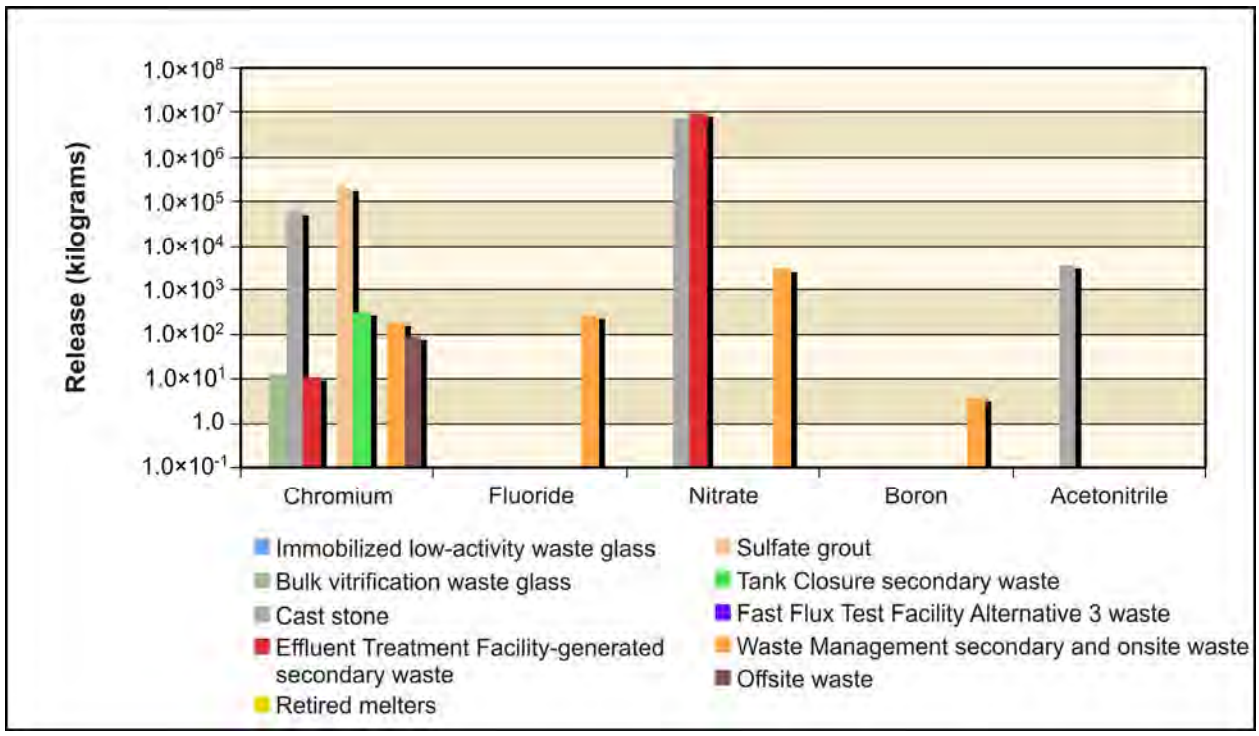


Figure 5–518. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–519 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–520, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the chromium, nitrate, fluoride, boron, and acetonitrile from the vadose zone are released to groundwater during the period of analysis. About 63 percent of the technetium-99 released to the vadose zone reached the groundwater in the analysis; about 92 percent of the iodine-129 reached the groundwater.

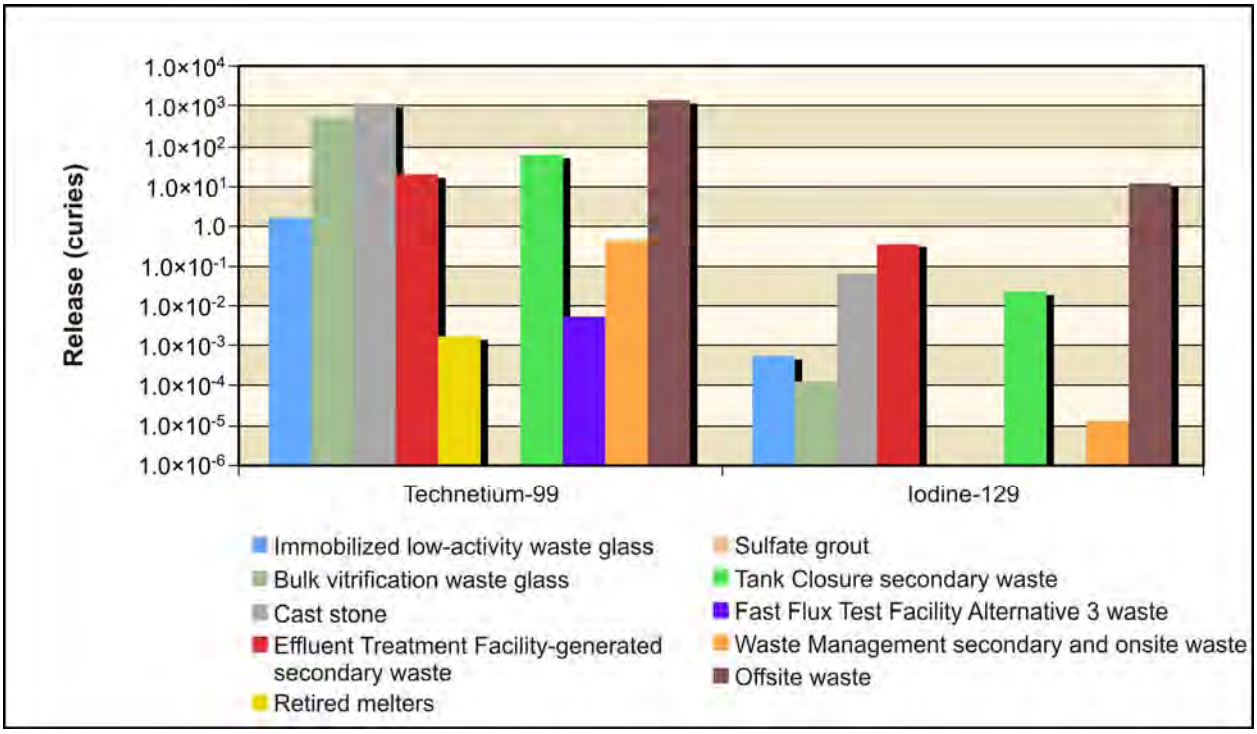


Figure 5–519. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

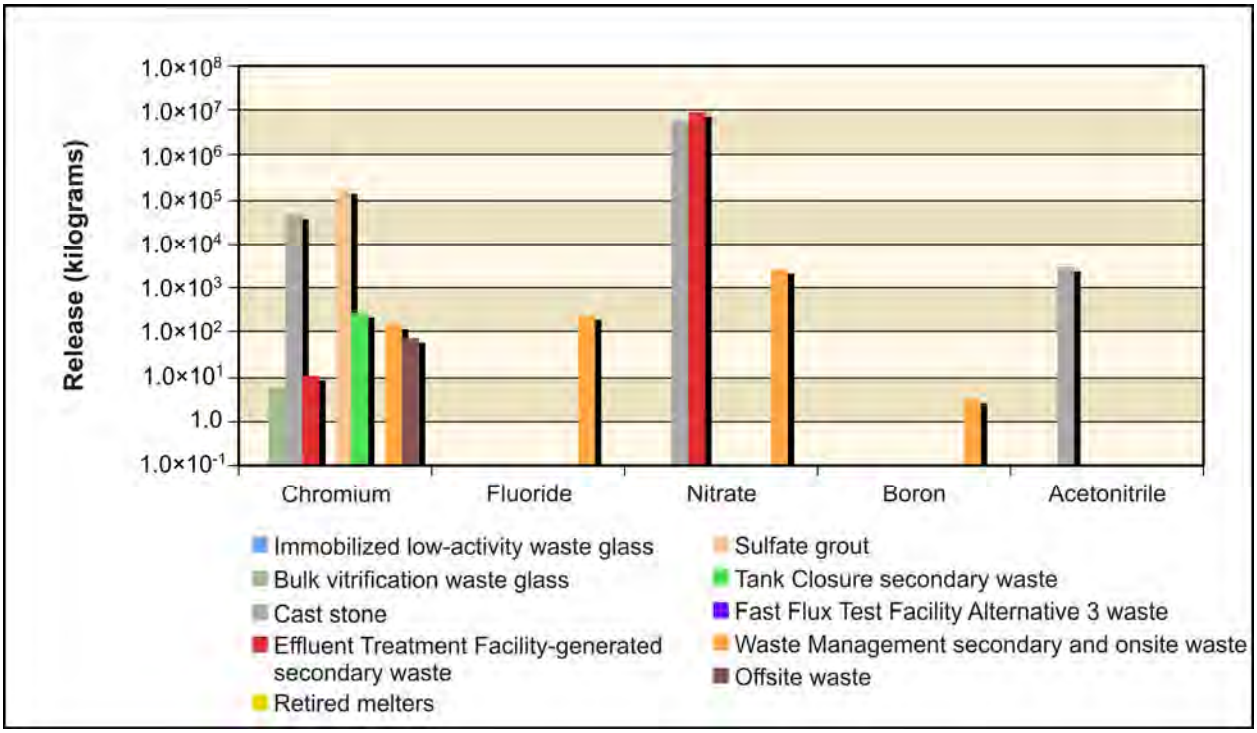


Figure 5–520. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–521 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–522, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPCs. All of the groundwater technetium-99, iodine-129, chromium, nitrate, fluoride, boron, and acetonitrile, are released to the Columbia River.

Overall, about 60 percent of the vadose zone technetium-99 and 90 percent of the iodine-129 reached the Columbia River within the time period of this analysis. About 96 to 98 percent of the vadose zone chromium, nitrate, fluoride, boron, and acetonitrile reached the Columbia River during the period of analysis. No uranium-238 or total uranium is released to the groundwater or Columbia River.

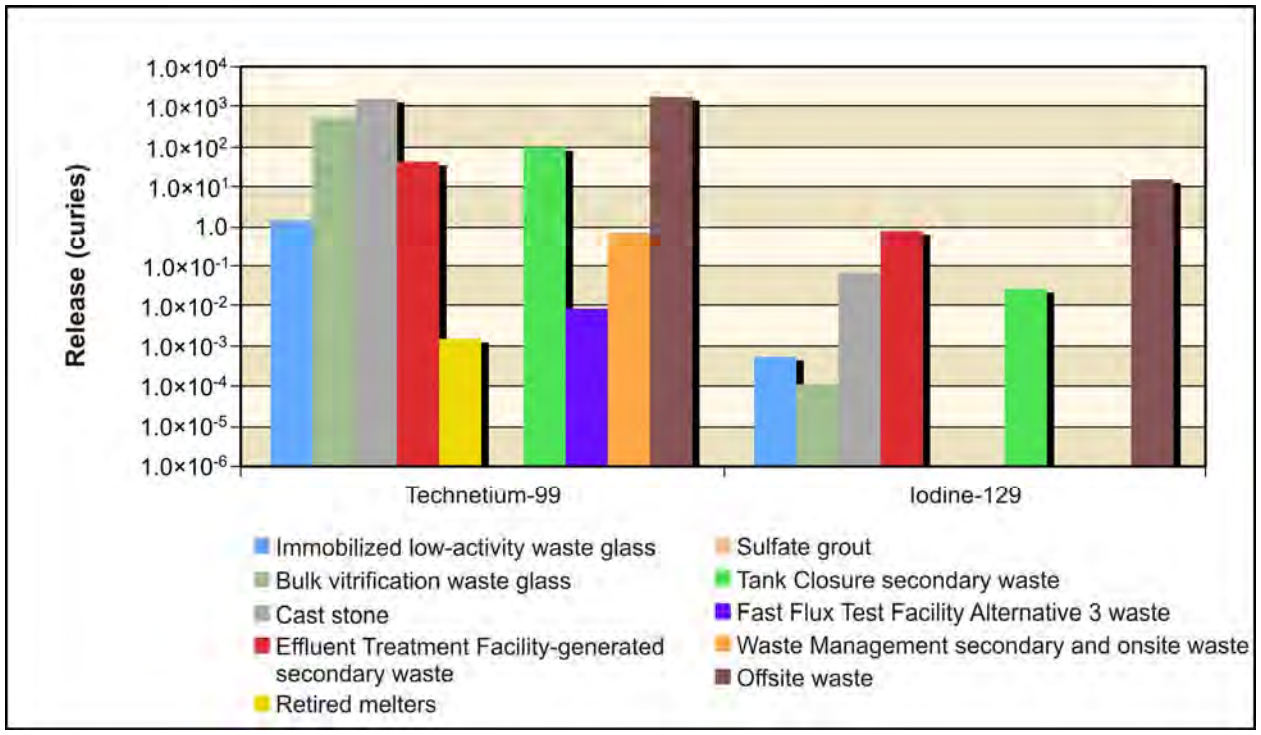


Figure 5–521. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

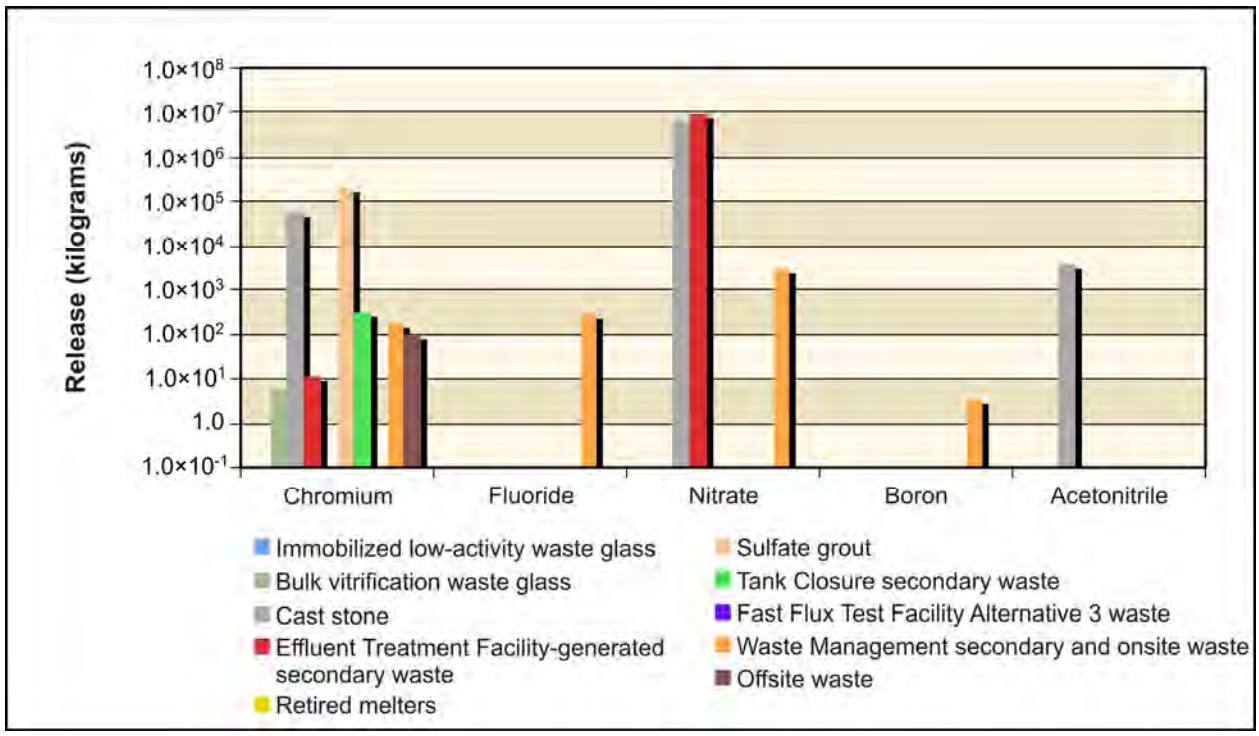


Figure 5–522. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. In the concentration versus time graphs, the concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter. The benchmark concentration is also shown for each radionuclide and chemical. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–82 gives the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–82. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**3,510**	N/A	**1,500**	891	900
	(8276)		(9155)	(8090)	
Iodine-129	**18**	N/A	**8**	**7**	1
	(8195)		(8858)	(8699)	
Chemical in micrograms per liter					
Acetonitrile	5	N/A	2	1	100
	(8475)		(9519)	(8575)	
Chromium	**335**	N/A	**148**	**110**	100
	(8735)		(8764)	(8819)	
Fluoride	0	N/A	1	0	4,000
	(8035)		(7258)	(8913)	
Nitrate	21,400	N/A	7,420	4,560	45,000
	(8448)		(8887)	(8787)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

Figures 5–523 through 5–526 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. During the latter part of the analysis time period, the groundwater concentrations of iodine-129 from IDF-East exceed the benchmark concentrations at both the Core Zone Boundary and the Columbia River nearshore (see Figure 5–523). However, the concentrations of iodine-129 are never more than one order of magnitude above the benchmark concentration level. The concentrations of technetium-99 and chromium (see Figures 5–524 and 5–525) approach but never exceed their benchmark concentrations. The concentration of nitrate always remains at least one order of magnitude less than its benchmark concentration (see Figure 5–526).

There are no detectable releases of either uranium-238 or total uranium to the environment over this analysis period.

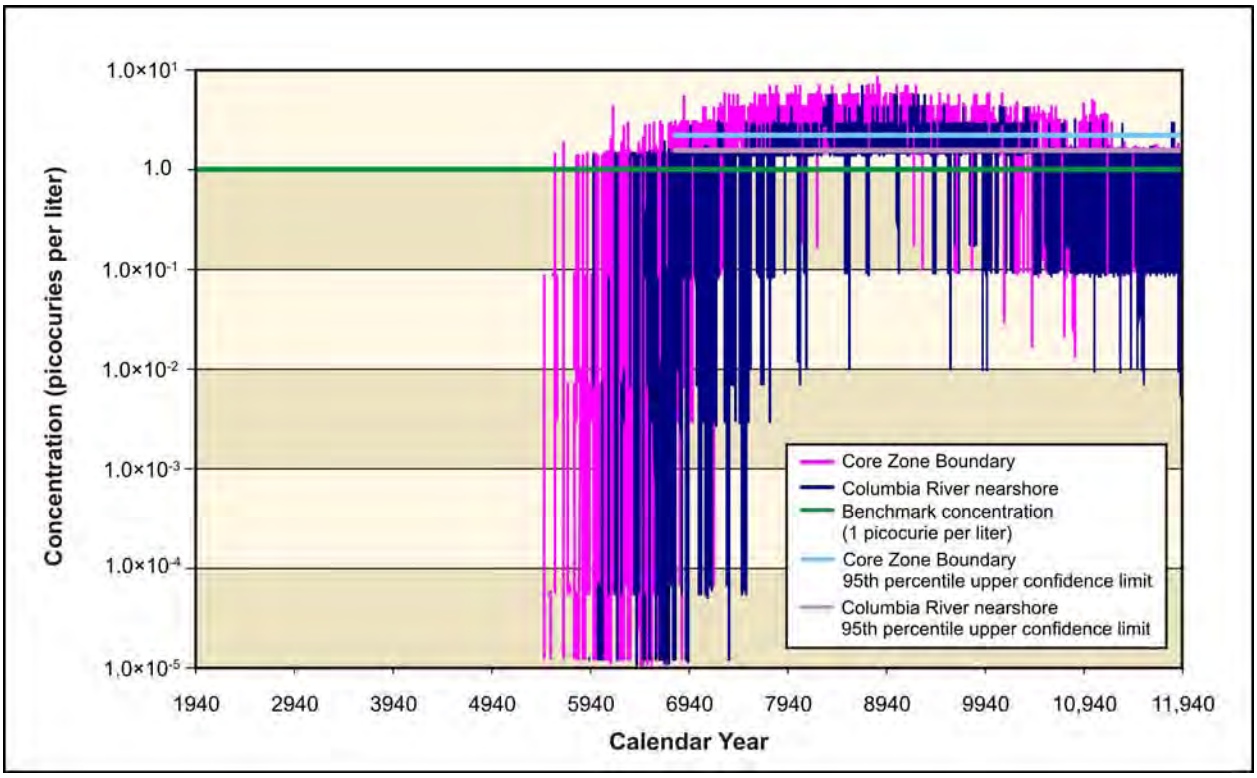


Figure 5–523. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Iodine-129 Concentration Versus Time

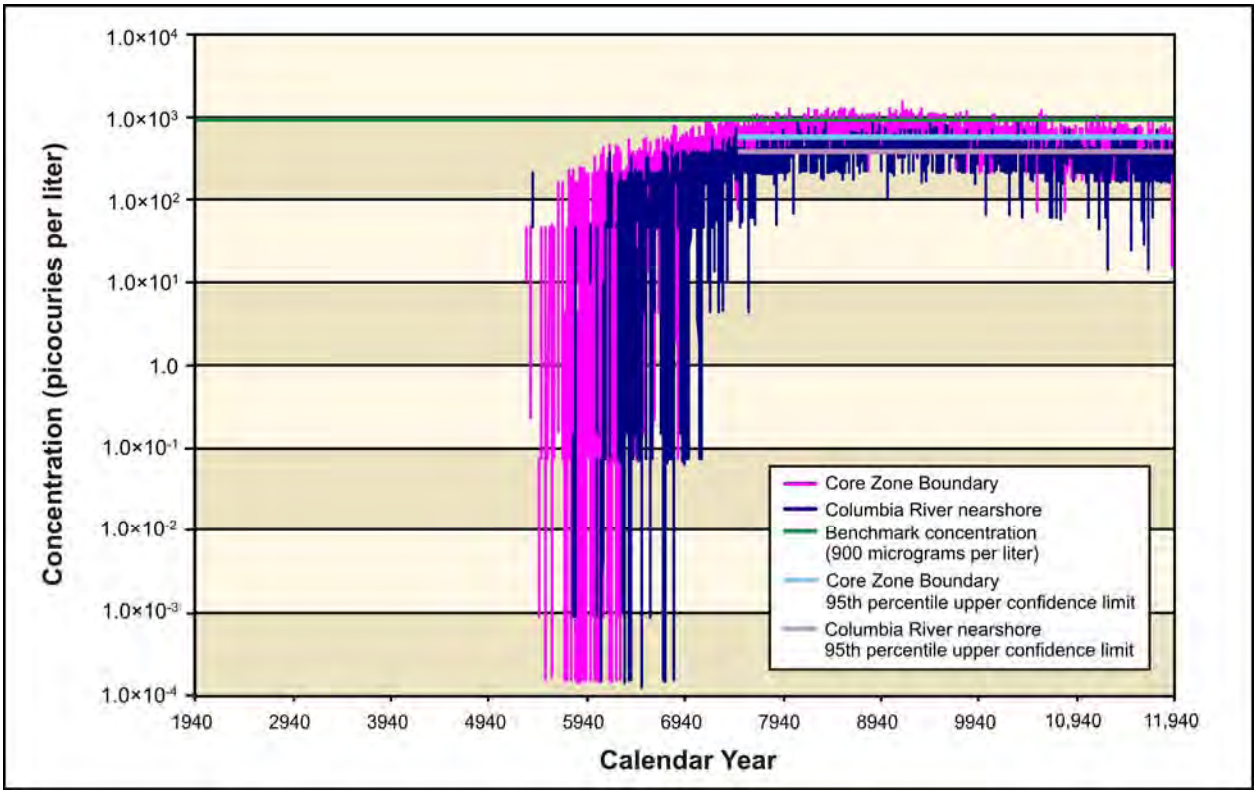


Figure 5–524. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Technetium-99 Concentration Versus Time

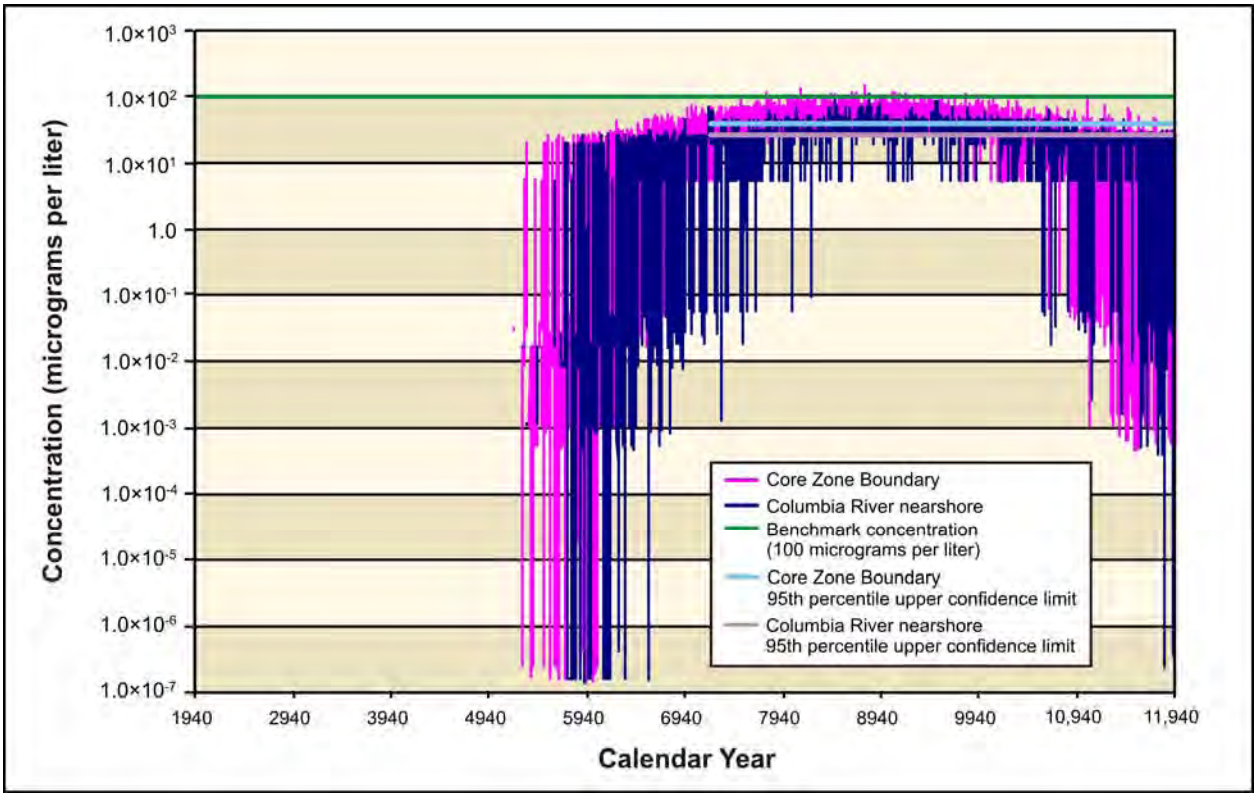


Figure 5–525. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chromium Concentration Versus Time

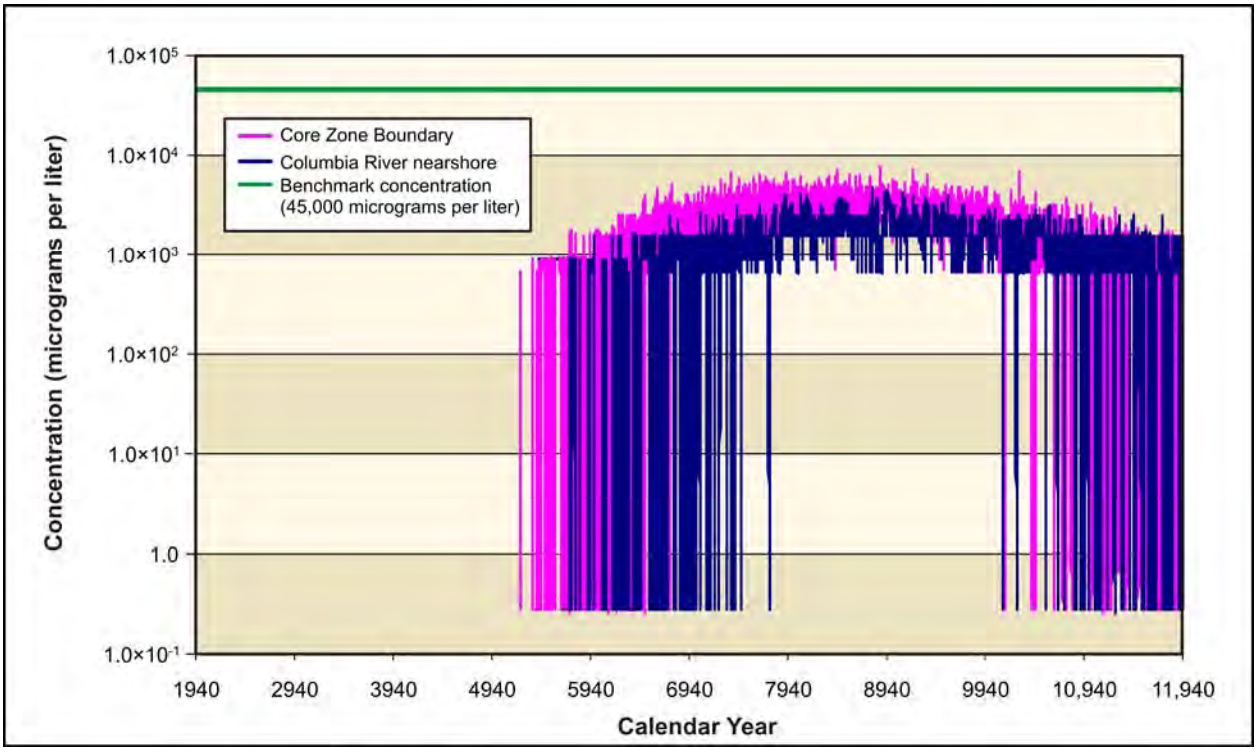


Figure 5–526. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Nitrate Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, in terms of the spatial distribution of groundwater concentration at selected times in this analysis period. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–527 through 5–534). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Figures 5–527 through 5–534 show groundwater releases that extend from the east edge of the Core Zone Boundary to the Columbia River. The iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity). Releases from IDF-East result in groundwater concentrations that extend from the release source east to the Columbia River. For each map, the concentrations that are greater than the benchmark concentration are indicated by the fully saturated colors (green, yellow, orange, and red) in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors (green, blue, indigo, and violet) in order of decreasing concentration. The concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

All plumes from IDF-East releases are initially contained in a narrow area moving eastward until they reach about one-third of the distance to the Columbia River nearshore boundary, where they spread out significantly and continue to the Columbia River. Figures 5–527 and 5–528 show the spatial distribution of iodine-129 groundwater concentration for CYs 7140 and 11,885, respectively. The CY 7140 data show that a release from IDF-East creates a plume outside of the east boundary between the Core Zone Boundary and the Columbia River nearshore. These data also show that there is an area east of the Core Zone Boundary where the concentration exceeds the benchmark concentration. By CY 11,885 (see Figure 5–528), the plume mass has continued to spread out and is still moving eastward toward the Columbia River. The CY 11,885 plume also shows areas where the concentrations exceed the benchmark concentration.

Figures 5–529 and 5–530 show a similar technetium-99 release moving east toward the Columbia River for CYs 7140 and 11,885. The plumes show areas where the concentration of technetium-99 exceeds the benchmark concentration. The CY 11,885 data show that the chromium is dissipating, but high-concentration areas remain.

Figures 5–531 and 5–532 (CYs 7140 and 11,885 data) show a chromium plume with a small area where the concentration approaches the benchmark concentration. The CY 11,885 data show a reduced-size and reduced-concentration plume compared with the CY 7140 plume. The CY 11,885 data also shows that the chromium concentration continues between the release source and the Columbia River, but that the distribution is dissipating.

Figures 5–533 and 5–534 show the spatial distributions of groundwater concentrations of nitrate for CYs 7140 and 11,885. The nitrate release appears to approach the benchmark concentration in a small area east of the Core Zone Boundary. The CY 11,885 data show a nitrate plume significantly reduced in both area and concentration.

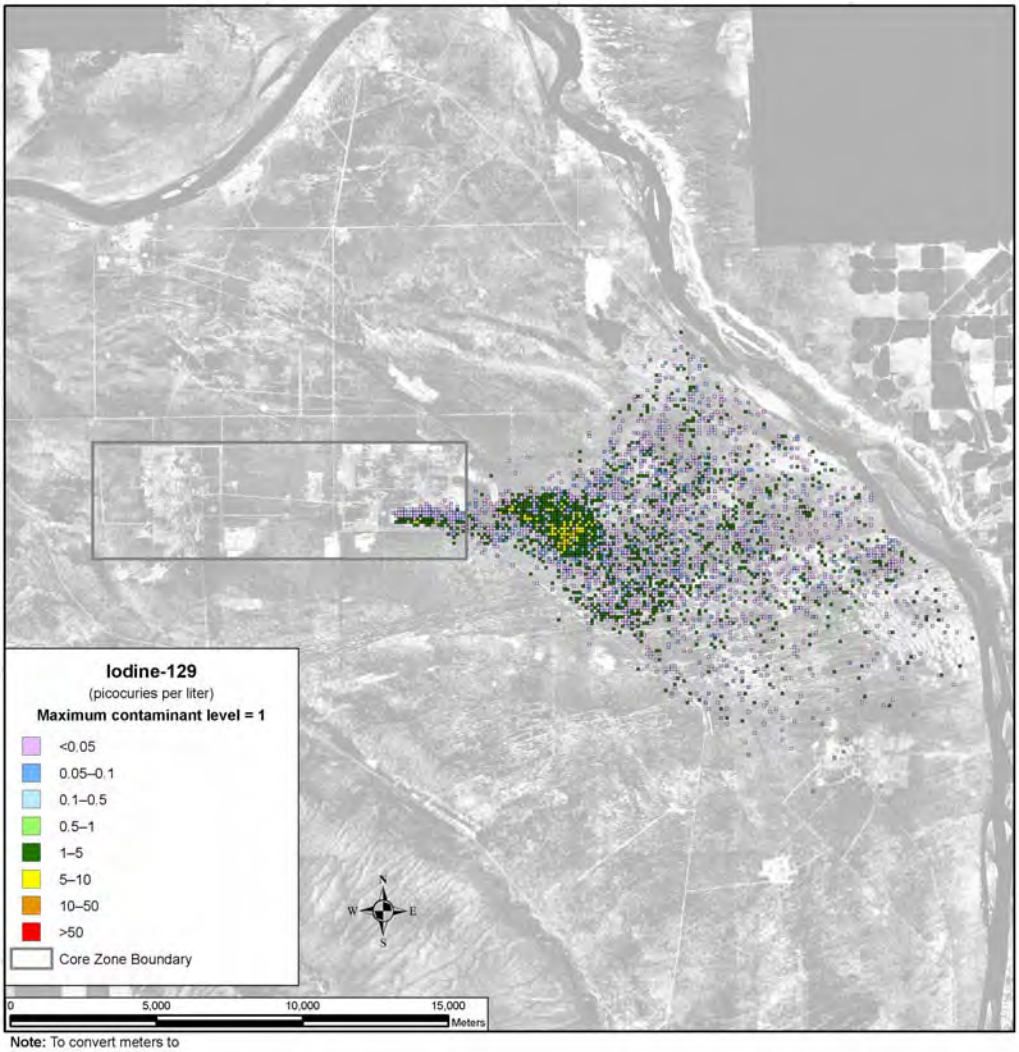


Figure 5–527. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

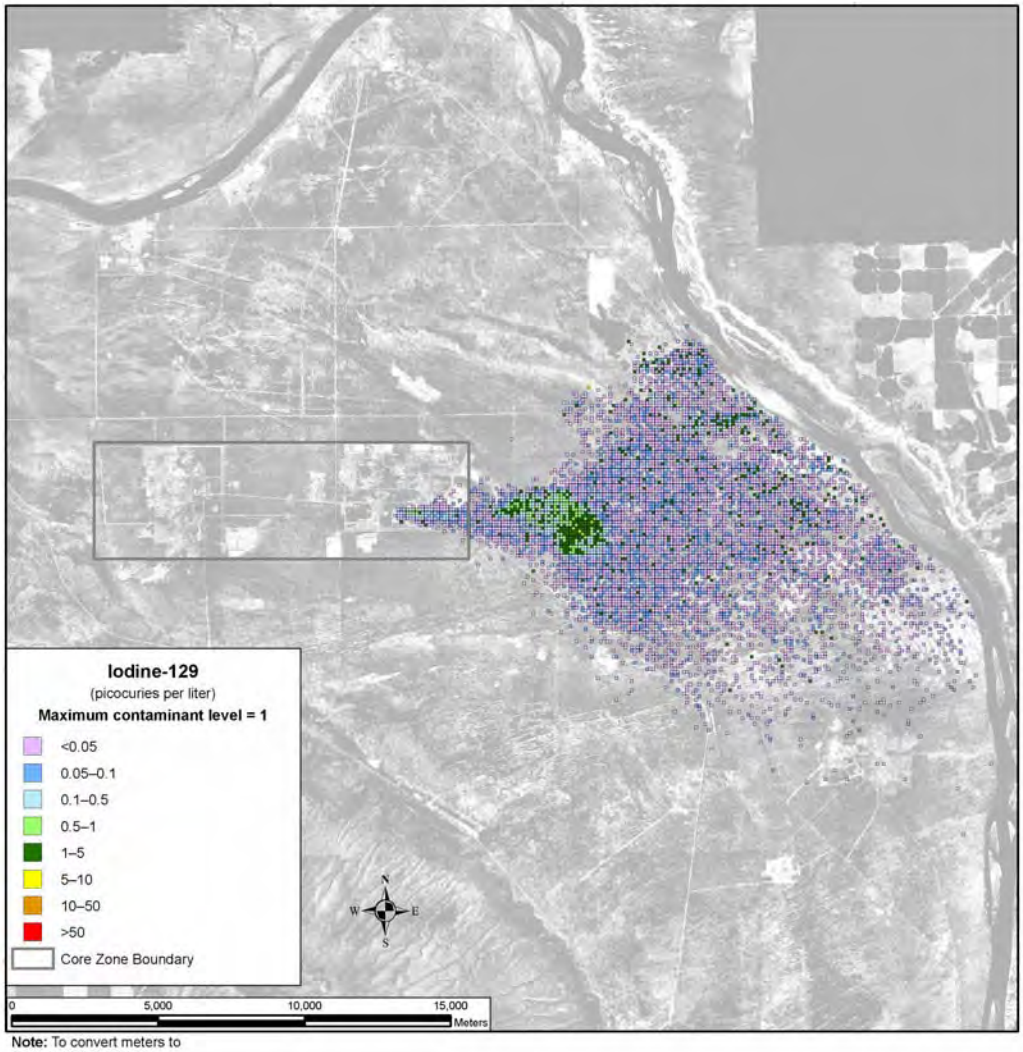


Figure 5–528. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

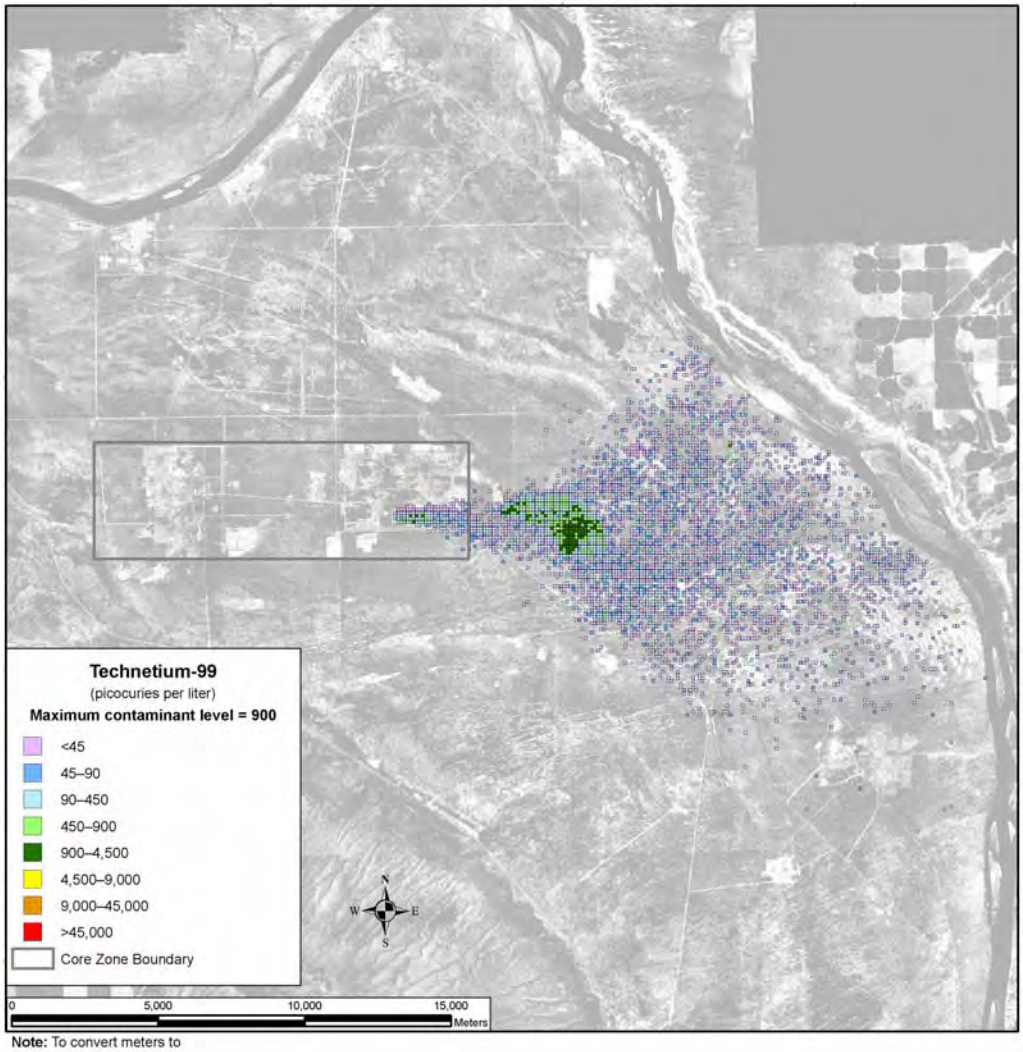


Figure 5–529. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

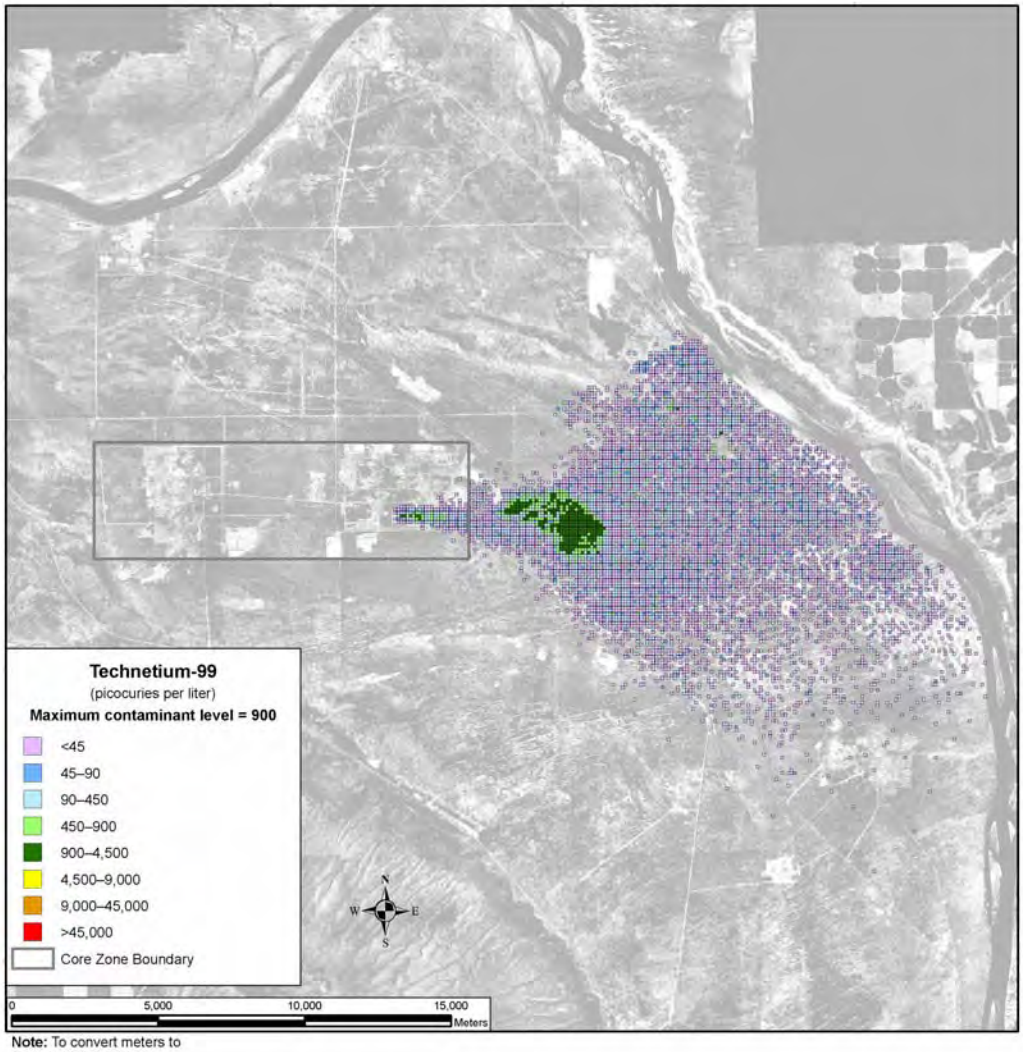


Figure 5–530. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

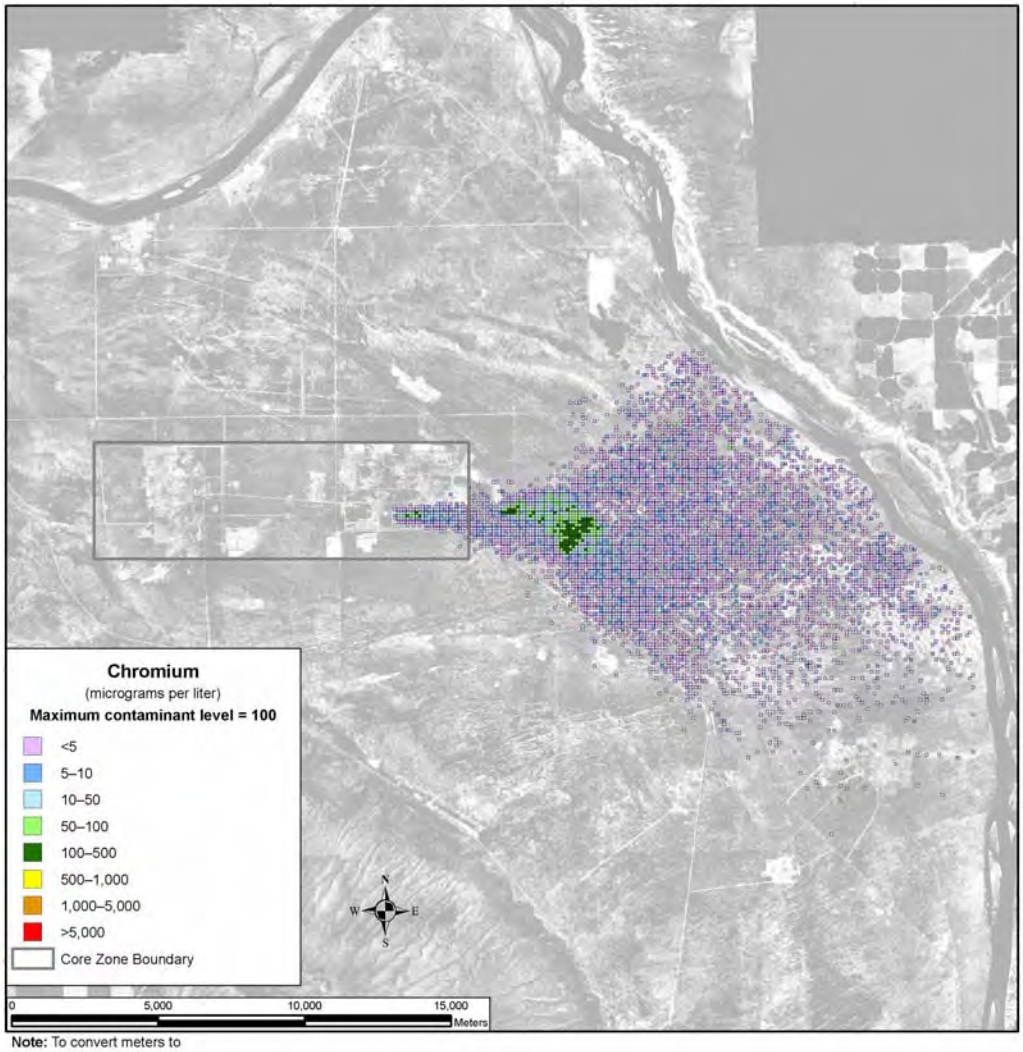


Figure 5–531. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

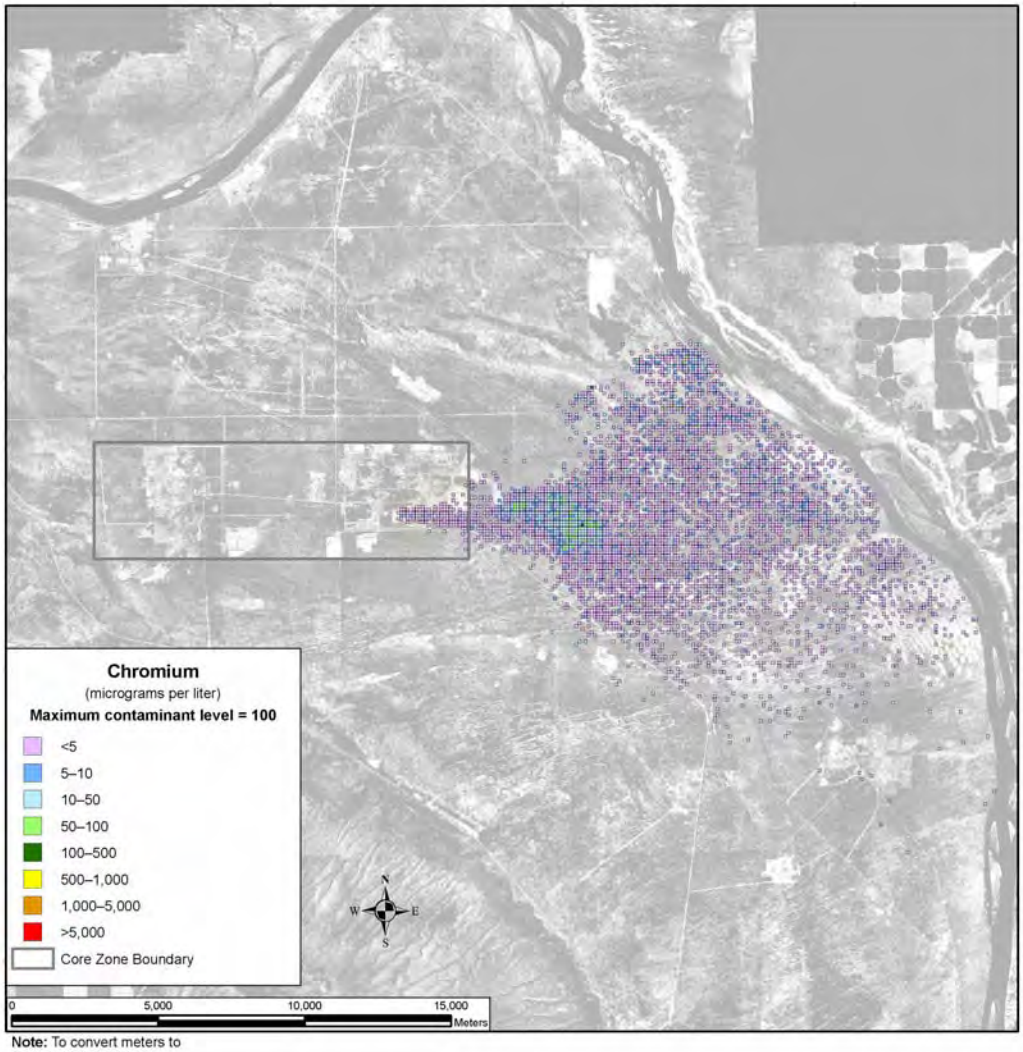


Figure 5–532. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

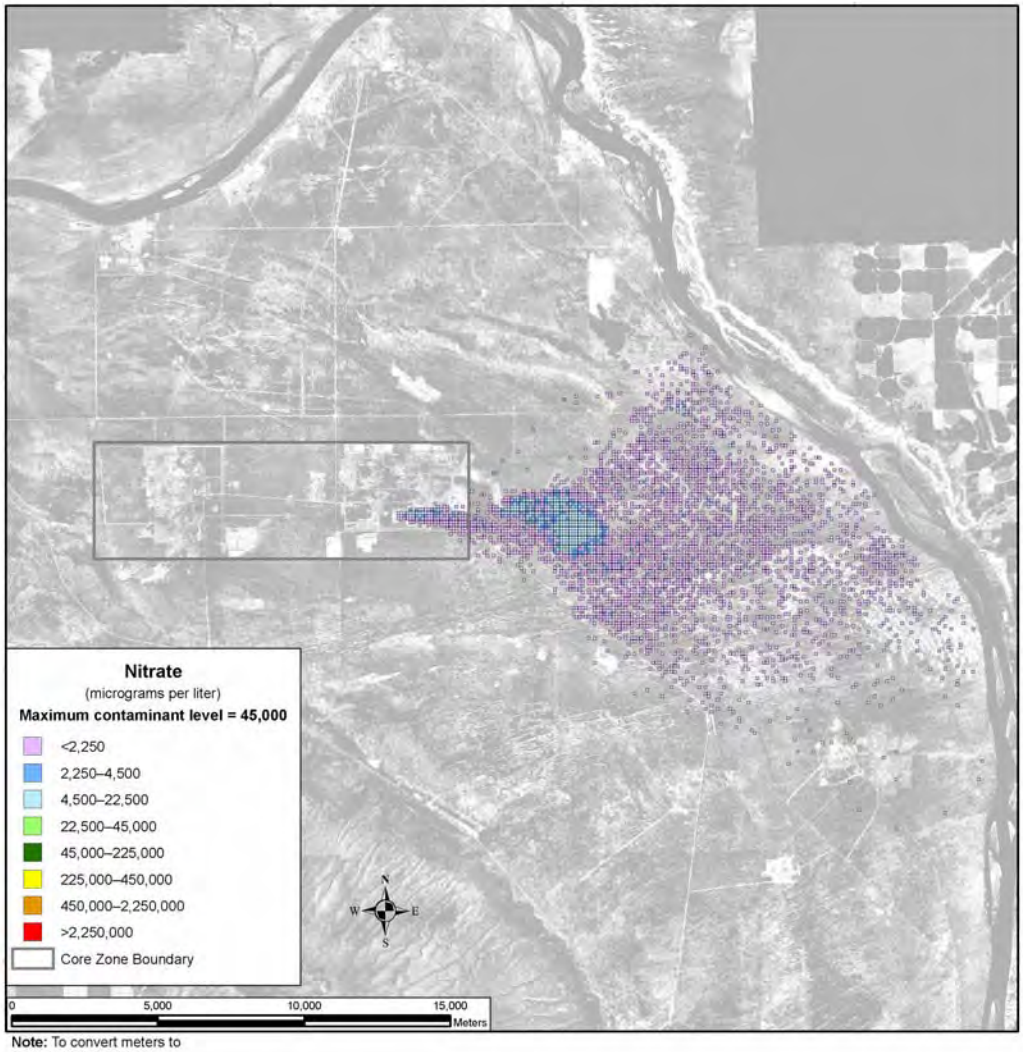


Figure 5–533. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

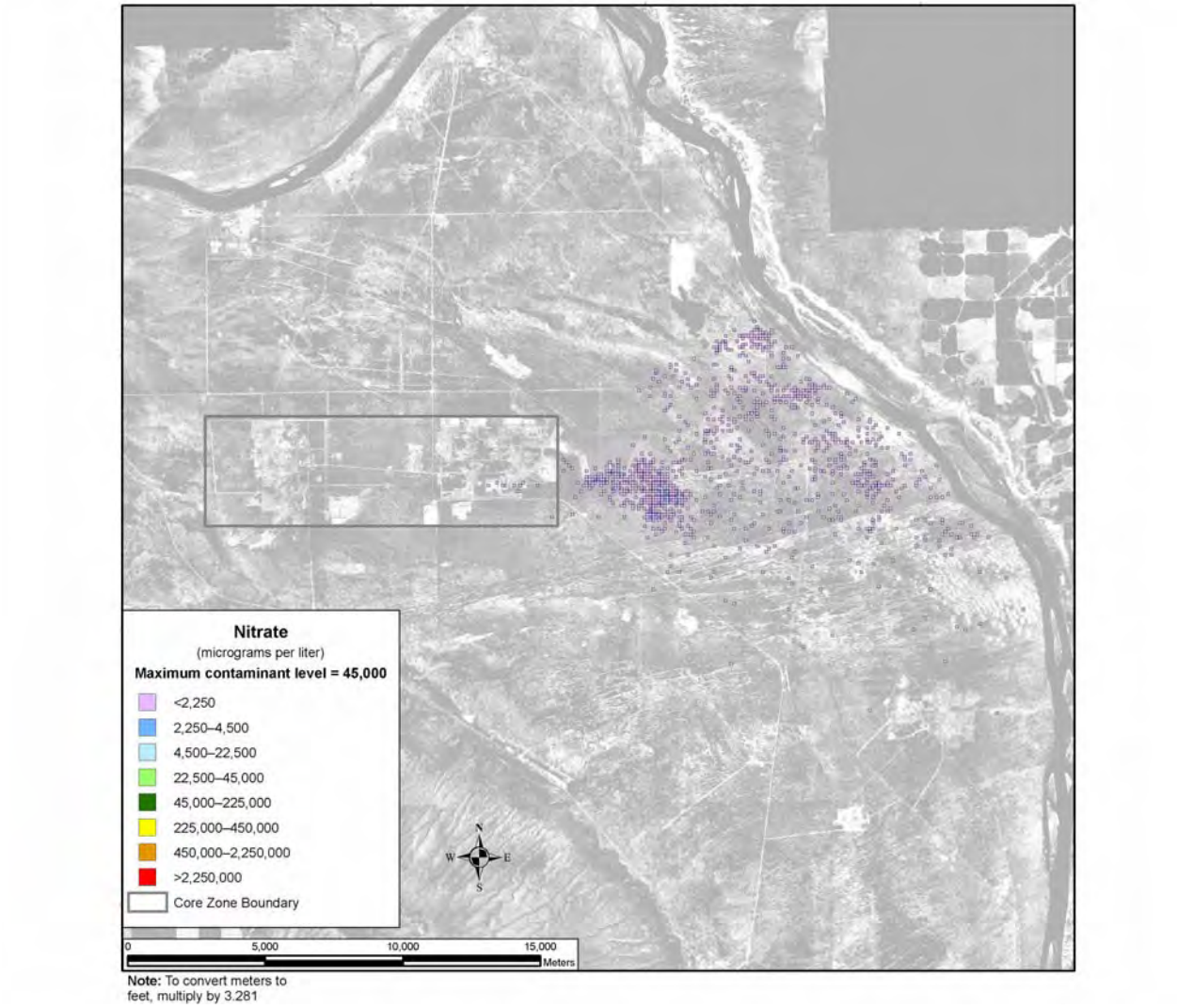


Figure 5–534. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, in general, the predominant contributor is the iodine-129 inventory at IDF-East that is available for release to the environment at the start of the post-disposal period. The technetium-99, chromium, and nitrate concentrations do not appear to exceed benchmark standards during the period of analysis. These COPCs have concentrations at the Columbia River nearshore that are about one order of magnitude smaller than the benchmark concentrations. In general, the intensities are highest and the areas of these groundwater plumes largest between CYs 7000 and 9000, with concentrations declining through CY 11,885.

5.3.1.2.1.7 Disposal Group 1, Subgroup 1-G

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-G covers disposal of waste generated under Tank Closure Alternative 6C and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW and ILAW glass. IHLW would be stored on site, while ILAW glass would be disposed of at IDF-East. For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, IDF-East and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G (IDF-East and RPPDF releases), in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figure 5–535 through 5–546). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has five subtotals plotted representing releases including ETF-generated secondary waste, tank closure and waste management secondary waste, FFTF Decommissioning Alternative 3 waste, and onsite- and offsite-generated waste.

Figure 5–535 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–536, the chemical hazard drivers. For all five types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and iodine-129 is offsite-generated waste. For chemicals, the predominant source of chromium is tank closure secondary waste and for nitrate is offsite-generated waste. The predominant sources of fluoride and boron are waste management secondary waste and onsite-generated waste.

Figure 5–537 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–538 the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, fluoride, and boron the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 90 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

Figure 5–539 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–540, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, nitrate, fluoride, and boron the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, about 97 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; approximately 99 percent of the chemical quantity (kilograms) reached the river.

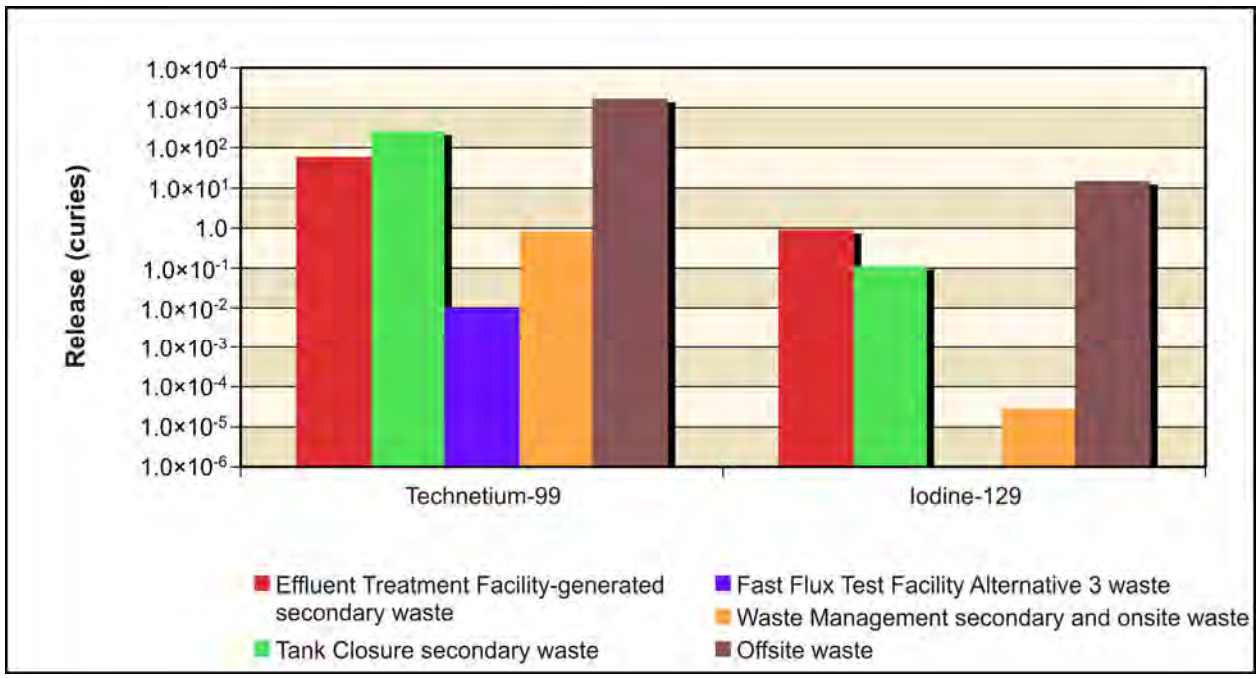


Figure 5–535. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

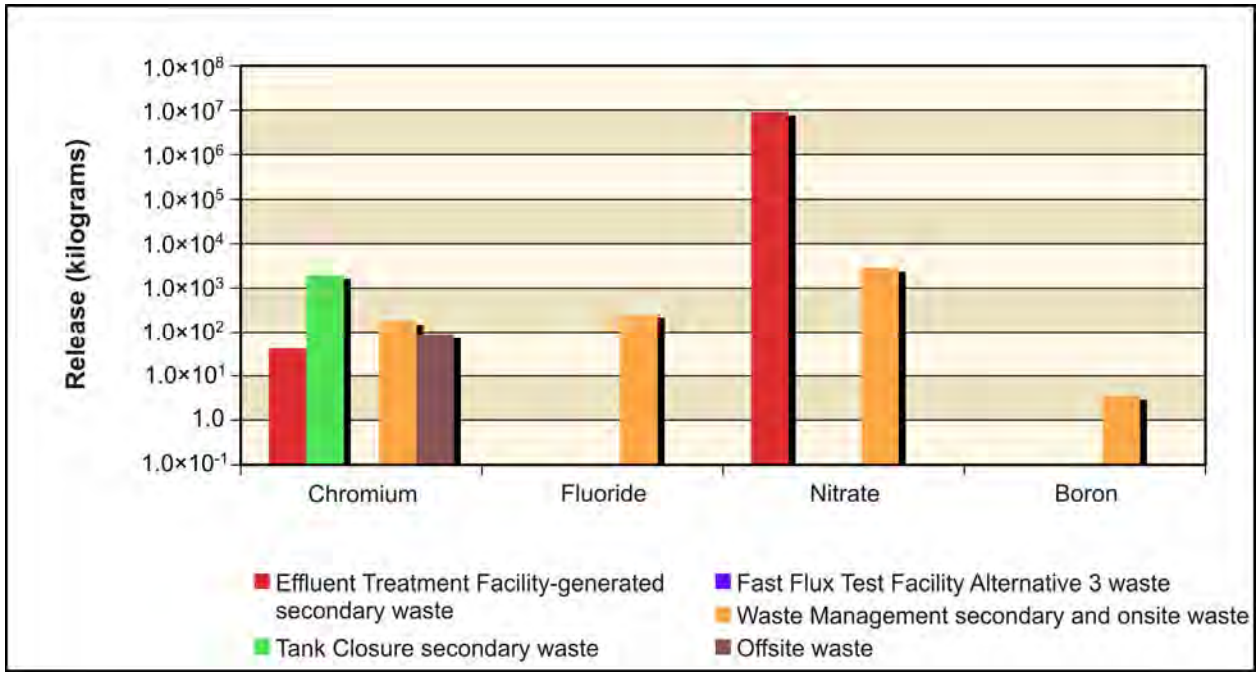


Figure 5–536. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

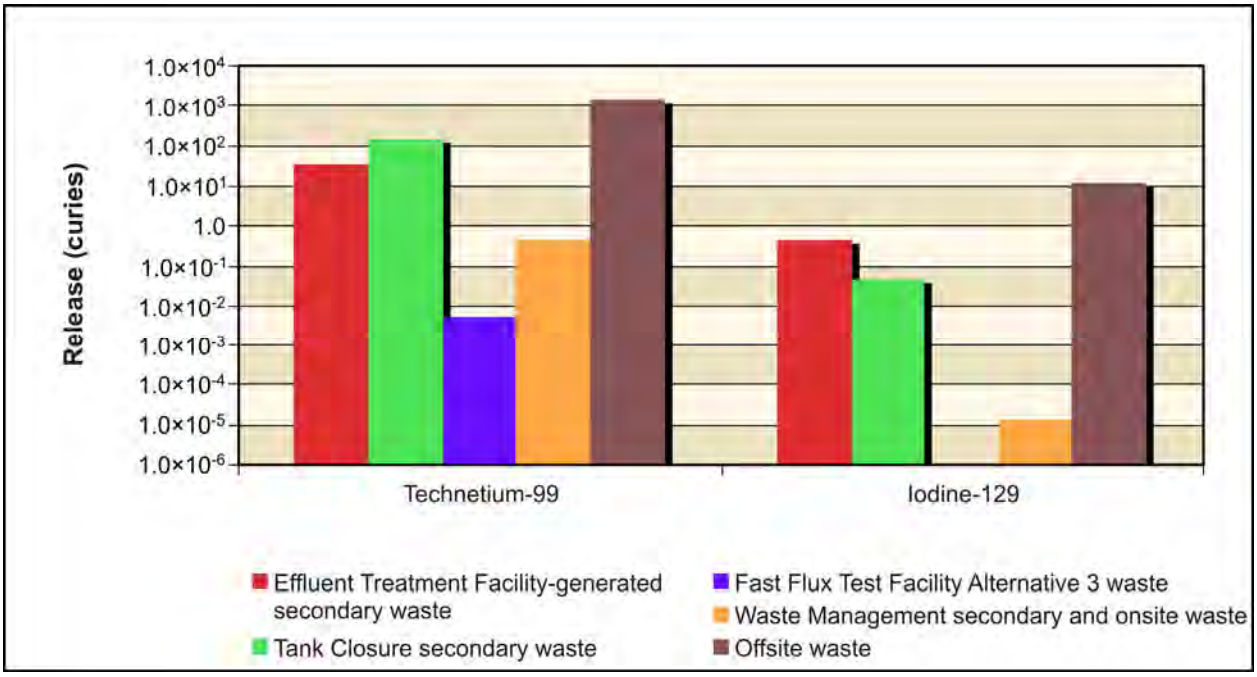


Figure 5–537. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

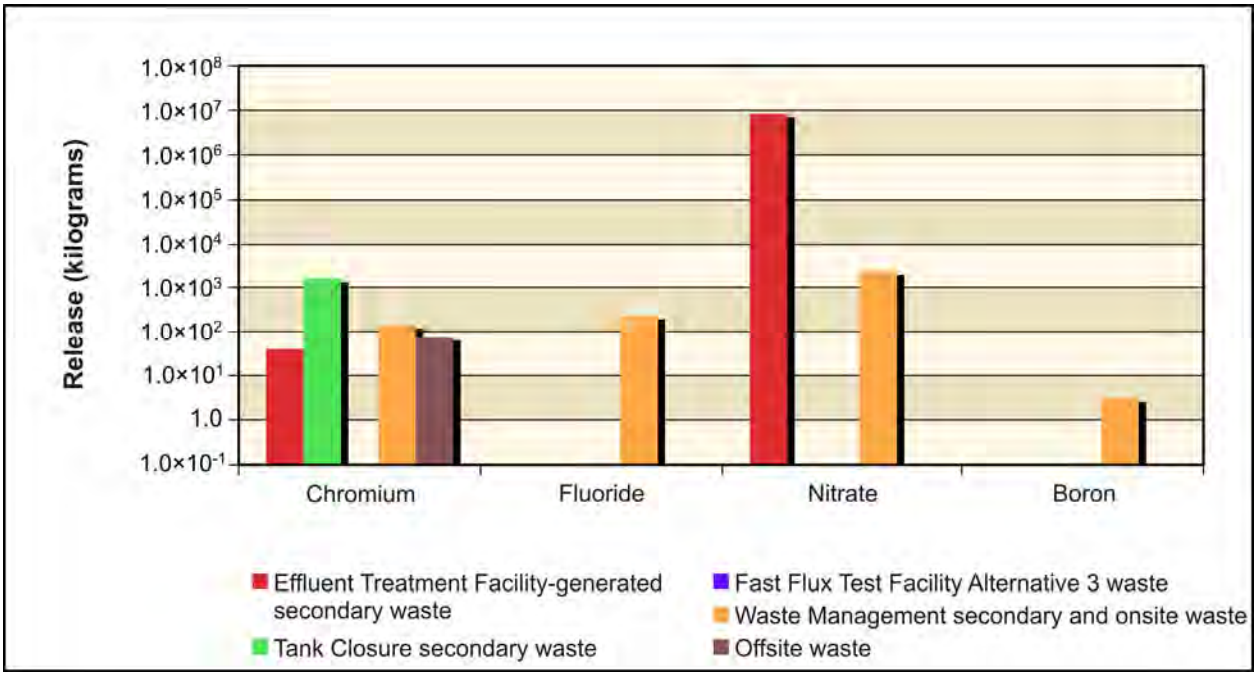


Figure 5–538. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

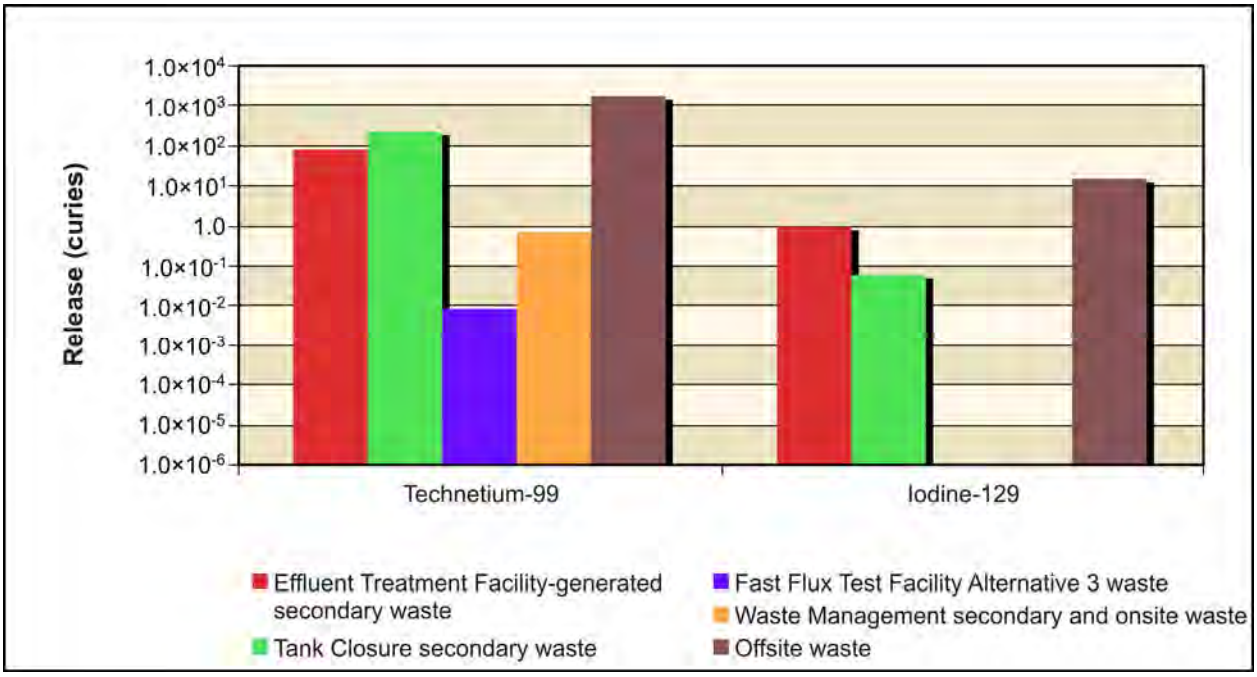


Figure 5–539. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

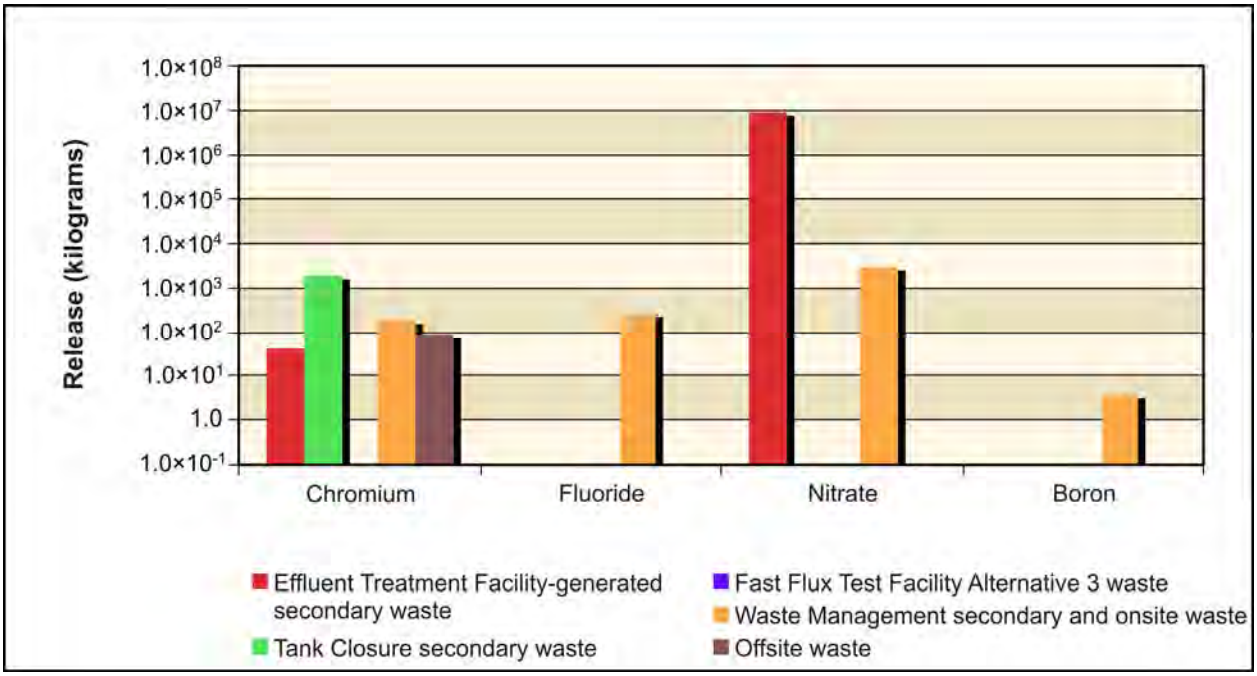


Figure 5–540. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–541 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–542, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium-99 (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). Fluoride and boron are not released from the RPPDF.

Figure 5–543 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–544, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

Figure 5–545 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–546, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 96 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; 96 percent of the chemical quantity (kilograms) reached the river.

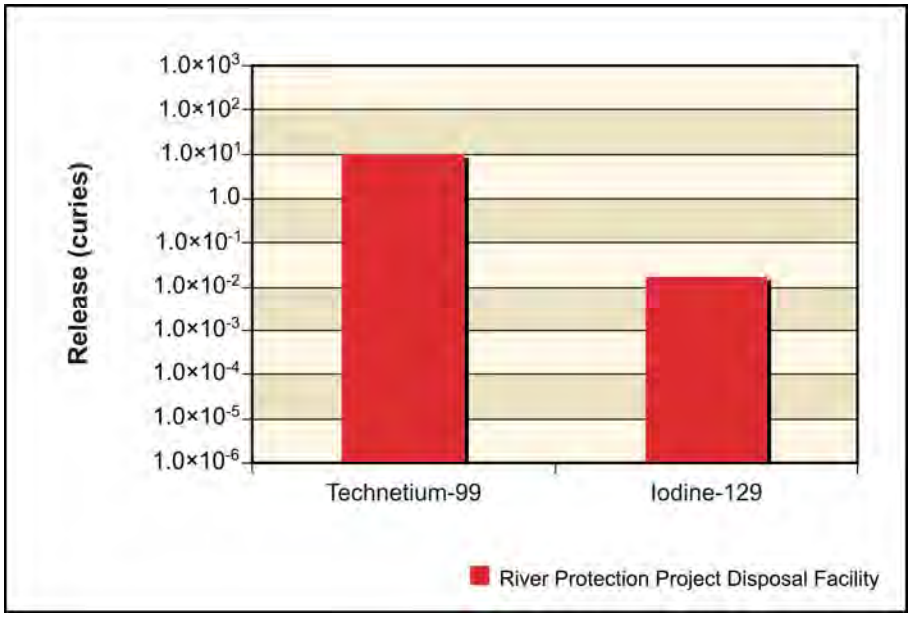


Figure 5–541. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases to River Protection Project Disposal Facility to Vadose Zone

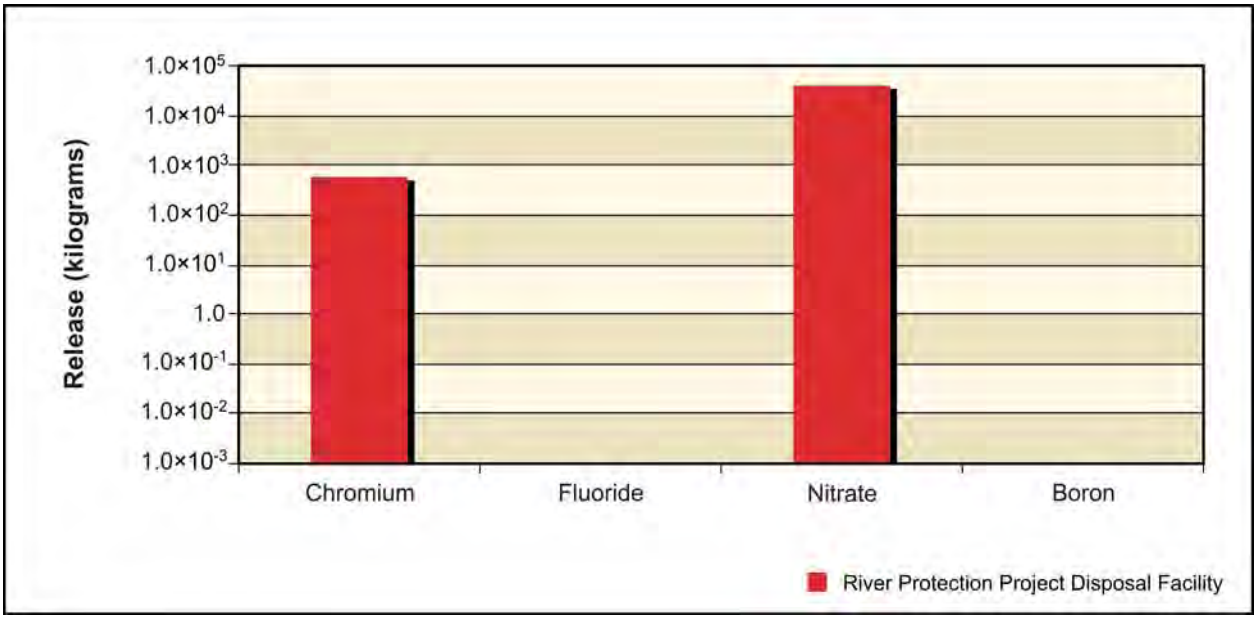


Figure 5–542. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases to River Protection Project Disposal Facility to Vadose Zone

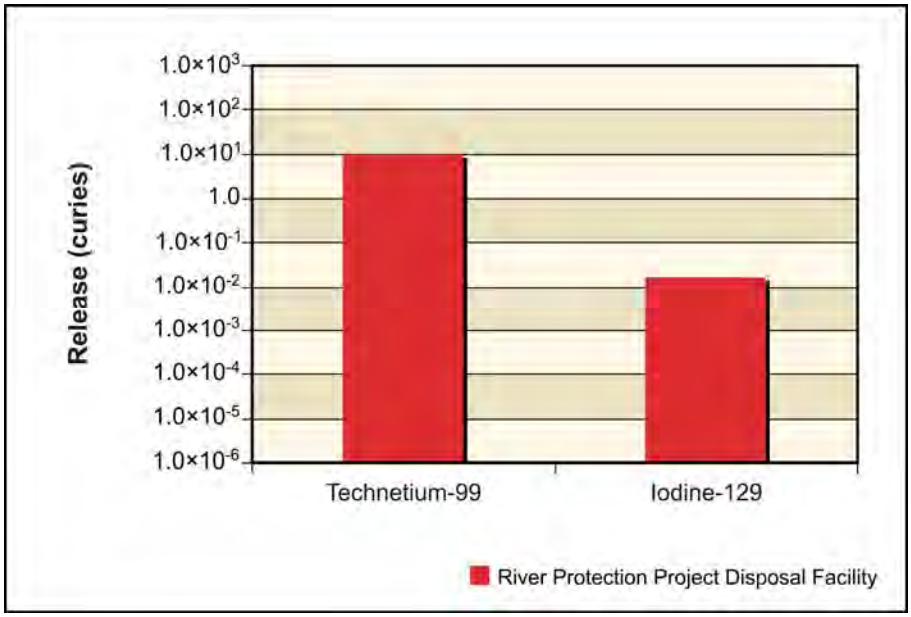


Figure 5–543. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases to River Protection Project Disposal Facility to Groundwater

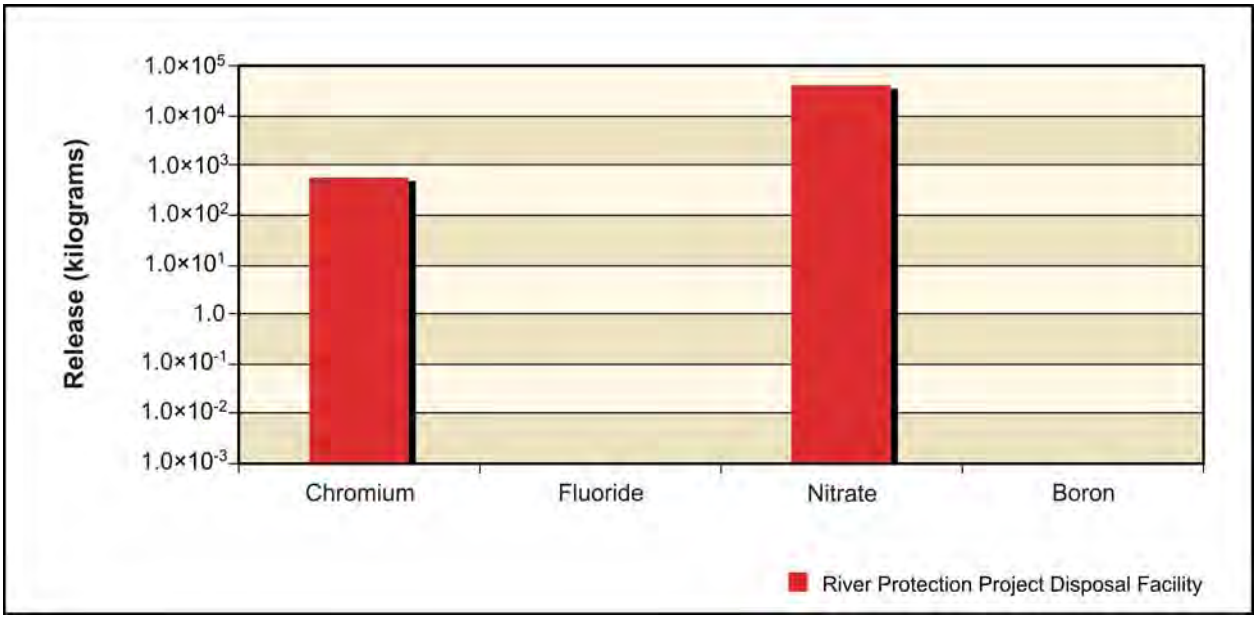


Figure 5–544. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases to River Protection Project Disposal Facility to Groundwater

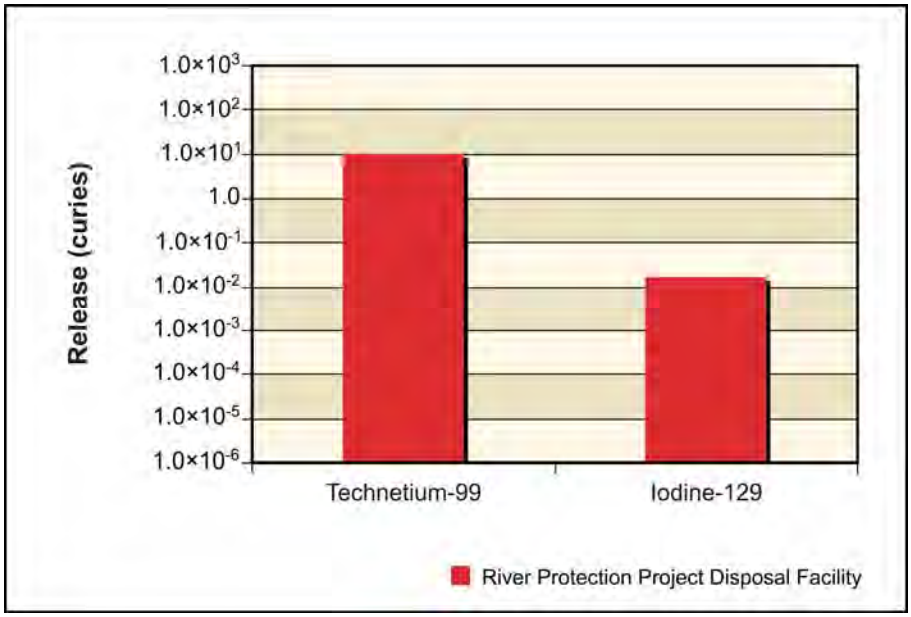


Figure 5–545. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases to River Protection Project Disposal Facility to Columbia River

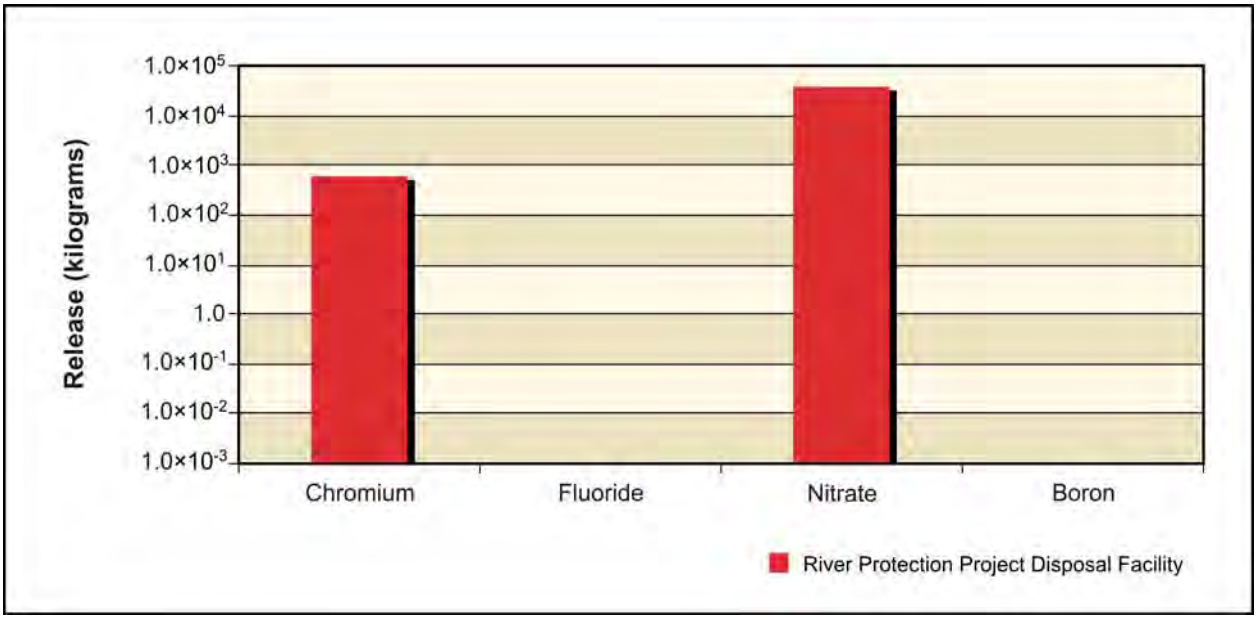


Figure 5–546. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases to River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figure 5–547 through 5–551). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–83 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–547 through 5–550 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East and the RPPDF cause groundwater concentrations to exceed benchmark concentrations at the Core Zone and Columbia River nearshore boundaries by less than one order of magnitude for iodine-129. Iodine-129 extends above the benchmark level during the later part of the period of analysis. Technetium-99, nitrate, and chromium do not exceed benchmark concentrations at the Core Zone or Columbia River nearshore boundaries.

Uranium-238 has no detectable release to the environment throughout the duration of the period of analysis. Figure 5–551 shows concentration versus time for total uranium.

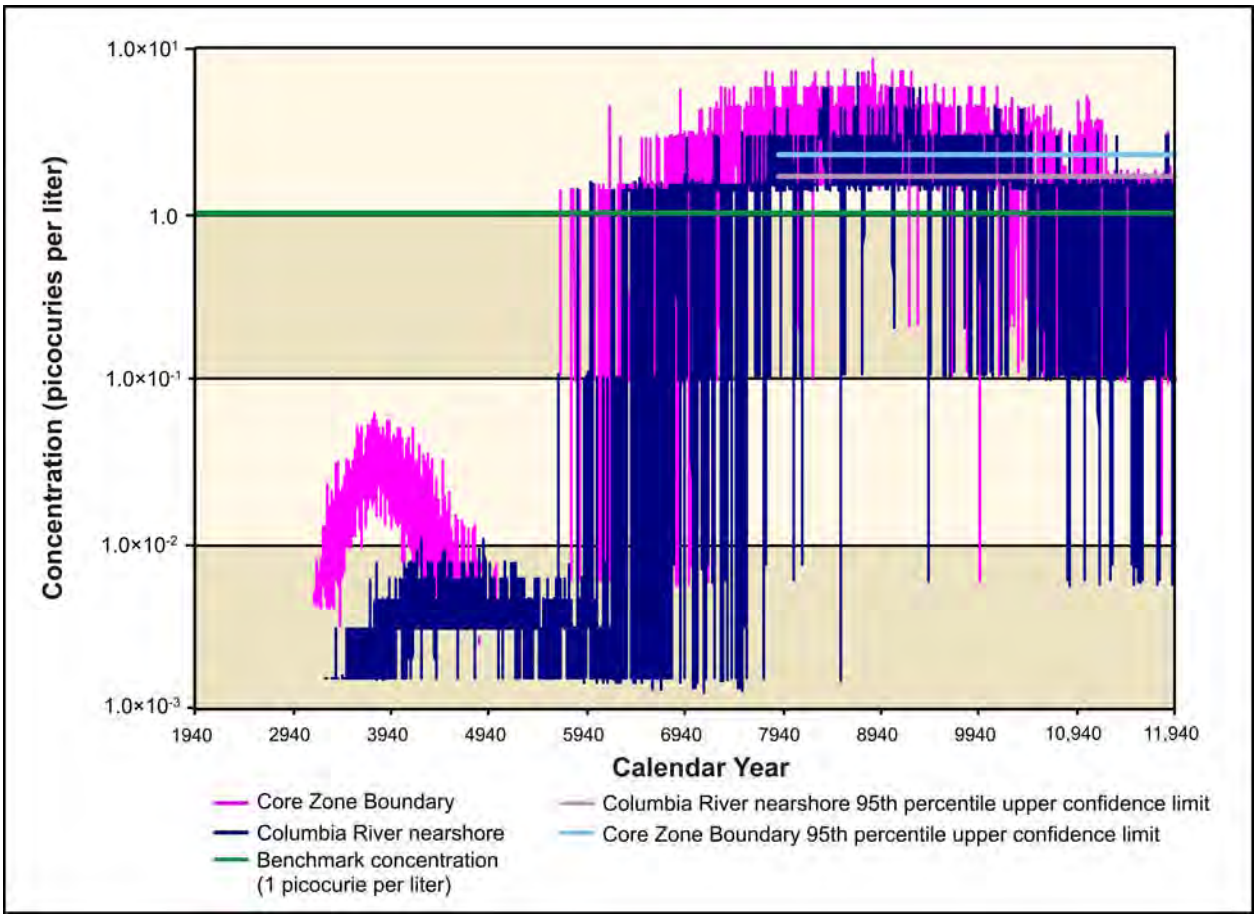


Figure 5–547. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Iodine-129 Concentration Versus Time

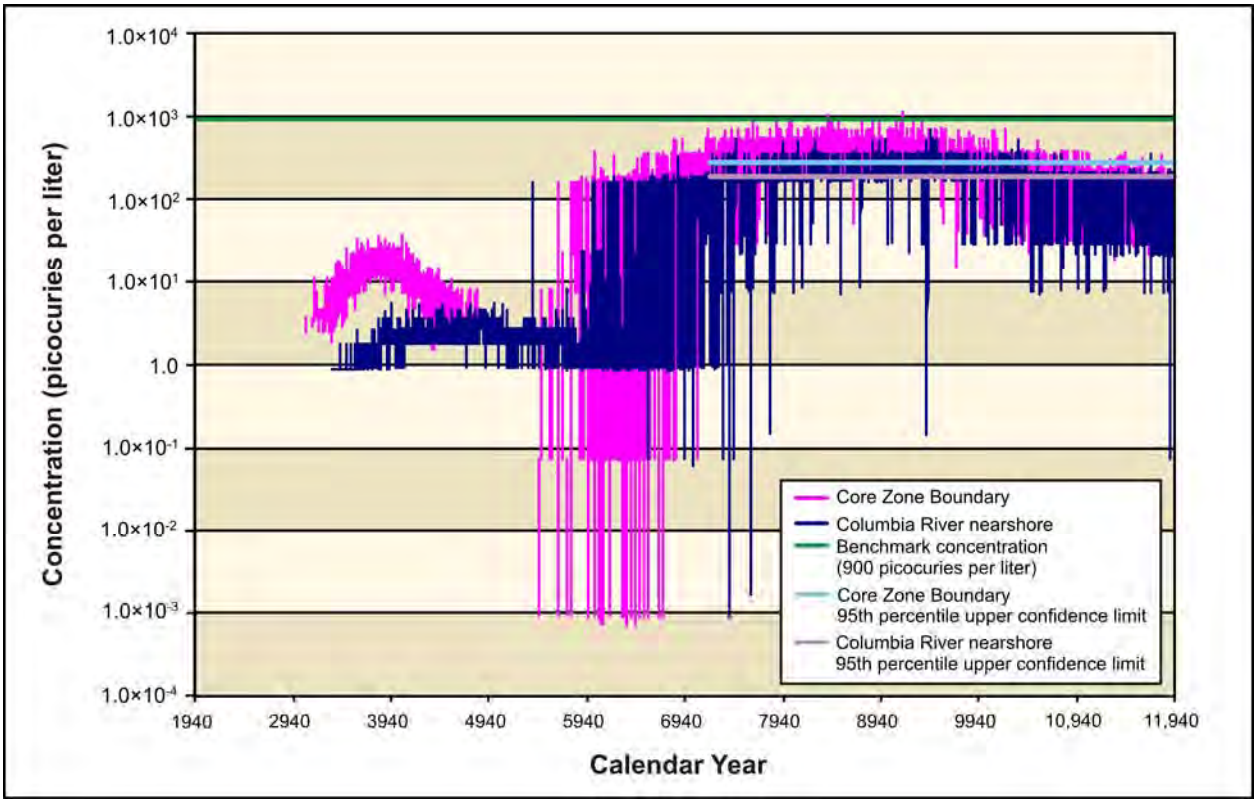


Figure 5–548. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Technetium-99 Concentration Versus Time

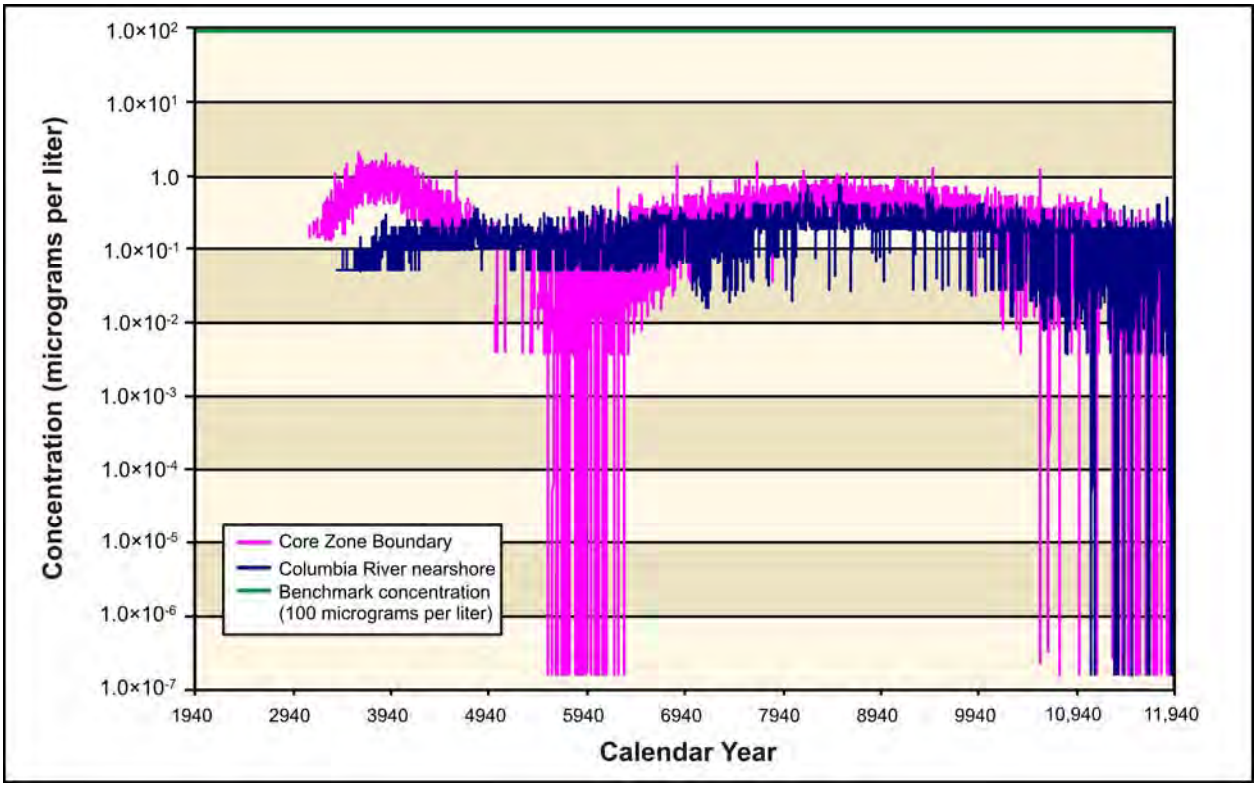


Figure 5–549. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chromium Concentration Versus Time

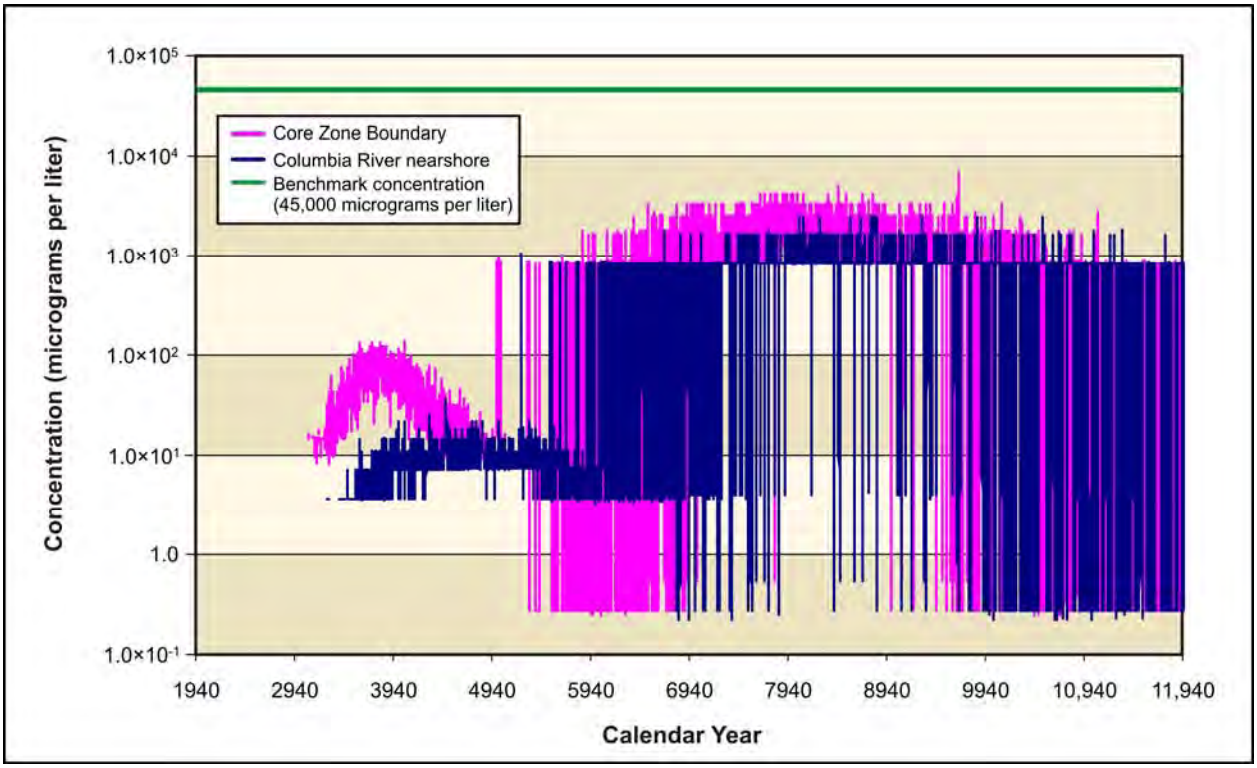


Figure 5–550. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Nitrate Concentration Versus Time

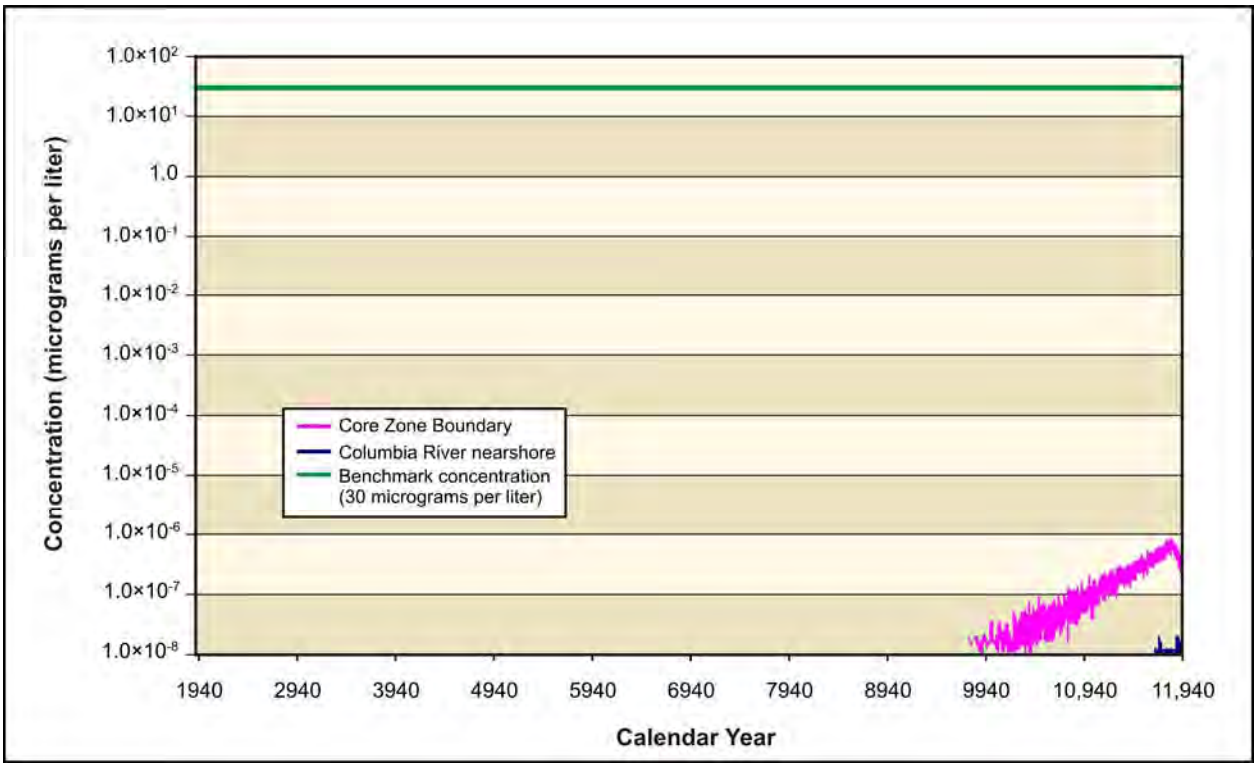


Figure 5–551. `Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Total Uranium Concentration Versus Time

Table 5–83. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,190**	33	**1,150**	674	900
	(9004)	(3825)	(9155)	(9451)	
Iodine-129	**19**	0.1	**9**	**7**	1
	(8739)	(3772)	(8858)	(8699)	
Chemical in micrograms per liter					
Chromium	4	2	2	1	100
	(8618)	(3856)	(3889)	(8528)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,200	149	5,630	2,440	45,000
	(8522)	(3811)	(9653)	(8827)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–552 through 5–564). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–552 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from the RPPDF result in a groundwater plume heading north through Gable Mountain. This plume does not exceed iodine-129's benchmark concentration north of the Core Zone. During CY 7140, releases from IDF-East create a plume exceeding the benchmark, extending from the 200-East Area moving eastward towards the Columbia River (see Figure 5–553). Also by CY 7140, most of the RPPDF plume continues to move north and reaches the Columbia River. By CY 11,885 most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small, isolated pockets of high concentration exceeding the benchmark (see Figure 5–554). Technetium-99 (see Figures 5–555 through 5–557), chromium (see Figures 5–558 through 5–560), and nitrate (see Figures 5–561 through 5–563) show similar spatial distributions at selected times, except none of them exceed their benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–564 shows the distribution of total uranium during CY 11,885. Releases from the RPPDF result in a groundwater plume that starts in the Core Zone and

moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.

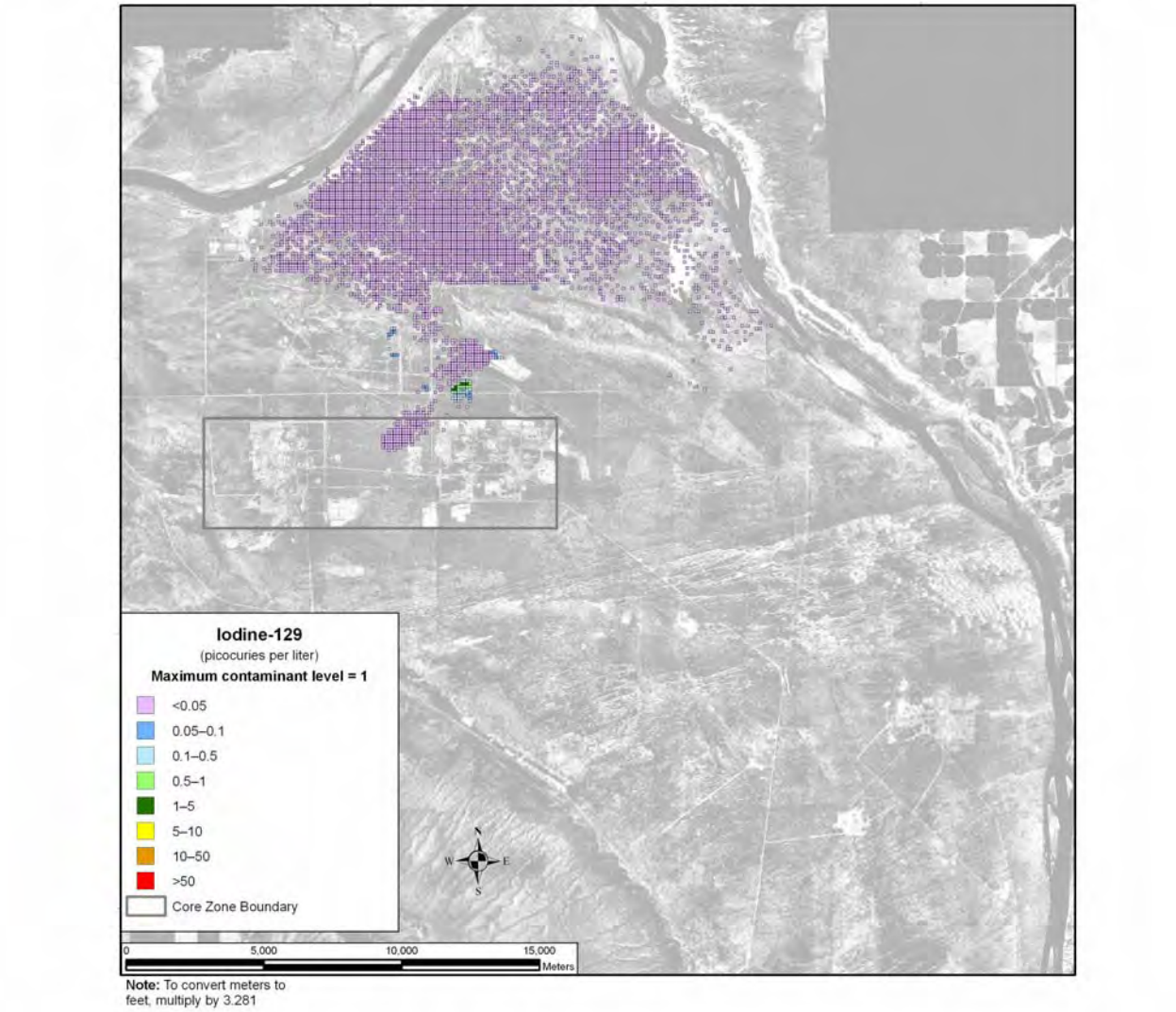
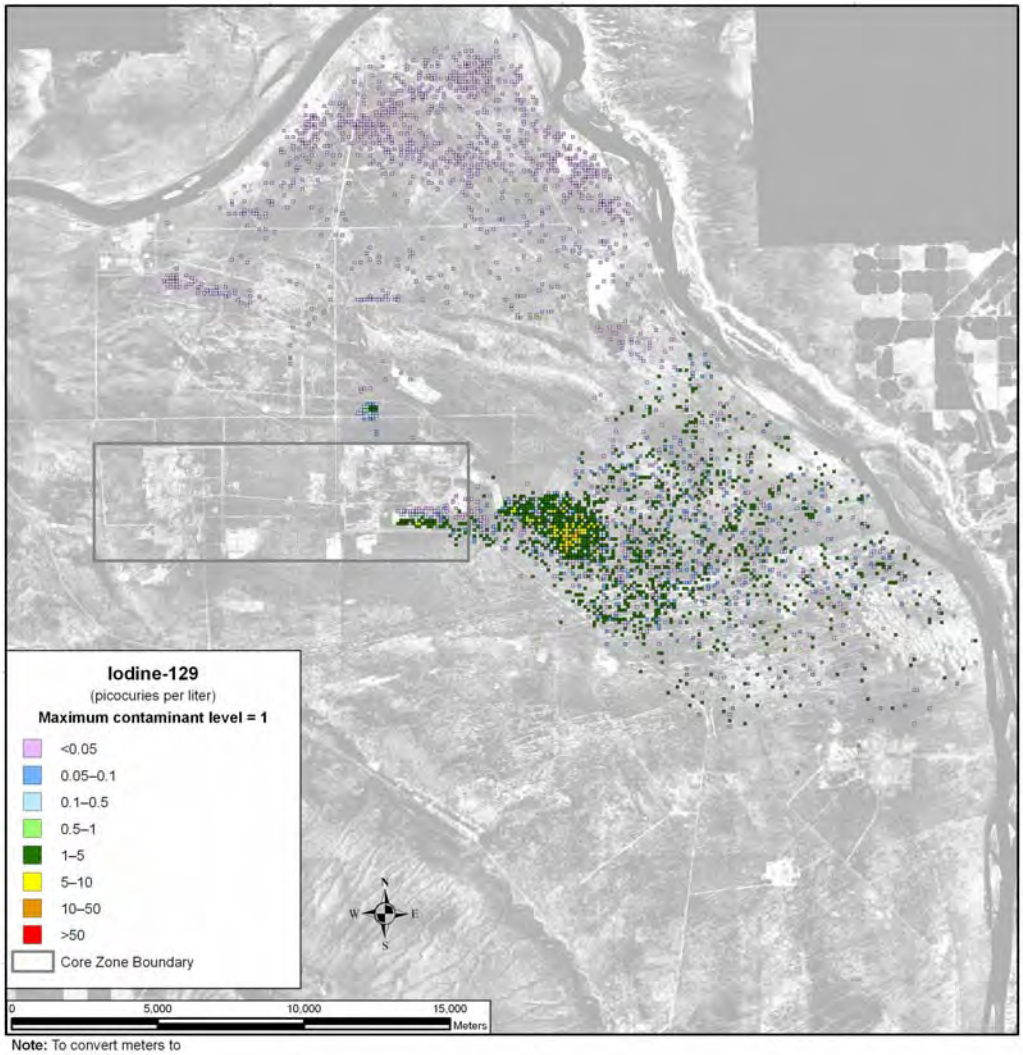


Figure 5–552. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–553. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

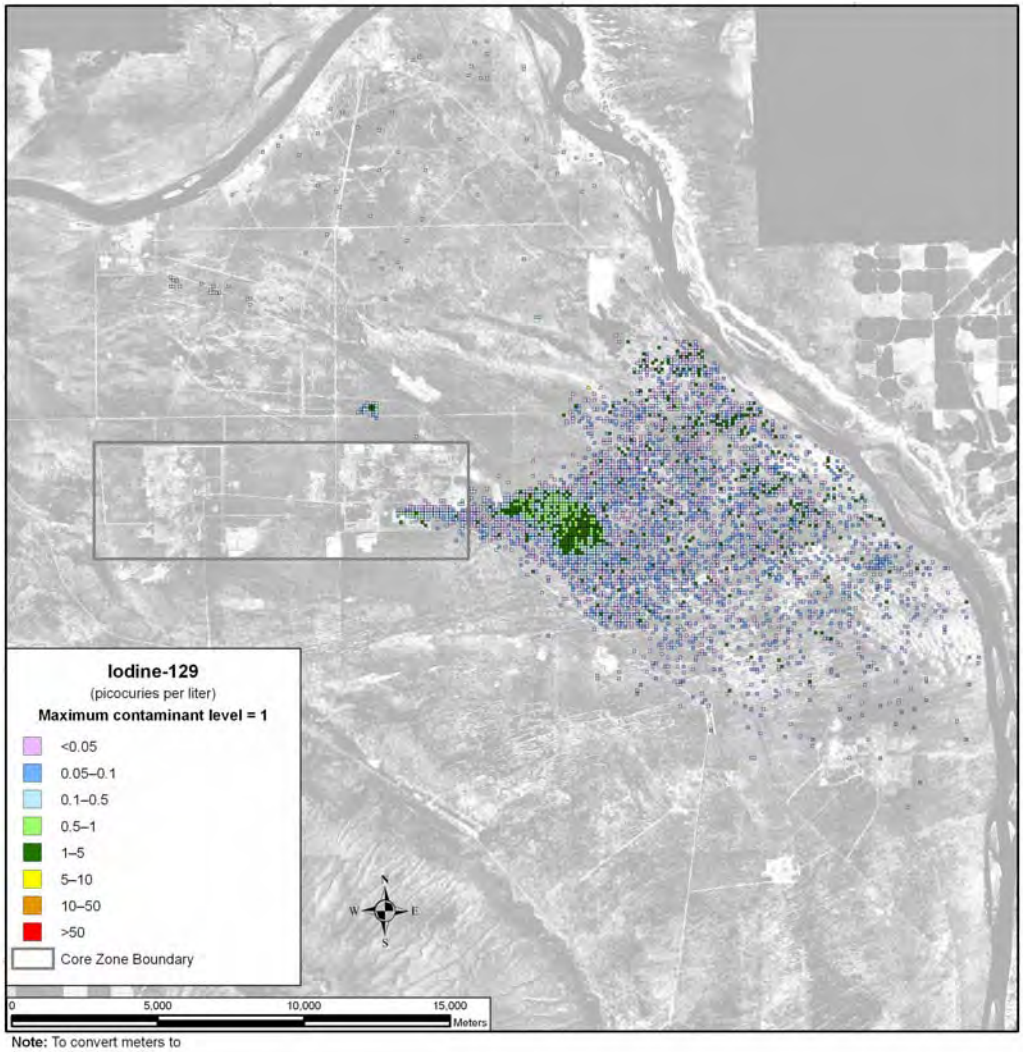


Figure 5–554. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

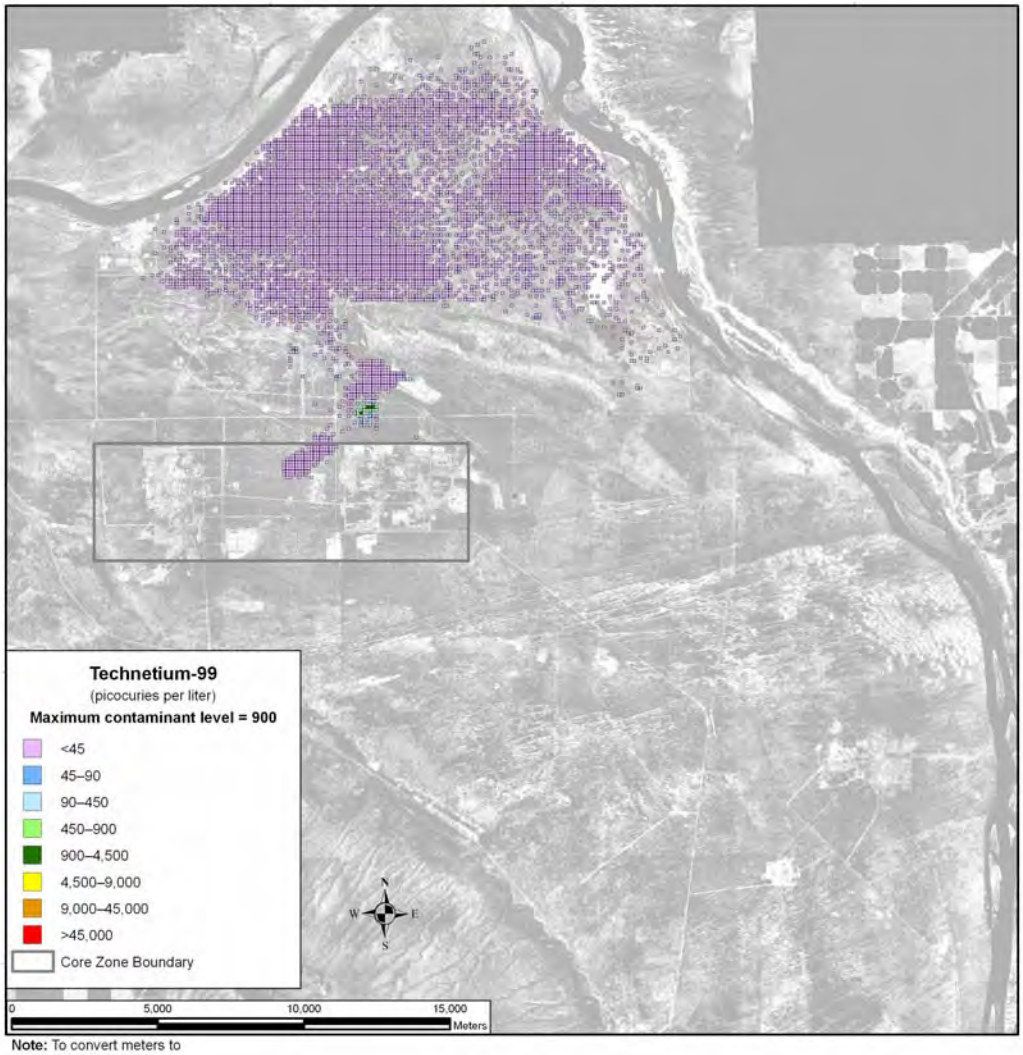


Figure 5–555. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

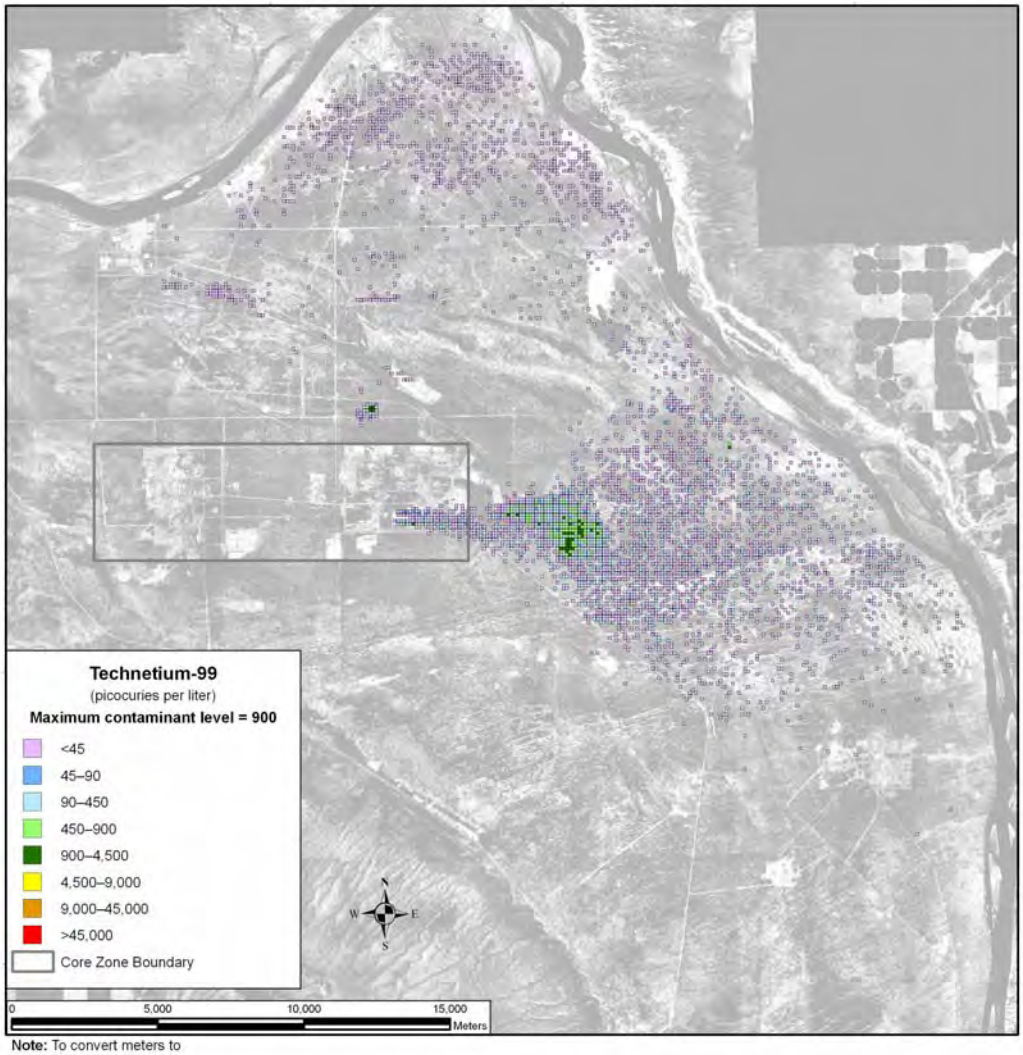


Figure 5–556. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

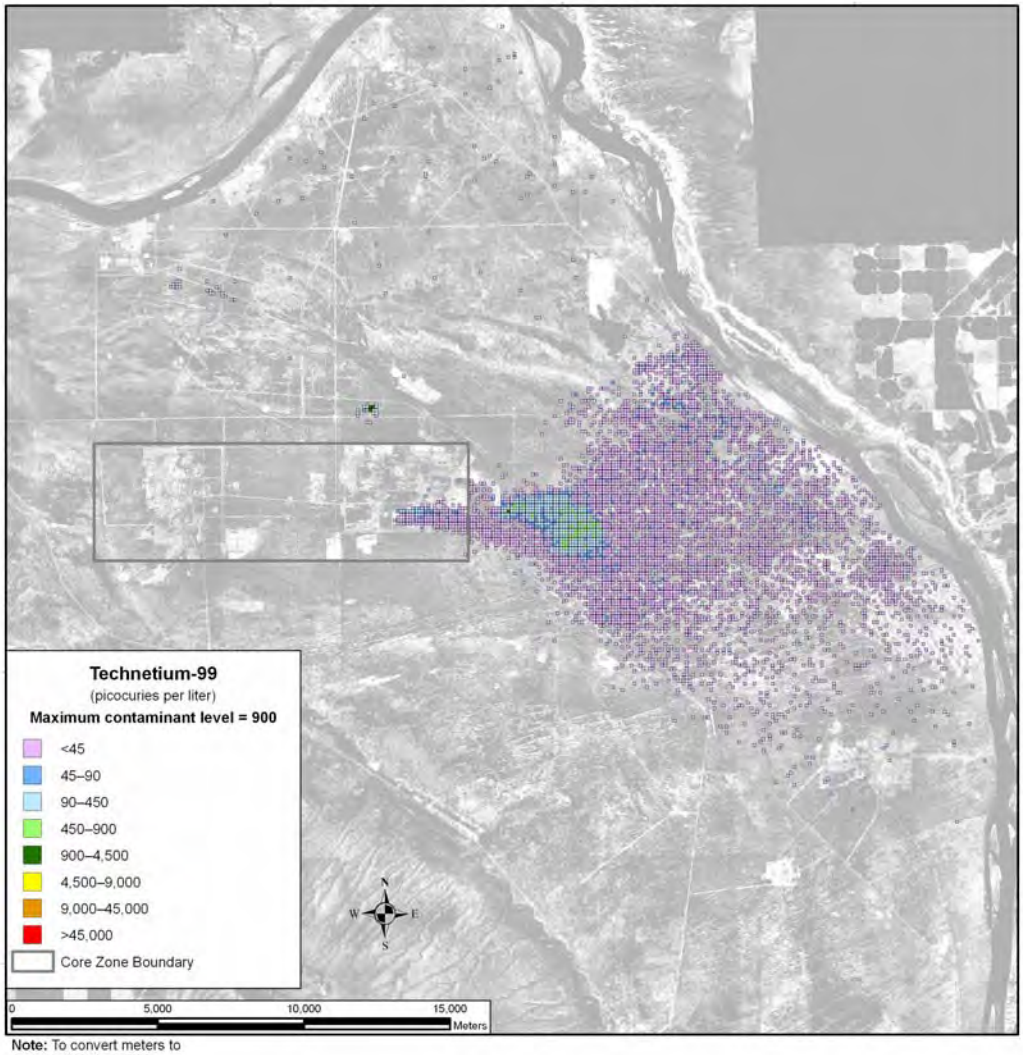


Figure 5–557. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

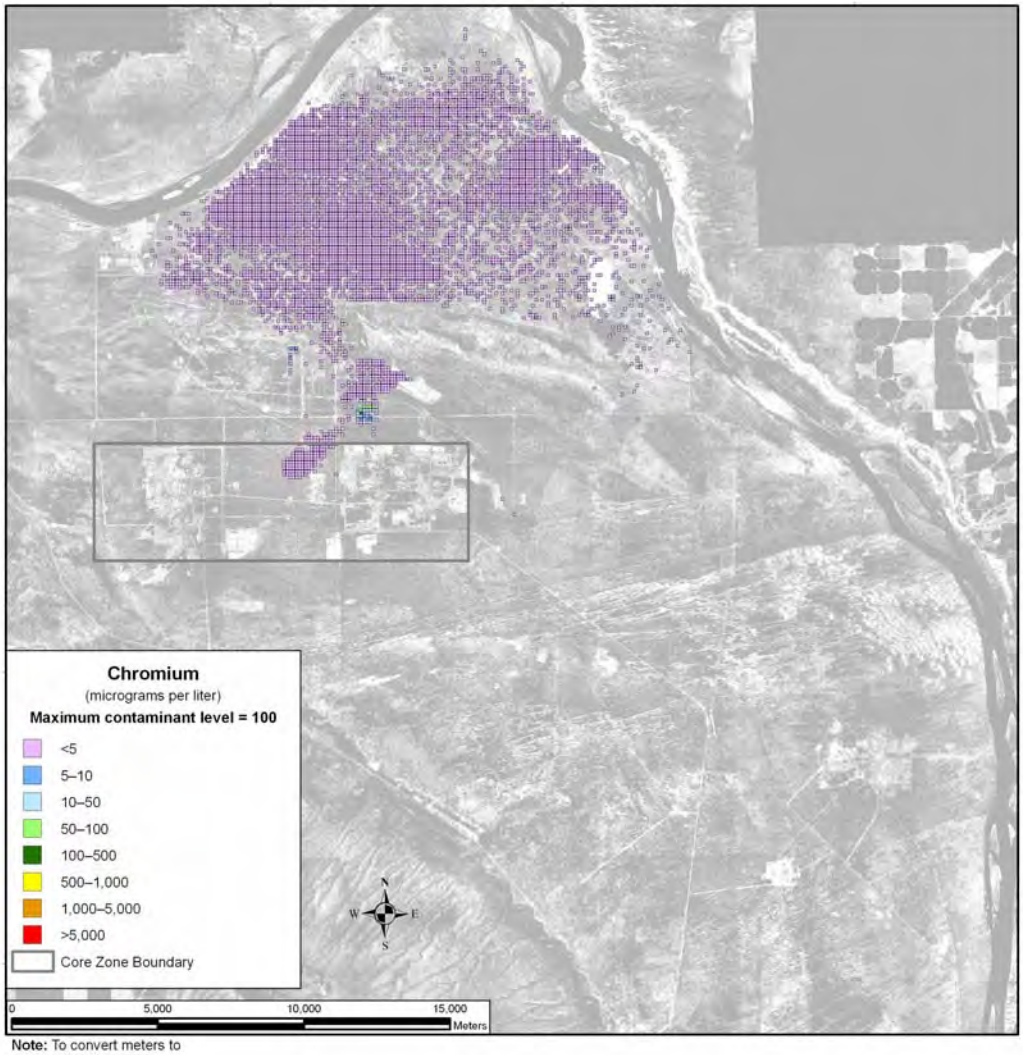


Figure 5–558. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

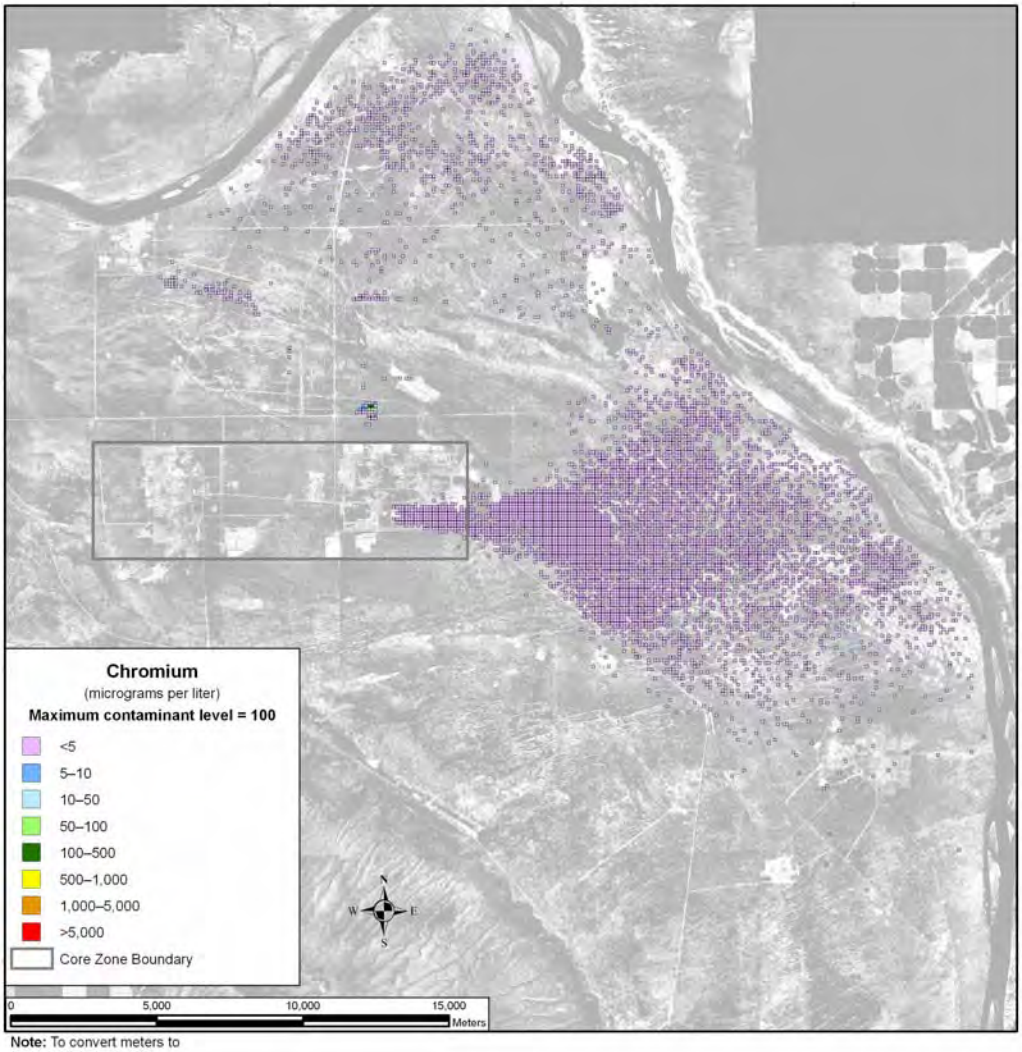


Figure 5–559. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

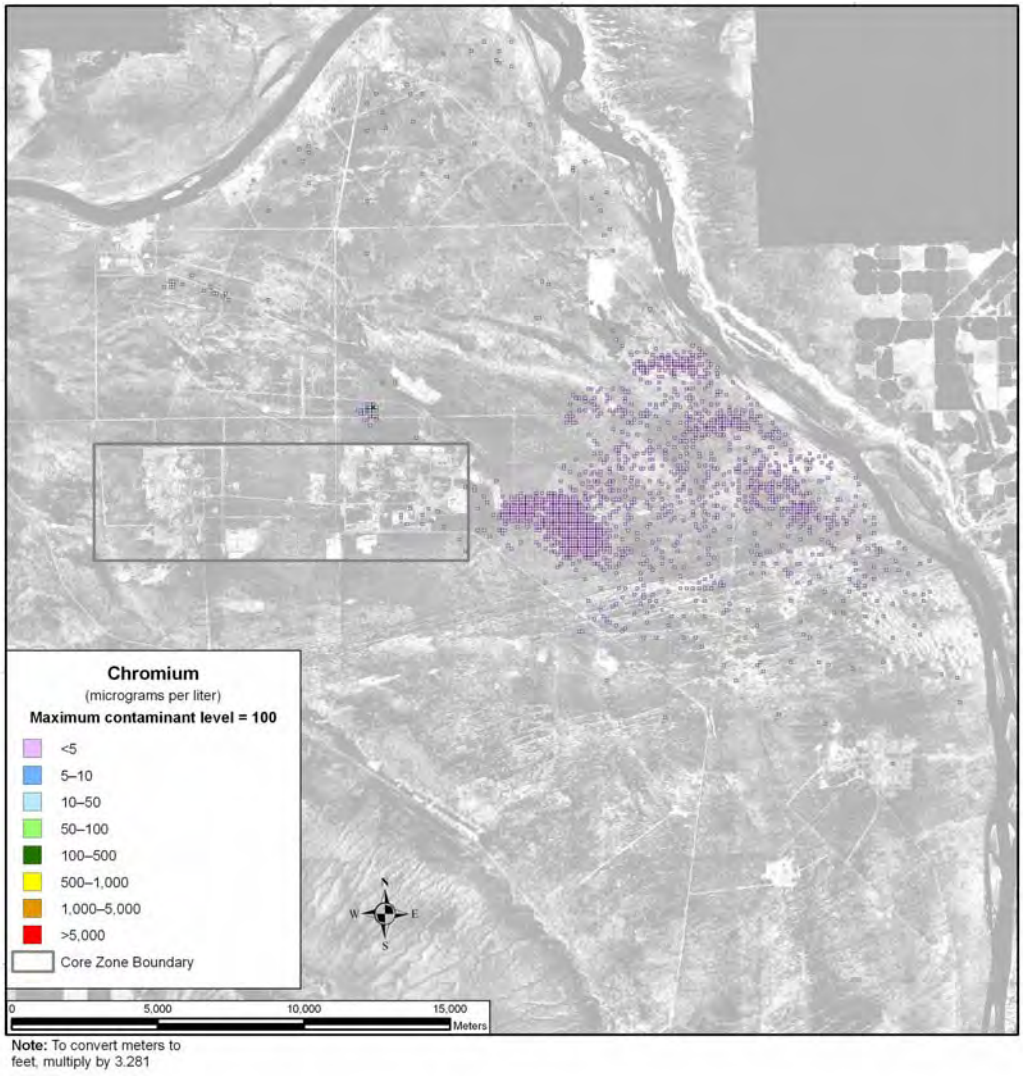


Figure 5–560. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

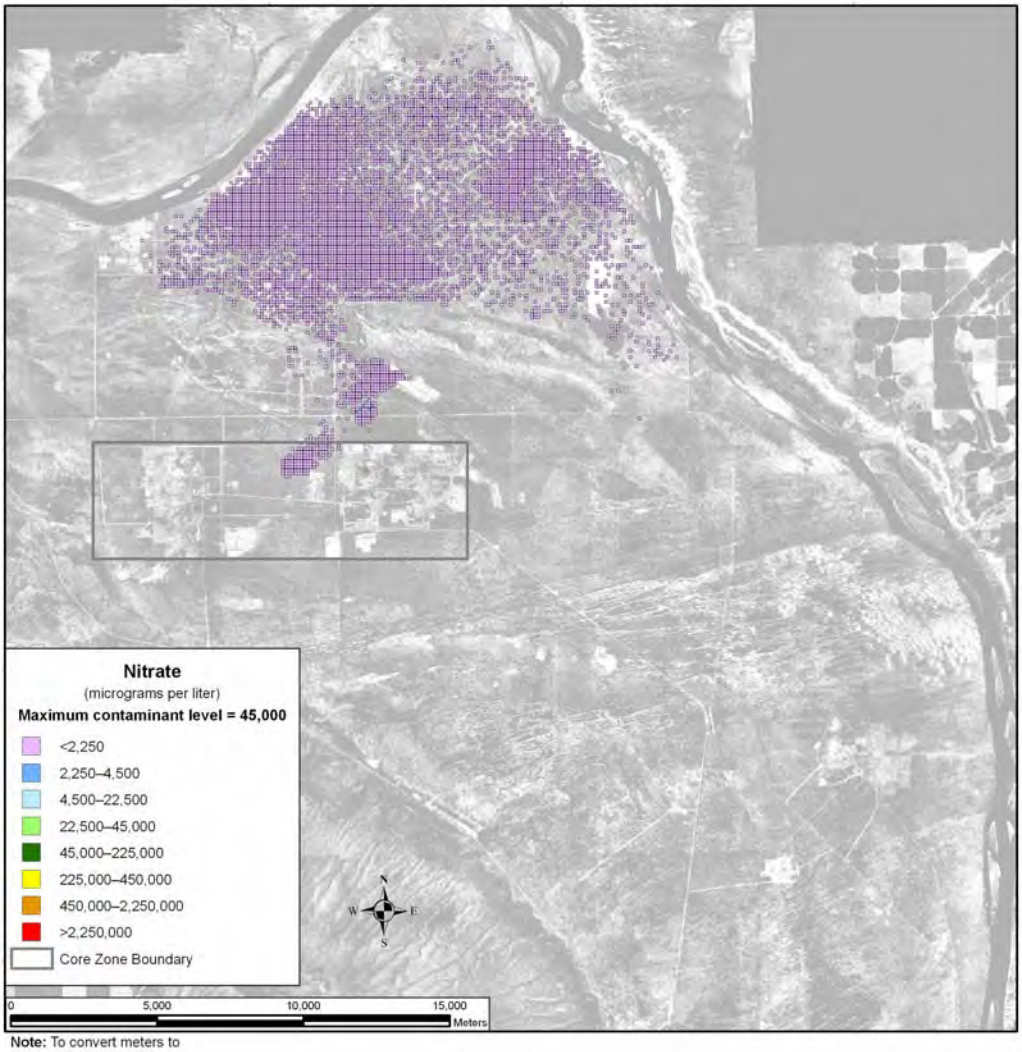


Figure 5–561. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

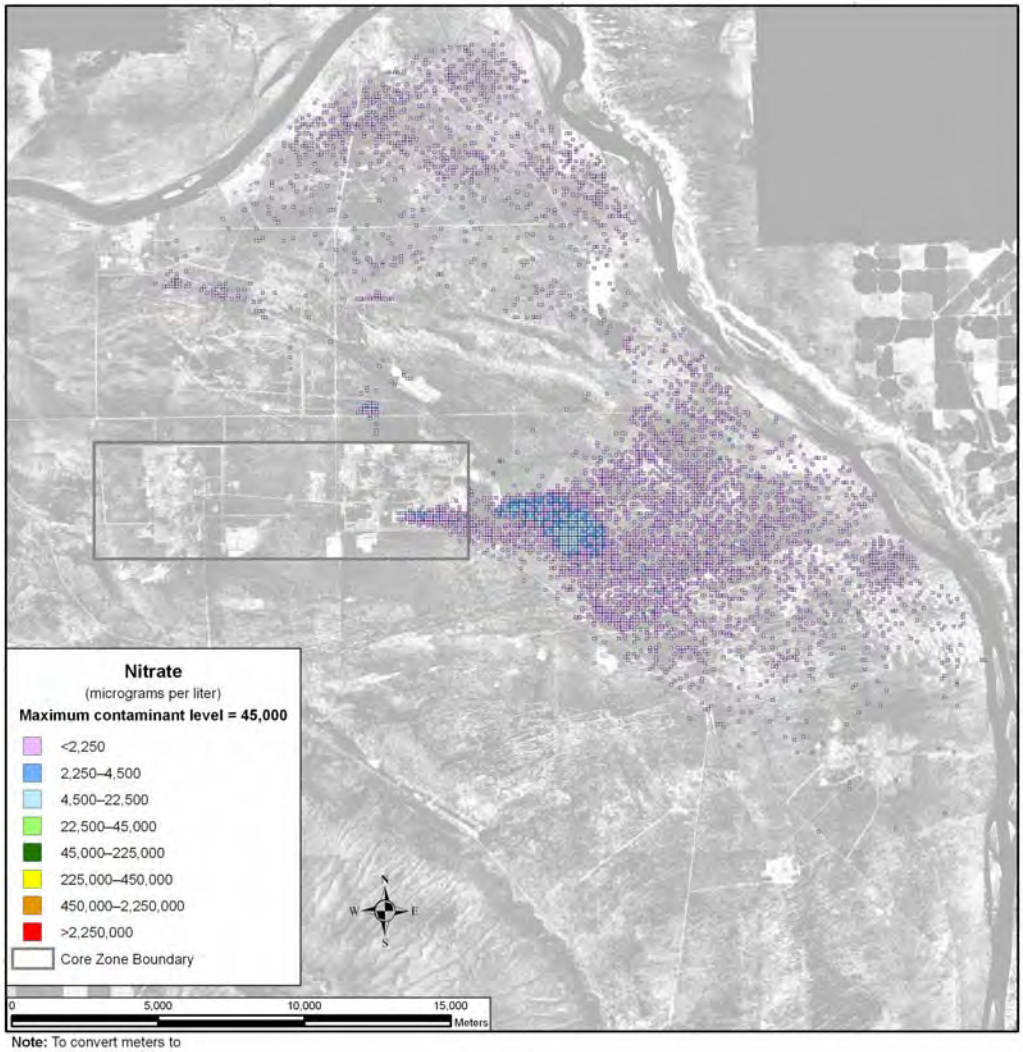


Figure 5–562. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

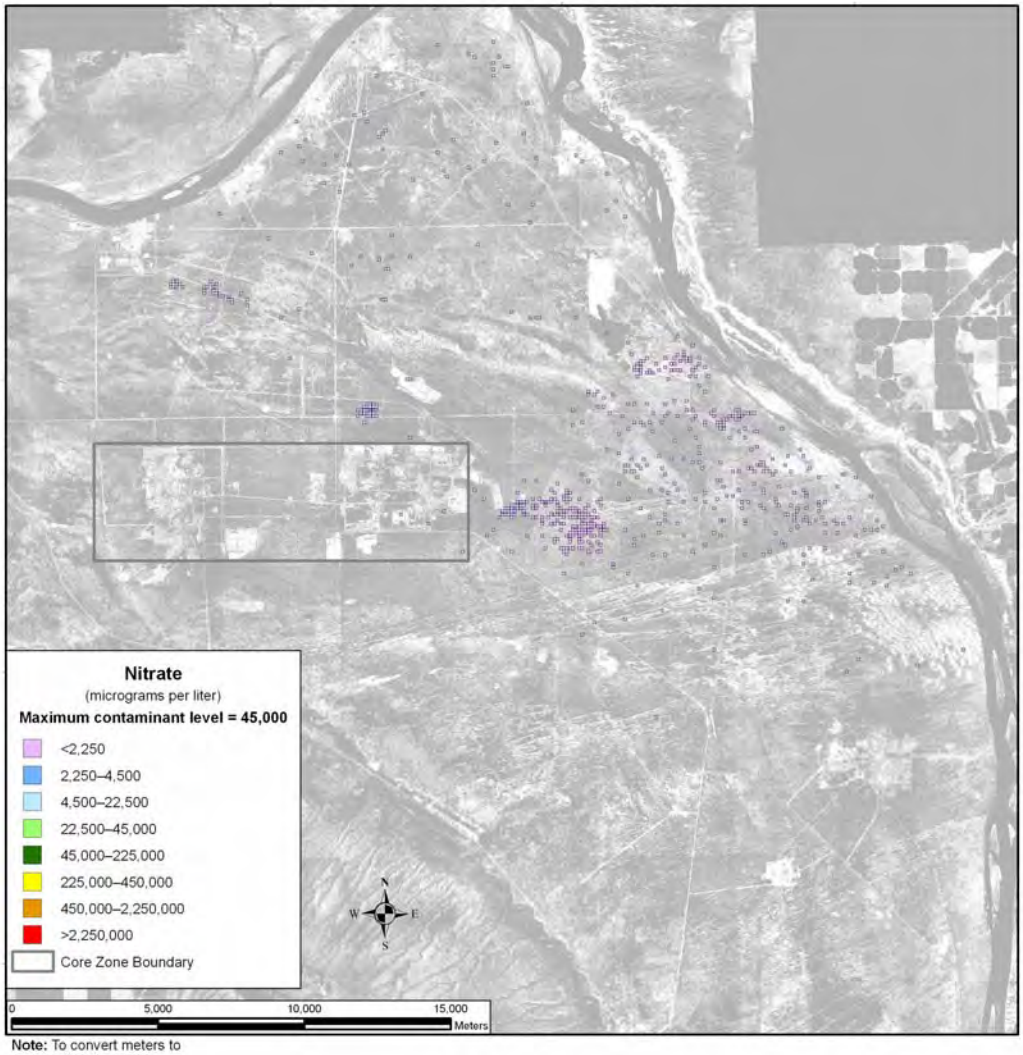


Figure 5–563. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

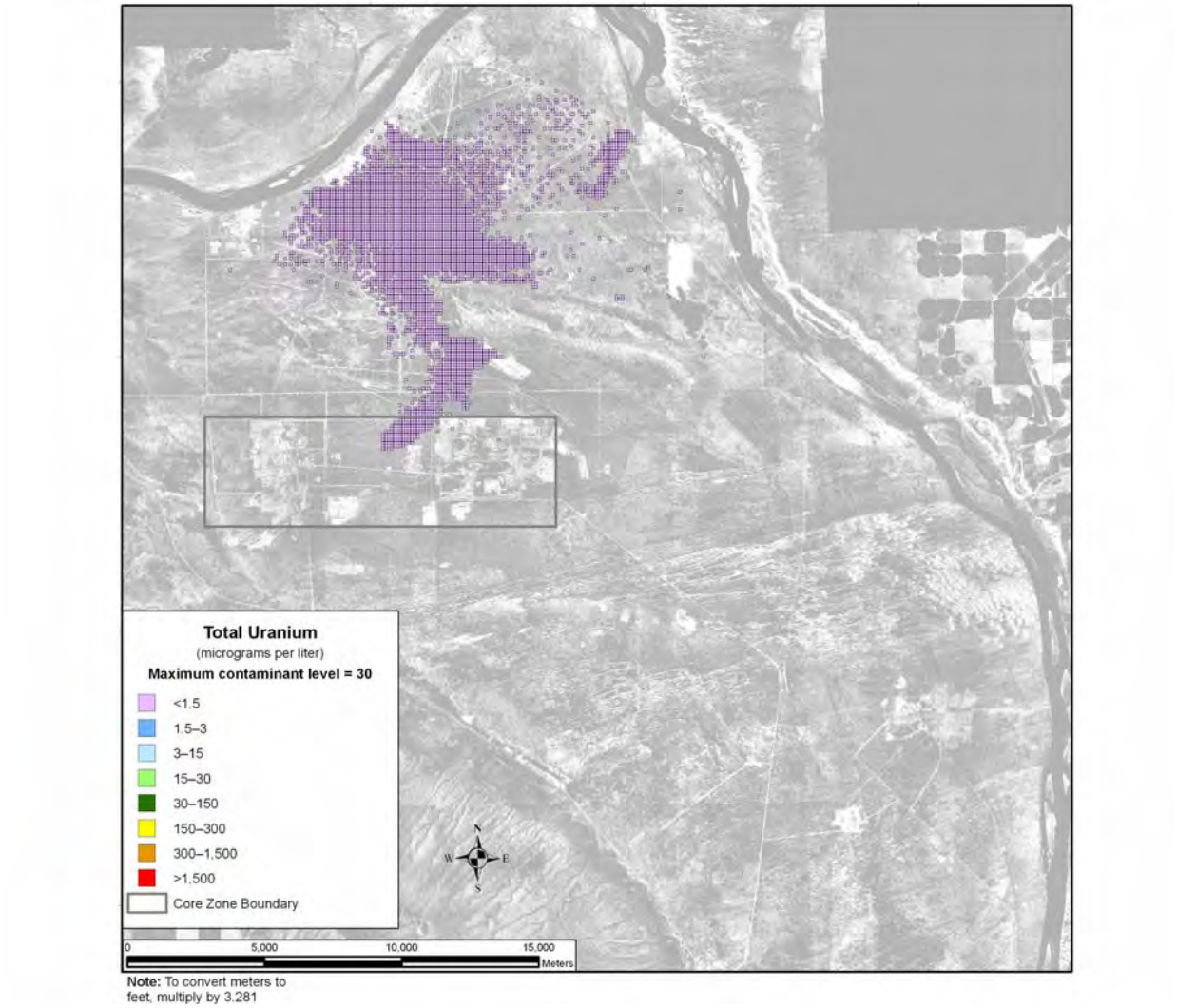


Figure 5–564. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, in general, the inventory remaining at IDF-East and the RPPDF, which are available for release to the environment at the start of the post-disposal period, are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one order of magnitude during most of the period of analysis. Concentrations at the Columbia River are about one order of magnitude smaller. The intensities and areas of these groundwater plumes peak between CYs 7140 and 11,885.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or Columbia River.

5.3.1.2.2 Disposal Group 2

Disposal Group 2 is characterized by an operational completion date of CY 2100 for both IDF-East and the RPPDF. Under Disposal Group 2, IDF-East would have a large capacity (425,000 cubic meters [556,000 cubic yards]) and the RPPDF would have a larger capacity (8,370,000 cubic meters [10,900,000 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternatives 2A and 6B, either FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

5.3.1.2.2.1 Disposal Group 2, Subgroup 2-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 2-A covers disposal of waste generated under Tank Closure Alternative 2A and FFTF Decommissioning Alternative 2 or 3, as well as, onsite- and offsite-generated waste. Waste would be converted to IHLW and ILAW glass. IHLW would be stored on site, while ILAW glass would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East in CY 2009 and continue through CY 2100, when the disposal facility would be operationally closed. During this disposal period, the materials in this permitted, operational facility would not be available for release to the environment due to engineered control of potential releases from materials placed in IDF-East.

- The post-disposal period for IDF-East was assumed to start in CY 2101. After CY 2101, the materials in IDF-East would become available for release to the environment. The post-disposal periods would continue through the 10,000-year period of analysis until CY 11,940. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, IDF-East is assumed to be covered by a barrier that limits infiltration for the first 500 hundred years of the IDF-East post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, in terms of the total amounts of radionuclide and chemical COPCs released to the vadose zone, groundwater, and Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–565 through 5–570). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility Figure 5–565 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–566, the chemical COPCs hazard drivers. The predominant source of technetium-99 in the vadose zone is offsite-generated waste (77 percent), followed by tank closure secondary waste (19 percent), and ETF-generated secondary waste (4 percent). The sources of the iodine-129 release are offsite waste (85 percent) and ETF-generated secondary waste (14 percent). All of the fluoride and boron released to the vadose zone are from waste management secondary waste and onsite-generated waste. All of the nitrate released is from ETF-generated secondary waste. The predominant source of chromium (81 percent) is tank closure secondary waste, followed by waste management secondary and onsite-generated waste (8 percent), ILAW glass (5 percent), and offsite-generated waste (4 percent).

Figure 5–567 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–568, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Nearly all of the chromium (96 percent) and essentially all (99 percent) of the fluoride, boron, and nitrate are released to the groundwater from the vadose zone. Most of the technetium-99 (89 percent) and iodine-129 (91 percent) are released to the groundwater from the vadose zone.

Figure 5–569 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–570, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPCs. About 89 percent of the groundwater technetium-99 and 91 percent of the iodine-129 is released to the Columbia River. Almost all of the groundwater chromium (97 percent), fluoride (97 percent), nitrate (greater than 98 percent), and boron (97 percent) are released to the Columbia River.

Overall, 86 percent of the technetium-99 and 89 percent of the iodine-129 from the vadose zone are released to the Columbia River. Overall, almost all of the chromium (93 percent), fluoride (96 percent), nitrate (98 percent), and boron (96 percent) from the vadose zone are released to the Columbia River. There is essentially no release of uranium-238 or total uranium to the groundwater or to the Columbia River.

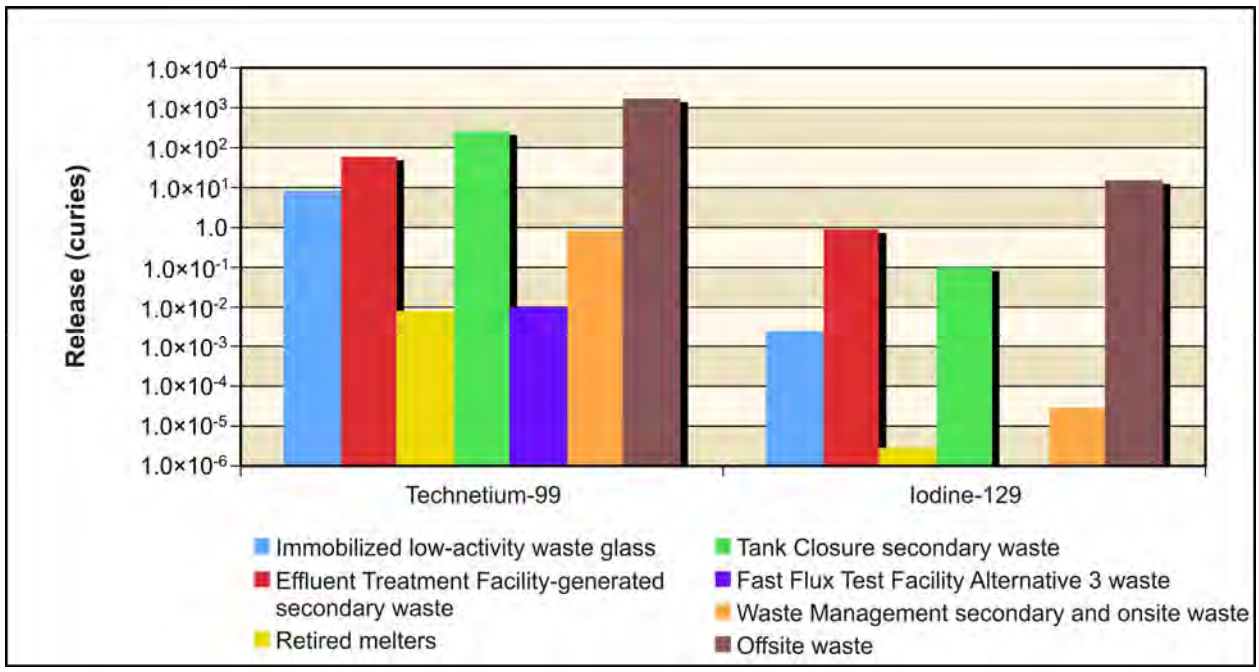


Figure 5–565. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

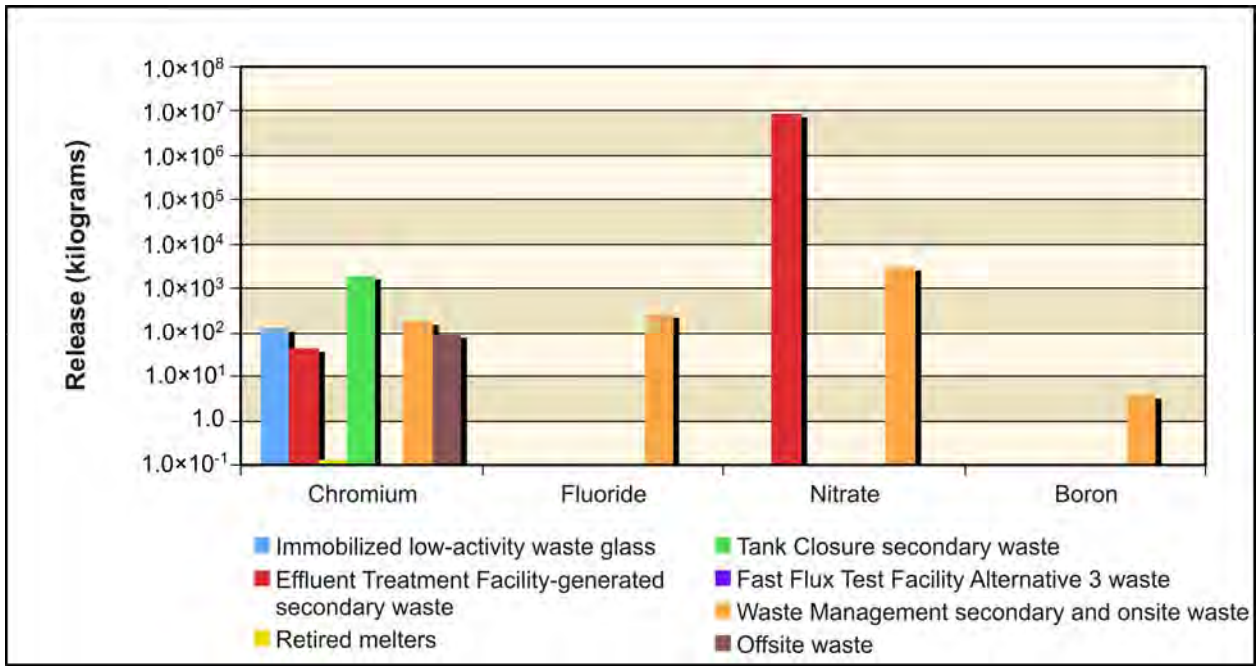


Figure 5–566. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

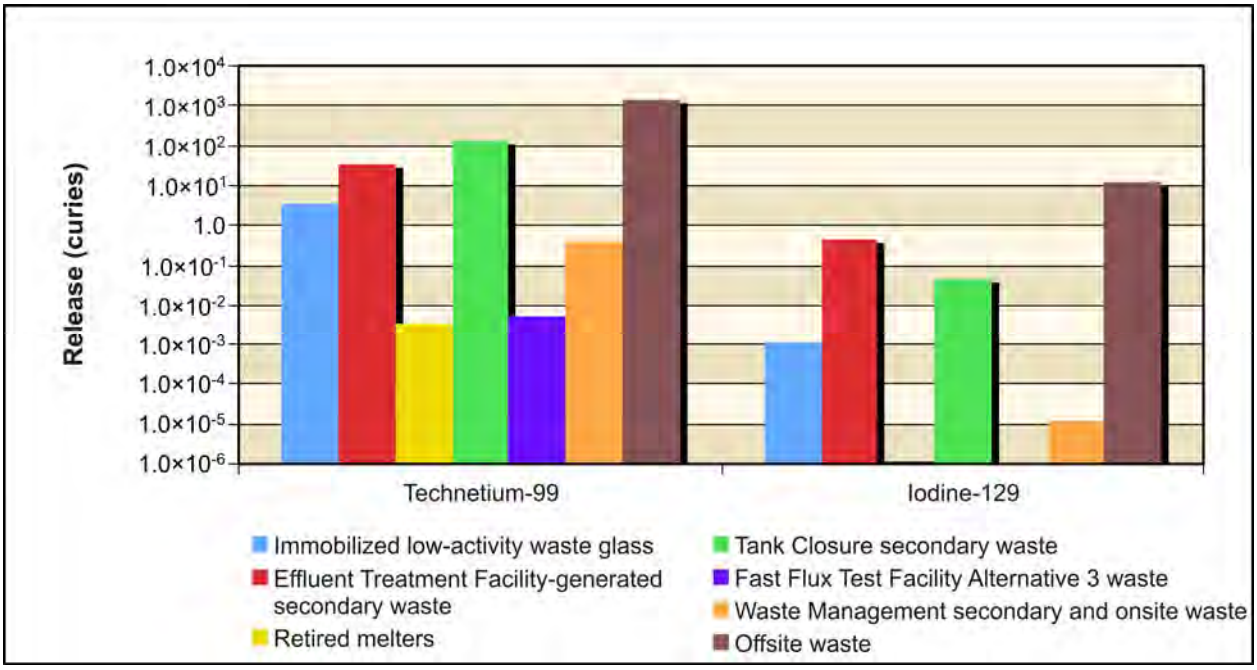


Figure 5–567. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

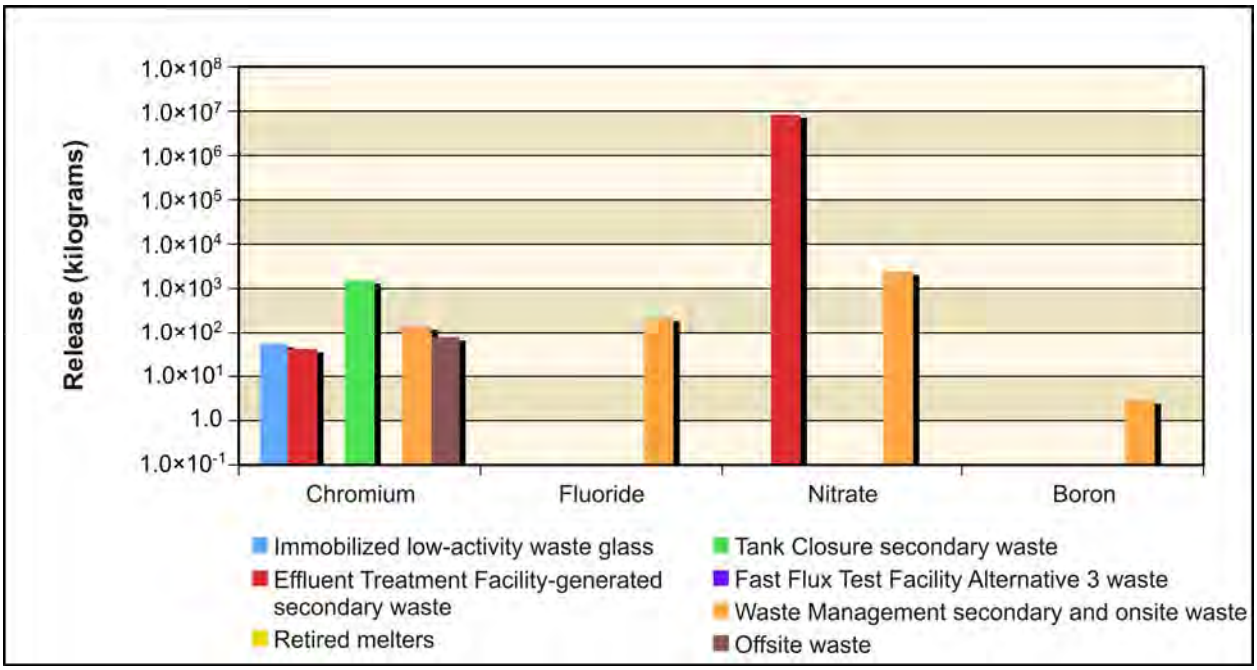


Figure 5–568. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

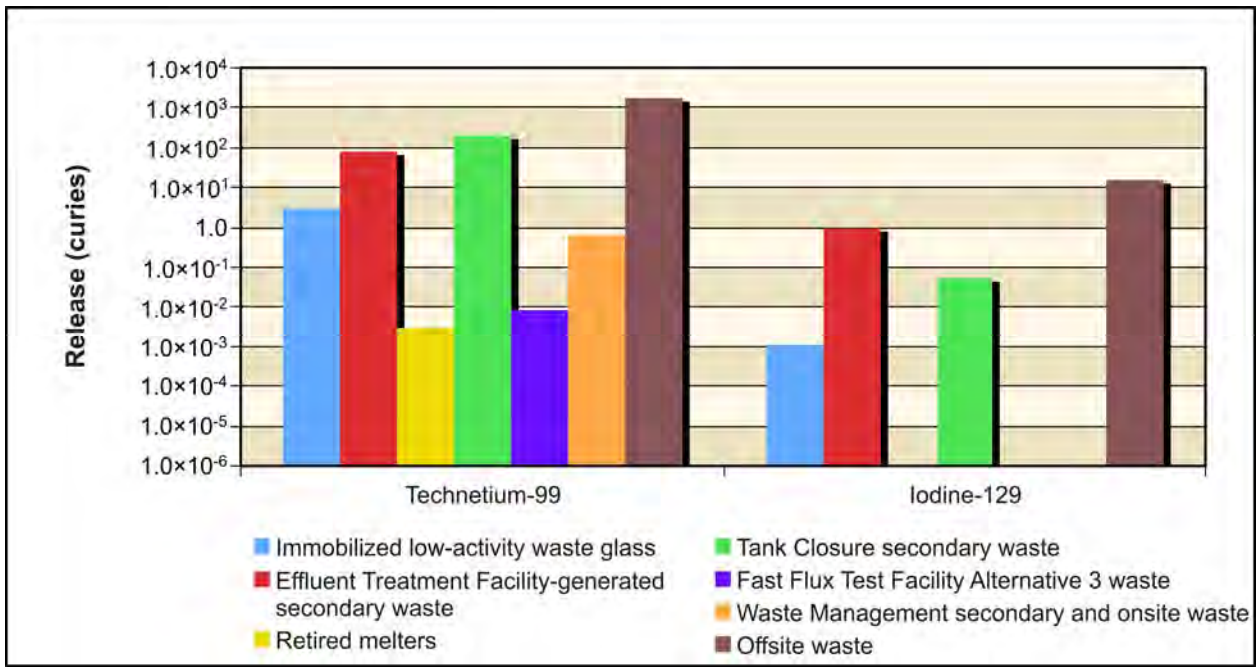


Figure 5–569. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

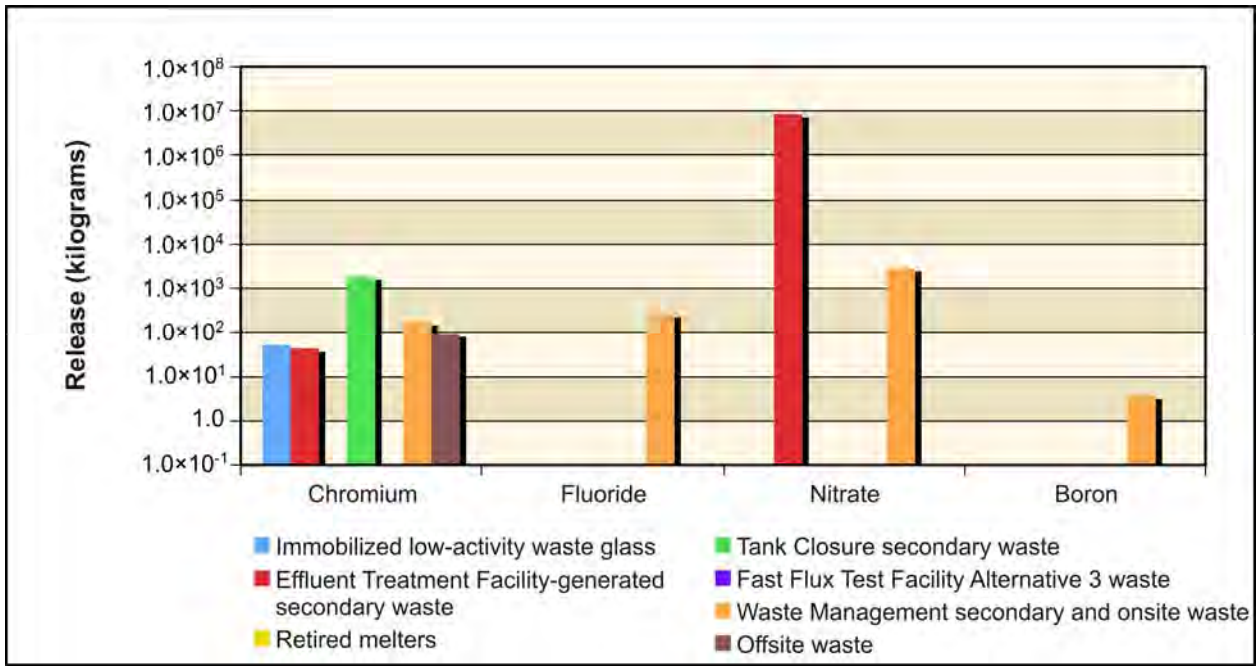


Figure 5–570. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–571 through 5–574). The benchmark concentration is also shown for each radionuclide and chemical. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–84 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–571 through 5–574 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. During the later part of the analysis time period, the groundwater concentrations of iodine-129 from IDF-East exceed the benchmark concentrations at both the Core Zone and Columbia River nearshore boundaries. However, the iodine-129 concentrations are never greater than one order of magnitude above the benchmark concentration. After peaking, the iodine-129 concentrations continue to decrease through 11,940 (see Figure 5–571). The technetium-99 shows a similar response, with a peak near the latter quarter of the analysis period and then a continuing decline through 11,940 (see Figure 5–572). The technetium-99 concentrations at both the Core Zone and Columbia River nearshore boundaries never exceed the benchmark concentration. The chromium and nitrate concentrations show a similar trend (see Figures 5–573 and 5–574). The chromium concentrations approach but never exceed the benchmark concentration. The peak nitrate concentrations are always at least one order of magnitude less than the benchmark concentration.

There are no detectable releases of either uranium-238 or total uranium to the environment over the analysis period.

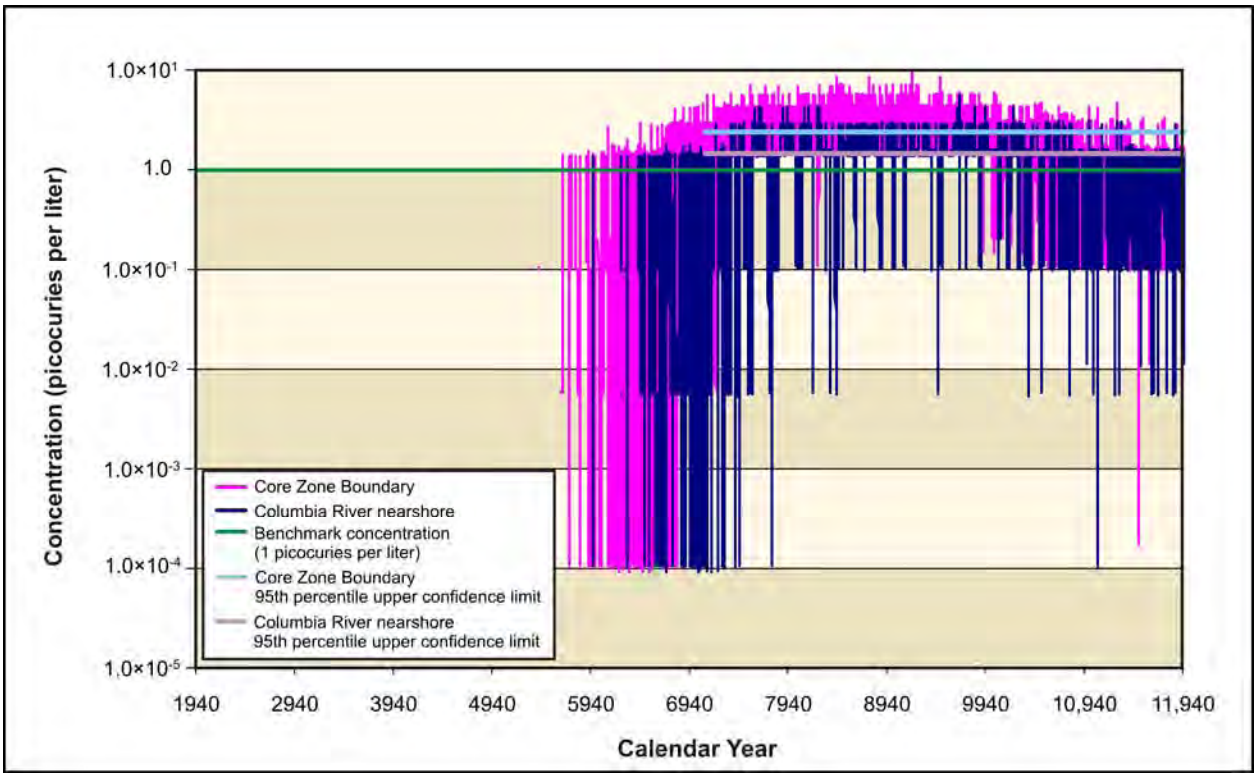


Figure 5–571. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Iodine-129 Concentration Versus Time

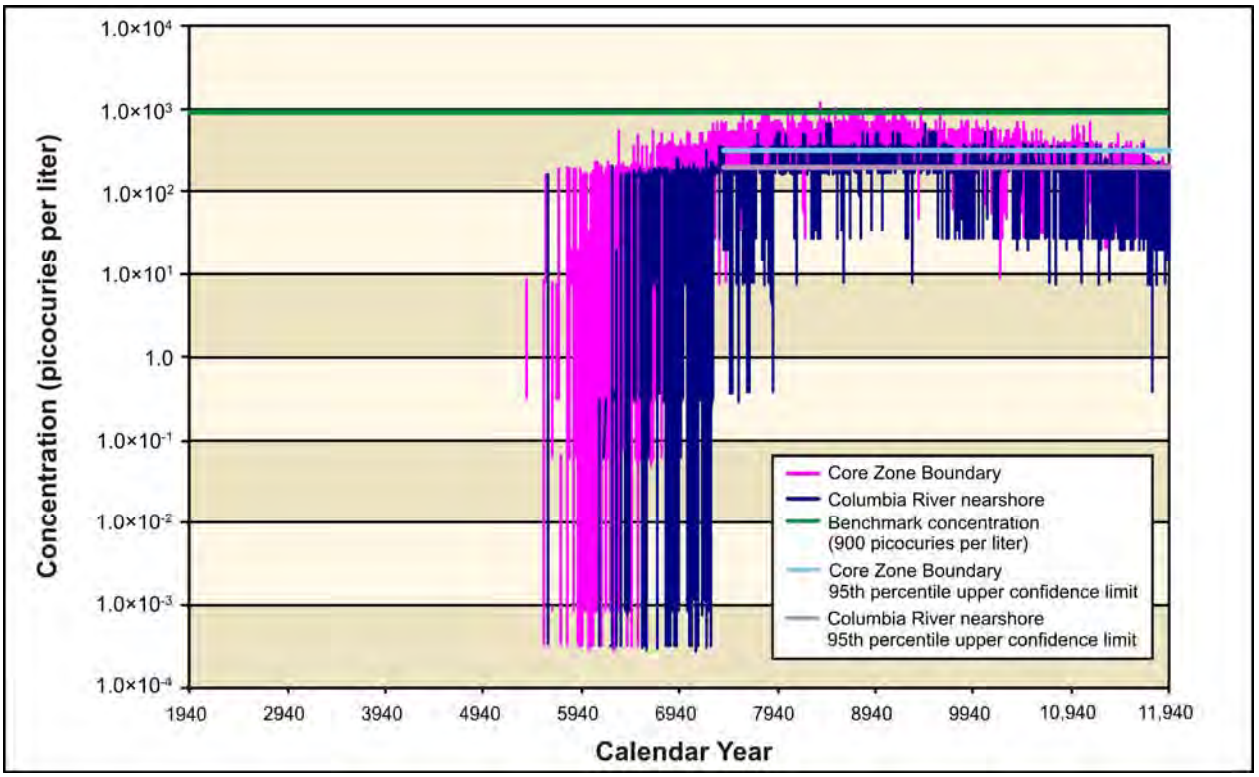


Figure 5–572. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Technetium-99 Concentration Versus Time

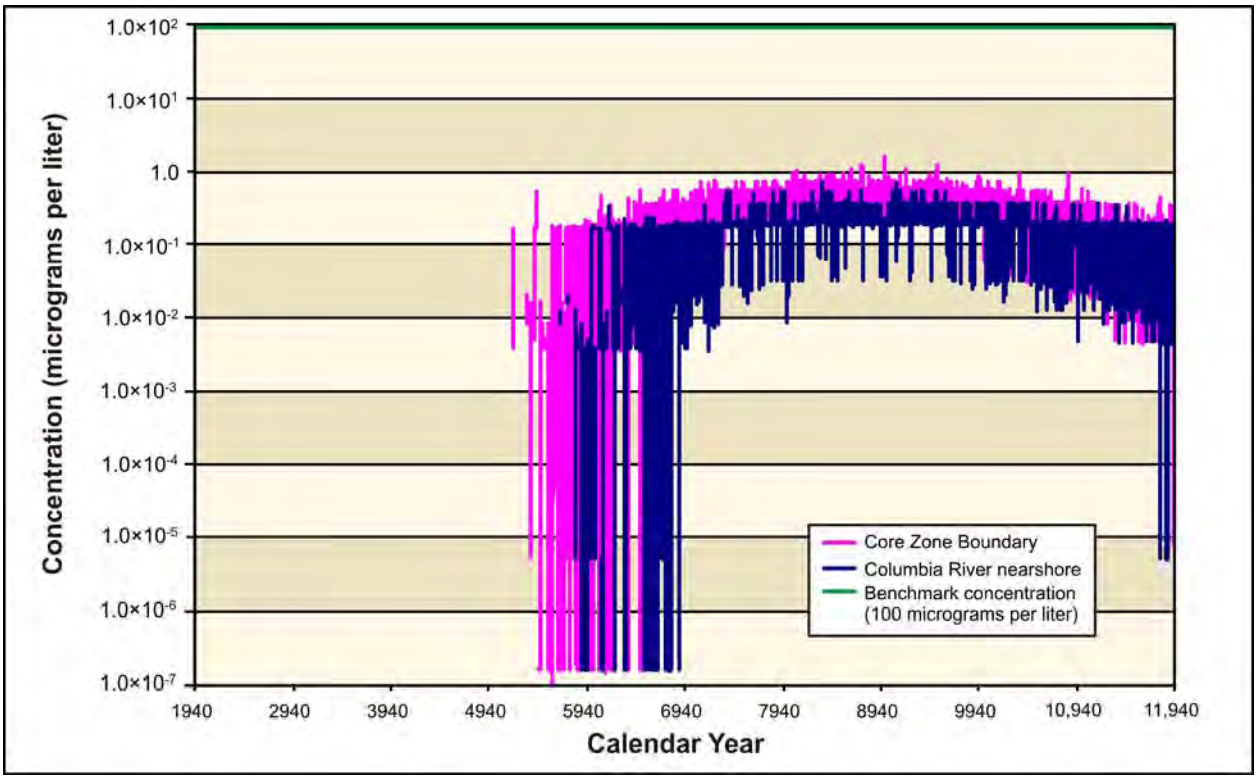


Figure 5–573. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chromium Concentration Versus Time

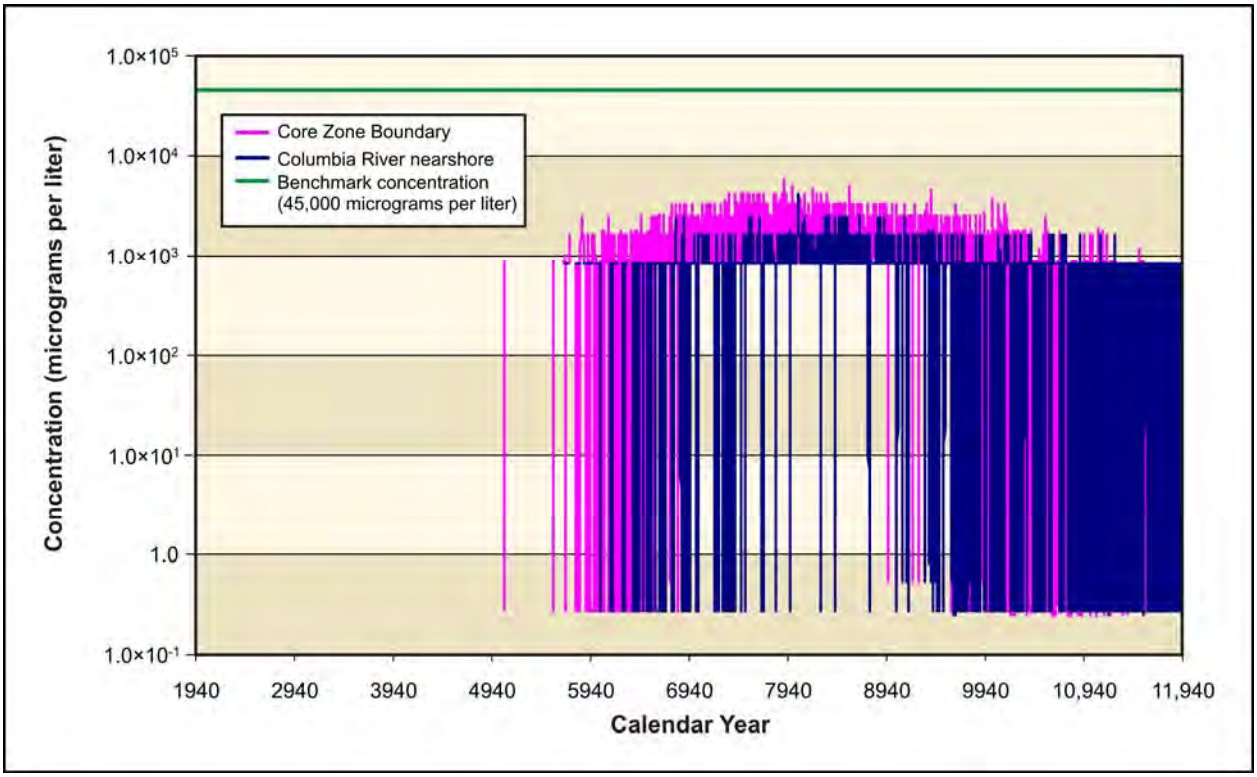


Figure 5–574. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Nitrate Concentration Versus Time

Table 5–84. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,820**	N/A	**1,150**	671	900
	(8580)		(8365)	(8478)	
Iodine-129	**24**	N/A	**10**	6	1
	(9058)		(9178)	(9652)	
Chemical in micrograms per liter					
Chromium	3	N/A	2	1	100
	(9308)		(8982)	(8354)	
Nitrate	15,500	N/A	5,700	4,070	45,000
	(8055)		(7905)	(8056)	

Note: corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, in terms of the spatial distribution of groundwater concentration at selected times in this analysis period. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–575 through 5–582). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration.

Figures 5–575 through 5–582 show that there are groundwater releases from IDF-East that extend to the Columbia River. The release distributions are confined in a narrow area until about a third of the distance to the Columbia River nearshore boundary, where they spread out significantly and continue to the Columbia River. The iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity) that are impacted by moisture content. For each distribution map, the concentrations that are greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red, in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet, in order of decreasing concentration. The concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–575 and 5–576 show the spatial distribution of groundwater concentration for iodine-129 during CYs 7140 and 11,885. These figures show a growing distribution in both size and concentration that is still present through CY 11,885. There are areas where concentration is above the benchmark concentration east of the Core Zone Boundary. However, over the period of analysis, most of the distribution concentration remains below the benchmark concentration.

Figures 5–577 and 5–578 show the technetium-99 release with a distribution from the release source to the Columbia River. There is also a small area east of the Core Zone Boundary where the technetium-99 concentration approaches (and potentially exceeds) the benchmark concentration. By CY 11,885 (see Figure 5–578), the distribution has increased over CY 7140 in size. Although most of the distribution is well below the benchmark concentration, this figure shows a distribution of technetium-99 through CY 11,885.

Figures 5–579 and 5–580 (CYs 7140 and 11,885) show a chromium release extending from the release source to the Columbia River. Comparisons of the CY 7140 and 11,885 distributions show about the same concentration and area for the releases. The concentration of chromium remains well below the benchmark concentration in both distributions.

Figures 5–581 and 5–582 show the spatial distribution of groundwater concentrations of nitrate for CYs 7140 and 11,885. There is an area east of the Core Zone Boundary where the nitrate release appears to approach the benchmark concentration. The CY 11,885 data show a significant reduction in concentration, especially for the isolated area of higher concentration. Most of the nitrate distribution is well below the benchmark concentration.

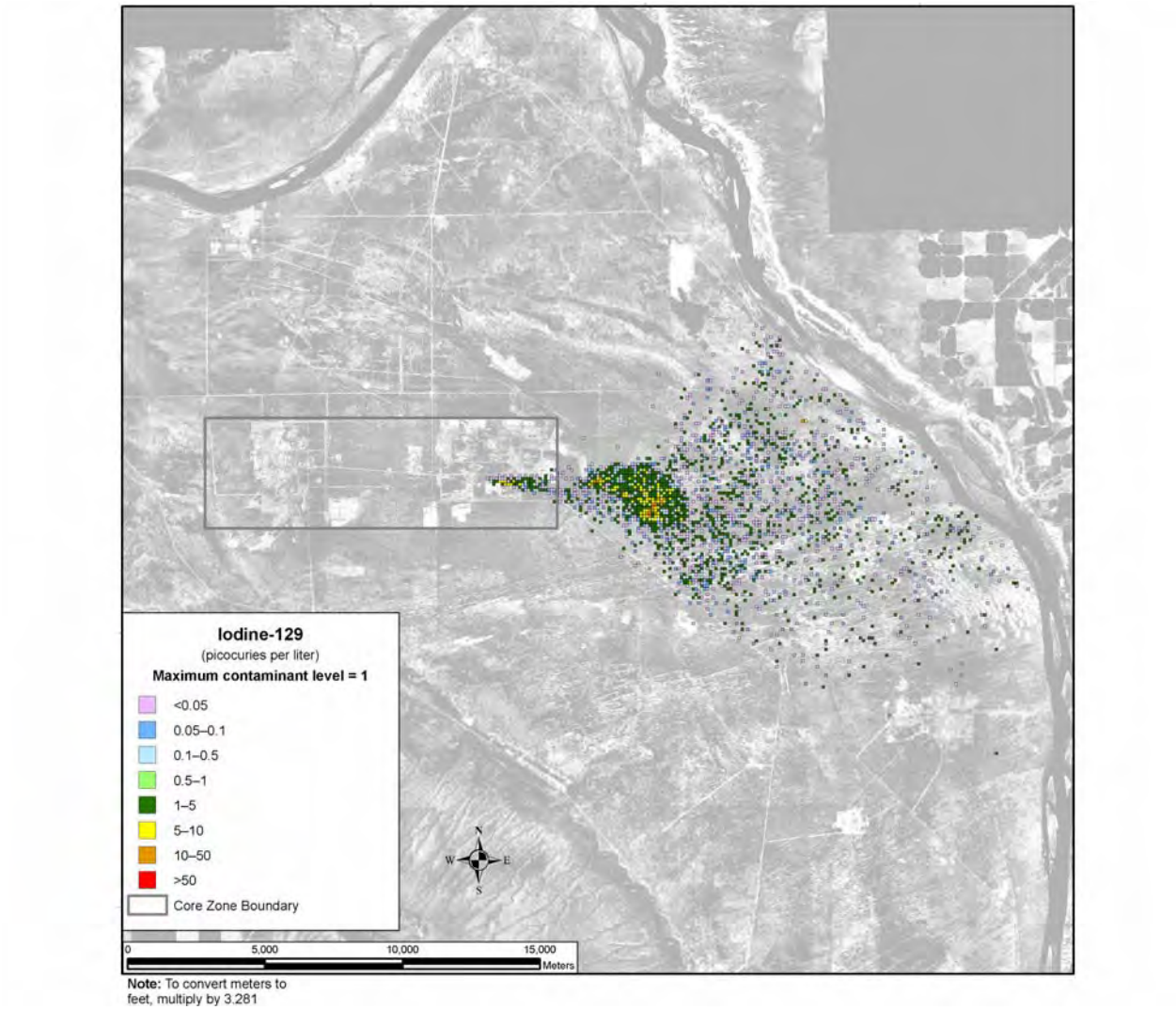


Figure 5–575. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

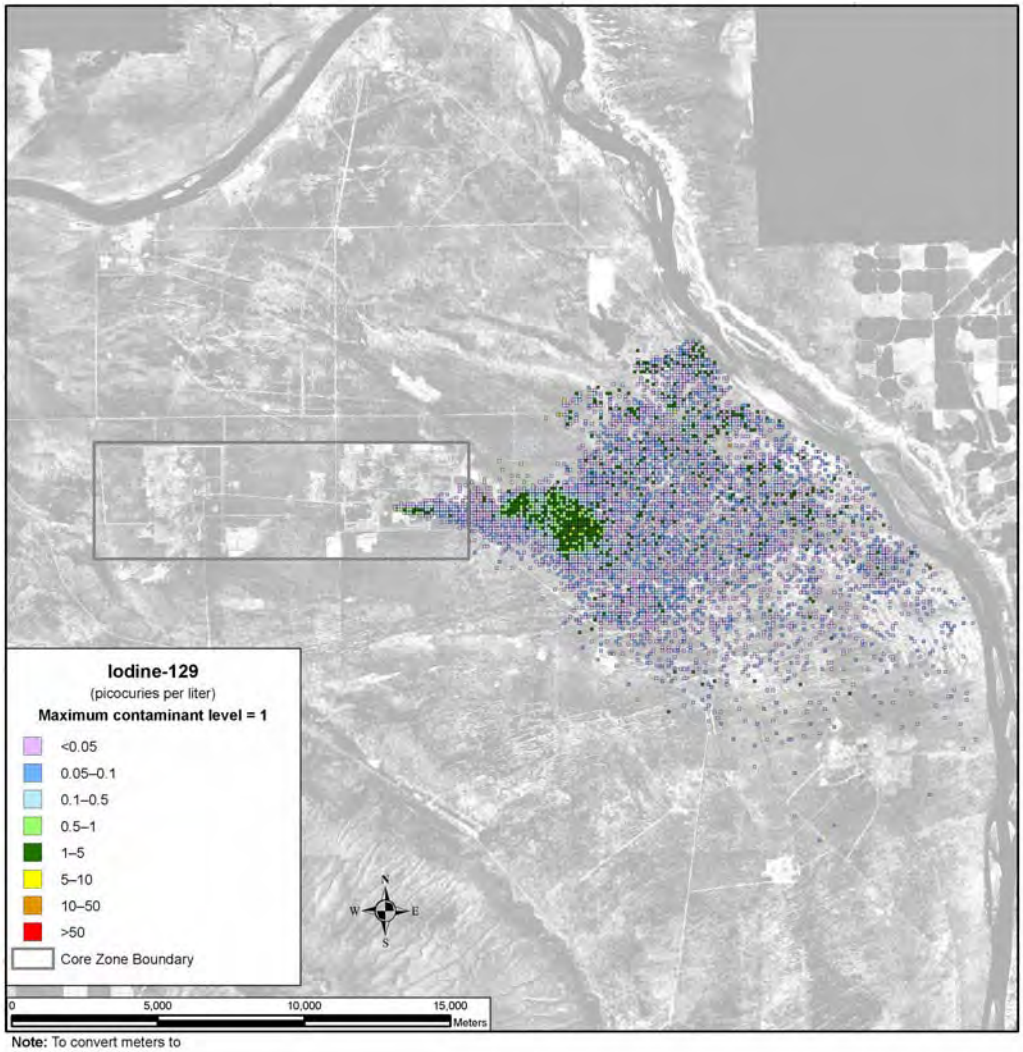


Figure 5–576. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

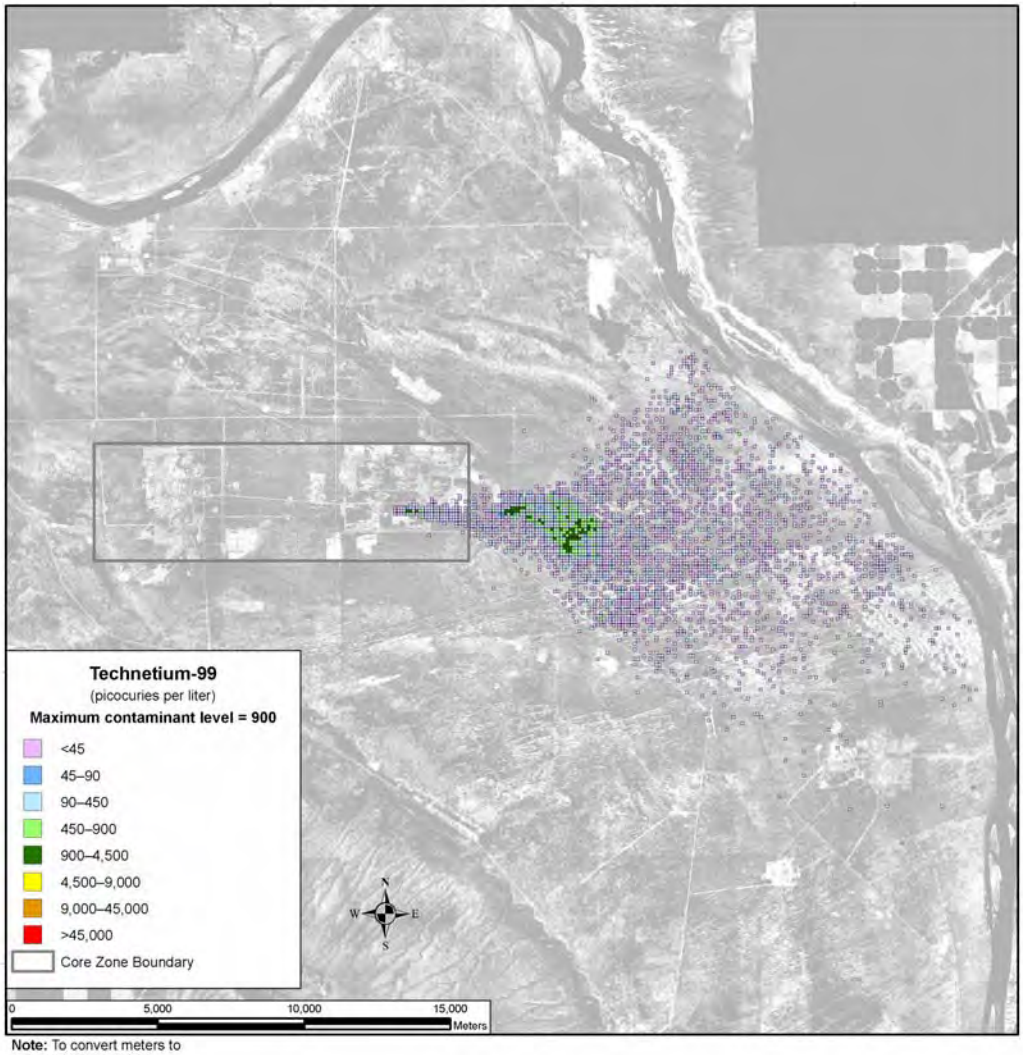


Figure 5–577. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

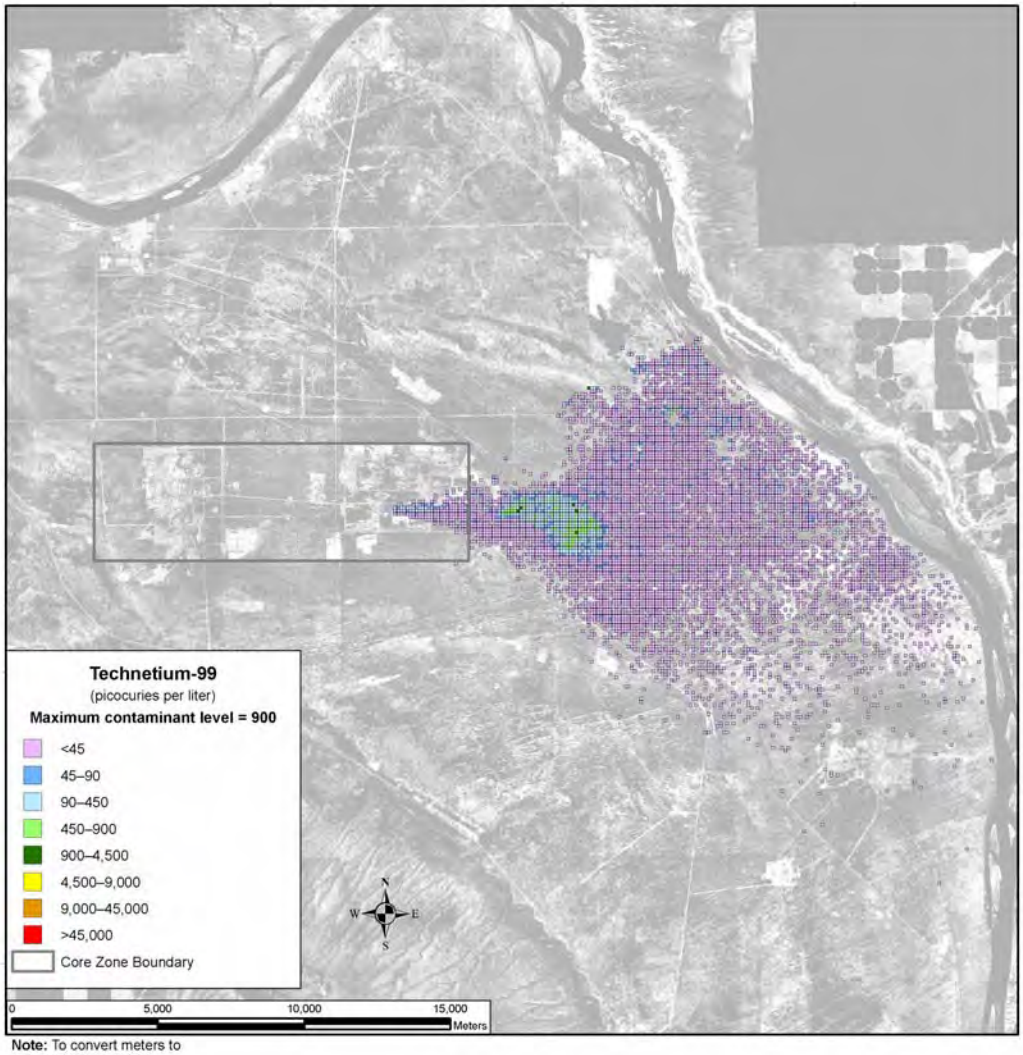


Figure 5–578. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

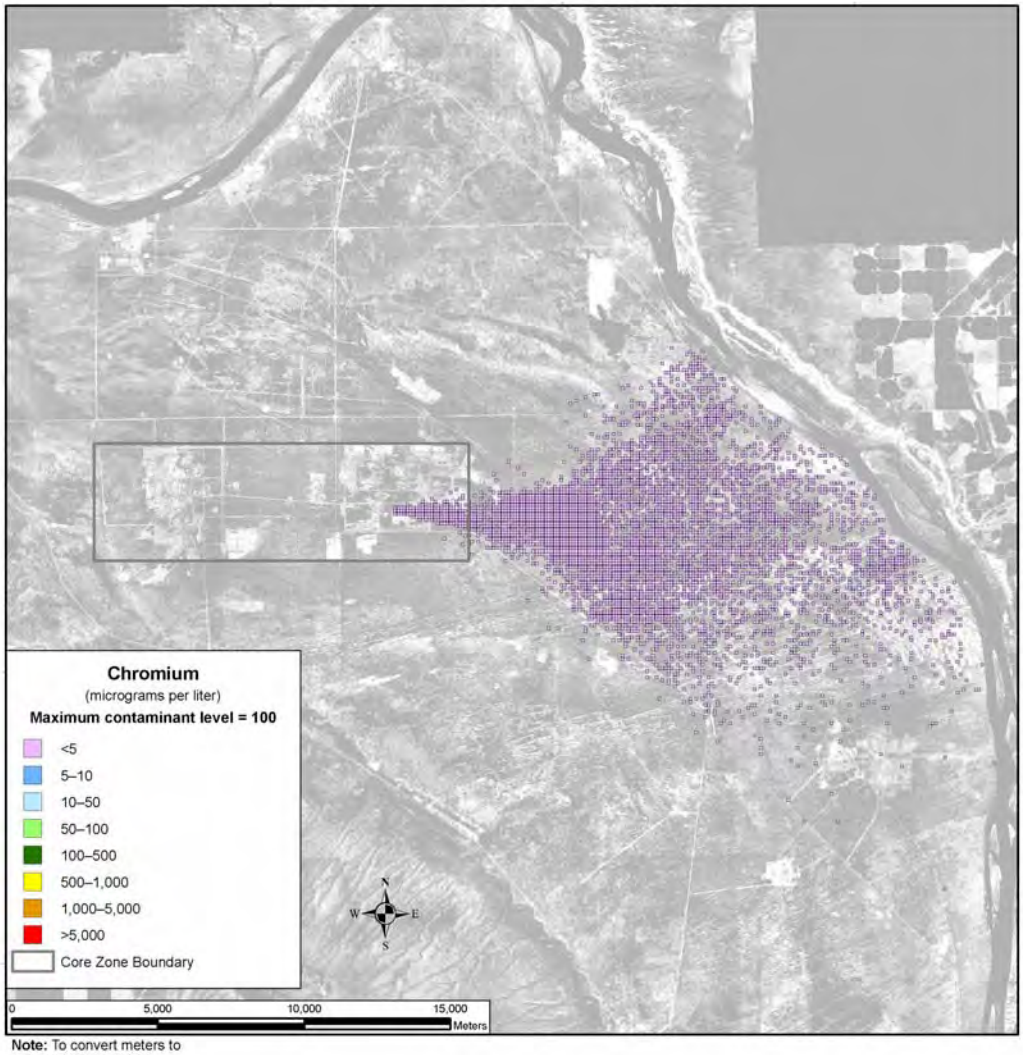


Figure 5–579. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

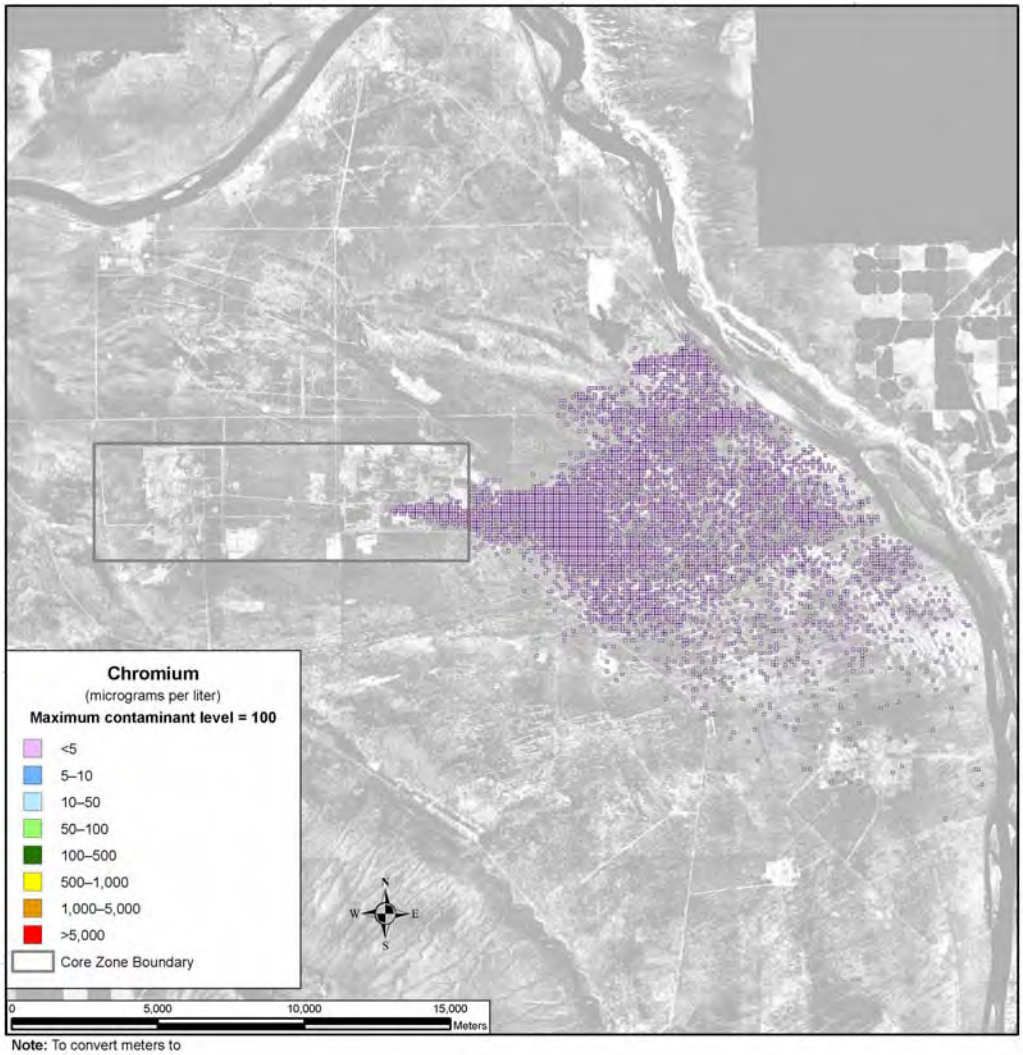


Figure 5–580. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

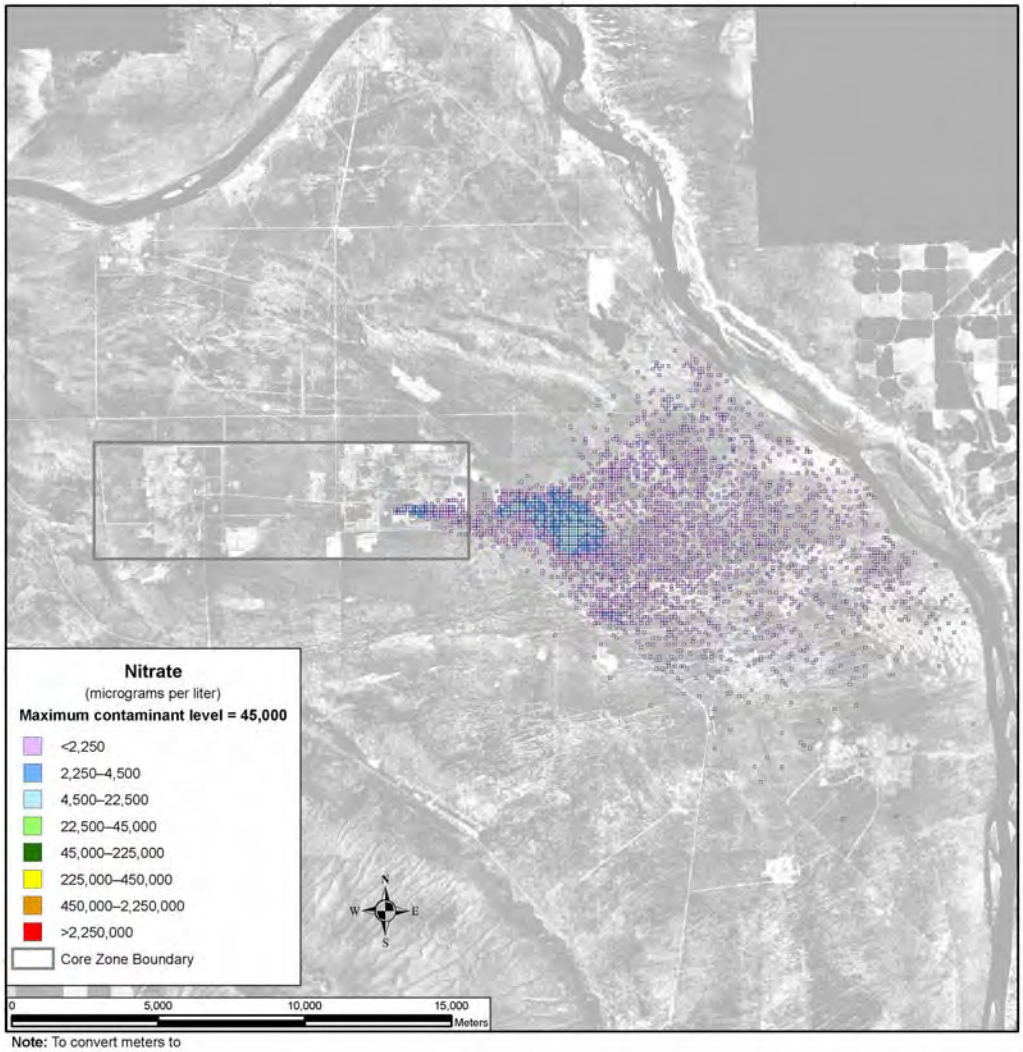


Figure 5–581. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

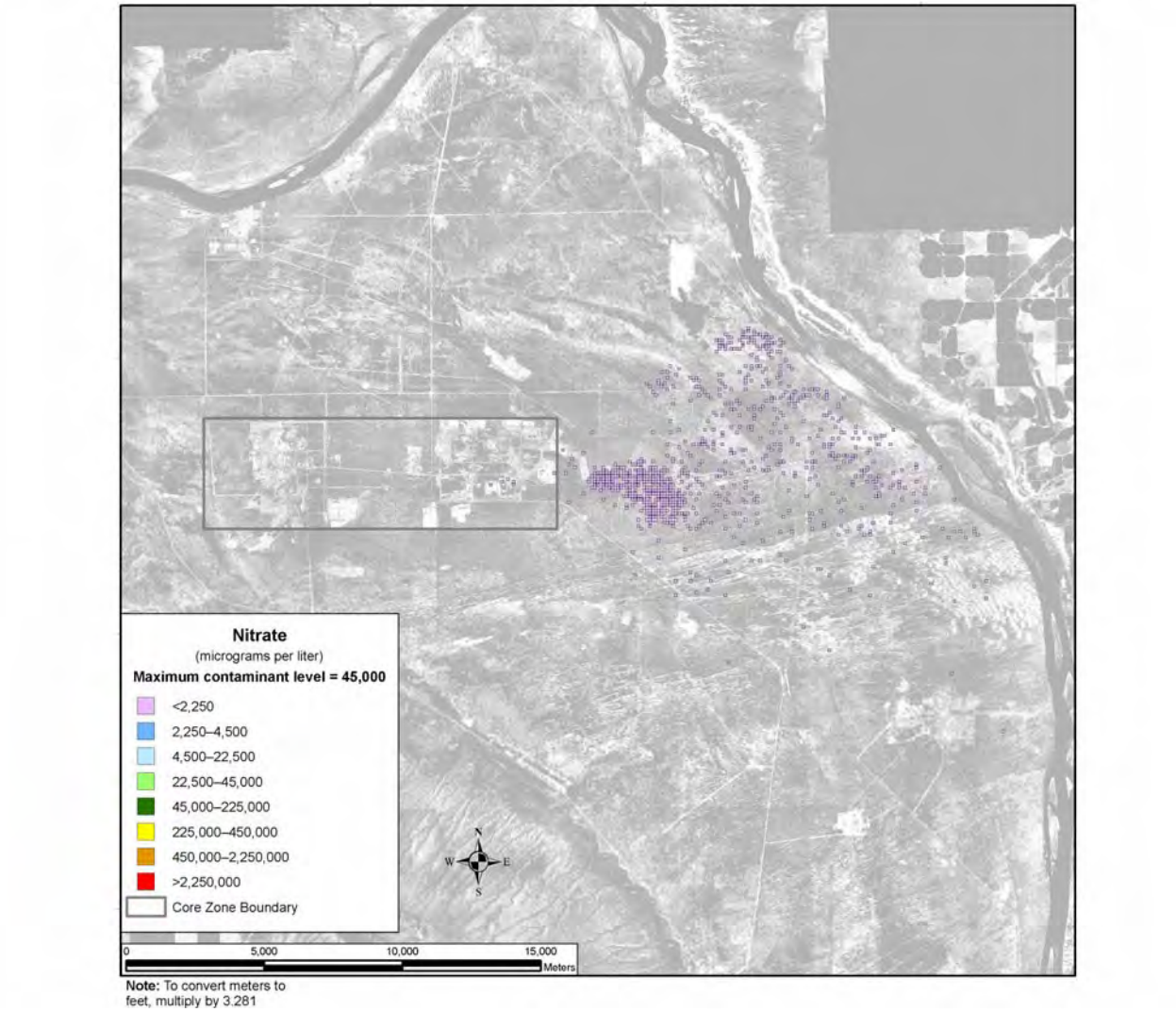


Figure 5–582. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, in general, the predominant contributor is the iodine-129 inventory at IDF-East that is available for release to the environment at the start of the post-disposal period. The technetium-99, chromium, and nitrate releases do not exceed benchmark concentrations during the period of analysis except in small, isolated areas (pockets). The release data show declining but significant concentrations through the end of this analysis period (CY 11,885).

5.3.1.2.2.2 Disposal Group 2, Subgroup 2-B, Base Case

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, includes Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste. Waste would be converted to IHLW and ILAW glass. IHLW would be stored on site, while ILAW glass would be managed on site as high-level radioactive waste (HLW) pending disposition.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, as follows:

- The disposal period starts with the onset of disposal operations for IDF-East and the RPPDF in CY 2009 and continues through CY 2100, when the disposal facilities will be operationally closed. During this disposal period, the materials in these permitted, operational facilities are assumed to be unavailable for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, IDF-East and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and acetonitrile

The COPC drivers for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

The COPC drivers that are discussed in detail in this section (nitrate iodine-129, technetium-99, chromium, nitrate, and acetonitrile) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case (IDF-East and the RPPDF), in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–583 shows the release to the vadose zone for the radiological risk drivers and Figure 5–584, the chemical hazard drivers. For all seven types of sources, the inventories in the waste forms are a major factor in the quantities released to the vadose zone. The predominant source of technetium-99 in the vadose zone is offsite-generated waste (77 percent), followed by tank closure secondary waste (19 percent), and ETF-generated secondary waste (4 percent). The sources of the iodine-129 release are offsite-generated waste (85 percent) and ETF-generated secondary waste (14 percent). The chromium release is from the tank closure secondary waste (86 percent), waste management secondary waste and onsite-generated waste (8 percent), with some from offsite-generated waste (4 percent) and ETF-generated secondary waste (2 percent). All of the nitrate released is from ETF-generated secondary waste. There is no acetonitrile from any of the waste forms in IDF-East.

Figure 5–585 shows the release to groundwater for the radiological risk drivers and Figure 5–586, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the vadose zone technetium-99 (89 percent), iodine-129 (91 percent), chromium (>99 percent), and nitrate (>99 percent) is released to groundwater during the period of analysis.

Figure 5–587 shows the release to the Columbia River for the radiological risk drivers and Figure 5–588, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most of the technetium-99 (97 percent), iodine-129 (97 percent), chromium (97 percent), and nitrate (>99 percent) in the groundwater is released to the Columbia River over the period of analysis.

Overall, most of the technetium-99 (86 percent), iodine-129 (89 percent), chromium (96 percent), and nitrate (98 percent) from the vadose zone is released to the Columbia River. These releases are identical to those of Waste Management Alternative 2, Disposal Group 2-B, Option Case, for these COPCs.

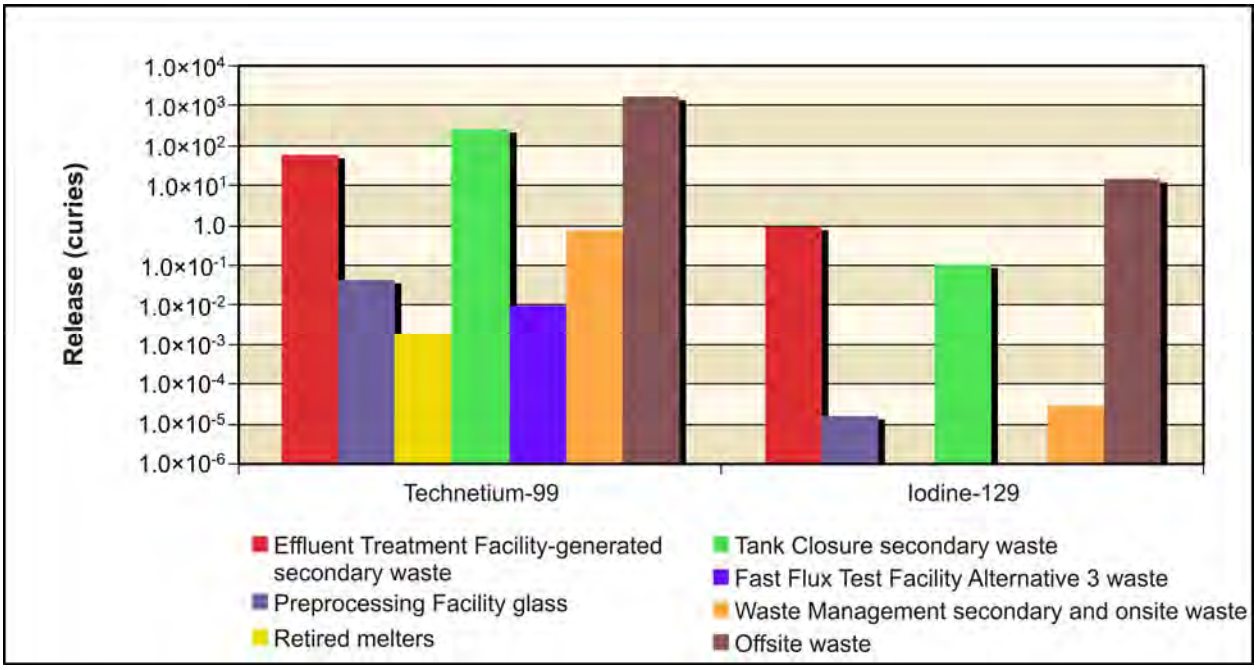


Figure 5–583. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

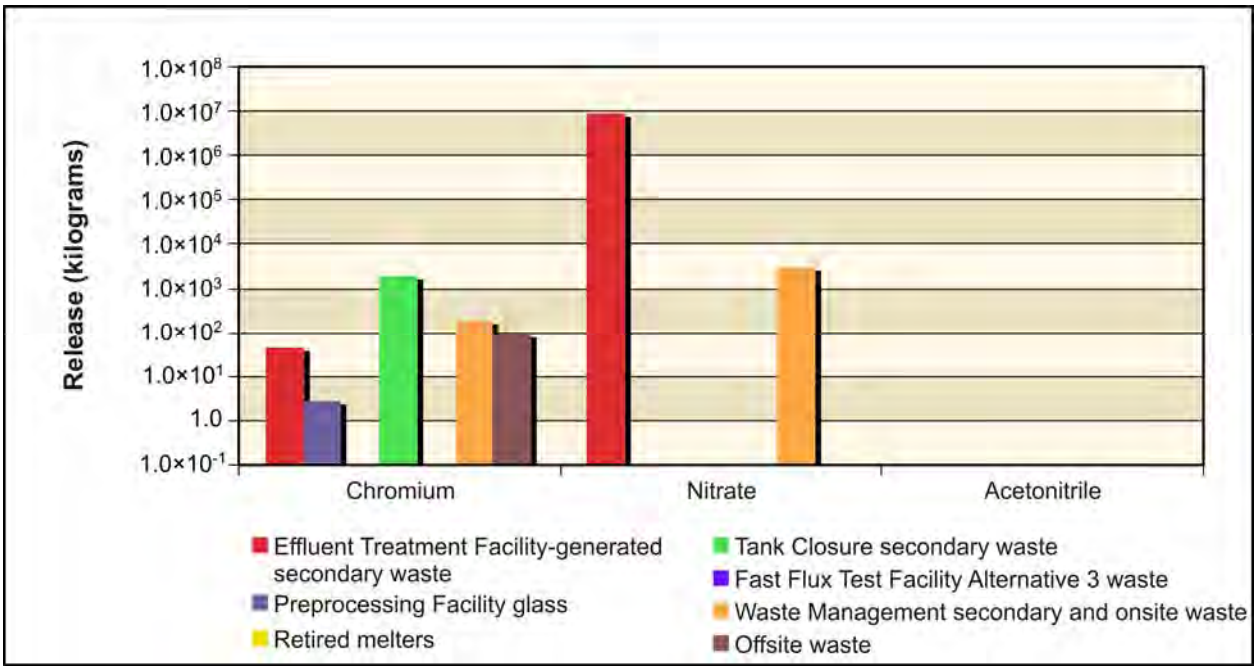


Figure 5–584. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

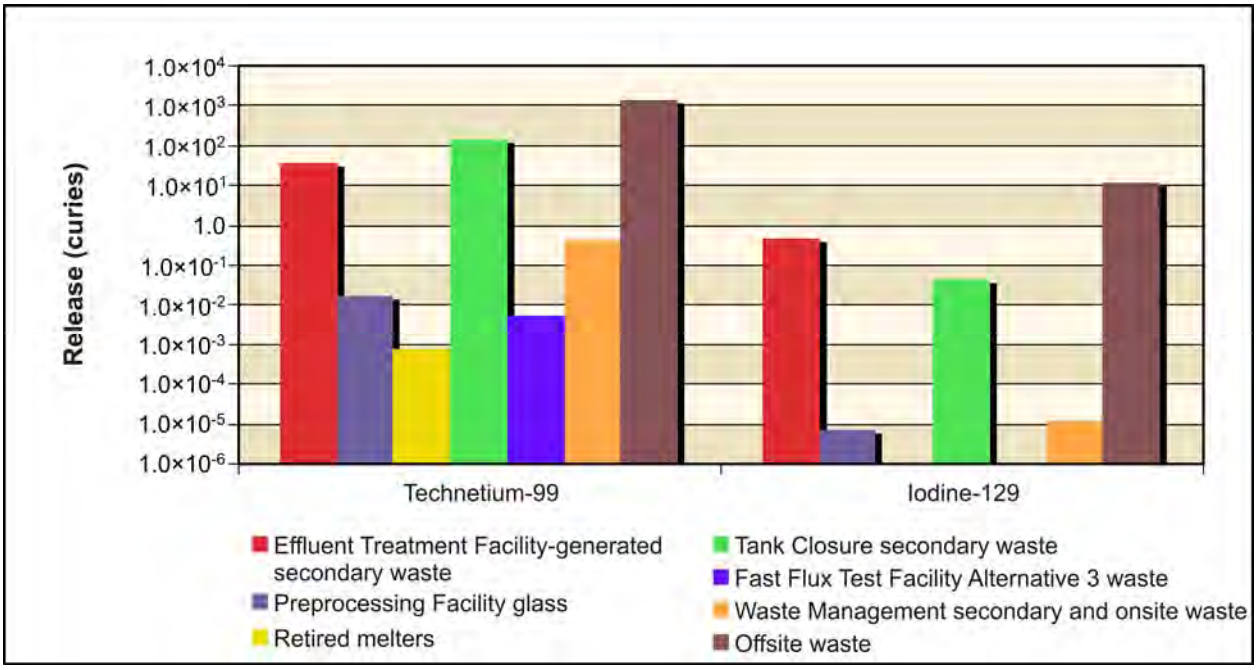


Figure 5–585. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

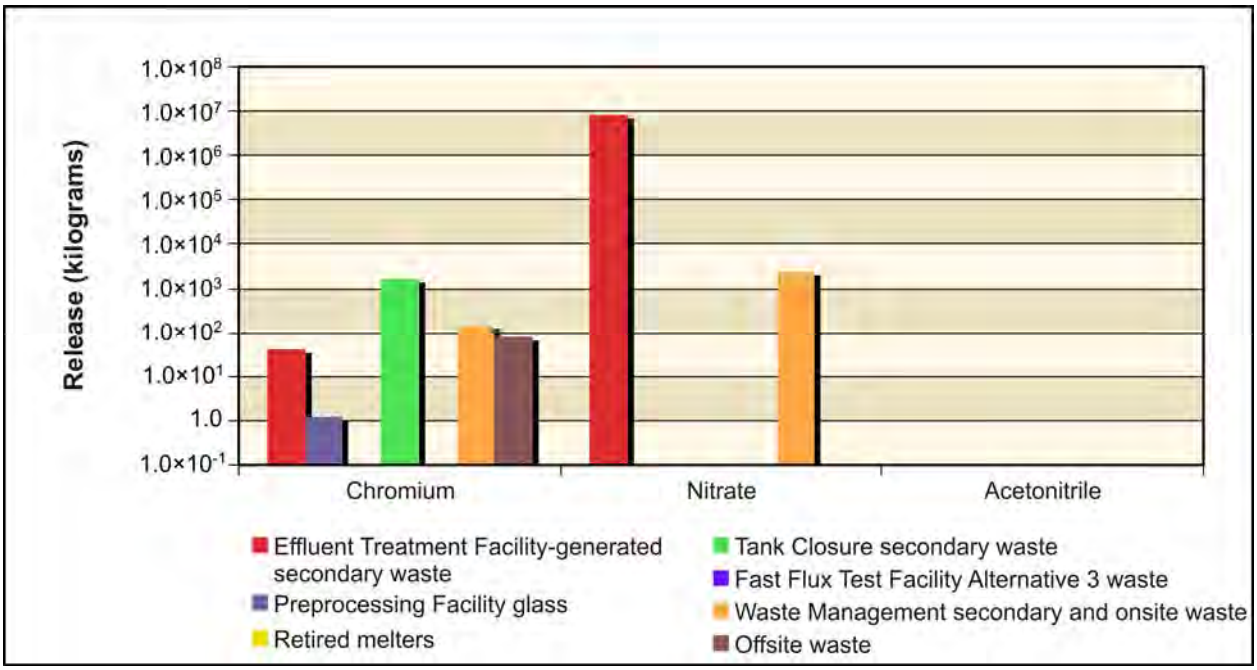


Figure 5–586. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

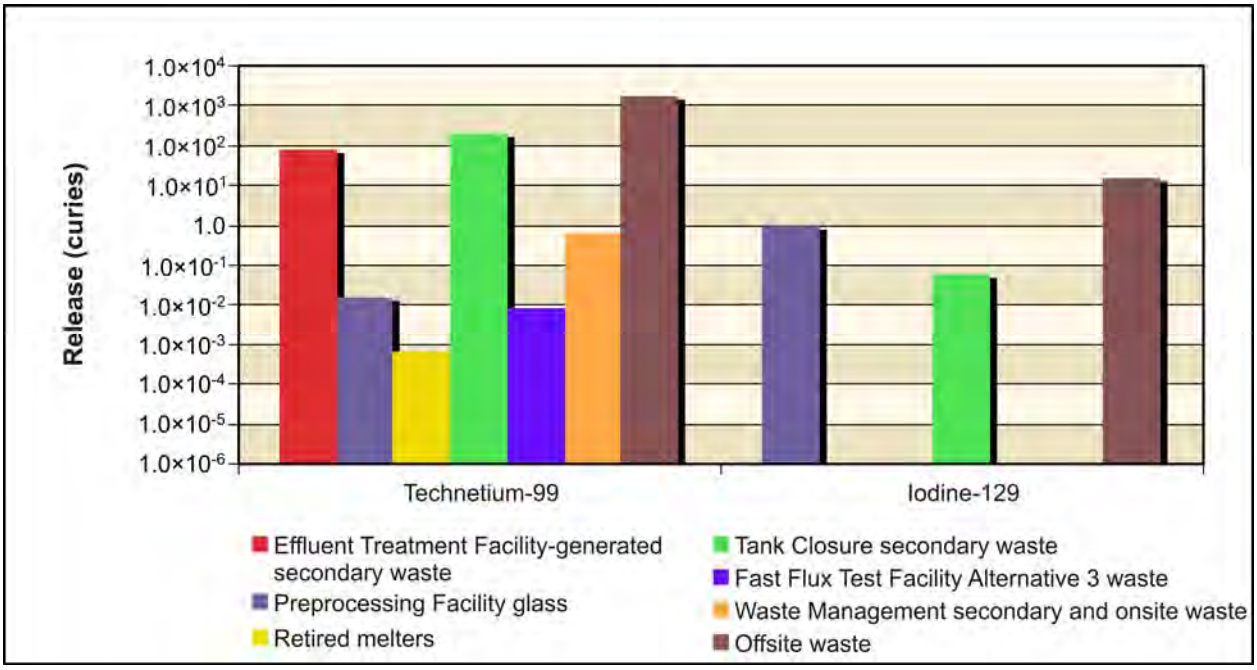


Figure 5–587. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

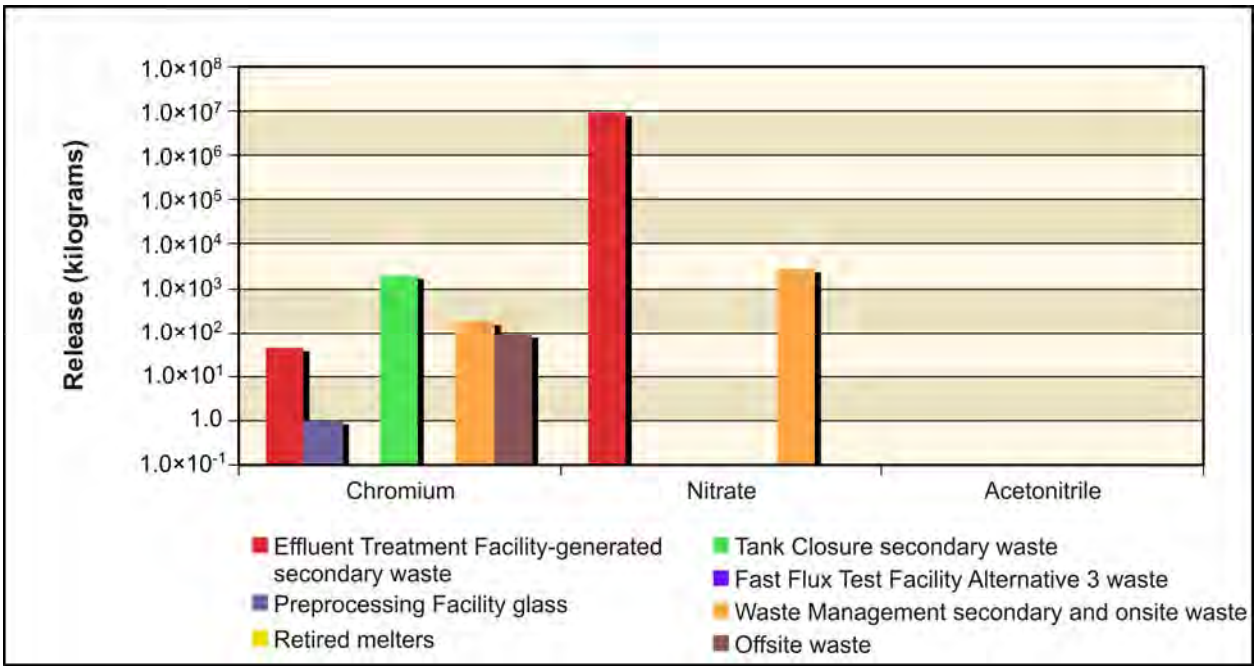


Figure 5–588. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–589 shows the release to the vadose zone for the radiological risk drivers and Figure 5–590, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant releases from the RPPDF are technetium-99 and iodine-129, with technetium-99 being the predominant radionuclide released. The chemical releases from the RPPDF include nitrate (largest), chromium, and acetonitrile (smallest).

Figure 5–591 shows the release to groundwater for the radiological risk drivers and Figure 5–592, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For technetium-99, iodine-129, chromium, nitrate, and acetonitrile, the amount released to groundwater is essentially equal to the amount released to the vadose zone.

Figure 5–593 shows the release to the Columbia River for the radiological risk drivers and Figure 5–594, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, nitrate, and acetonitrile, the amount released to the Columbia River is essentially equal to the amount released to groundwater.

Overall, about 96 percent of the radionuclides and chemicals released by the RPPDF to the vadose zone are released to the Columbia River during the period of analysis. Identical results were observed for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case.

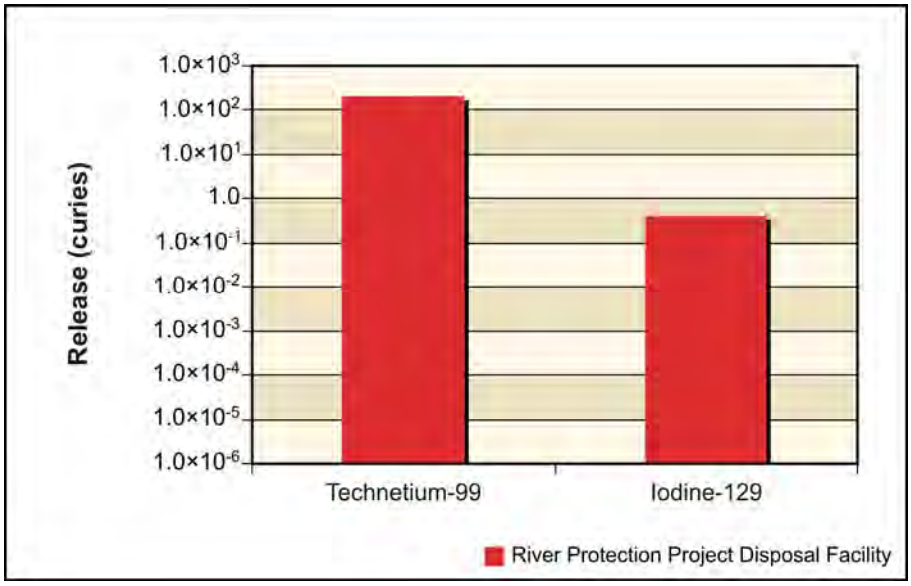


Figure 5–589. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

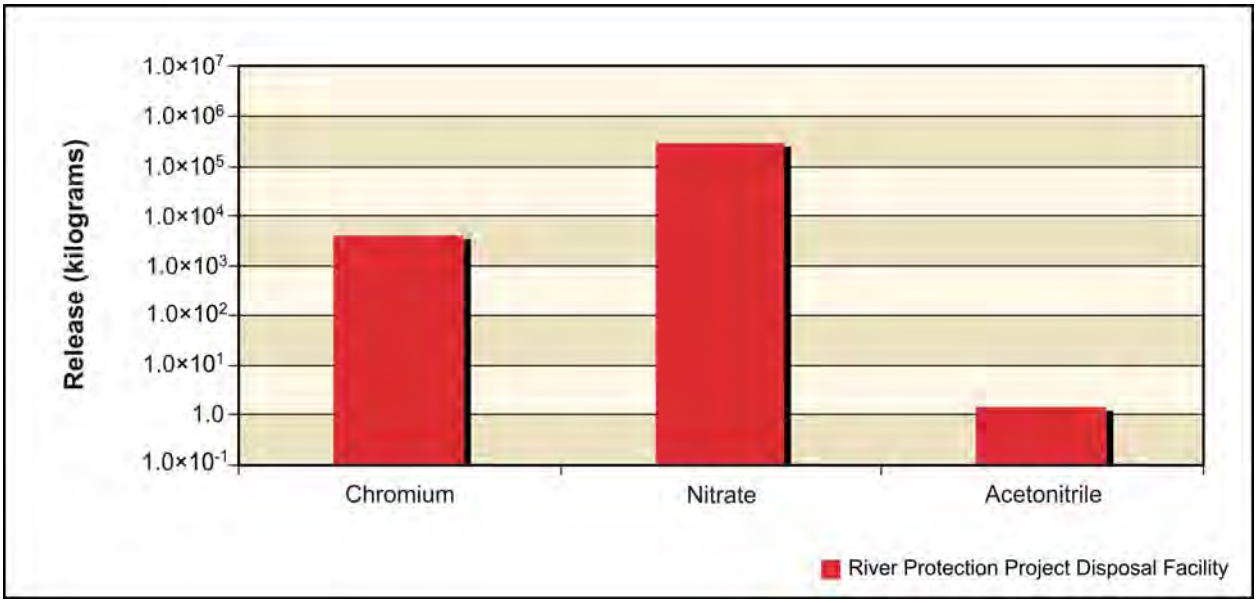


Figure 5–590. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

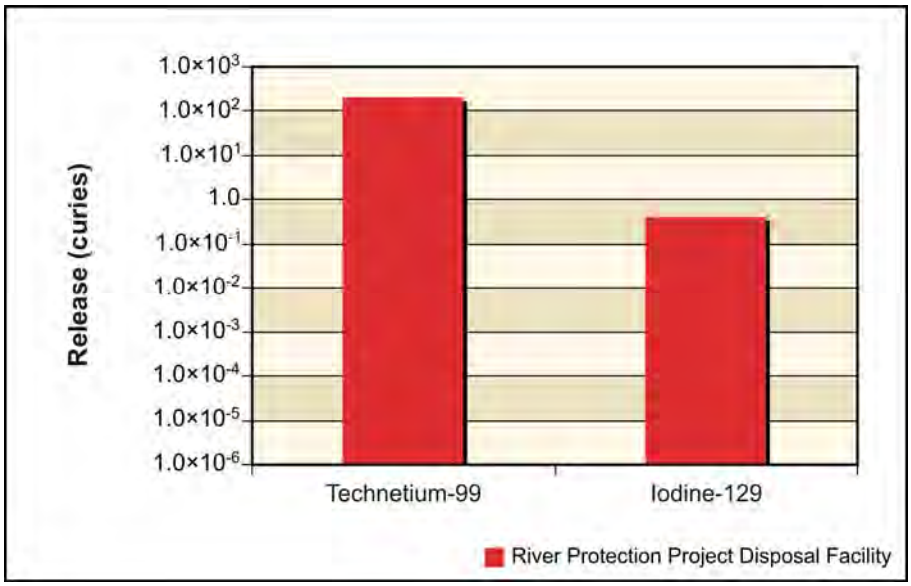


Figure 5–591. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

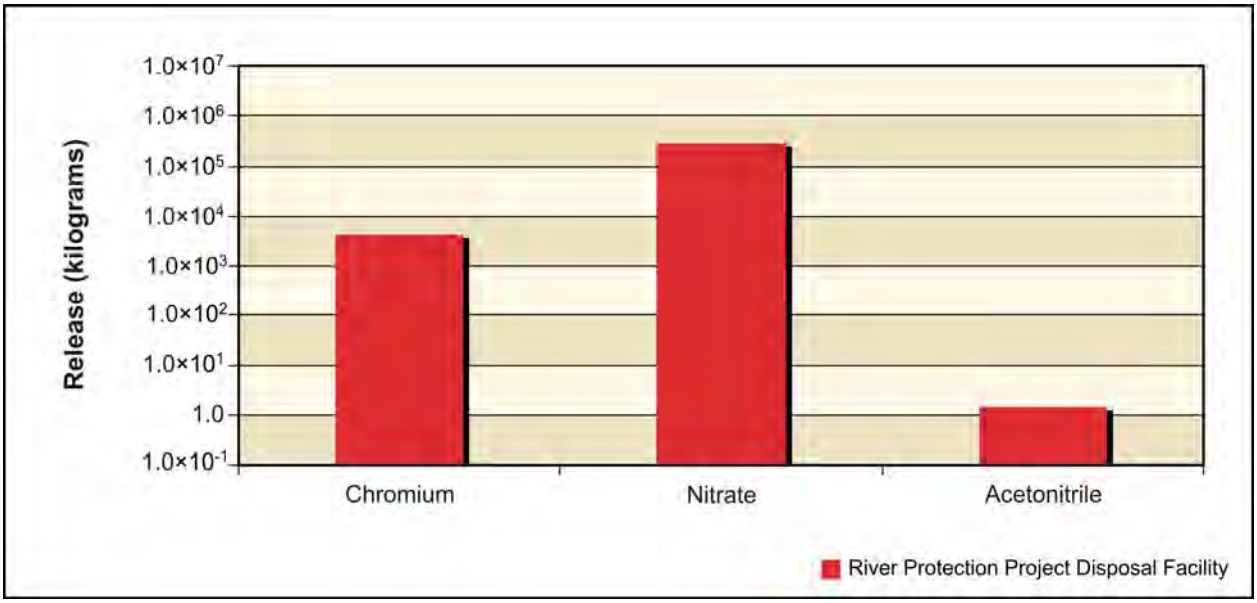


Figure 5–592. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

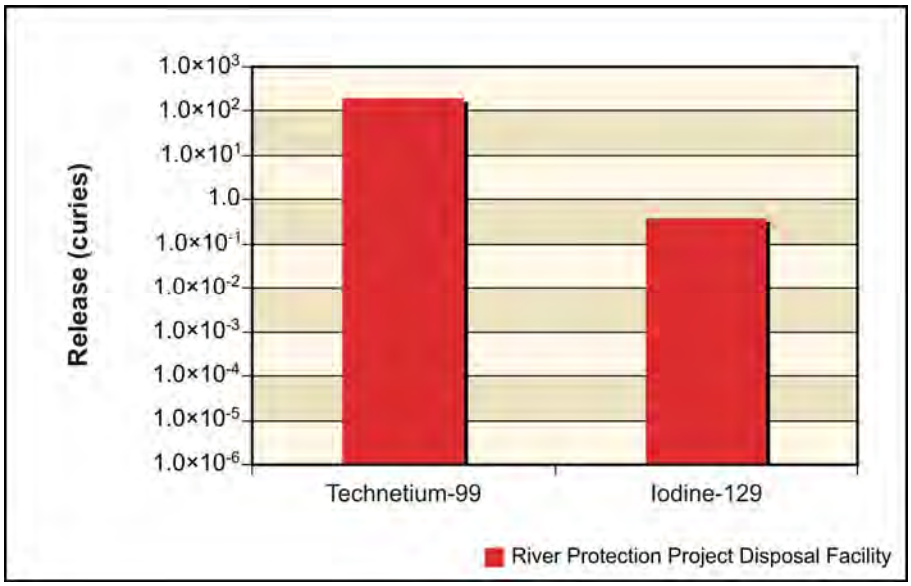


Figure 5–593. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

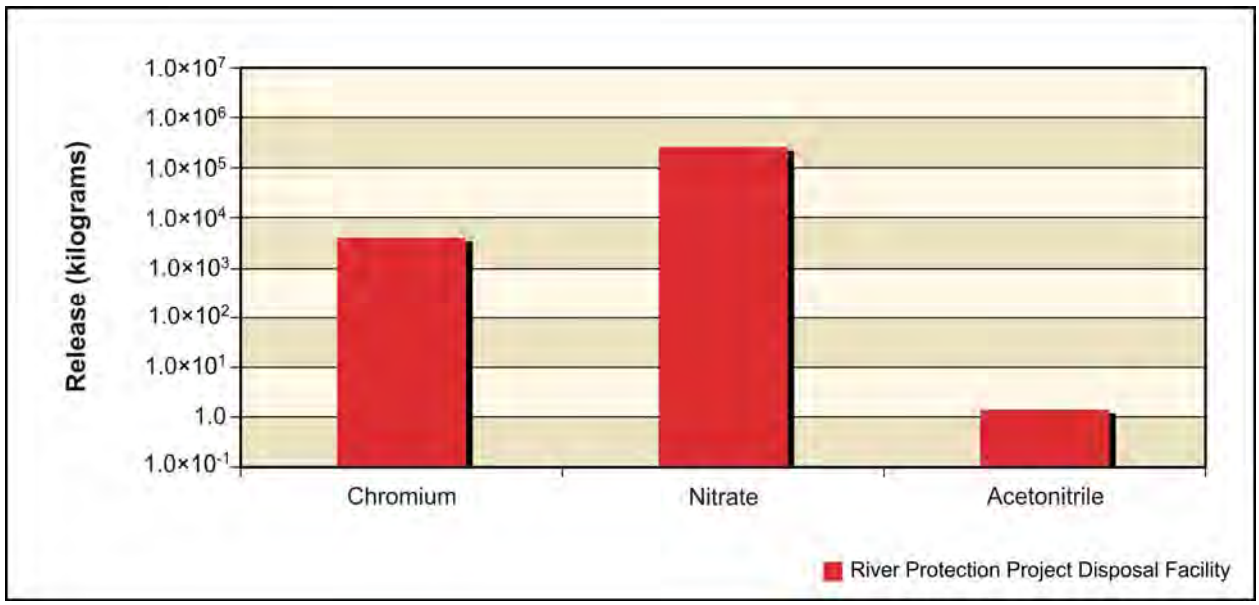


Figure 5–594. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. The concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Table 5–85 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–85. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,890**	283	**1,140**	703	900
	(8580)	(3889)	(8365)	(8477)	
Iodine-129	**24**	0.5	**10**	**6**	1
	(9058)	(4089)	(9188)	(9652)	
Chemical in micrograms per liter					
Chromium	3	6	11	2	100
	(8281)	(3868)	(11232)	(5035)	
Nitrate	16,600	353	5,750	3,310	45,000
	(8162)	(3996)	(8245)	(7837)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–595 through 5–598 show concentration versus time for technetium-99, iodine-129, nitrate, and chromium, respectively. The releases of technetium-99 from IDF-East and the RPPDF do not exceed the benchmark concentrations at the Core Zone Boundary or the Columbia River nearshore (see Figure 5–595). The technetium-99 concentrations at both boundaries remain fairly constant for most of the analysis period and then decrease into CY 11,940.

Figure 5–596 shows iodine-129 exceeding benchmark concentrations starting about CY 5940 and continuing through CY 11,940 for both the Core Zone Boundary and the Columbia River nearshore. Figures 5–597 and 5–598 show that the nitrate and chromium releases do not reach the benchmark concentrations over the period of analysis. The nitrate and chromium concentrations at the Core Zone Boundary and the Columbia River nearshore are always at least one order of magnitude lower than their benchmark concentrations.

Figure 5–599 shows concentration versus time for total uranium. Uranium-238 has no detectable release to the environment. Total uranium concentrations, while very low, continue to increase during the period of analysis and beyond. The total uranium concentration never approaches closer than six orders of magnitude to the benchmark concentration during the period of analysis (through CY 11,940).

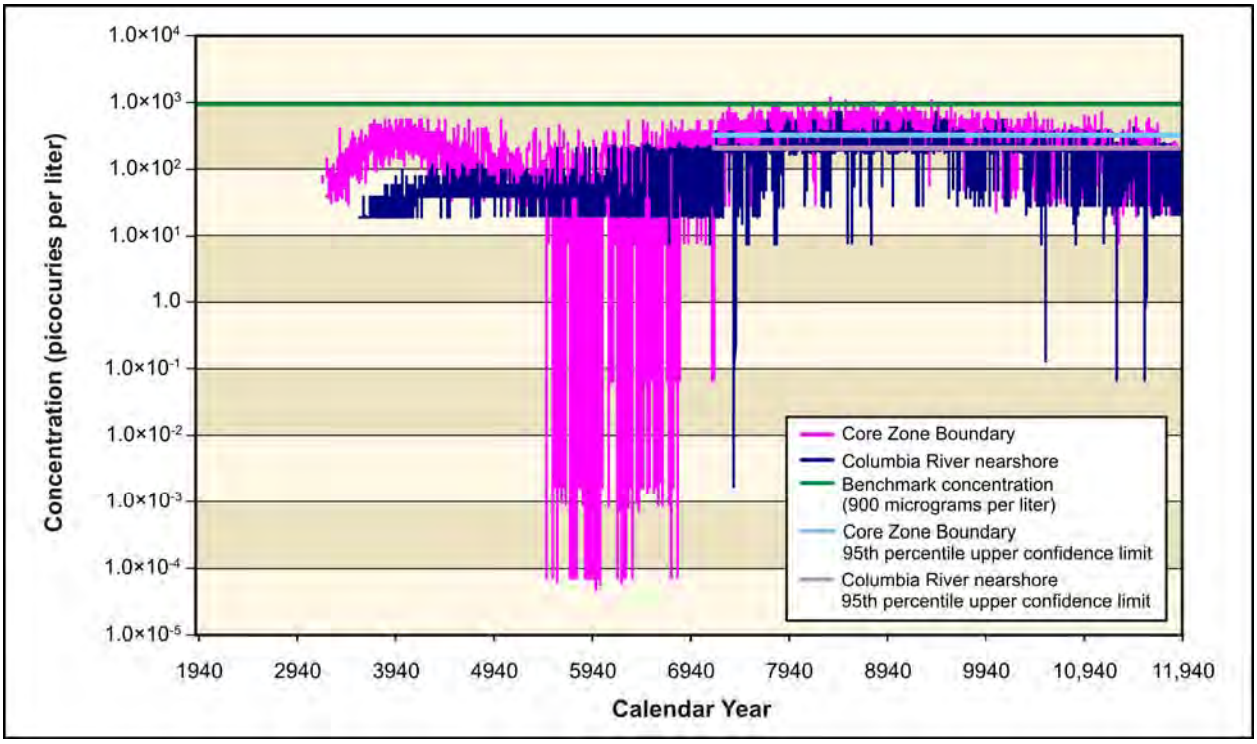


Figure 5–595. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Technetium-99 Concentration Versus Time

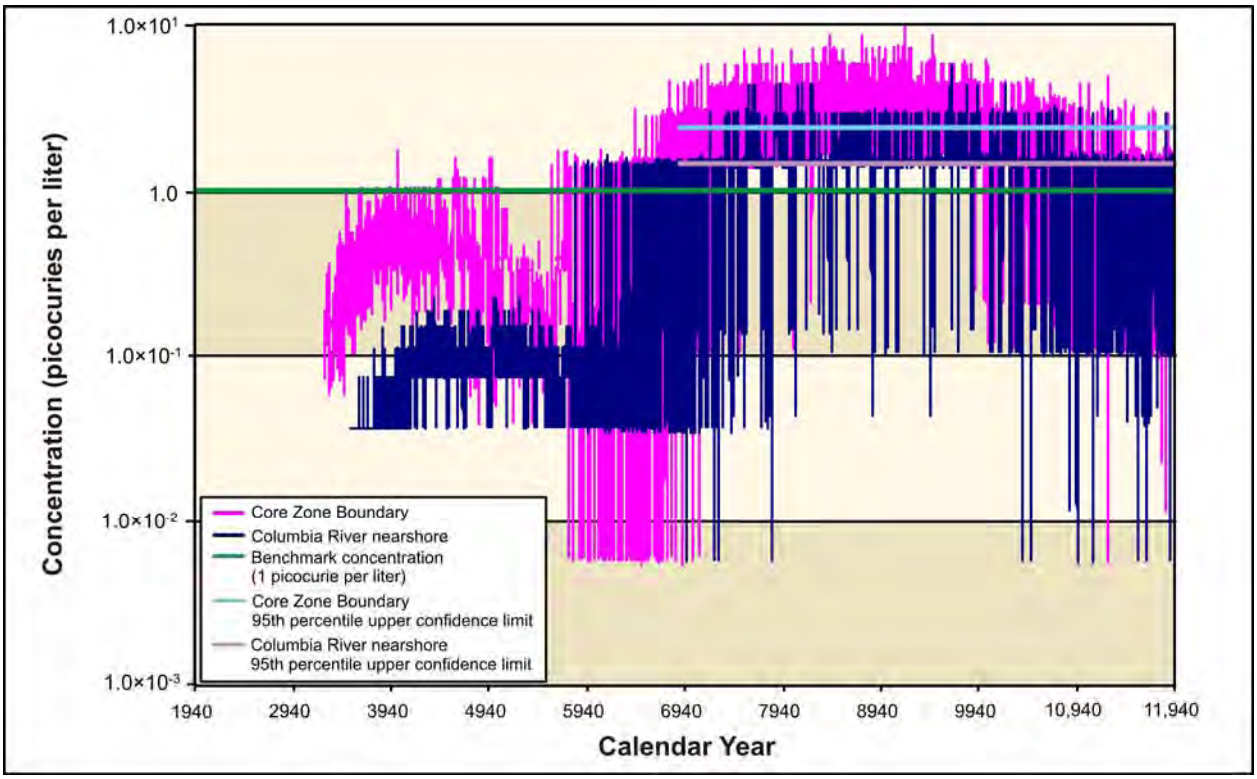


Figure 5–596. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Iodine-129 Concentration Versus Time

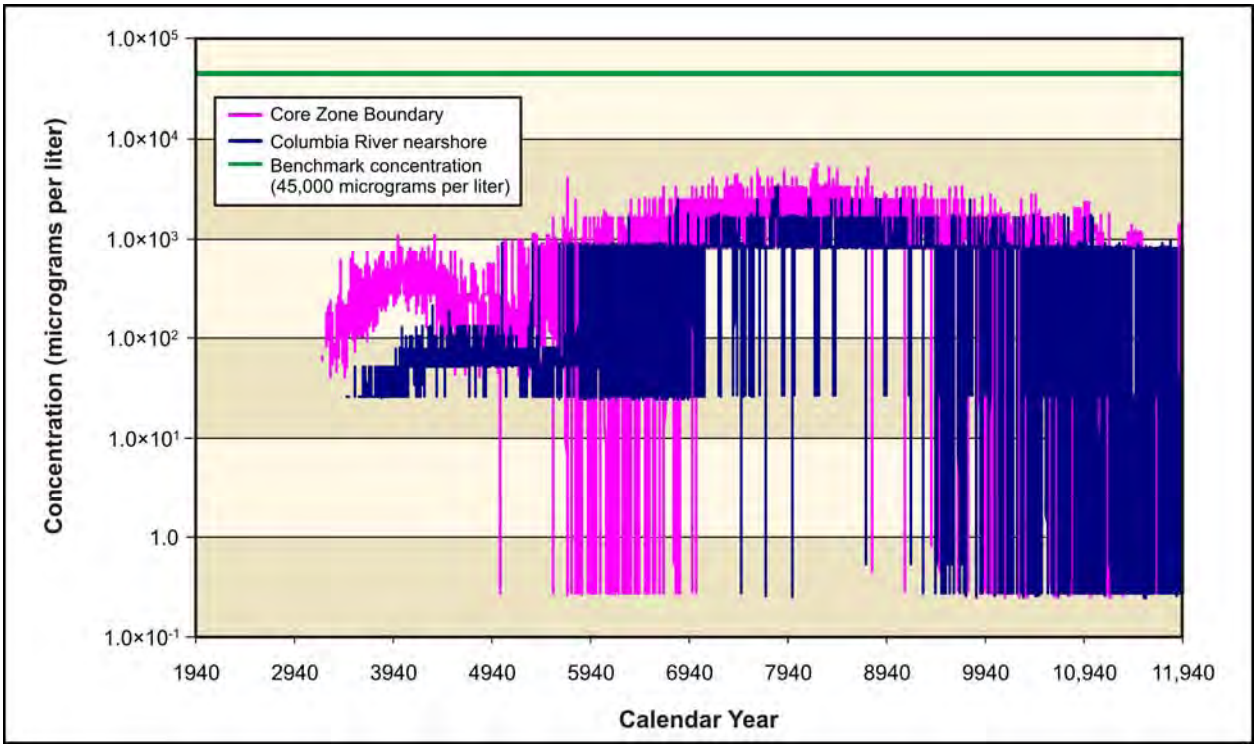


Figure 5–597. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Nitrate Concentration Versus Time

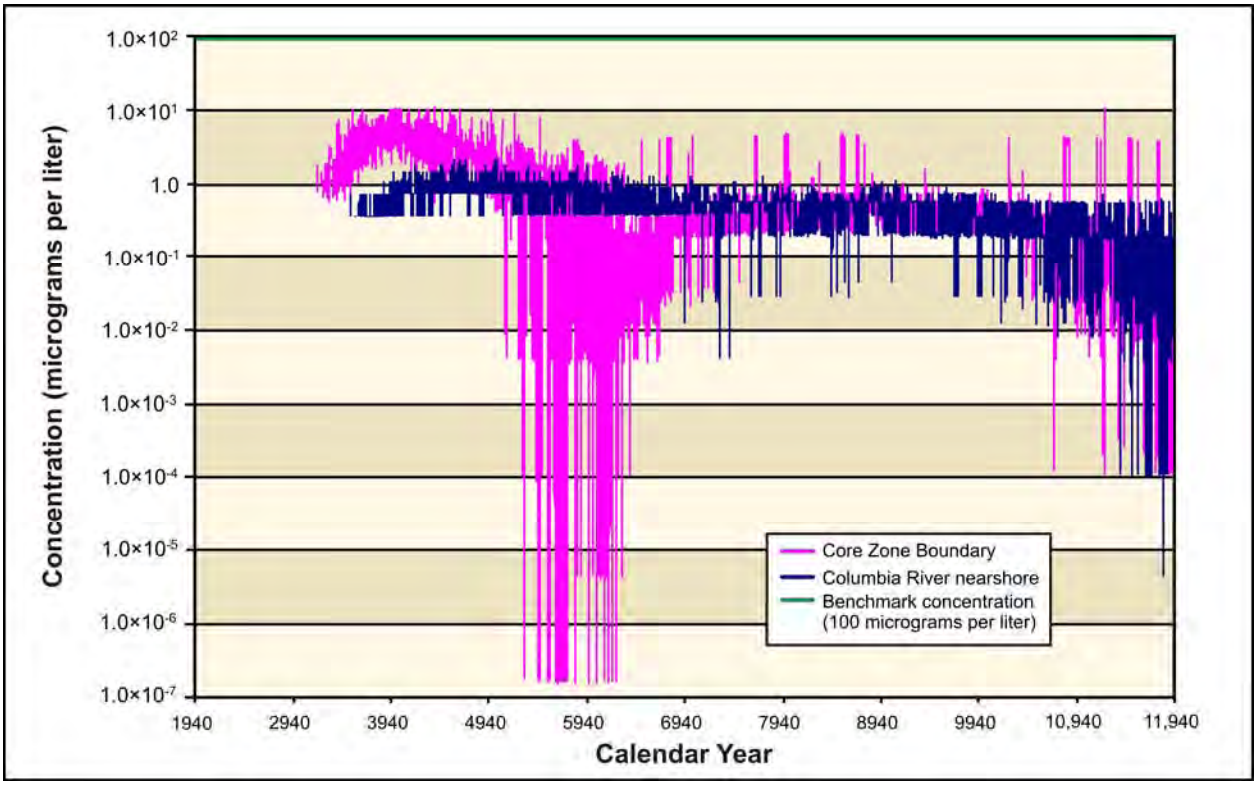


Figure 5–598. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chromium Concentration Versus Time

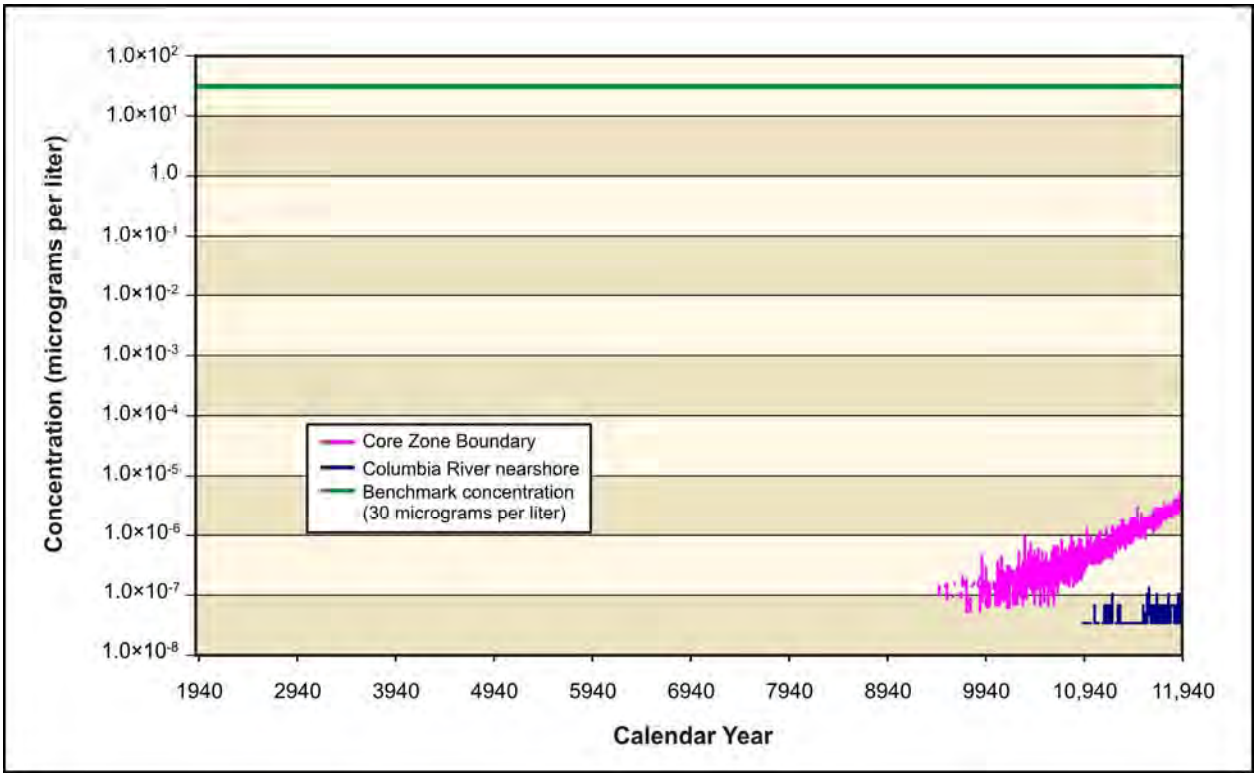


Figure 5–599. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully-saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark concentration by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–600 through 5–611 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. Figure 5–612 shows the concentration distribution for total uranium at CY 11,885. These groundwater releases from IDF-East that extend from the east of the Core Zone Boundary to the Columbia River and from the RPPDF north from the Core Zone Boundary to the Columbia River. The releases from the RPPDF remain in a fairly narrow area until about halfway to the Columbia River nearshore, where the plume spreads out and continues to the shoreline. The IDF-East plume is contained in a narrow area until it reaches about one-third of the distance to the Columbia River nearshore, where it spreads out and continues to the shoreline.

Figure 5–600 (CY 3890) shows that the technetium-99 release from the RPPDF exceeds the benchmark concentrations in small areas north of the Core Zone Boundary. Figure 5–601 (CY 7140) shows that the RPPDF technetium-99 distribution has nearly dissipated, but that areas of higher technetium-99 concentration remain. This figure also shows that the release from IDF-East extends from the release site to the Columbia River. By CY 11,885 (see Figure 5–602), the RPPDF-released technetium-99 has nearly

dissipated, with the exception of a small, isolated area of high concentration. The IDF-East technetium-99 release has increased significantly, and the concentration in groundwater continues in a widely distributed plume through CY 11,885. Those concentrations, however, remain below the benchmark concentration.

Figures 5–603 through 5–605 show similar concentration distribution for iodine-129, the RPPDF plume extending north from the Core Zone Boundary and the IDF-East plume extending east. Figure 5–603 shows an RPPDF plume at CY 3890 and but no IDF-East plume, the IDF-East release having occurred in later years. Figure 5–604 shows a dissipated RPPDF iodine-129 distribution and a significant IDF-East plume extending from the release site to the Columbia River. There is an area east of the Core Zone Boundary in which the iodine-129 concentration exceeds the benchmark concentration. Figure 5–605 (CY 11,885) shows almost no RPPDF iodine-129 but a small area (pocket) of high-concentration iodine-129 remains. This indicates that the IDF-East iodine-129 release to the Columbia River continues through CY 11,885, and that in smaller areas the concentrations approach or exceed the benchmark concentration.

Figures 5–606 through 5–608 show chromium releases from the RPPDF and IDF-East that produce plume maps (time, space, and concentration) similar to those of the technetium-99 and iodine-129 releases. These also show a delayed (relative to the RPPDF release) release of chromium from IDF-East. However, areas of higher nitrate concentrations from both releases do not exceed benchmark concentrations. A small area of higher nitrate concentration from the RPPDF nitrate release appears to be maintained through CY 11,885.

The nitrate release shown in Figures 5–609 through 5–611 is nearly identical to the chromium release (time and space ranges). The IDF-East nitrate release never reaches the benchmark concentration. In CY 7140, the RPPDF shows a small area in which a high nitrate concentration is maintained, but this appears to dissipate by CY 11,885.

Figure 5–612 shows the concentration distribution for total uranium released from the RPPDF for CY 11,885. The released total uranium produces a fairly even distribution between the release source and the Columbia River nearshore. As total uranium is not as mobile as the other COPCs, the total uranium release results in a fairly homogeneous distribution between the release source and the Columbia River. The concentration is consistently well below the benchmark concentration and there are no areas of higher levels, as were observed for other COPCs. The distribution and consistency of the CY 11,885 total uranium distribution would indicate that the released total uranium plume will remain well past CY 11,885.

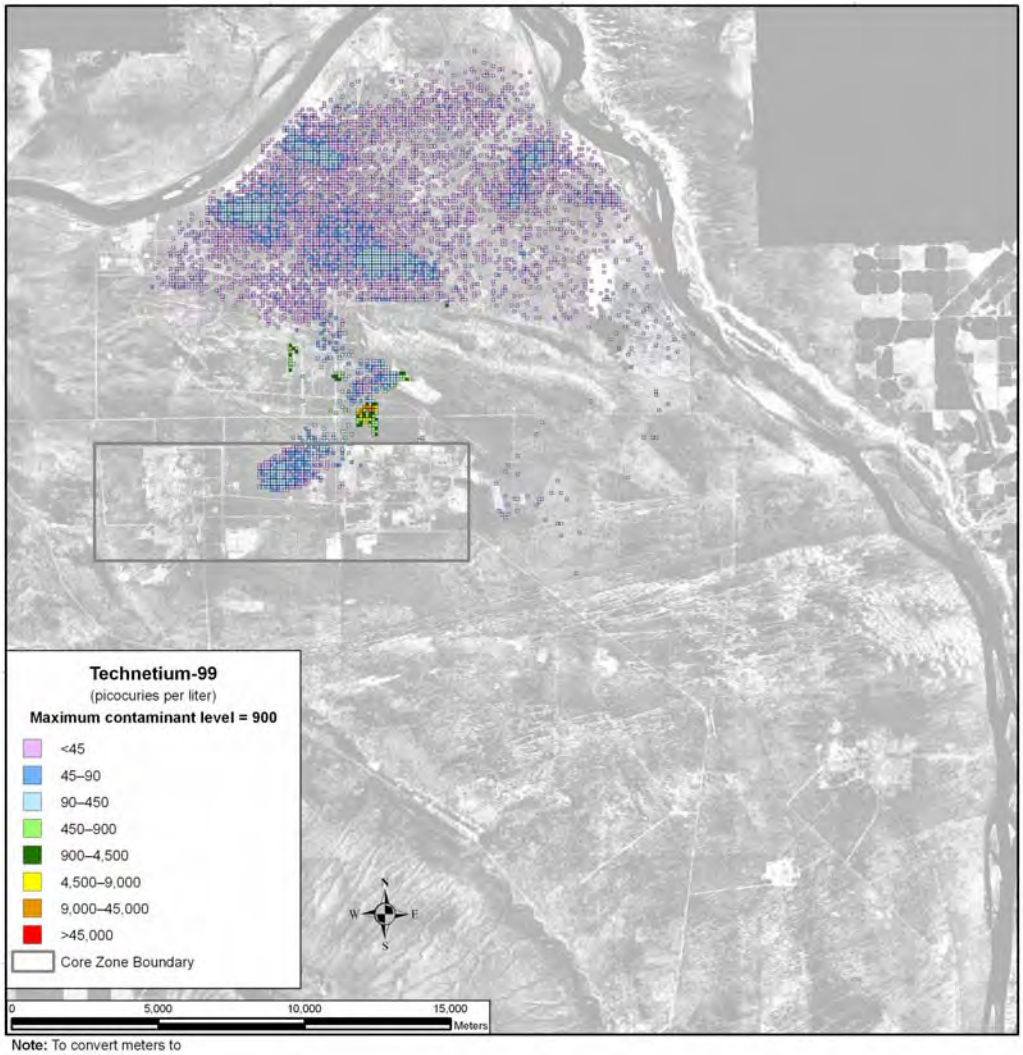


Figure 5–600. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

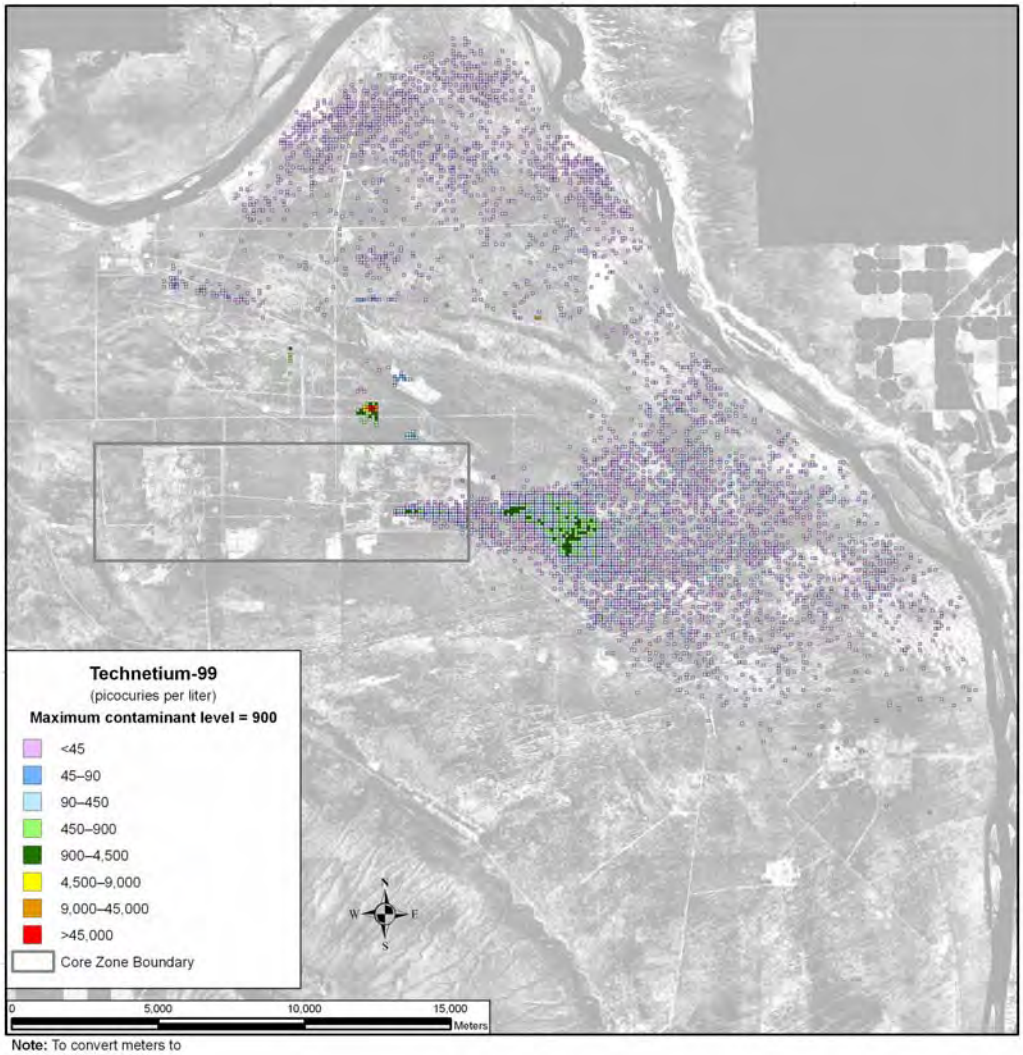


Figure 5–601. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

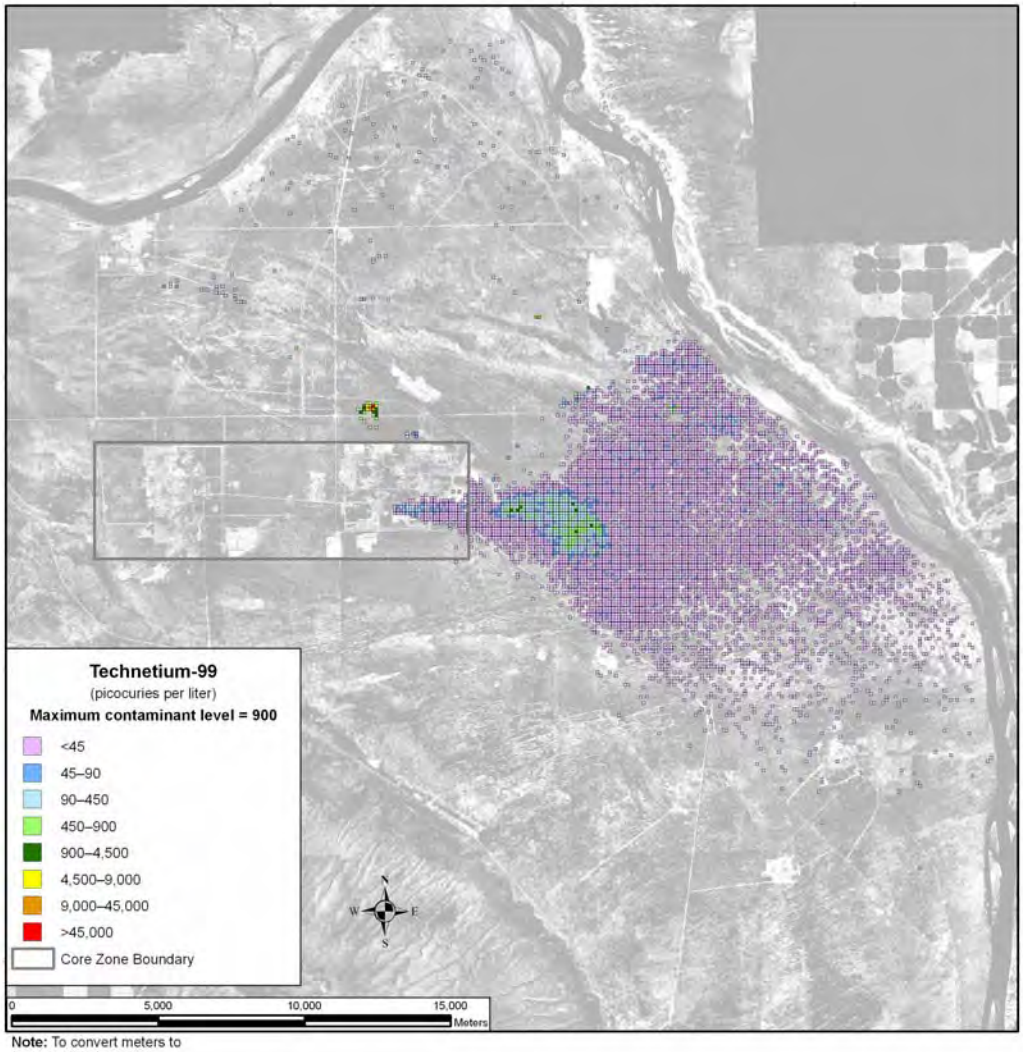


Figure 5–602. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

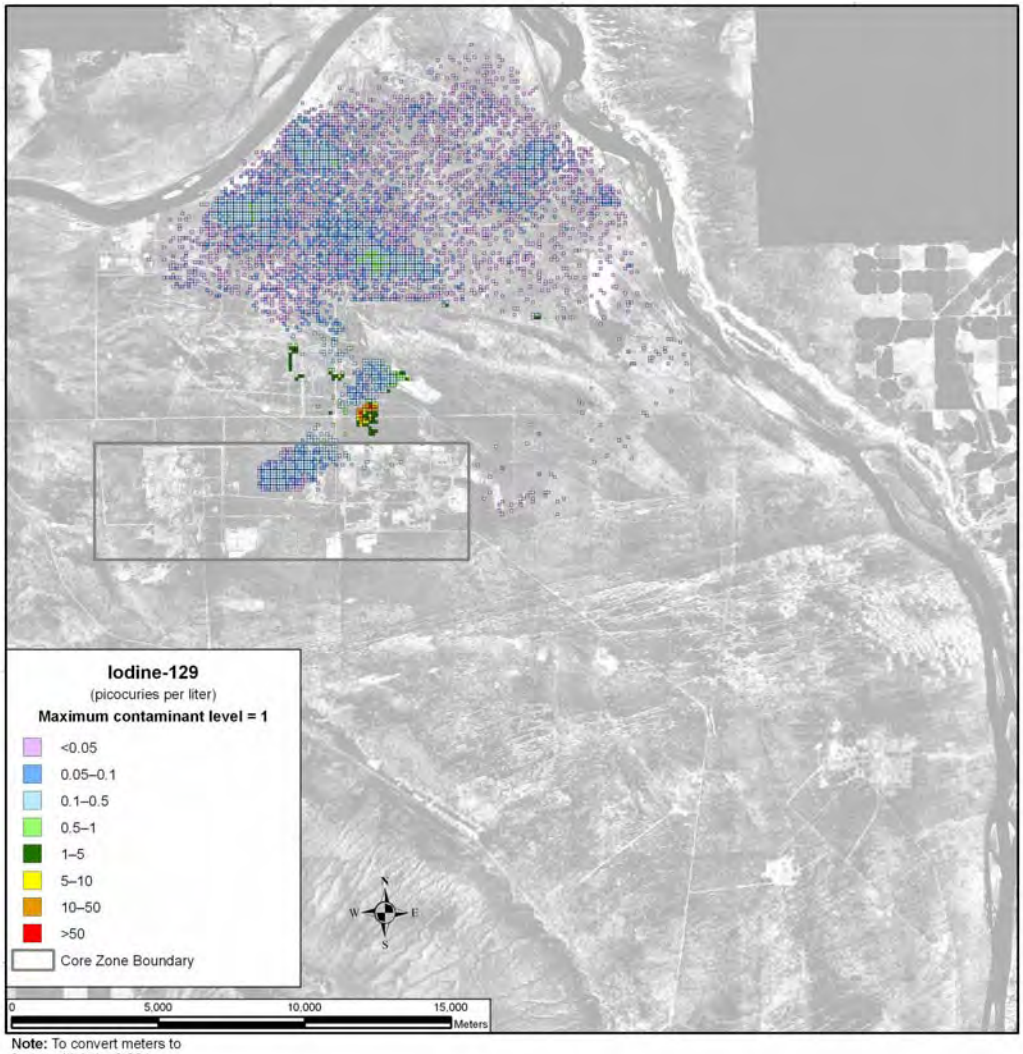
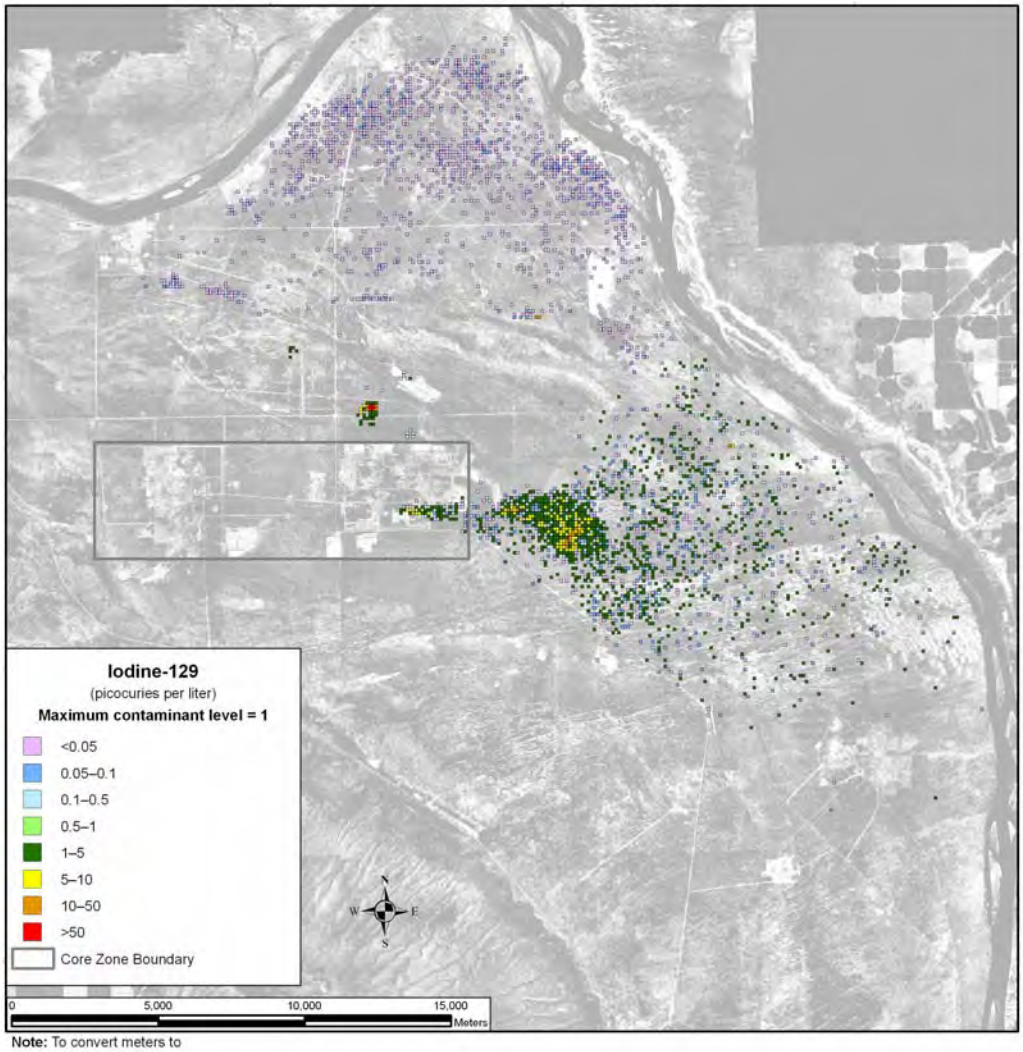
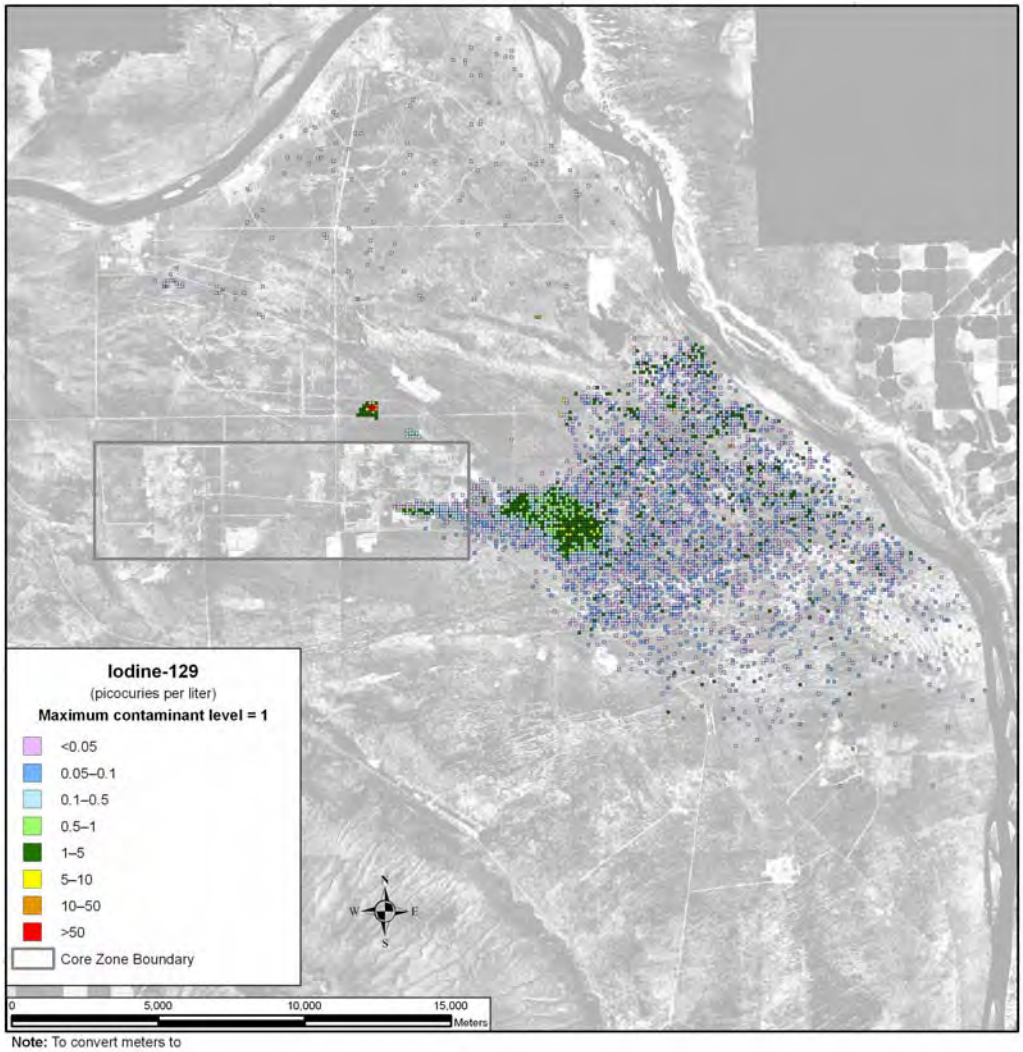


Figure 5–603. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–604. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–605. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

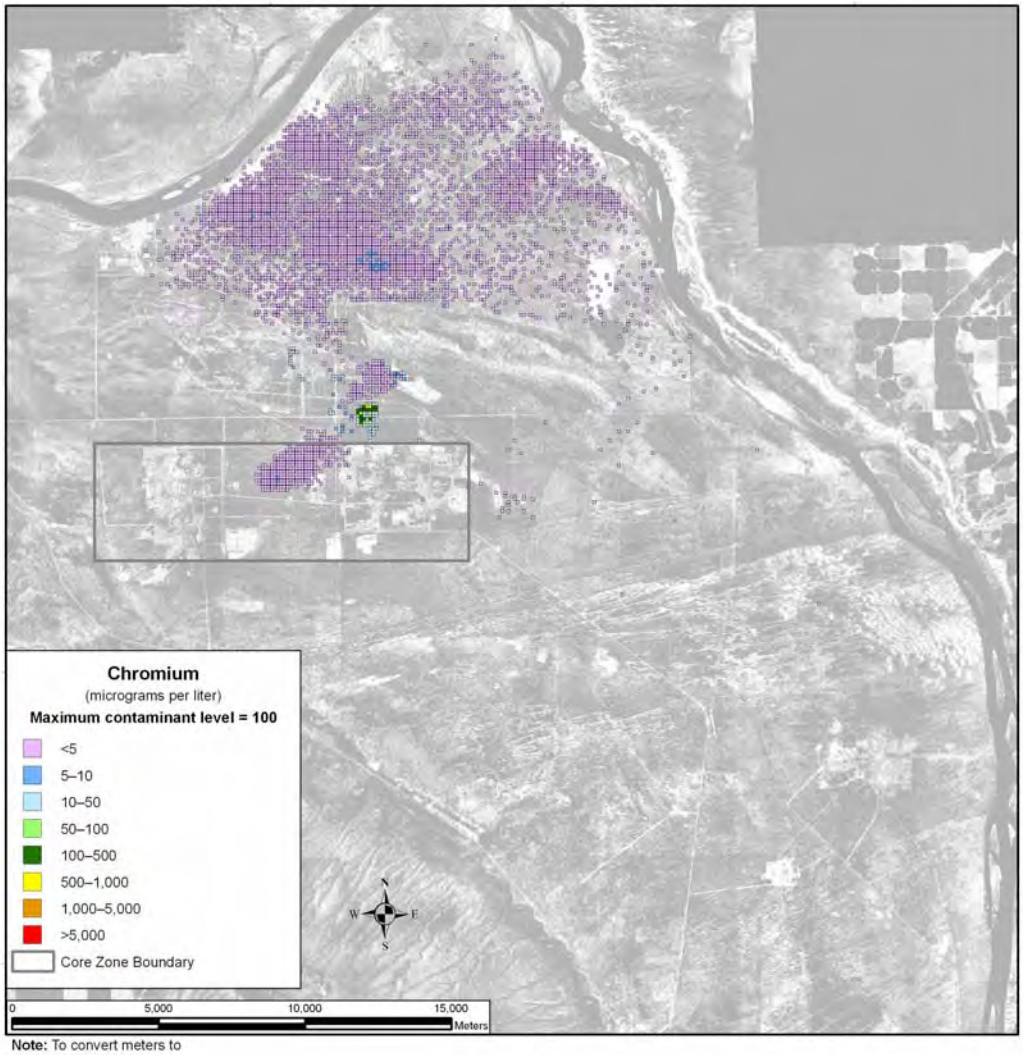


Figure 5–606. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

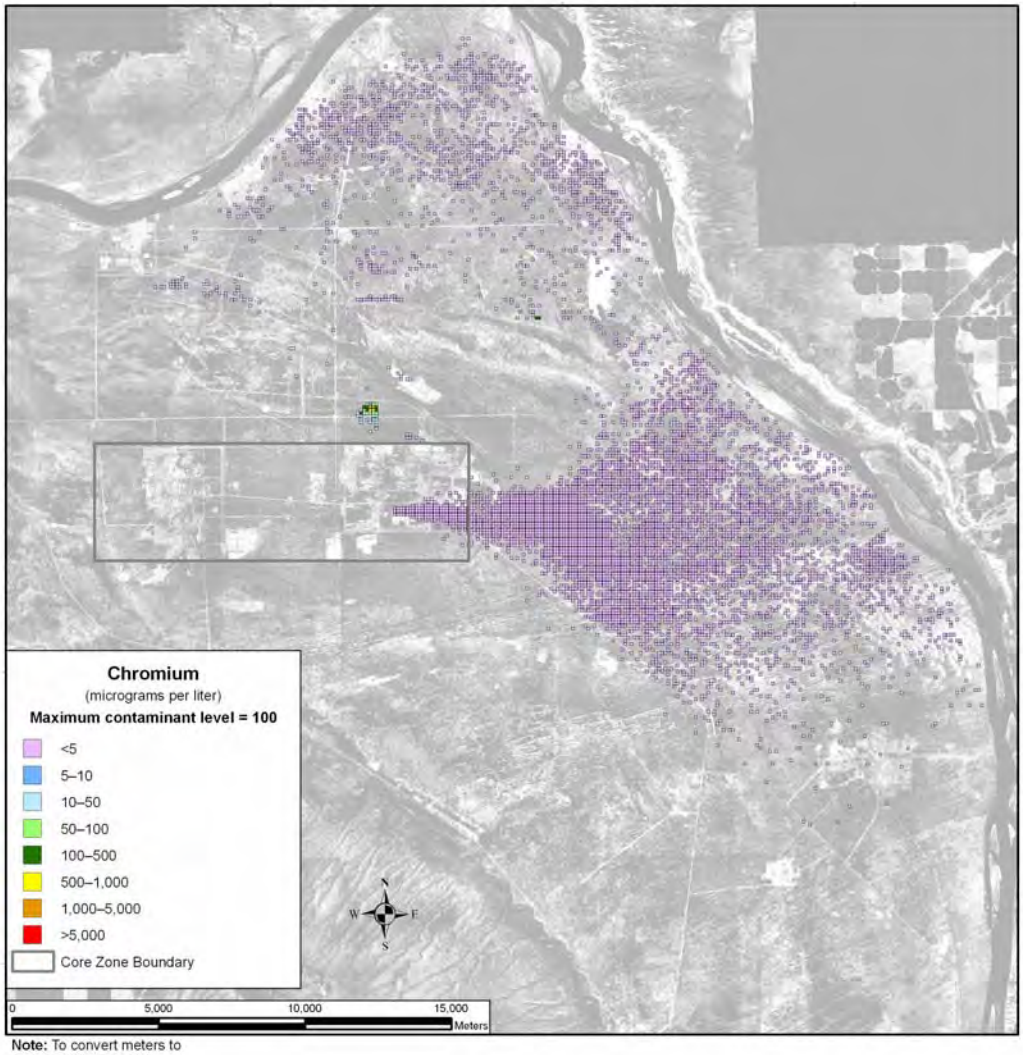


Figure 5–607. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

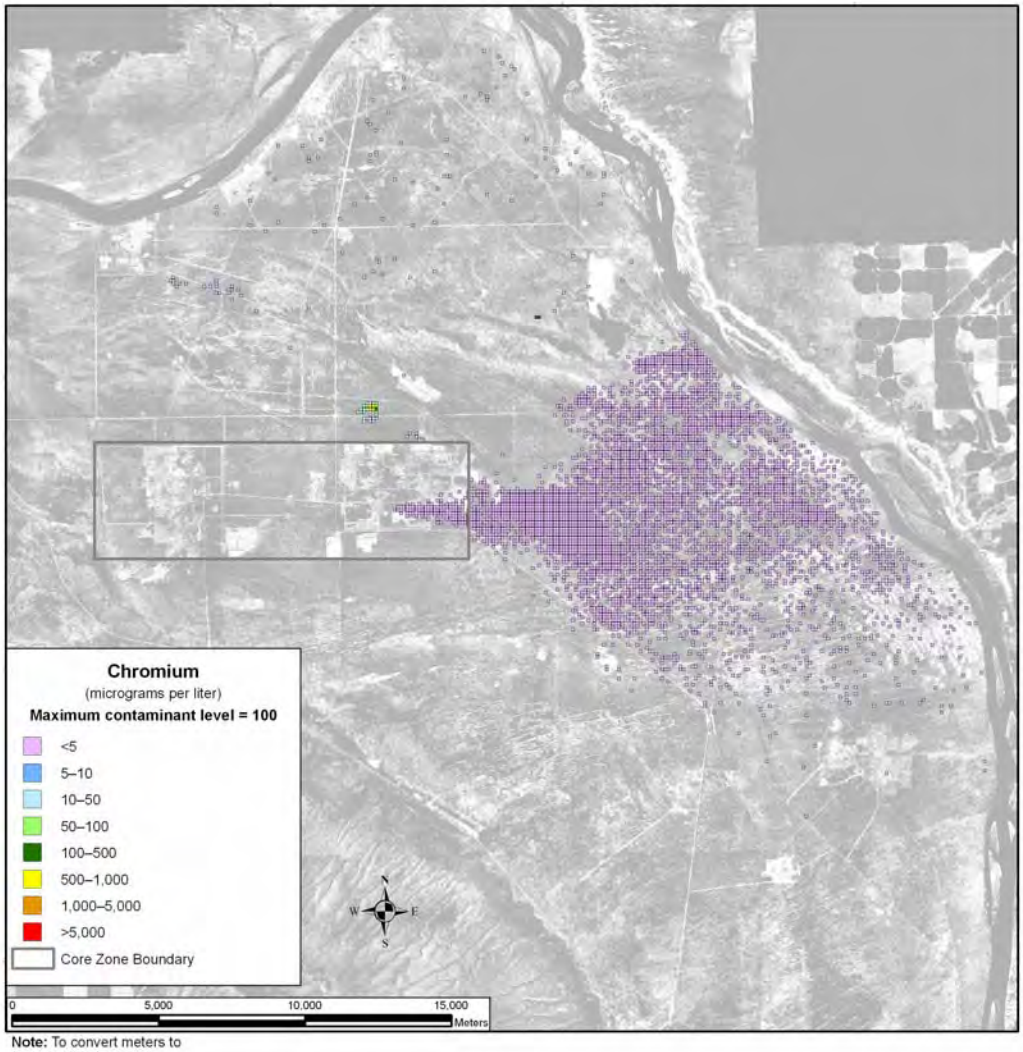


Figure 5–608. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

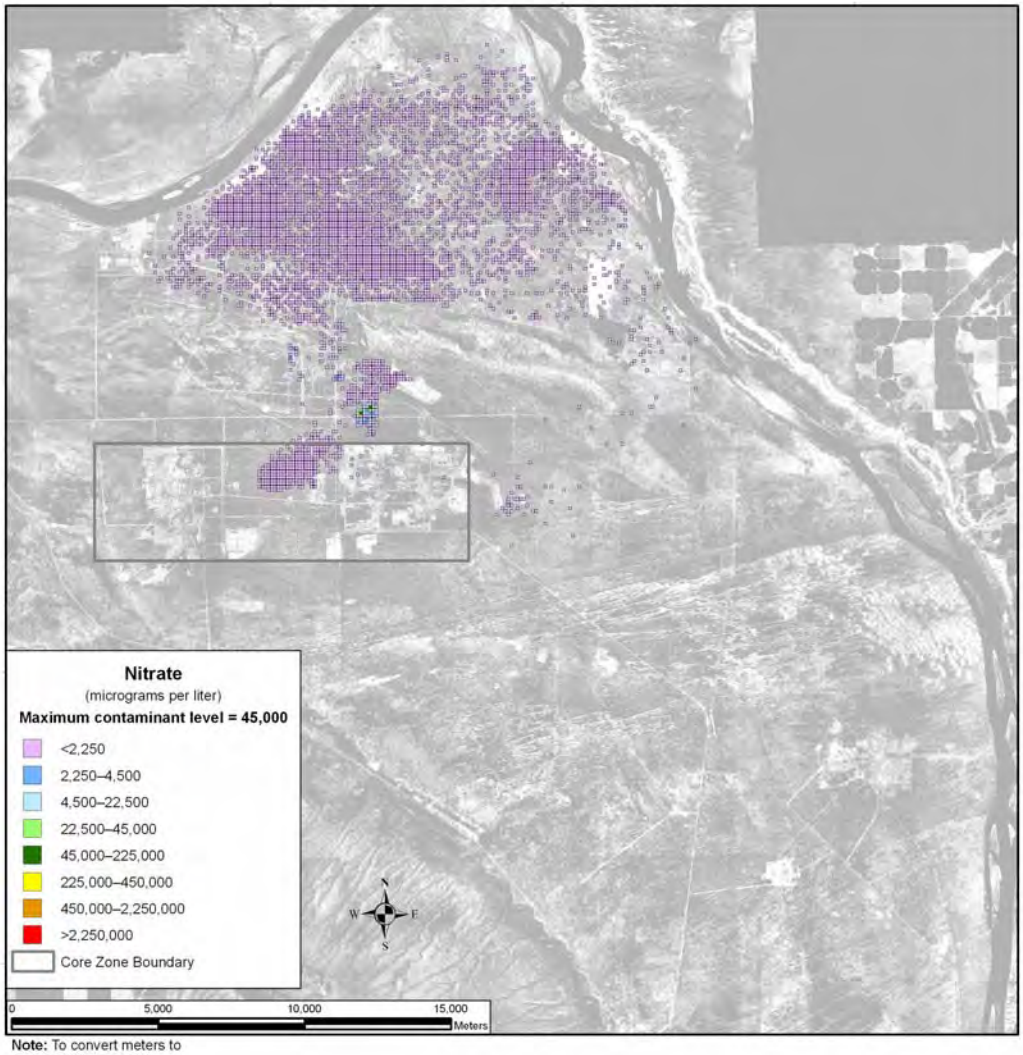


Figure 5–609. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

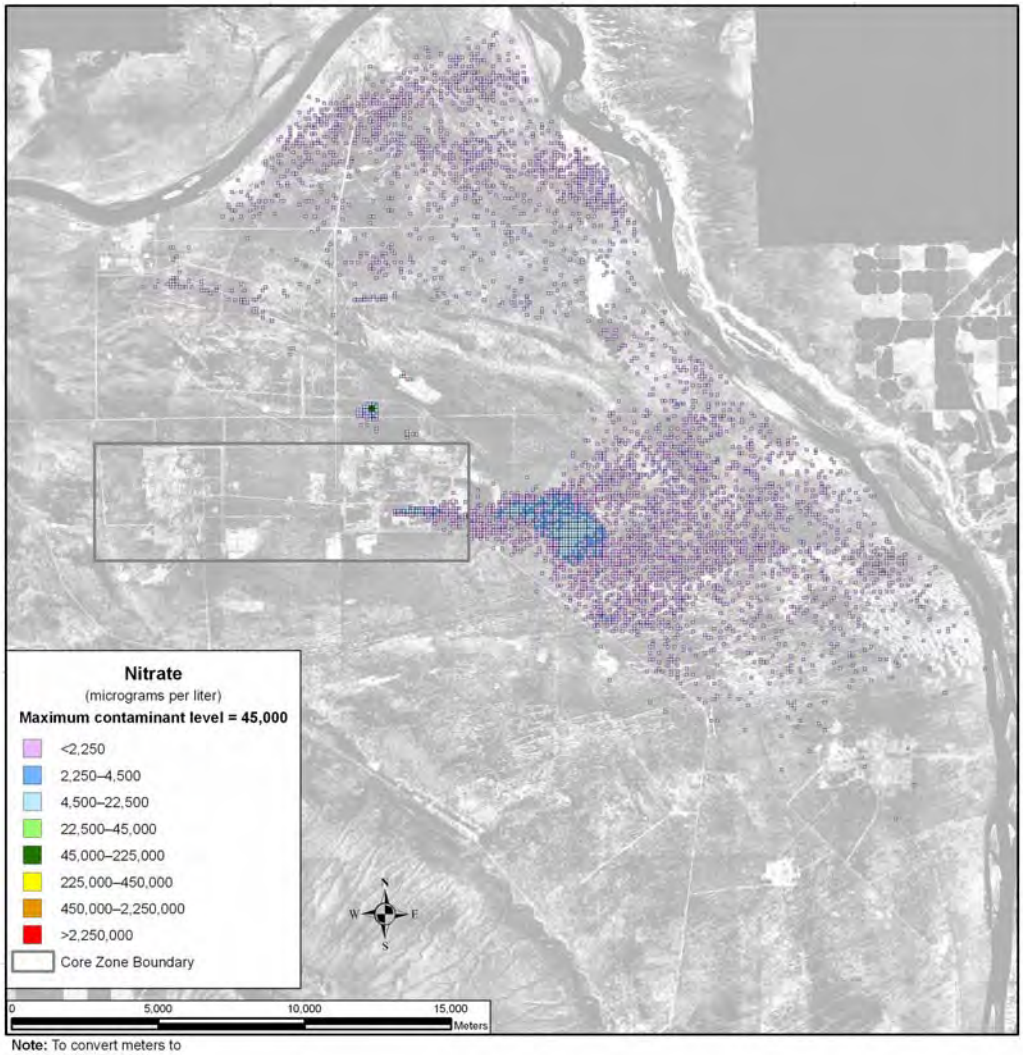


Figure 5–610. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

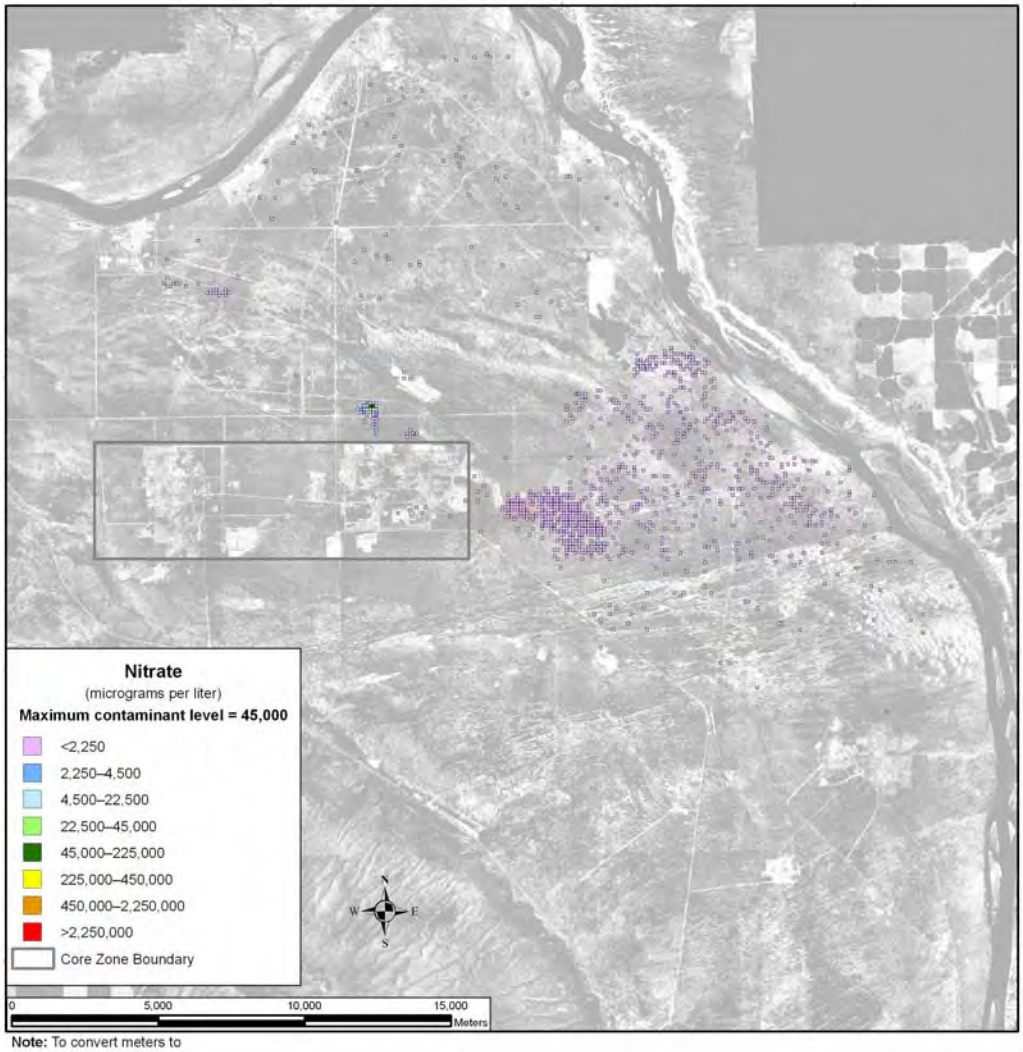


Figure 5–611. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

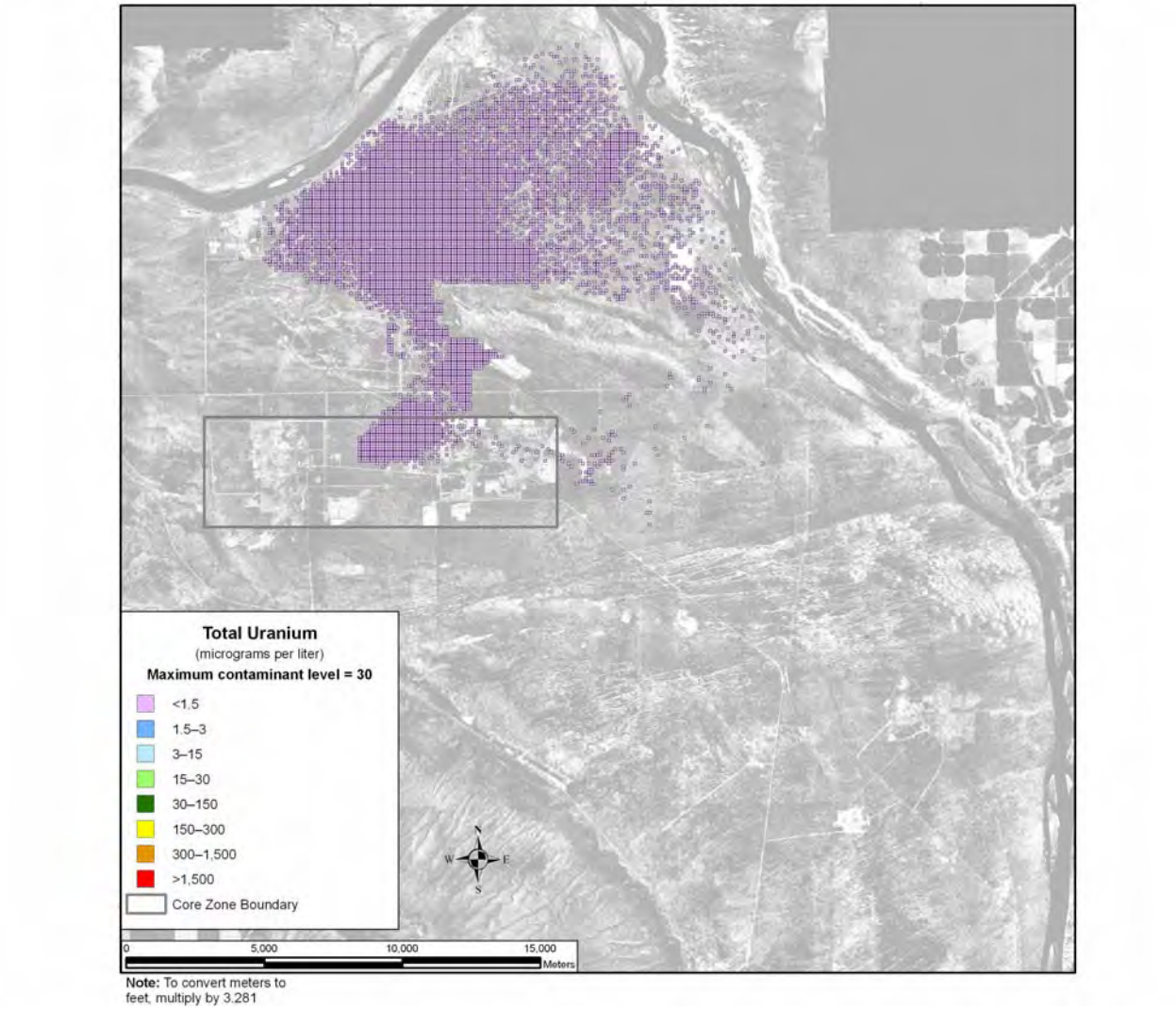


Figure 5–612. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, released iodine-129 is the major source of this risk. The analysis indicates that the concentrations of the COPCs at these points decrease to levels significantly below the benchmark concentrations through CY 11,885.

As for the conservative tracers, there are small, isolated areas near the outer Core Zone Boundary in which high concentrations appear not to dissipate; they remain high through the end of the period of analysis. The release of total uranium appears fairly homogeneous between the release source and the Columbia River nearshore. Although the concentration in this plume is well below the benchmark, total uranium remains in the environment and trends shows an increasing concentration through the end of this analysis period (CY 11,885).

5.3.1.2.2.3 Disposal Group 2, Subgroup 2-B, Option Case

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, includes Tank Closure Alternative 6B, Option Case; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste. Summaries of the actions and timelines for Waste Management Alternative 2 are provided in Chapter 2, Section 2.5.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E:

- The disposal period starts with the onset of disposal operations for IDF-East and the RPPDF in CY 2009 and continues through CY 2100. During this disposal period, the materials in these permitted, operational facilities are assumed to be unavailable for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, IDF-East and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and acetonitrile

The COPC drivers for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazards drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, chromium, nitrate, and acetonitrile) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2 Subgroup 2-B, Option Case, in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has seven subtotals plotted representing releases from ETF-generated secondary waste, Preprocessing Facility (PPF) glass, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary and onsite-generated waste, and offsite-generated waste.

Figure 5–613 shows the release to the vadose zone for the radiological risk drivers and Figure 5–614, chemical hazard drivers. The inventories in the waste forms are a major factor in the quantities released to the vadose zone. The predominant source of technetium-99 in the vadose zone is offsite-generated waste (77 percent), followed by tank closure secondary waste (19 percent), and ETF-generated secondary waste (4 percent). The sources of the iodine-129 release are offsite-generated waste (85 percent) and ETF-generated secondary waste (14 percent). The chromium release is from the tank closure secondary waste (85 percent), waste management secondary and onsite-generated waste (8 percent) offsite-generated waste (4 percent), ETF-generated secondary waste (2 percent), and PPF glass (1 percent). All of the nitrate released is from ETF-generated secondary waste. There is no acetonitrile from any of the waste forms in IDF-East.

Figure 5–615 shows the release to groundwater for the radiological risk drivers and Figure 5–616, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the vadose zone technetium-99 (89 percent), iodine-129 (91 percent) and all of the chromium and nitrate are released to groundwater during the period of analysis.

Figure 5–617 shows the release to the Columbia River for the radiological risk drivers and Figure 5–618, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most of the groundwater technetium-99 (97 percent), iodine-129 (97 percent), chromium (97 percent), and nitrate (>99 percent) are released to the Columbia River over the period of analysis.

Overall, most of the vadose zone technetium-99 (86 percent), iodine-129 (89 percent), chromium (96 percent), and nitrate (98 percent) from IDF-East is released to the Columbia River. These releases are identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

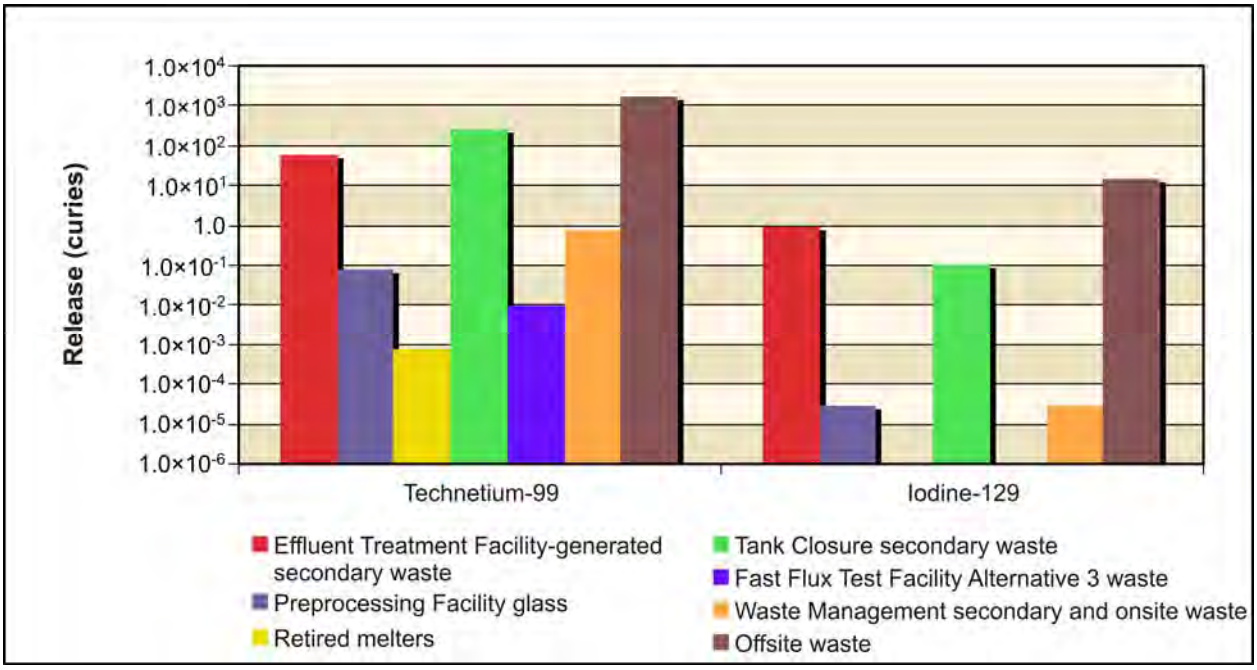


Figure 5–613. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

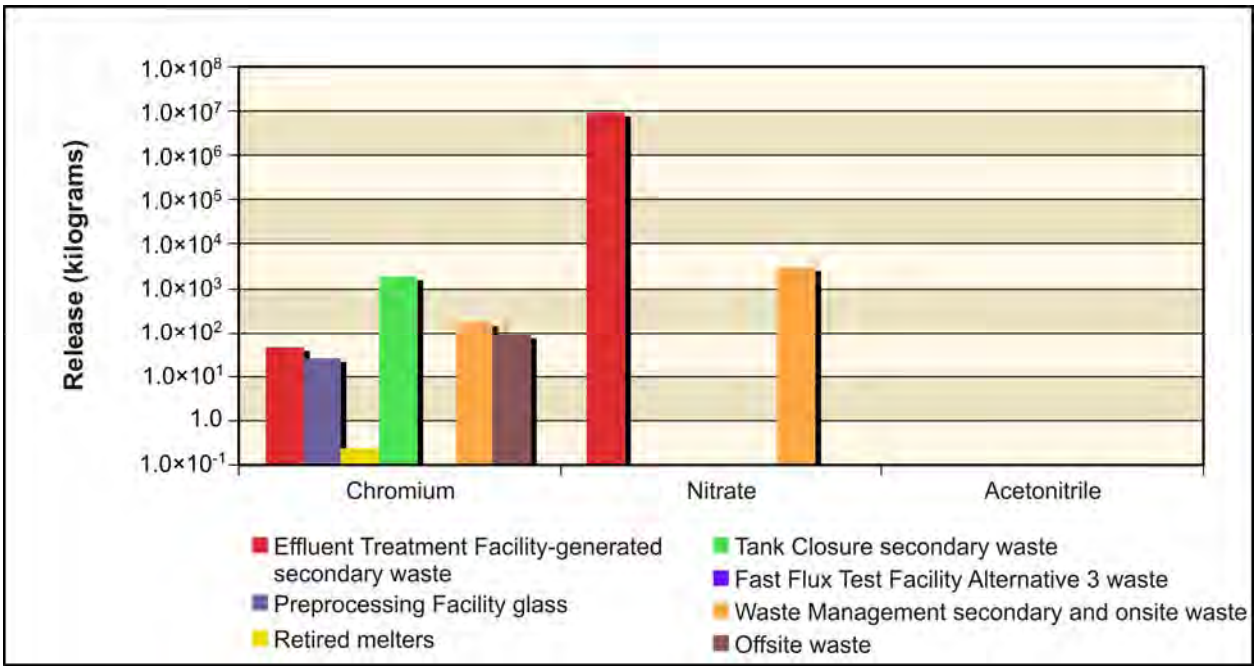


Figure 5–614. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

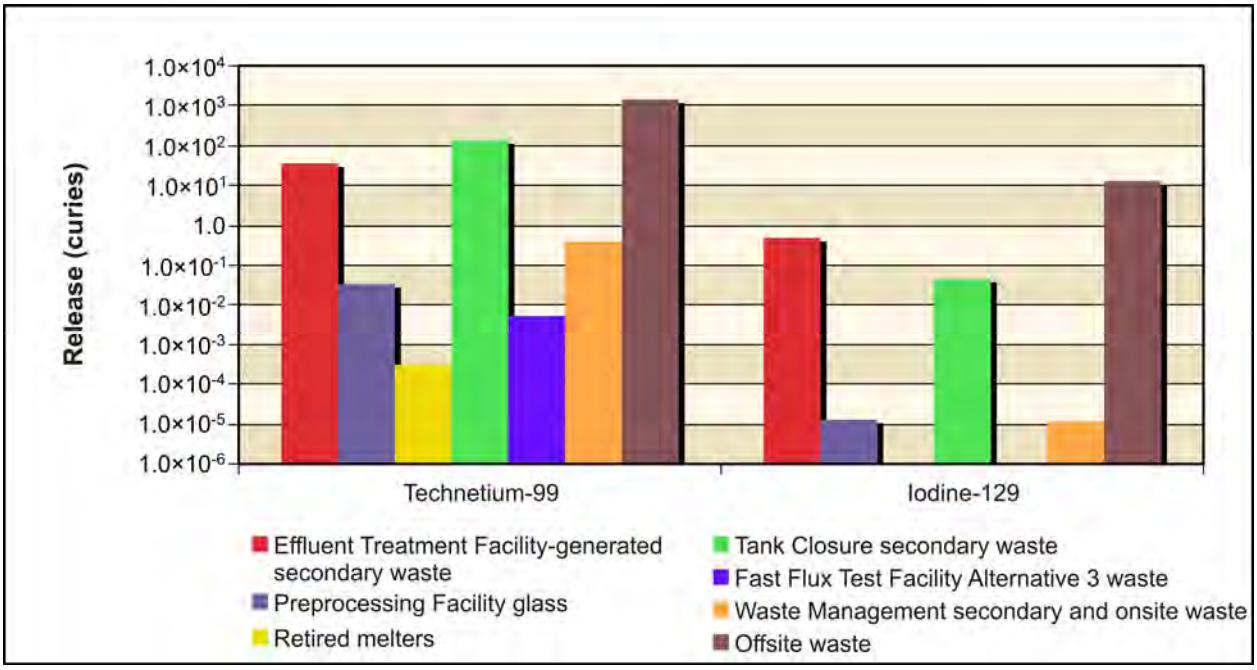


Figure 5–615. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

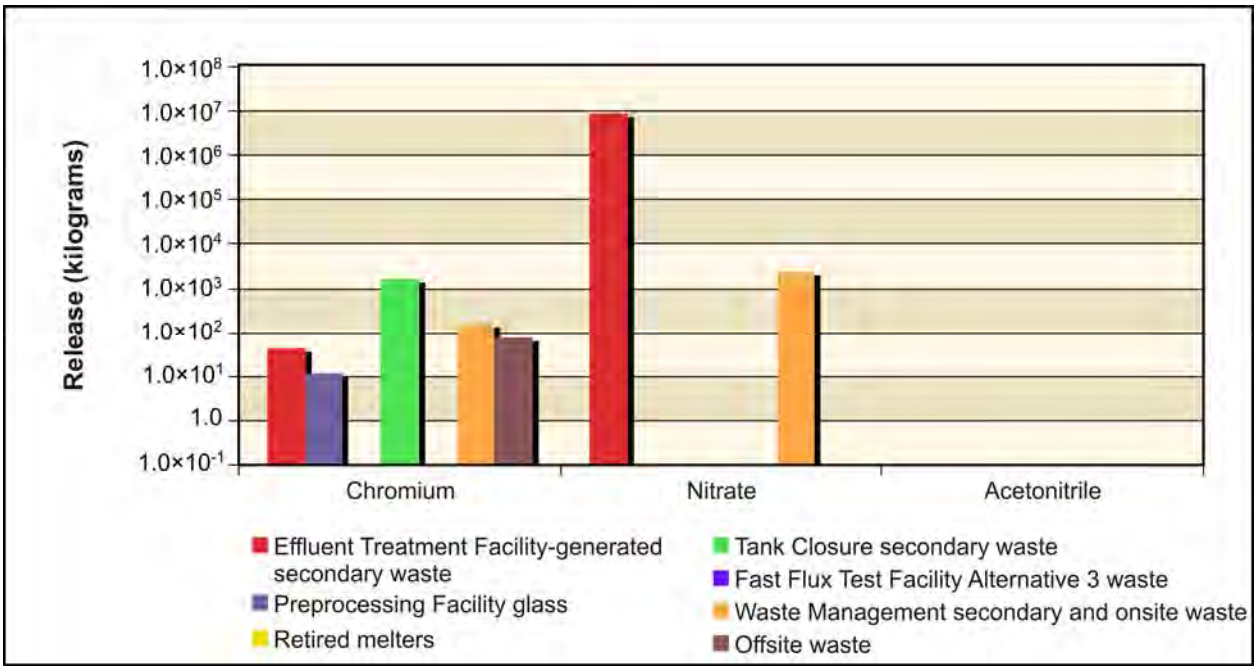


Figure 5–616. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

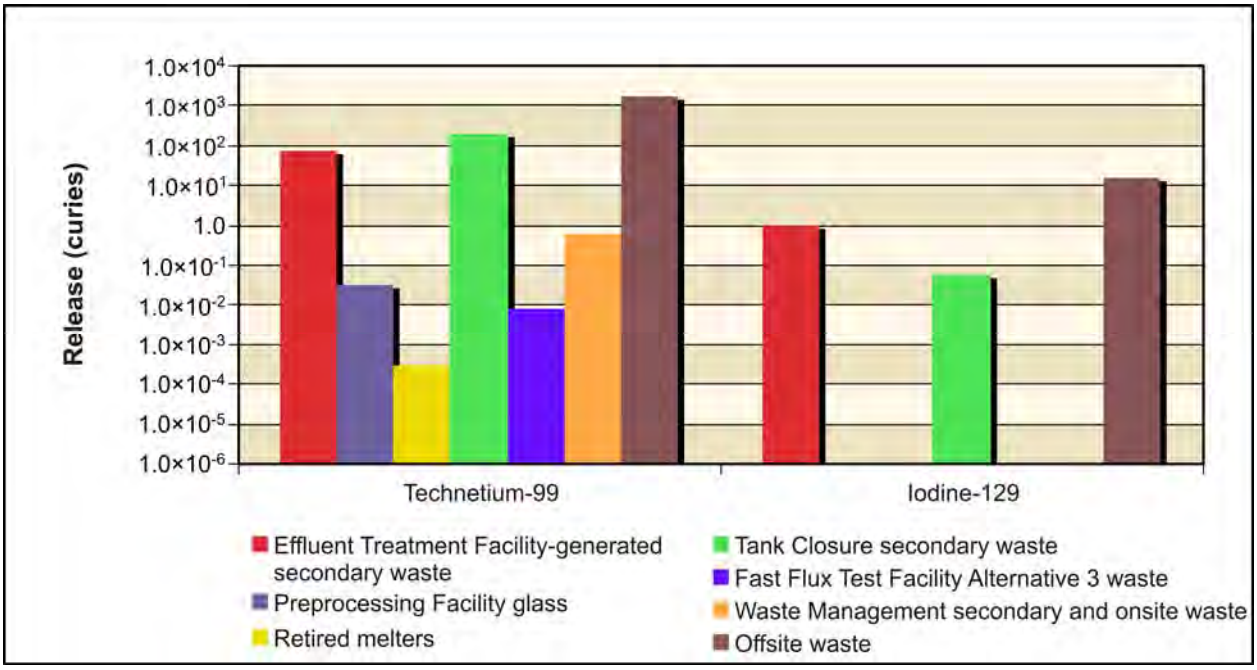


Figure 5–617. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

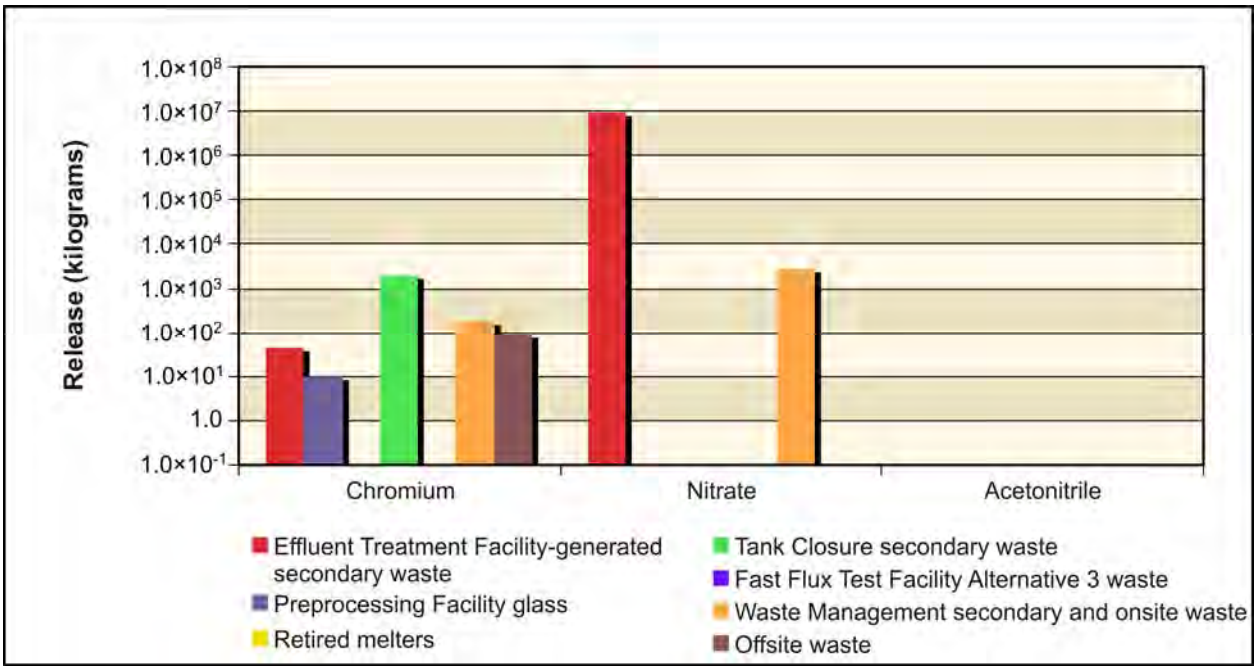


Figure 5–618. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–619 shows the release to the vadose zone for the radiological risk drivers and Figure 5–620, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant releases from the RPPDF are technetium-99 and iodine-129, with technetium-99 being the predominant radionuclide released. The chemical releases from the RPPDF include nitrate (largest), chromium, and acetonitrile (smallest).

Figure 5–621 shows the release to groundwater for the radiological risk drivers and Figure 5–622, the chemical hazard drivers. In addition to the inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the RPPDF vadose zone technetium-99, iodine-129, chromium, nitrate, and acetonitrile is released to groundwater.

Figure 5–623 shows the release to the Columbia River for the radiological risk drivers and Figure 5–624, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. All of the RPPDF groundwater iodine-129, technetium-99, chromium, nitrate, and acetonitrile, is released to the Columbia River.

Overall, about 95 percent of the RPPDF vadose zone radionuclides and chemicals are released to the Columbia River during the period of analysis. This release is almost identical to that identified for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

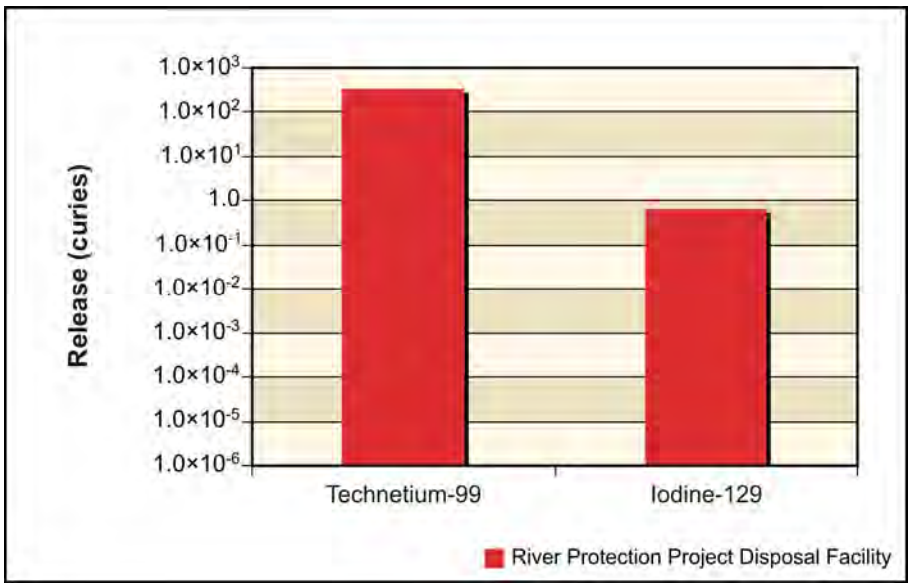


Figure 5–619. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

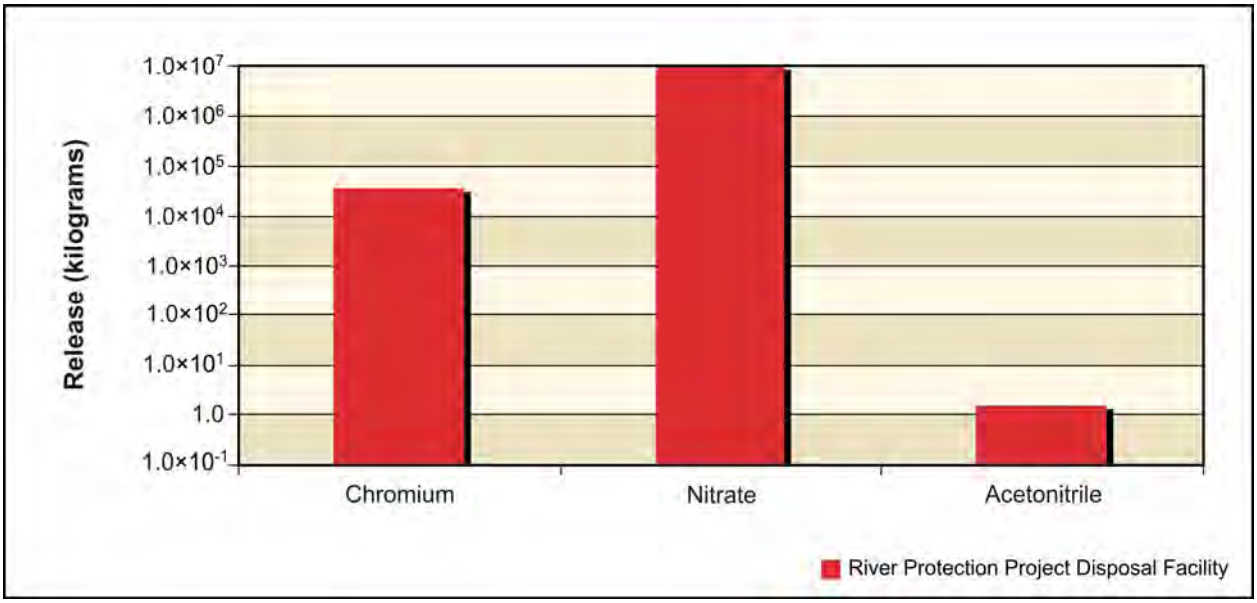


Figure 5–620. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

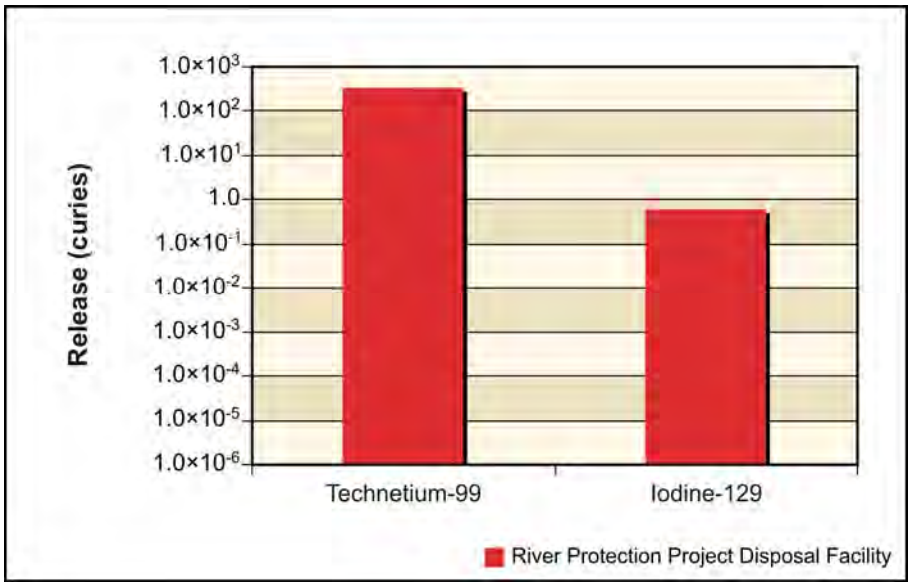


Figure 5–621. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

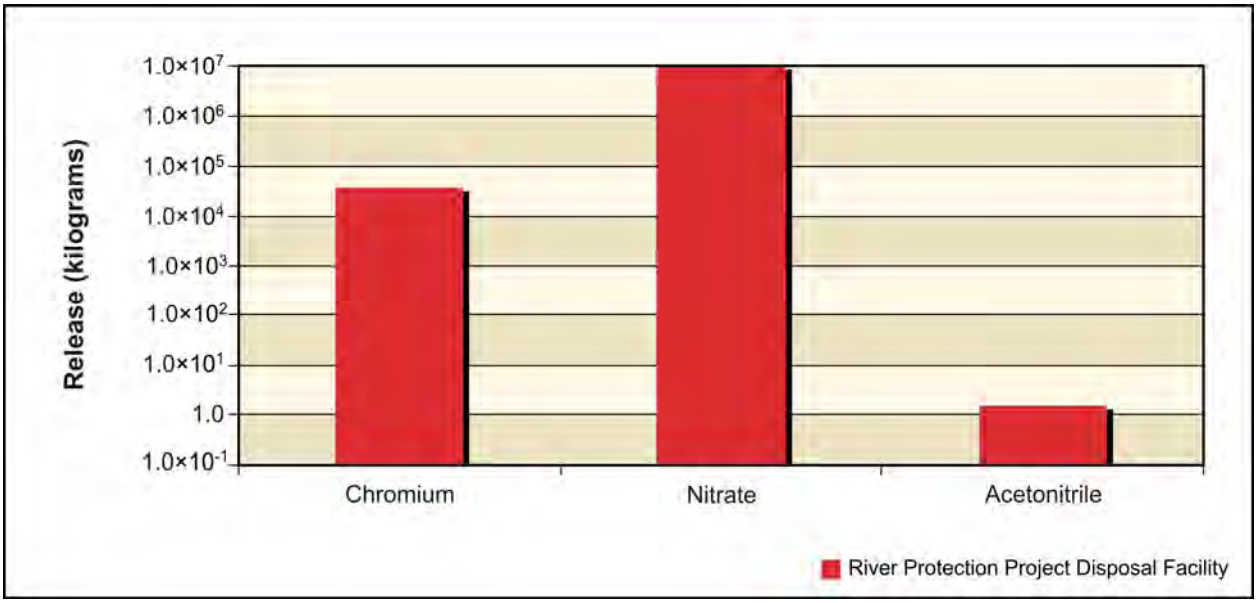


Figure 5–622. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

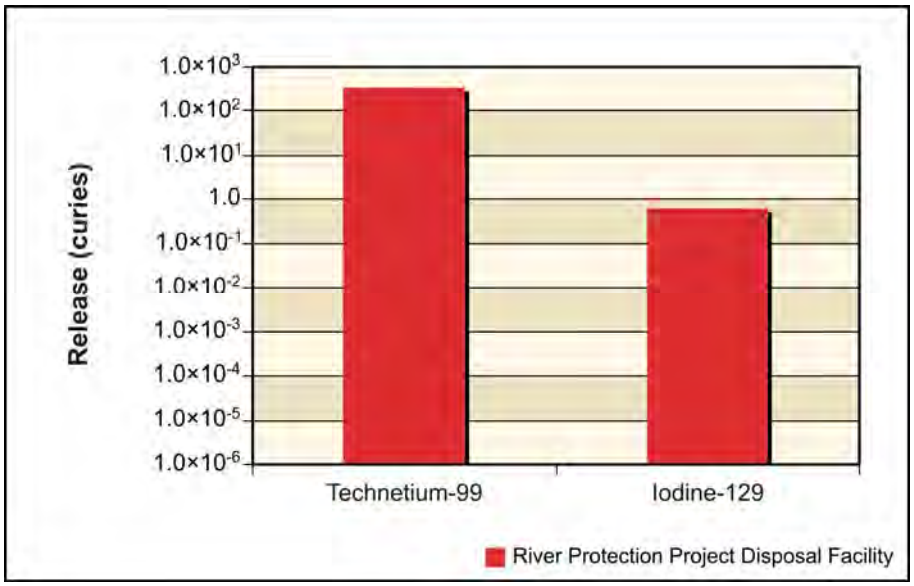


Figure 5–623. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

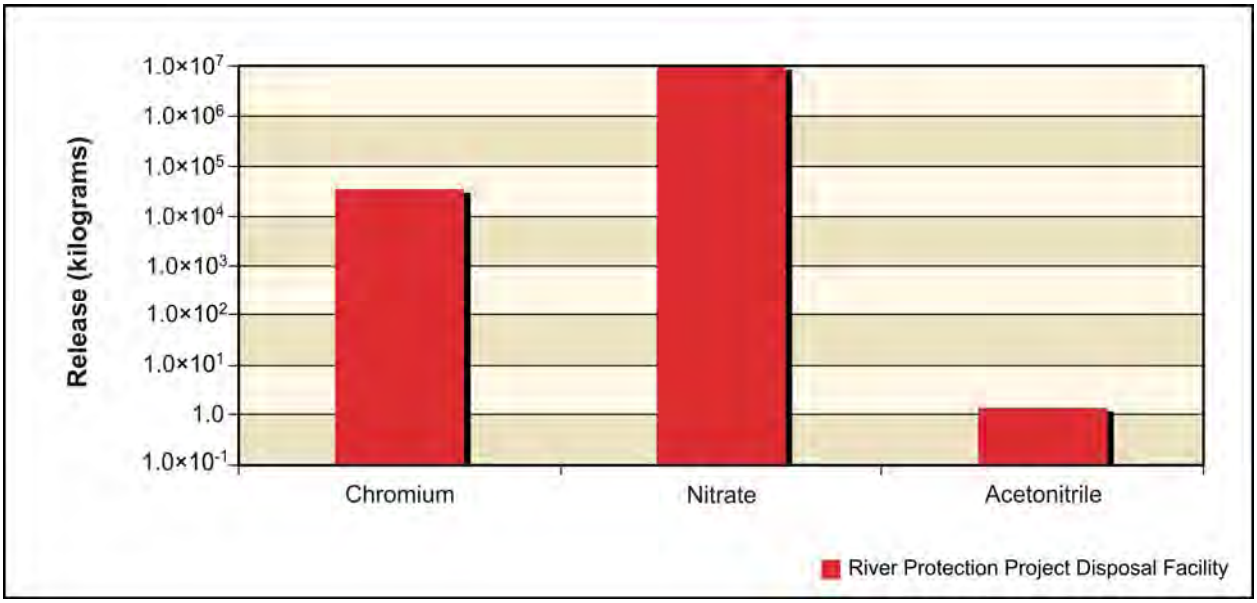


Figure 5–624. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, in terms of groundwater concentration versus time at the Core Zone Boundary, and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. The concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Table 5–86 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary and Columbia River nearshore.

Table 5–86. Waste Management Alternative 2, Disposal Group 2, Subgroup 2B, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,890** (8580)	340 (4213)	**1,350** (4466)	717 (8477)	900
Iodine-129	**24** (9058)	0.6 (4176)	**10** (9188)	**6** (9652)	1
Chemical in micrograms per liter					
Chromium	3 (8281)	33 (4118)	97 (10533)	17 (5522)	100
Nitrate	16,600 (8162)	9,070 (3962)	28,400 (9305)	5,700 (4618)	45,000

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–625 through 5–628 show concentration versus time for technetium-99, iodine-129, nitrate, and chromium, respectively. With the exception of nitrate, the concentrations versus time are essentially identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

The concentration of technetium-99 (see Figure 5–625) is below the benchmark at the Core Zone Boundary and the Columbia River nearshore. The technetium-99 concentrations remains fairly constant for most of the analysis period and then decreases through CY 11,940, staying within about one order of magnitude from the benchmark. Figure 5–626 shows iodine-129 exceeding benchmark concentrations starting at about CY 5940 and continuing through CY 11,940 at both the Core Zone Boundary and the Columbia River nearshore. This concentration peaks during the last one-third of the analysis period and then declines, reaching the benchmark concentration at about CY 11,940.

Nitrate concentrations at the Core Zone Boundary and Columbia River nearshore peak near the start of the analysis period (see Figure 5–627). Both concentrations then decrease through CY 11,885, always at least one order of magnitude below the benchmark concentration. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, shows a similar nitrate release, but with a peak about three-quarters of the way through the analysis period and then a decline to the benchmark concentration at about CY 11,885.

Figure 5–628 shows that the chromium concentrations at the Core Zone Boundary and the Columbia River nearshore always remain just below the benchmark concentration. In Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, the chromium is below the benchmark by at least one order of magnitude.

Figure 5–629 shows concentration versus time for total uranium. Uranium-238 has no detectable release to the environment. Total uranium concentrations, while very low, continue to increase during the period of analysis and beyond. The total uranium concentrations remain at least six orders of magnitude below the benchmark concentration throughout the analysis period (through CY 11,940). These release concentrations are basically identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

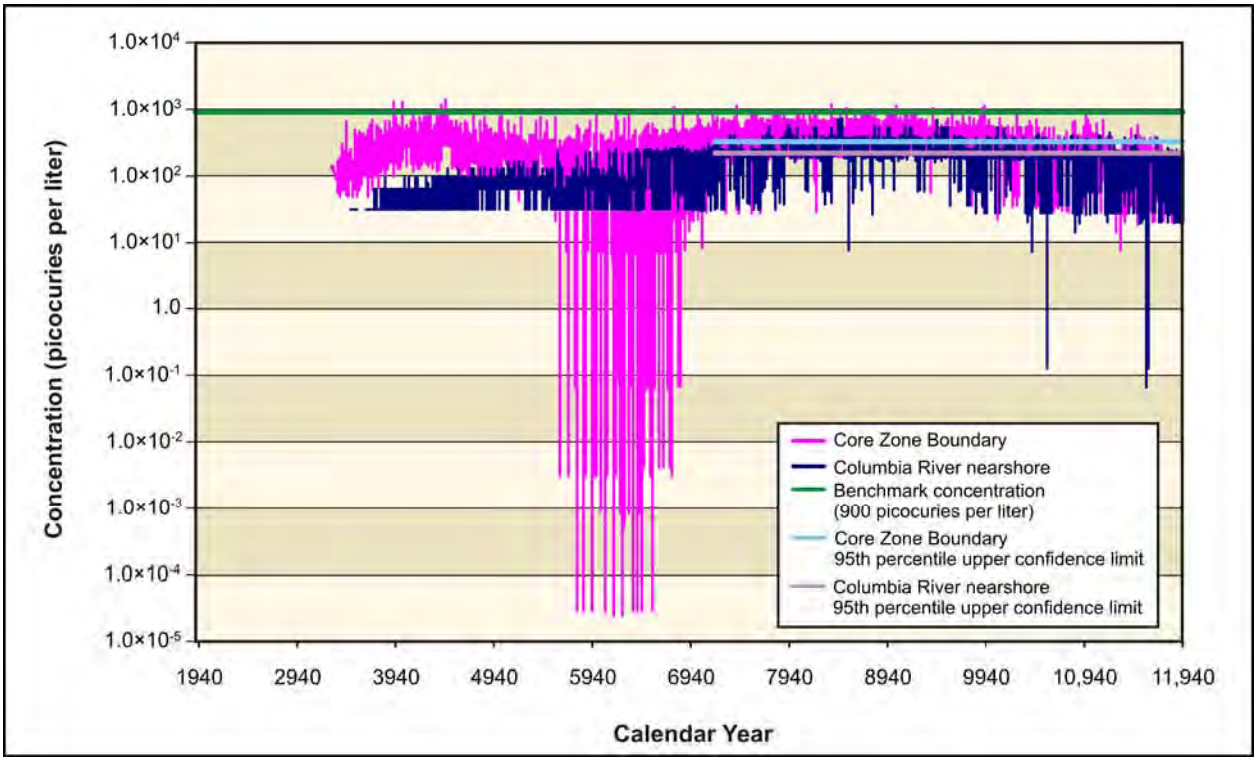


Figure 5–625. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Technetium-99 Concentration Versus Time

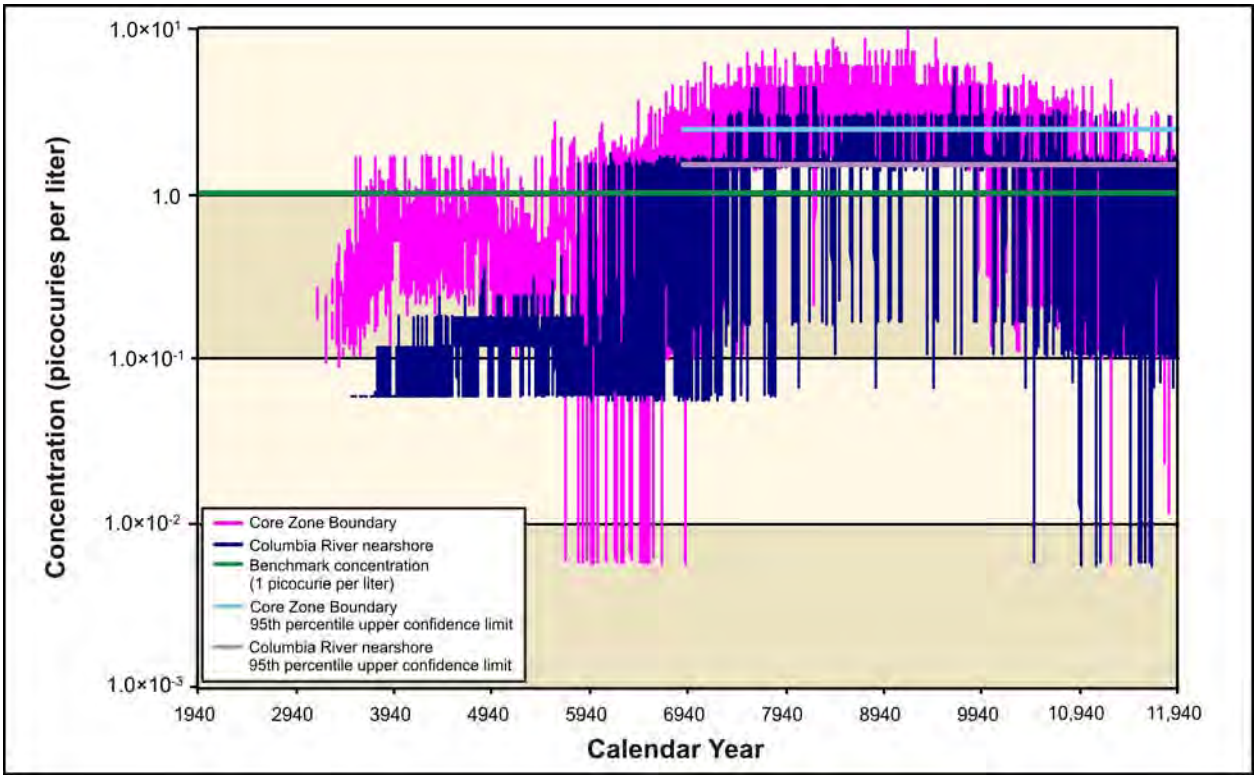


Figure 5–626. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Iodine-129 Concentration Versus Time

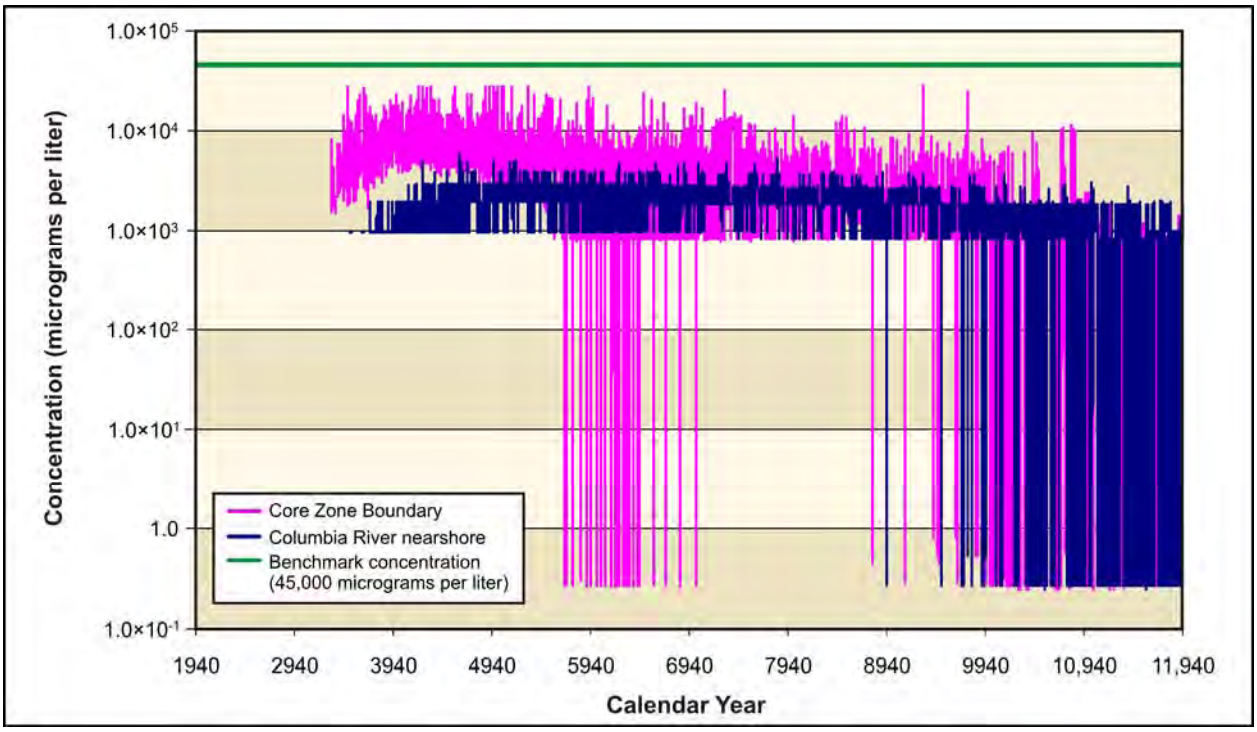


Figure 5–627. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Nitrate Concentration Versus Time

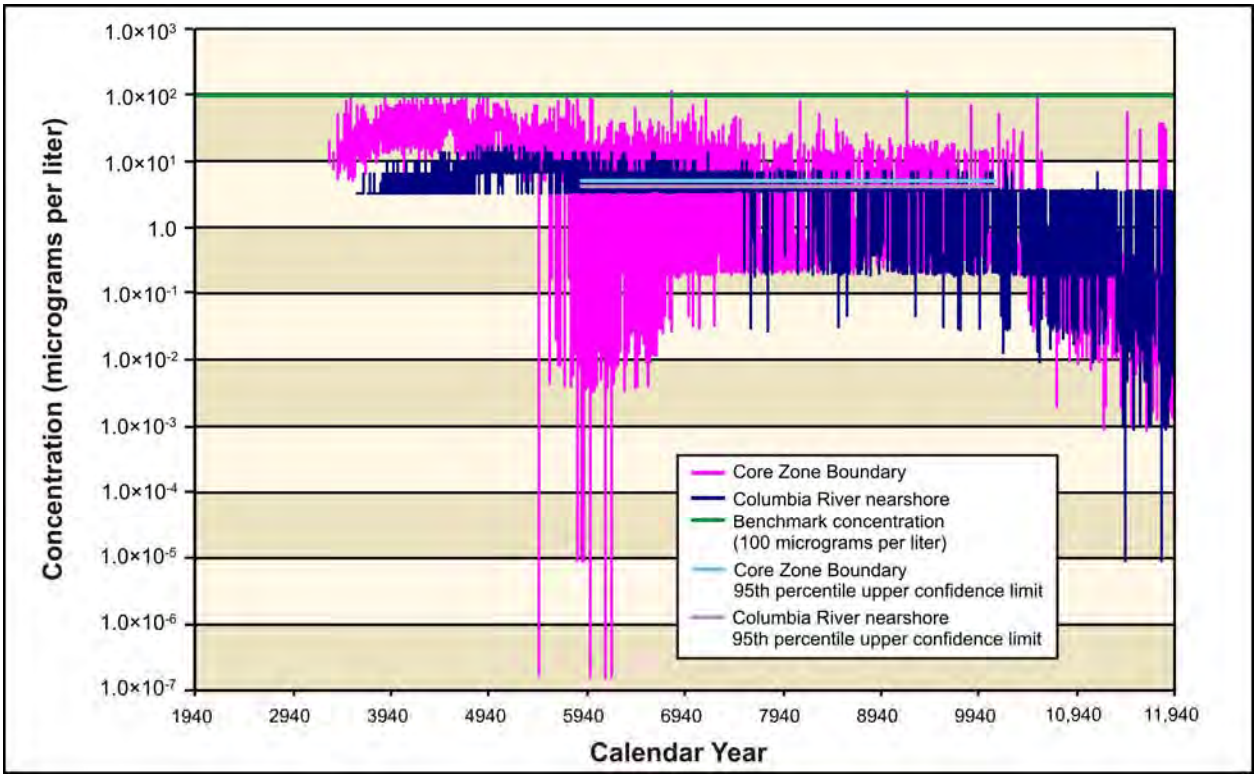


Figure 5–628. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chromium Concentration Versus Time

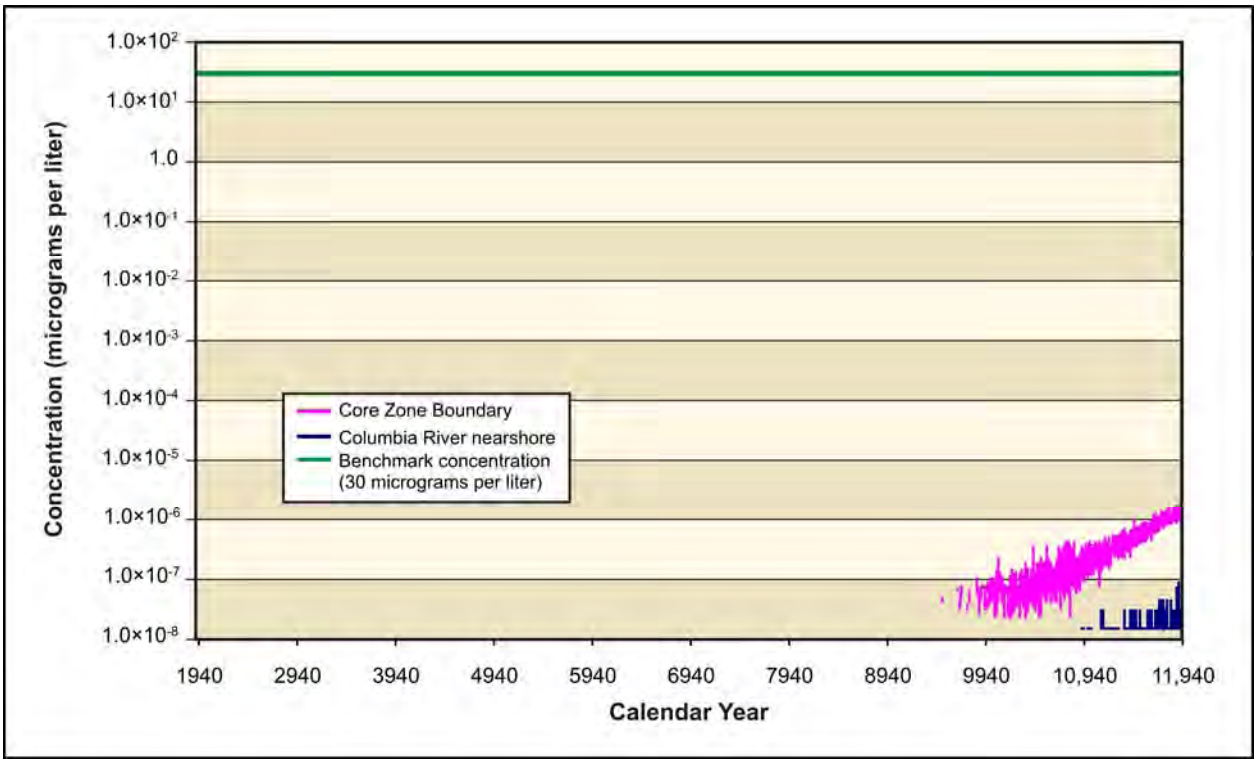


Figure 5–629. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark concentration, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–630 through 5–641 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. Figure 5–642 shows the concentration distribution of total uranium at CY 11,885. These data show that groundwater releases extend from IDF-East east to the Columbia River and from the RPPDF north to the Columbia River. The RPPDF release remains in a fairly narrow channel until about halfway to the Columbia River, where it spreads out. The IDF-East release is also contained in a narrow area until it reaches one-third the distance to the Columbia River, where it begins to spread.

Figure 5–630 (CY 3890) shows a technetium-99 releases from the RPPDF that exceeds the benchmark concentrations in small areas just outside the Core Zone Boundary. Figure 5–631 (CY 7140) shows a nearly dissipated RPPDF technetium-99 distribution, as well as several very small areas in which the concentration exceeds the benchmark. It also shows several areas in which the technetium-99 released from IDF-East approaches and potentially exceeds the technetium-99 benchmark concentration. By CY 11,885 (see Figure 5–632), the technetium-99 from the RPPDF is nearly dissipated, though there

remains a small, isolated area of high concentration. The IDF-East technetium-99 release continues through CY 11,882, but most of the concentrations remain below the benchmark.

Figures 5–633 through 5–635 show similar concentration distributions of iodine-129 from the RPPDF and IDF-East, the RPPDF plume extending to the north from the Core Zone and the IDF-East plume to the east. Figure 5–633 shows an RPPDF plume at CY 3890 and but no IDF-East plume; it only becomes visible later. Figure 5–634 shows the dissipation of the RPPDF iodine-129 plume and a significant IDF-East plume. A small area (pocket) of high-concentration RPPDF iodine-129 remains and an area of IDF-East iodine-129 in concentrations higher than the benchmark has developed to the east of the Core Zone Boundary. Figure 5–635 (CY 11,885) shows a nearly dissipated RPPDF iodine-129 plume and the small higher-concentration area. It also shows an expanded IDF-East iodine-129 distribution and an area in which the iodine-129 exceeds the benchmark concentration. The spatial distributions of technetium-99 and iodine-129 over the analysis period are nearly identical to those of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

Figures 5–636 through 5–638 show plume maps (time, space, and concentration) for nitrate releases from the RPPDF and IDF-East that are similar to those for technetium-99 and iodine-129 releases. In isolated areas north of the Core Zone Boundary, the RPPDF-released nitrate concentrations exceed the benchmark concentrations, a circumstance not observed in Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, nitrate releases. There is also a small area of high nitrate concentration from the RPPDF release that appears to continue through CY 11,885.

The chromium release shown in Figures 5–639 through 5–641 is nearly identical to the nitrate release in time and spatial ranges. The RPPDF release distribution includes a small area in which the chromium concentration exceeds the benchmark through CY 11,885. The IDF-East chromium release never reaches the benchmark, but the distribution continues through CY 11,885. In Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, the nitrate high-concentration areas dissipate more rapidly and are below the benchmark concentration by CY 11,885.

Figure 5–642 shows the concentration distribution for total uranium released from the RPPDF for CY 11,885. The released total uranium produces a fairly homogeneous distribution between the release source and the Columbia River nearshore. The distribution concentration is consistently below the benchmark concentration. The retardation of total uranium yields a fairly consistent distribution between the point of release and the Columbia River. This indicates that the total uranium distribution will remain past CY 11,885. Identical results were observed for Waste Management Alternative 2, Disposal Group 2 Subgroup 2-B, Base Case.

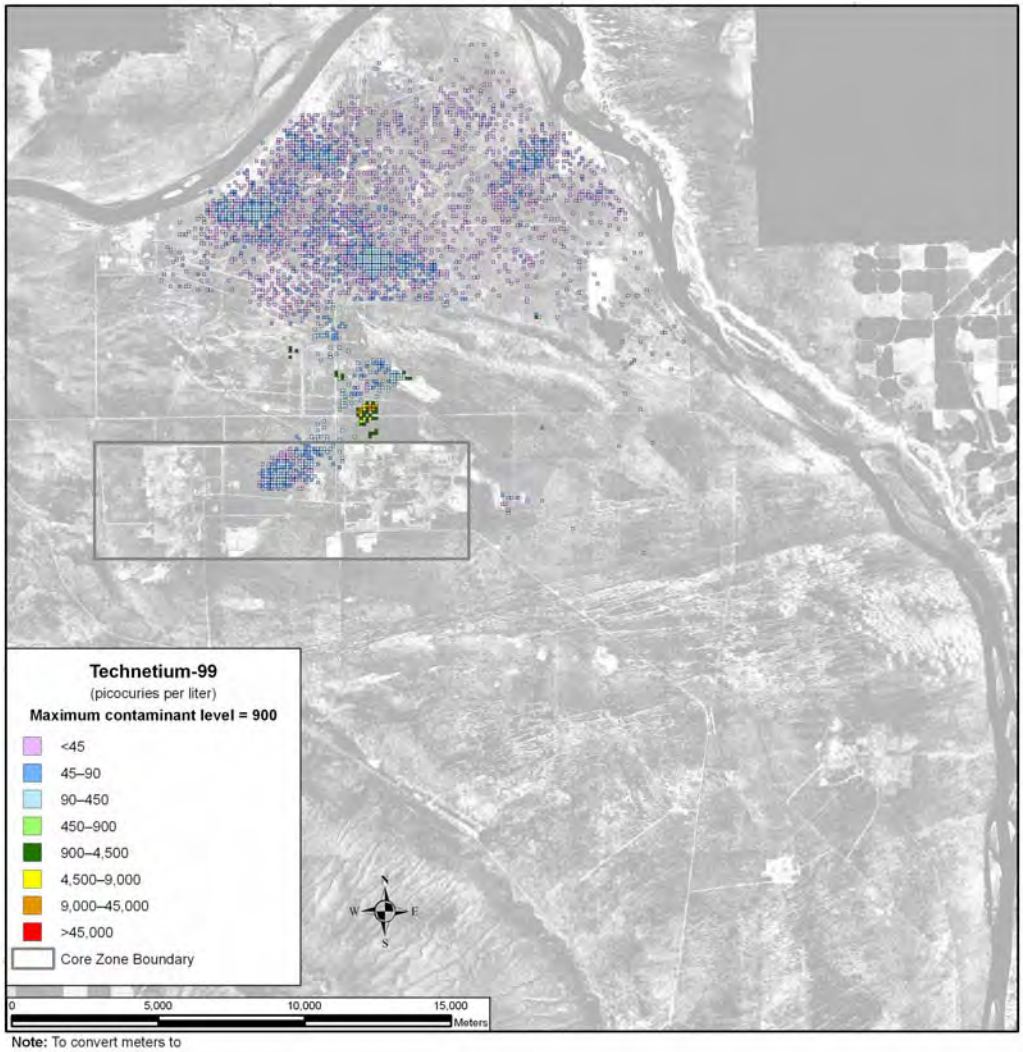


Figure 5–630. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

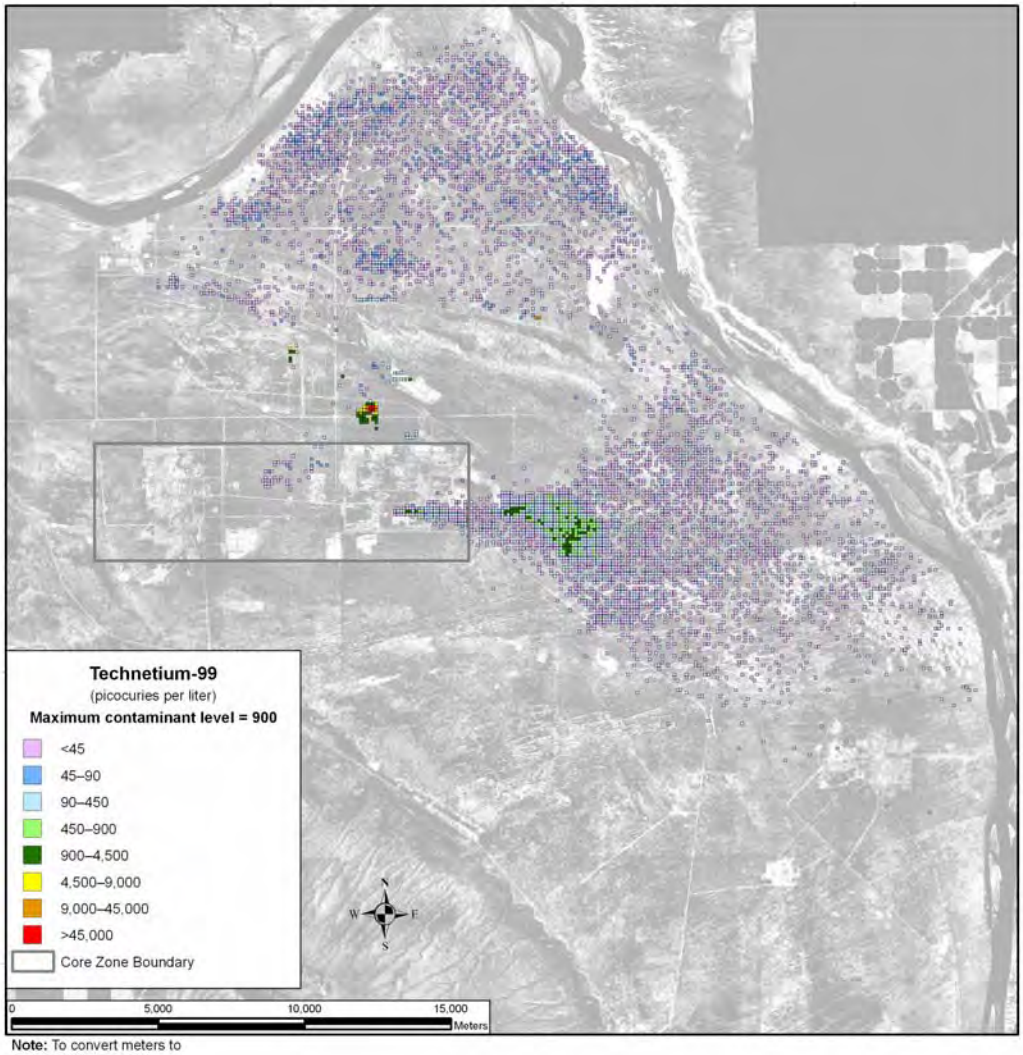


Figure 5–631. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

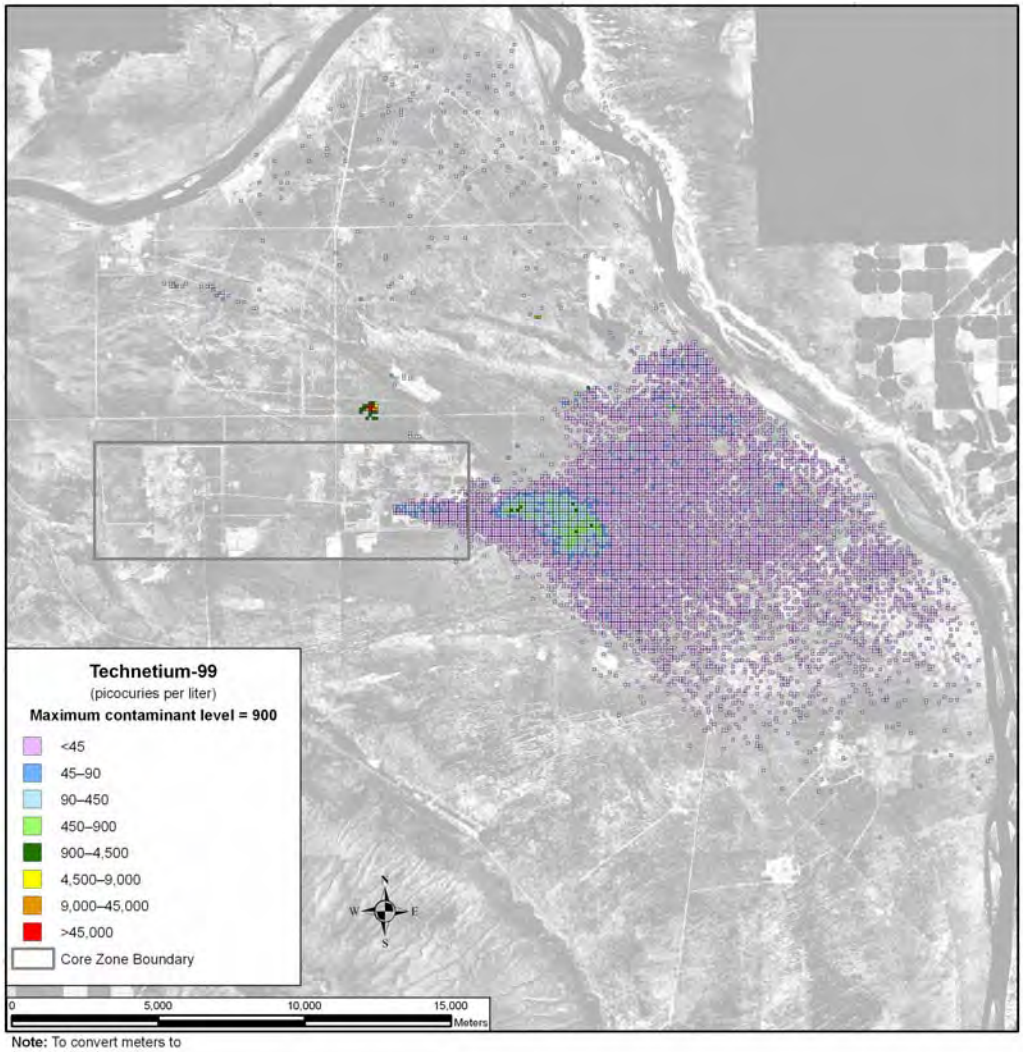


Figure 5–632. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

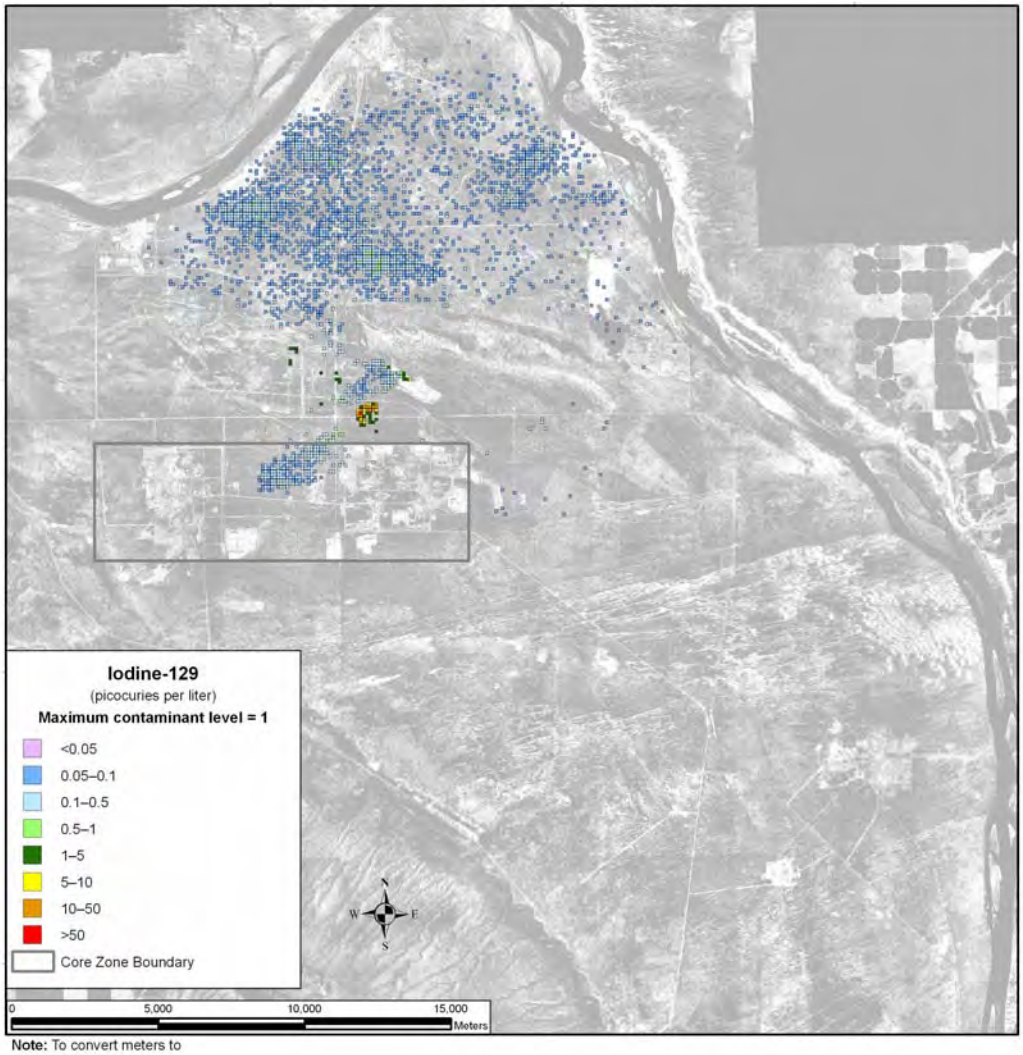


Figure 5–633. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

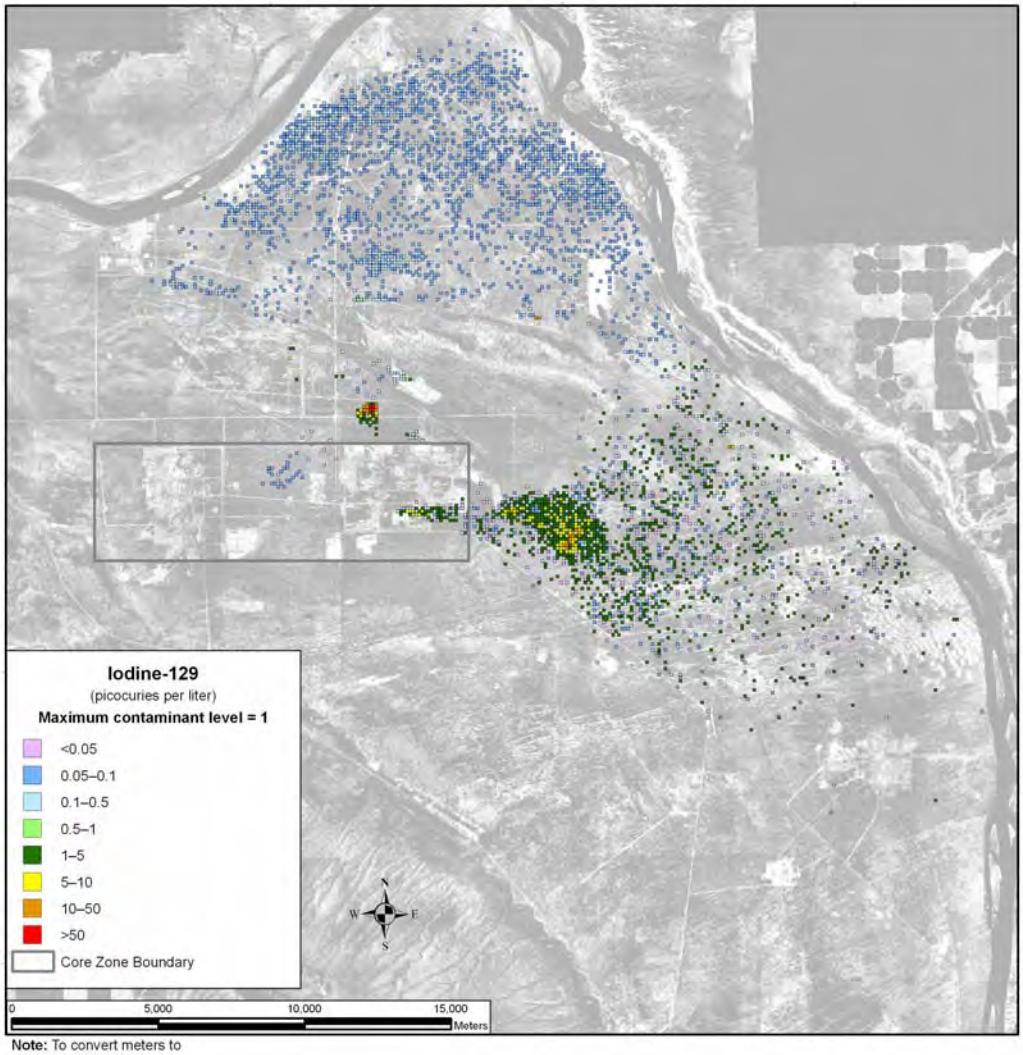


Figure 5–634. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

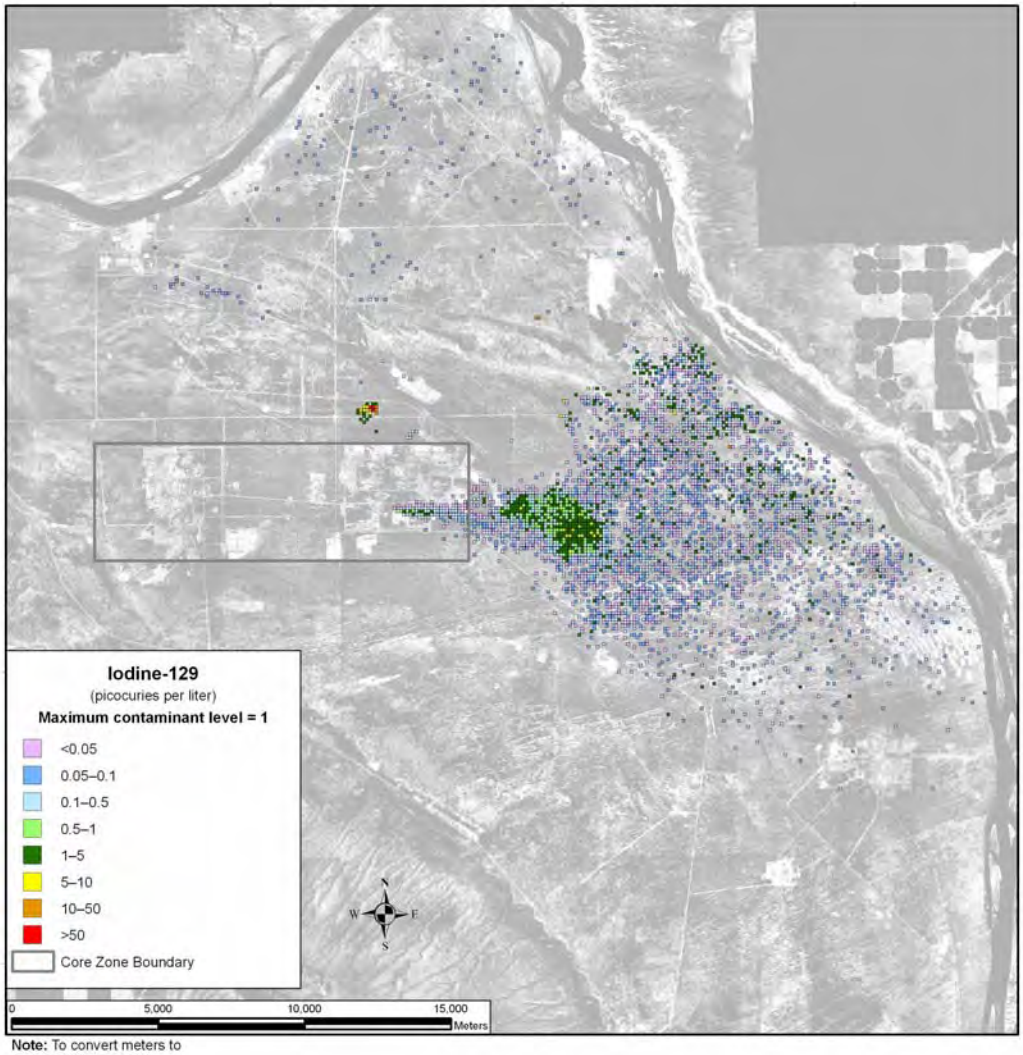


Figure 5–635. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

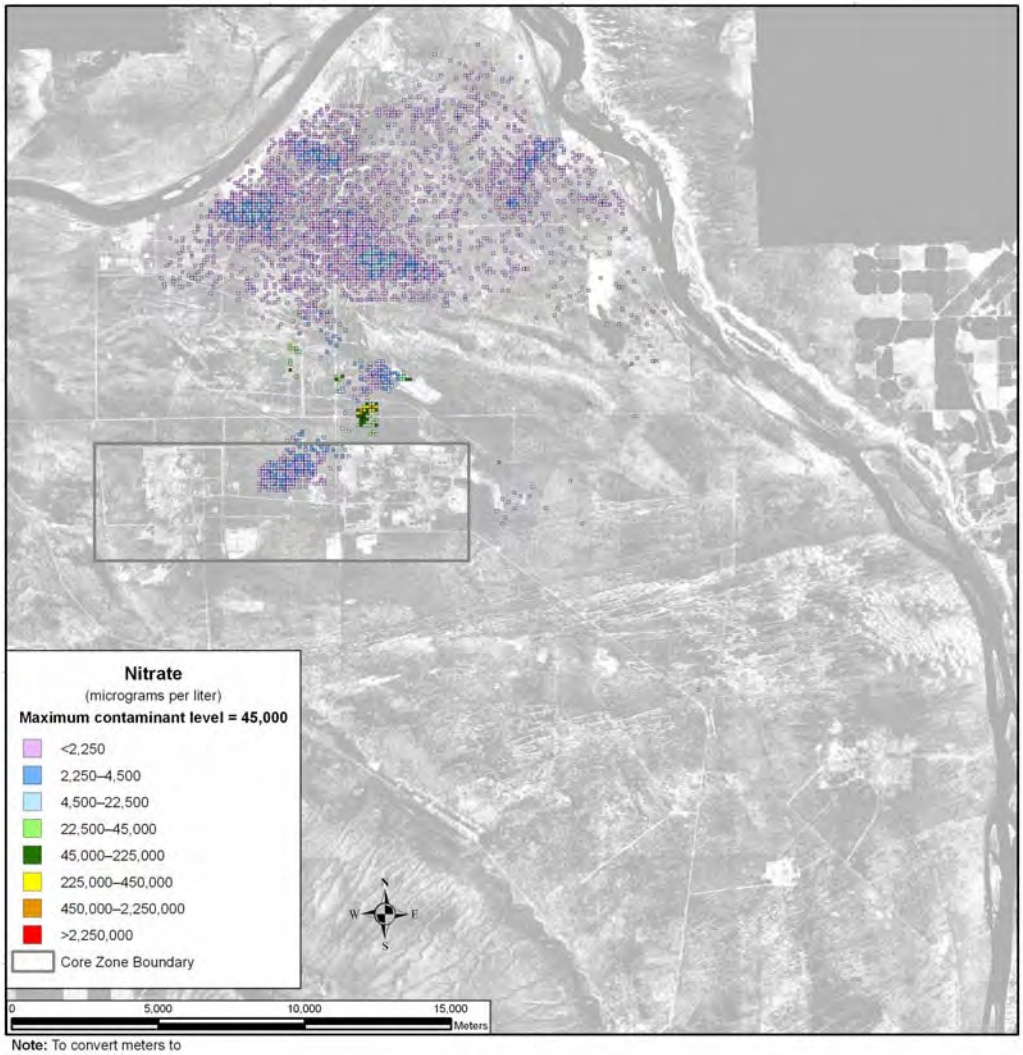


Figure 5–636. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

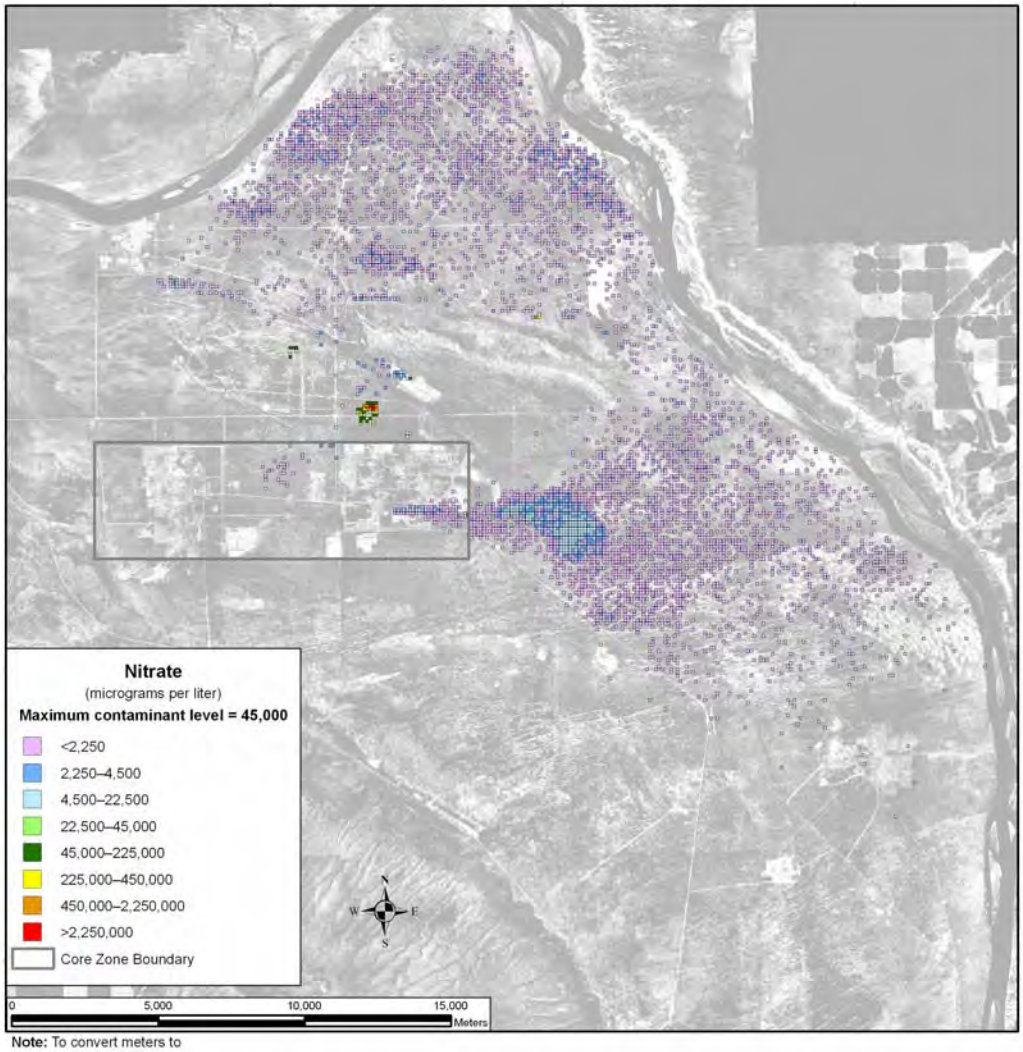


Figure 5–637. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

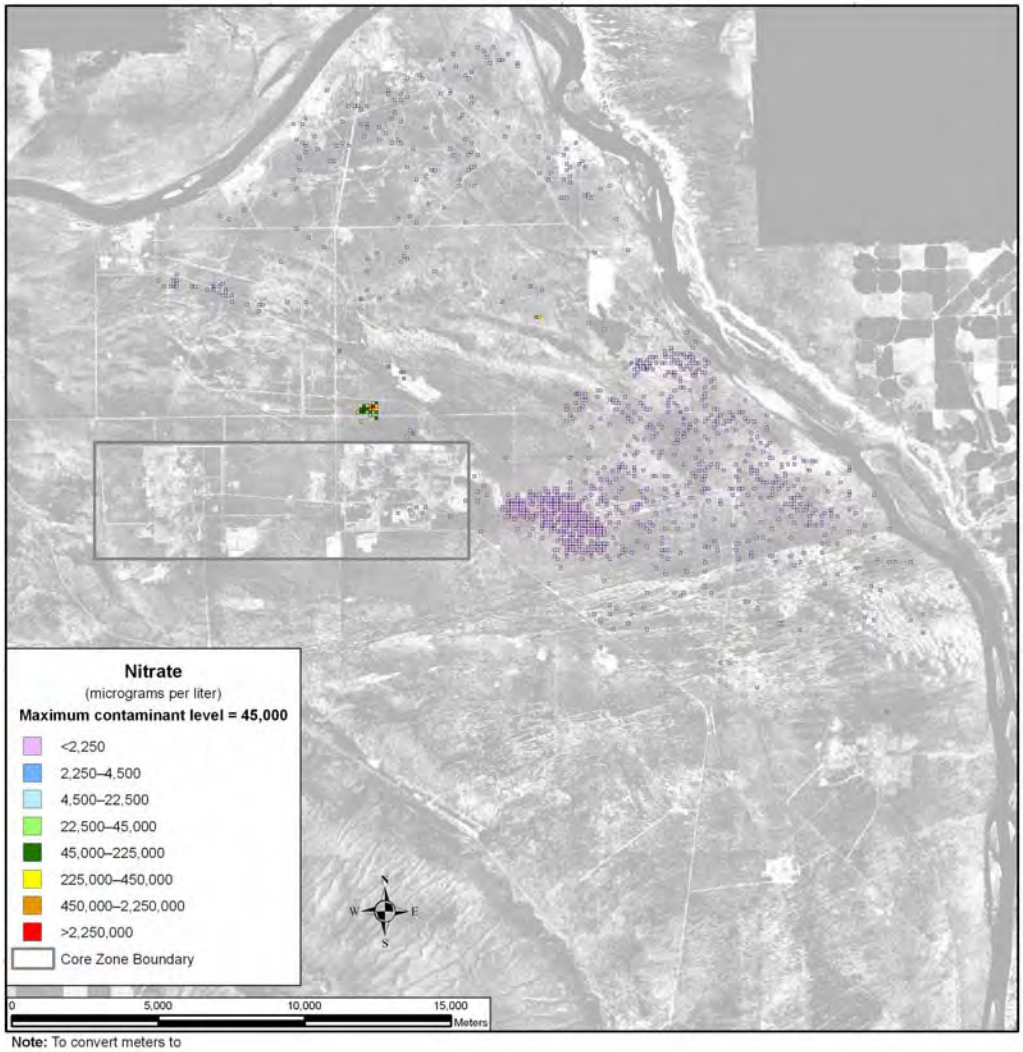


Figure 5–638. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

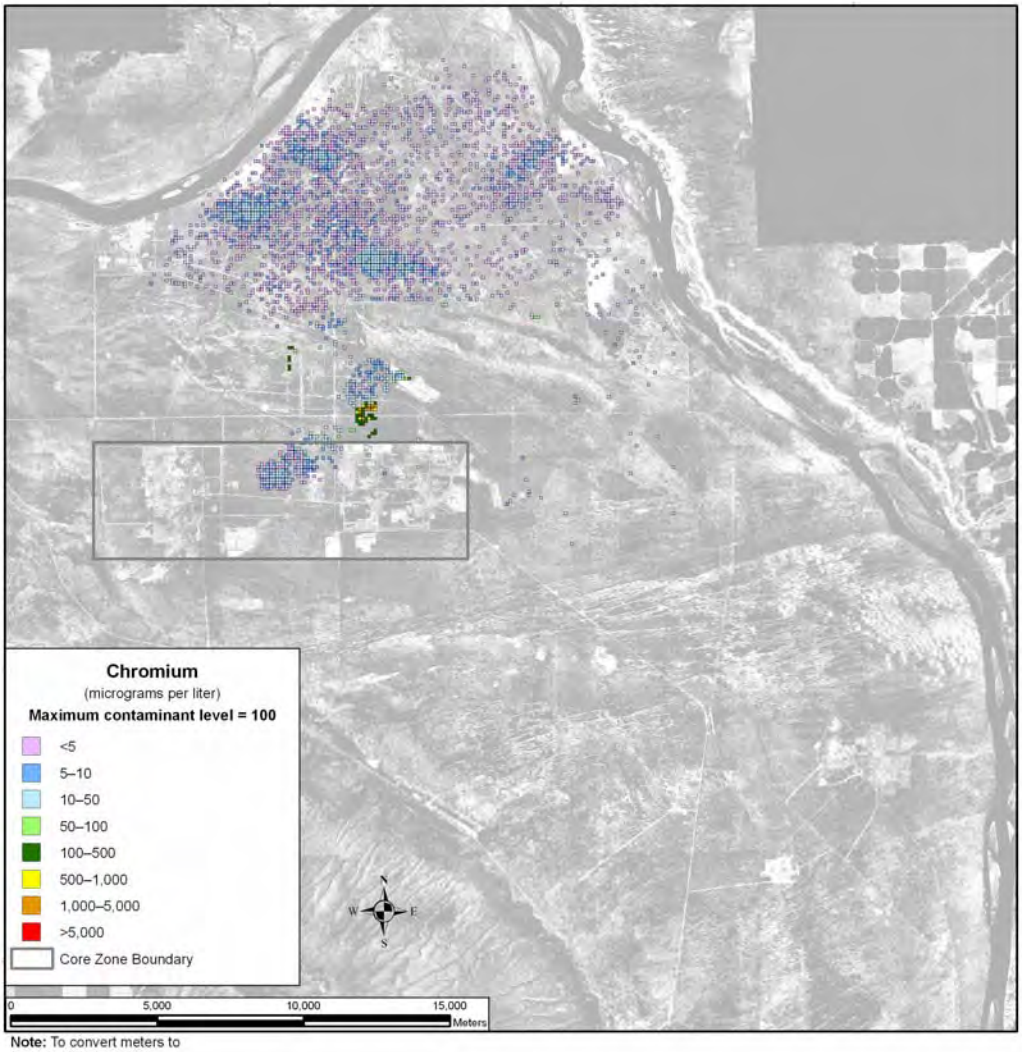


Figure 5–639. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

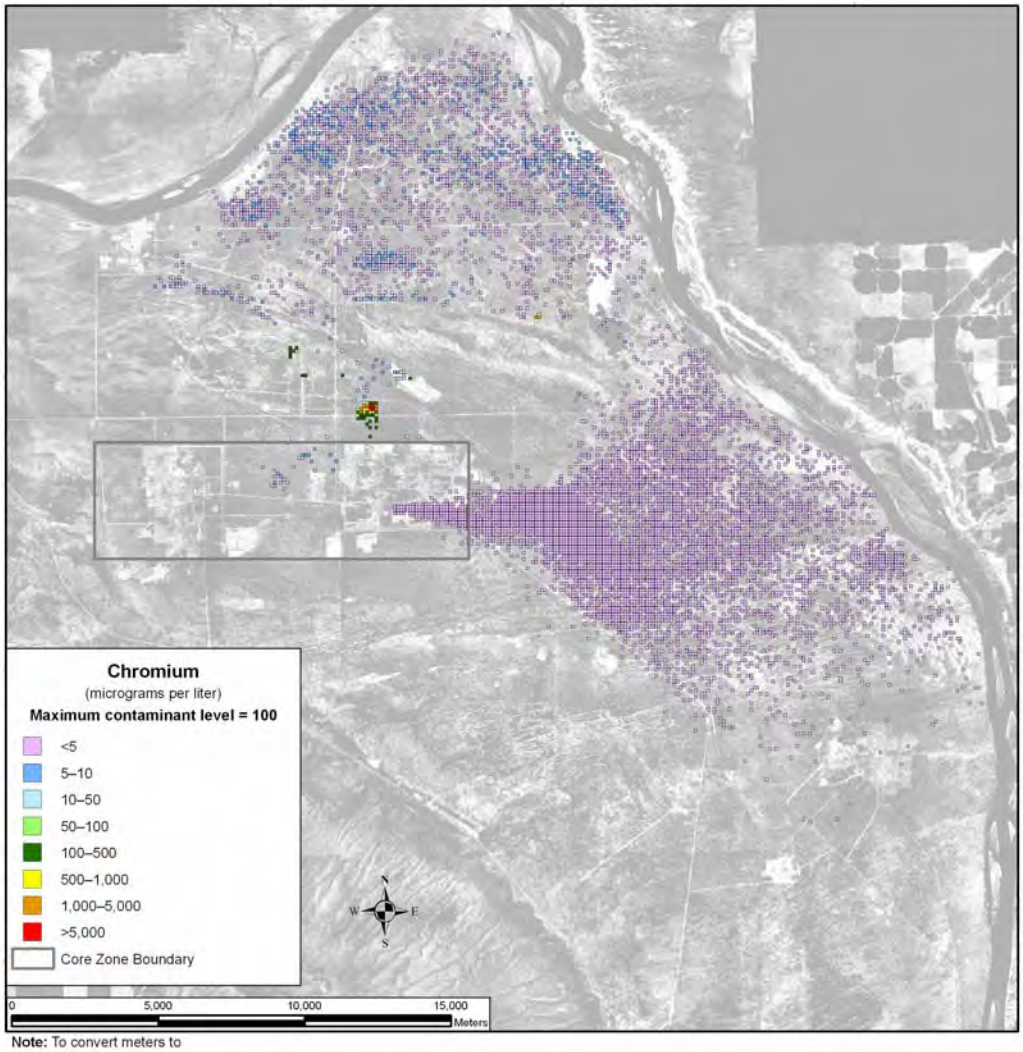


Figure 5–640. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

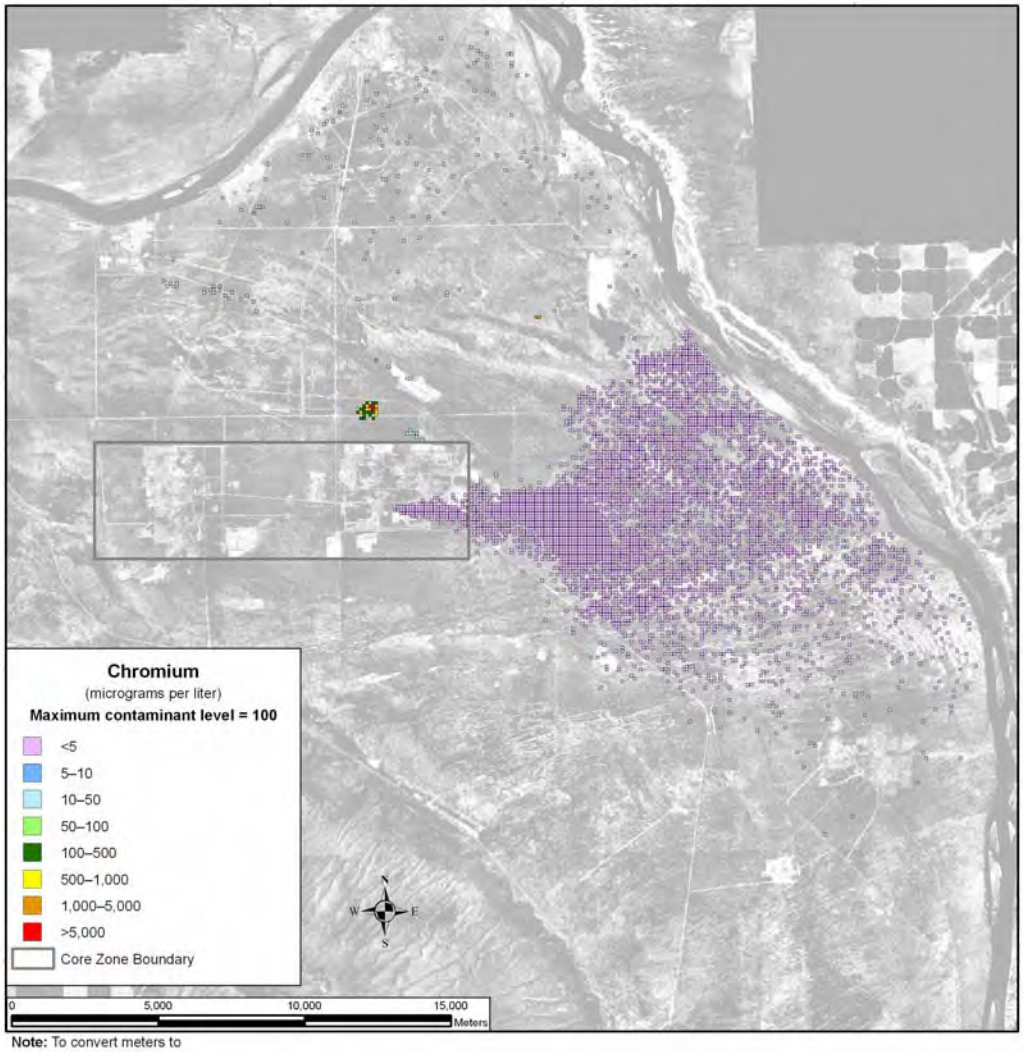


Figure 5–641. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

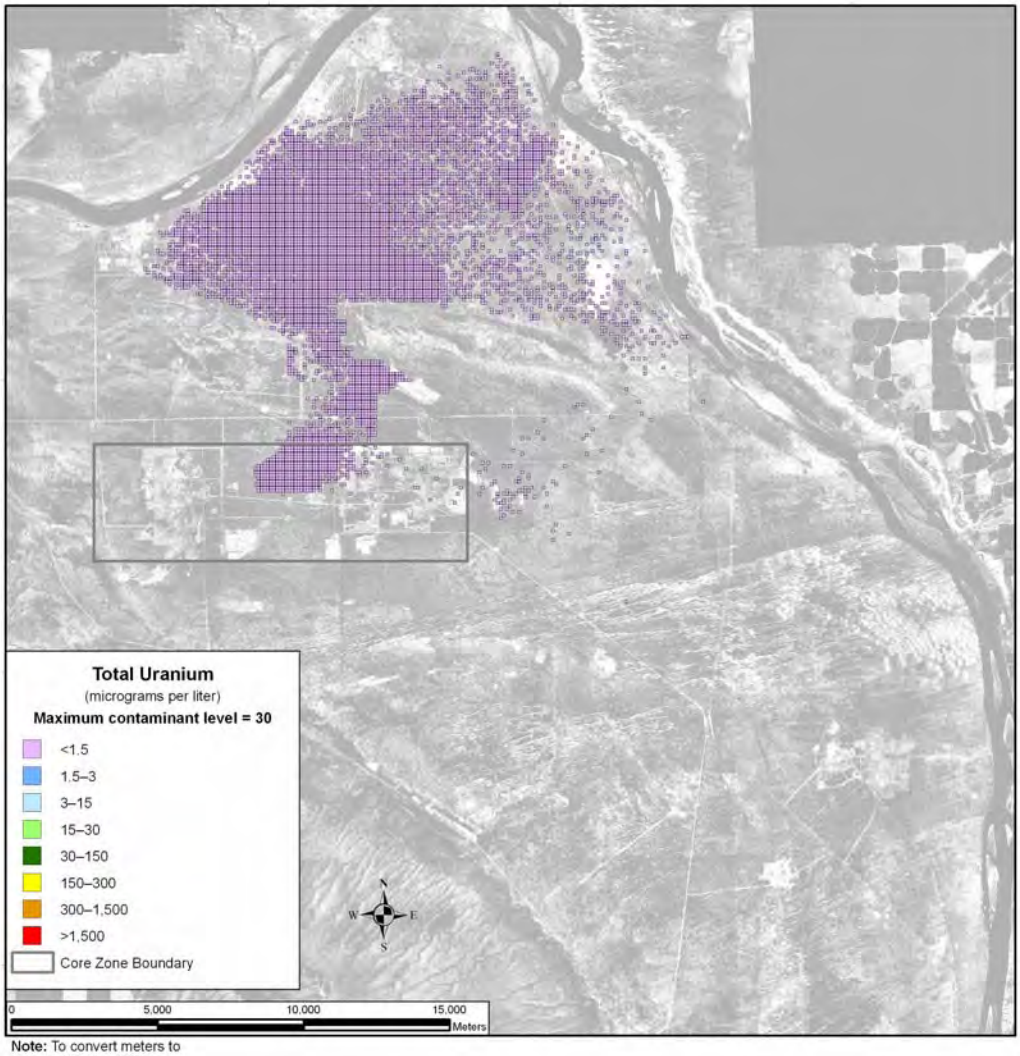


Figure 5–642. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, in general, the analysis indicates that the concentrations of the COPCs at Core Zone Boundary and the Columbia River nearshore decrease to levels significantly below the benchmark concentrations.

In small, isolated areas near the outer Core Zone Boundary, there are high concentrations of the conservative tracers that remain high (i.e., they appear not to dissipate) through the end of the period of analysis. A fairly homogeneous plume of released uranium lies between the release source and the Columbia River nearshore. Although the concentrations of total uranium are both two orders of magnitude lower than the benchmark concentrations during this analysis period, the trend appears to show a continuing increase through the end of that period.

Except for isolated areas with nitrate and chromium, the spatial and time distributions are nearly identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

5.3.1.2.3 Disposal Group 3

Disposal Group 3 is characterized by an operational completion date of CY 2165 for both IDF-East and the RPPDF. In Disposal Group 3, IDF-East has a large capacity (425,000 cubic meters [556,000 cubic yards]) and the RPPDF an even larger capacity (8,370,000 cubic meters [10,900,000 cubic yards]). These capacities are designed to meet the waste generation volumes associated with Tank Closure Alternative 6A, Base and Option Cases; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste.

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Disposal Group 3 covers Tank Closure Alternative 6A, Base and Option Cases; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste. For both the Base and Option Cases, waste will be converted to IHLW and PPF glass. IHLW would be stored on site, while PPF glass would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 2, Disposal Group 3:

- The disposal period starts with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continues through CY 2165 when these facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are unavailable for release to the environment.

- The post-disposal period starts in CY 2166 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the facilities become available for release to the environment. For purposes of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 3, IDF-East and RPPDF are assumed to be covered by a barrier limiting infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 3. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 2 is focused on the following COPC drivers:

- Radiological risk drivers: technetium-99 and iodine-129
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, total uranium, and acetonitrile

The COPC drivers for Waste Management Alternative 2, Disposal Group 3 were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 2, Disposal Group 3.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, chromium, and nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Total uranium was added to the list because it begins to appear toward the end of the period of analysis. Total uranium is long-lived or stable, but is not as mobile as the other COPC drivers; it moves about seven times more slowly than groundwater. Acetonitrile was added because of its appearance in the RPPDF. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Alternative 2, Disposal Group 3, Base and Option Cases, in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

200-East Area Integrated Disposal Facility

Seven subtotals are plotted for IDF-East representing releases from ETF-generated secondary waste, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, offsite-generated waste, steam reforming waste, retired melters, and waste management secondary and onsite-generated waste. Figure 5–643 shows the release to the vadose zone at IDF-East in the Base Case for the radiological risk drivers and Figure 5–644, the chemical hazard drivers. Technetium-99 is significantly released to the vadose zone from each on the subtotaled sources, with offsite-generated waste and tank closure secondary waste contributing the most. Iodine-129 has significant releases from five of the subtotaled sources, with offsite-generated waste and ETF-generated secondary waste contributing the most. Chromium has six significant sources, with ETF-generated secondary waste and tank closure secondary waste providing the most releases. Nitrate is only significantly released from ETF-generated secondary waste and waste management secondary waste, and onsite-generated waste.

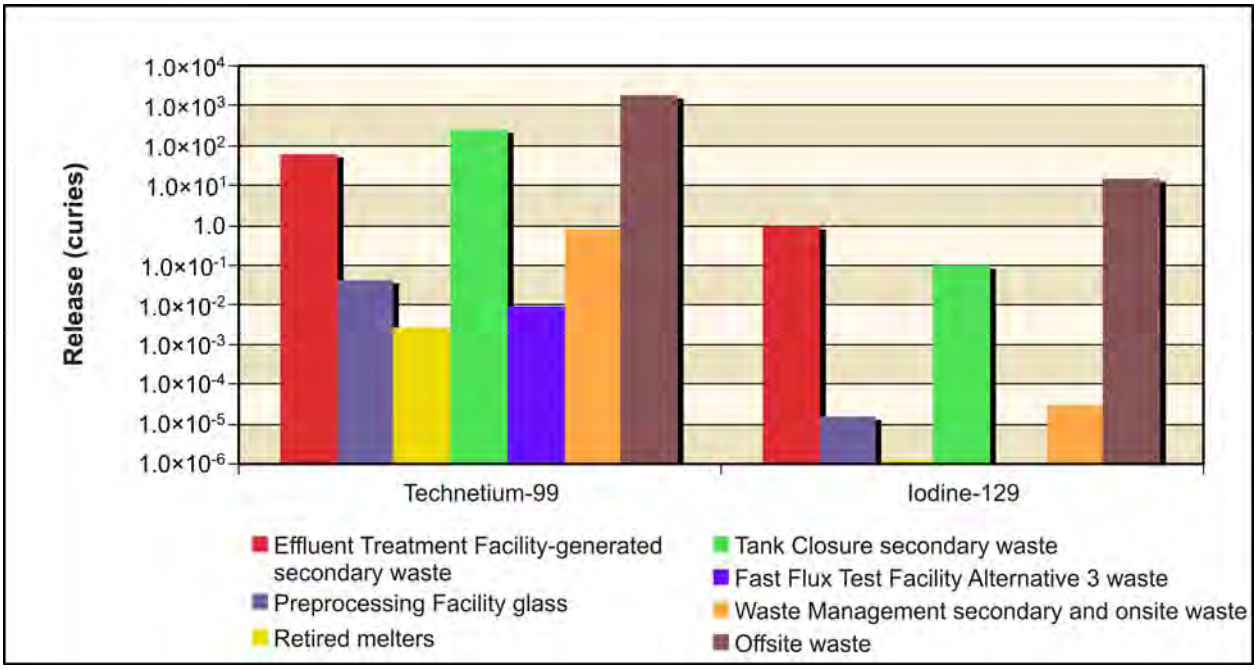


Figure 5–643. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

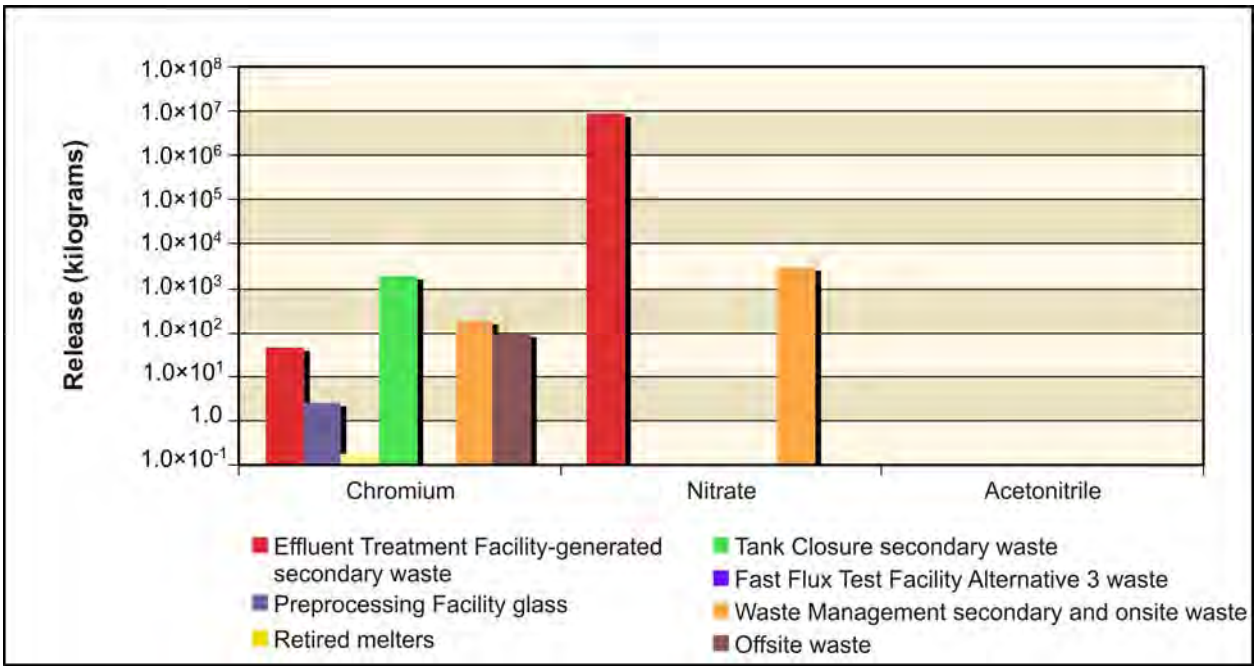


Figure 5–644. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–645 shows the release to the vadose zone at IDF-East in the Option Case for the radiological risk drivers and Figure 5–646, the chemical hazard drivers. The radiological risk drivers and the chemical hazard drivers released to the vadose zone in the Option Case are essentially identical to those in the Base Case.

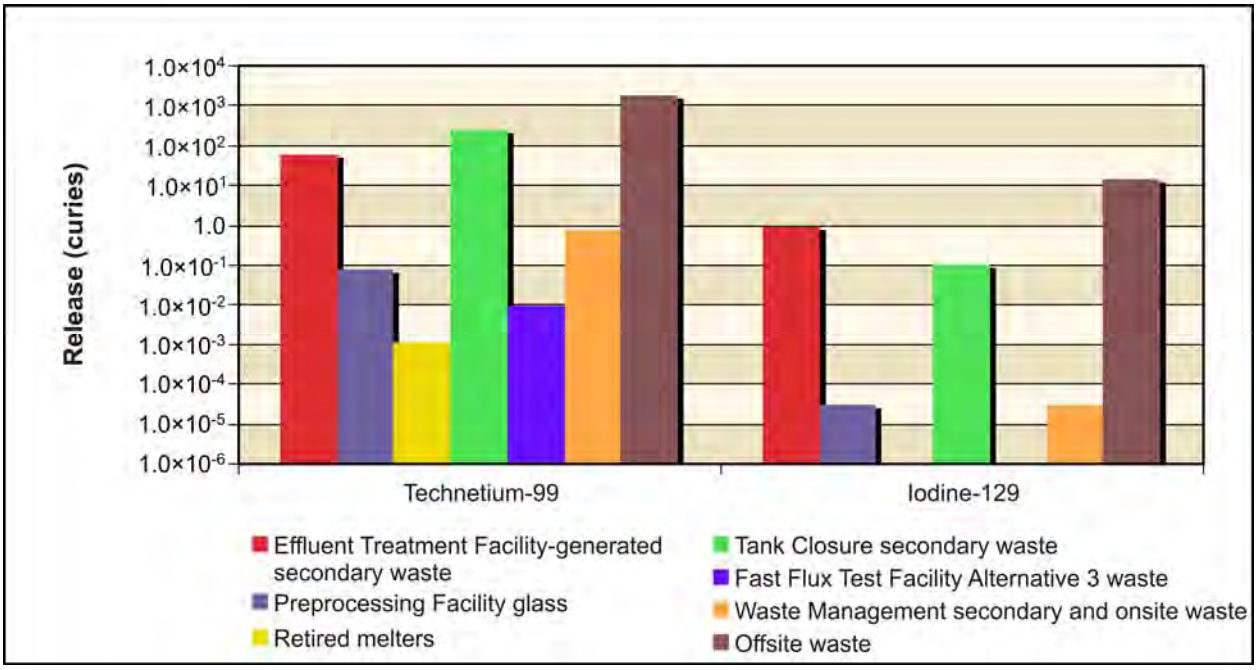


Figure 5–645. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

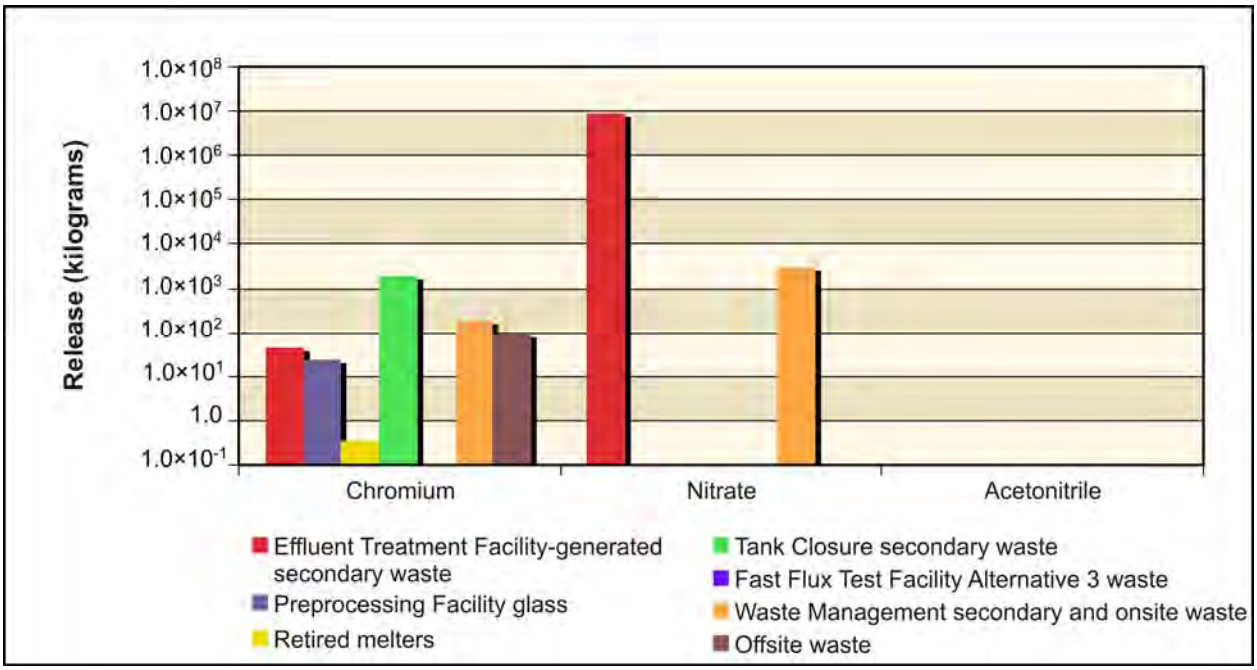


Figure 5–646. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–647 shows the release to groundwater at IDF-East in the Base Case for the radiological risk drivers and Figure 5–648, the chemical hazard drivers. Release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (technetium-99, iodine-129, chromium, and nitrate), the amount released to groundwater is typically equal to the amount released to the vadose zone. Ninety-five to 100 percent of the technetium-99 released to the vadose zone released from ETF-generated secondary waste and offsite-generated waste reaches groundwater. Forty to 60 percent of the technetium-99 released to the vadose zone from other sources—i.e., PPF glass, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, and waste management secondary and onsite-generated waste—reaches groundwater. For iodine-129 from offsite-generated waste, releases to groundwater and to the vadose zone are essentially equal. Only about 40 percent of the iodine-129 released to the vadose zone—i.e., releases from ETF-generated secondary waste, PPF glass, tank closure secondary waste, and waste management secondary and onsite-generated waste—reaches groundwater. Chromium released to groundwater from ETF-generated secondary waste, tank closure secondary waste, waste management secondary and onsite-generated waste, and offsite-generated waste is essentially equal to that released to the vadose zone. About 45 percent of the chromium released from PPF glass and retired melters to the vadose zone is transferred to the groundwater. Finally, nitrate released to groundwater from ETF-generated secondary waste, waste management secondary waste, and onsite-generated waste is essentially equal to that released to the vadose zone.

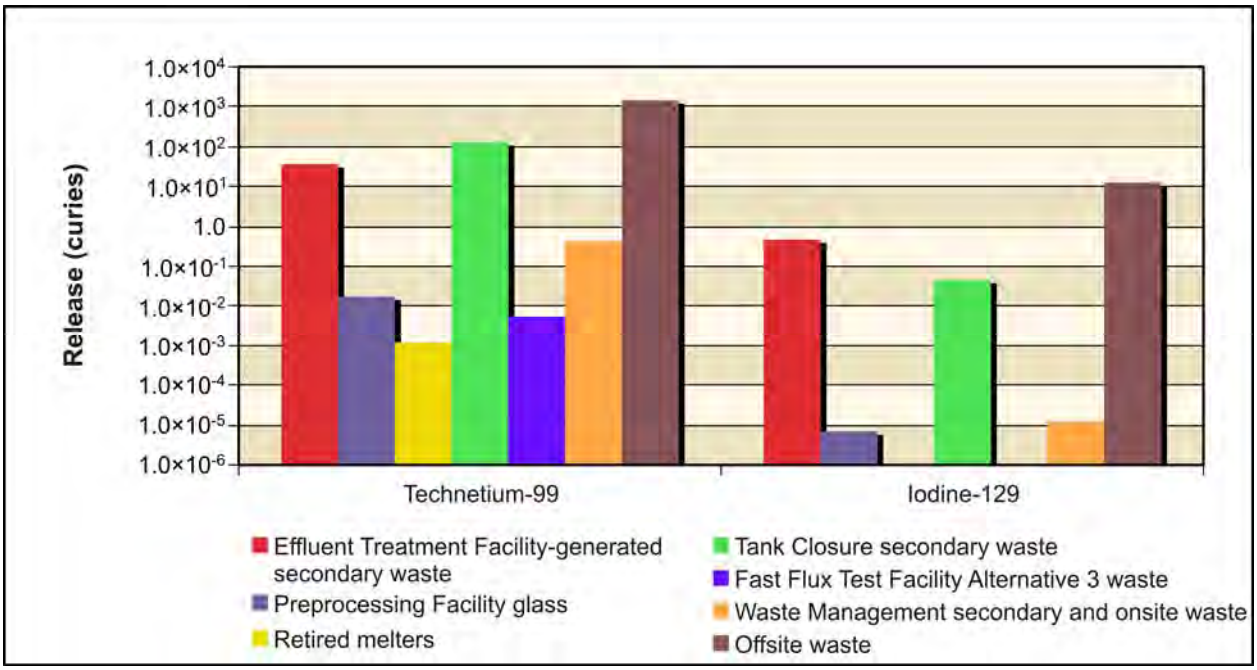


Figure 5–647. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

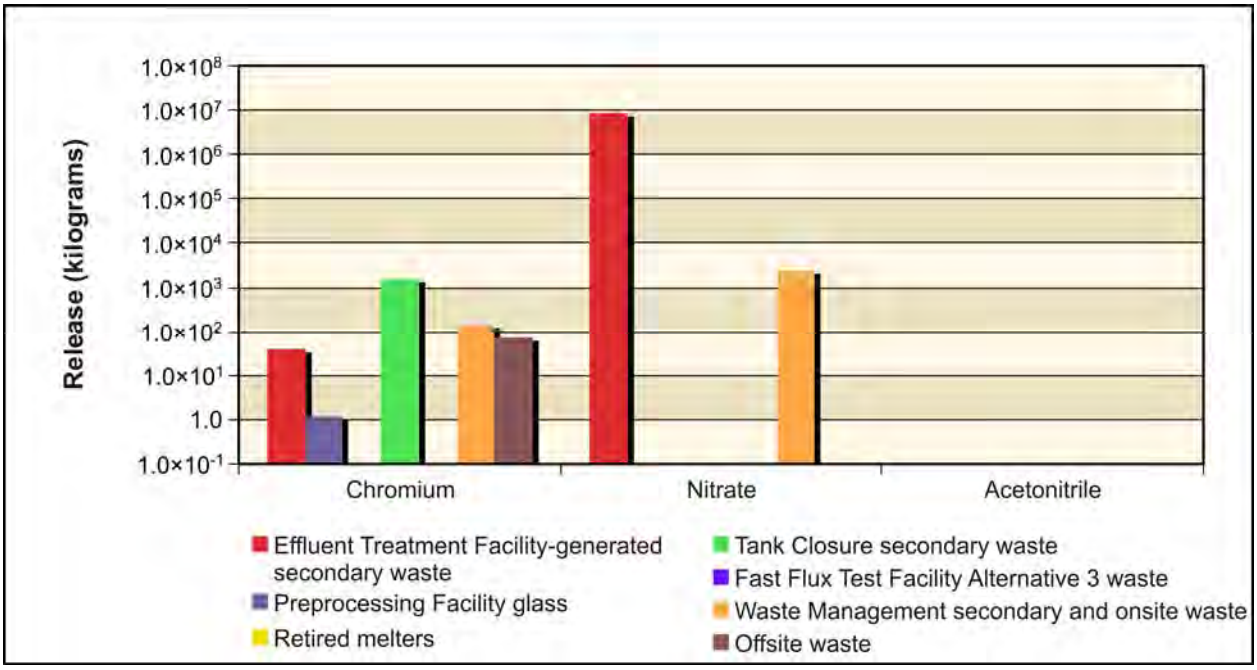


Figure 5–648. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–649 shows the release to groundwater at IDF-East in the Option Case for the radiological risk drivers and Figure 5–650, the chemical hazard drivers. The releases of radiological risk drivers and the chemical hazard drivers to groundwater in the Option Case are essentially identical to those in the Base Case.

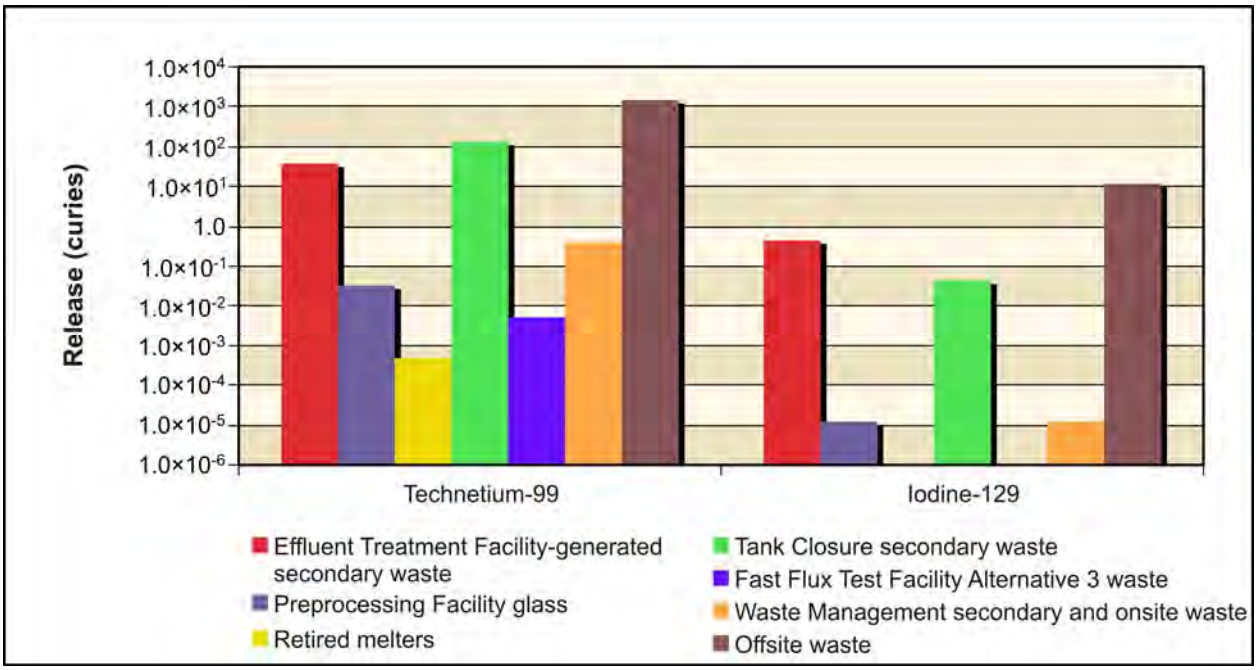


Figure 5–649. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

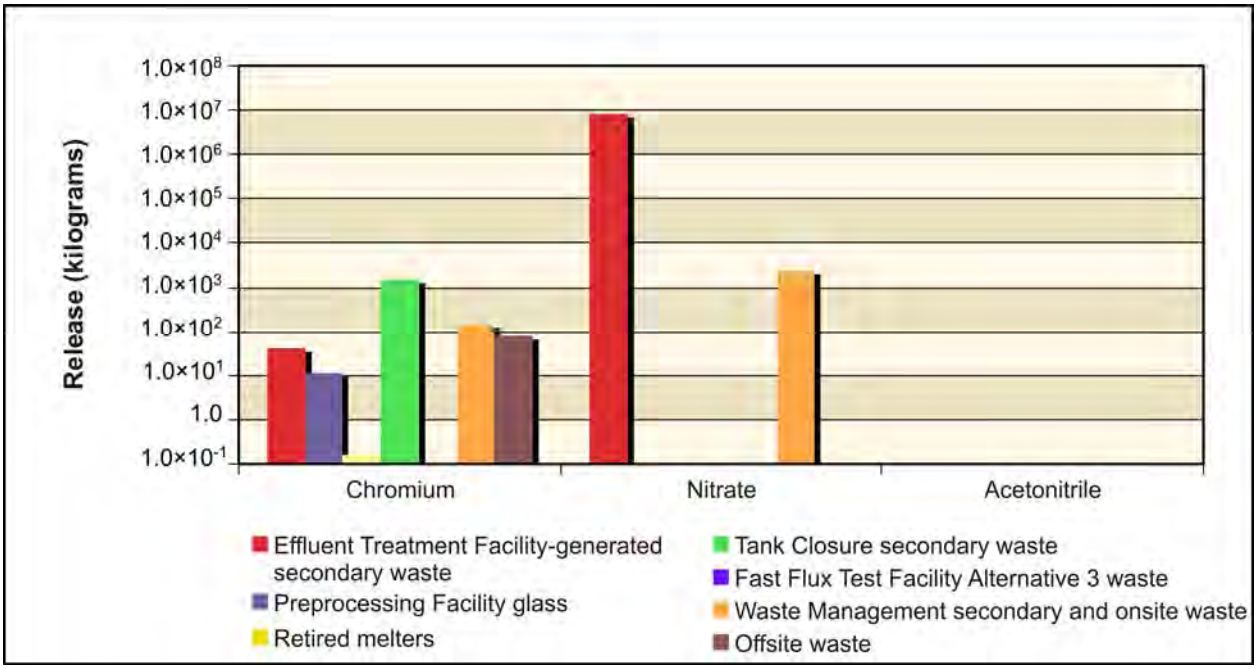


Figure 5–650. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–651 shows the release to the Columbia River at IDF-East in the Base Case for the radiological risk drivers and Figure 5–652, the chemical hazard drivers. For the conservative tracers (technetium-99, iodine-129, chromium, and nitrate), the amount released to the Columbia River is typically essentially equal to the amount released to the vadose zone. Ninety to 97 percent of the technetium-99 released to groundwater from ETF-generated secondary-waste, PPF glass, retired melters, FFTF Decommissioning Alternative 3 waste, waste management secondary and onsite-generated waste, and offsite-generated waste reaches the Columbia River. Only about 60 percent of the technetium-99 released to groundwater from the tank closure secondary waste reaches the river. Ninety to 97 percent of the iodine-129 released to groundwater from ETF-generated secondary waste and offsite-generated waste reaches the Columbia River. Only about 25 percent of the iodine-129 released from the tank closure secondary waste to groundwater is transferred to the river. Essentially none of the iodine-129 released to groundwater from PPF glass, waste management secondary waste, and onsite-generated is transferred to the river. As for chromium, 90 to 98 percent of the amount released from ETF-generated secondary waste, PPF glass, retired melters, tank closure secondary waste, waste management secondary and onsite-generated waste, and offsite-generated waste is released to the Columbia River. The amount of nitrate released to the Columbia River from ETF-generated secondary waste, waste management secondary waste, and onsite-generated waste is essentially equal to that released to the groundwater.

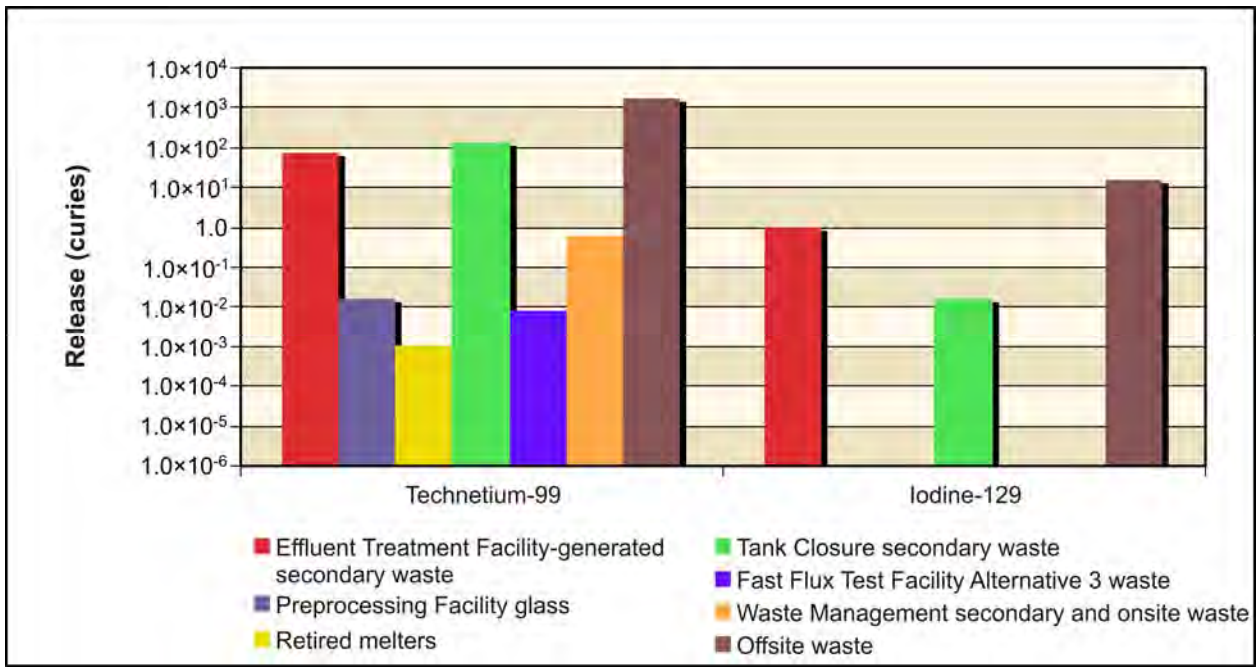


Figure 5–651. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

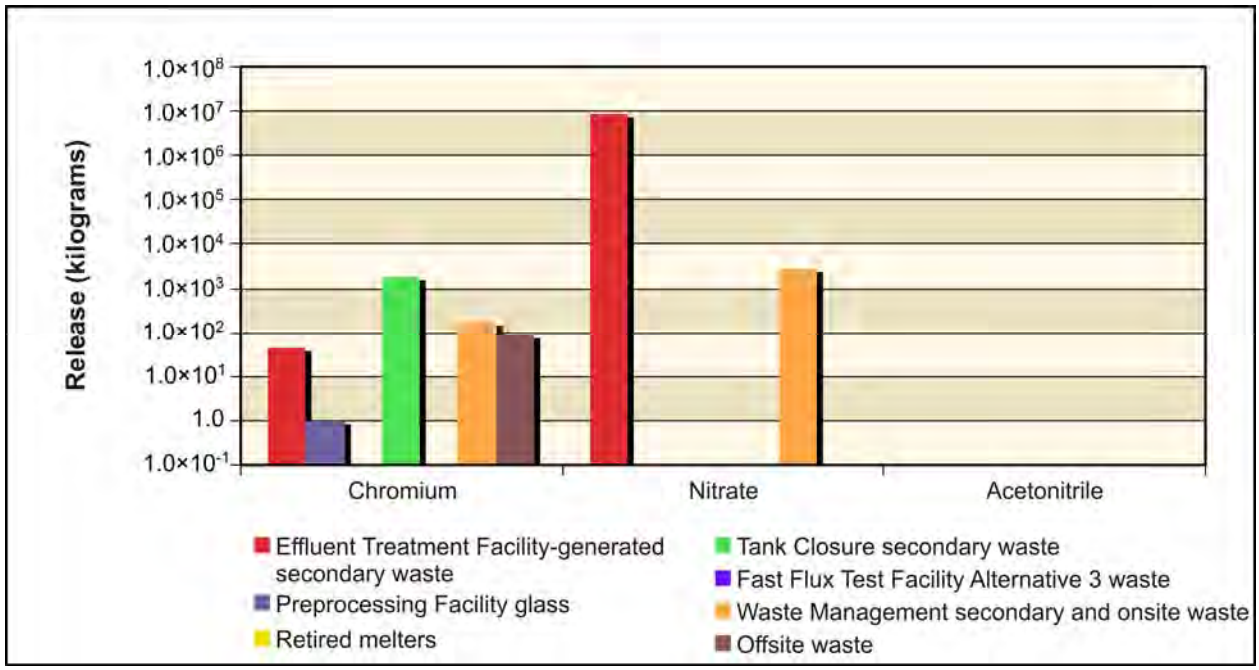


Figure 5–652. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Figure 5–653 shows the release to the Columbia River at IDF-East in the Option Case for the radiological risk drivers and Figure 5–654, the chemical hazard drivers. For the IDF, the radiological risk drivers and the chemical hazard drivers released to the Columbia River in the Option Case are essentially identical to those in the Base Case.

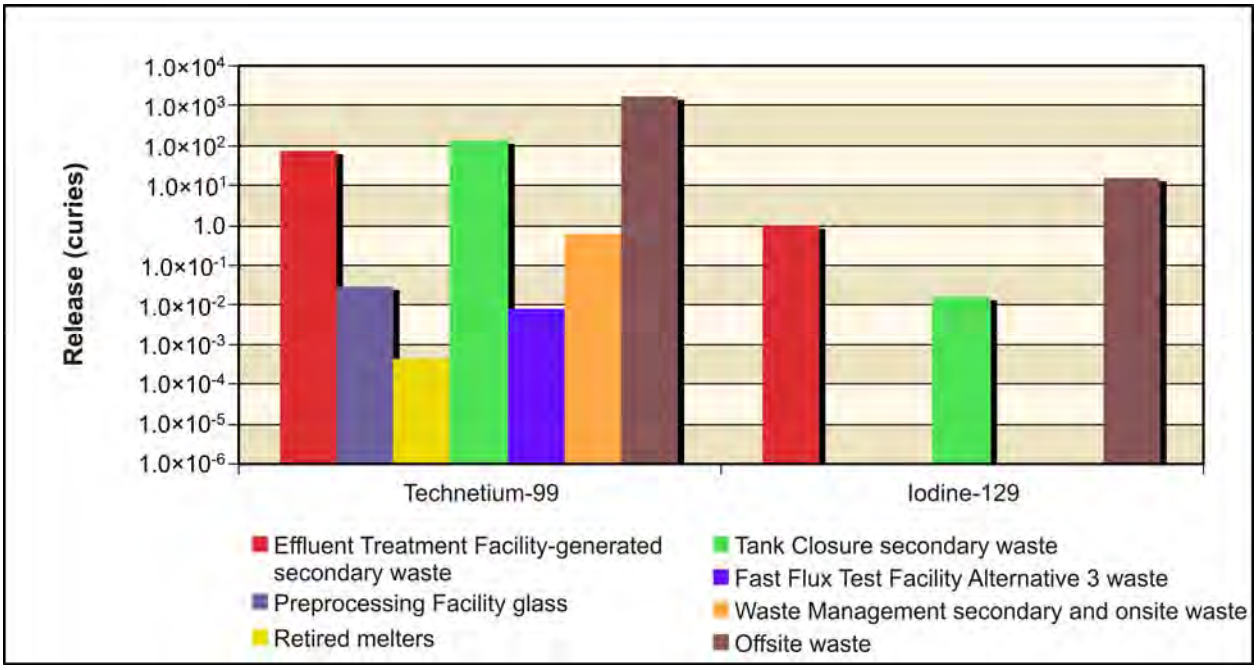


Figure 5–653. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

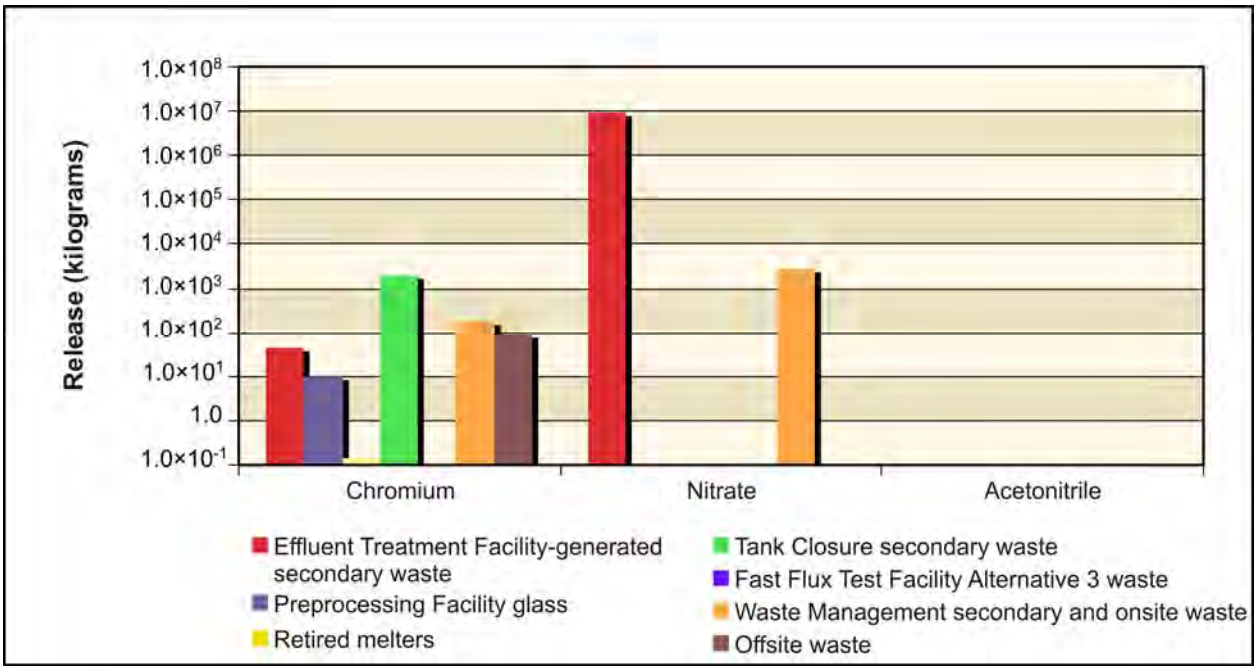


Figure 5–654. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–655 shows the release to the vadose zone at the RPPDF in the Base Case for the radiological risk drivers and Figure 5–656, the chemical hazard drivers. The only constituents significantly released to the vadose zone from the RPPDF were technetium-99, iodine-129, chromium, and nitrate.

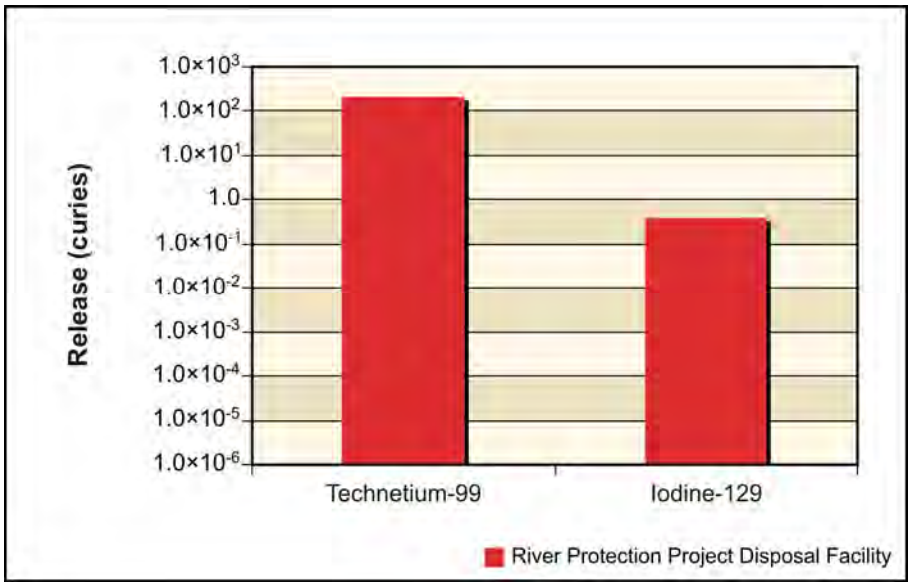


Figure 5–655. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

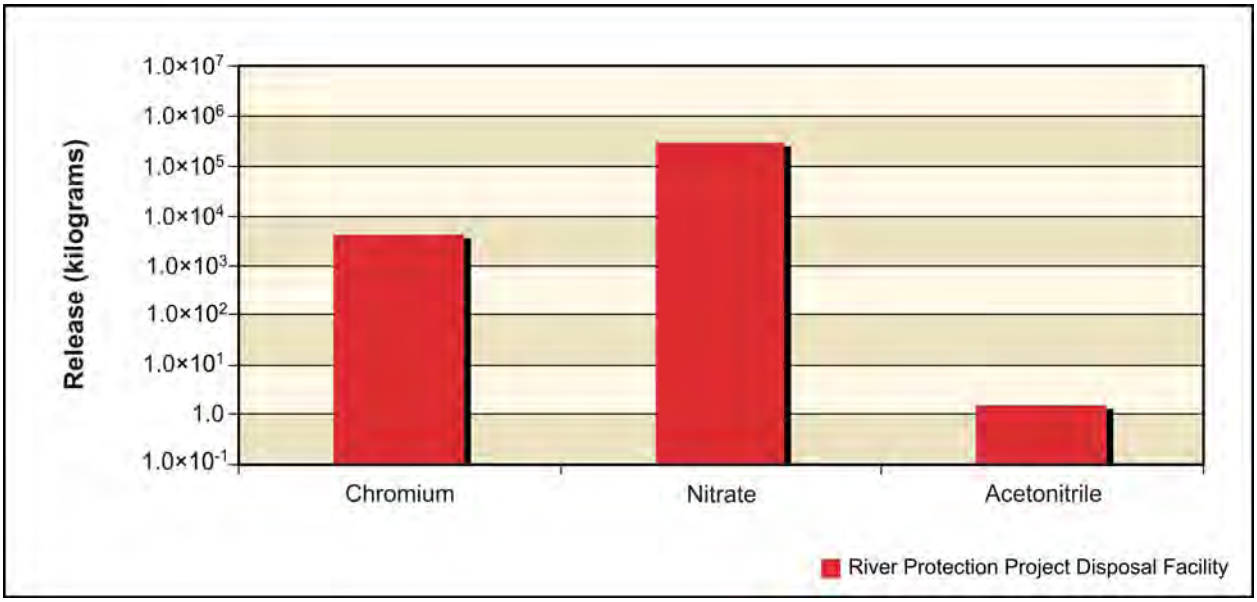


Figure 5–656. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–657 shows the release to the vadose zone for the Option Case at the RPPDF for the radiological risk drivers, and Figure 5–658, the chemical hazard drivers. For the RPPDF, the radiological risk drivers and the chemical hazard drivers for the Option Case have essentially identical releases to the vadose zone as in the Base Case.

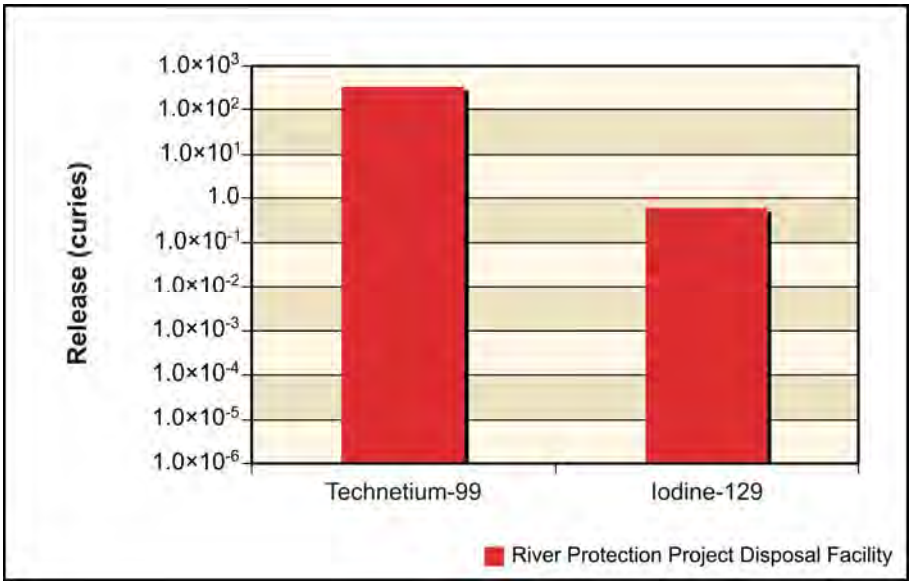


Figure 5–657. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

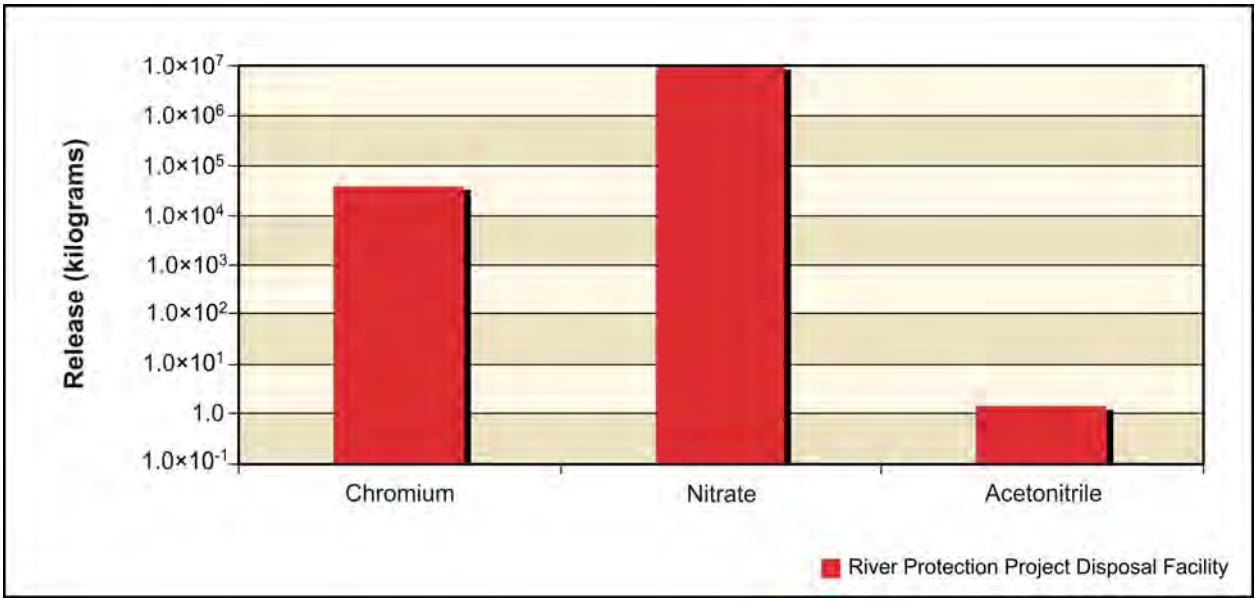


Figure 5–658. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–659 shows the release to groundwater for the Base Case at the RPPDF for the radiological risk drivers and Figure 5–660, the chemical hazard drivers. For the RPPDF, the amount released to groundwater was essentially equal to that released to the vadose zone for technetium-99, iodine-129, chromium, nitrate, and acetonitrile.

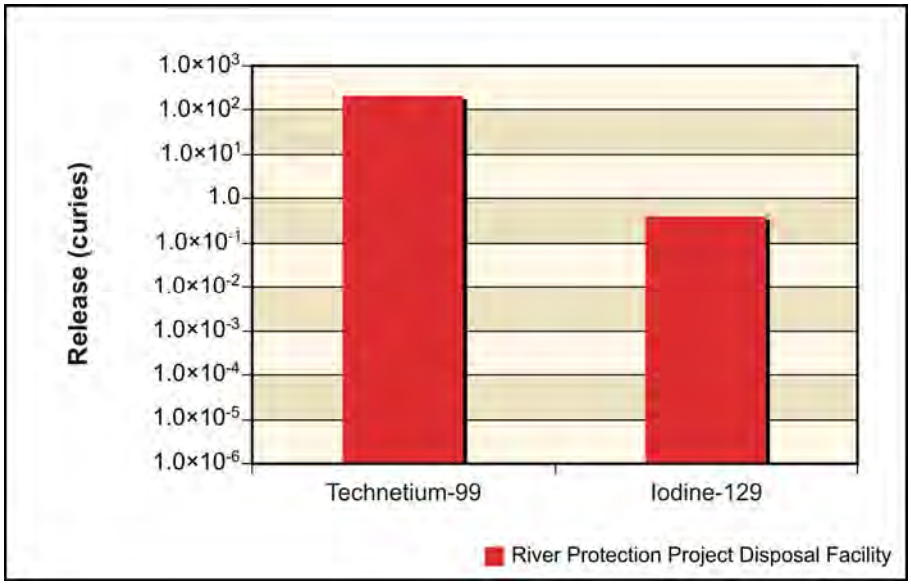


Figure 5–659. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

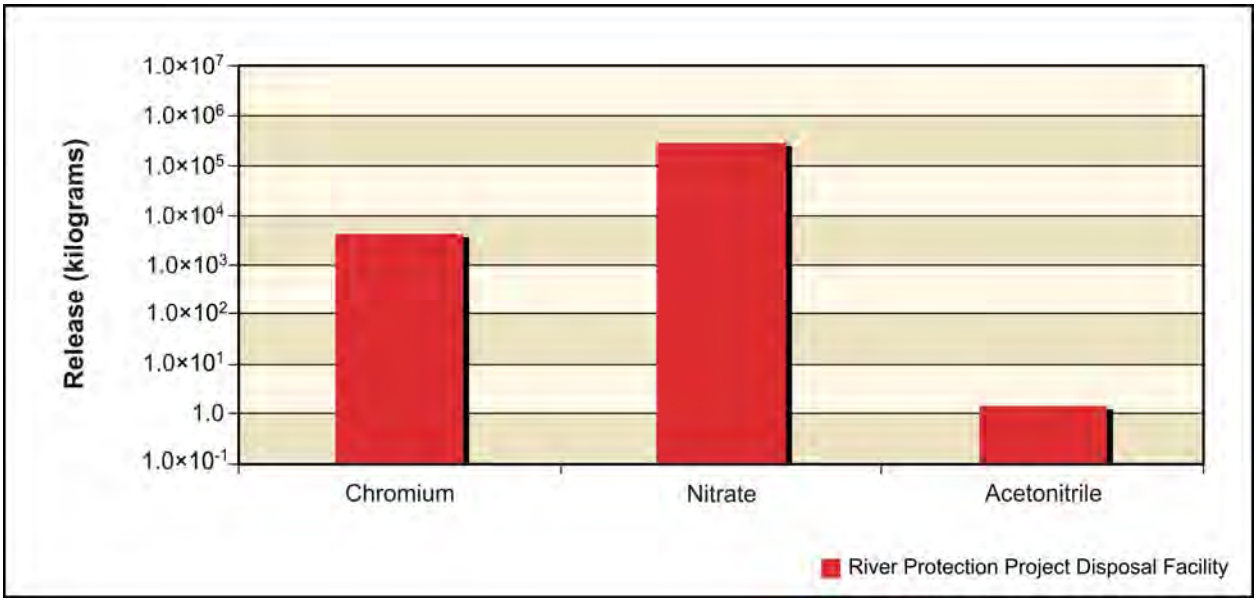


Figure 5–660. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–661 shows the release to groundwater for the Option Case at the RPPDF for the radiological risk drivers and Figure 5–662, the chemical hazard drivers. For the RPPDF, the radiological risk drivers and the chemical hazard drivers for the Option Case have essentially identical releases to the groundwater as in the Base Case.

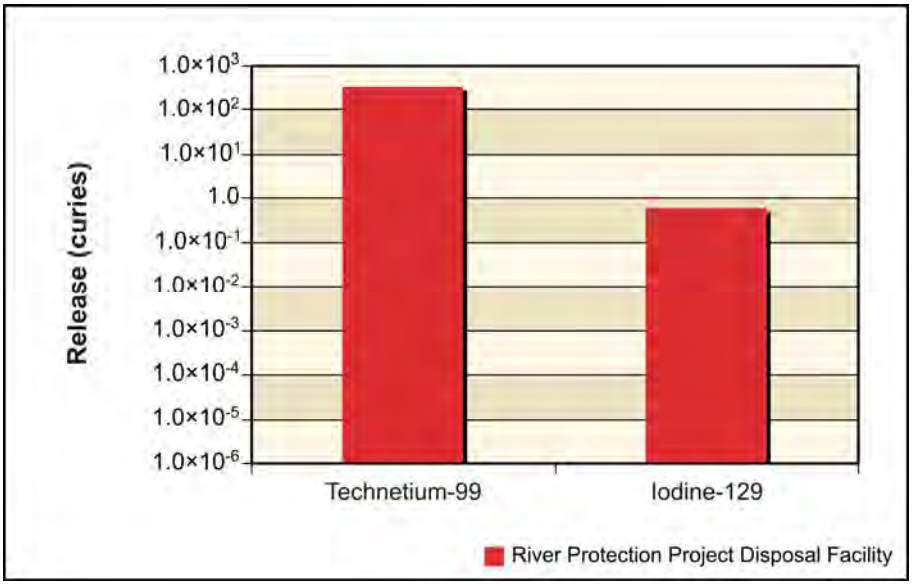


Figure 5–661. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

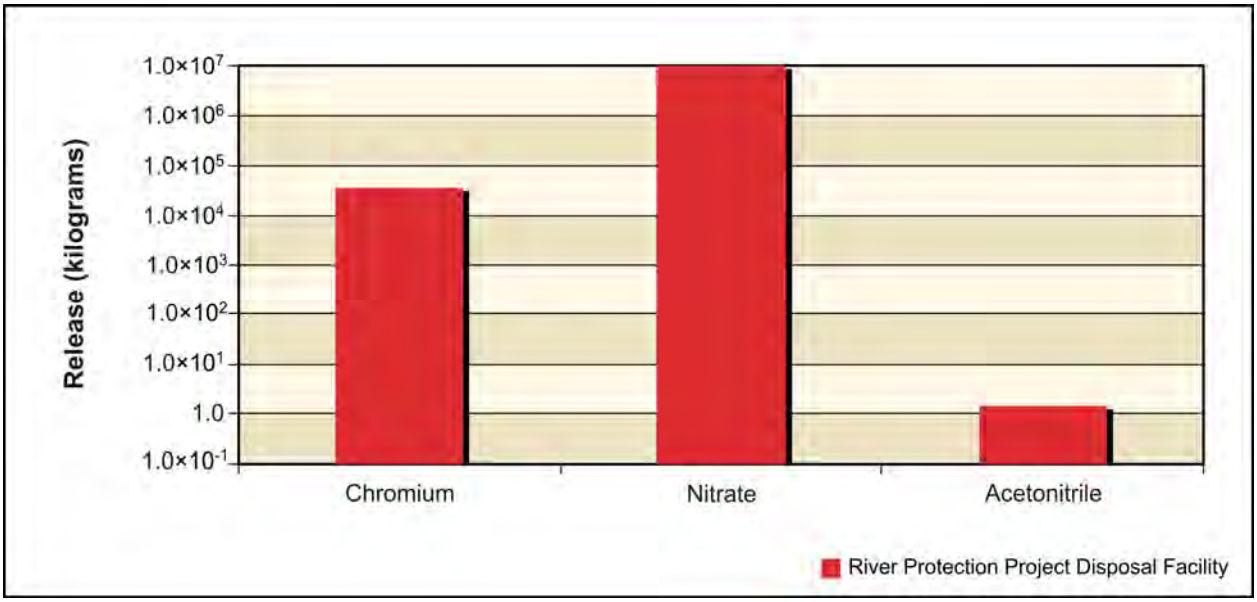


Figure 5–662. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–663 shows the release to the Columbia River for the Base Case at the RPPDF for the radiological risk drivers and Figure 5–664, the chemical hazard drivers. For the RPPDF, about 95 percent of the amount that was released from the groundwater reached the Columbia River for technetium-99, iodine-129, chromium, nitrate, and acetonitrile.

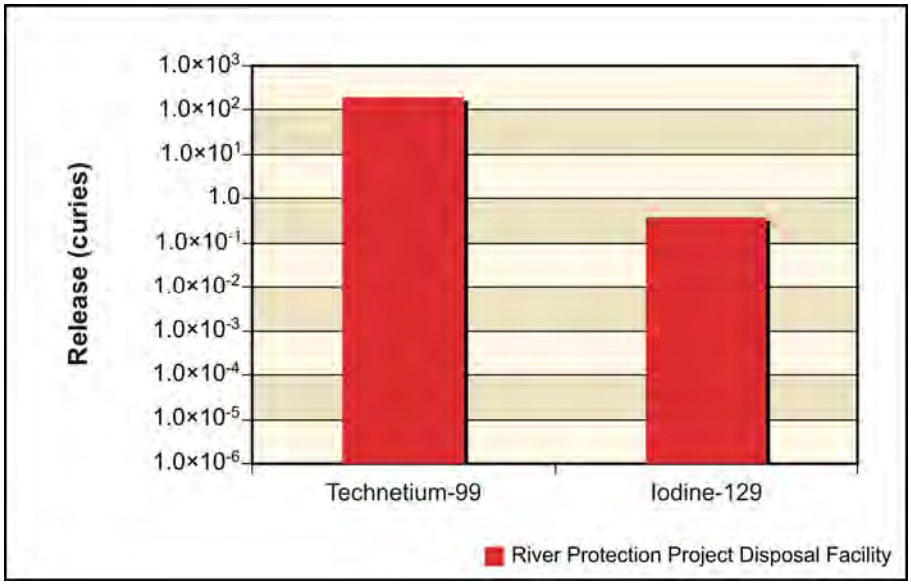


Figure 5–663. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

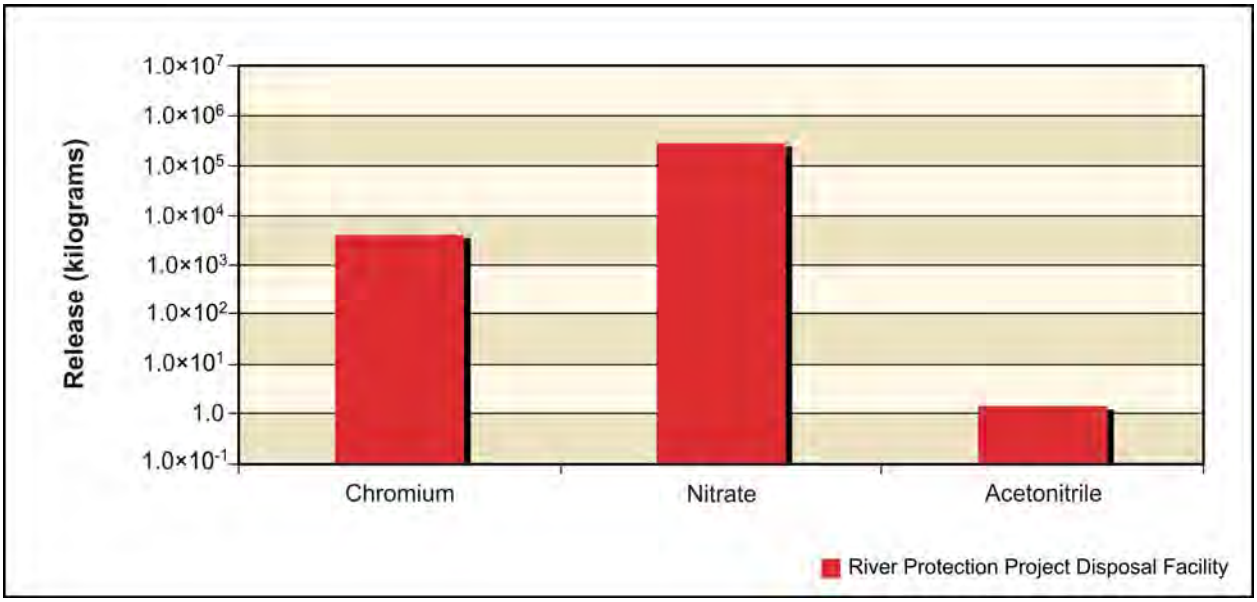


Figure 5–664. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

Figure 5–665 shows the release to the Columbia River for the Option Case at the RPPDF for the radiological risk drivers and Figure 5–666, the chemical hazard drivers. For the RPPDF, the radiological risk drivers and the chemical hazard drivers for the Option Case have essentially identical releases to the Columbia River as in the Base Case.

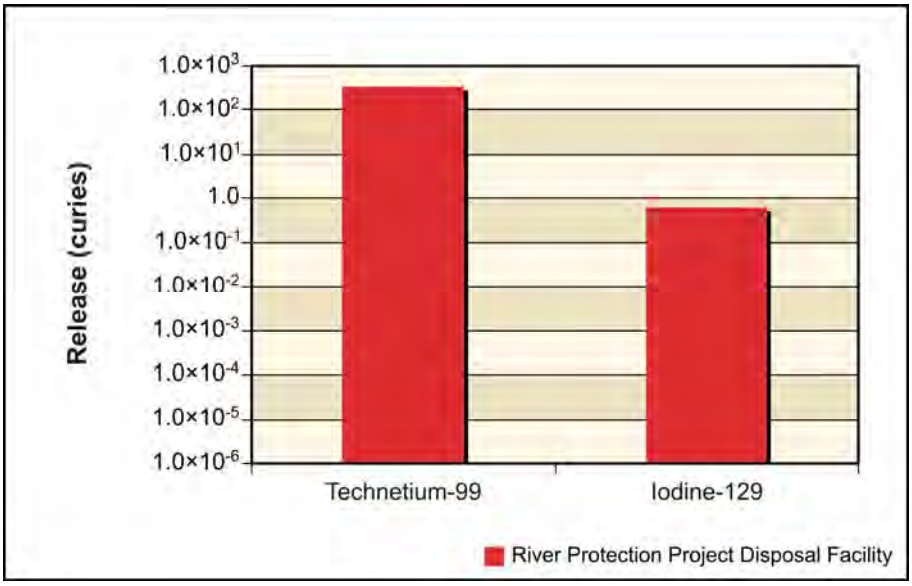


Figure 5–665. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

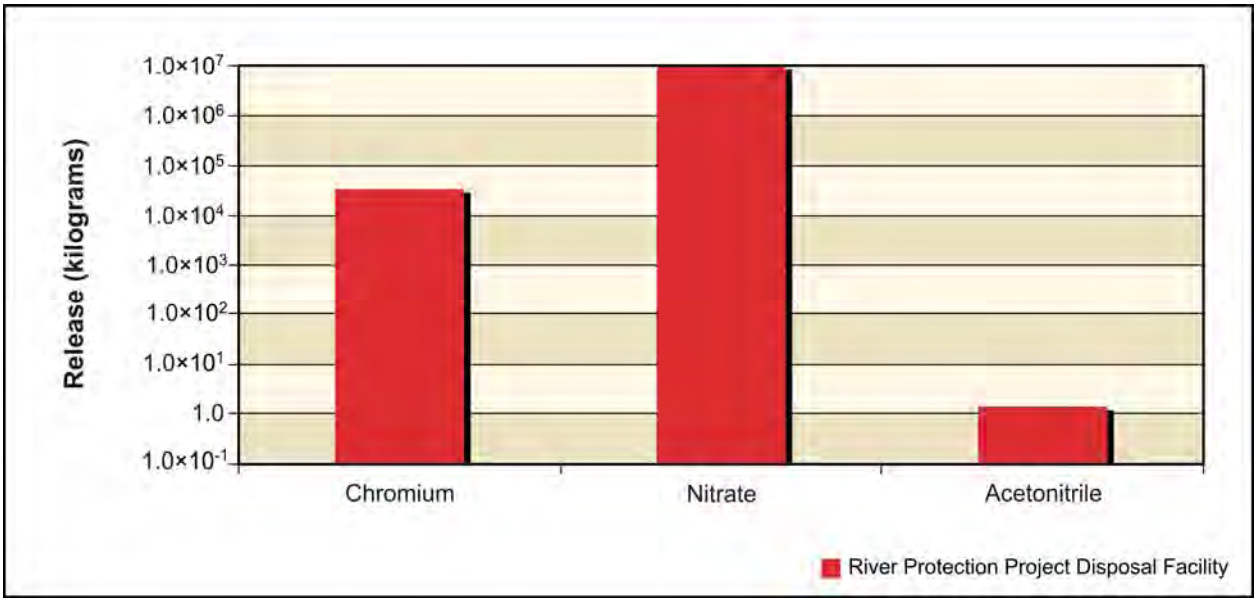


Figure 5–666. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 2, Disposal Group 3, Base and Option Cases, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per

liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval (95 percent of the time) is likely to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when: the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Tables 5–87 and 5–88 list the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary and Columbia River nearshore.

Table 5–87. Waste Management Alternative 2, Disposal Group 3, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**3,040** (8646)	303 (3987)	**1,180** (8173)	848 (9284)	900
Iodine-129	**22** (8850)	0.5 (4073)	**11** (11300)	**6** (8985)	1
Chemical in micrograms per liter					
Chromium	3 (8561)	6 (4109)	11 (6384)	3 (4877)	100
Nitrate	16,600 (7367)	404 (4001)	6,550 (6859)	3,310 (7741)	45,000

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Table 5–88. Waste Management Alternative 2, Disposal Group 3, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**3,040** (8646)	386 (4013)	**1,180** (8173)	861 (9284)	900
Iodine-129	**22** (8850)	0.6 (4172)	**11** (11300)	**6** (8985)	1
Chemical in micrograms per liter					
Chromium	3 (8561)	36 (3878)	125 (6610)	20 (6701)	100
Nitrate	16,600 (7367)	10,300 (4544)	30,200 (4627)	5,620 (6522)	45,000

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figure 5–667 shows the concentration versus time plot in the Base Case for technetium-99. Releases cause the groundwater concentrations at the Core Zone Boundary and the Columbia River nearshore to approach the benchmark concentration around CY 7000 to CY 10,000. The concentrations at the Core Zone Boundary and at the Columbia River nearshore never constantly remain above the benchmark concentration throughout the period of analysis.

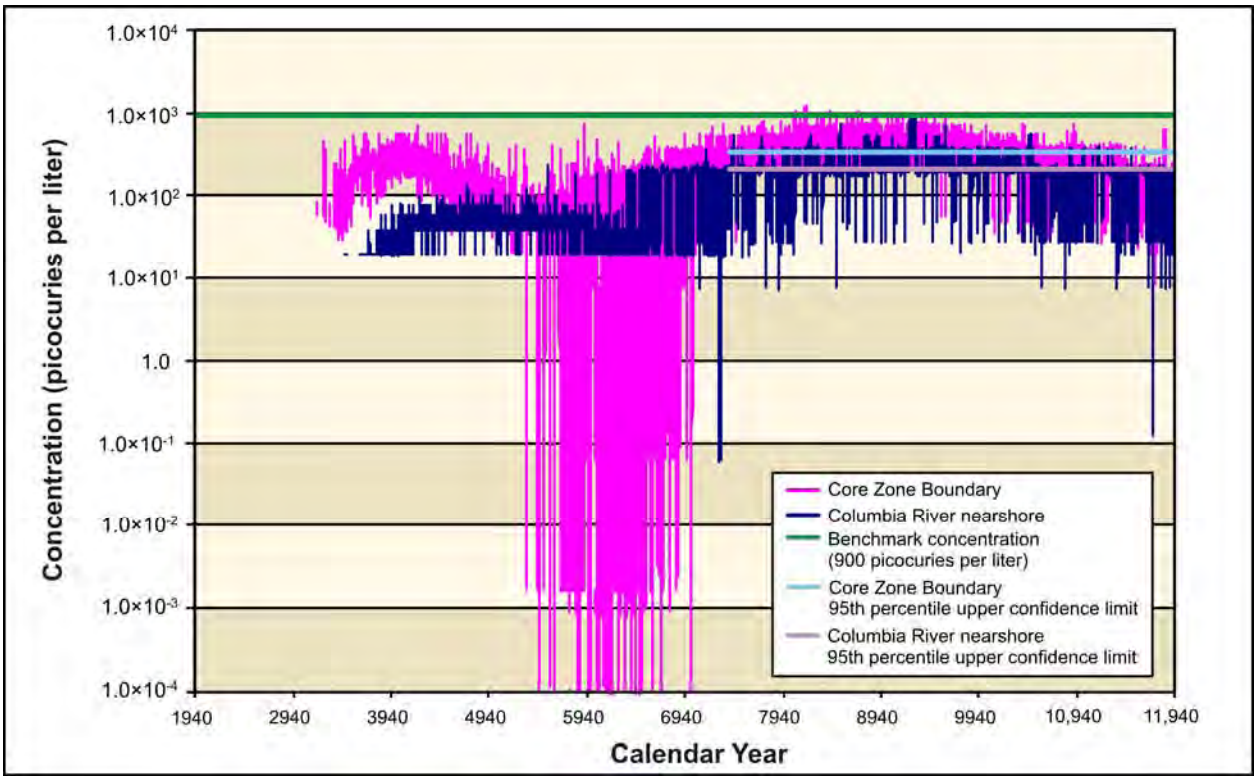


Figure 5–667. Waste Management Alternative 2, Disposal Group 3, Base Case, Technetium-99 Concentration Versus Time

Figure 5–668 shows the concentration versus time plot in the Option Case for technetium-99. The plot for technetium-99 in the Option Case is similar that in the Base Case.

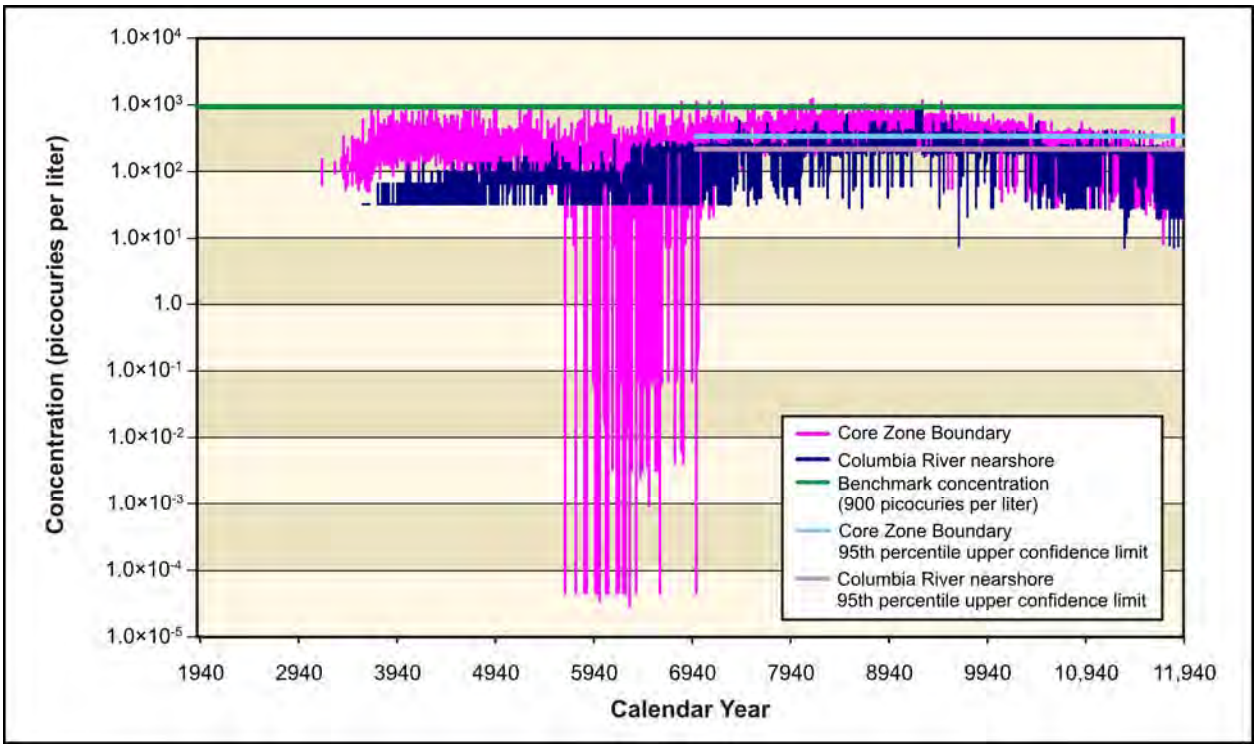


Figure 5–668. Waste Management Alternative 2, Disposal Group 3, Option Case, Technetium-99 Concentration Versus Time

The concentration versus time plot for iodine-129 in the Base Case shows a pattern similar to that of technetium-99, except that iodine-129 concentrations at the Core Zone Boundary and at the Columbia River nearshore exceed the benchmark from about CY 6000 until the end of the period of analysis. Exceedances peaked at around one order of magnitude above the benchmark concentration (see Figure 5–669).

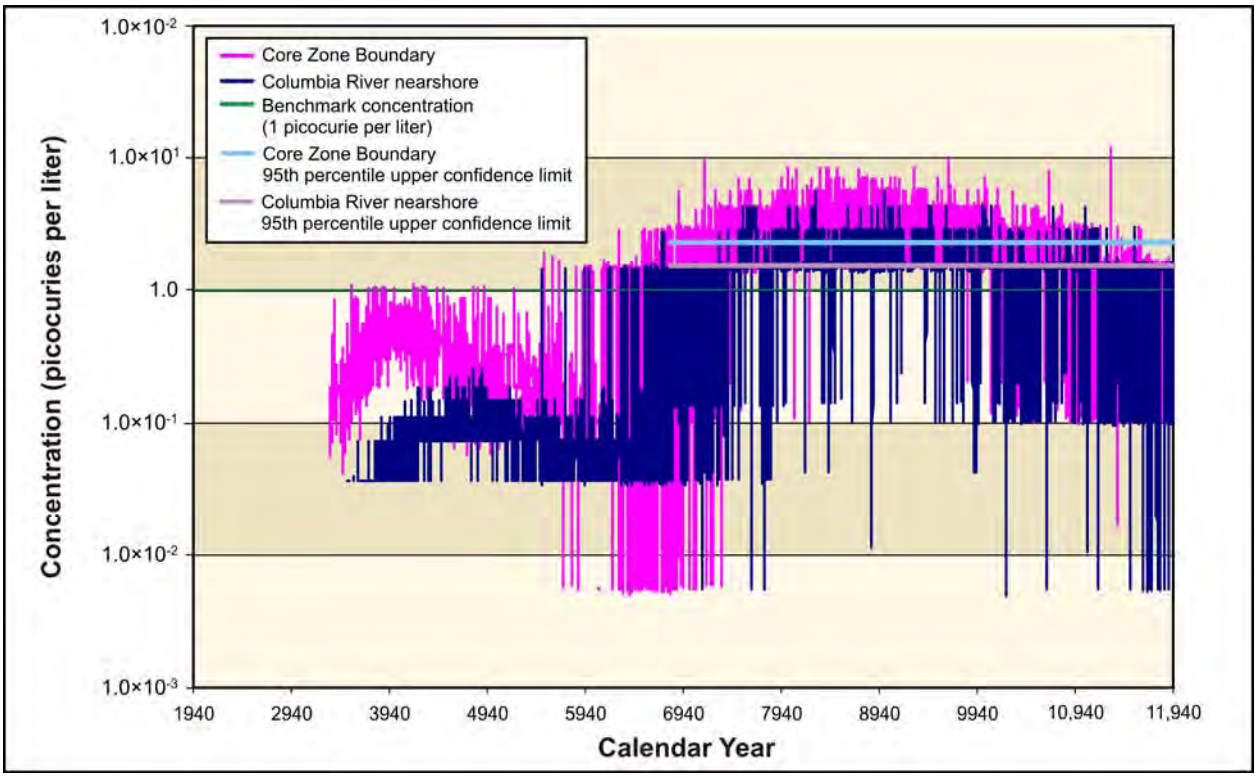


Figure 5–669. Waste Management Alternative 2, Disposal Group 3, Base Case, Iodine-129 Concentration Versus Time

The plot of iodine-129 concentration versus time in the Option Case is similar to that in the Base Case (see Figure 5–670).

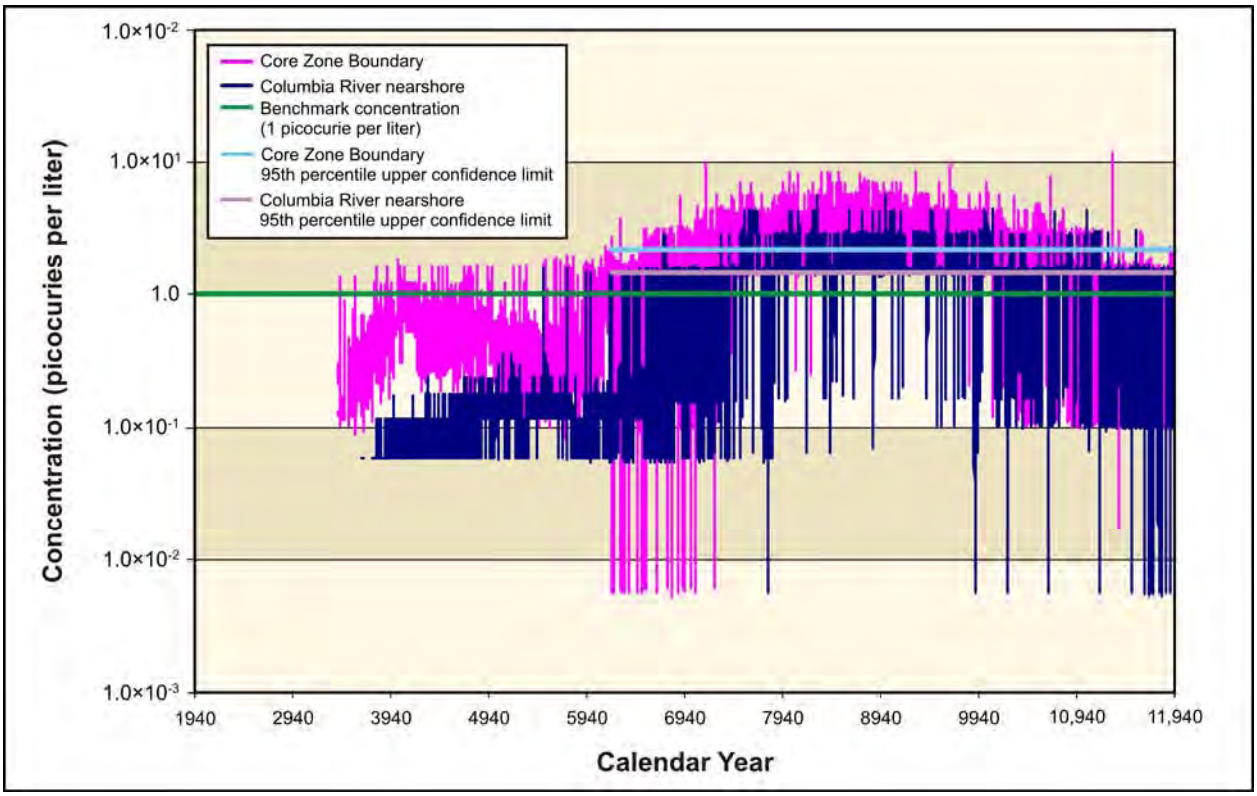


Figure 5–670. Waste Management Alternative 2, Disposal Group 3, Option Case, Iodine-129 Concentration Versus Time

Figure 5–671 shows the plot of concentration versus time for chromium in the Base Case. The concentrations at the Core Zone Boundary approach but do not exceed the benchmark from about CY 3800 to CY 5800. The concentrations at the Columbia River nearshore remained about two orders of magnitude below the benchmark.

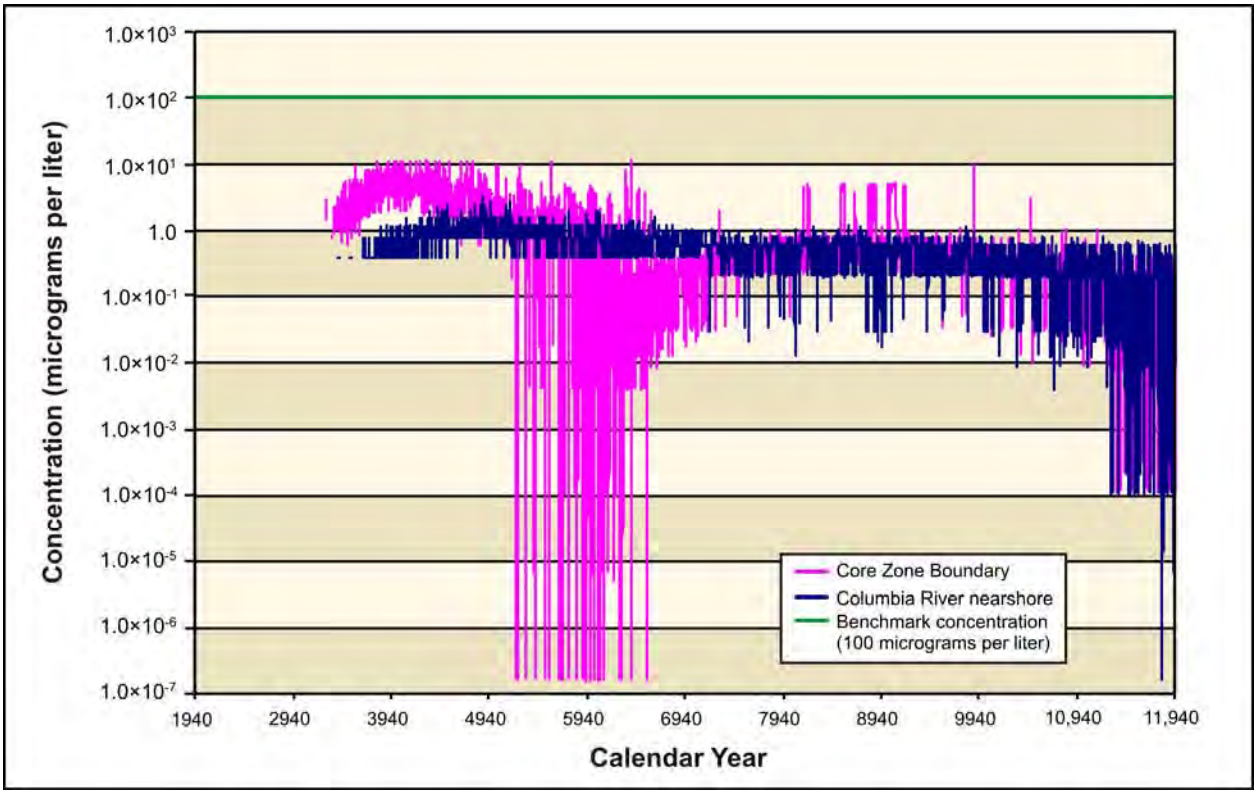


Figure 5–671. Waste Management Alternative 2, Disposal Group 3, Base Case, Chromium Concentration Versus Time

Figure 5–672 shows the plot of concentration versus time plot for chromium in the Option Case. The concentrations at the Core Zone Boundary and the Columbia River nearshore remain about one to two orders of magnitude below the benchmark.

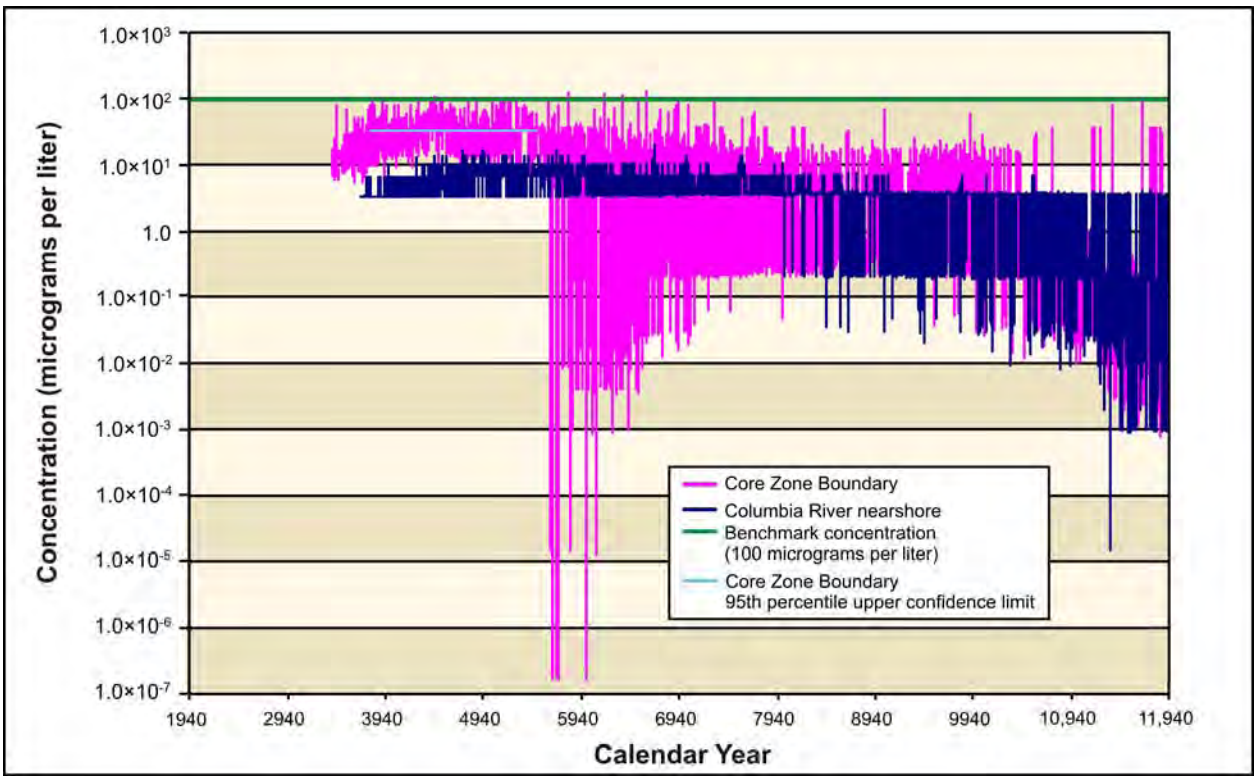


Figure 5–672. Waste Management Alternative 2, Disposal Group 3, Option Case, Chromium Concentration Versus Time

Figure 5–673 shows the plot of concentration versus time for nitrate in the Base Case. The concentrations at the Core Zone Boundary and the Columbia River nearshore both peak at around CY 8000. Even at the peak concentration levels, nitrate concentrations still remain about one order of magnitude below the benchmark.

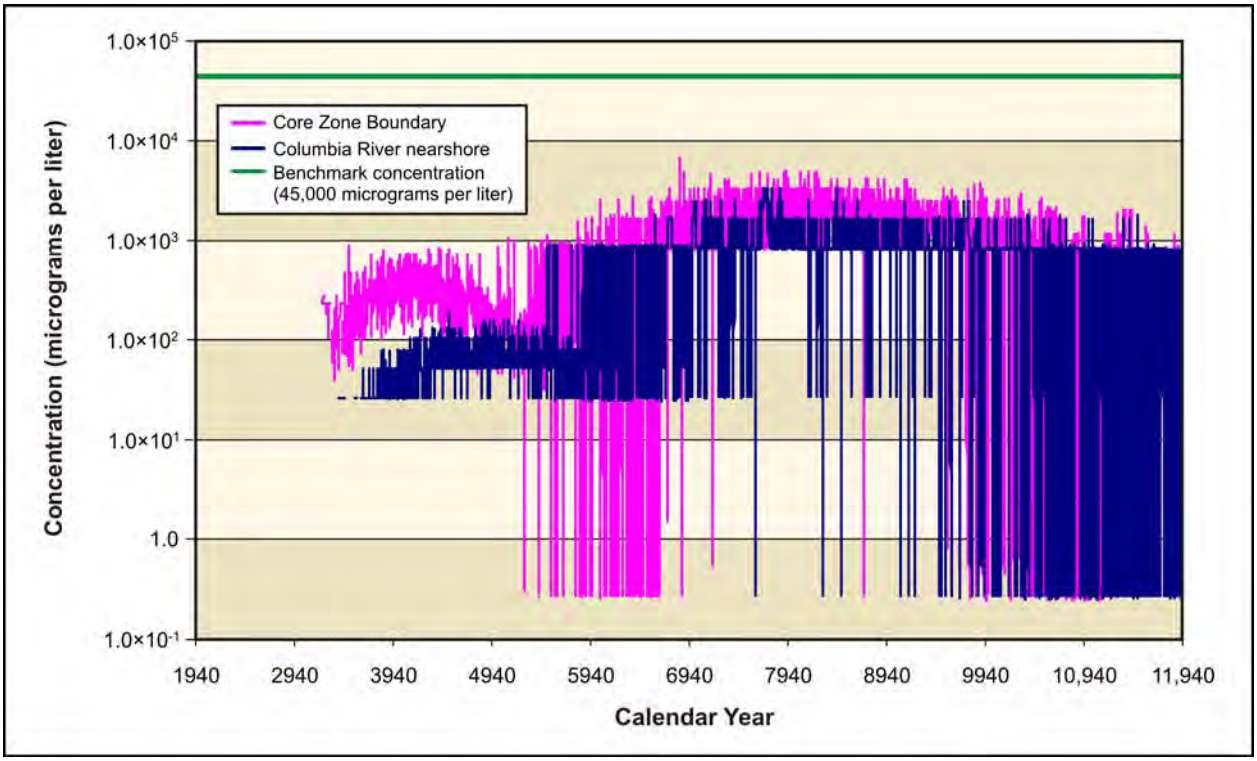


Figure 5–673. Waste Management Alternative 2, Disposal Group 3, Base Case, Nitrate Concentration Versus Time

Figure 5–674 shows the concentration versus time plot in the Option Case for nitrate. The concentrations at the Core Zone Boundary peak at around CY 4800 but remain about one-half order of magnitude below the benchmark concentration. Concentrations from the Columbia River nearshore remain fairly steady at around one order of magnitude below the benchmark.

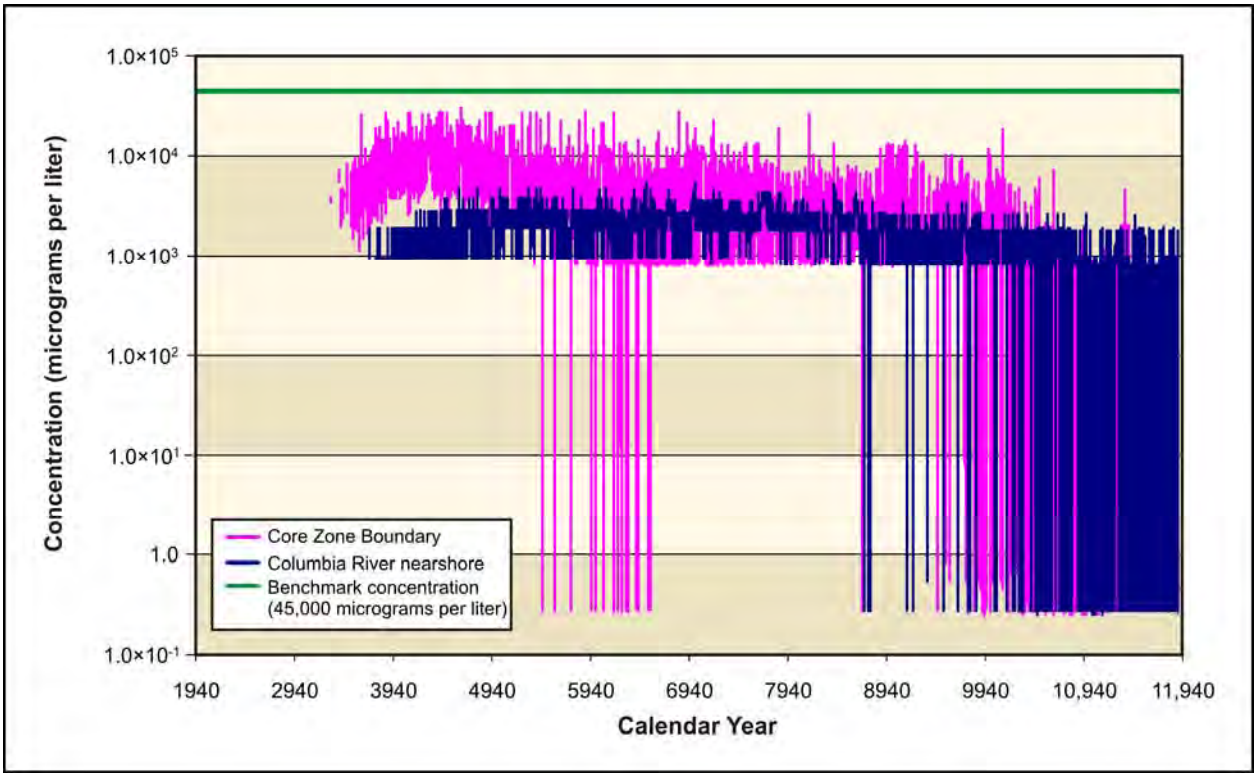


Figure 5–674. Waste Management Alternative 2, Disposal Group 3, Option Case, Nitrate Concentration Versus Time

Figure 5–675 shows the plot of concentration versus time for total uranium in the Base Case. It is not until around CY 9500 that concentrations begin to appear on the graph. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about seven to nine orders of magnitude below the benchmark.

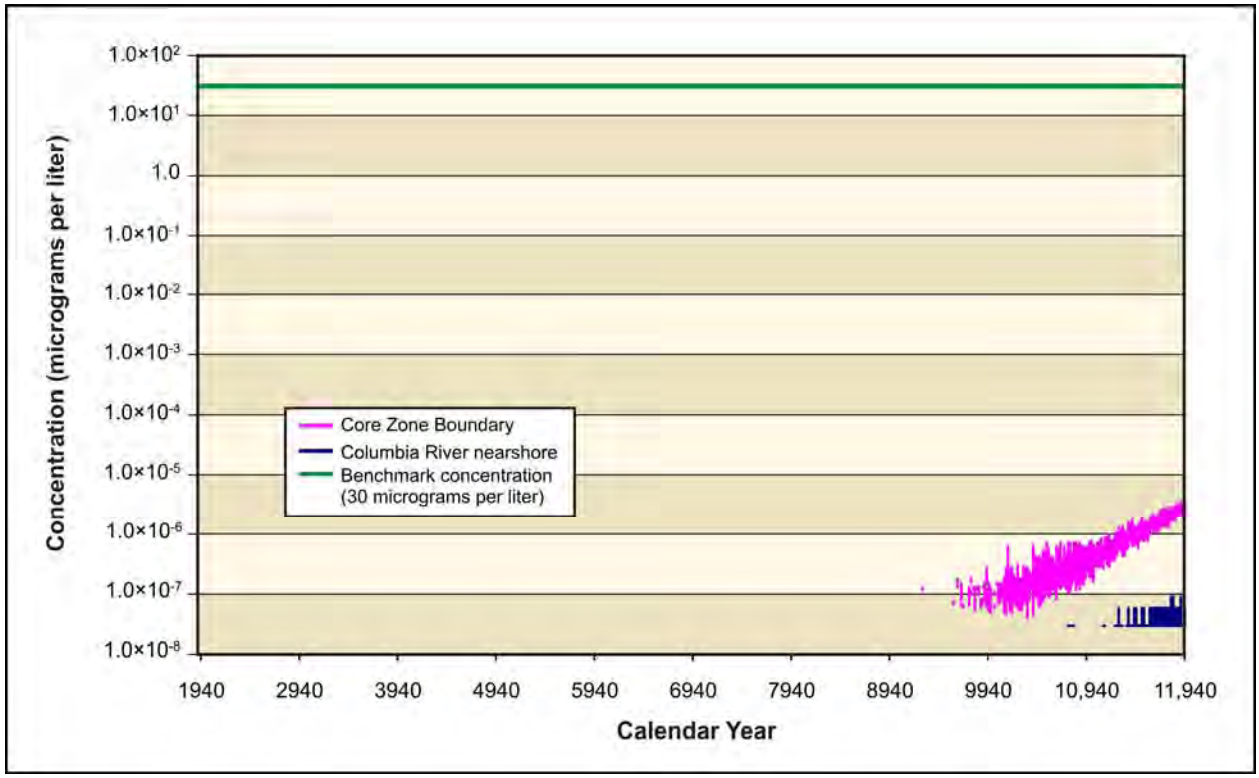


Figure 5–675. Waste Management Alternative 2, Disposal Group 3, Base Case, Total Uranium Concentration Versus Time

The plot of total uranium's concentration versus time in the Option Case is similar to that in the Base Case (see Figure 5–676).

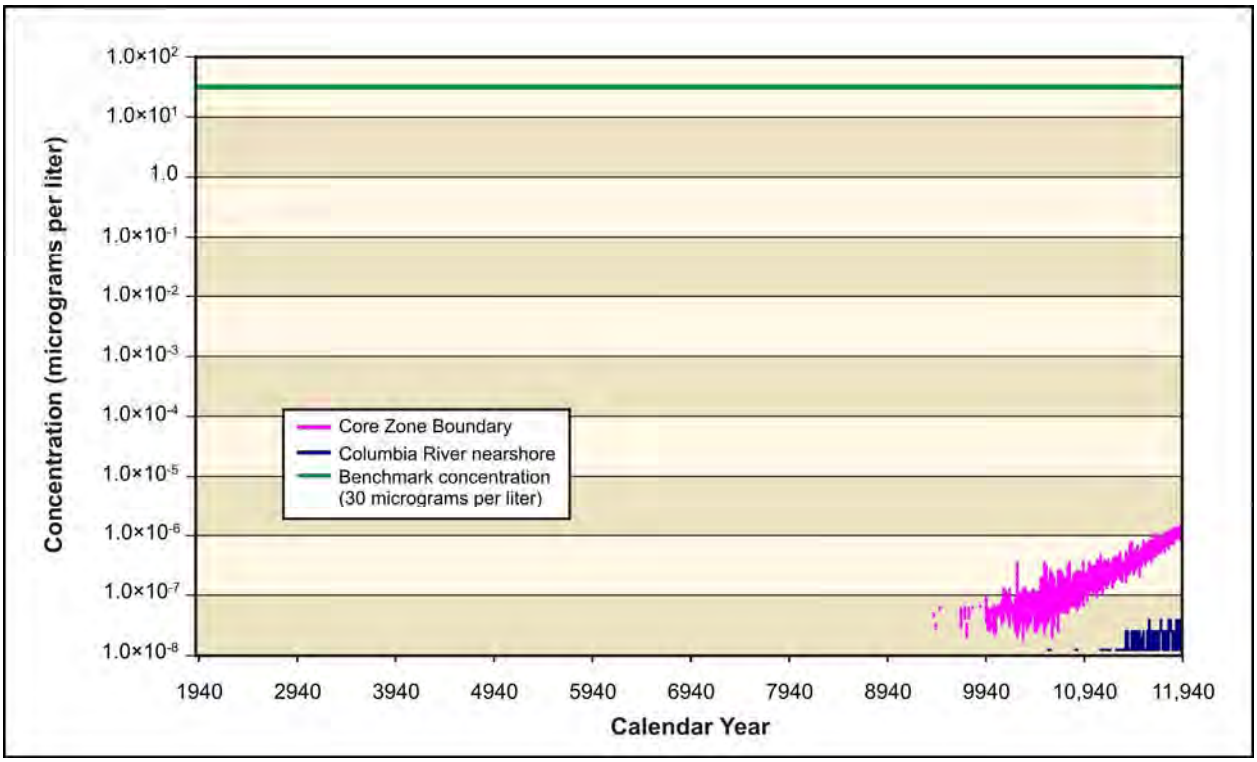


Figure 5–676. Waste Management Alternative 2, Disposal Group 3, Option Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 3, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark concentration, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–677 shows the spatial distribution of groundwater concentration for technetium-99 in the Base Case during CY 3890. Releases from the RPPDF create a plume extending northerly through Gable Gap toward the Columbia River. Peak concentrations in this plume exceed the benchmark by about 10 to 50 times, although most of the plume is below the benchmark. By CY 7140, releases from the IDF create a new plume extending easterly toward the Columbia River (see Figure 5–678). Peak concentrations in this plume exceed the benchmark by five times. By the end of the period of analysis (CY 11,885), the plume created by the RPPDF has mostly dissipated, while the IDF plume persists, most of it below the benchmark (see Figure 5–679). Iodine-129 shows a similar spatial distribution over time but with slightly more intense peak concentrations (see Figures 5–680 through 5–682). Chromium and nitrate also show a similar spatial distribution over time, but with less intense areas of peak concentration (see Figures 5–683 through 5–685 and Figures 5–686 through 5–688).

The spatial distributions of the conservative tracers in the Option Case are essentially identical to those in the Base Case (see Figures 5–689 through 5–700).

Total uranium is not as mobile as those radionuclides discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–701 shows the distribution of total uranium during CY 11,885 for the Base Case. A plume that is less than one-twentieth of the benchmark has been released from the RPPDF and is extending northerly through Gable Gap toward the Columbia River. Because of the slow nature of uranium's pore water velocity, most of the uranium releases are expected after the period of analysis. The spatial distribution of total uranium in the Option Case is essentially identical to that of the Base Case (see Figure 5-702).

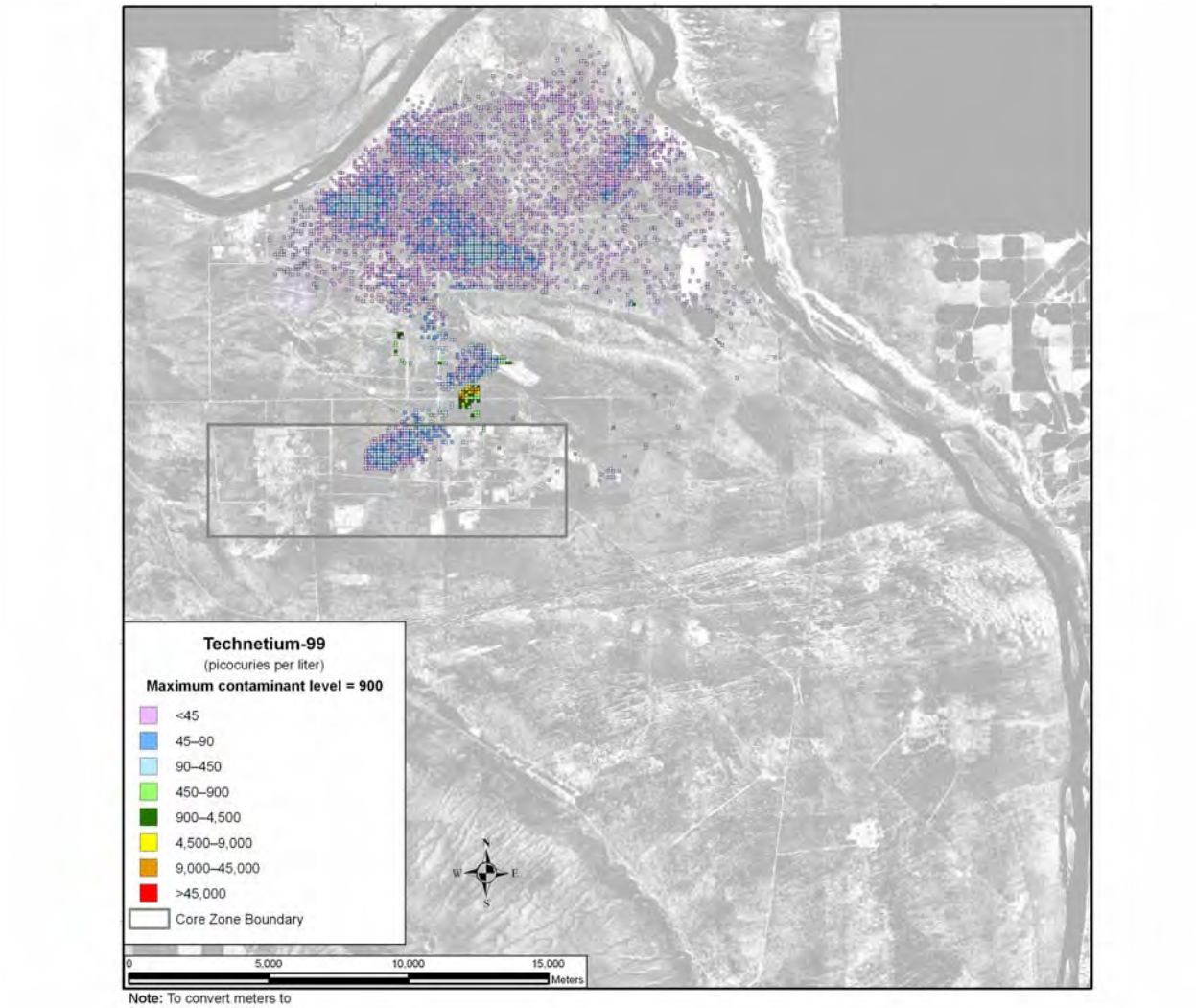


Figure 5–677. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

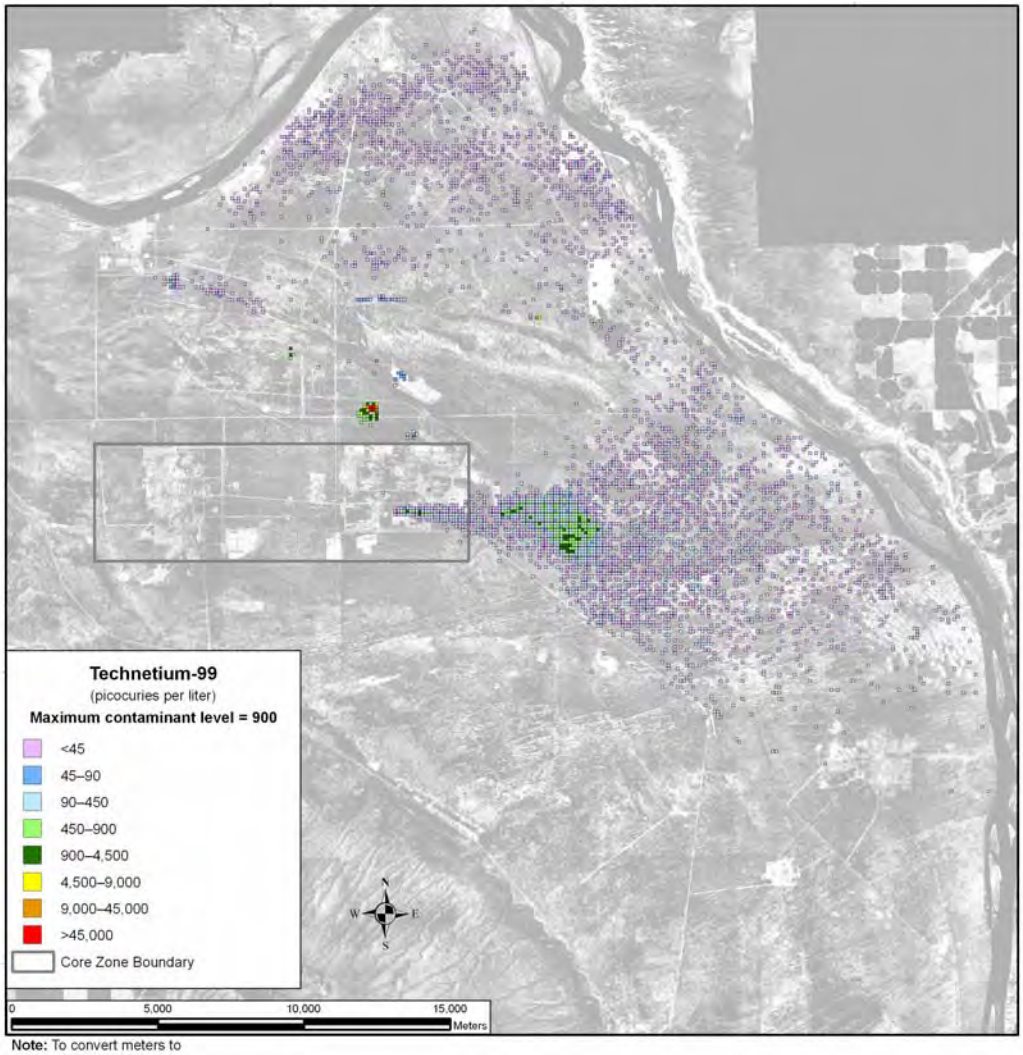


Figure 5–678. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

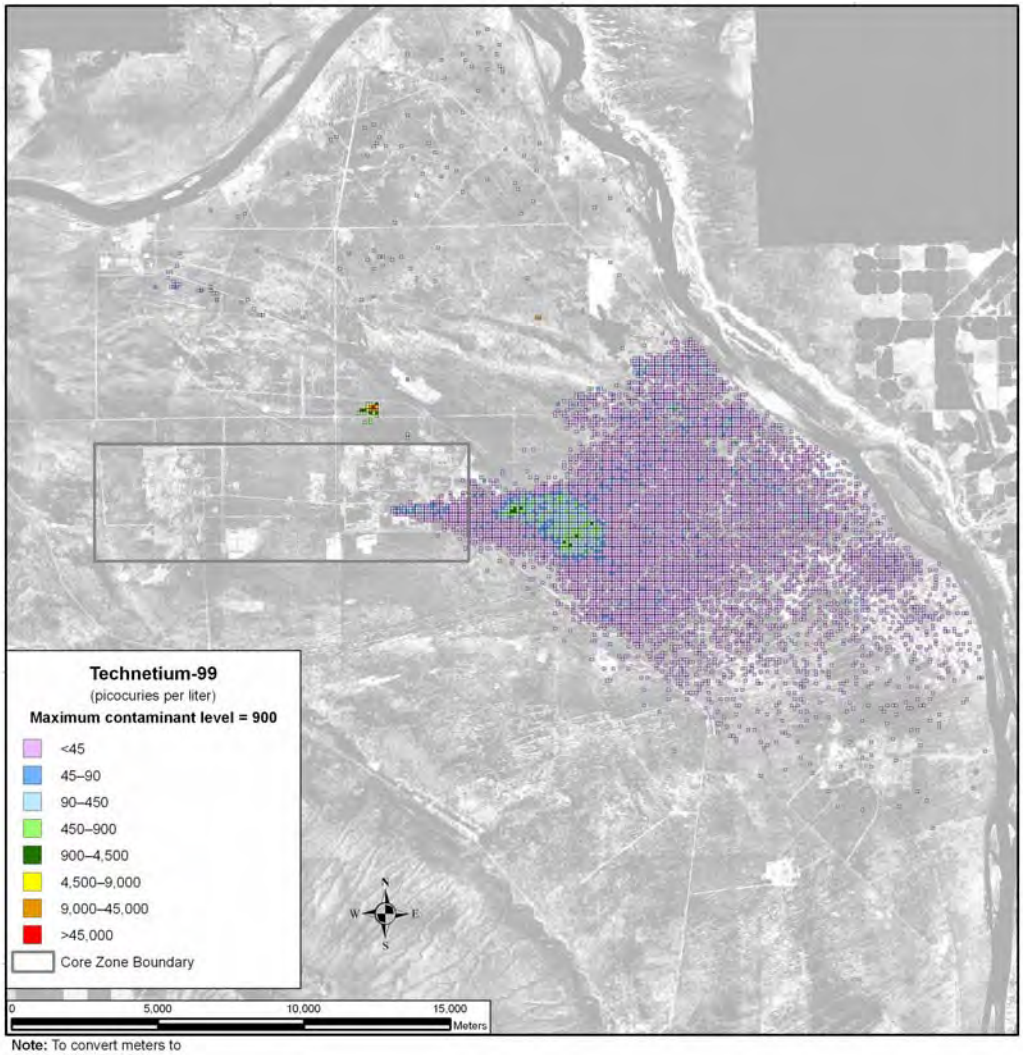


Figure 5–679. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

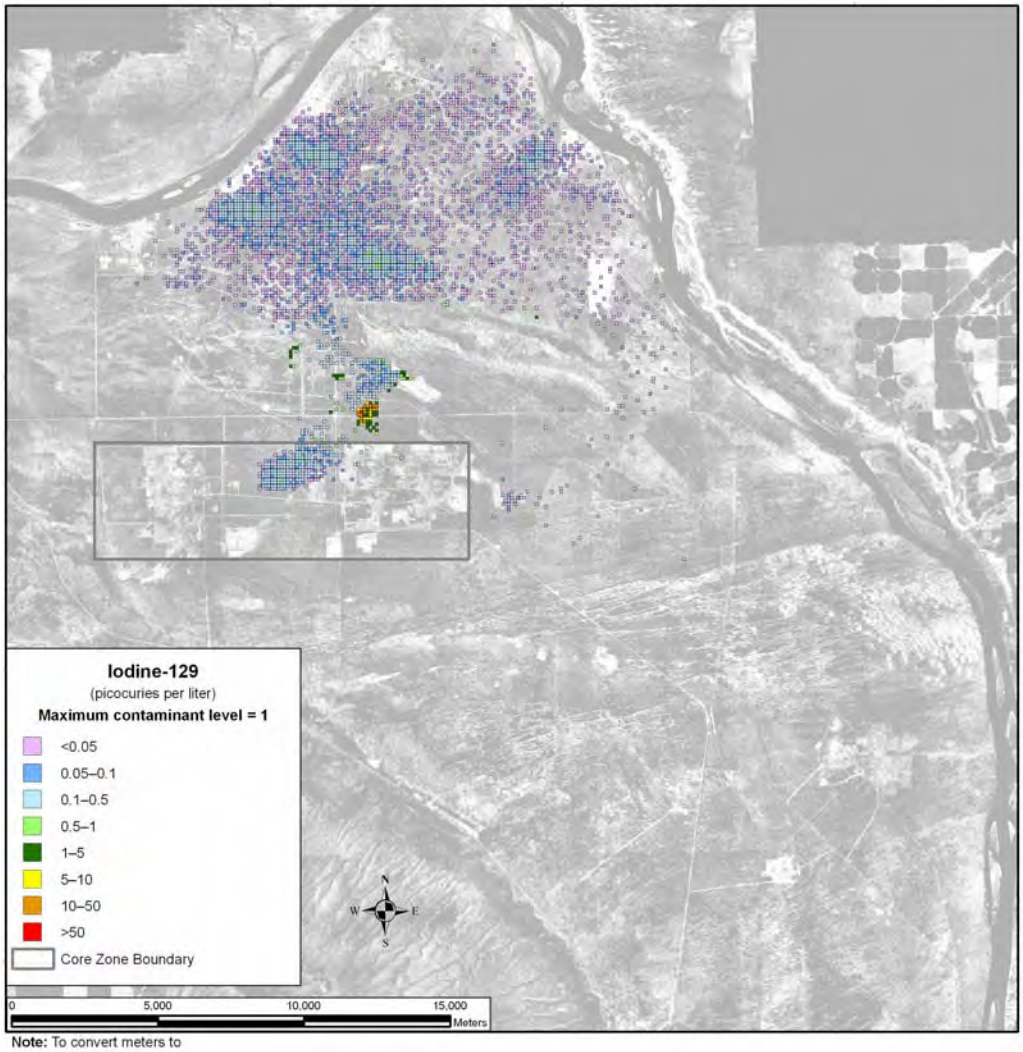


Figure 5–680. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

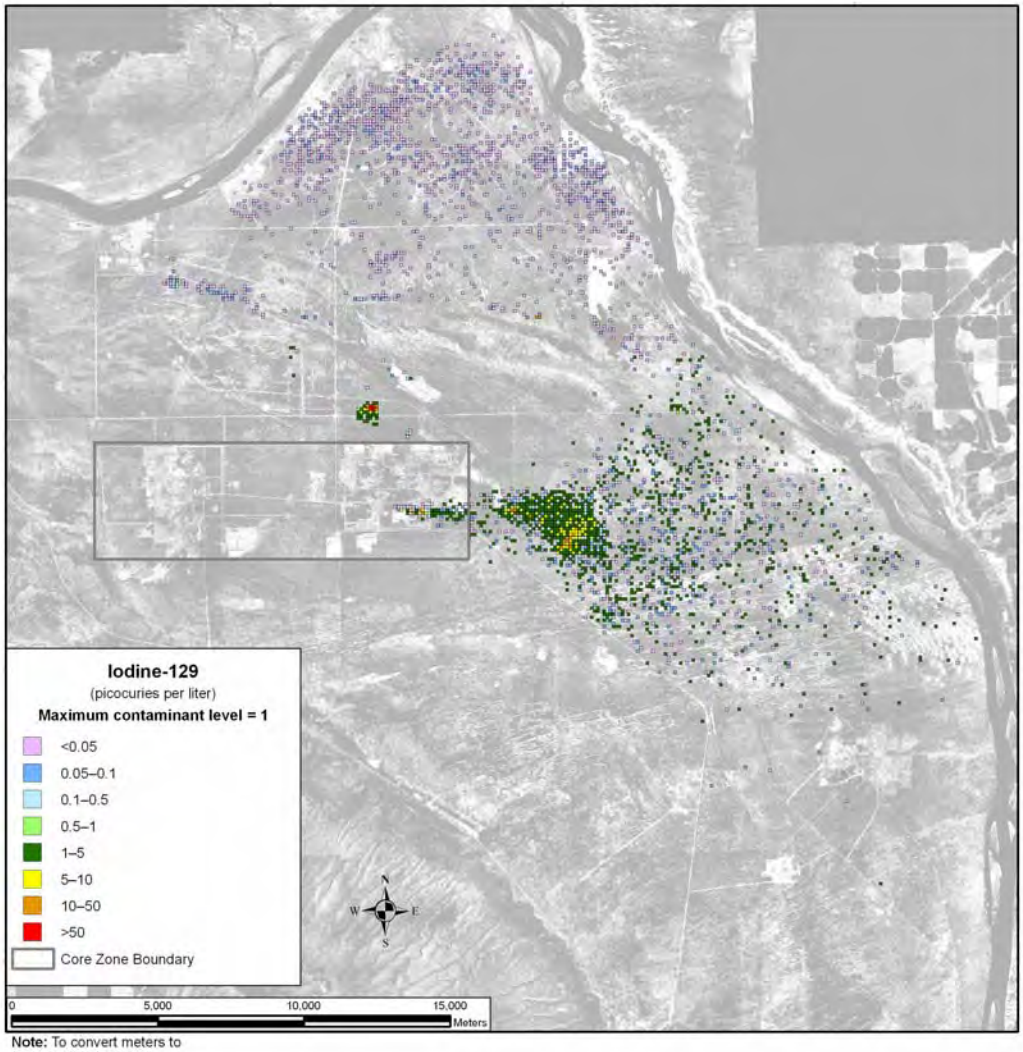


Figure 5–681. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

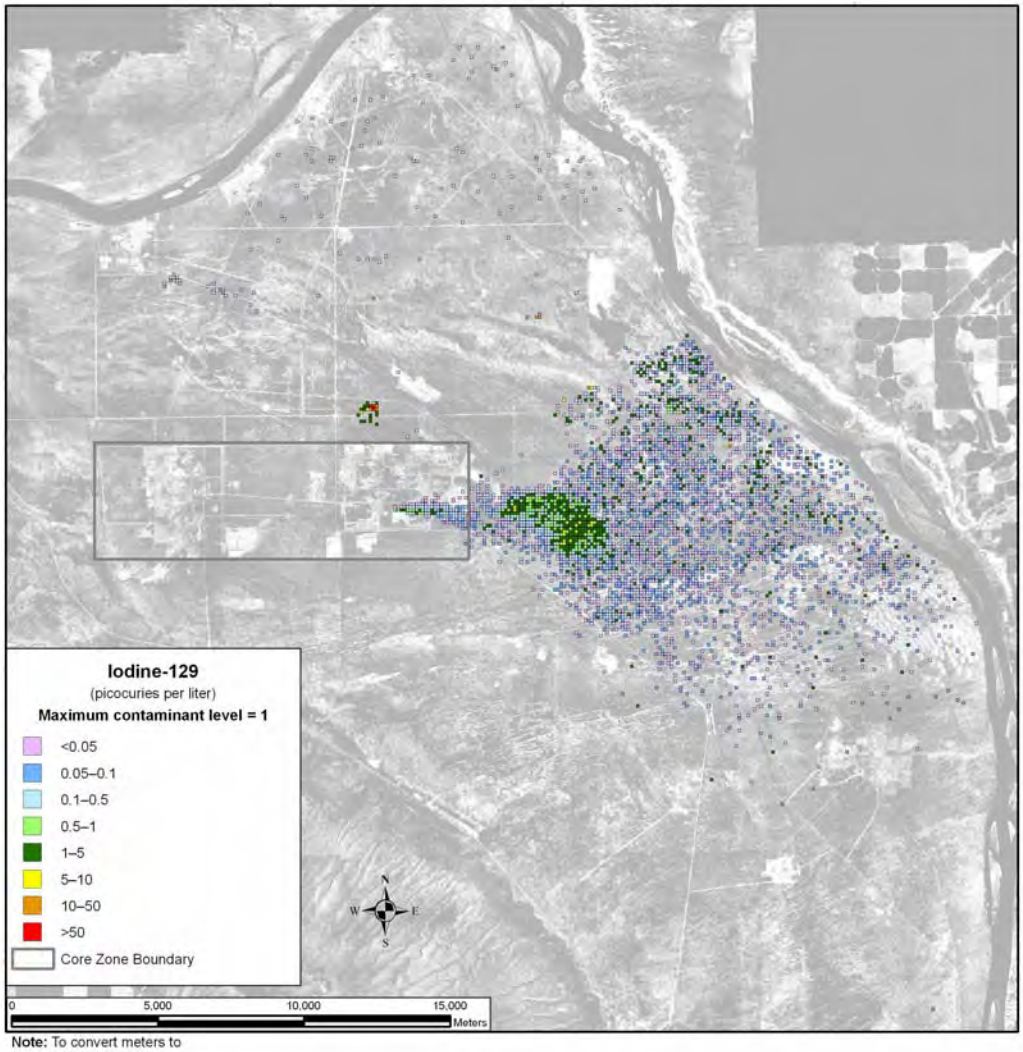


Figure 5–682. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

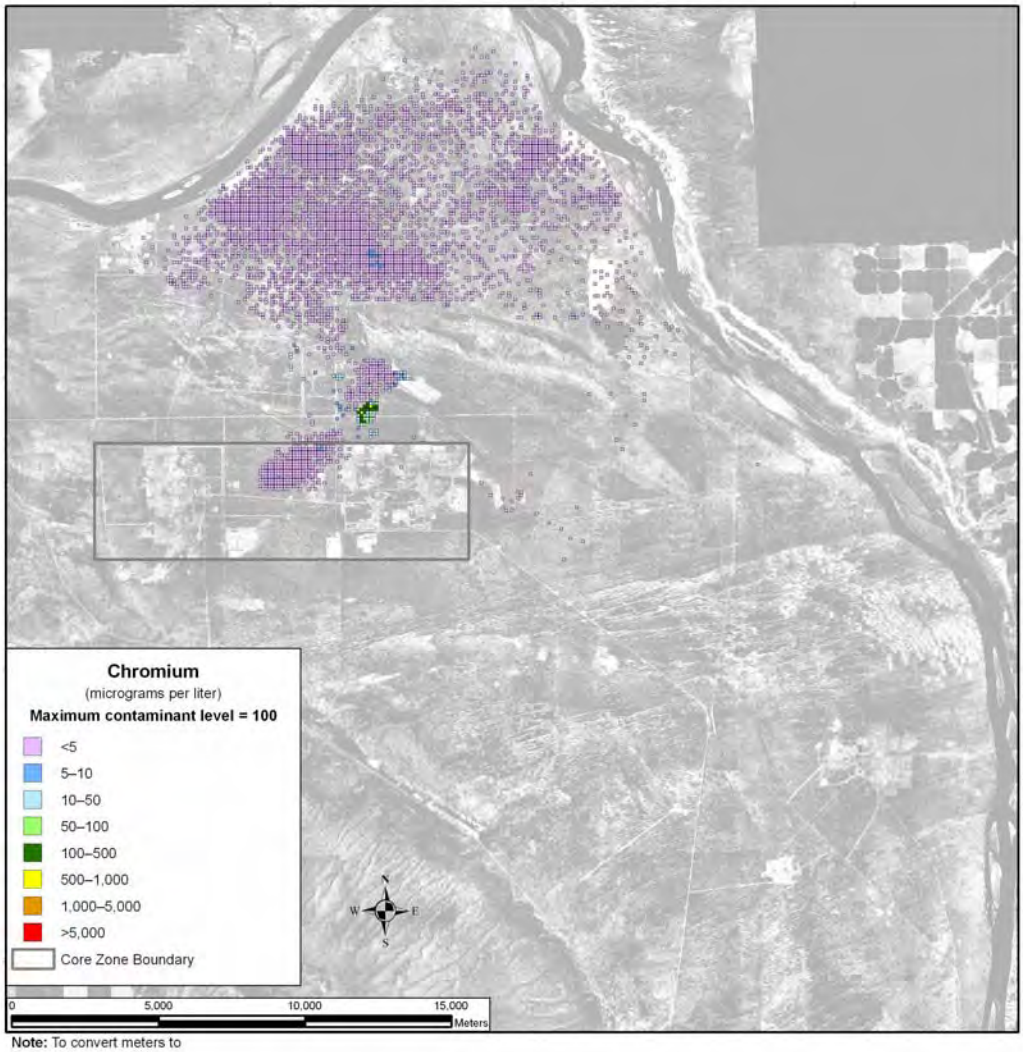


Figure 5–683. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

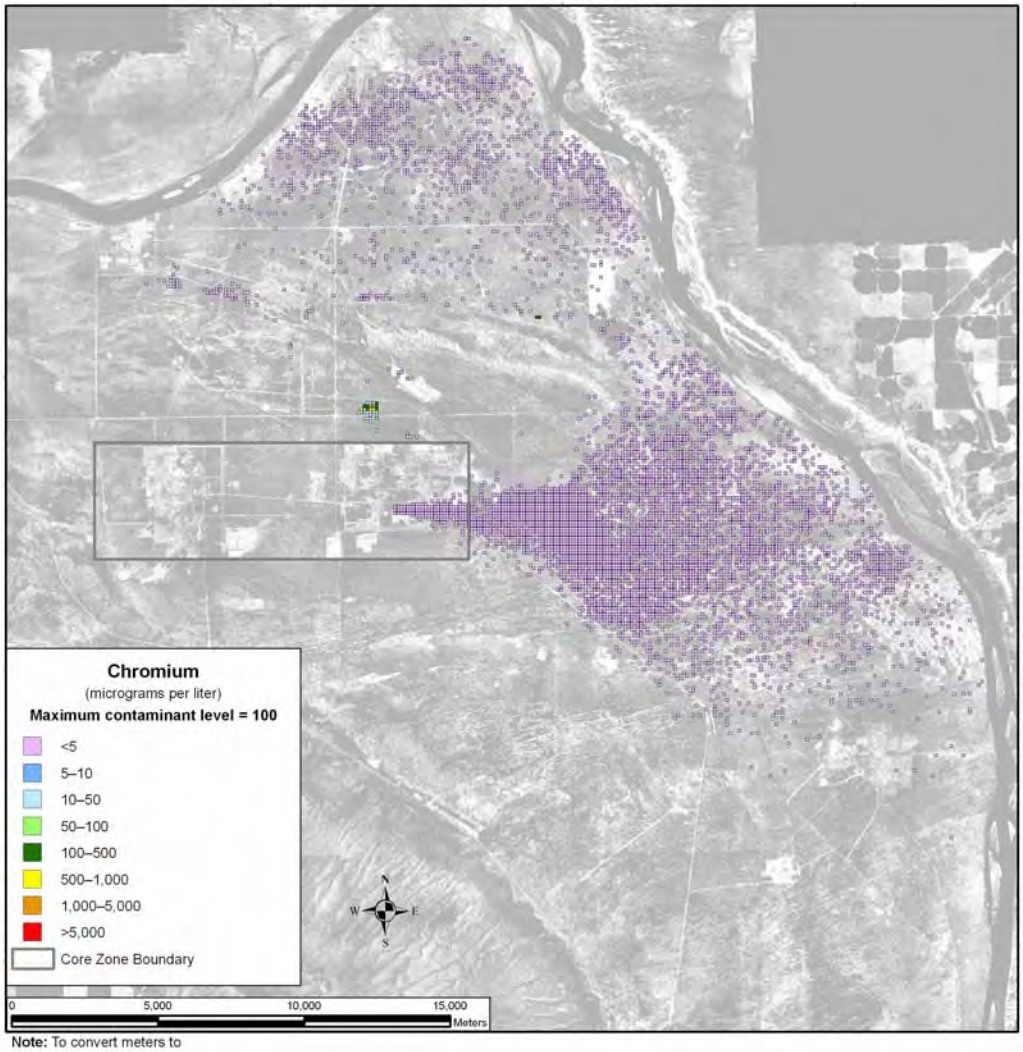


Figure 5–684. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

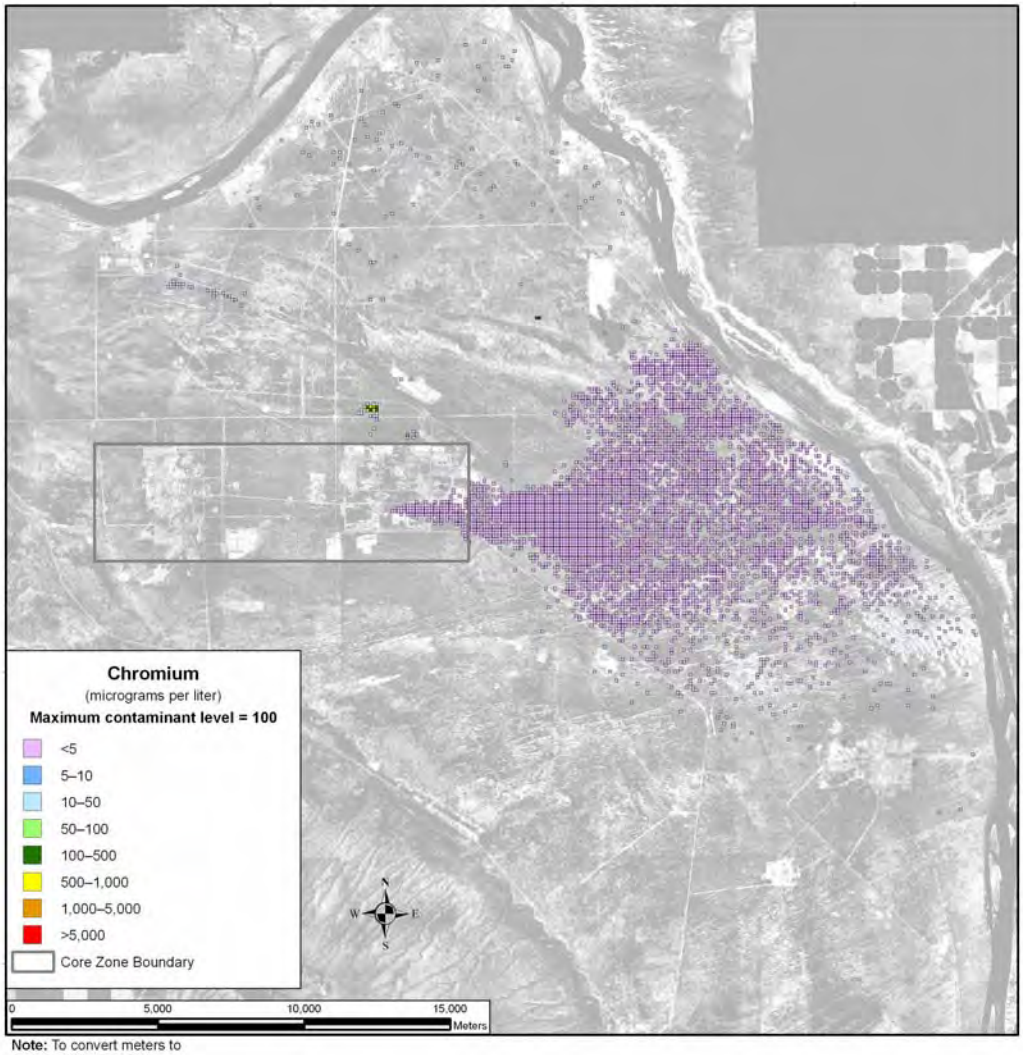


Figure 5–685. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

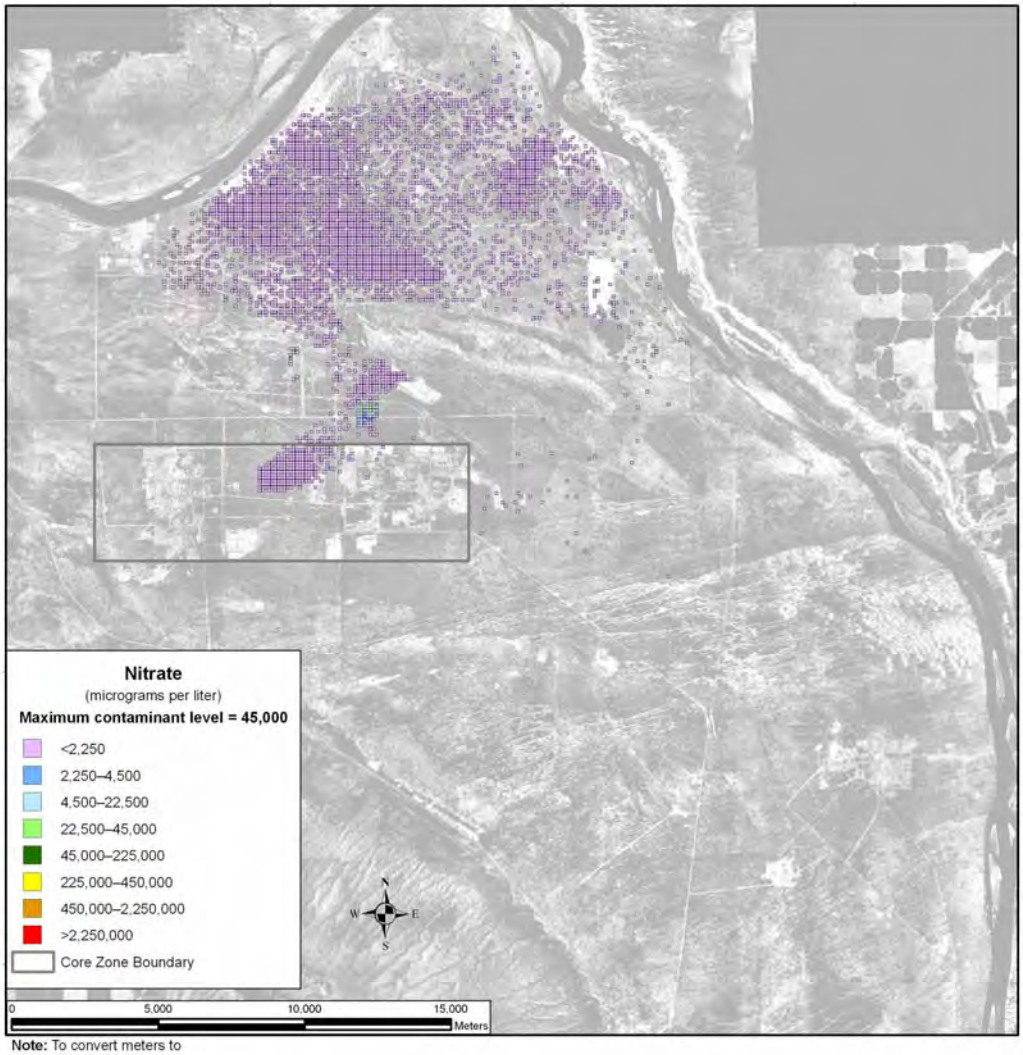


Figure 5–686. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

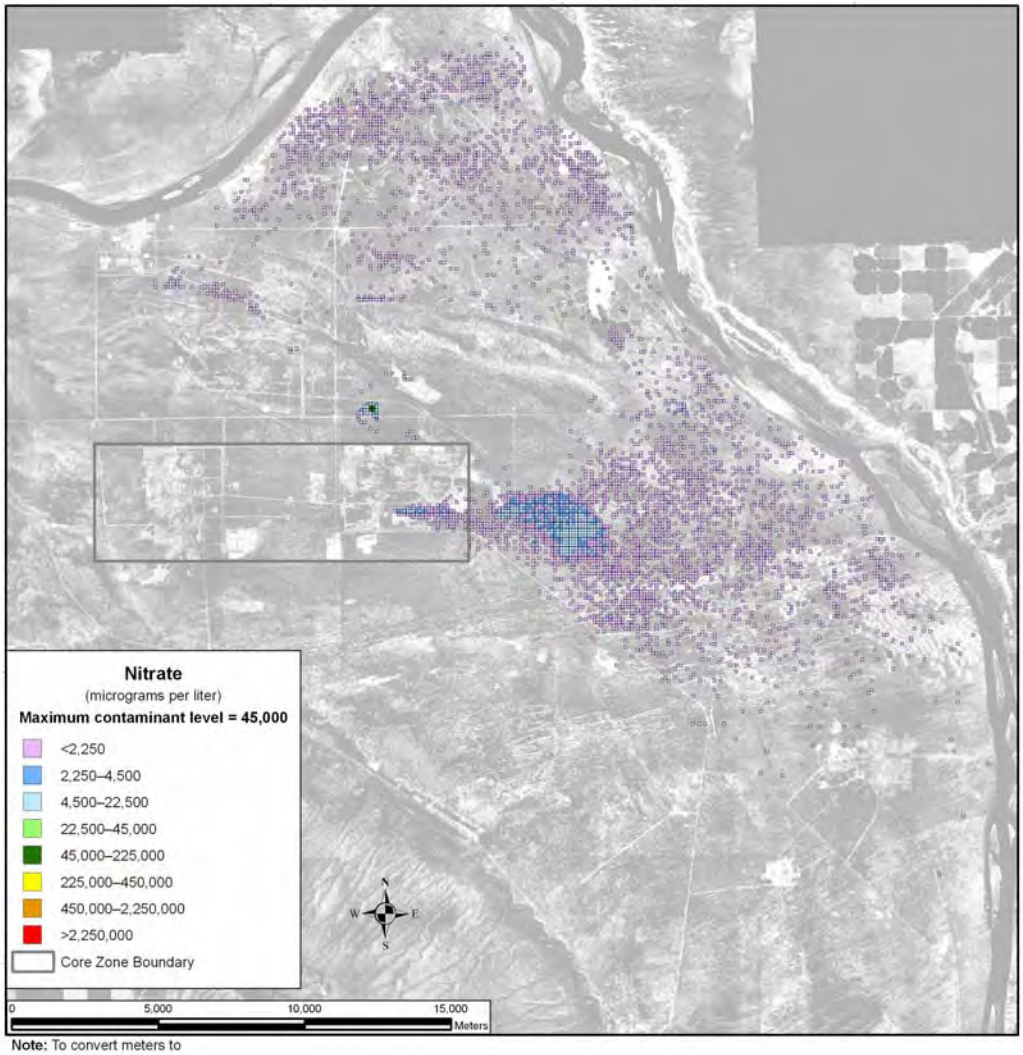


Figure 5–687. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

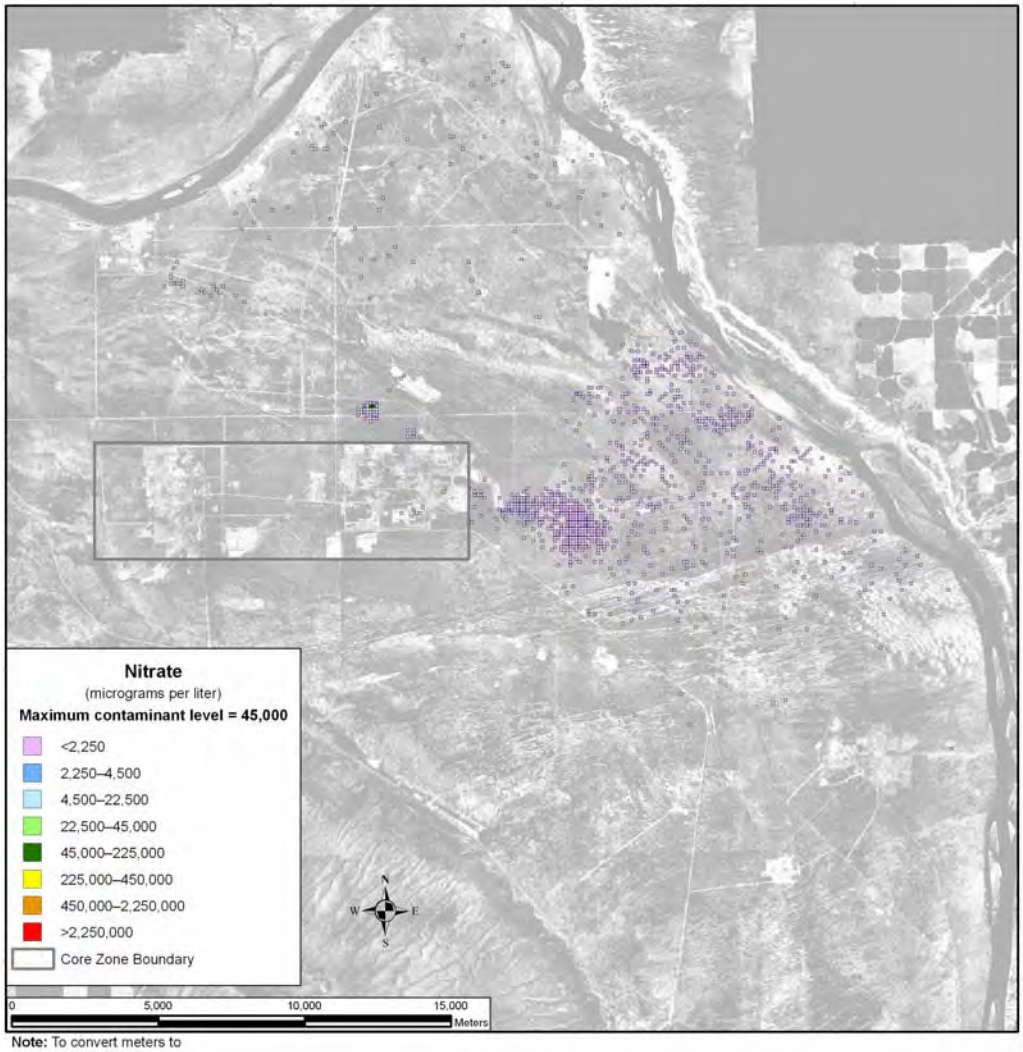


Figure 5–688. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

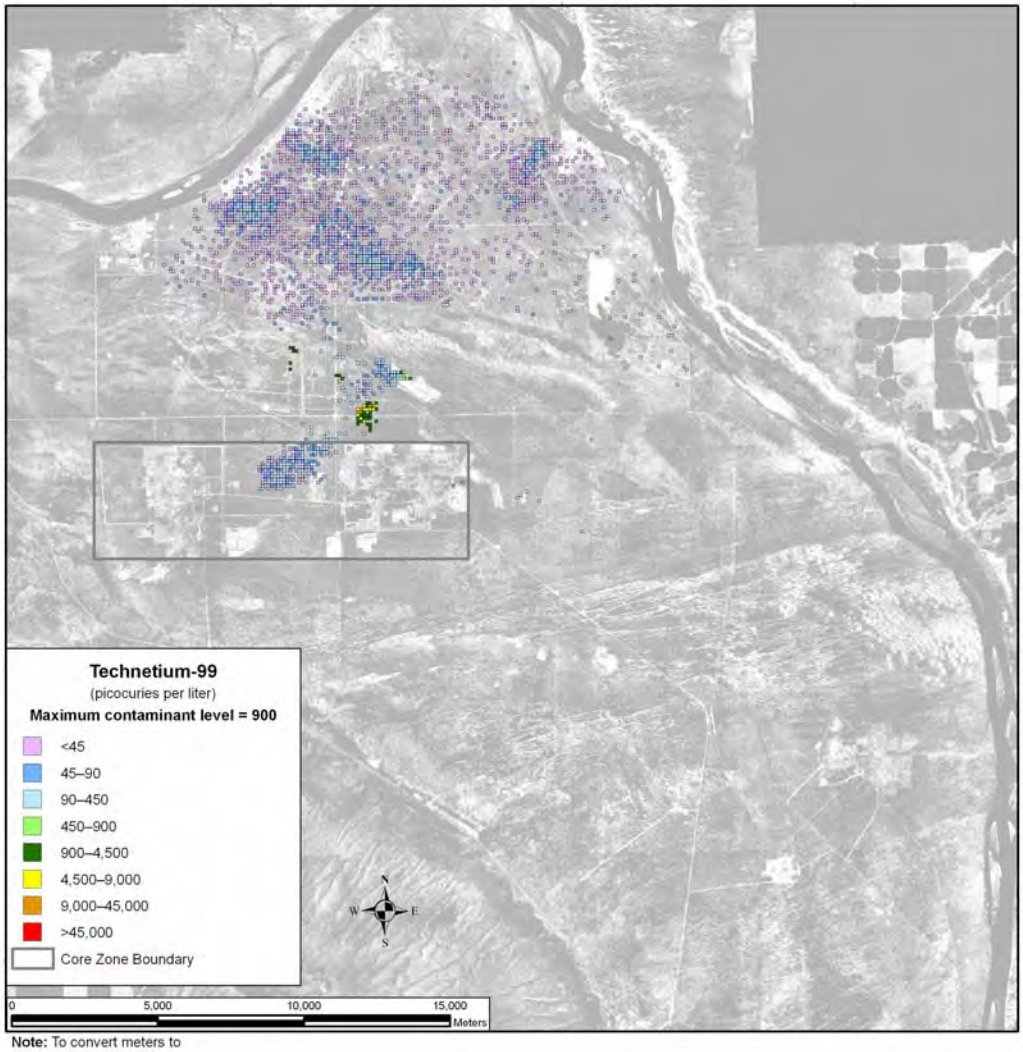


Figure 5–689. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

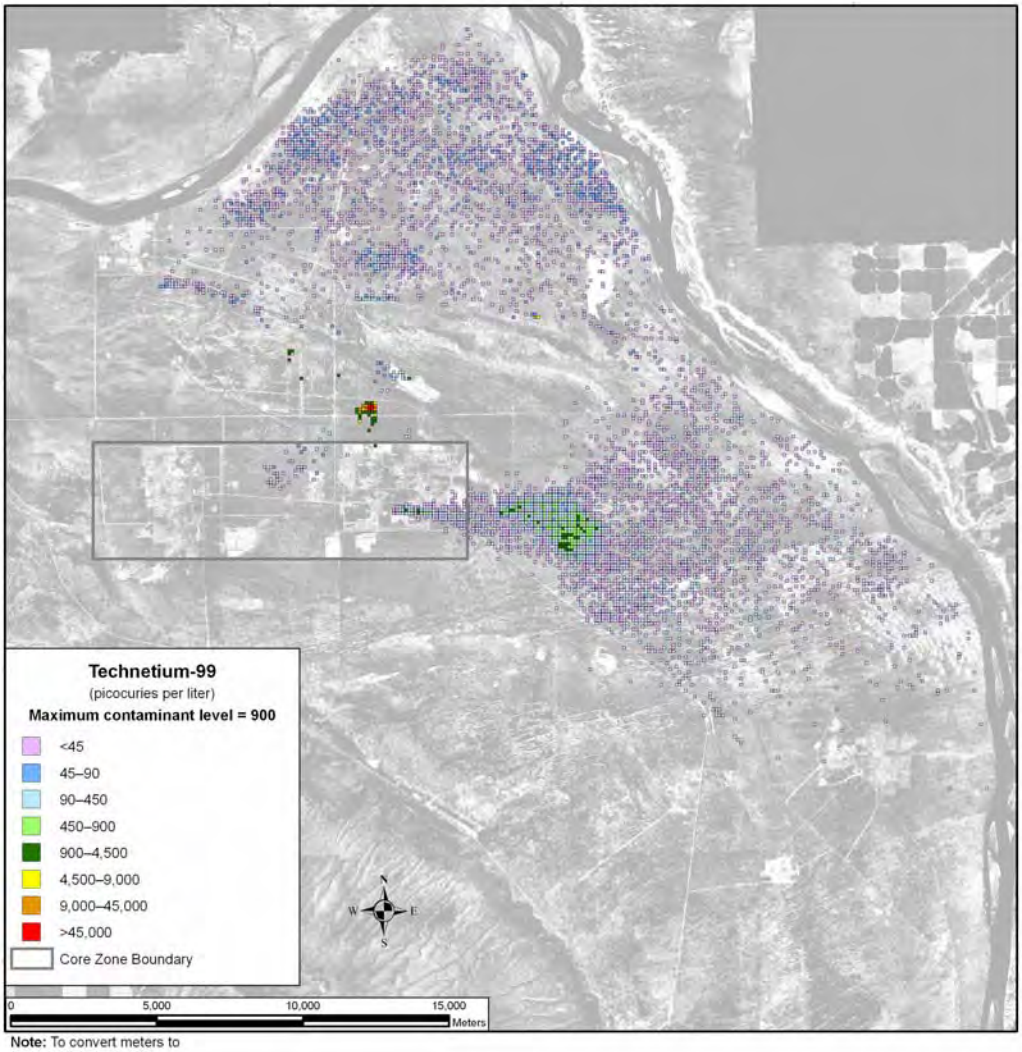


Figure 5–690. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

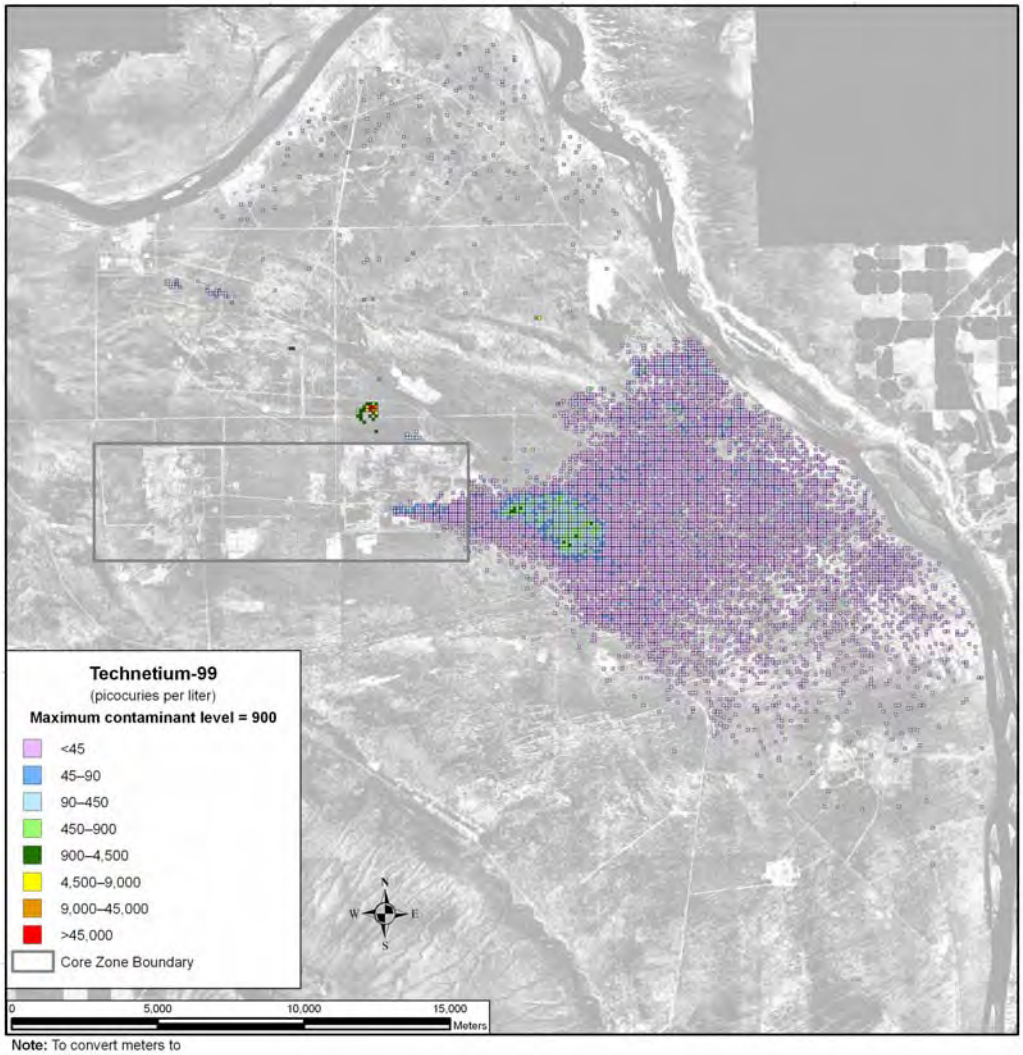


Figure 5–691. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

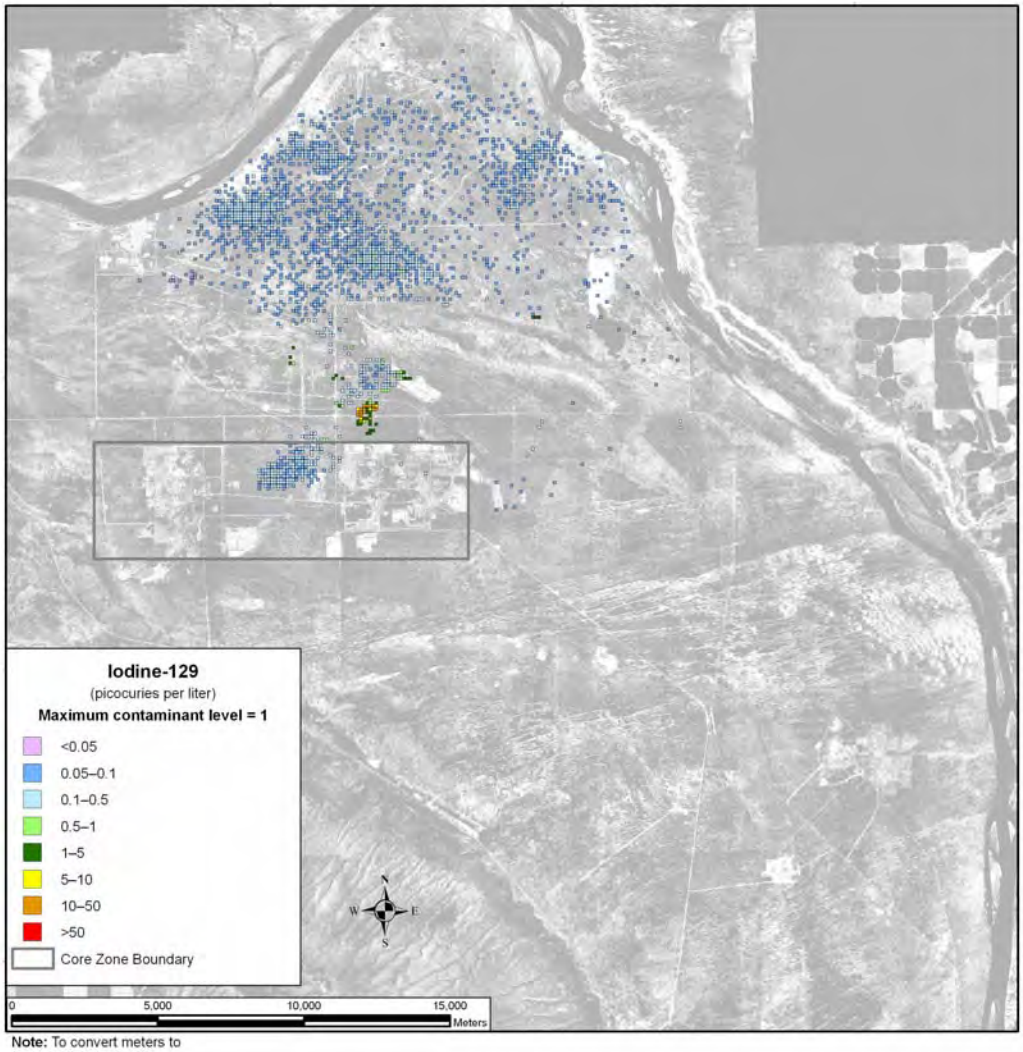


Figure 5–692. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

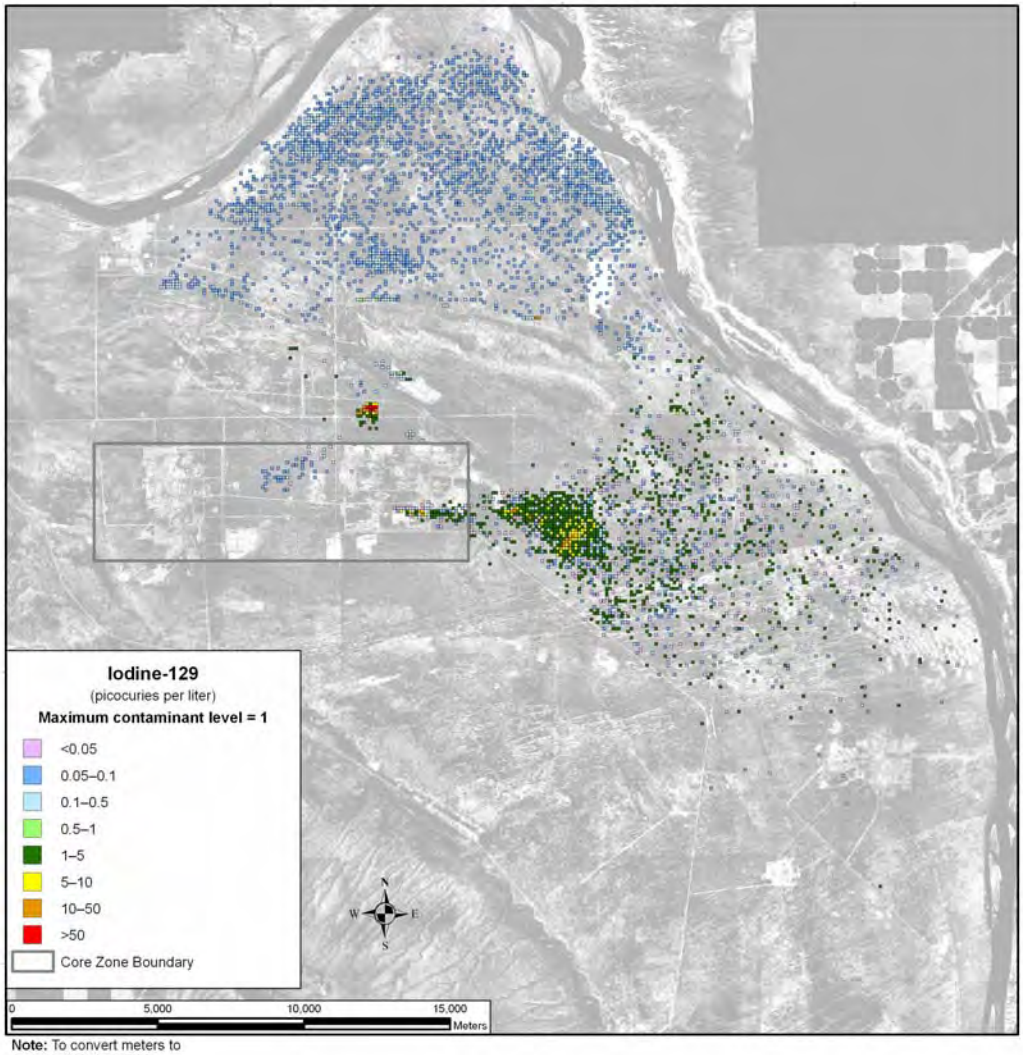


Figure 5–693. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

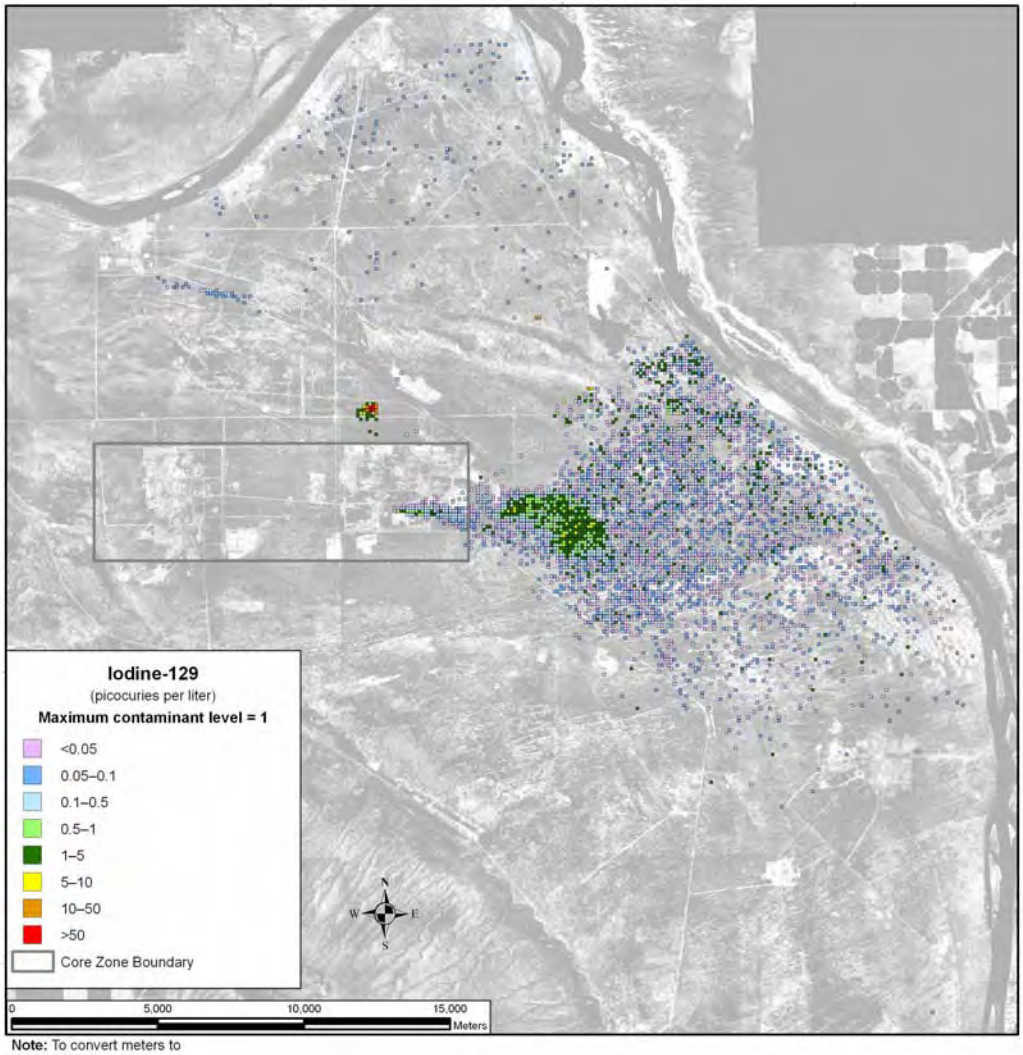


Figure 5–694. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

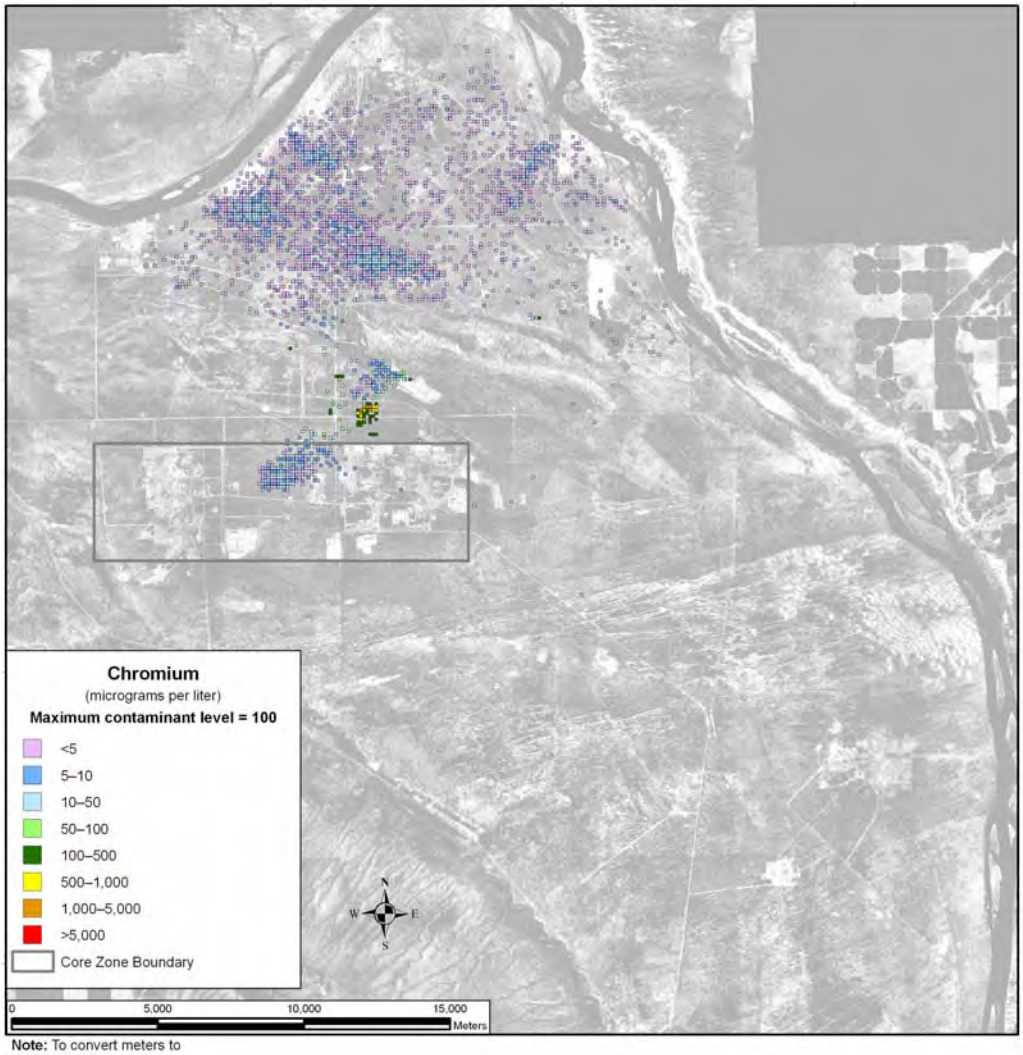


Figure 5–695. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

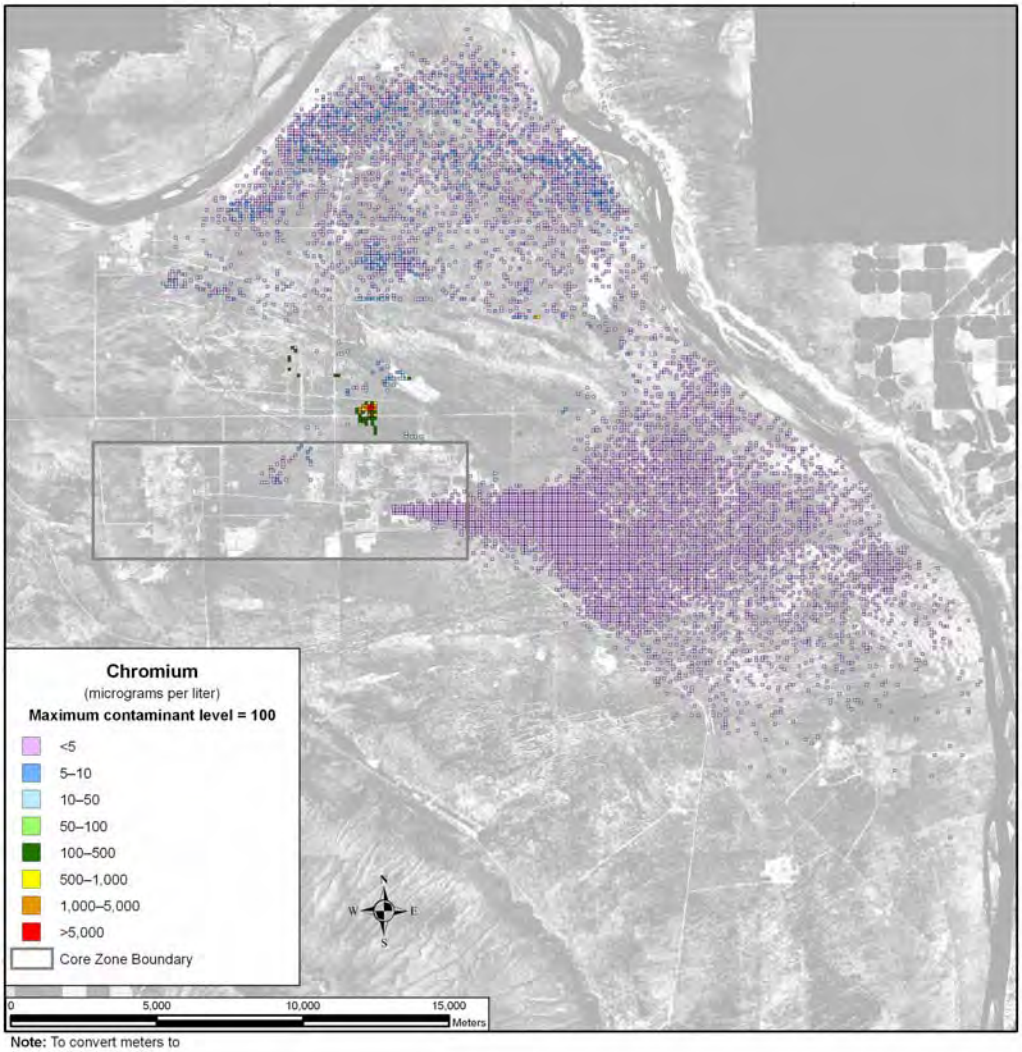


Figure 5–696. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

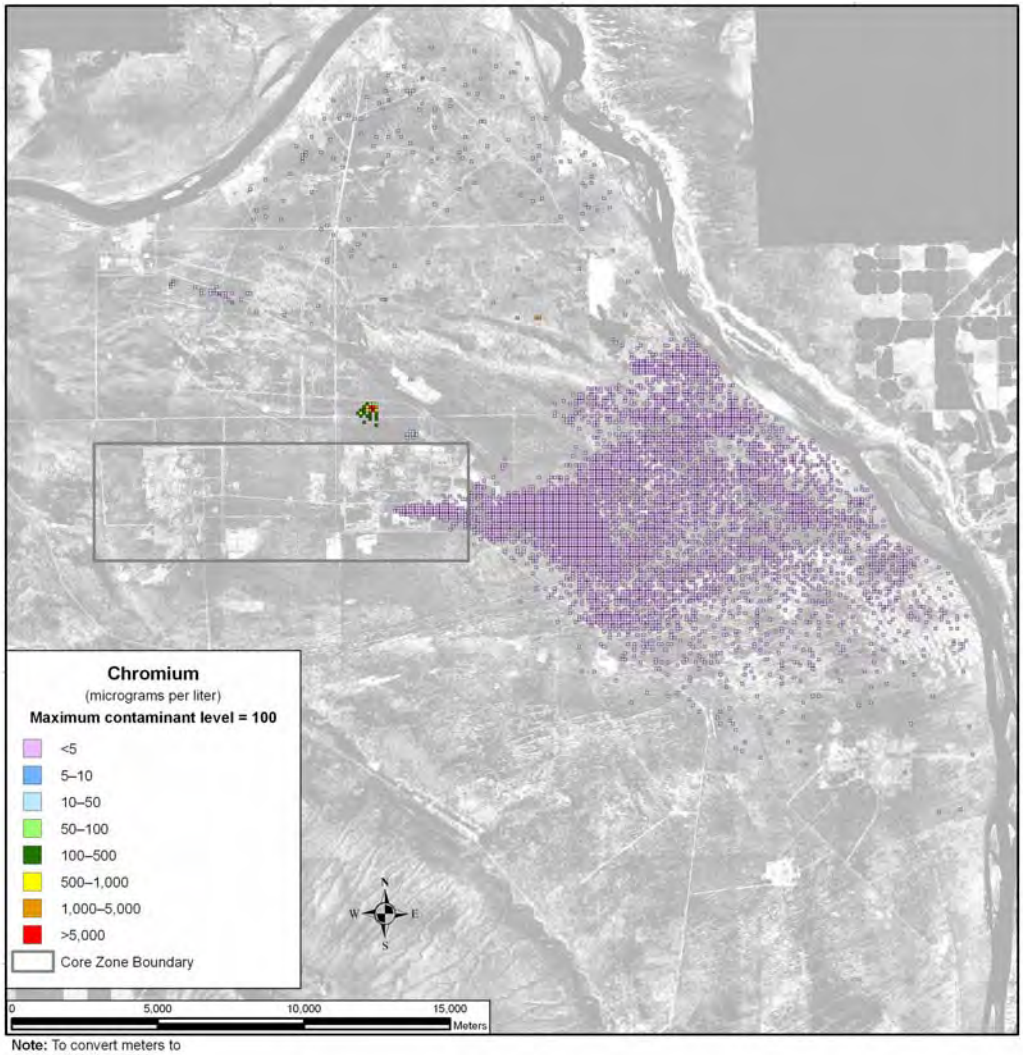


Figure 5–697. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

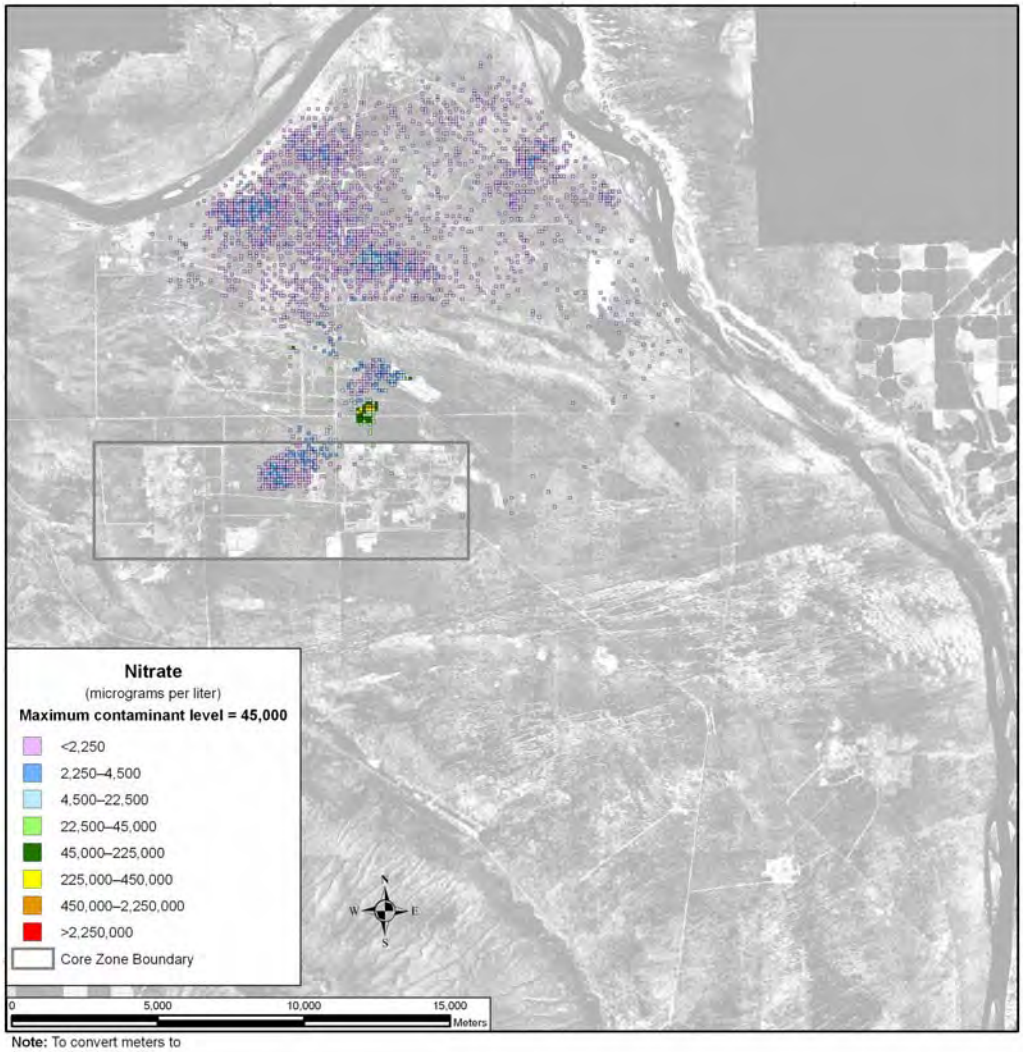


Figure 5–698. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

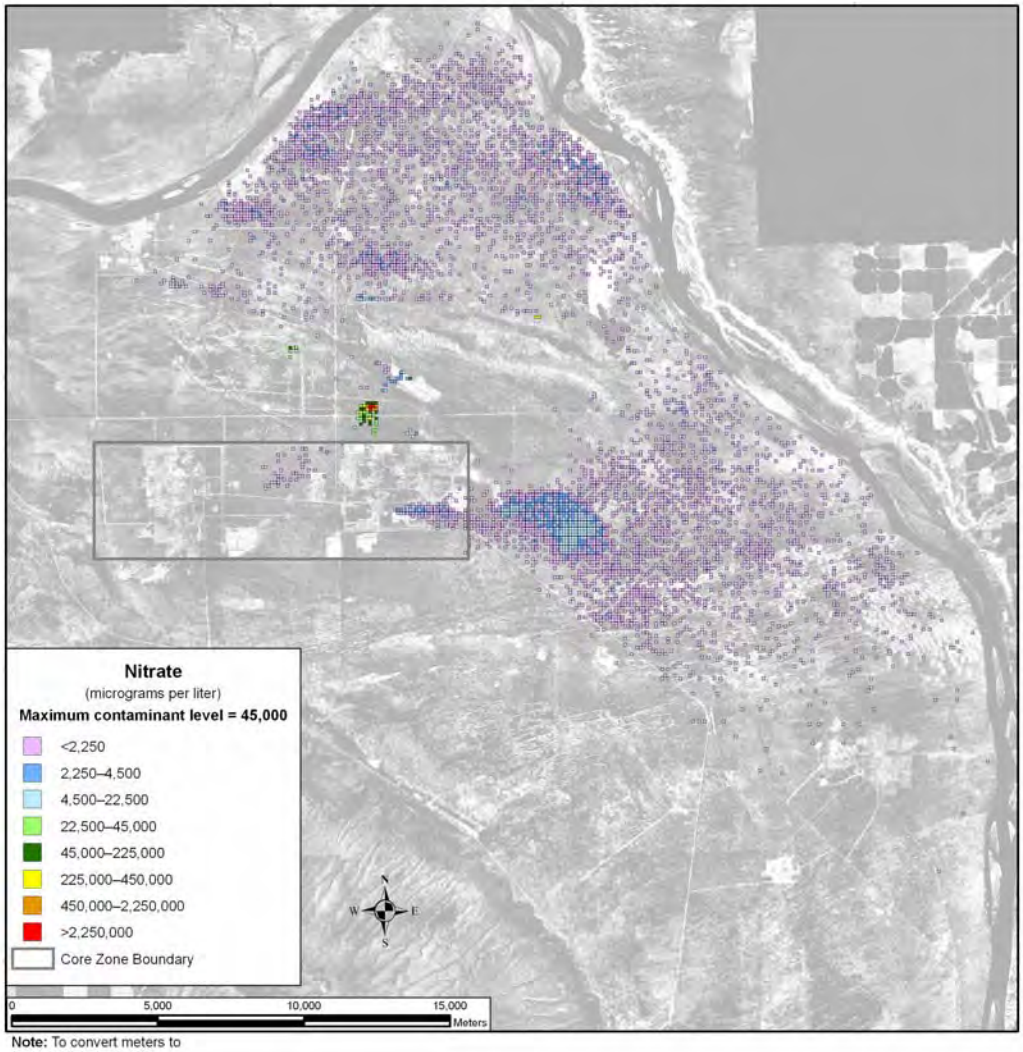


Figure 5–699. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

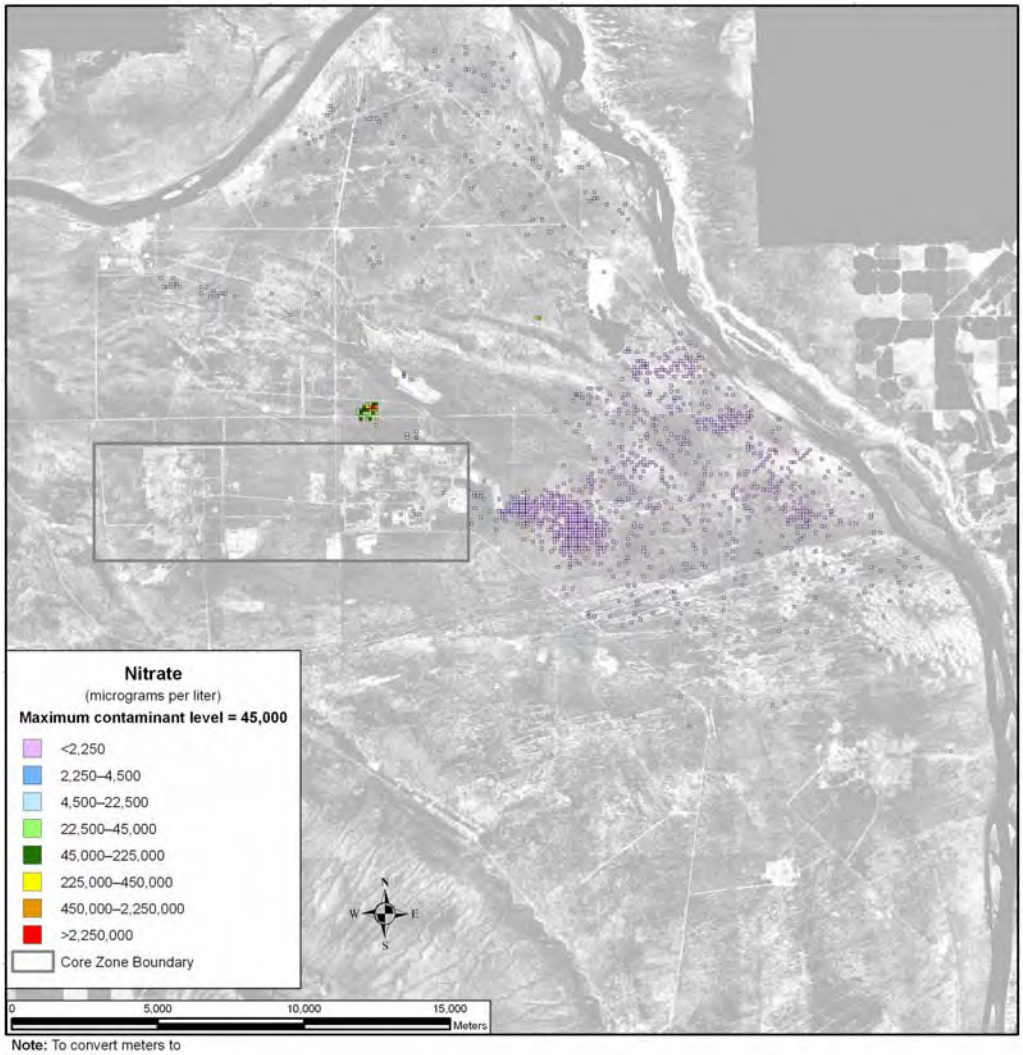


Figure 5–700. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

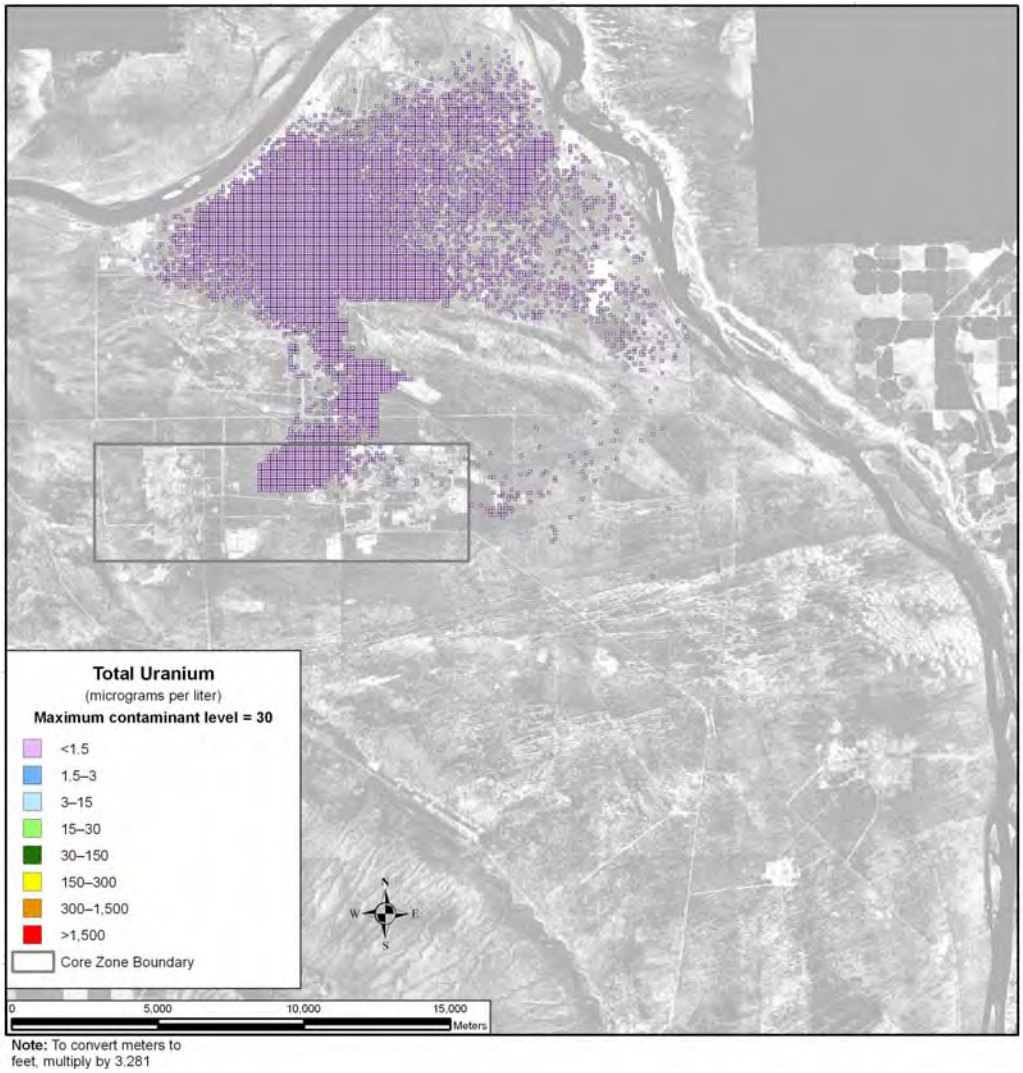


Figure 5–701. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

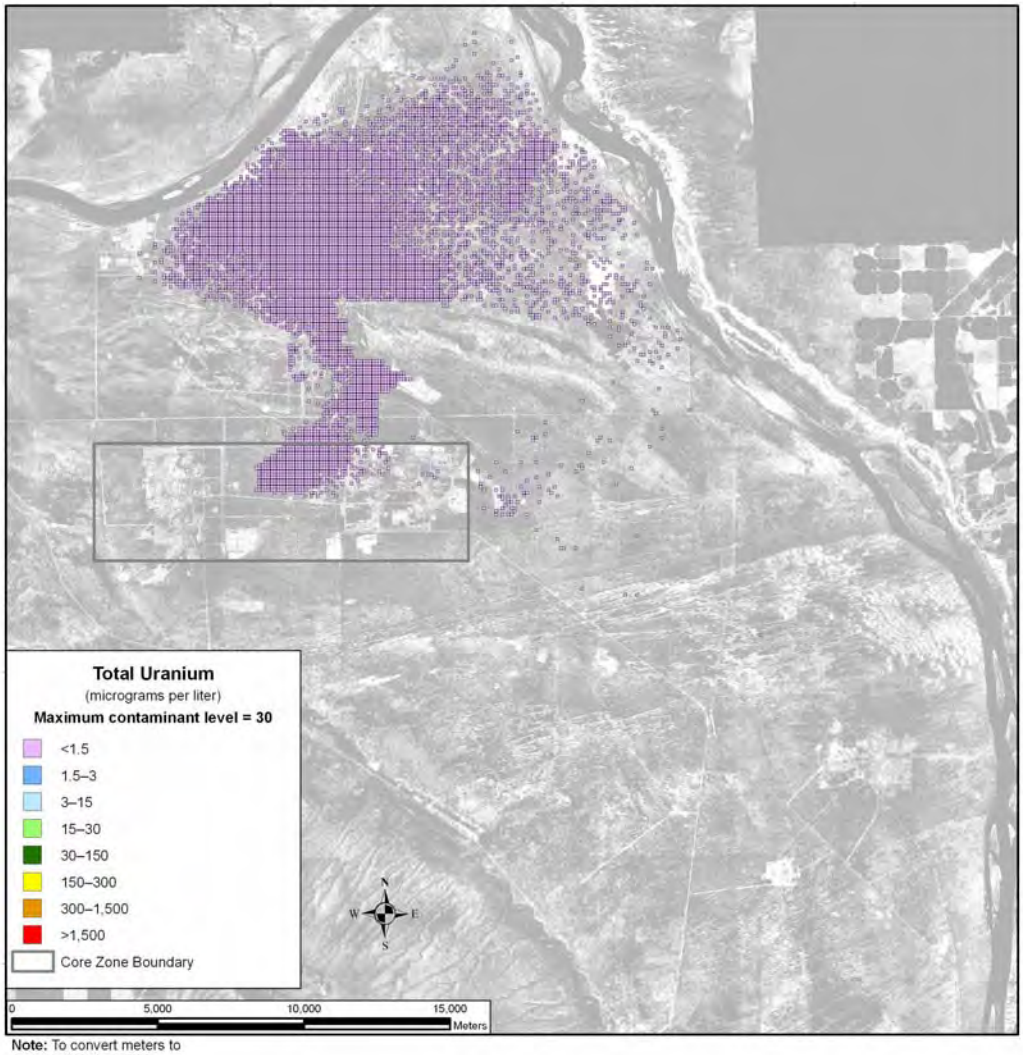


Figure 5–702. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For technetium-99 in the Base Case, releases cause the groundwater concentrations at the Core Zone Boundary and at the Columbia River nearshore to approach the benchmark concentration around CY 7000 to CY 10,000. The concentrations at the Core Zone Boundary and the Columbia River nearshore never consistently remain above the benchmark throughout the period of analysis.

The behavior of technetium-99 in the Option Case is similar to that in the Base Case.

Iodine-129 concentrations in the Base Case at the Core Zone Boundary and the Columbia River nearshore exceed the benchmark from about CY 6000 until the end of the period of analysis. Peak exceedances were approximately one order of magnitude above the benchmark concentration.

Iodine-129 concentrations in the Option Case show a pattern similar to that in the Base Case.

Concentrations of chromium at the Core Zone Boundary in the Base Case approach the benchmark from about CY 3800 to CY 5800. During that time, there are no significant benchmark exceedances. The concentrations from the Columbia River nearshore remained about one order of magnitude below the benchmark.

The concentrations over time in the Option Case for chromium at the Core Zone Boundary and from the Columbia River nearshore remain just below the benchmark.

For the Base Case, nitrate concentrations at the Core Zone Boundary and from the Columbia River nearshore peak at around CY 8000. Even at the concentrations peak, nitrate levels still remain about one order of magnitude below the benchmark level.

In the Option Case, the concentrations over time for nitrate at the Core Zone Boundary peaked around CY 4800 but remain about one order of magnitude below the benchmark. Concentrations from the Columbia River nearshore remained fairly steady at around one order of magnitude below the benchmark.

For the Base Case, total uranium concentrations begin to register on the graph at CY 9500. The concentrations at the Core Zone Boundary and from the Columbia River nearshore both remain about seven to eight orders of magnitude below the benchmark level.

Total uranium concentrations in the Option Case behave similarly.

5.3.1.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

This section describes the results of Waste Management Alternative 3. It includes analysis of long-term groundwater impacts from sources within the IDF-East, IDF-West, and RPPDF Barriers. Impacts of sources remaining within the tank farm barriers are discussed in Section 5.1, which deals with tank closure impacts. Impacts of sources remaining within the FFTF Barrier are discussed in Section 5.2.

Waste Management Alternative 3 is designed to show the impacts of waste disposal at IDFs in the 200-East and 200-West Areas. Summaries of the actions and timelines for Waste Management Alternative 3 are provided in Chapter 2, Section 2.5. There are three disposal facilities:

- Two IDFs, one in the south-central part of the 200-East Area, which would receive tank wastes, and the other in the northern part of the 200-West Area, which would receive FFTF decommissioning waste, onsite-generated non-CERCLA waste, and offsite-generated LLW and MLLW. The LLW and MLLW inventories for trenches 31 and 34 are also included with the IDF inventory in this analysis.

- The RPPDF, located in the Core Zone between the 200-East and 200-West Areas, which would receive lightly contaminated equipment and soils resulting from tank farm closure activities.

Three disposal groups are analyzed. Each has a different configuration and timeline for the IDF and RPPDF facilities. The three disposal groups are discussed in detail in the following subsections.

5.3.1.3.1 Disposal Group 1

Disposal Group 1 is characterized by an operational completion date of CY 2050 for IDF-East, IDF-West, and the RPPDF. In Disposal Group 1, IDF-West has a large capacity (90,000 cubic meters [117,720 cubic yards]), IDF-East a larger capacity (1,300,000 cubic meters [1,700,400 cubic yards]), and the RPPDF a capacity of 1,080,000 cubic meters (1,412,640 cubic yards). These capacities are designed to meet the waste generation volumes associated with Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, 6C; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste.

5.3.1.3.1.1 Disposal Group 1, Subgroup 1-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, includes Tank Closure Alternative 2B, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste. Tank Closure waste would be converted to IHLW and ILAW glass. For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009 and the RPPDF in CY 2022 and continues for all three through CY 2050 when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2051 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group, Subgroup 1-A, were selected by evaluating the risk or hazard associated with all 28 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A.

The COPC drivers discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, (IDF-East, IDF-West, and the RPPDF), in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Integrated Disposal Facility

IDF-East has four subtotals plotted representing releases from ILAW glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

Figure 5–703 shows the release to the vadose zone for the radiological risk drivers and Figure 5–704, the chemical hazard drivers. For all four sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and chromium is tank closure secondary waste. For iodine-129 and nitrate, ETF-generated secondary waste is the predominant source. Boron and fluoride do not exist at IDF-East.

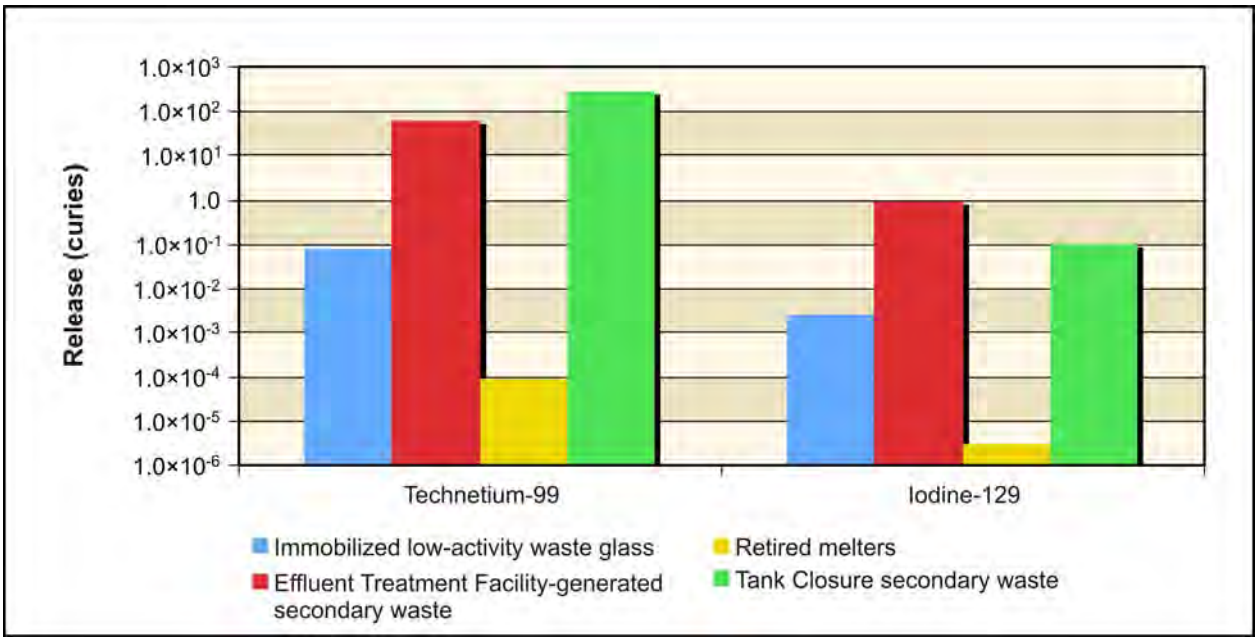


Figure 5–703. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

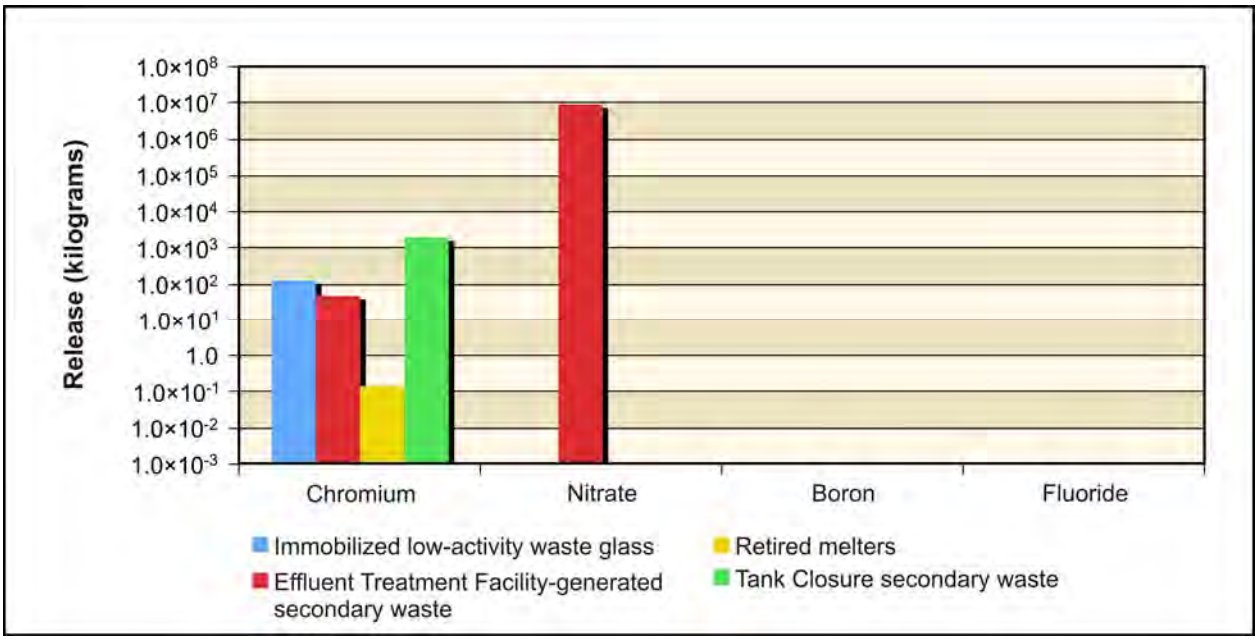


Figure 5–704. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–705 shows the release to groundwater for the radiological risk drivers and Figure 5–706, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 60 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches groundwater; approximately 100 percent of the chemical quantity (kilograms) reaches groundwater.

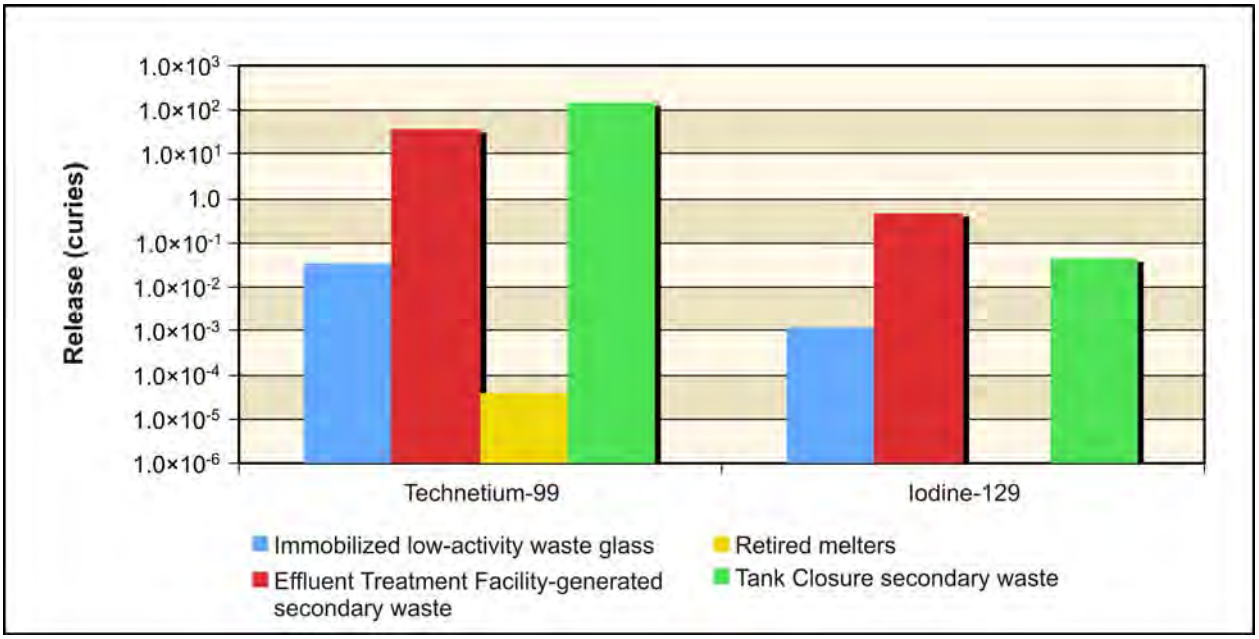


Figure 5–705. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

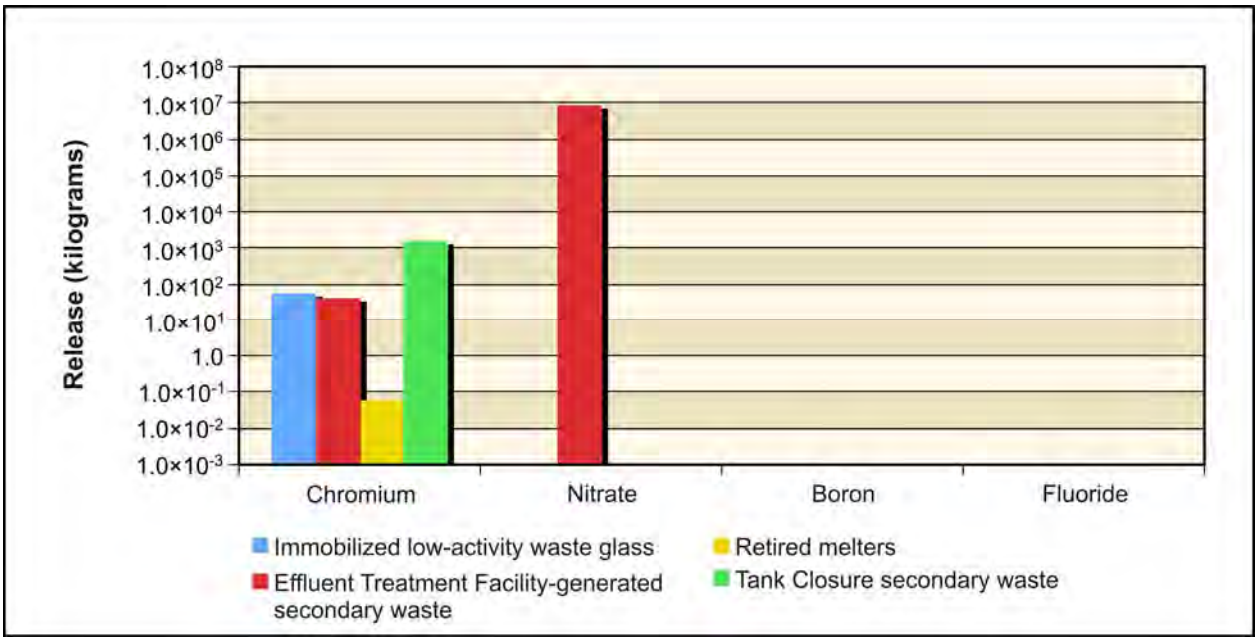


Figure 5–706. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–707 shows the release to the Columbia River for the radiological risk drivers and Figure 5–708, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. The exception is waste from retired melters for technetium-99. In this case, releases to groundwater did not reach the Columbia River. About 90 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reaches the river; approximately 99 percent of the chemical quantity (kilograms) reaches the river.

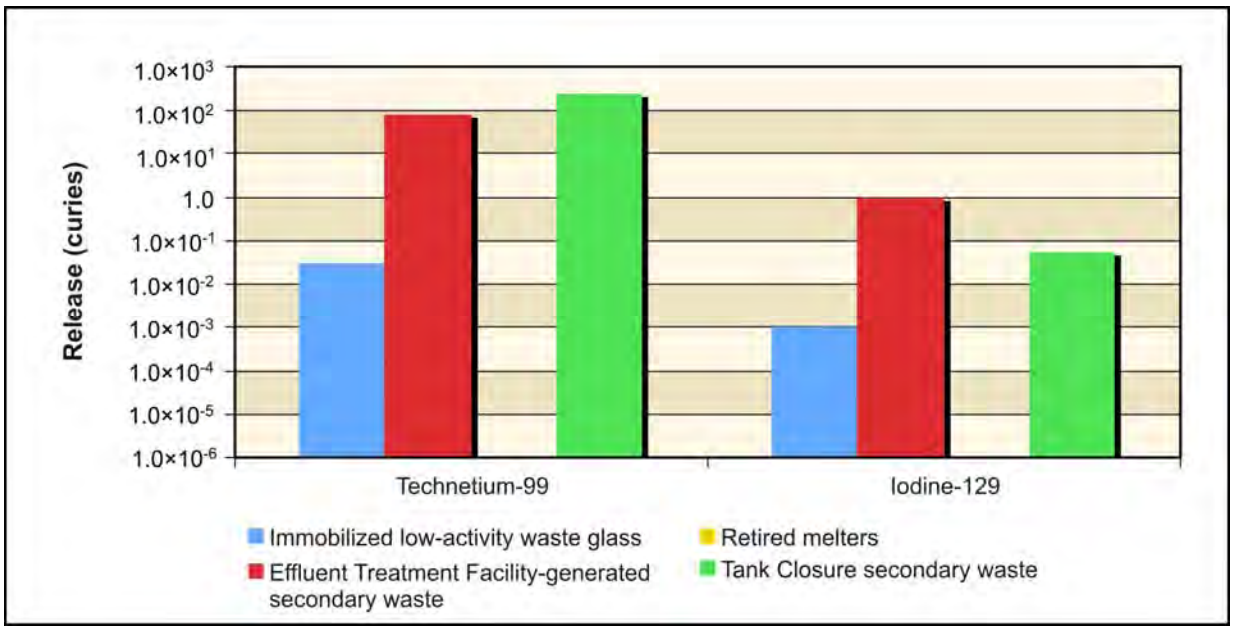


Figure 5–707. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

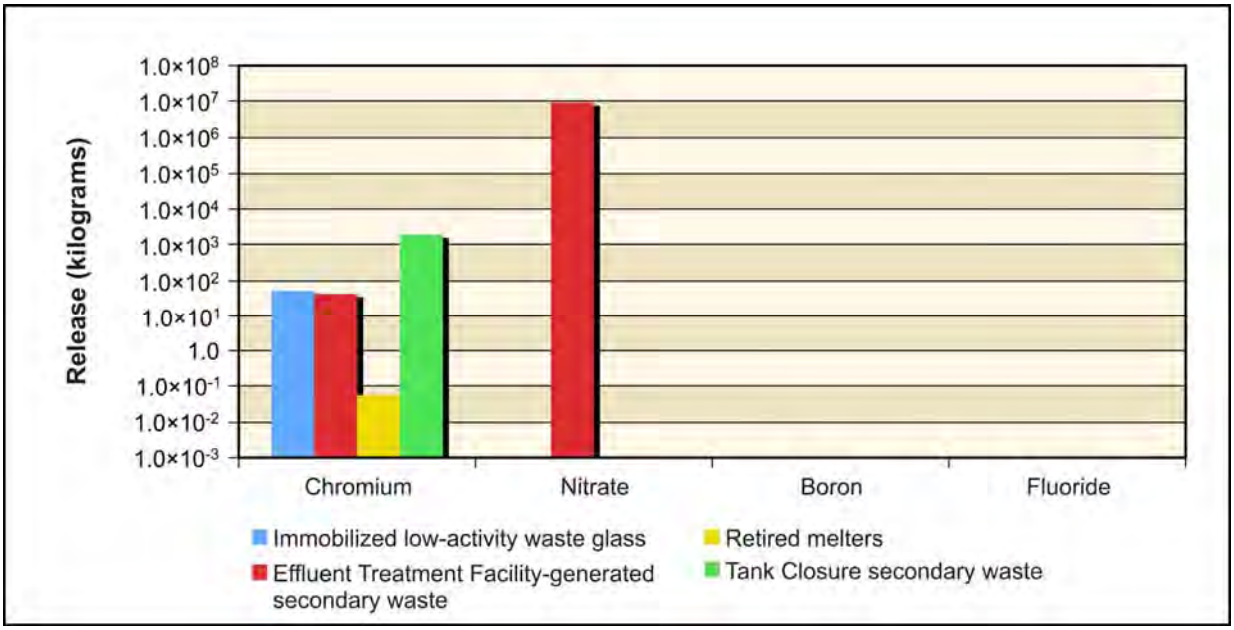


Figure 5–708. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases: FFTF Decommissioning Alternative 3 waste, waste management and onsite-generated waste, and offsite-generated waste.

Figure 5–709 shows the release to the vadose zone for the radiological risk drivers and Figure 5–710, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and iodine-129 is offsite-generated waste. For chromium, nitrate, boron, and fluoride, the predominant source is waste management secondary waste and onsite-generated waste.

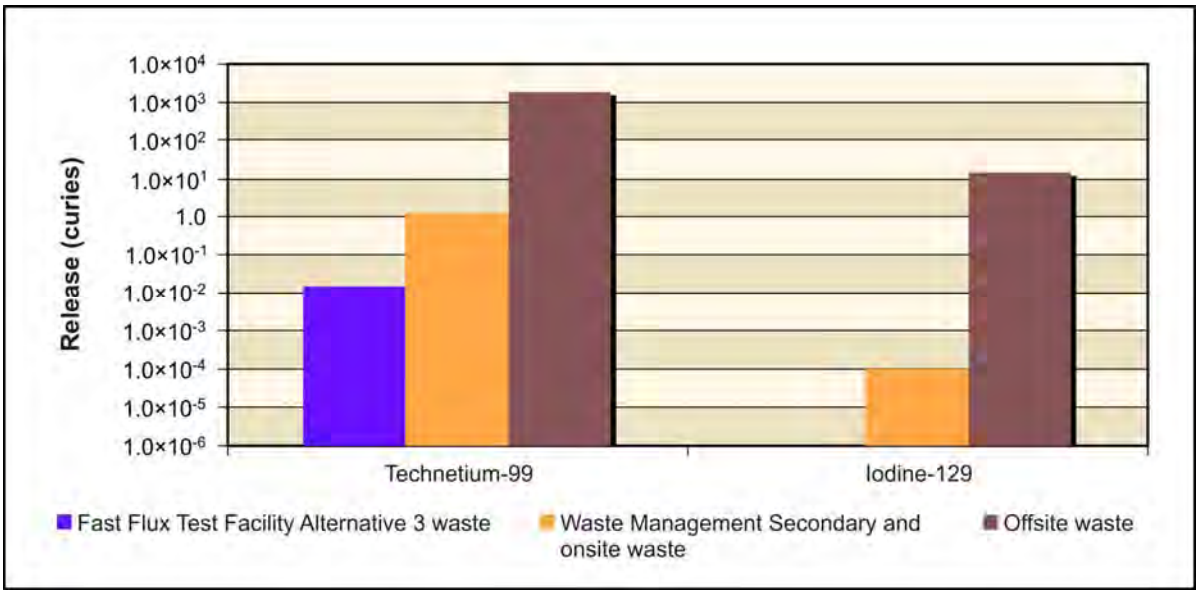


Figure 5–709. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

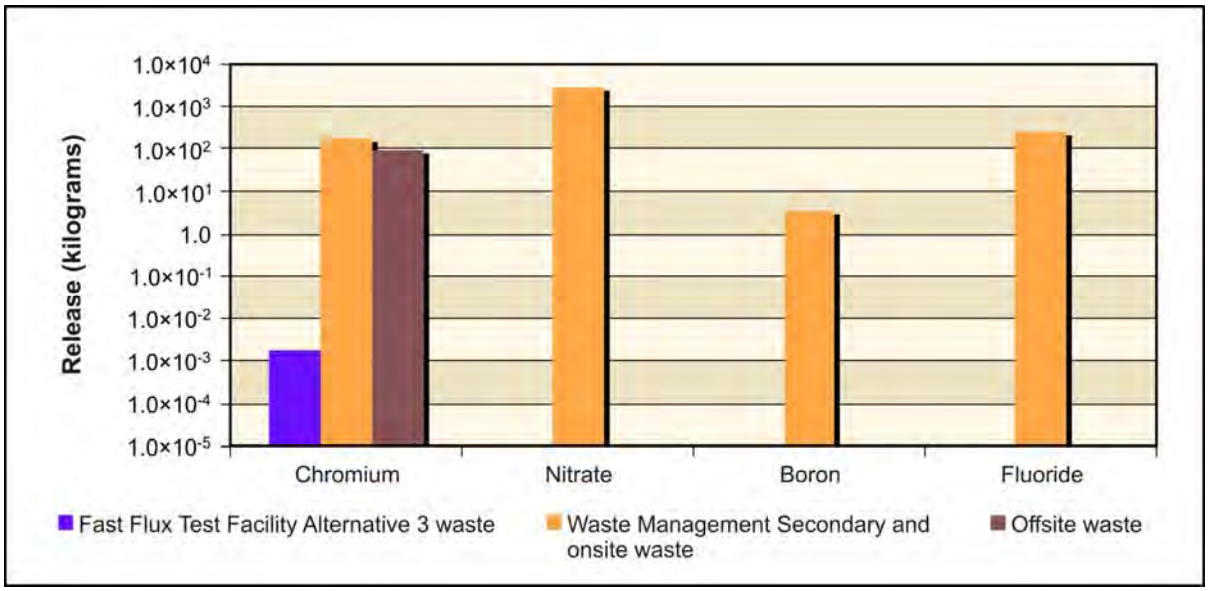


Figure 5–710. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–711 shows the release to groundwater for the radiological risk drivers and Figure 5–712, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, boron, and fluoride, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 98 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches groundwater; approximately 100 percent of the chemical quantity (kilograms) reaches groundwater.

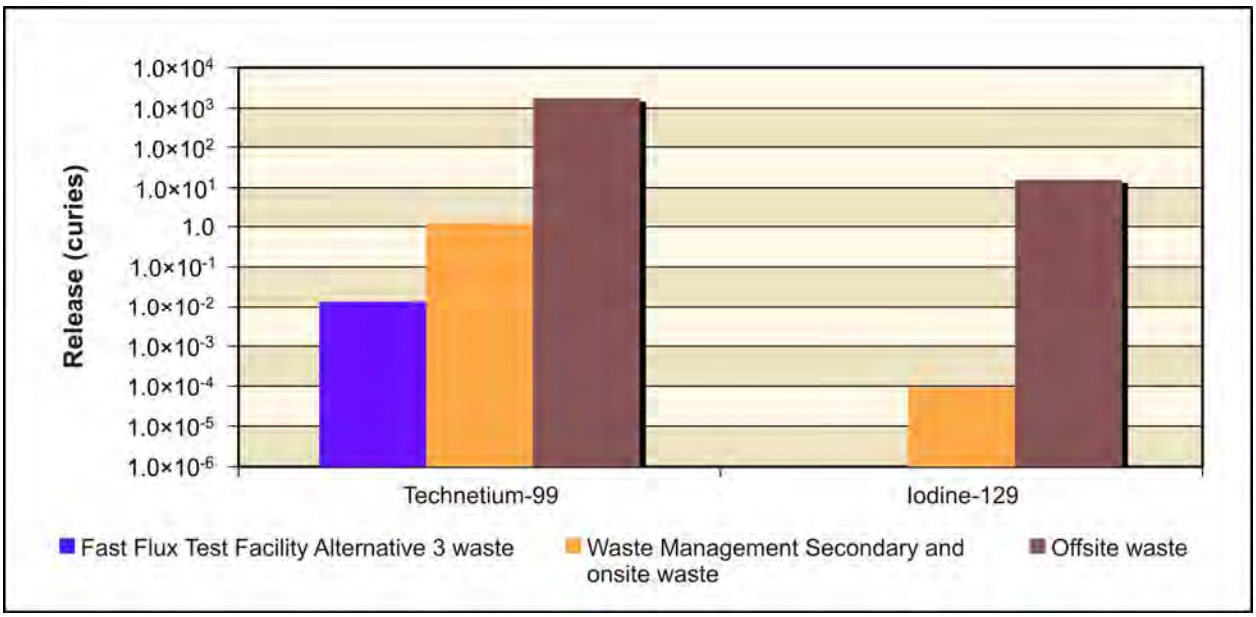


Figure 5–711. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

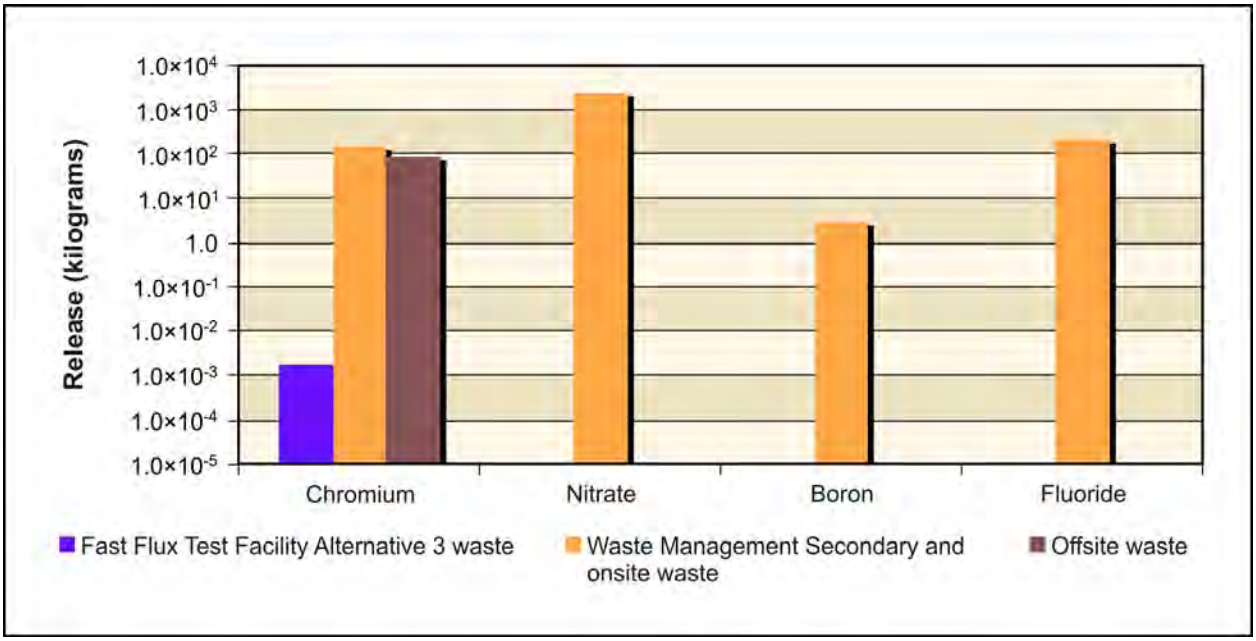


Figure 5–712. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–713 shows the release to the Columbia River for the radiological risk drivers and Figure 5–714, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For techetium-99, iodine-129, chromium, nitrate, boron, and fluoride, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclide amount (curies) released to groundwater during the period of analysis reaches the river; while approximately 98 percent of the chemical quantity (kilograms) reaches the river.

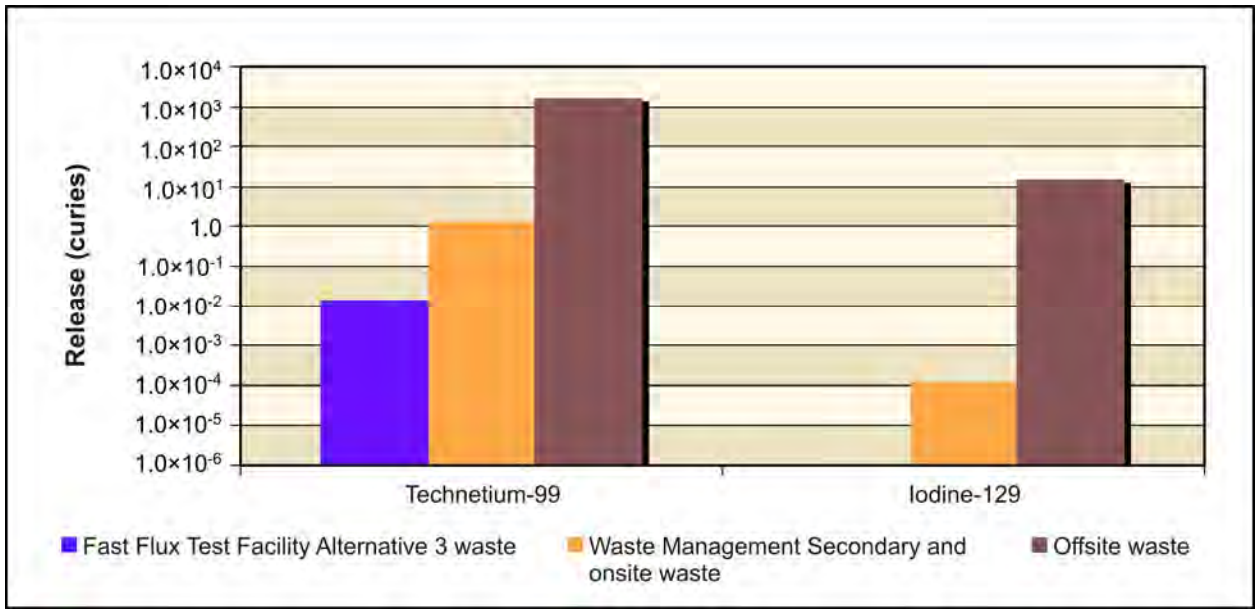


Figure 5–713. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

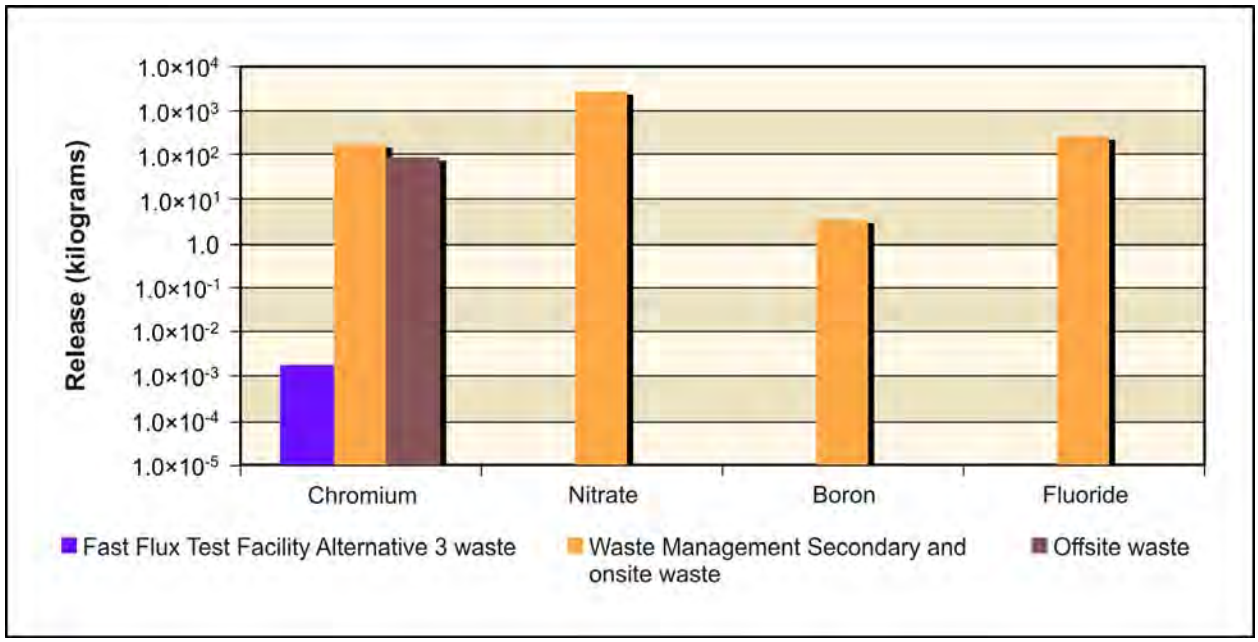


Figure 5–714. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–715 shows the release to the vadose zone for the radiological risk drivers and Figure 5–716, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The radiological releases to the vadose zone from the RPPDF include technetium-99 (largest) and iodine-129 (smallest). The chemical releases from the RPPDF include nitrate (largest) and chromium (smallest). Fluoride and boron do not exist at the RPPDF.

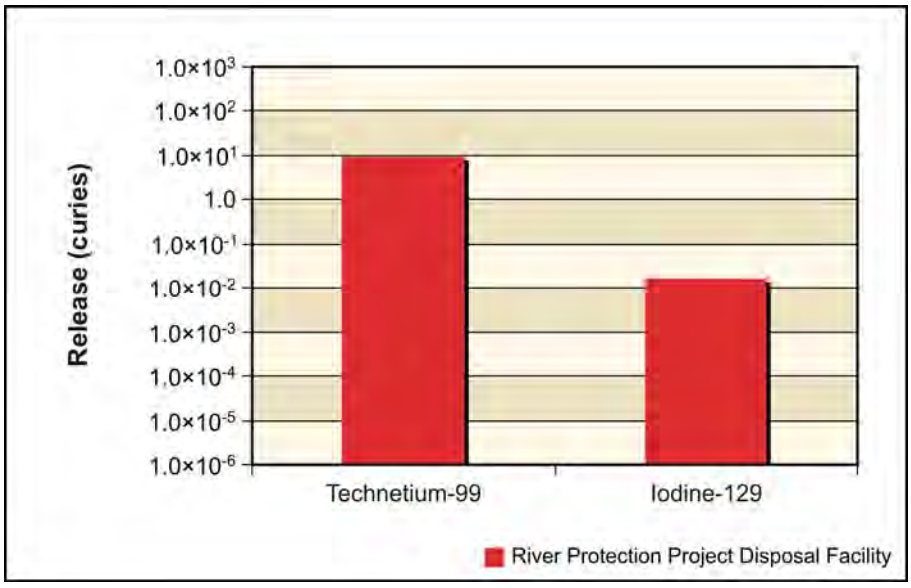


Figure 5–715. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

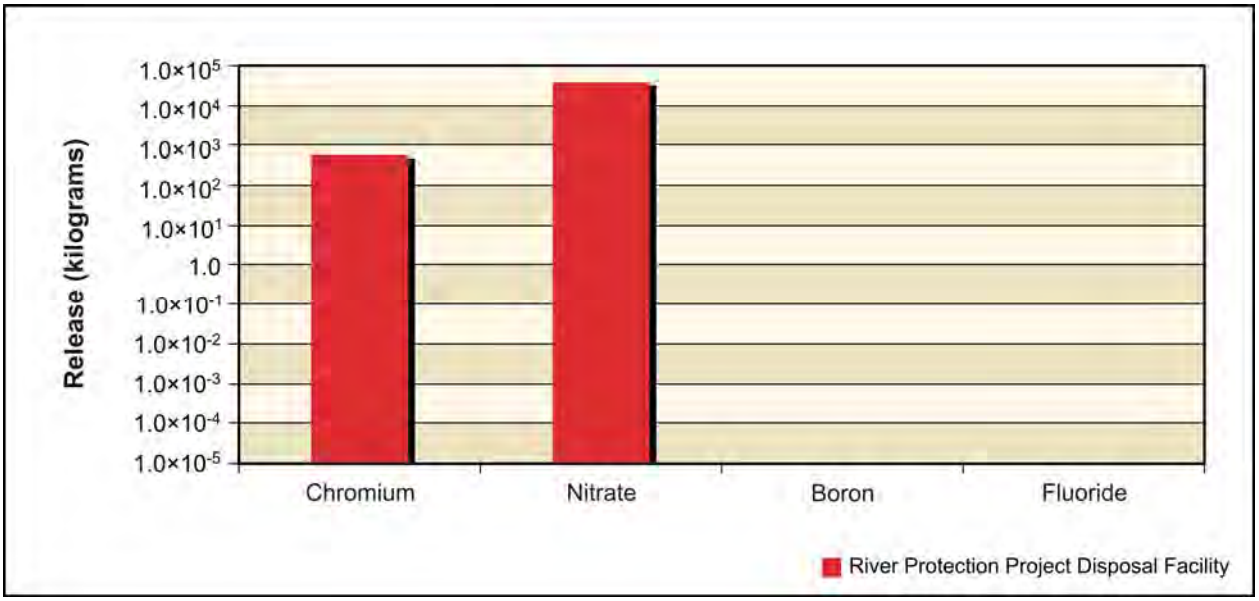


Figure 5–716. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–717 shows the release to groundwater for the radiological risk drivers and Figure 5–718, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches the groundwater; approximately 100 percent of the chemical quantity (kilograms) reaches the groundwater.

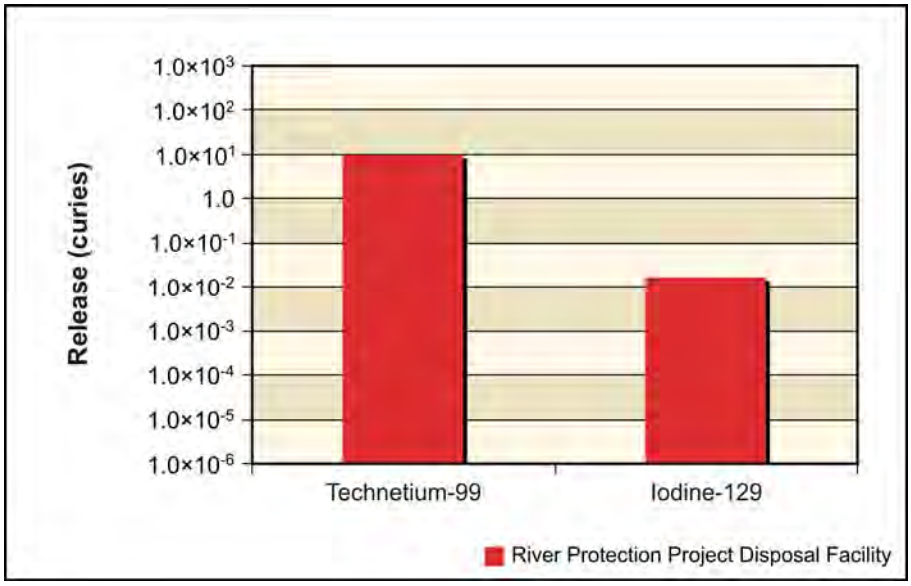


Figure 5–717. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Groundwater

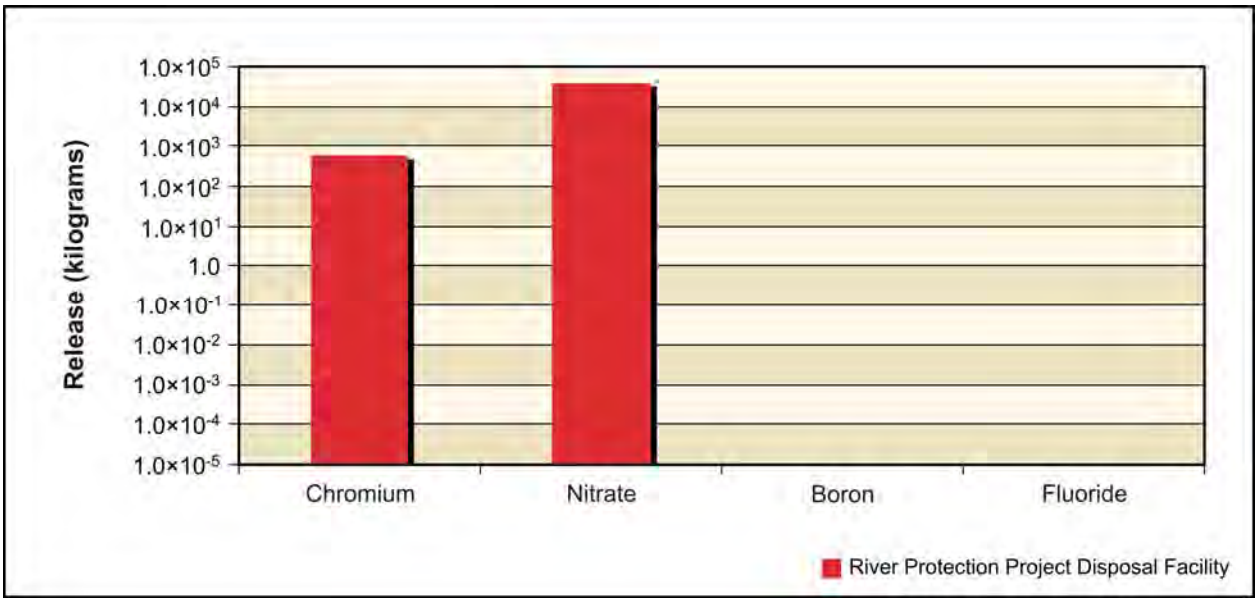


Figure 5–718. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–719 shows the release to the Columbia River for the radiological risk drivers and Figure 5–720, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 96 percent of the radionuclide amount (curies) released to groundwater during the period of analysis reaches the river; 96 percent of the chemical quantity (kilograms) reaches the river.

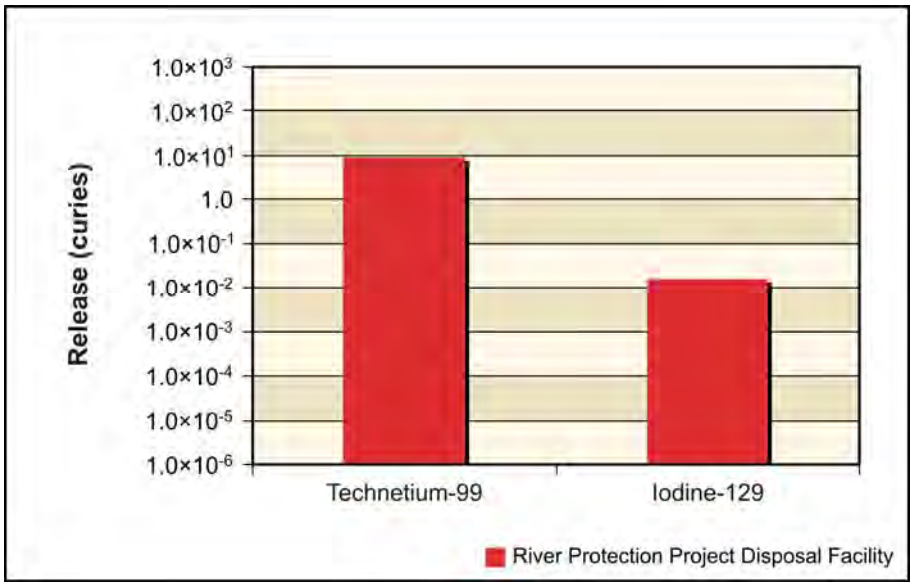


Figure 5–719. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Columbia River

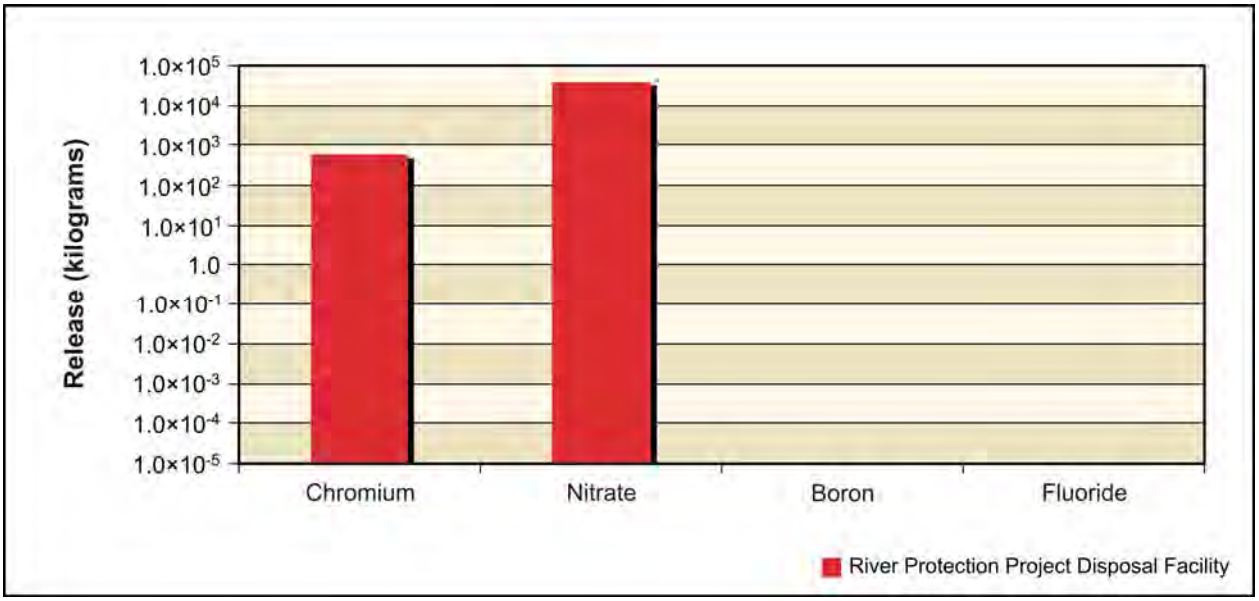


Figure 5–720. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–89 lists the maximum concentrations of the COPCs in the peak year at the IDF-East, RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–89. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	471	**20,200**	33	**7,560**	**1,130**	900
	(8991)	(3713)	(3825)	(3690)	(4528)	
Iodine-129	**1**	**173**	0.1	**60**	**8**	1
	(11243)	(3797)	(3772)	(3853)	(4729)	
Chemical in microgram per liter						
Chromium	4	2	2	3	1	100
	(8511)	(3696)	(3856)	(3628)	(8879)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,200	17	149	5,630	2,440	45,000
	(8522)	(3703)	(3811)	(9653)	(8043)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–721 through 5–724 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East, IDF-West, and the RPPDF cause groundwater concentrations of iodine-129 to exceed benchmark concentrations at the Core Zone Boundary and Columbia River nearshore by approximately one order of magnitude. Iodine-129 extending above the benchmark occurs in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak only lasts for approximately 10 percent of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or Columbia River nearshore.

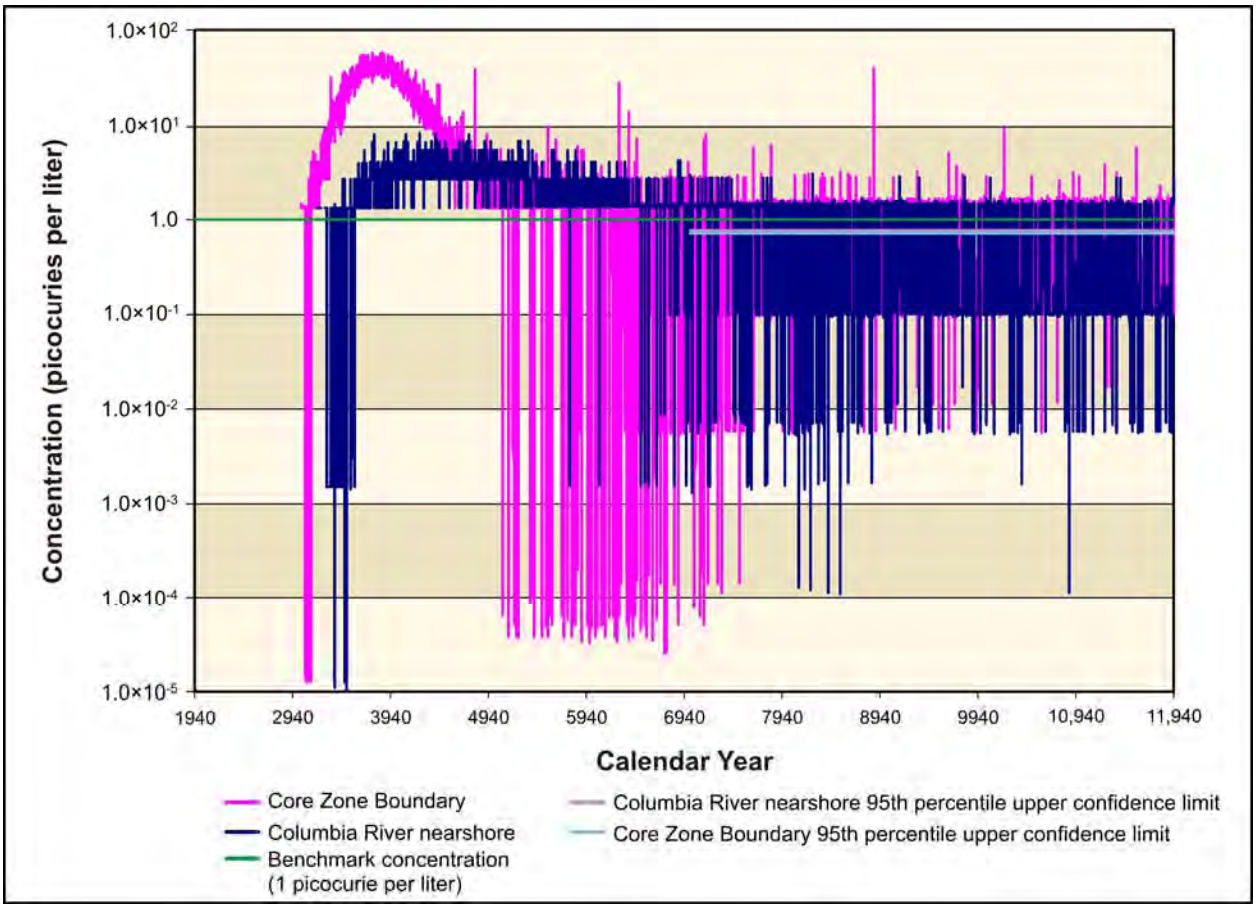


Figure 5–721. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time

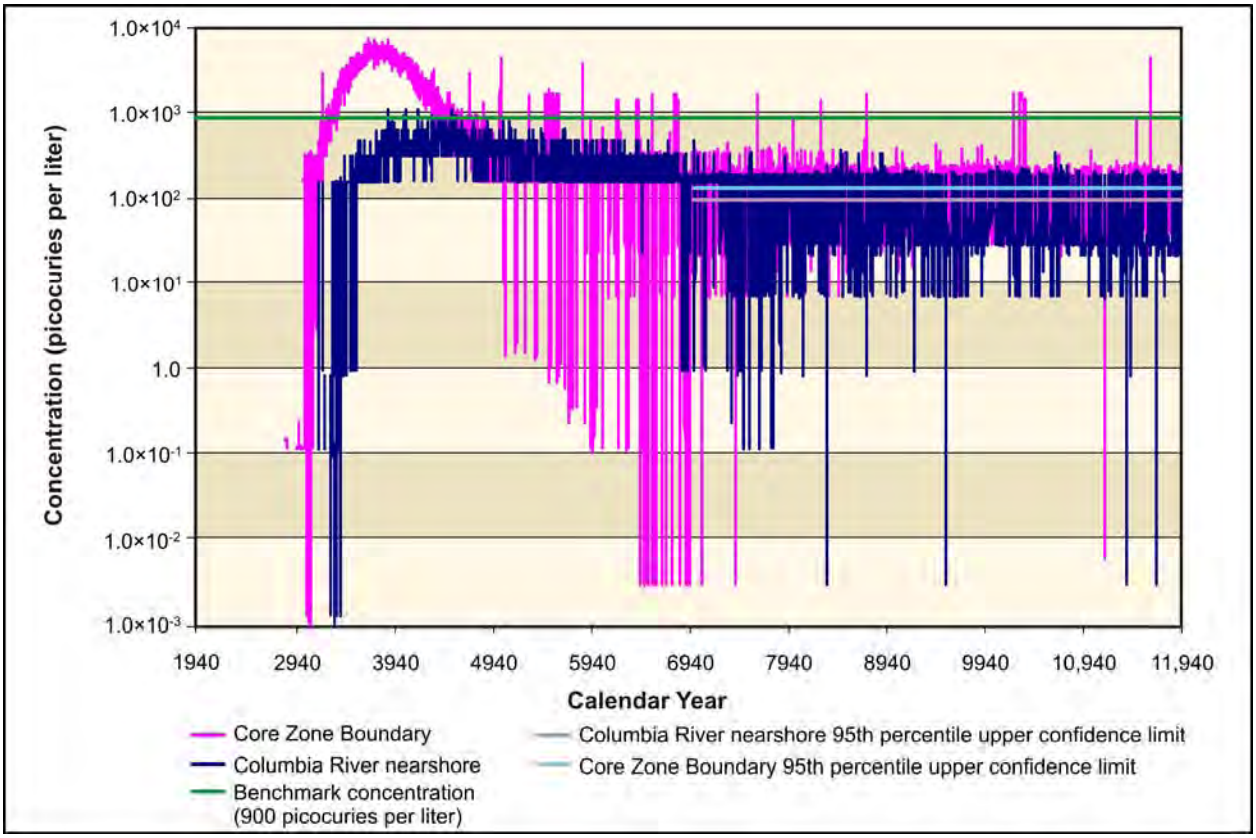


Figure 5–722. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time

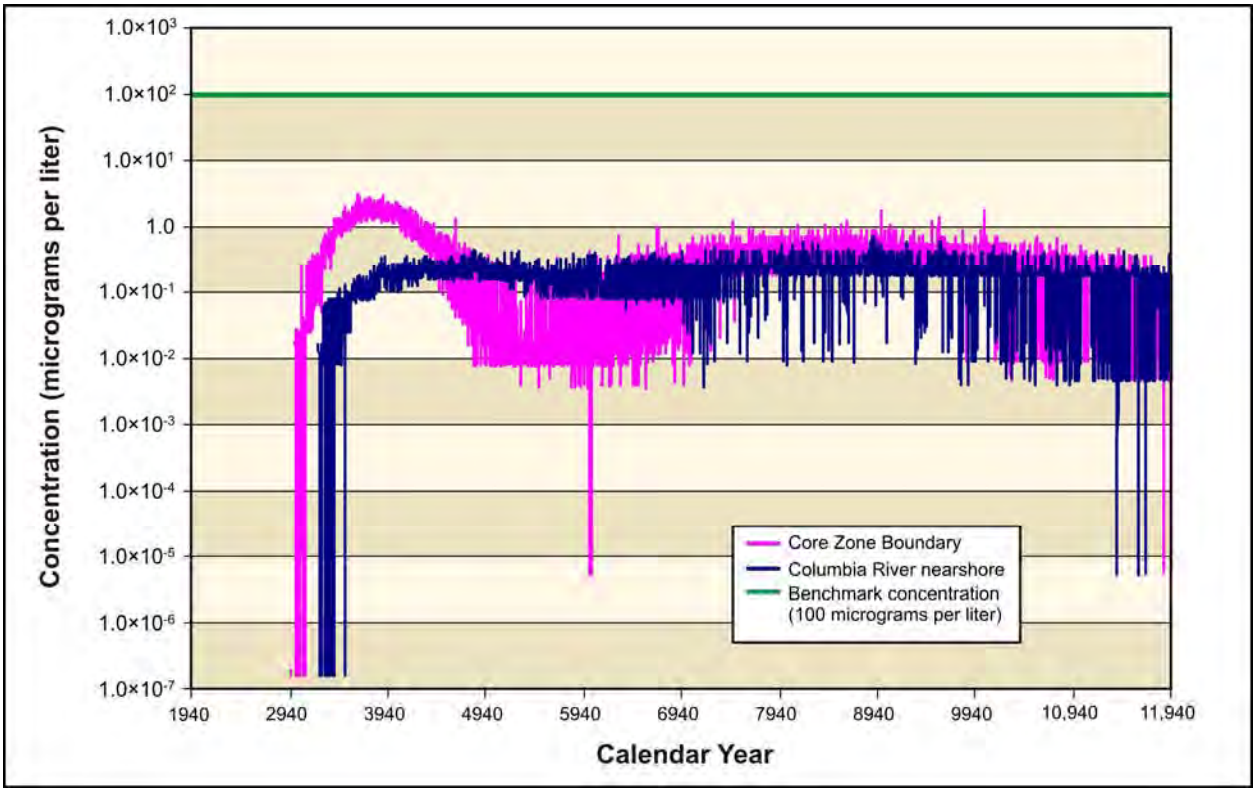


Figure 5–723. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chromium Concentration Versus Time

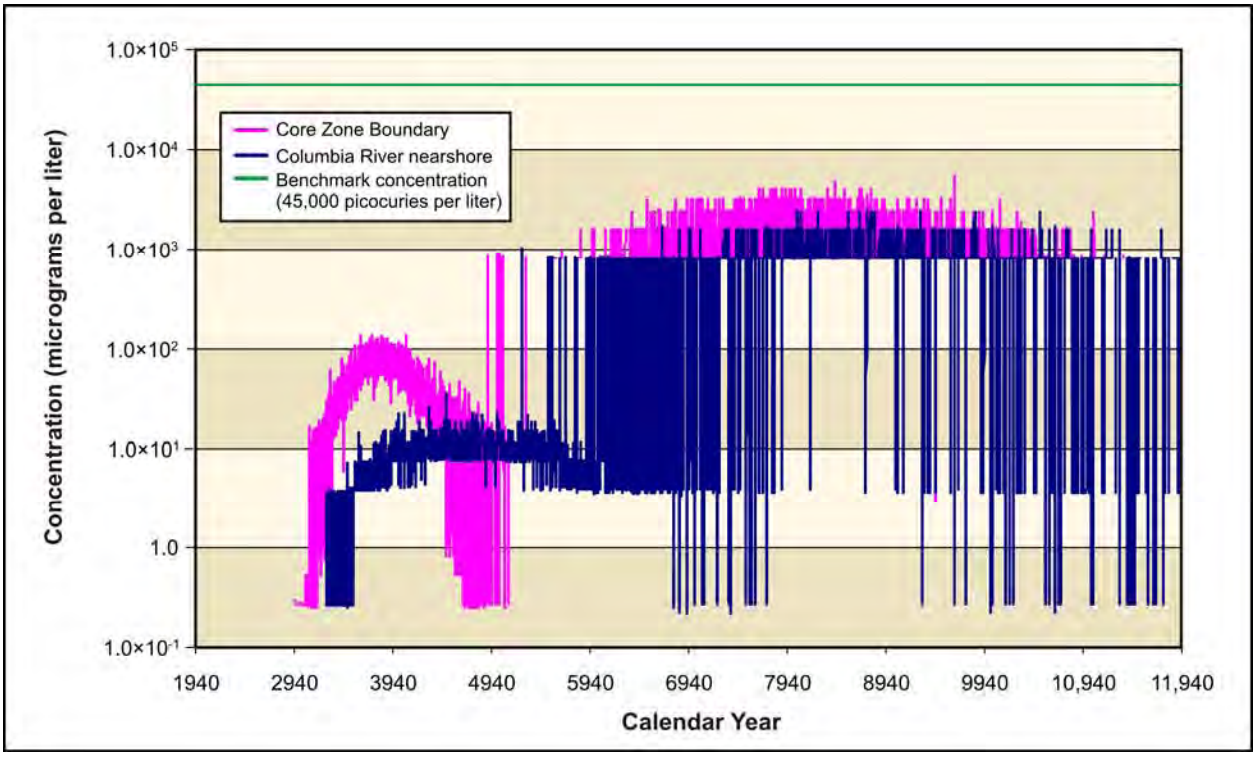


Figure 5–724. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Nitrate Concentration Versus Time

Figures 5–725 and 5–726 show concentration versus time for uranium-238 and total uranium. Because uranium-238 and total uranium are slow moving through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 and total uranium concentrations, while minimal, continue to rise throughout the duration of the period of analysis, but they never get higher than three orders of magnitude below the benchmark concentrations by the end of the period of analysis.

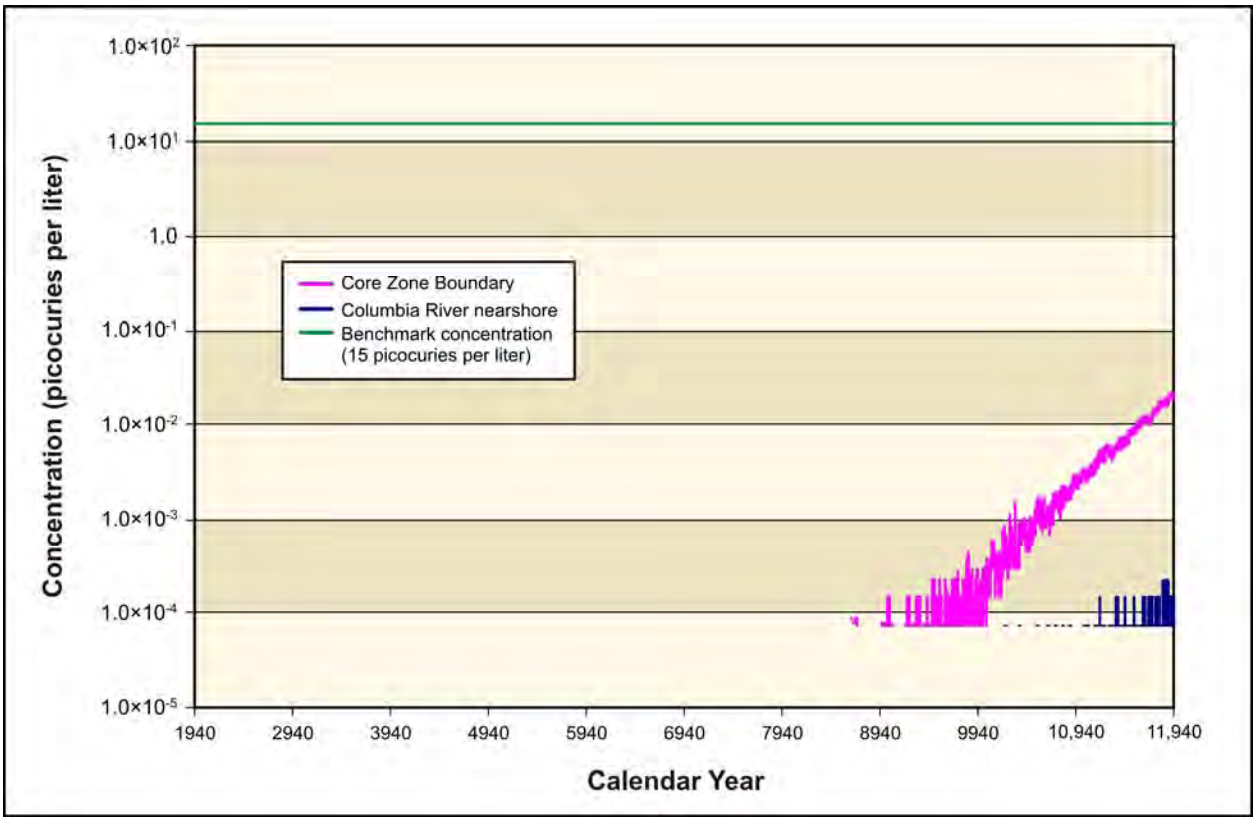


Figure 5–725. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Uranium-238 Concentration Versus Time

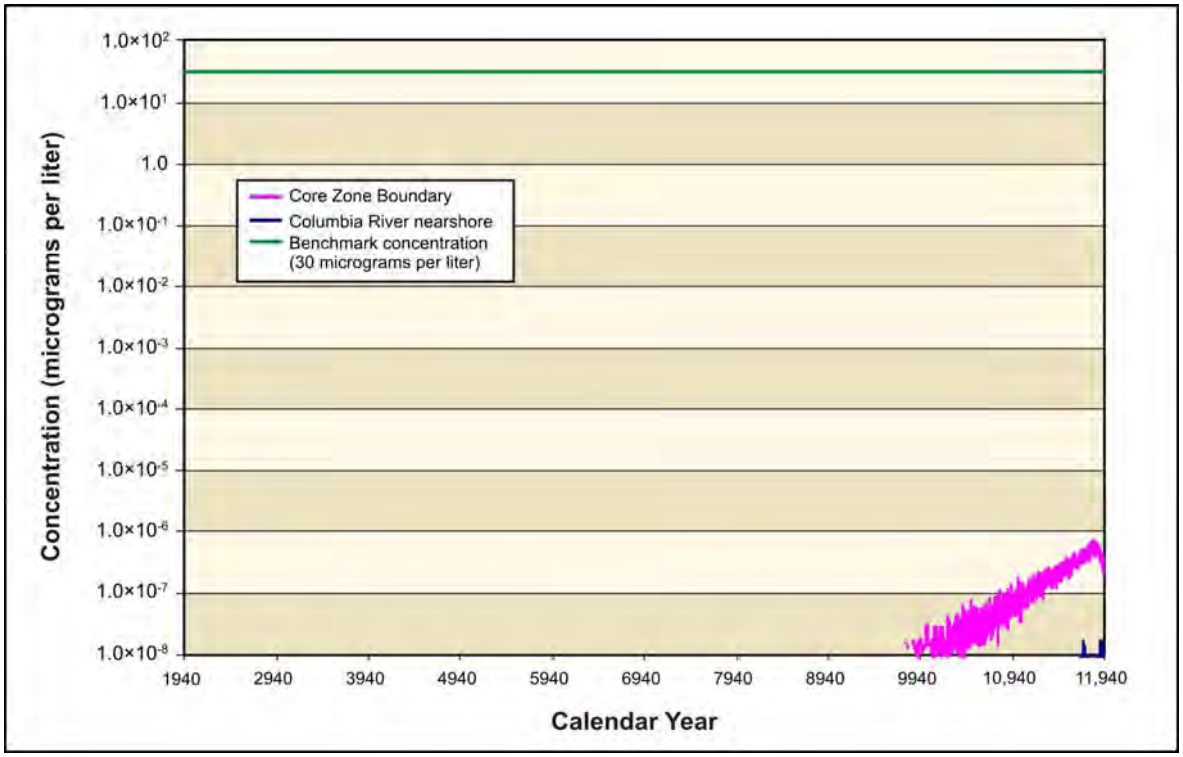


Figure 5–726. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark concentration by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–727 shows the spatial distribution of groundwater concentrations of iodine-129 during CY 3890. Releases from IDF-West and the RPPDF result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area and moving eastward toward the Columbia River (see Figure 5–728). Also by CY 7140, most of the IDF-West and RPPDF plume continued to move north and reached the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River with only small isolated pockets of concentration exceeding the benchmark (see Figure 5–729). Technetium-99 (see Figures 5–730 through 5–732) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–733 through 5–735), and nitrate (see Figures 5–736 through 5–738) show similar spatial distributions at selected times, but none of them exceed the benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).

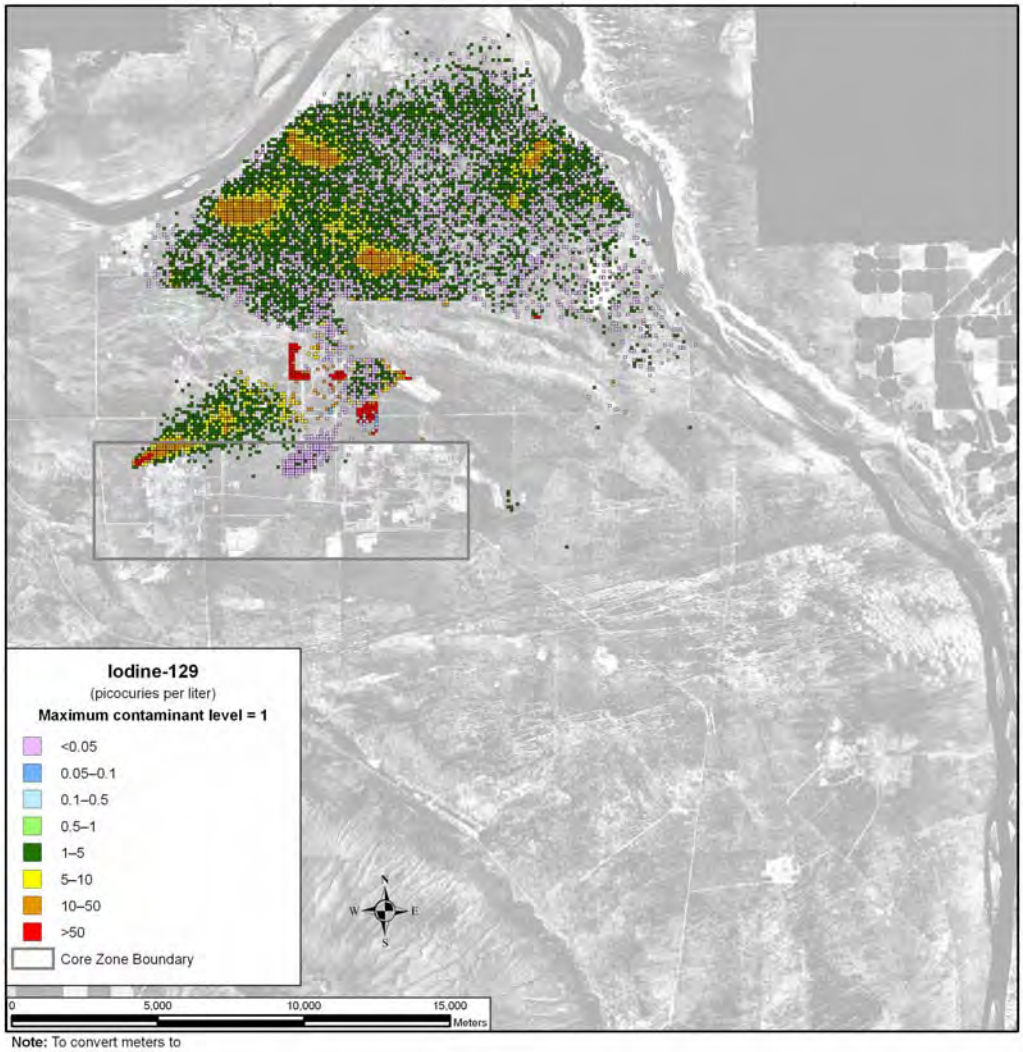


Figure 5–727. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

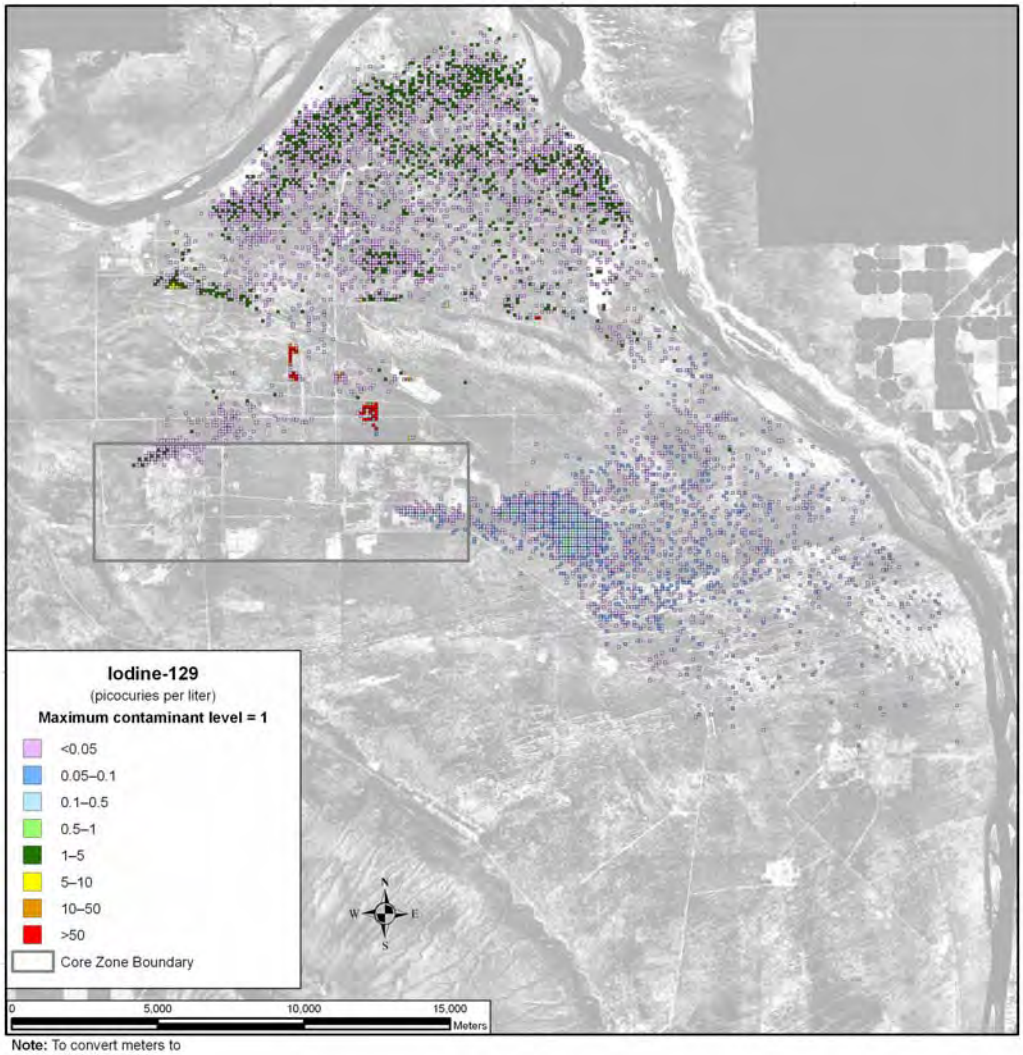


Figure 5–728. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

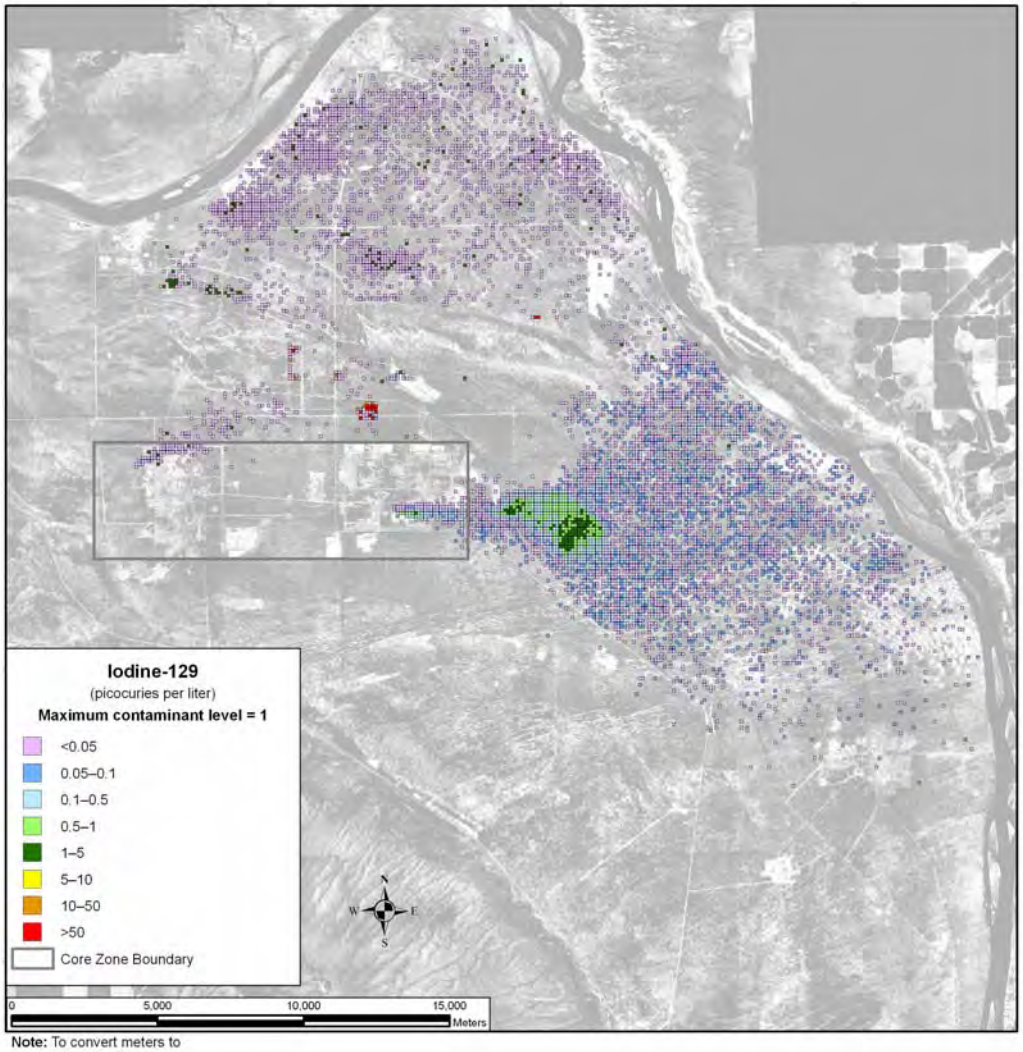


Figure 5–729. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

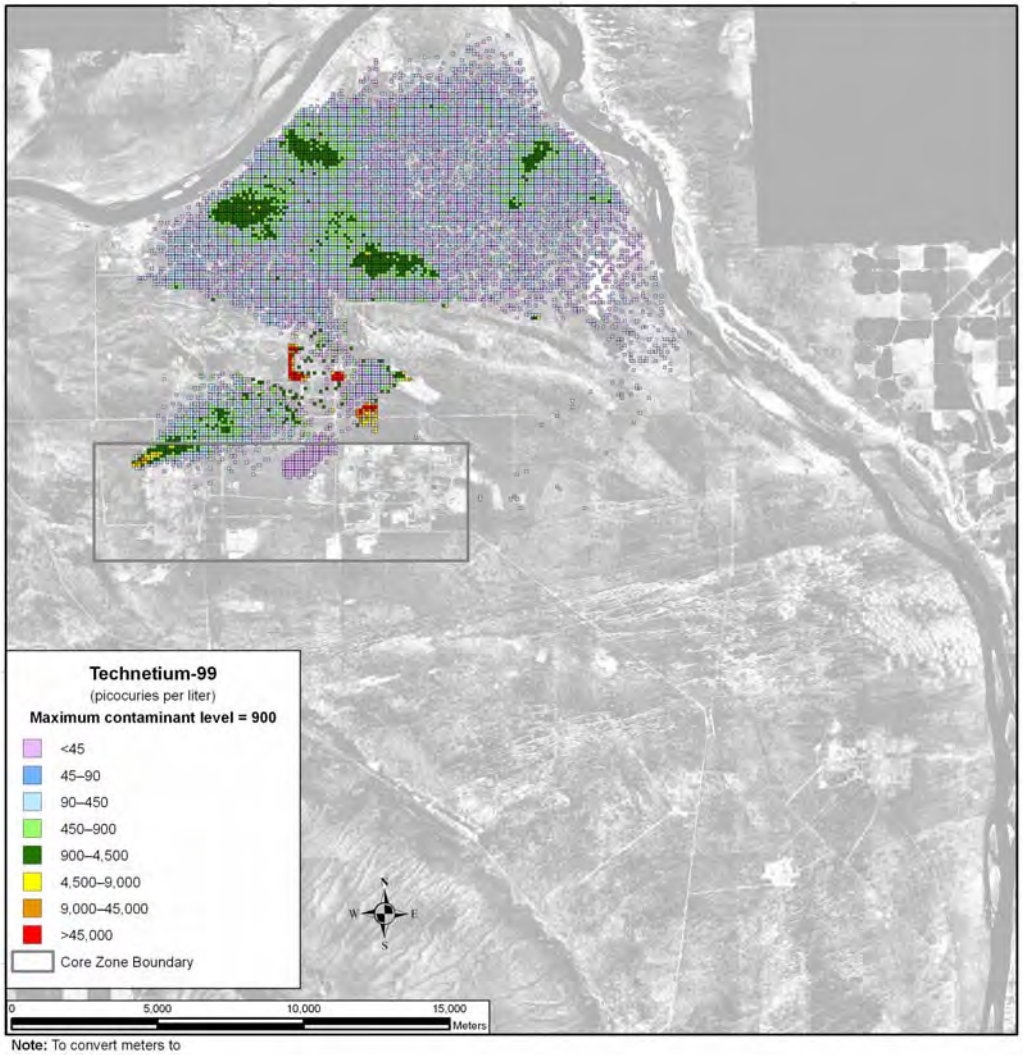


Figure 5–730. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

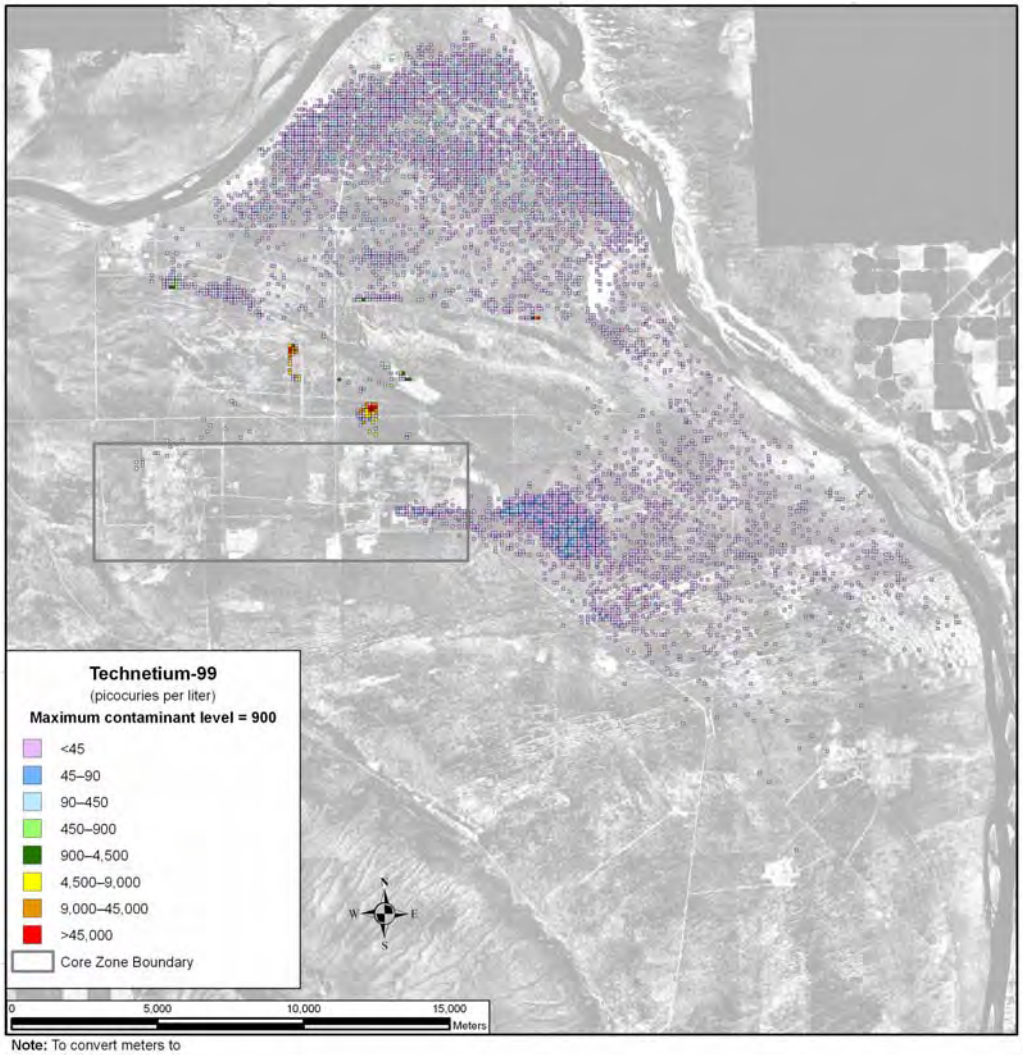


Figure 5–731. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

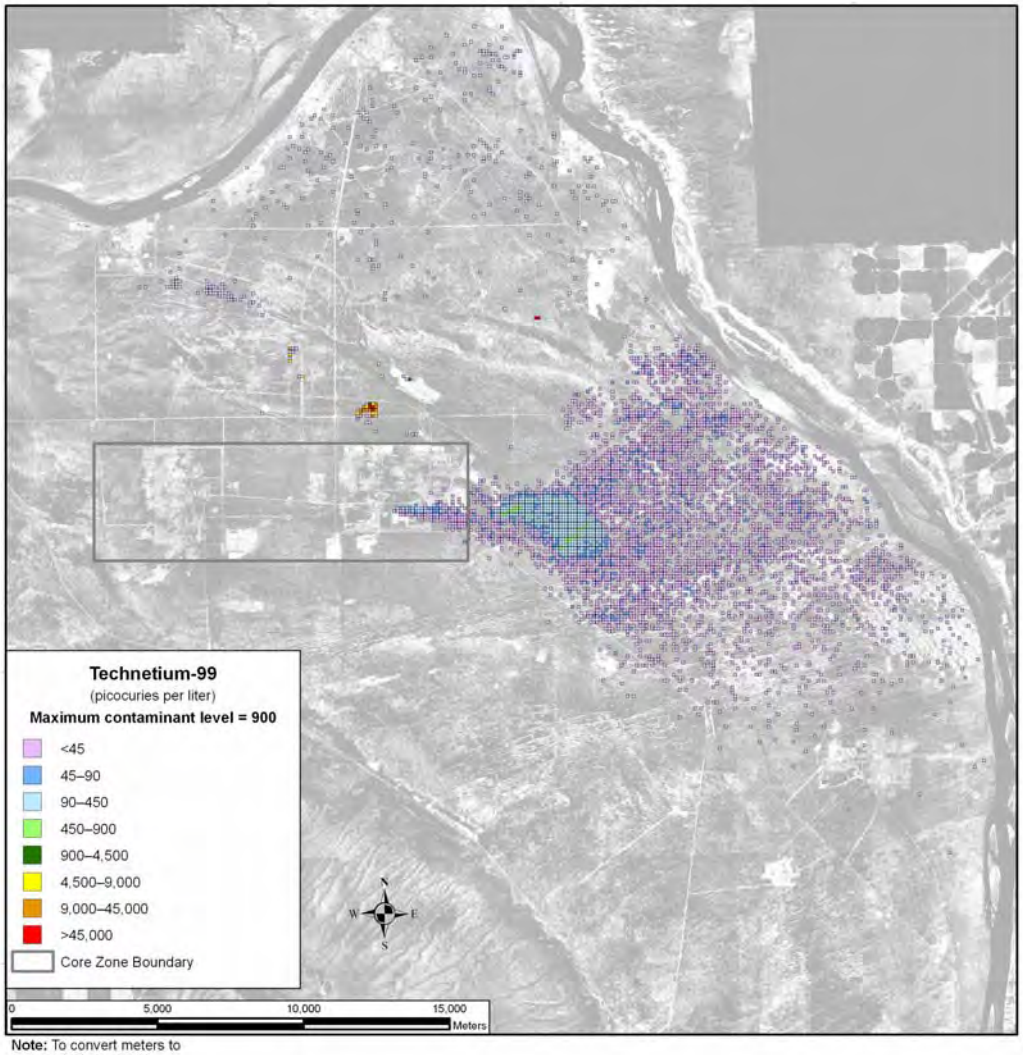


Figure 5–732. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

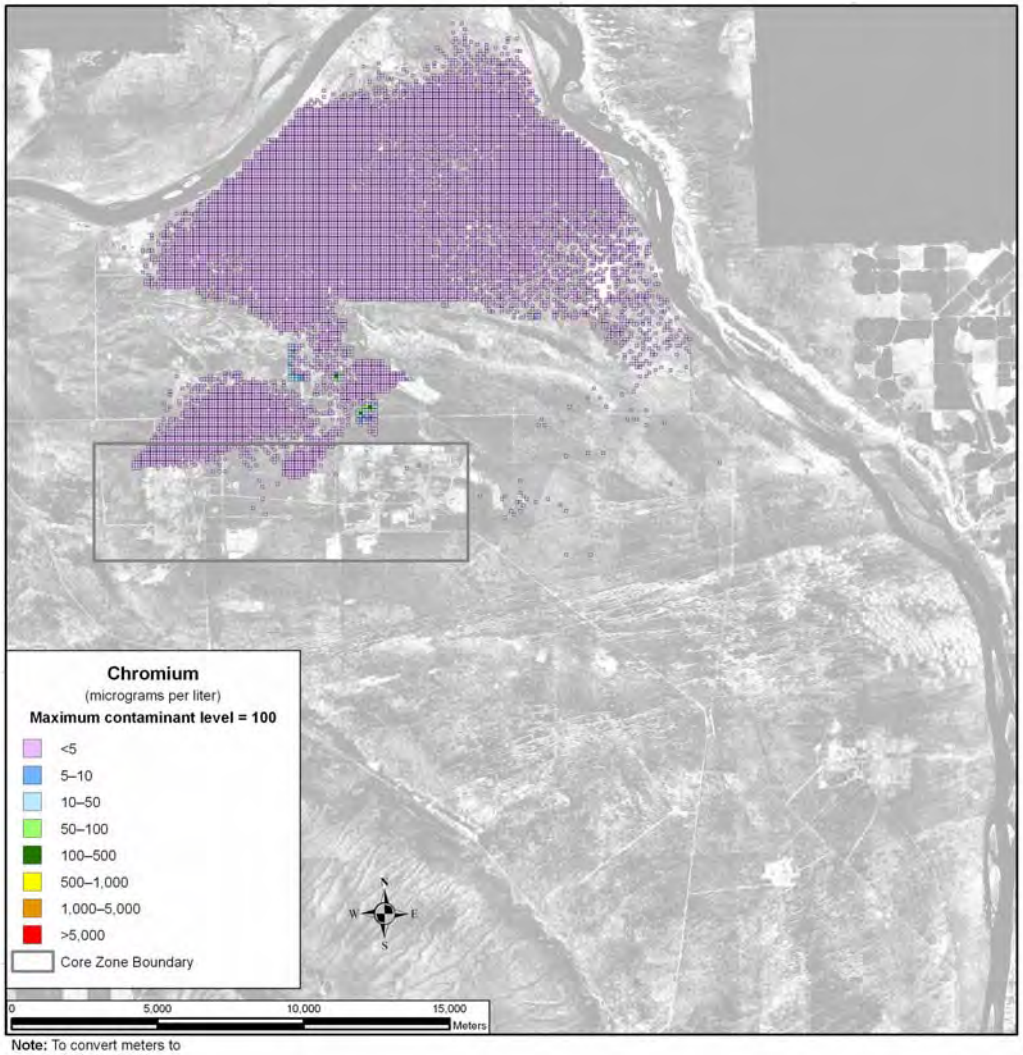


Figure 5–733. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

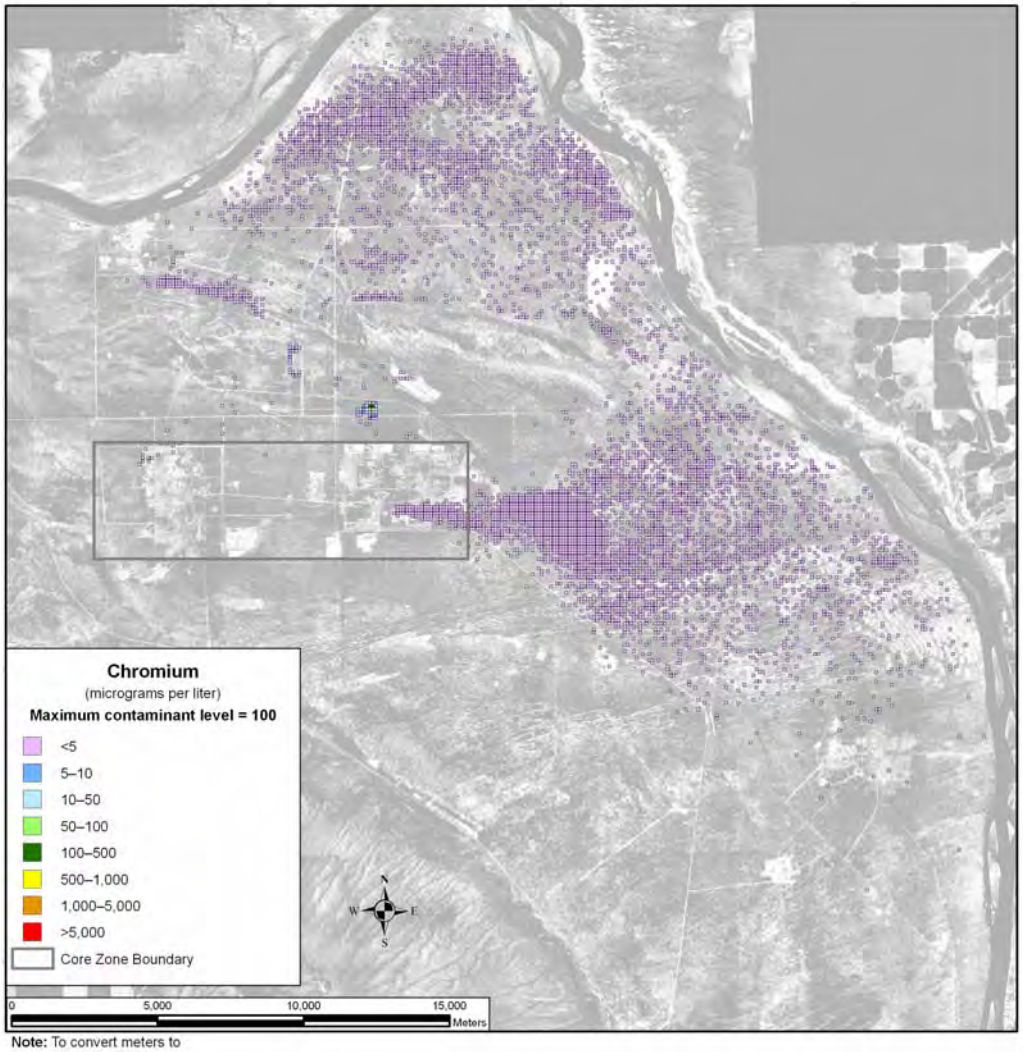


Figure 5–734. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

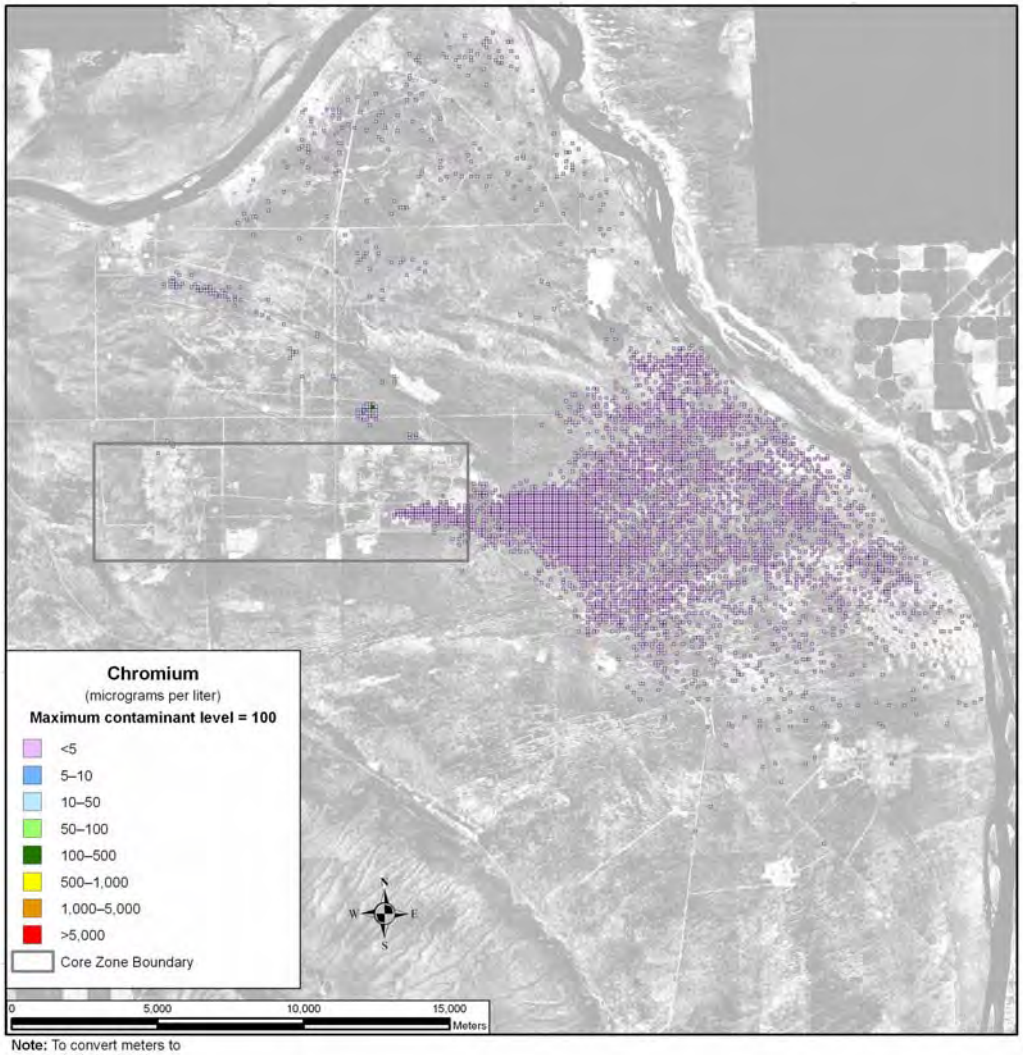


Figure 5–735. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

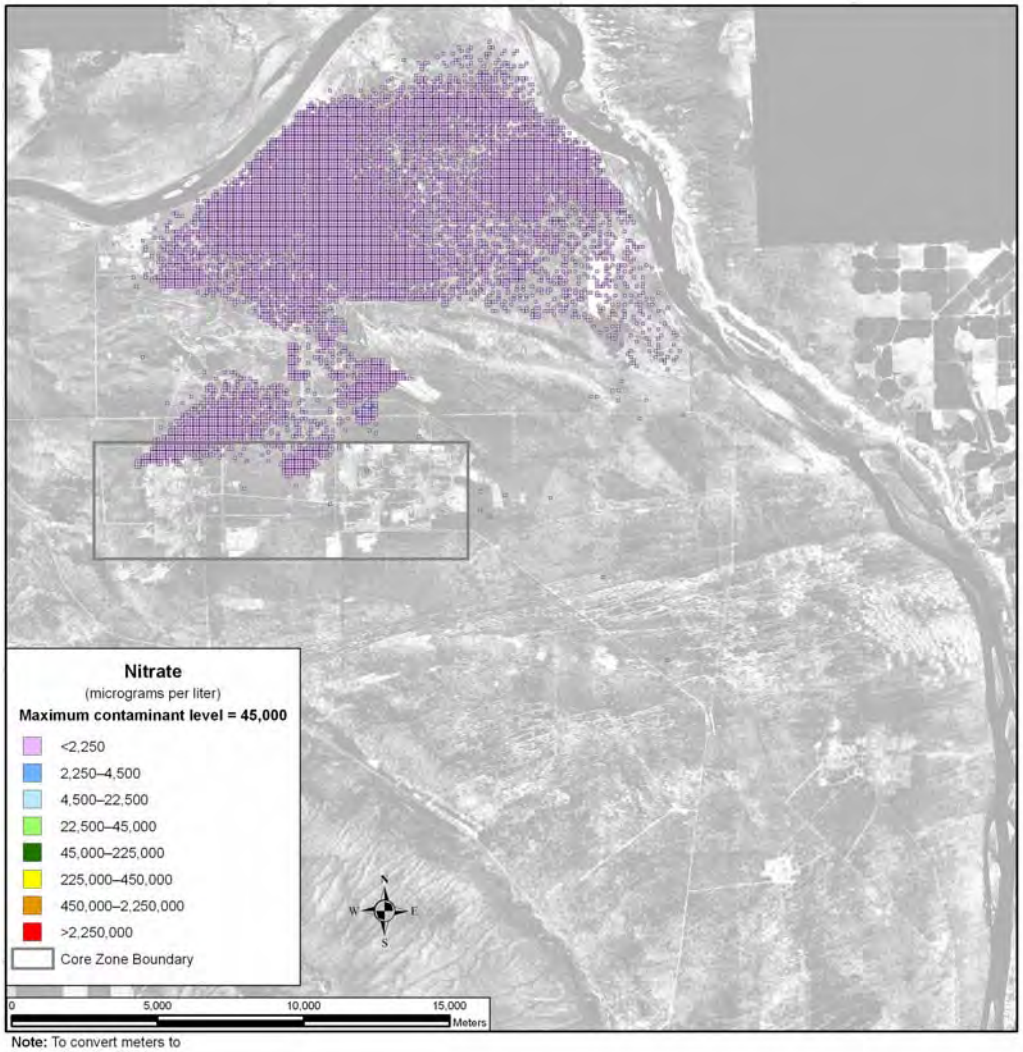


Figure 5–736. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

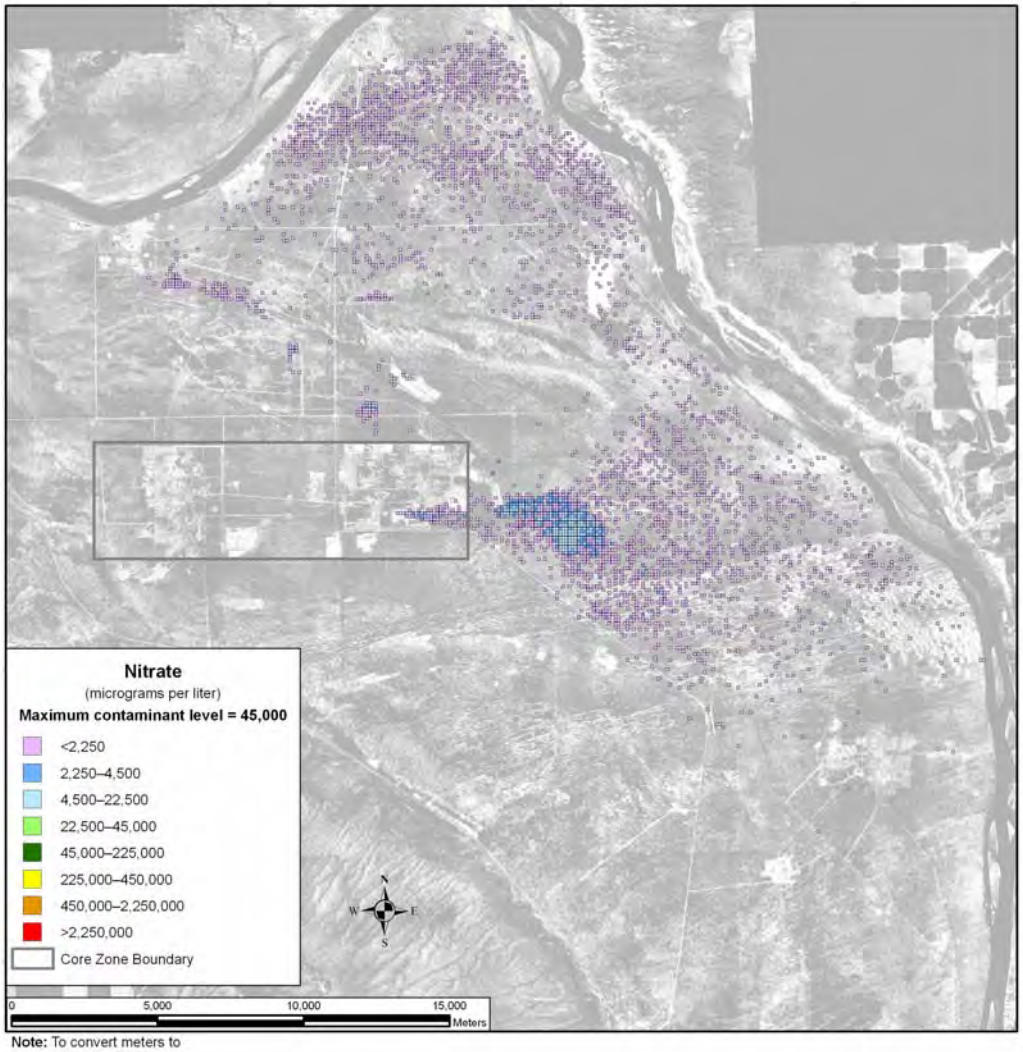


Figure 5–737. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

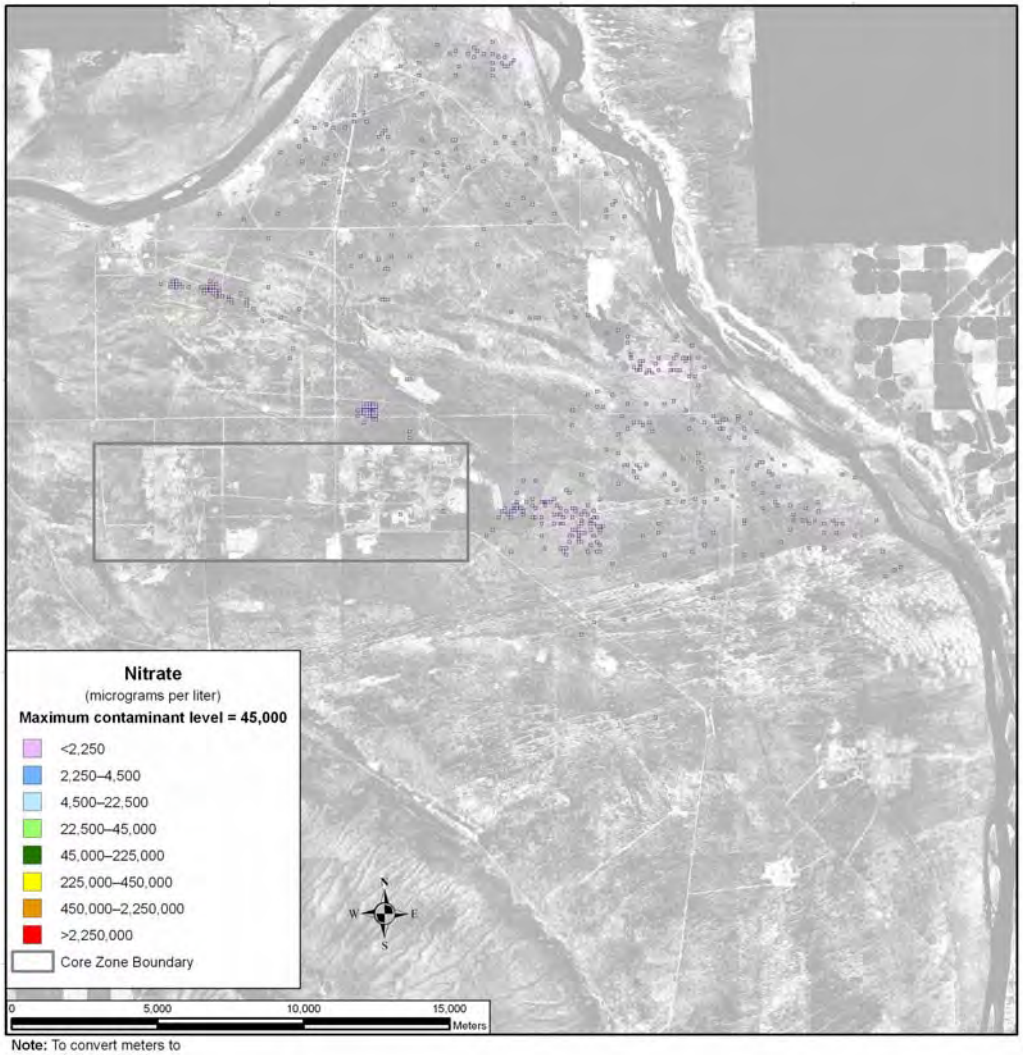


Figure 5–738. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figures 5–739 and 5–740 show the distribution of uranium-238 and total uranium during CY 11,885. Releases from IDF-West and the RPPDF result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.

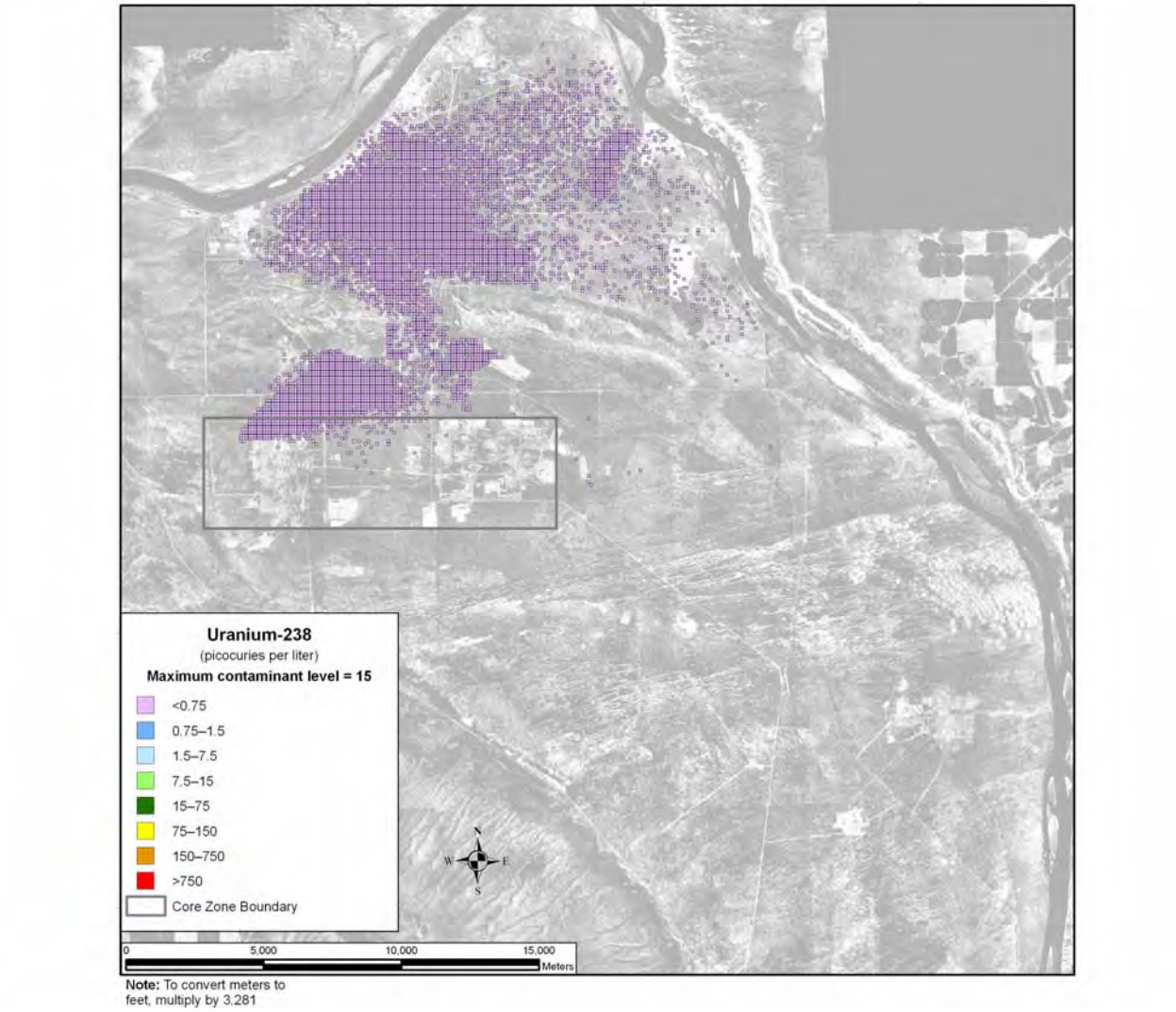


Figure 5–739. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

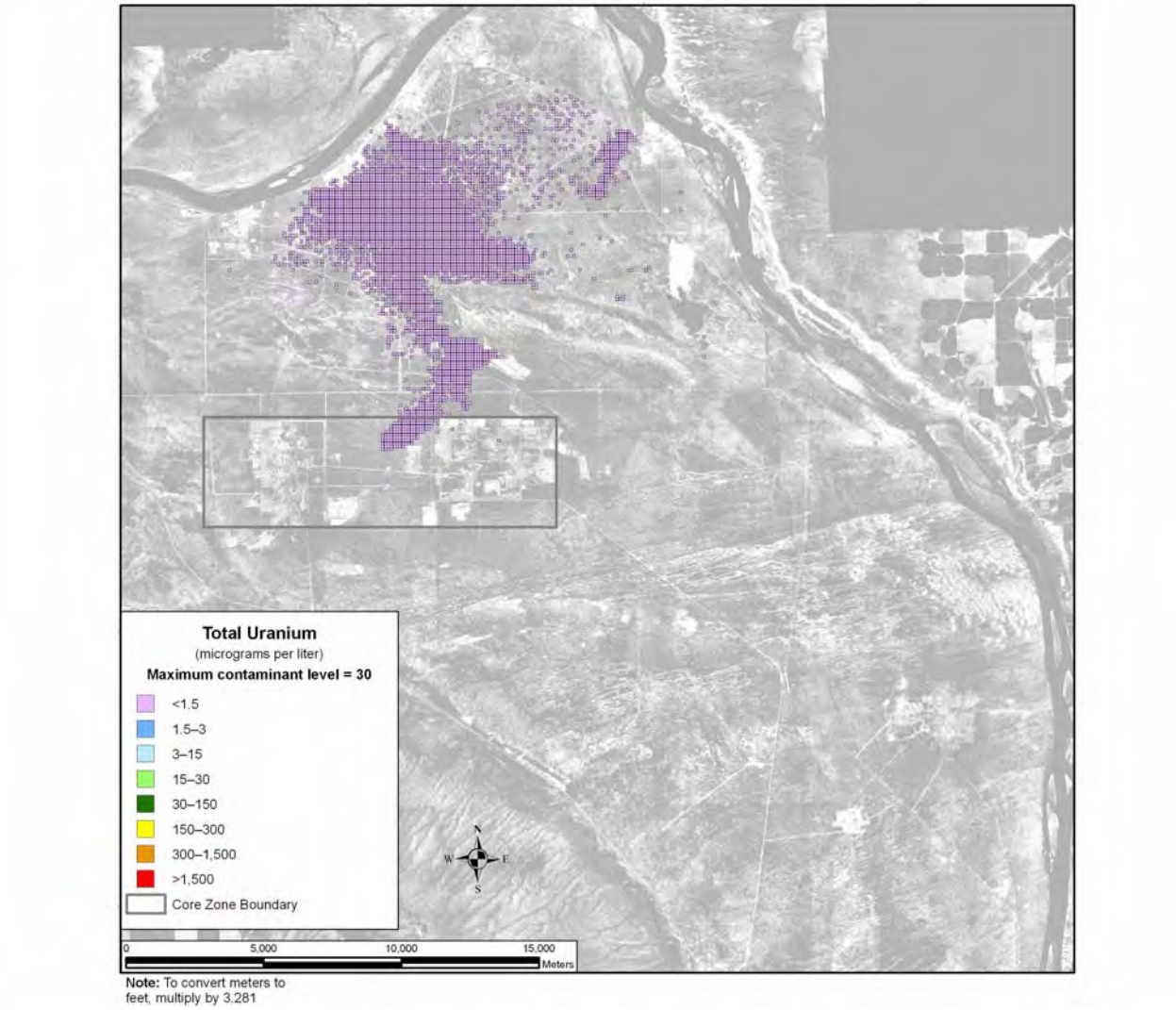


Figure 5–740. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in general, the inventories remaining at IDF-East, IDF-West, and the RPPDF, and available for release to the environment at the start of the post-disposal period are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. Concentration at the Columbia River is about one to two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or Columbia River nearshore.

5.3.1.3.1.2 Disposal Group 1, Subgroup 1-B

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-B covers disposal of waste generated under Tank Closure Alternative 3A and either FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Tank Closure waste would be converted to IHLW, ILAW glass, and bulk vitrification glass.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B (IDF-East, IDF-West, and RPPDF releases), in terms of total amount of COPCs released to the vadose

zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–741 through 5–758). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has five subtotals plotted representing releases from ILAW glass, bulk vitrification glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

Figure 5–741 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–742, the chemical hazard drivers. For all five types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 is bulk vitrification glass and of iodine-129 is ETF-generated secondary waste. The predominant sources of chromium are tank closure secondary waste, while the predominant source of nitrate is ETF-generated secondary waste. Boron and fluoride are not released from IDF-East.

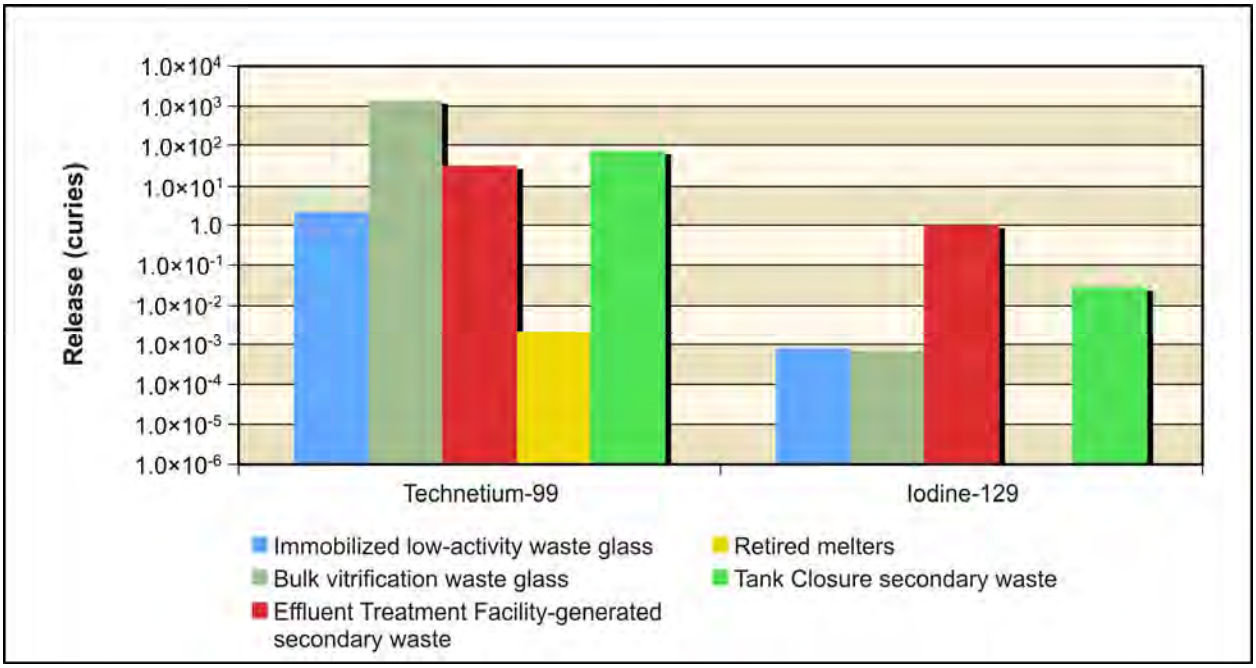


Figure 5–741. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–743 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–744, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 87 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

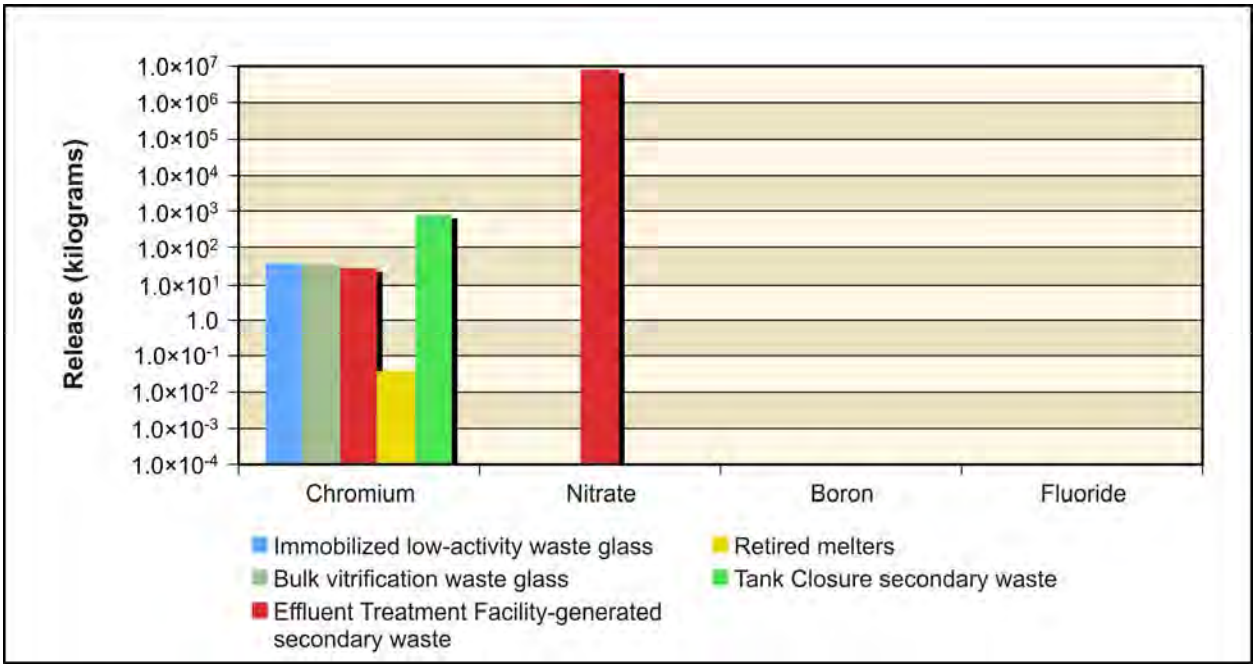


Figure 5–742. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

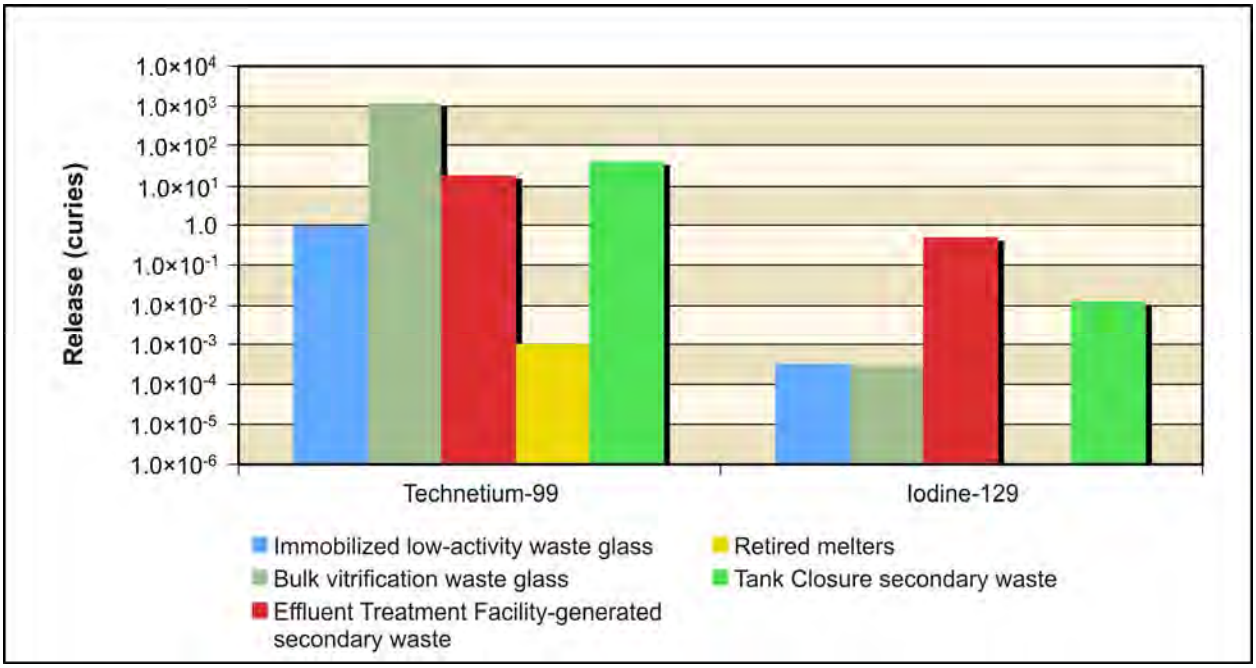


Figure 5–743. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

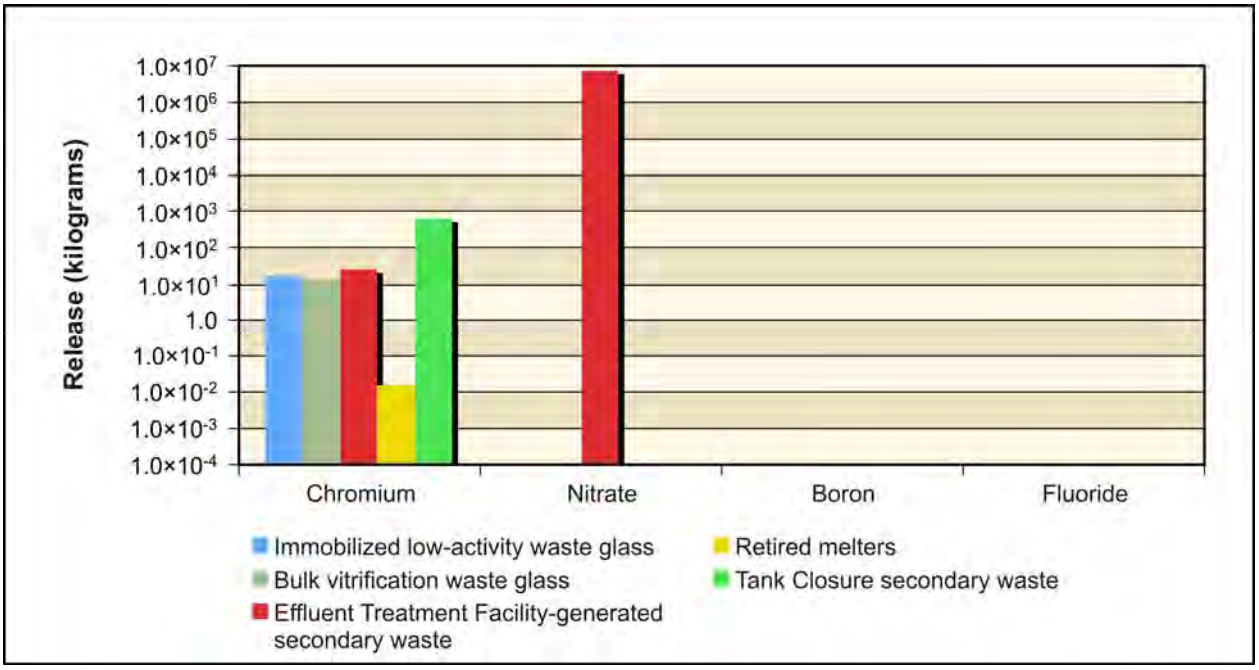


Figure 5–744. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–745 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–746, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 96 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; approximately 99 percent of the chemical quantity (kilograms) reached the river.

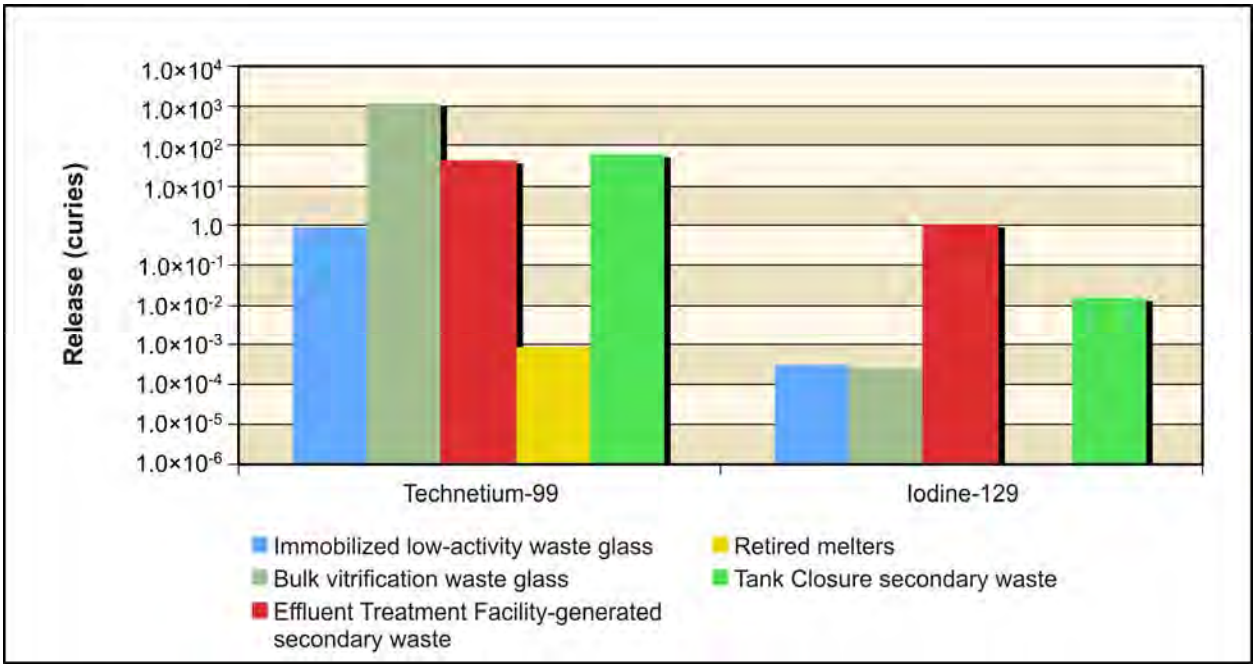


Figure 5–745. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

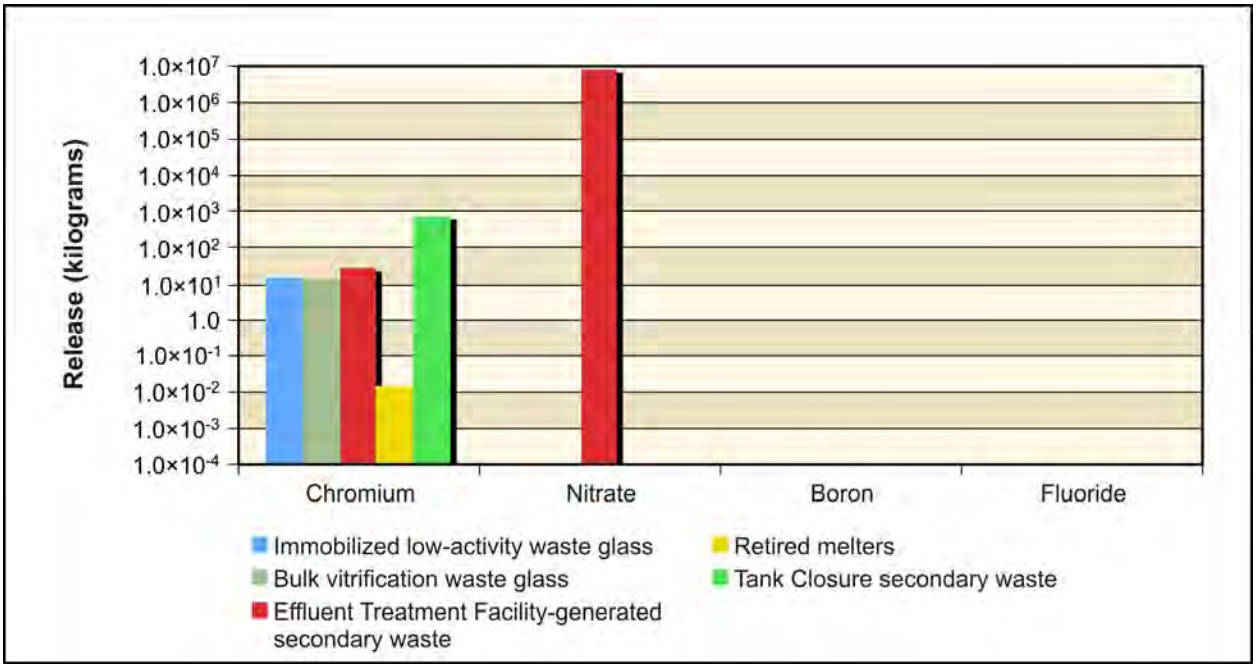


Figure 5–746. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite- and offsite-generated waste.

Figure 5–747 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–748, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and iodine-129 is offsite-generated waste. The predominant sources of chromium, nitrate, boron, and fluoride are waste management secondary and onsite-generated waste.

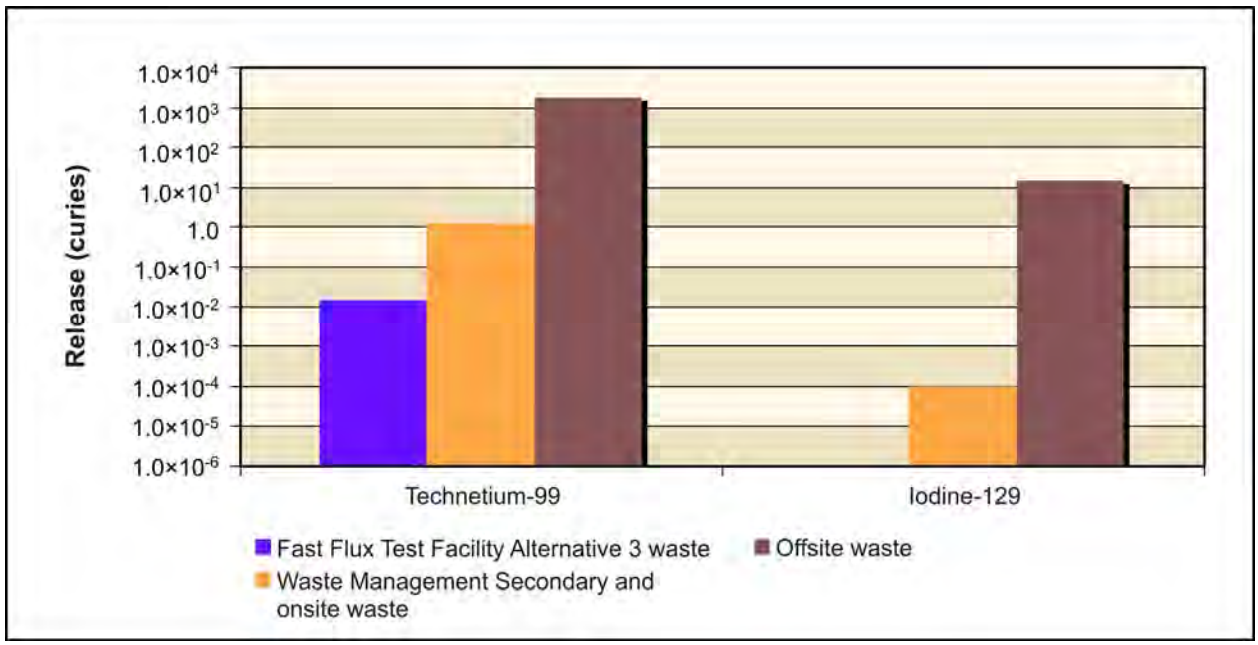


Figure 5–747. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

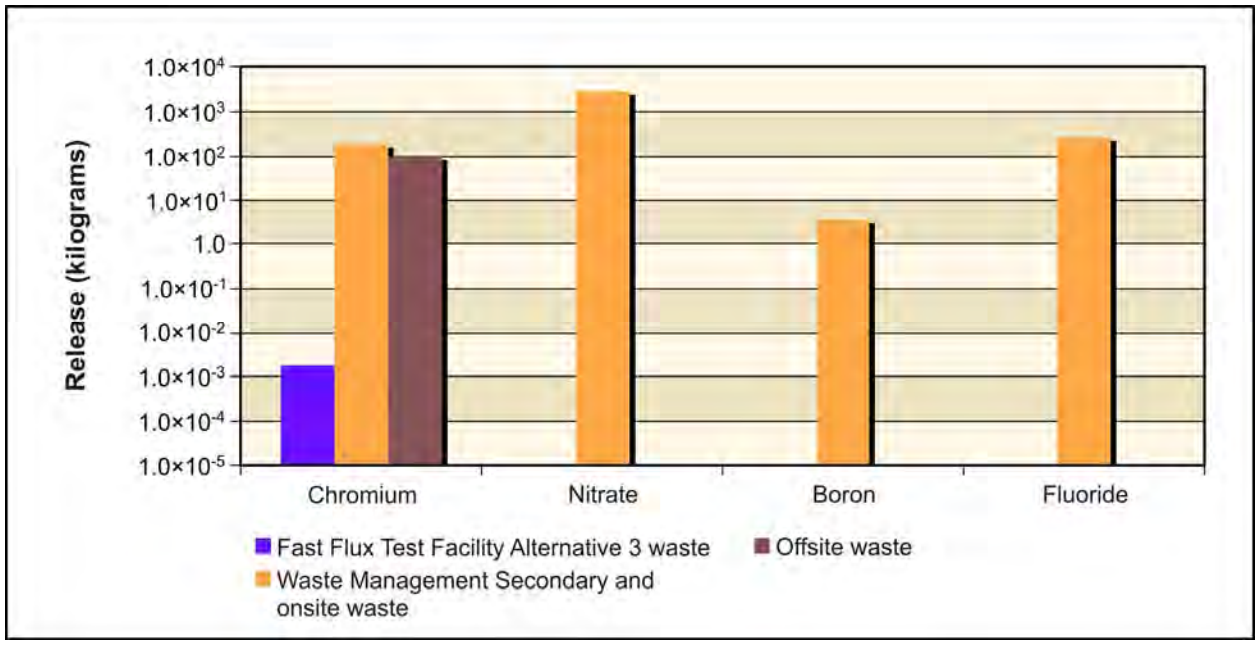


Figure 5–748. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–749 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–750, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, boron, and fluoride, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 98 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

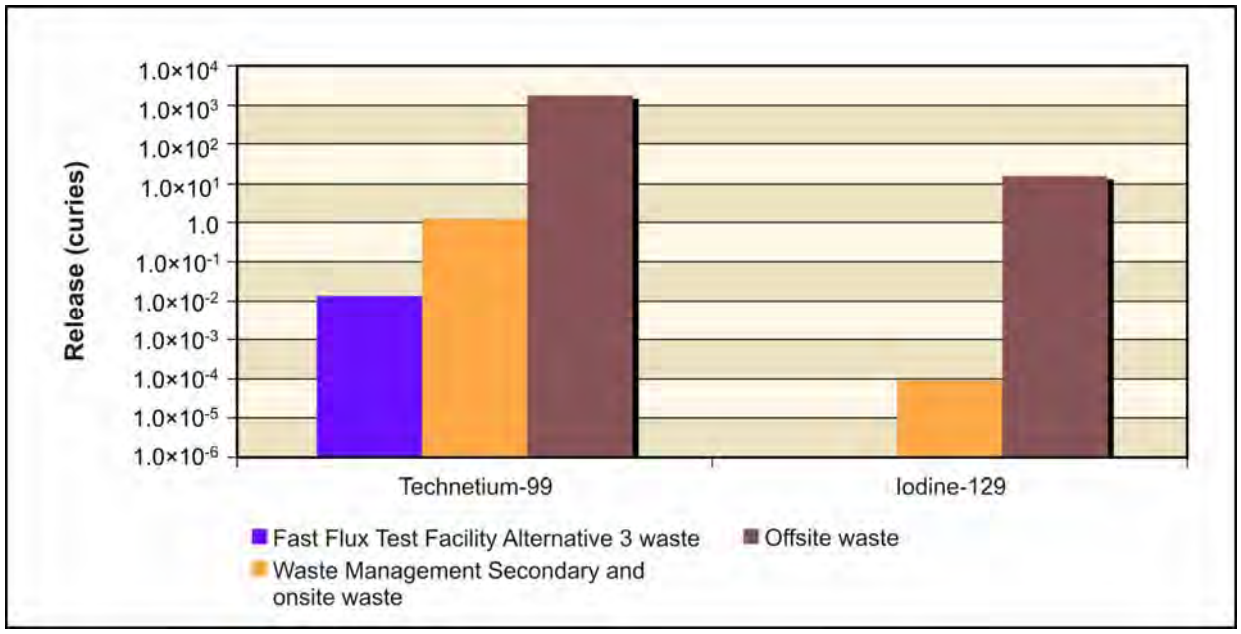


Figure 5–749. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

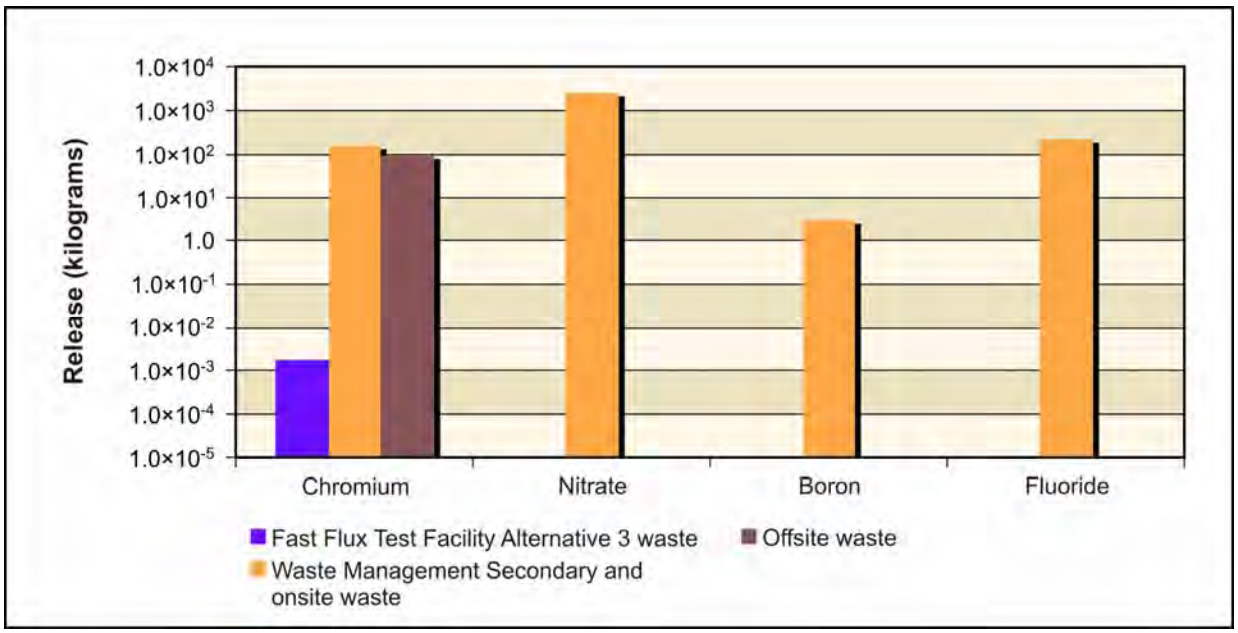


Figure 5–750. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–751 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–752, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, nitrate, boron, and fluoride, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; approximately 98 percent of the chemical quantity (kilograms) reached the river.

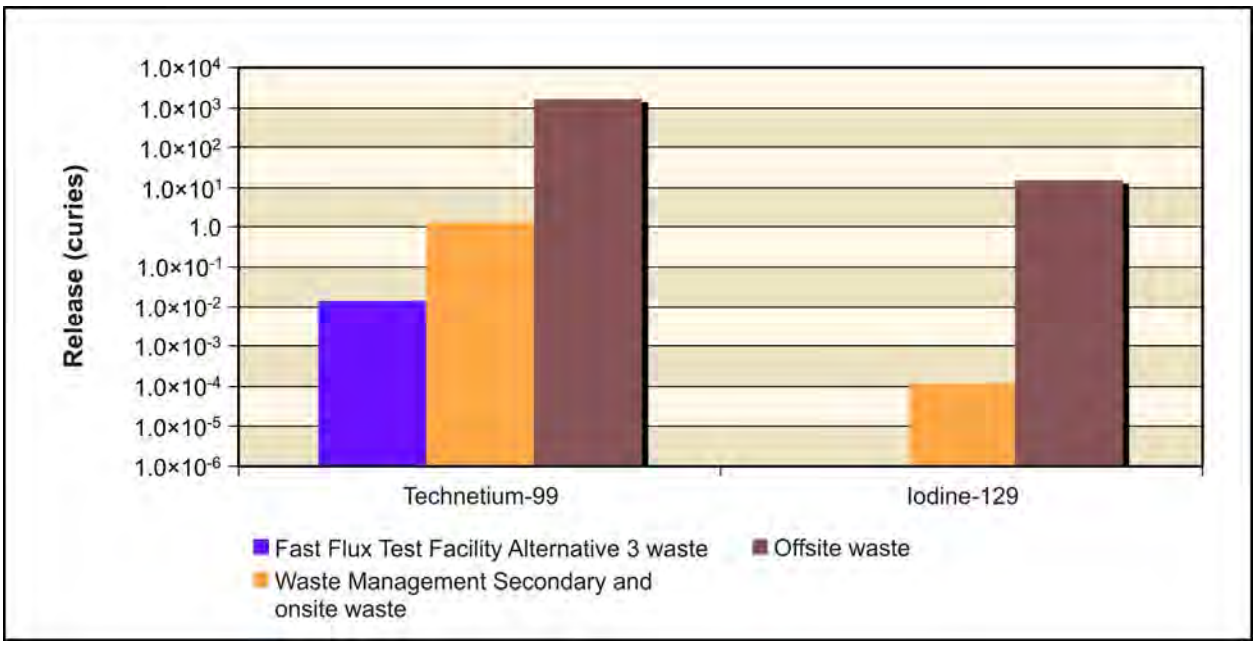


Figure 5–751. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

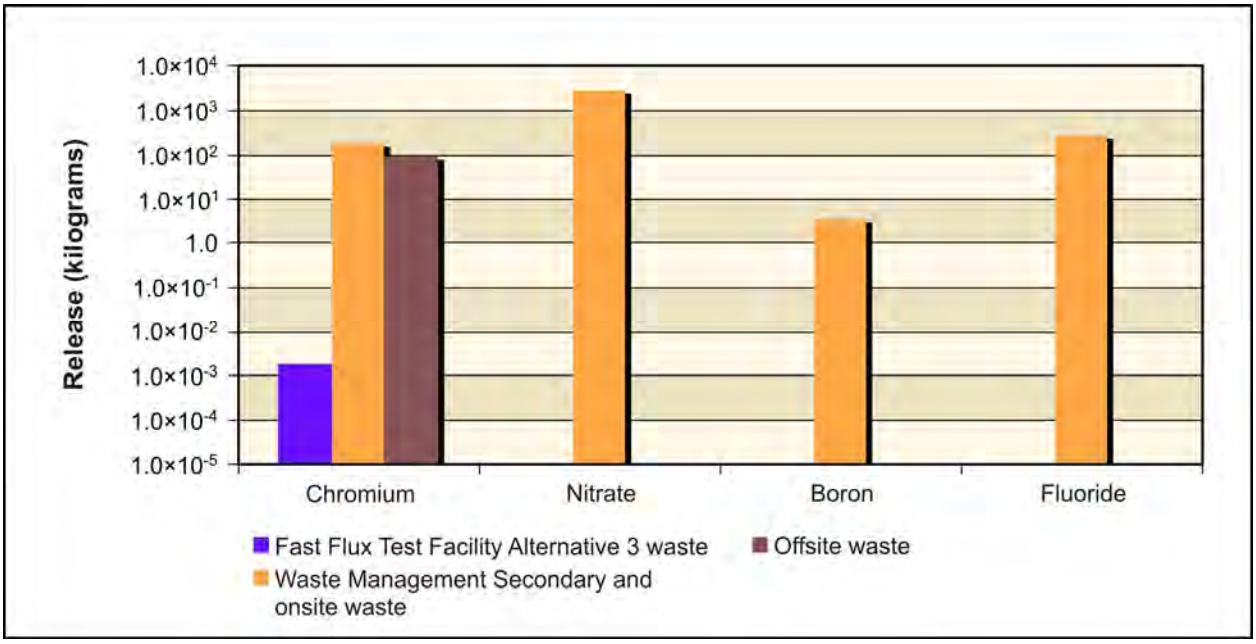


Figure 5–752. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–753 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–754, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium-99 (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). Fluoride and boron are not released from the RPPDF.

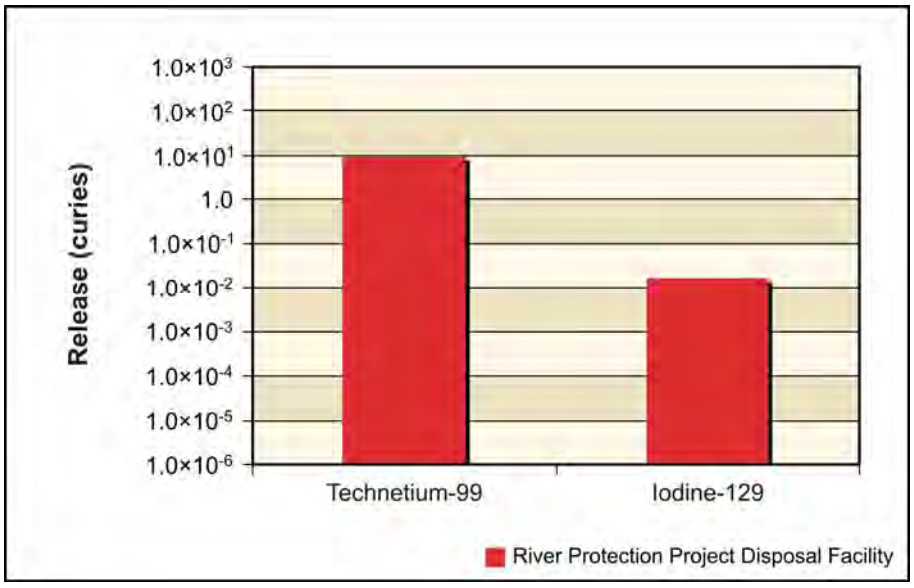


Figure 5–753. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

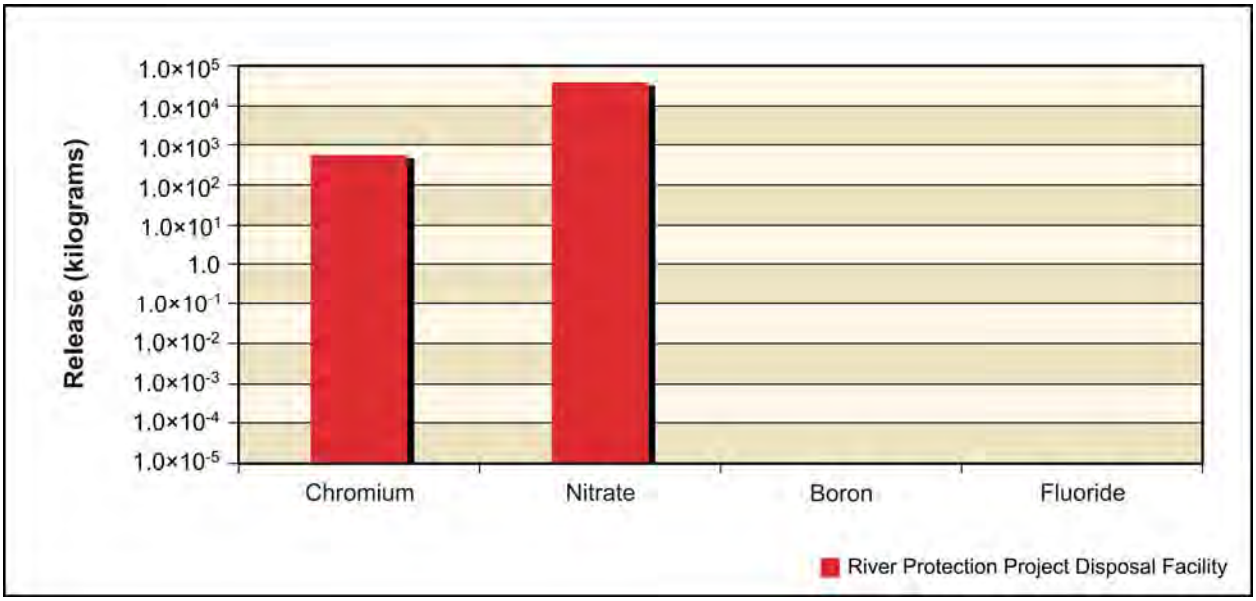


Figure 5–754. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–755 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–756, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

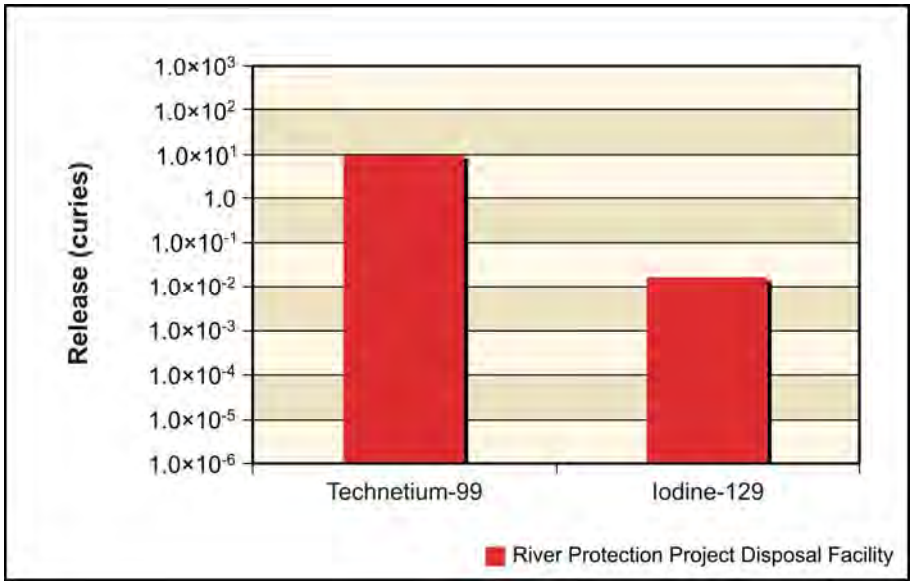


Figure 5–755. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Groundwater

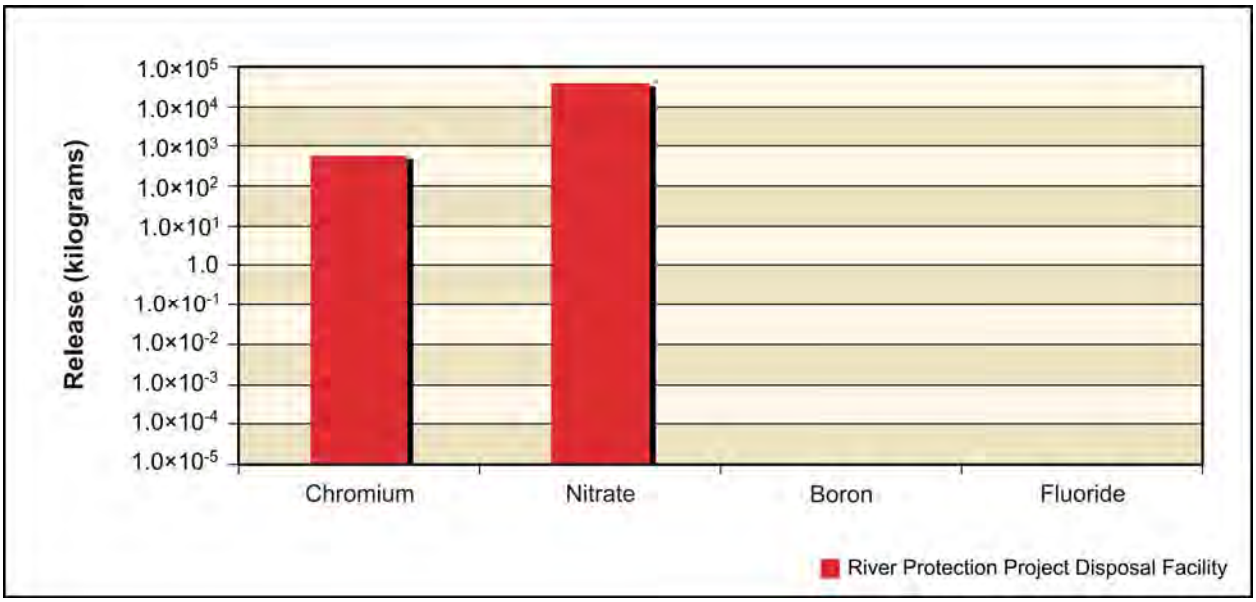


Figure 5–756. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–757 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–758, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 96 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; 96 percent of the chemical quantity (kilograms) reached the river.

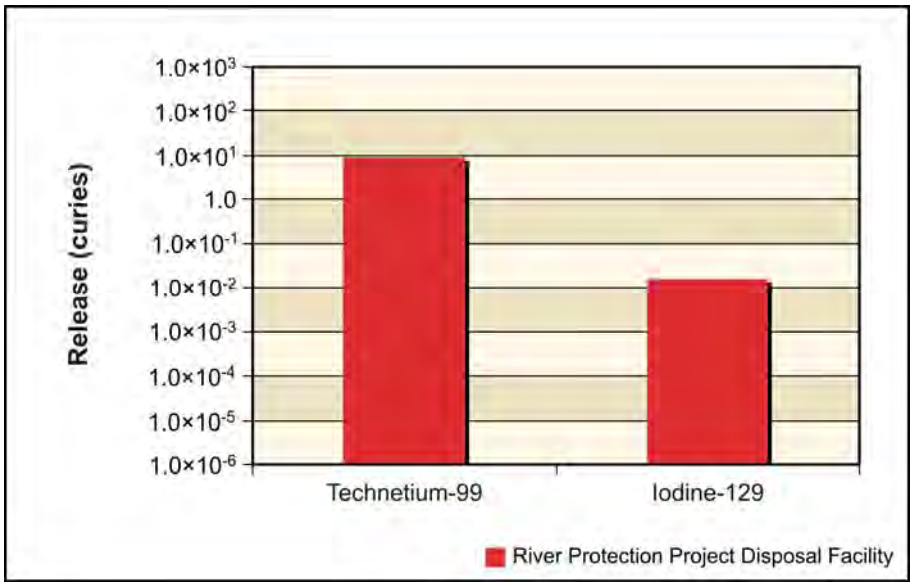


Figure 5–757. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Columbia River

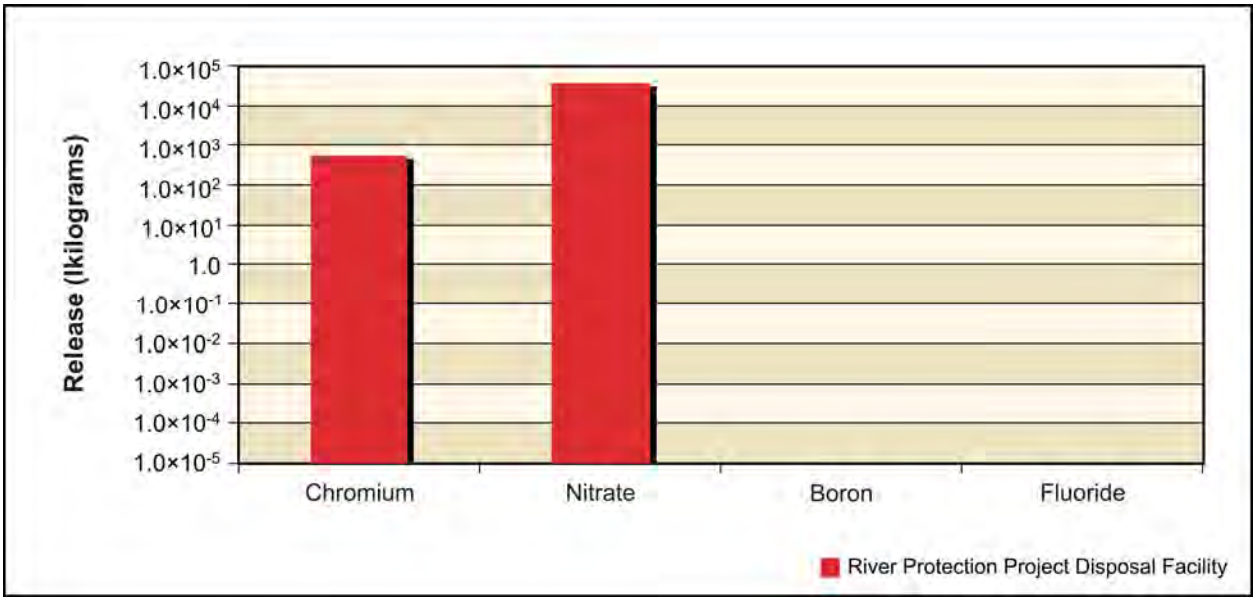


Figure 5–758. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–759 through 5–764). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–90 lists the maximum concentrations of the COPCs in the peak year at IDF-East, IDF-West, and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–90. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**1,600**	**20,200**	33	**7,560**	**1,130**	900
	(8486)	(3713)	(3825)	(3690)	(4528)	
Iodine-129	**2**	**173**	0.1	**60**	**8**	1
	(11,284)	(3797)	(3772)	(3853)	(4729)	
Chemical in micrograms per liter						
Chromium	2	2	2	3	0	100
	(8278)	(3696)	(3856)	(3628)	(4812)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,400	17	149	5,860	3,680	45,000
	(7821)	(3703)	(3811)	(8905)	(8144)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text**.**

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–759 through 5–762 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate, respectively. Releases from IDF-East, IDF-West, and the RPPDF cause groundwater concentrations to exceed benchmark concentrations at the Core Zone Boundary and Columbia River nearshore by approximately one order of magnitude for iodine-129. This exceedance occurs in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak only lasts for approximately 10 percent of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or Columbia River nearshore.

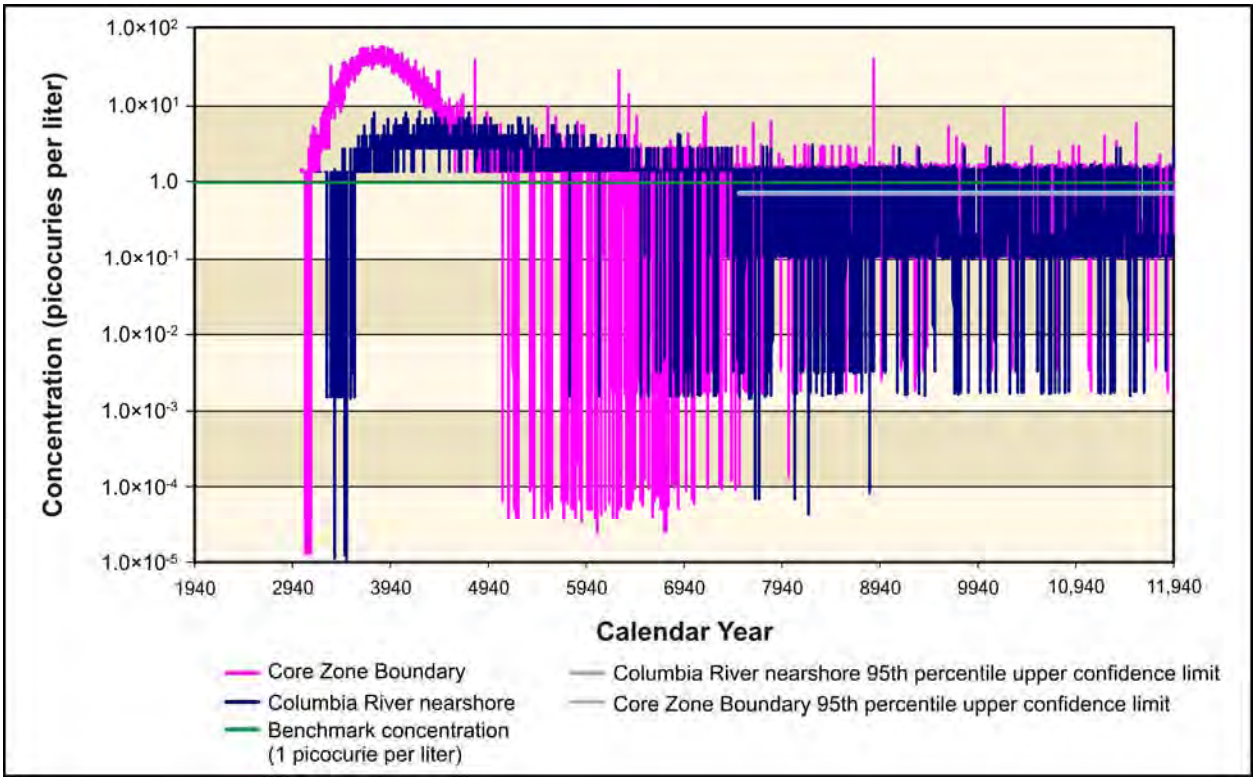


Figure 5–759. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Iodine-129 Concentration Versus Time

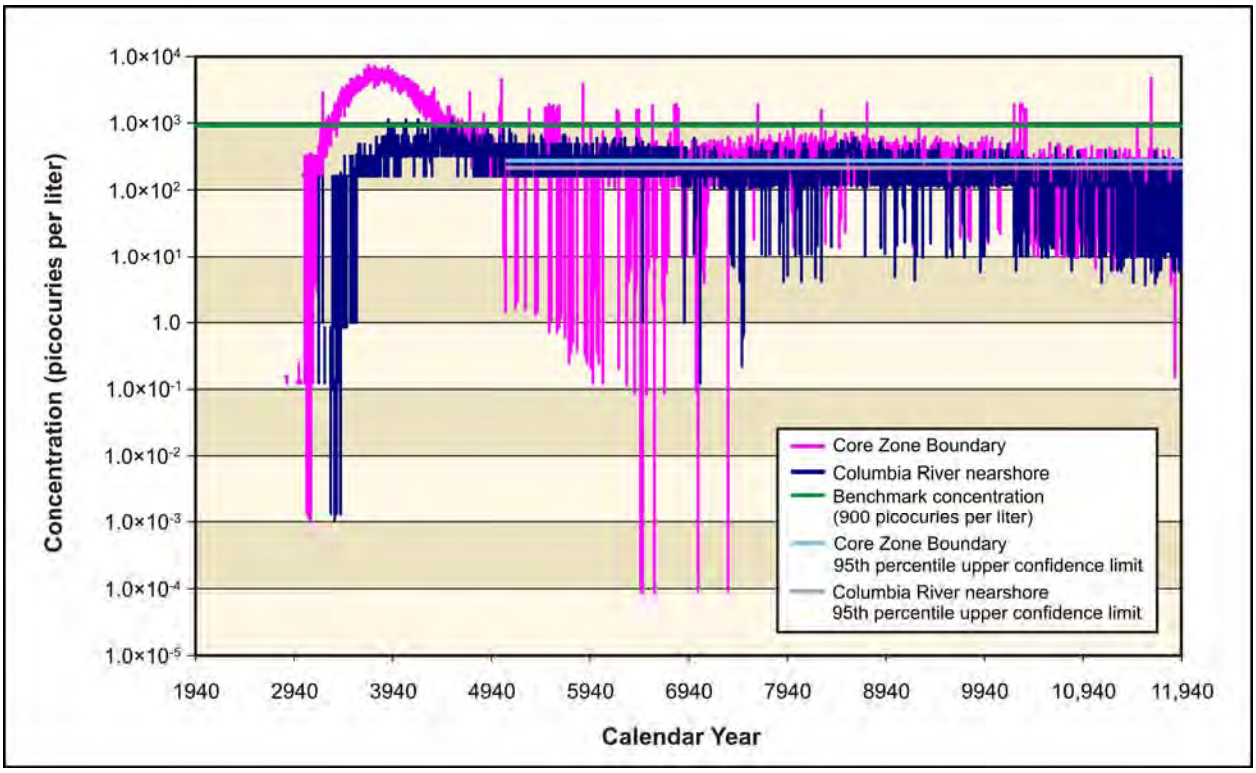


Figure 5–760. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Technetium-99 Concentration Versus Time

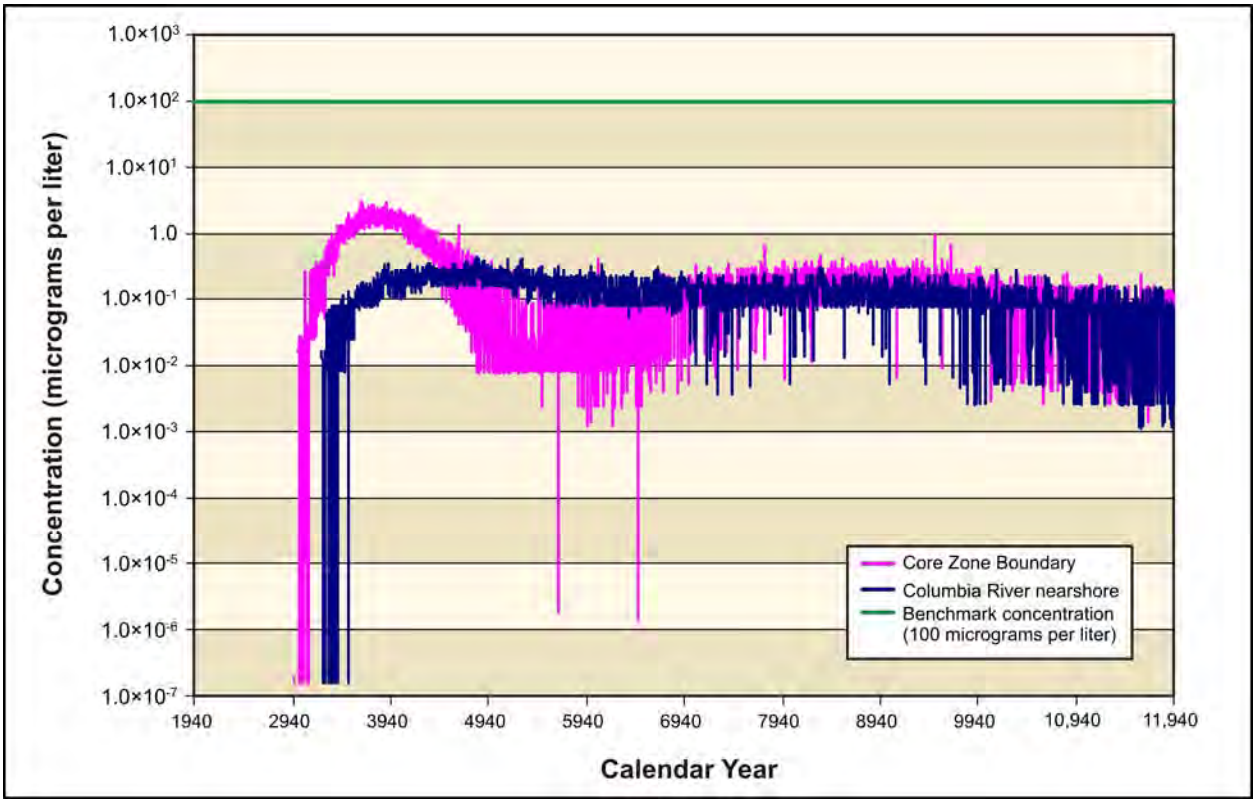


Figure 5–761. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chromium Concentration Versus Time

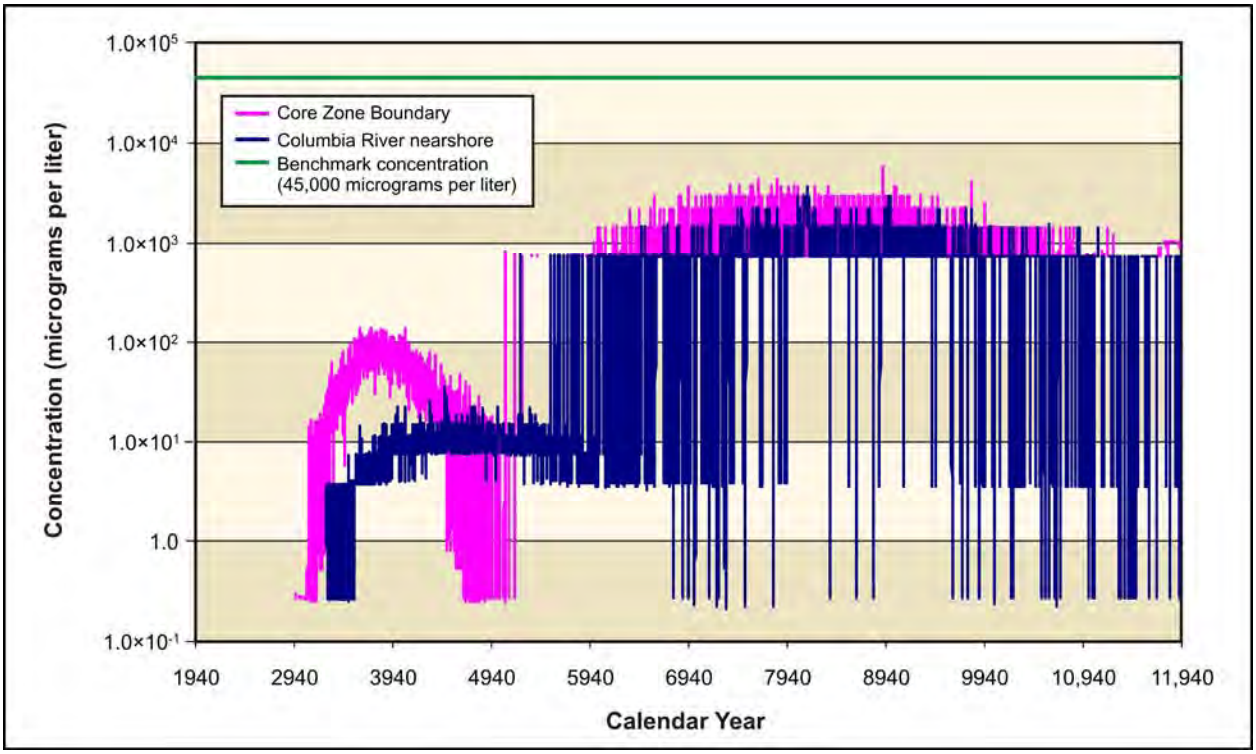


Figure 5–762. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Nitrate Concentration Versus Time

Figures 5–763 and 5–764 show concentration versus time for uranium-238 and total uranium, respectively. Because uranium-238 and total uranium move slowly through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 and total uranium concentrations, while very minimal, continue to rise throughout the duration of the period of analysis, but never get closer than three orders of magnitude of exceeding benchmark concentrations by the end of the period of analysis.

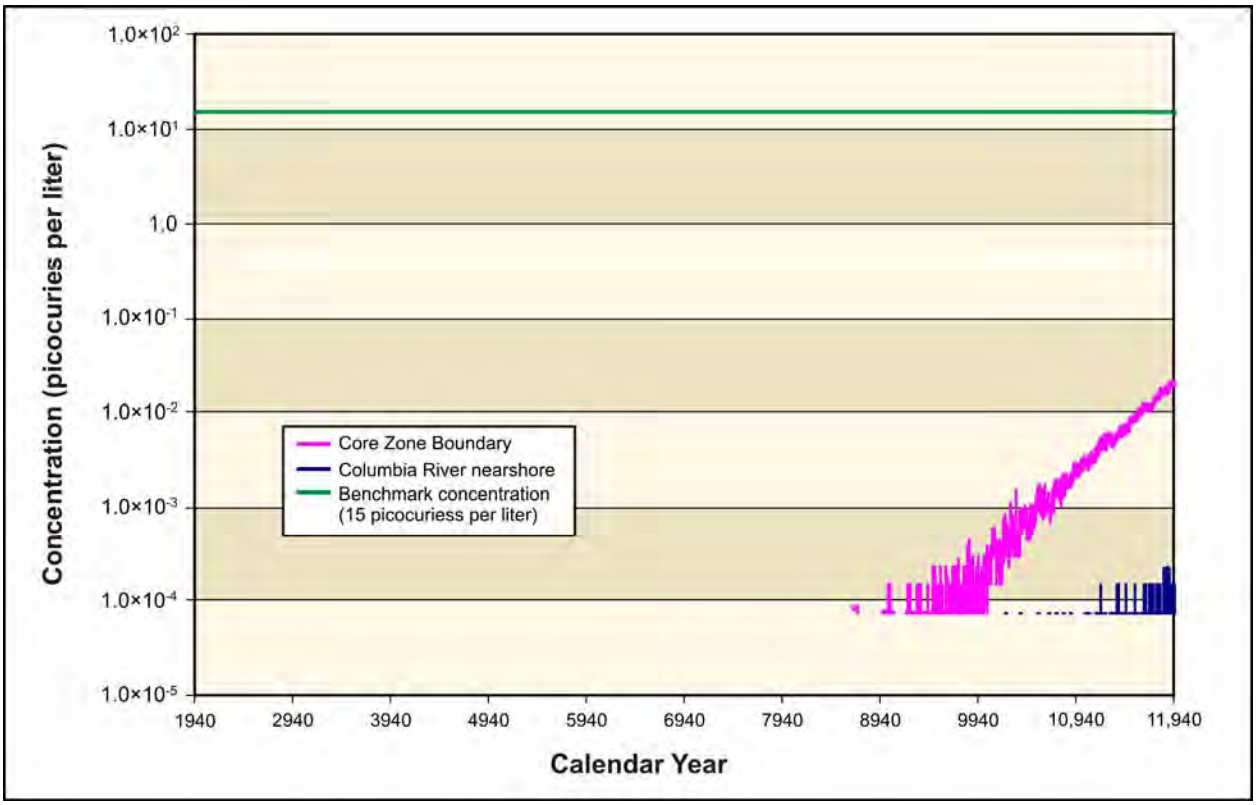


Figure 5–763. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Uranium-238 Concentration Versus Time

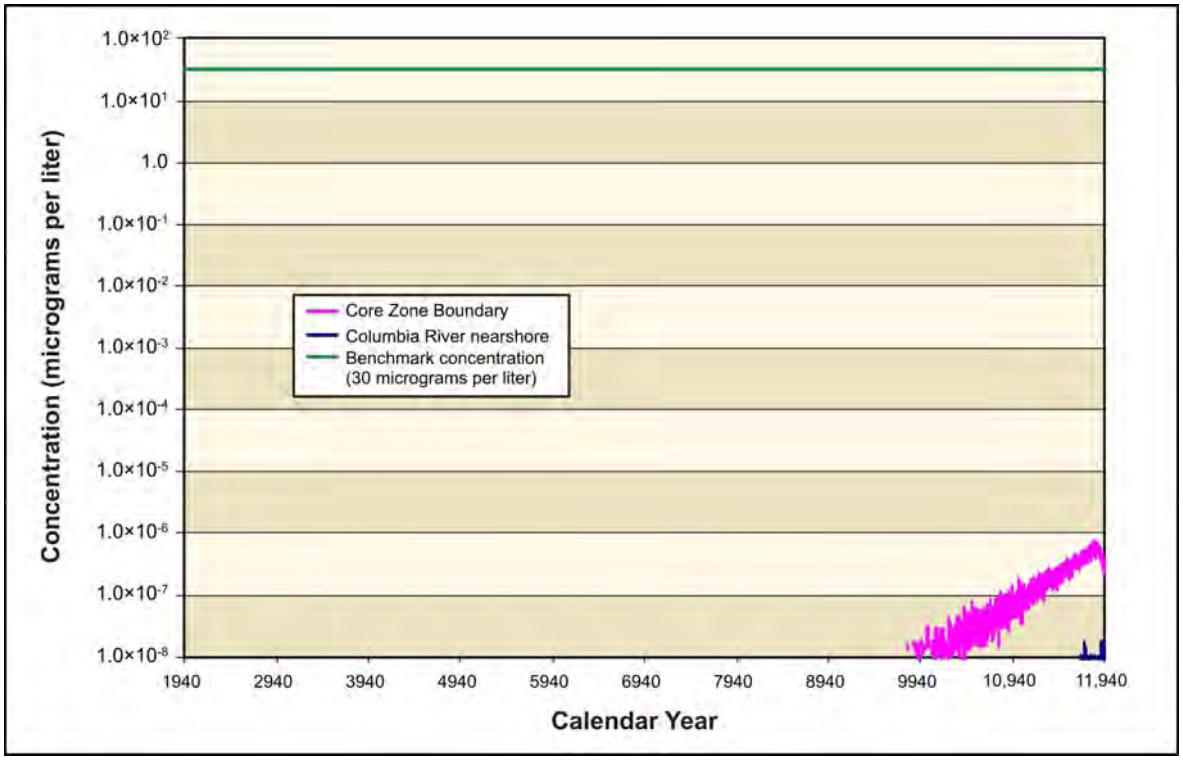


Figure 5–764. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–765 through 5–778). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–765 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from IDF-West and the RPPDF result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area, moving eastward towards the Columbia River (see Figure 5–766). Also, by CY 7140, most of the IDF-West and RPPDF plume continued to move north and reached the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small isolated pockets of concentration exceeding the benchmark (see Figure 5–767). Technetium-99 (see Figures 5–768 through 5–770) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–771 through 5–773) and nitrate (see Figures 5–774 through 5–776) show similar spatial distributions at selected times, except none of them exceed the benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

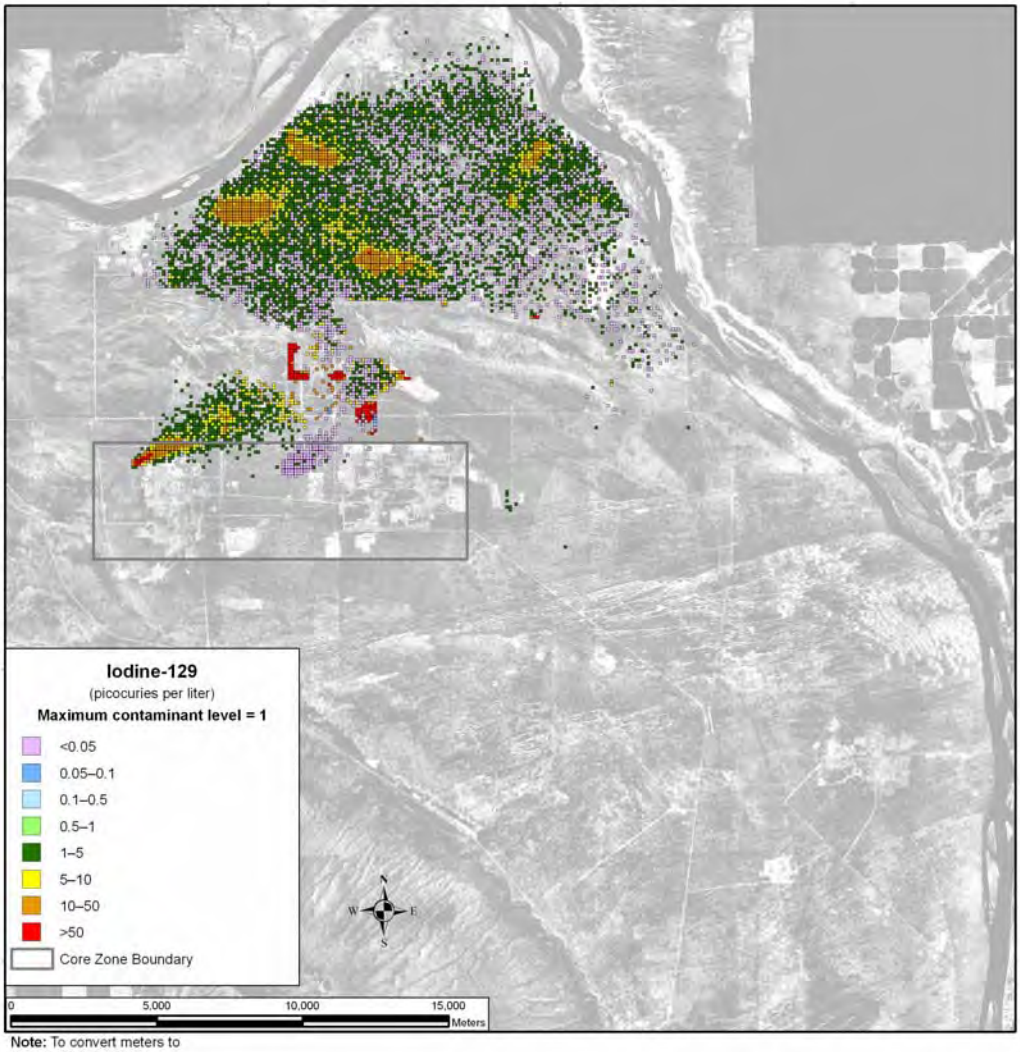


Figure 5–765. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

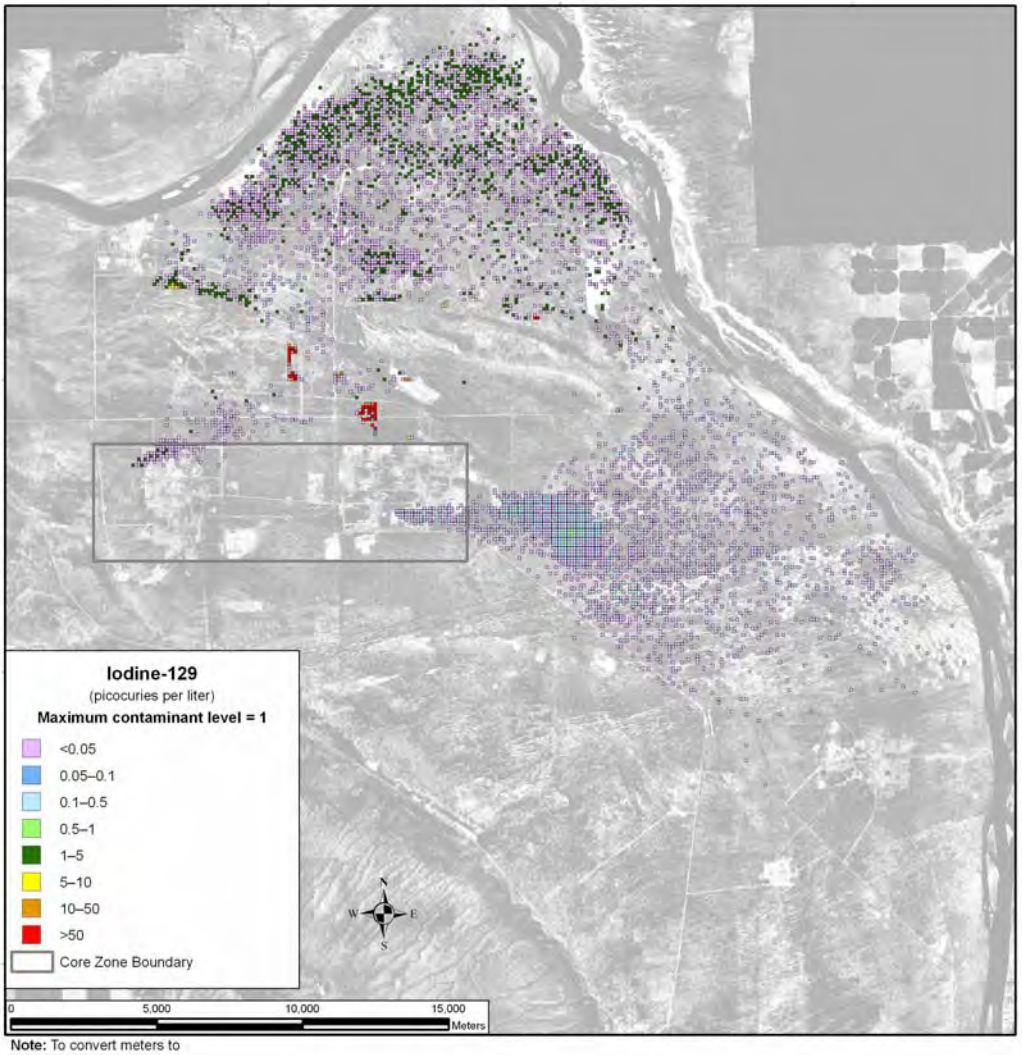


Figure 5–766. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

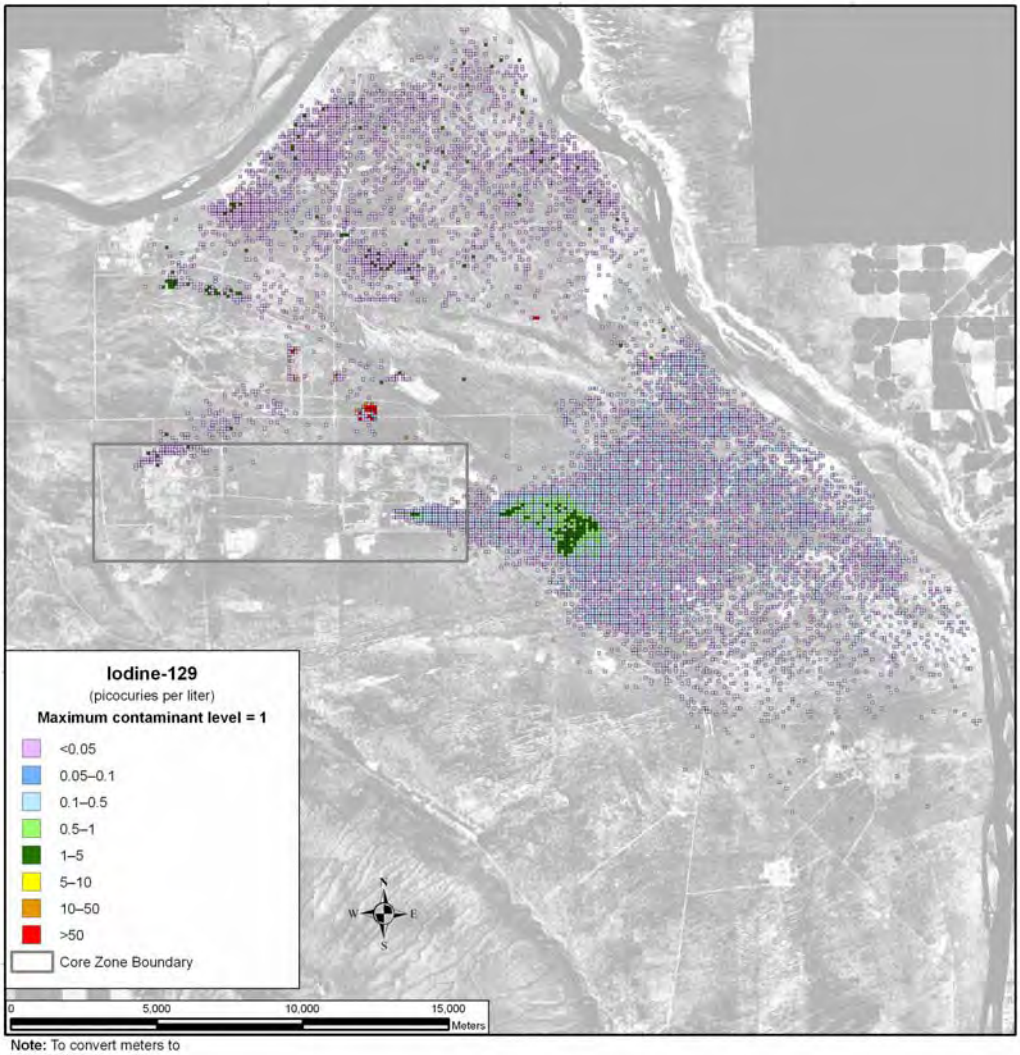


Figure 5–767. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

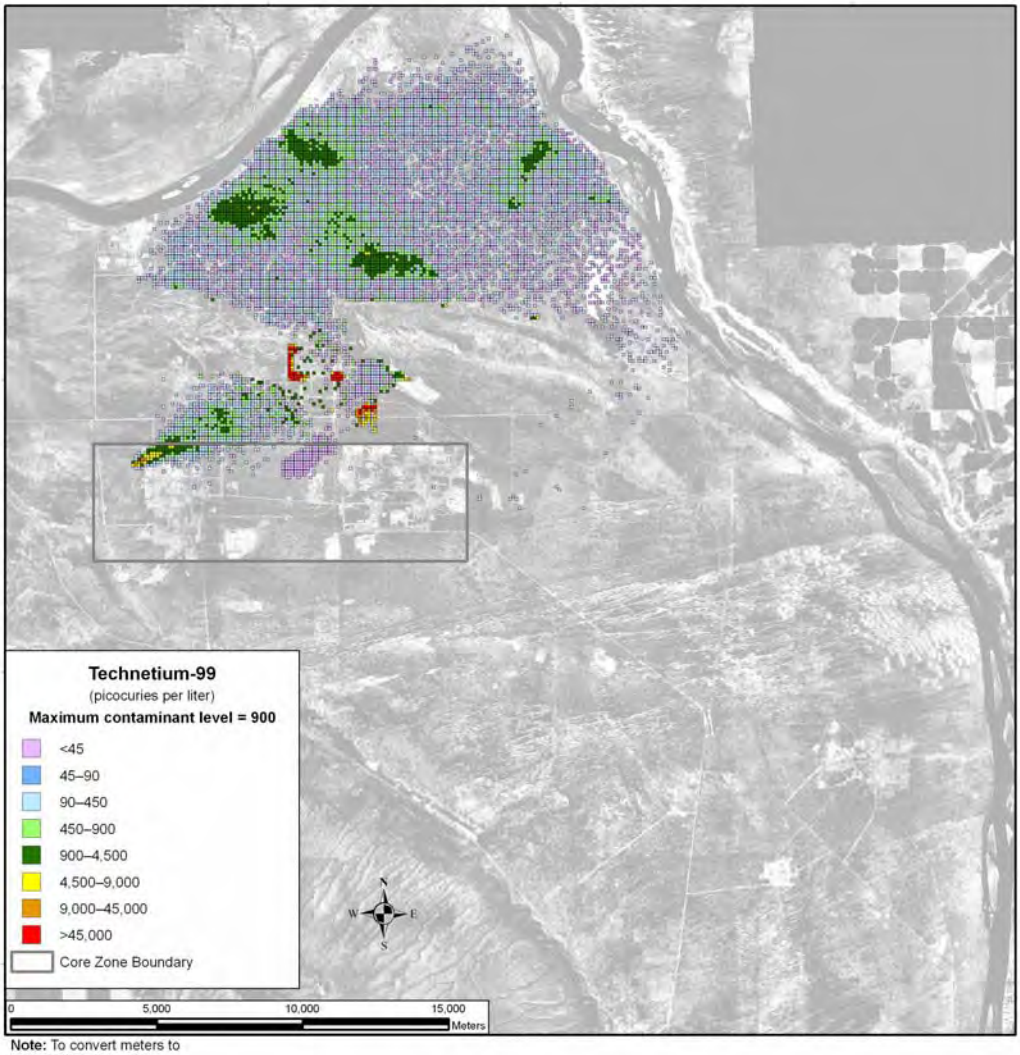
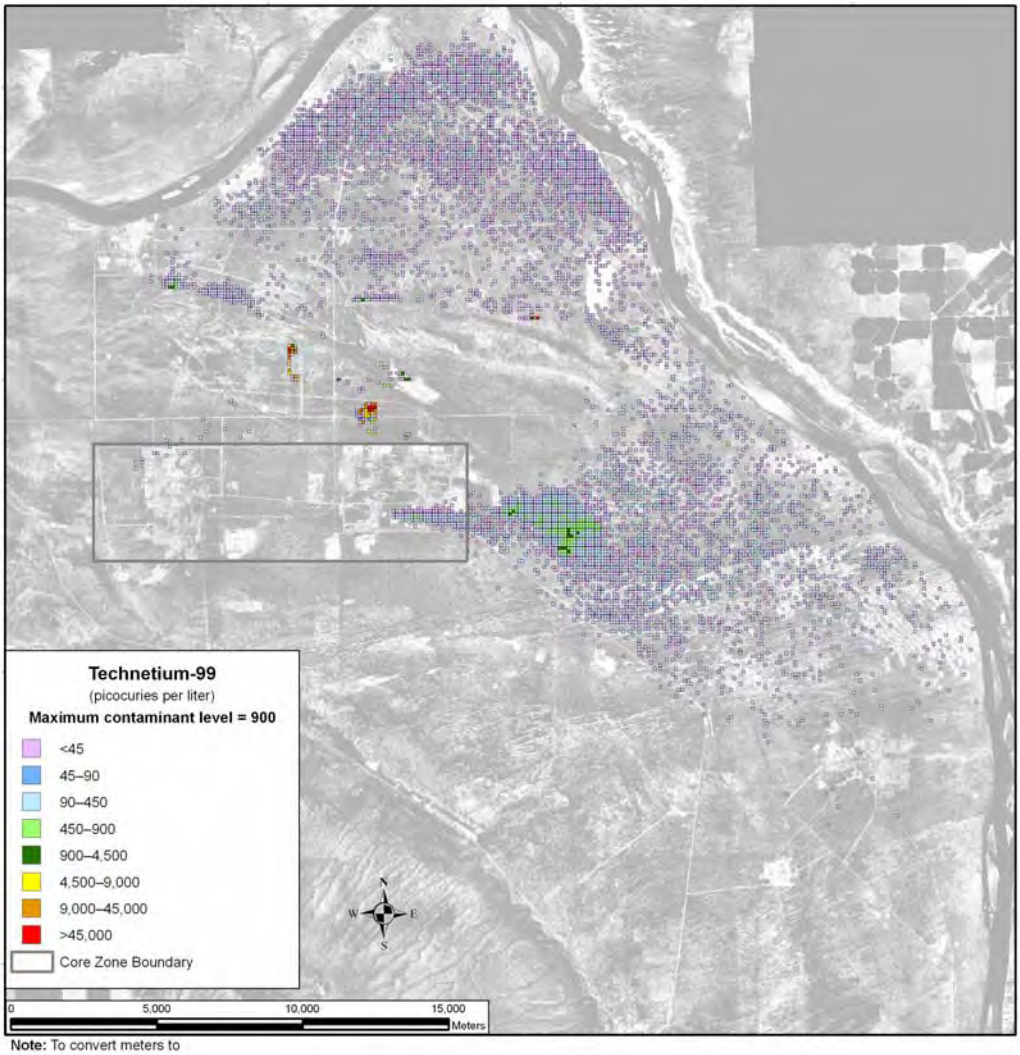


Figure 5–768. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–769. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

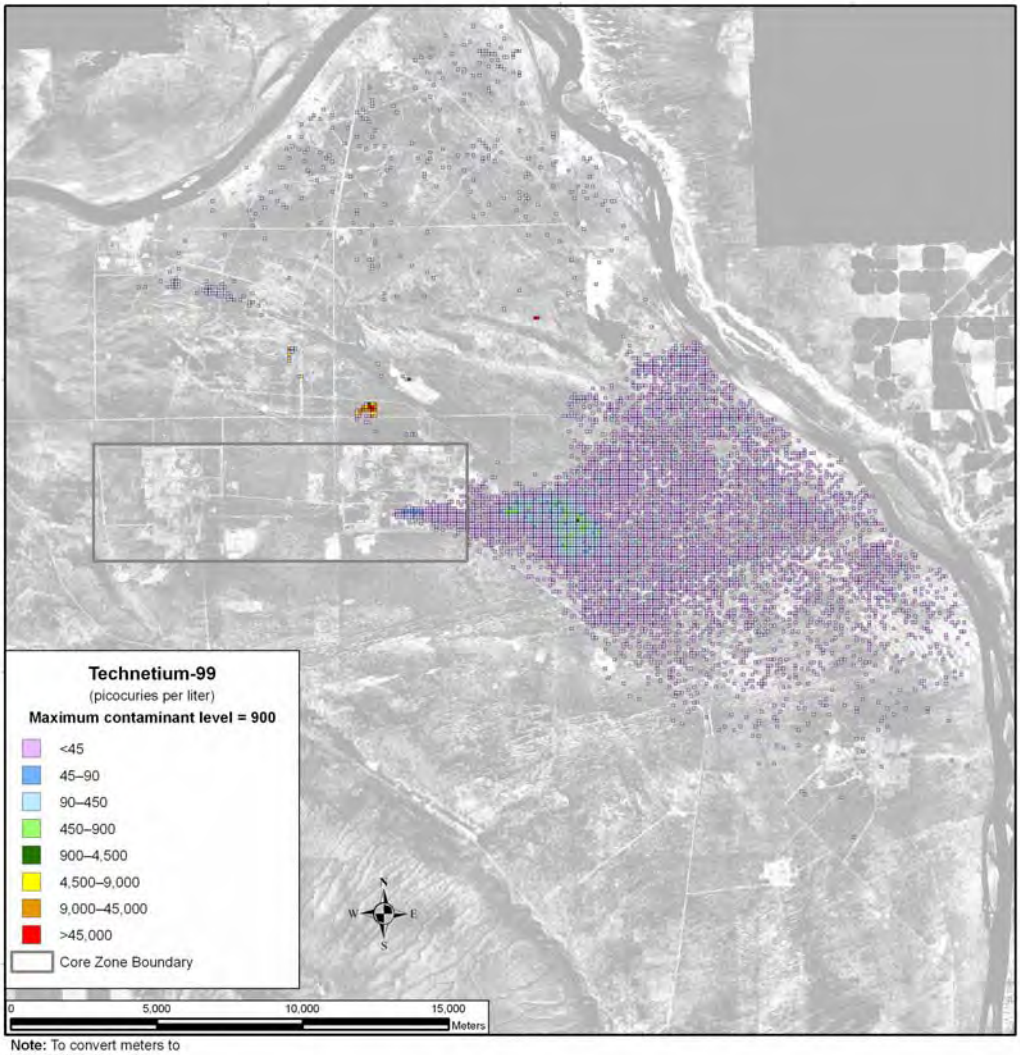


Figure 5–770. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

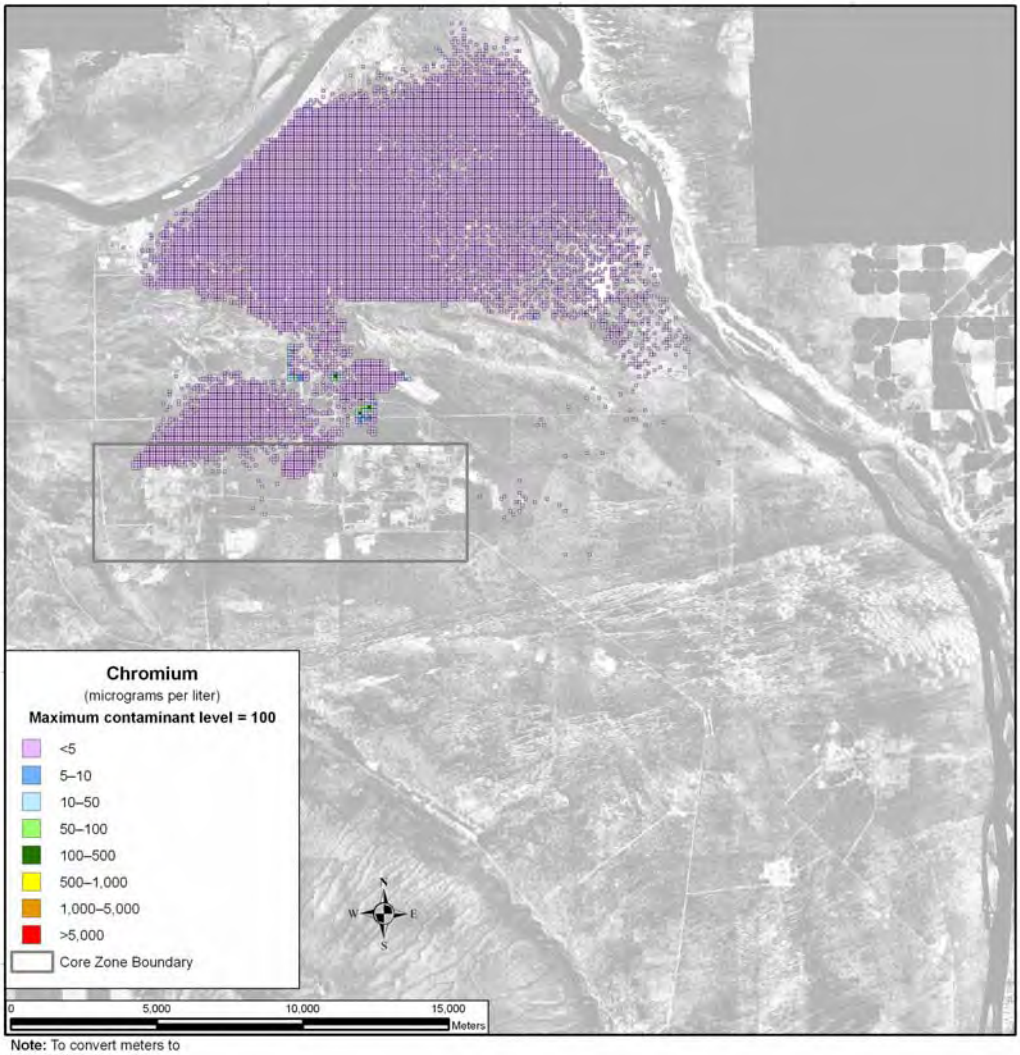


Figure 5–771. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

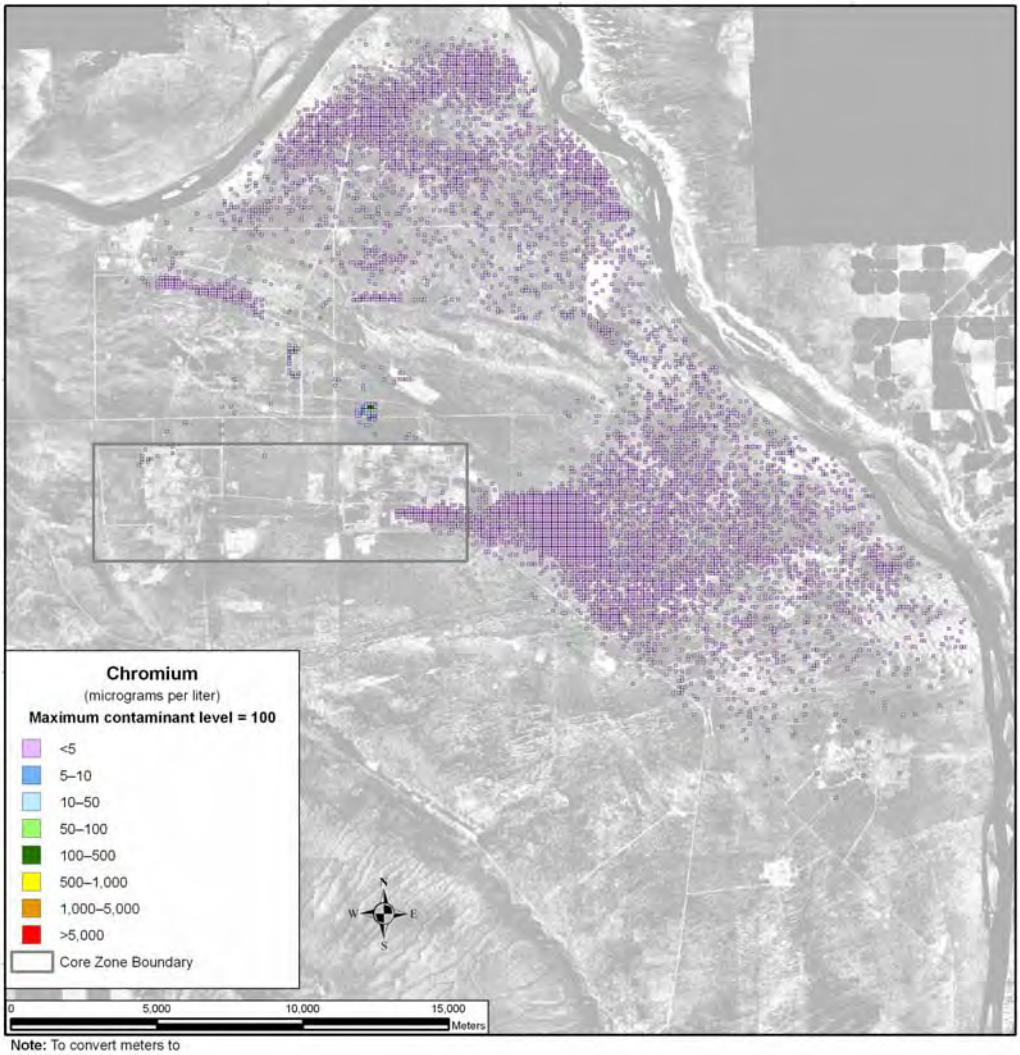


Figure 5–772. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

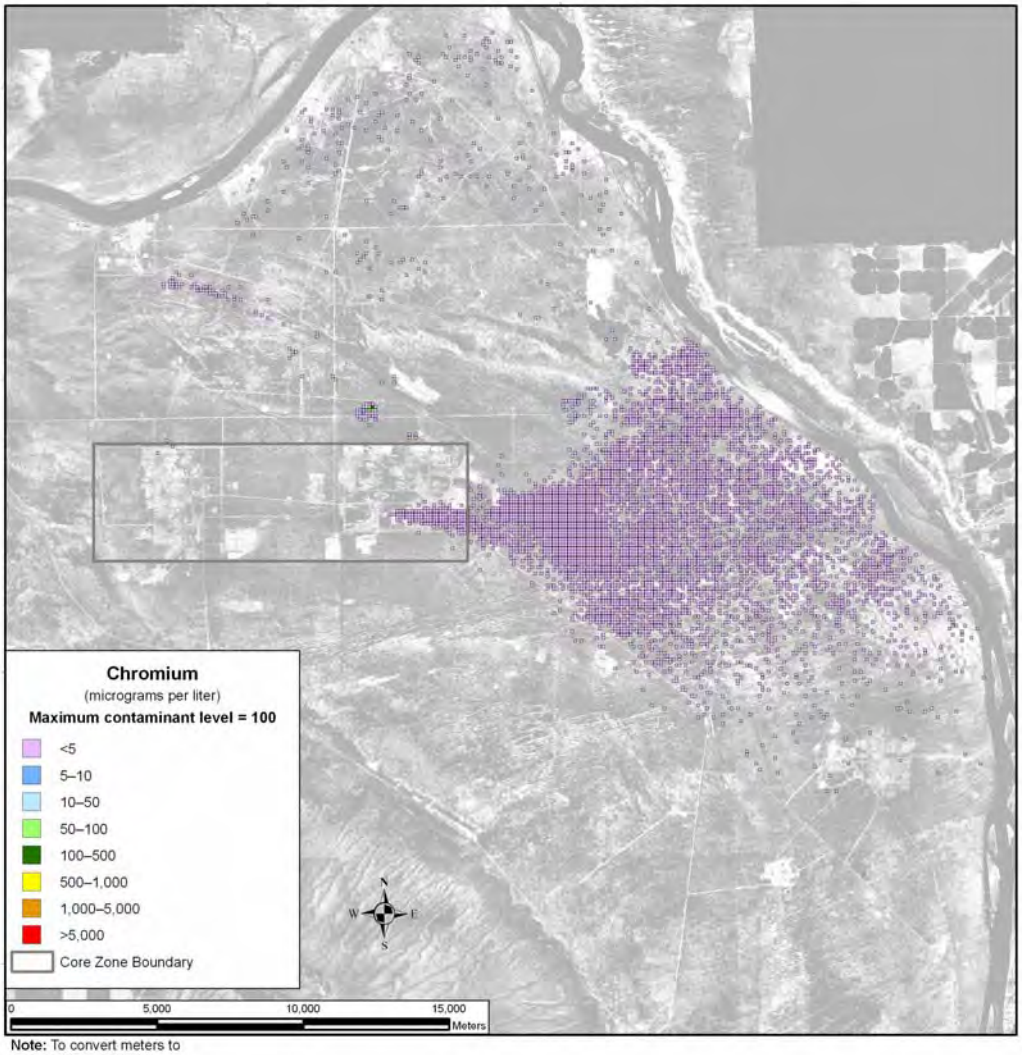


Figure 5–773. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

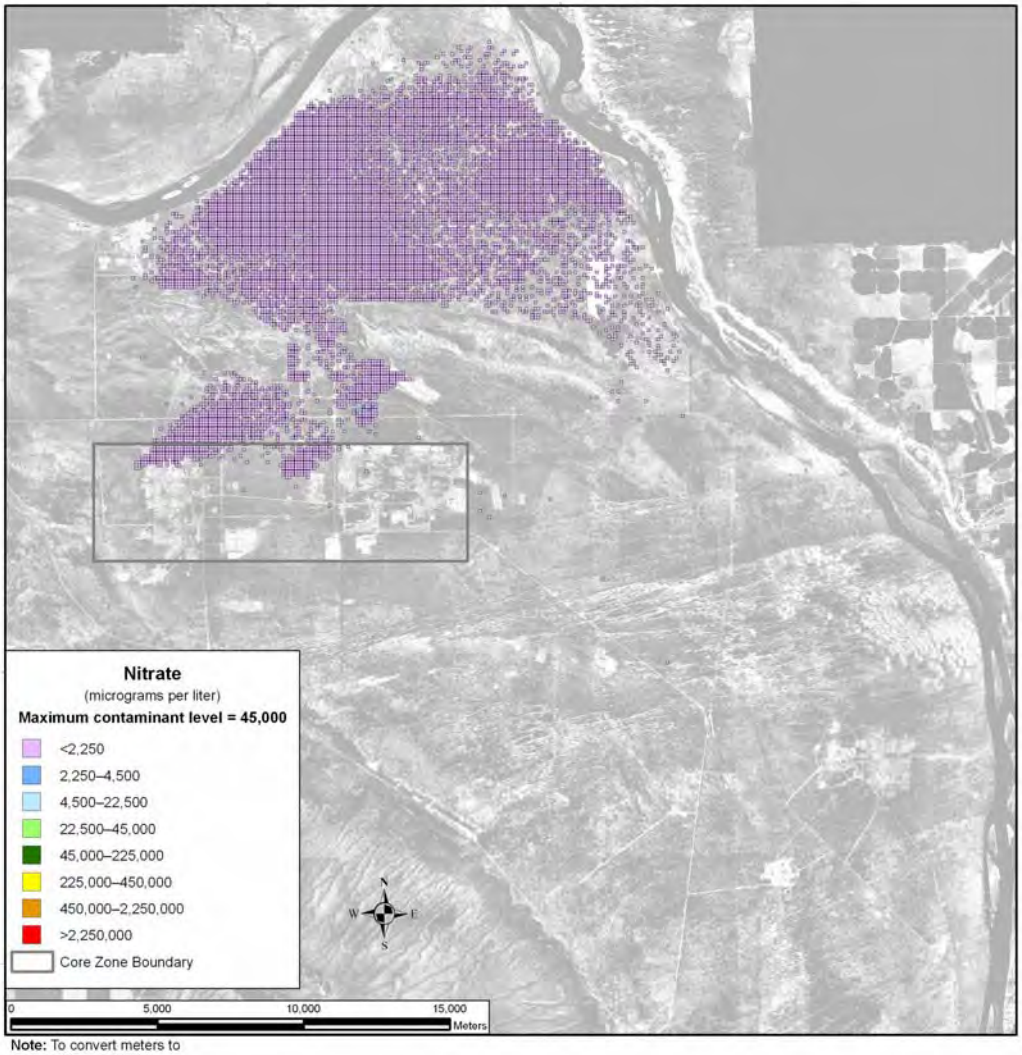


Figure 5–774. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

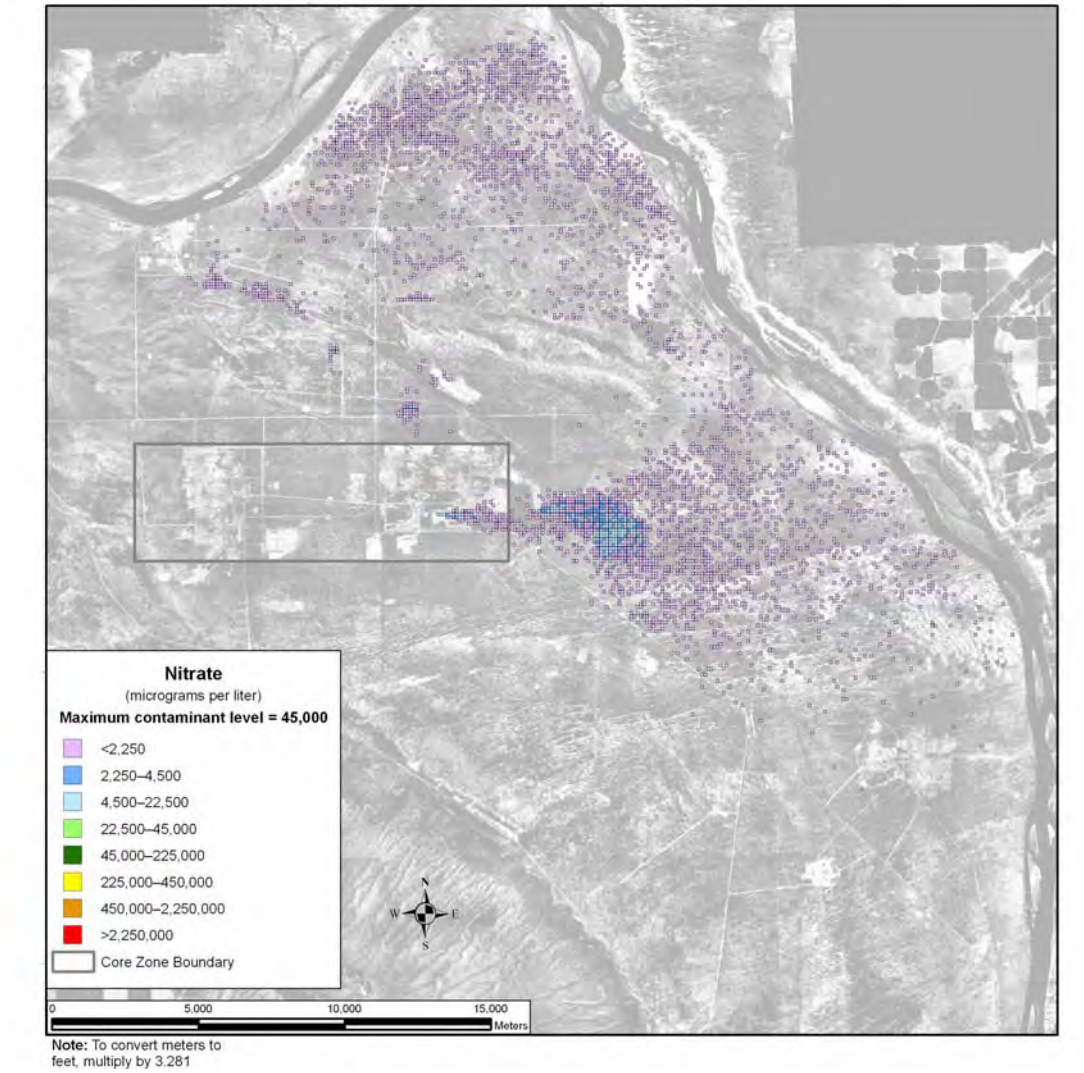


Figure 5–775. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

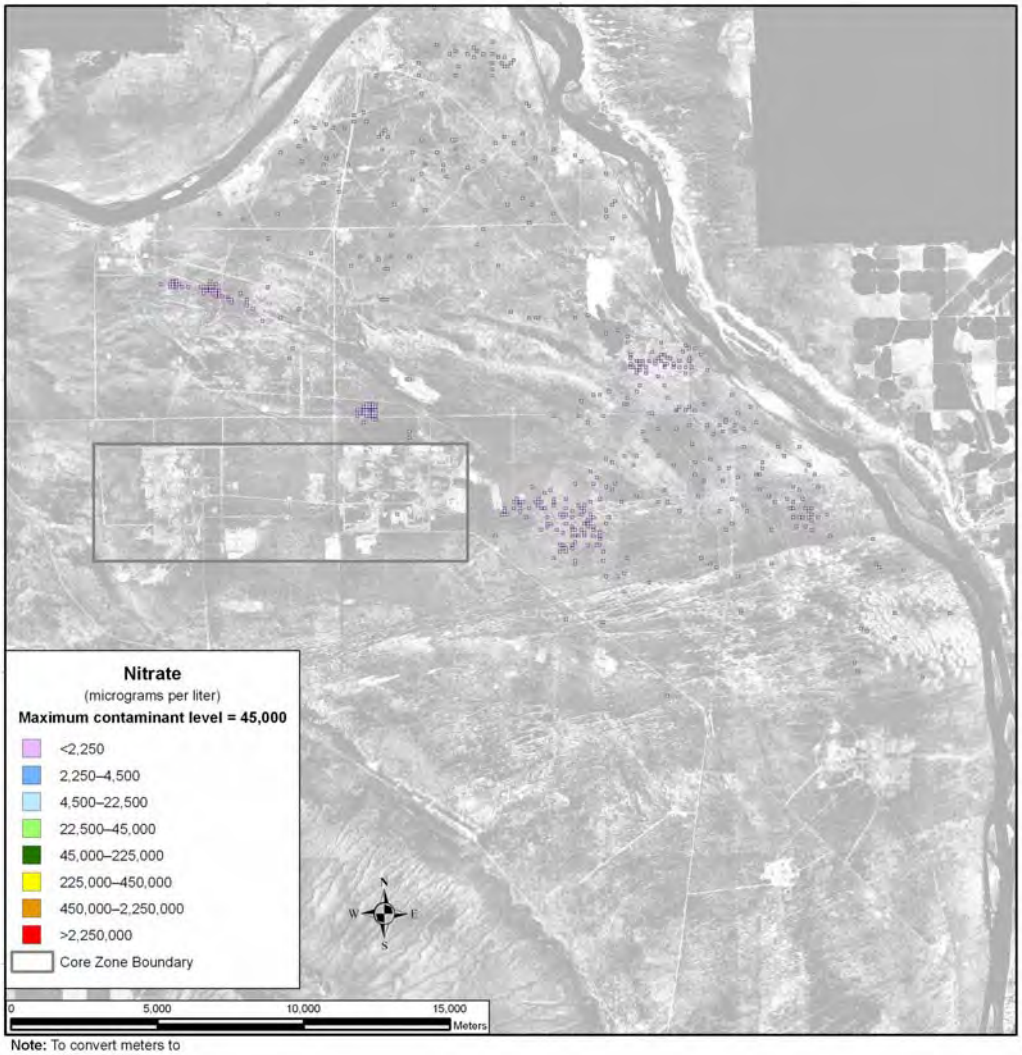


Figure 5–776. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figures 5–777 and 5–778 show the distribution of uranium-238 and total uranium, respectively, during CY 11,885. Releases from IDF-West and the RPPDF result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.

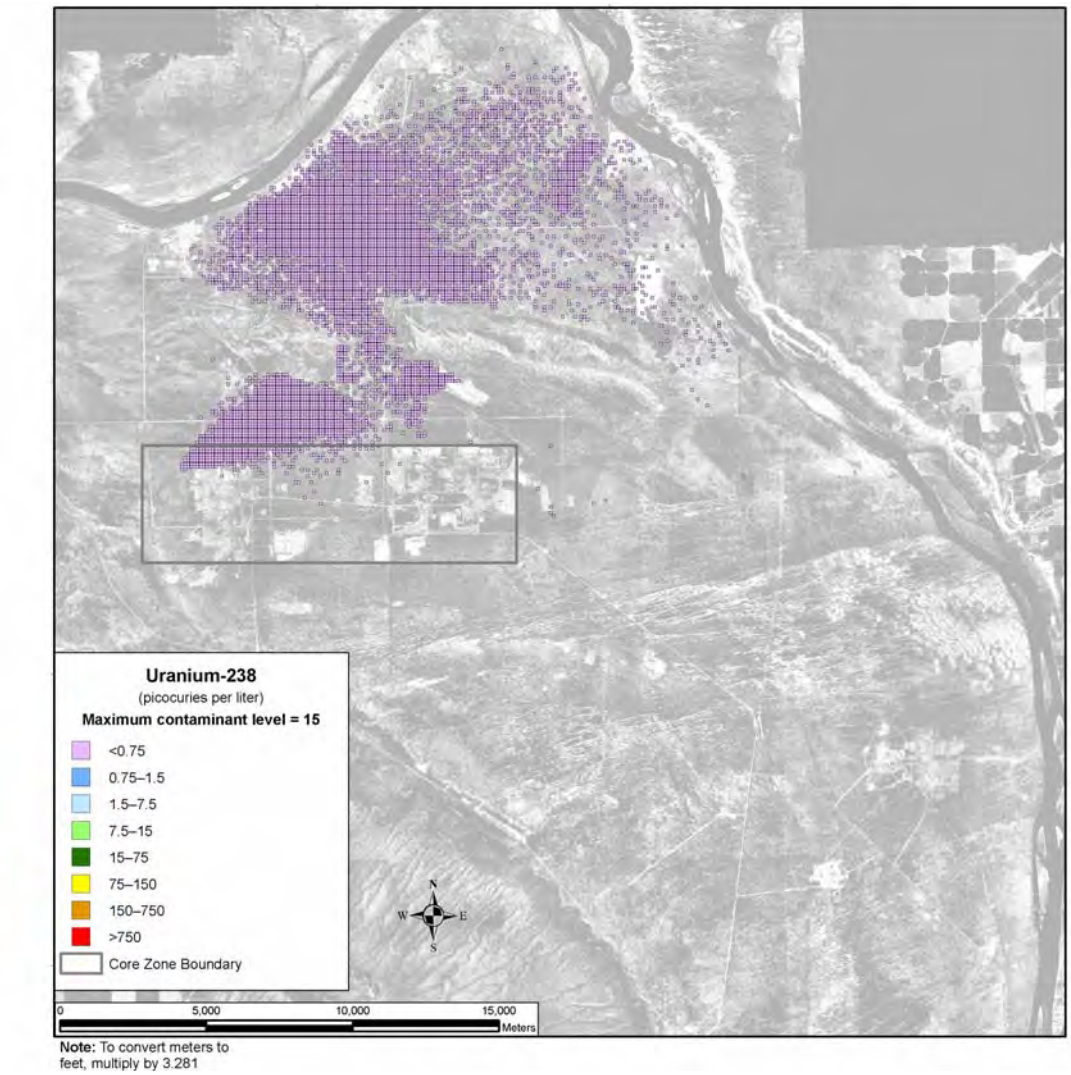


Figure 5–777. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

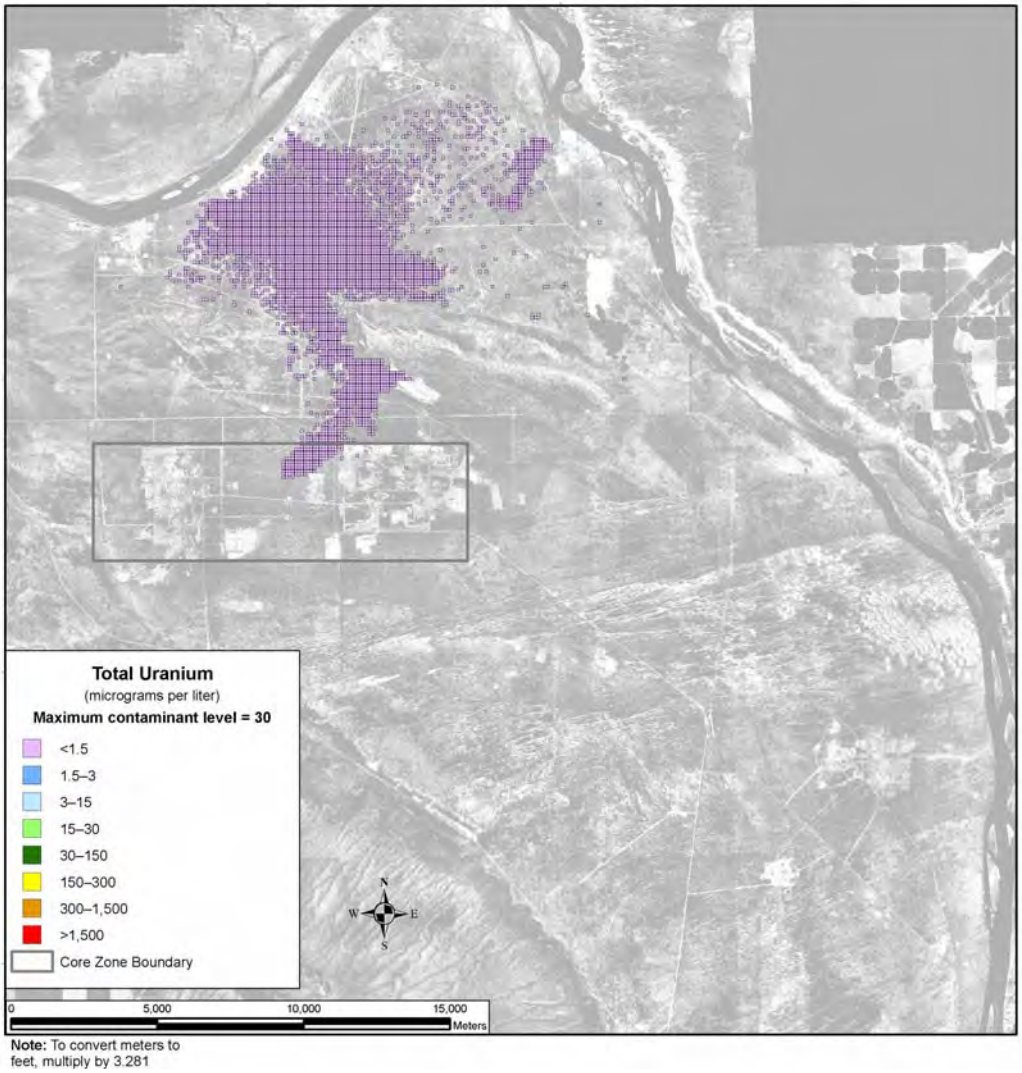


Figure 5–778. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, in general, the inventories remaining at IDF-East, IDF-West, and the RPPDF, which are available for release to the environment at the start of the post-disposal period, are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. Concentration at the Columbia River is about one to two orders of magnitude smaller. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or Columbia River.

5.3.1.3.1.3 Disposal Group 1, Subgroup 1-C

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-C covers disposal of waste generated under Tank Closure Alternative 3B, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, and cast stone waste. IHLW would be stored on site, while ILAW glass and cast stone waste would be disposed of at an IDF.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, chromium, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for 100 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C.

The COPC drivers that are discussed in detail in this section fall into two categories. Iodine-129, technetium-99, acetonitrile, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, in terms of total amount of COPCs released to the vadose zone, to groundwater, and to the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms. Nine subtotals are plotted representing releases from ILAW glass, cast stone waste, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite-generated waste, off-site generated waste, and the RPPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–779 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–780, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant source of acetonitrile, chromium, nitrate, iodine-129, and technetium-99 is cast stone waste. Other sources of contamination examined include ILAW glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

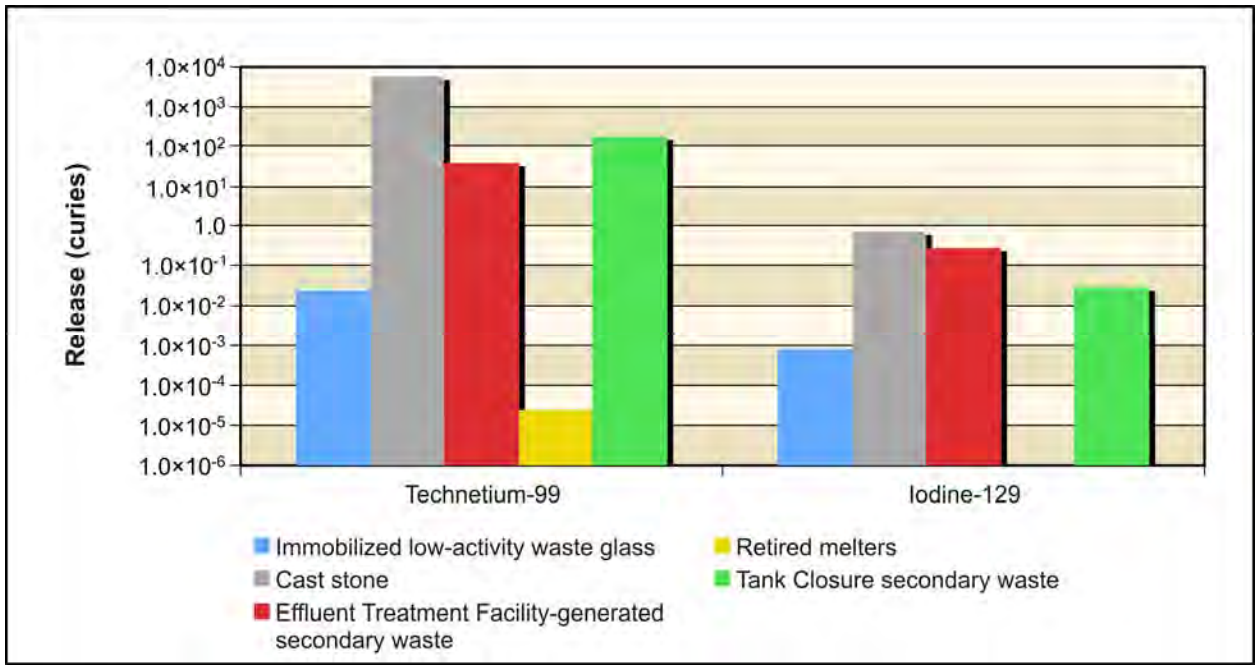


Figure 5–779. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Vadose Zone

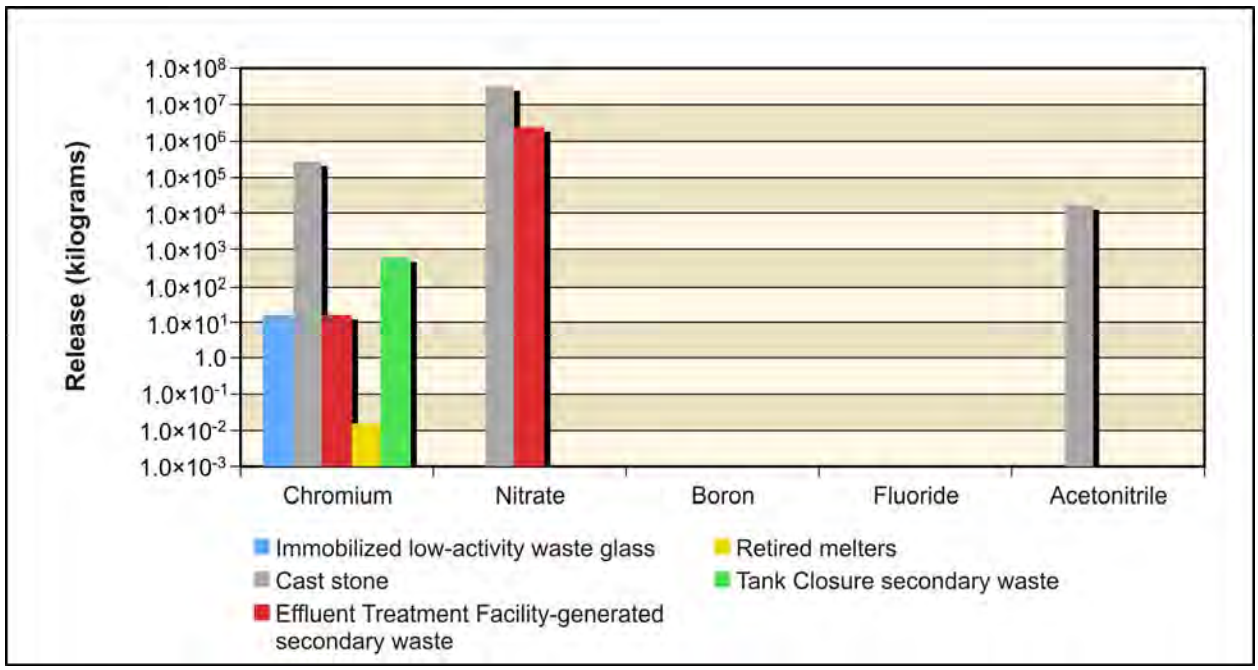


Figure 5–780. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Vadose Zone

Figure 5–781 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–782, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. With the exception of technetium-99 released from ETF-generated secondary waste, of which nearly all released to the vadose zone reached groundwater in the analysis, only 40 to 50 percent of the technetium-99 and iodine-129 released to the vadose zone reached groundwater. Chromium from ILAW glass and retired melters behaves similarly to technetium-99 and iodine-129. When released from other sources, nearly all the chromium that enters the vadose zone reached groundwater in the analysis. For nitrate, fluoride, boron, and acetonitrile, nearly everything released to the vadose zone reached groundwater.

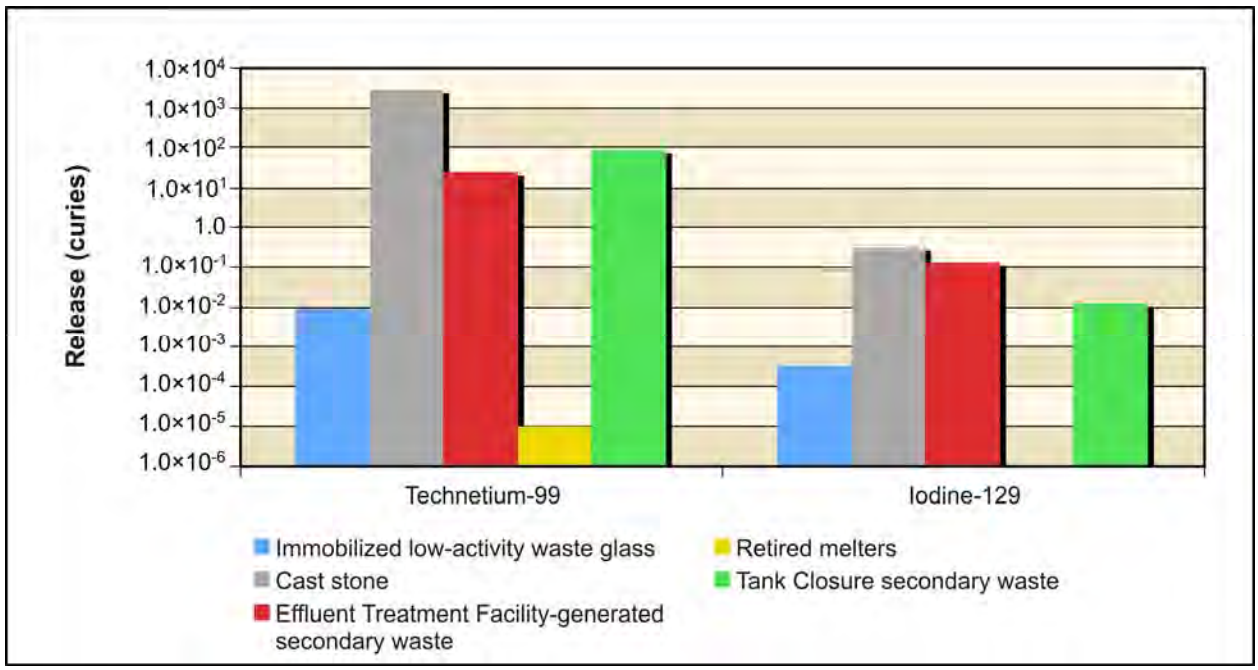


Figure 5–781. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Groundwater

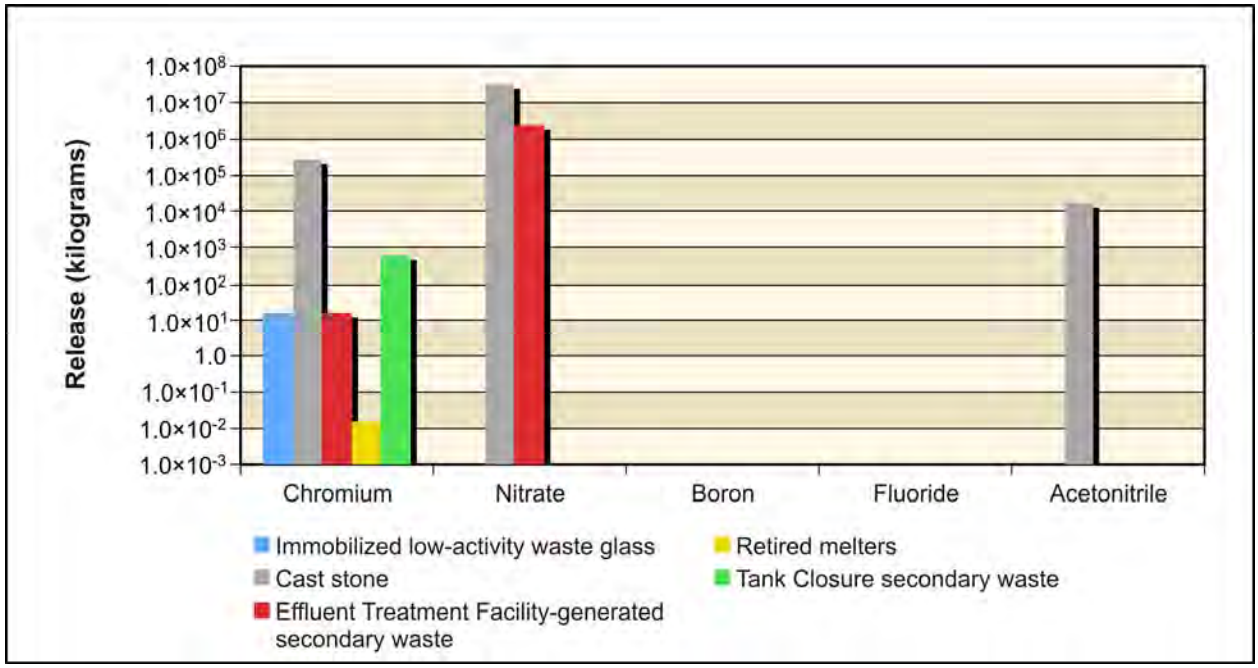


Figure 5–782. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Groundwater

Figure 5–783 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–784, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In nearly all cases, between 90 and 100 percent of the amount released to groundwater reached the Columbia River in the analysis. The exception to this trend is waste from retired melters for technetium-99. In this case, nothing released to groundwater reached the Columbia River.

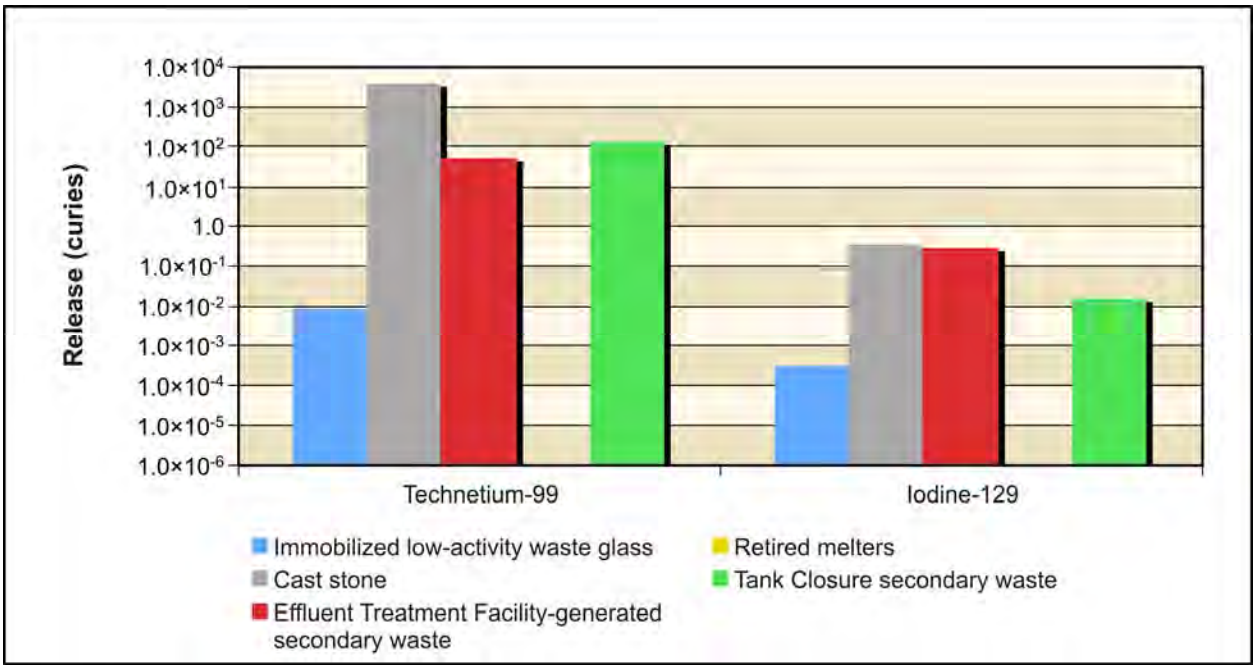


Figure 5–783. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Columbia River

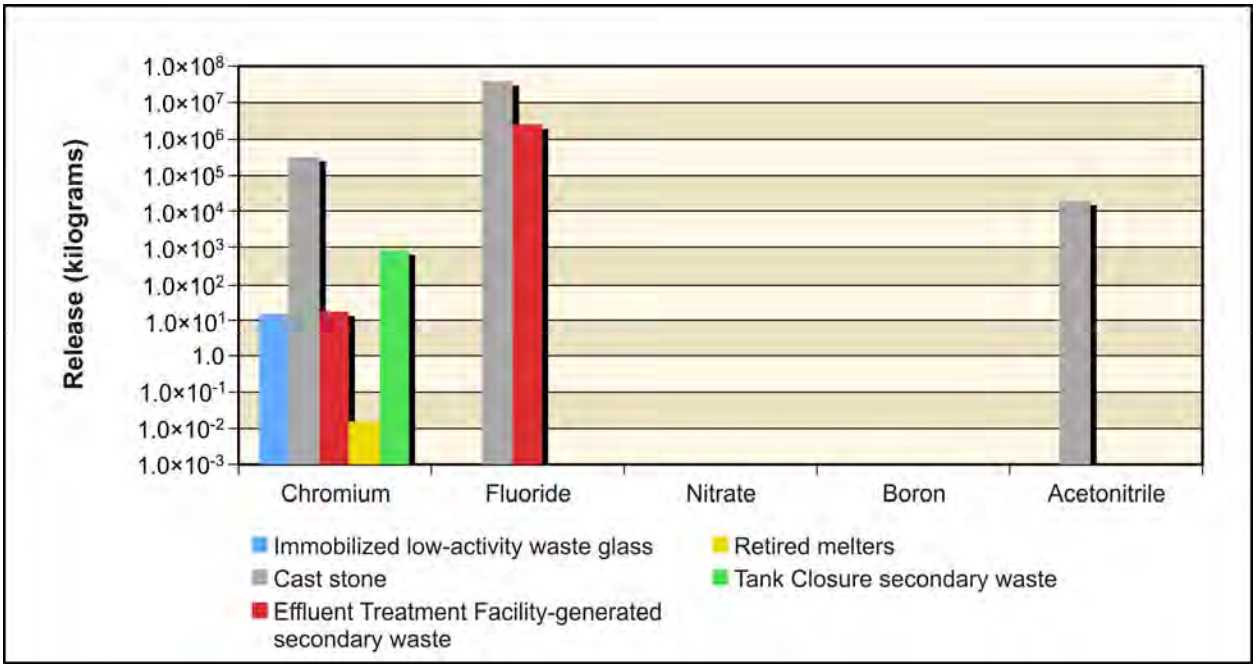


Figure 5–784. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Columbia River

200-West Area Integrated Disposal Facility

Figure 5–785 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers for Figure 5–786, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, boron, chromium, fluoride, and nitrate are all present at IDF-West.

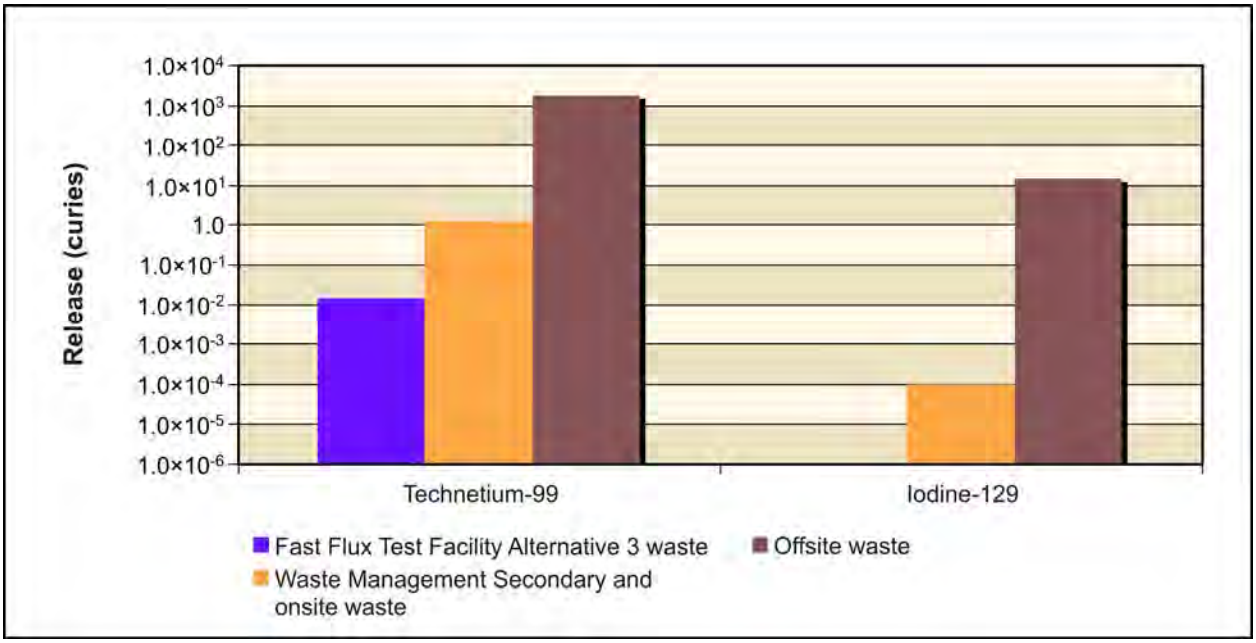


Figure 5–785. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Vadose Zone

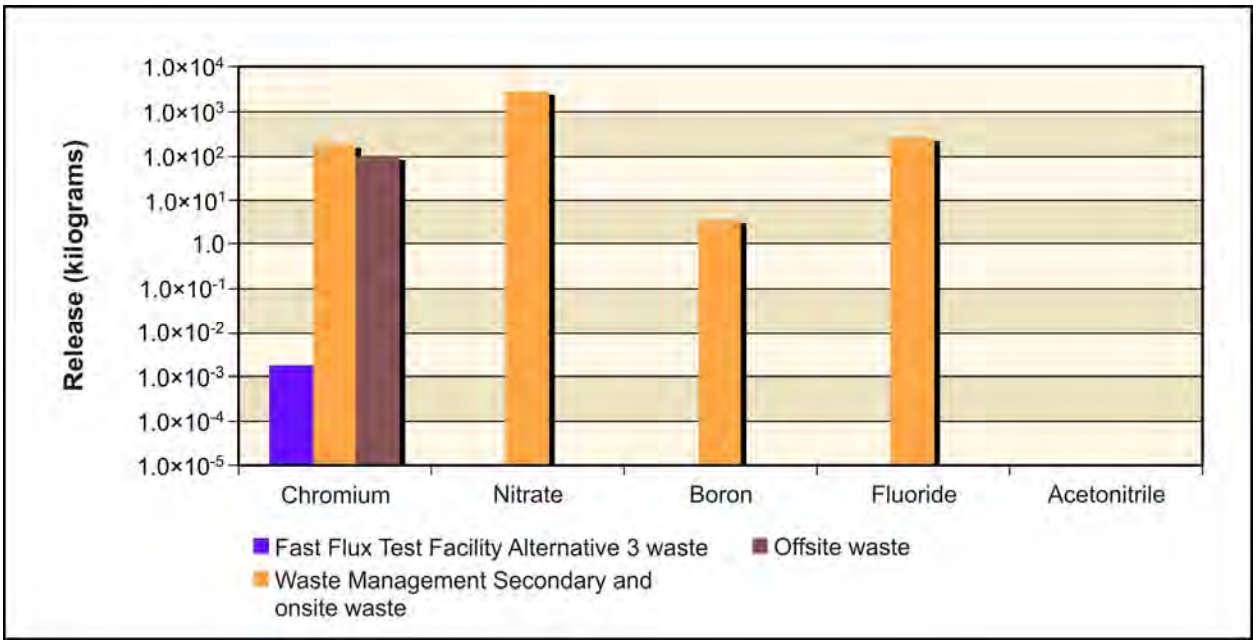


Figure 5–786. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Vadose Zone

Figure 5–787 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–788, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at IDF-West behave as conservative tracers; essentially all of the mass released to the vadose zone reached groundwater in the analysis.

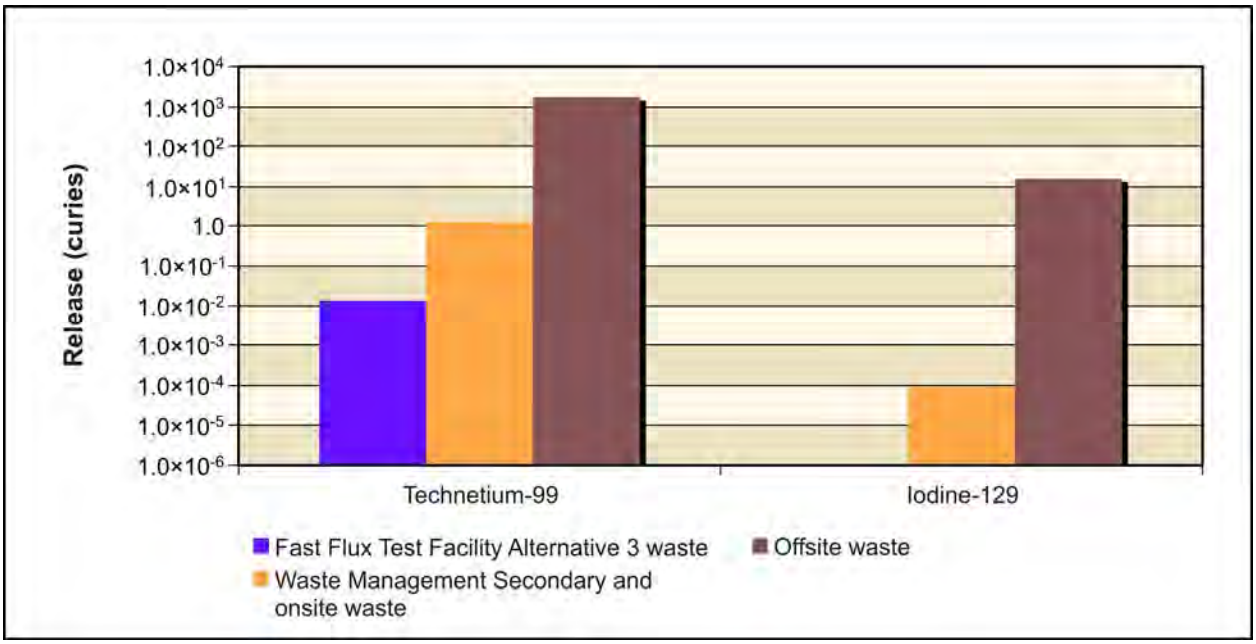


Figure 5–787. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Groundwater

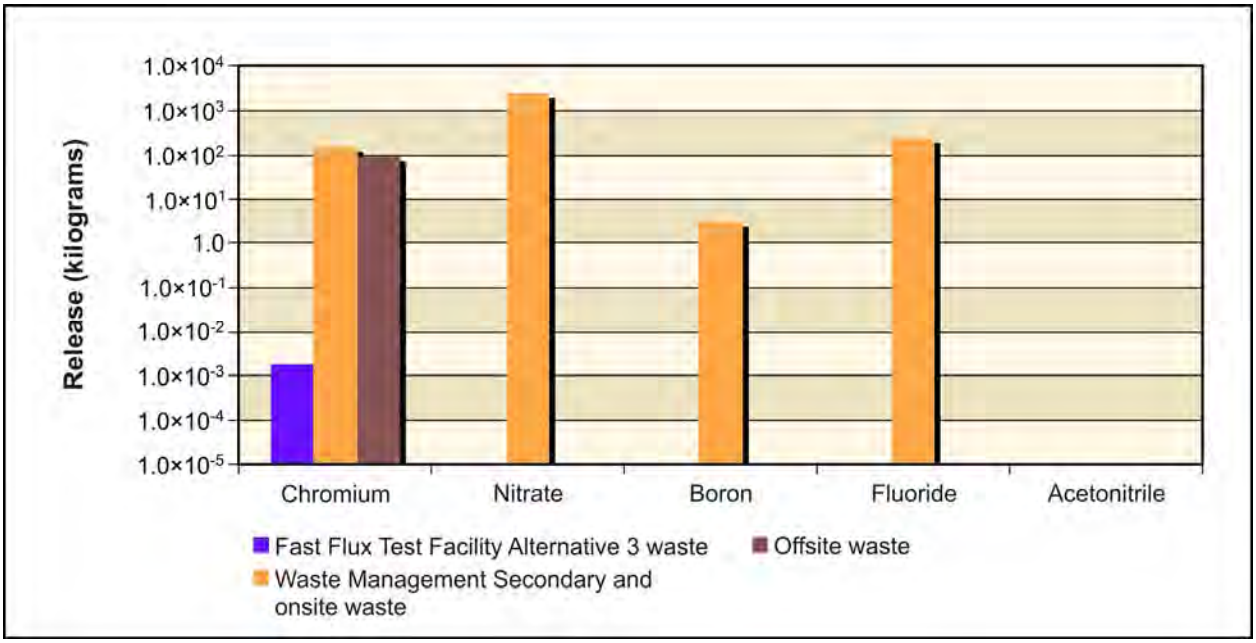


Figure 5–788. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Groundwater

Figure 5–789 shows the estimated release at the IDF-West to the Columbia River for the radiological risk drivers and Figure 5–790, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In the analysis, essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

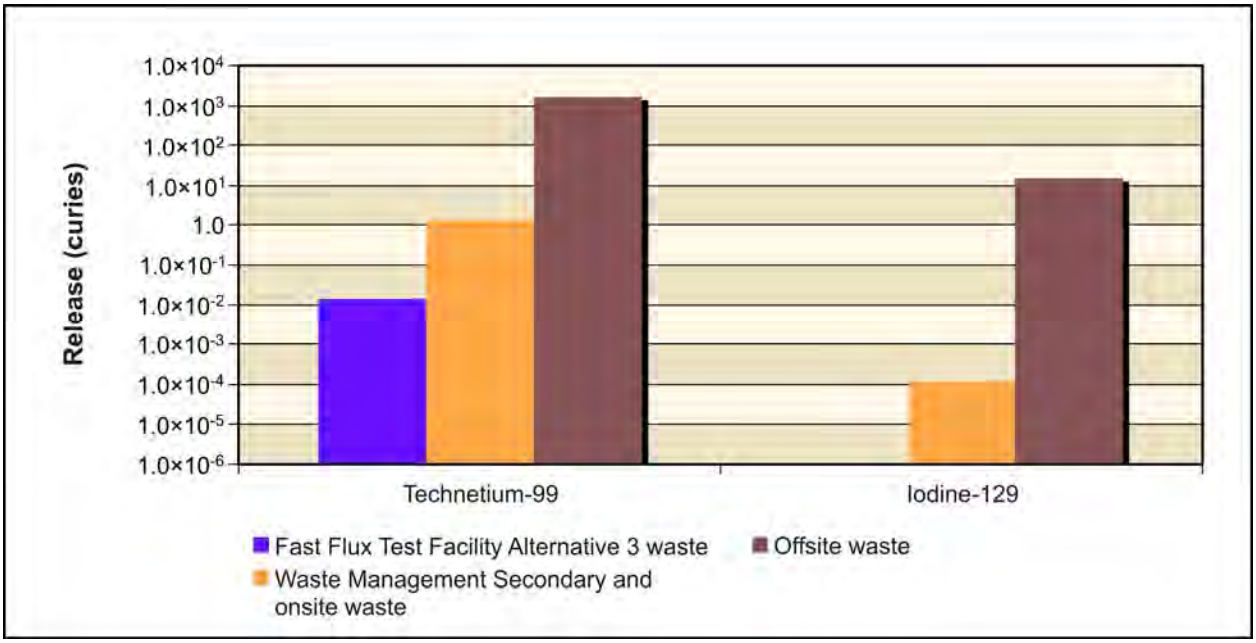


Figure 5–789. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Columbia River

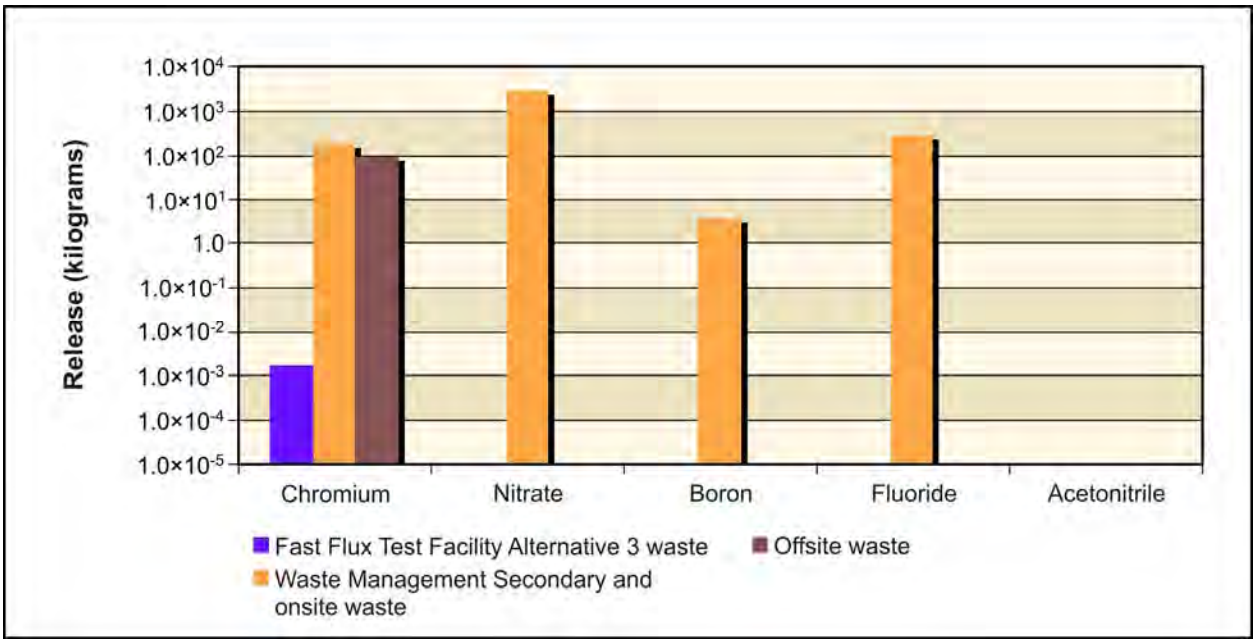


Figure 5–790. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Columbia River

River Protection Project Disposal Facility

Figure 5–791 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–792, the chemical hazard. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF.

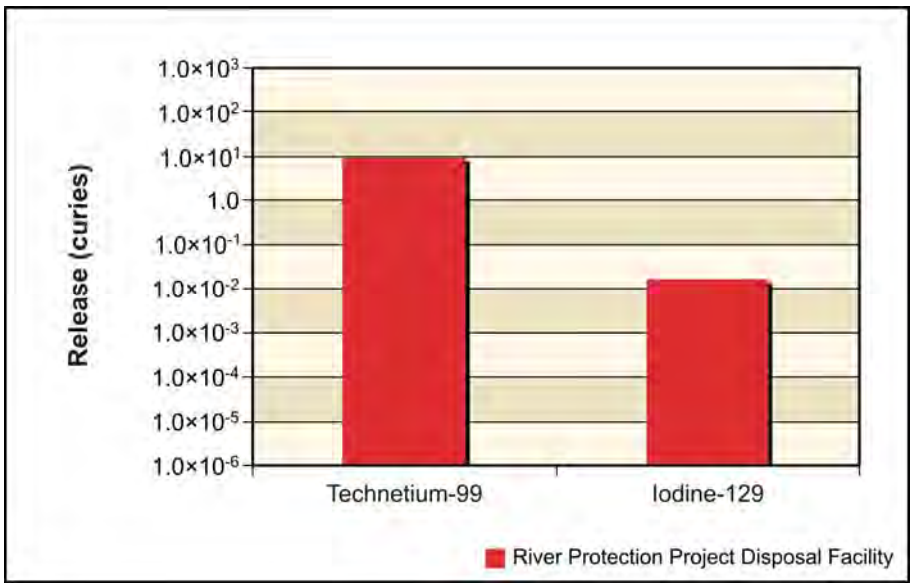


Figure 5–791. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Vadose Zone

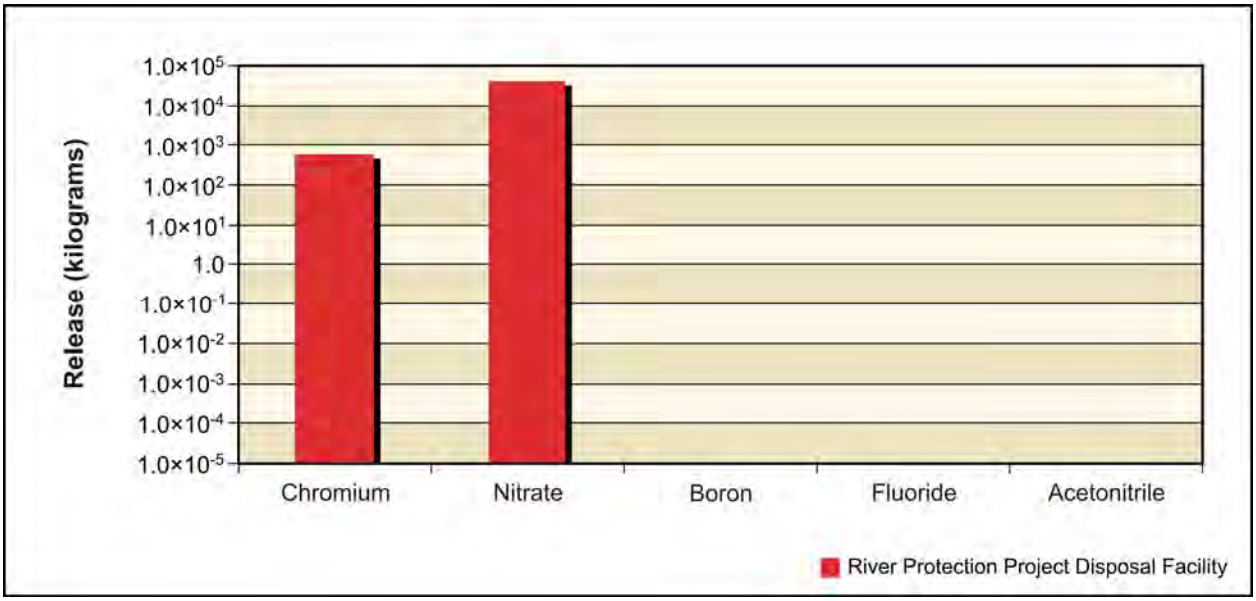


Figure 5–792. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Vadose Zone

Figure 5–793 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–794, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers; essentially all of the mass released to the vadose zone reached groundwater in the analysis.

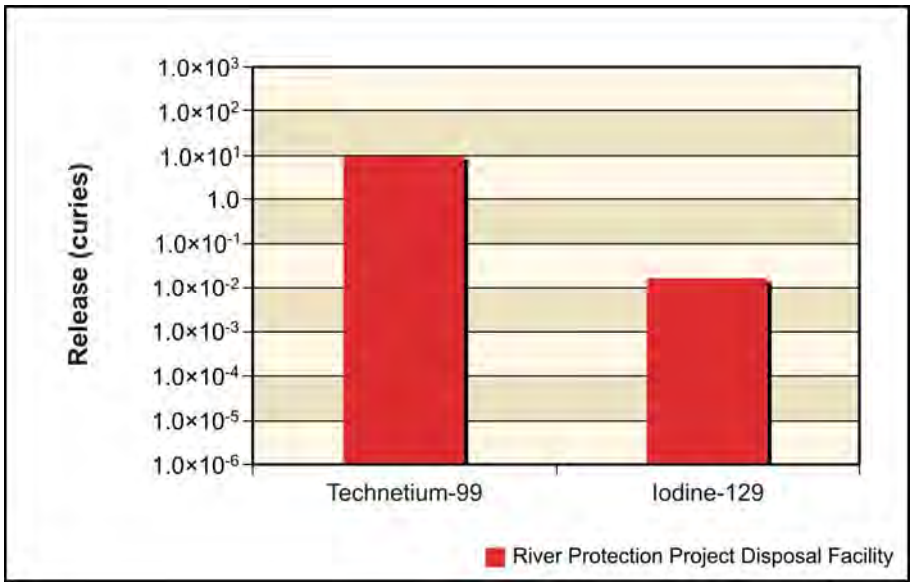


Figure 5–793. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Groundwater

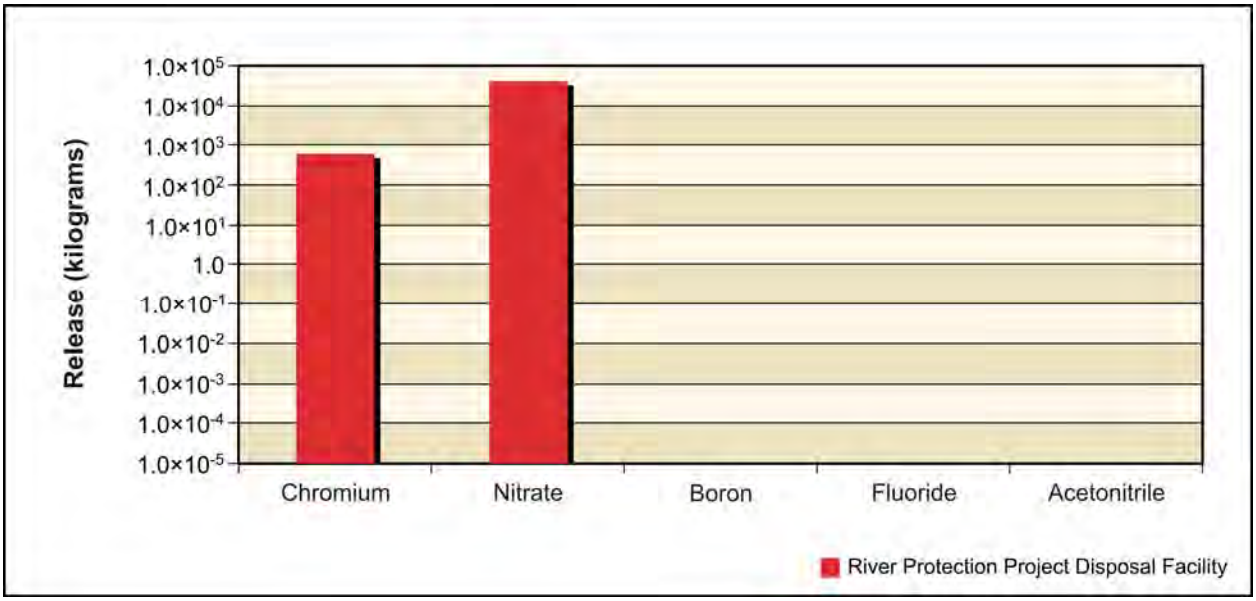


Figure 5–794. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Groundwater

Figure 5–795 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–796, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In the analysis, essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

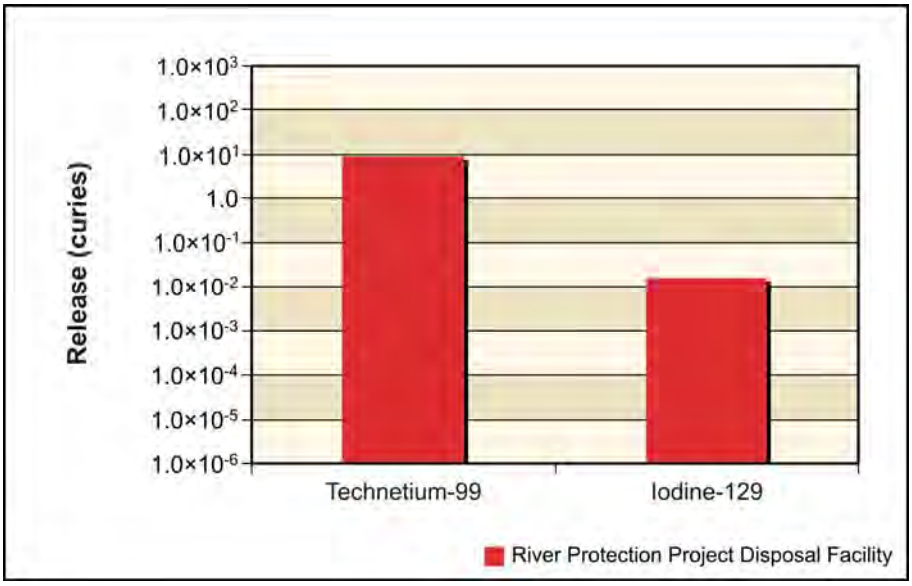


Figure 5–795. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Columbia River

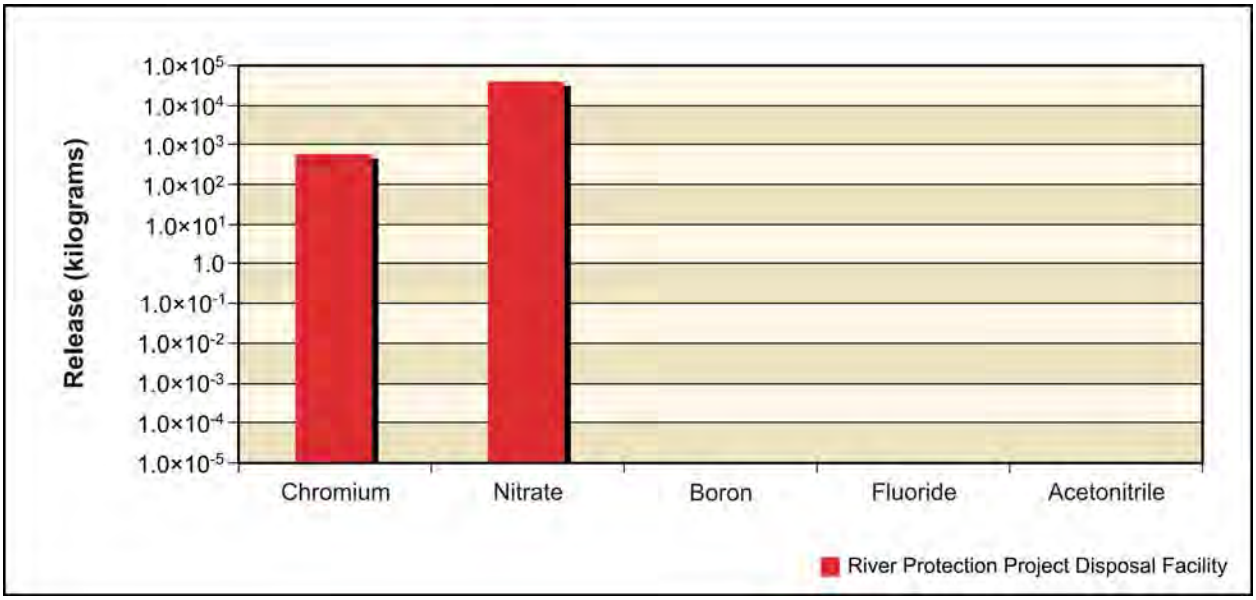


Figure 5–796. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–91 shows the maximum concentrations in groundwater.

Table 5–91. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**5,020**	**20,200**	33	**7,840**	**1,690**	900
	(9048)	(3713)	(3825)	(9163)	(8939)	
Iodine-129	0.7	**173**	0.1	**60**	**8**	1
	(10915)	(3797)	(3772)	(3853)	(4729)	
Chemical in micrograms per liter						
Acetonitrile	25	0	0	9	7	100
	(8281)	(1940)	(1940)	(8313)	(8973)	
Chromium	**436**	2	2	**265**	**116**	100
	(8940)	(3696)	(3856)	(8760)	(9311)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	**50,200**	17	149	21,200	14,100	45,000
	(8665)	(3703)	(3811)	(8290)	(9453)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–797 through 5–800 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers), respectively. For technetium-99, concentrations rise early in the simulation, reaching a peak around CY 3940 at about one order of magnitude above the benchmark concentration. Concentrations drop until CY 5400, when they start climbing again, although not as quickly. Around CY 7940, concentrations begin to hold steady just below the benchmark. Iodine-129 does not have the secondary rise in concentration, instead stabilizing below the benchmark after its initial peak, nearly two orders of magnitude above the benchmark. Chromium and nitrate show a different pattern, with their initial peak concentrations about one order of magnitude lower than their second, more stable peaks. Both chromium and nitrate remain below the benchmark throughout the simulation, although chromium more closely approaches the benchmark concentration.

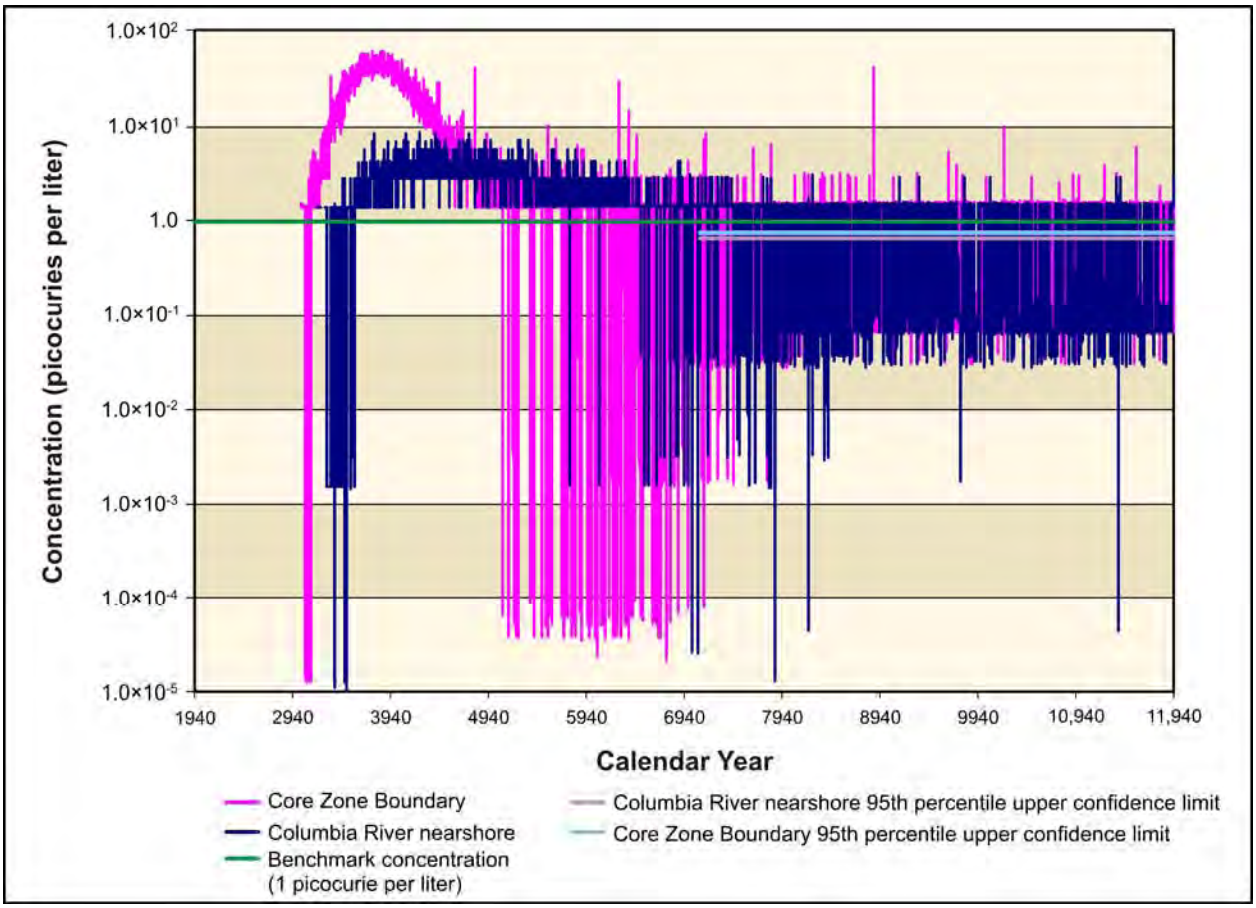


Figure 5–797. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Iodine-129 Concentration Versus Time

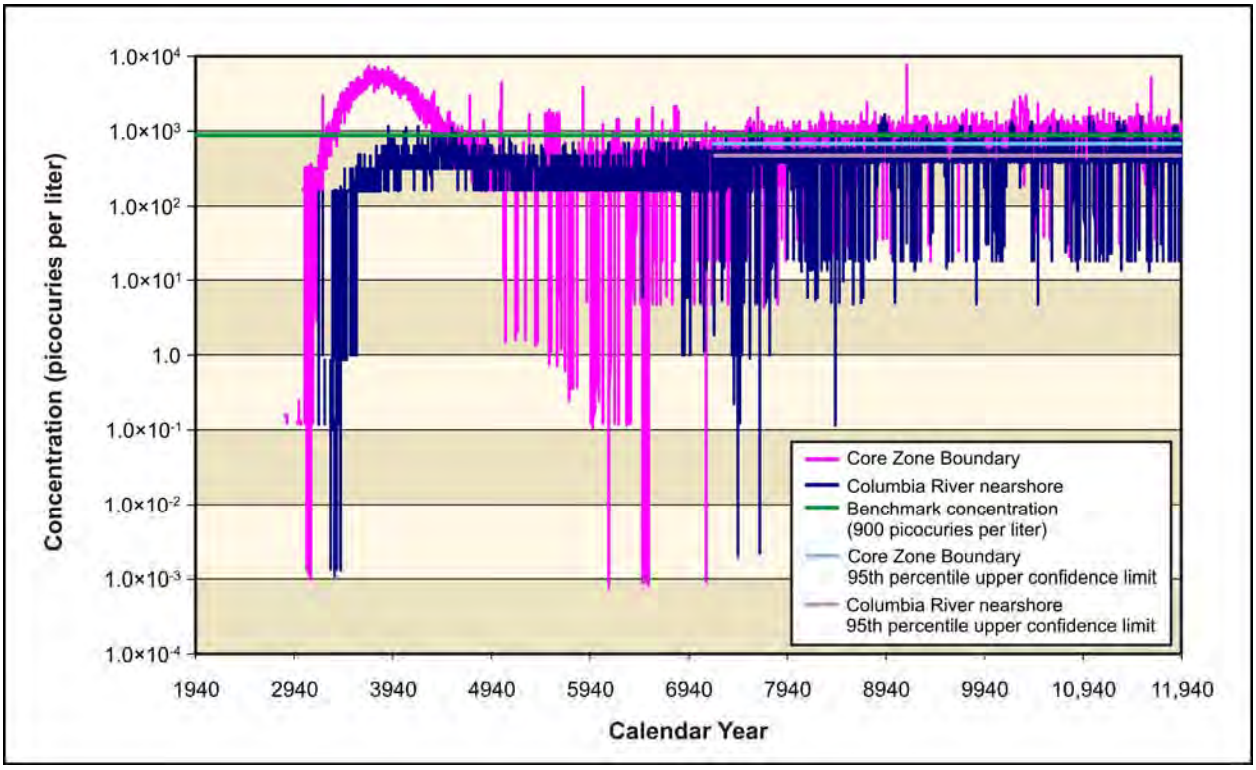


Figure 5–798. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Technetium-99 Concentration Versus Time

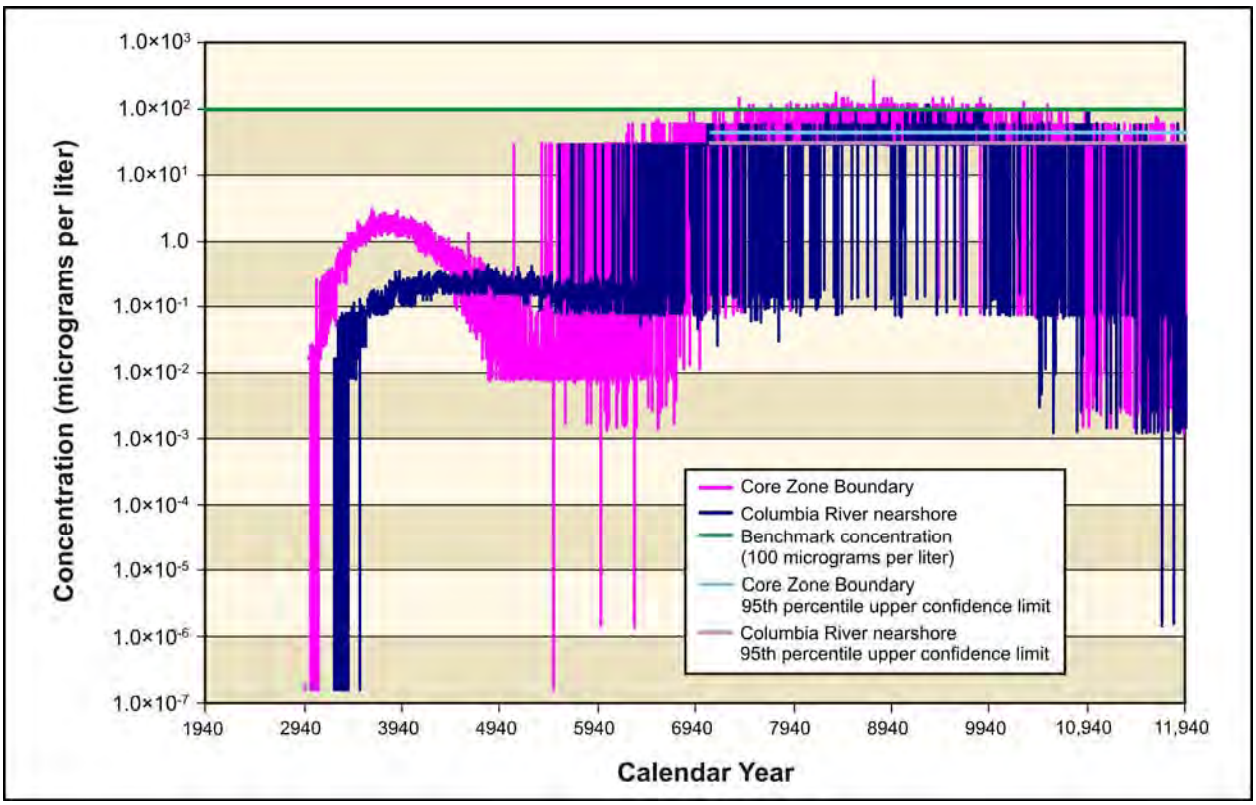


Figure 5–799. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chromium Concentration Versus Time

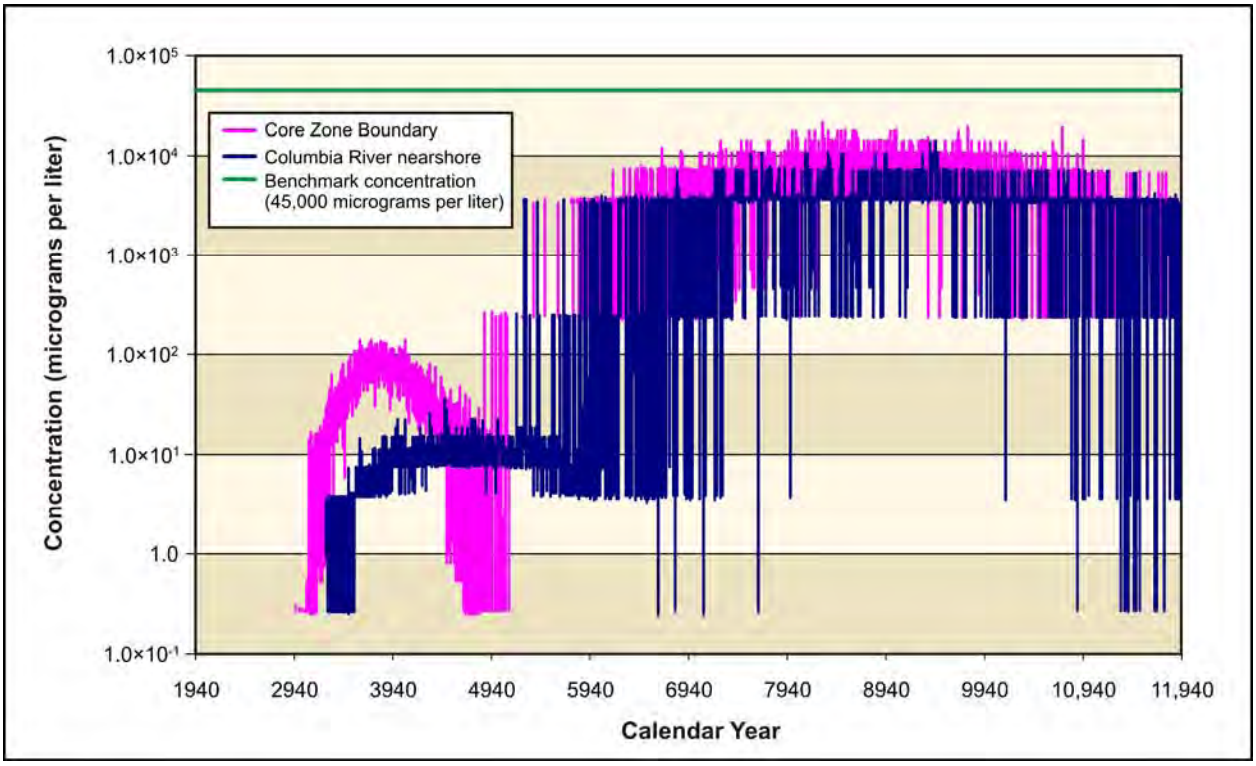


Figure 5–800. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Nitrate Concentration Versus Time

Figures 5–801 and 5–802 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of uranium, no contamination appears until CY 8940, when uranium-238 concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 remains three orders of magnitude below the benchmark during the simulation. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation.

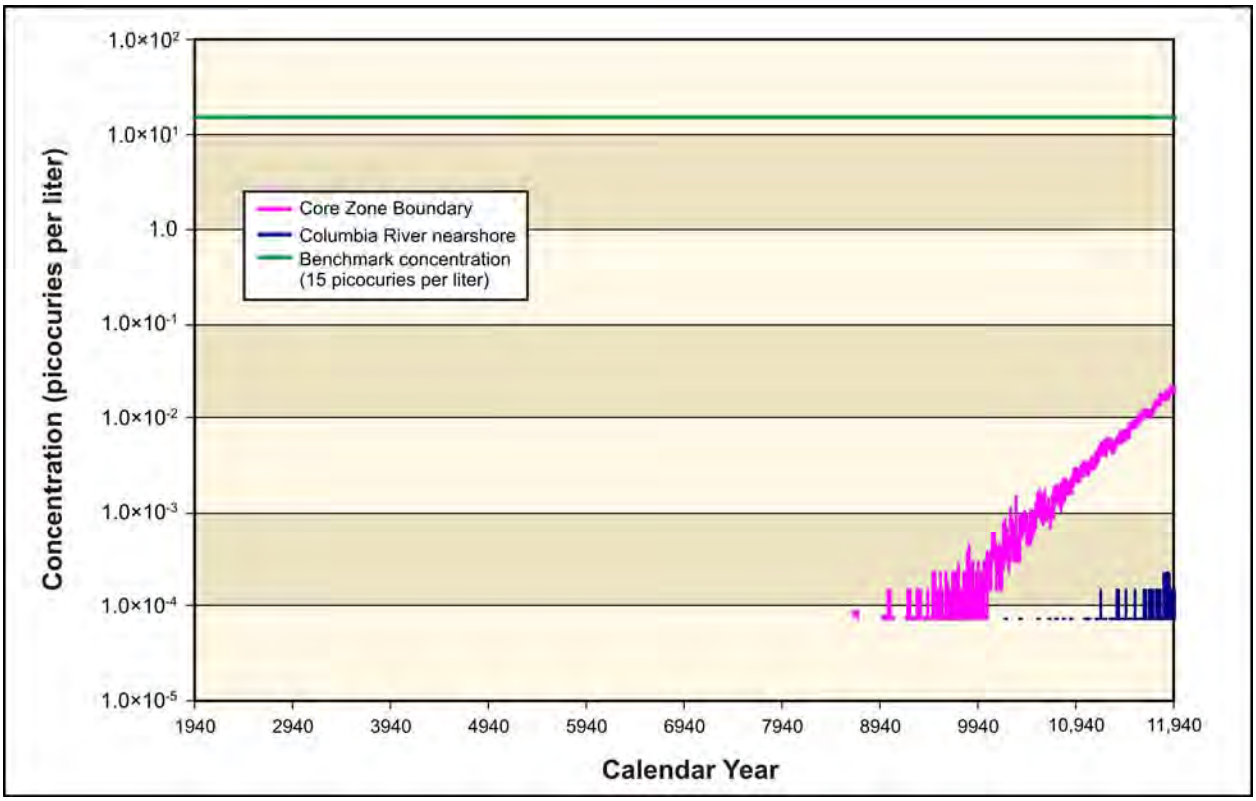


Figure 5–801. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Uranium-238 Concentration Versus Time

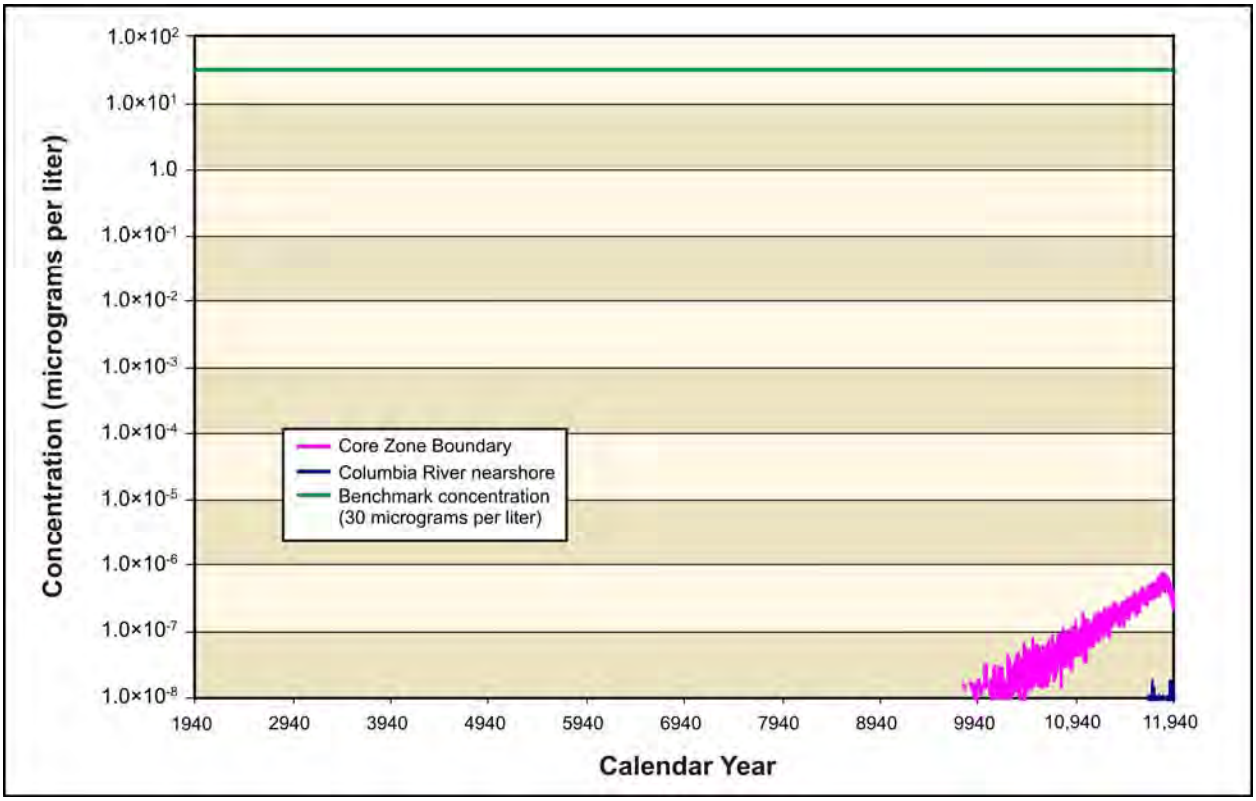
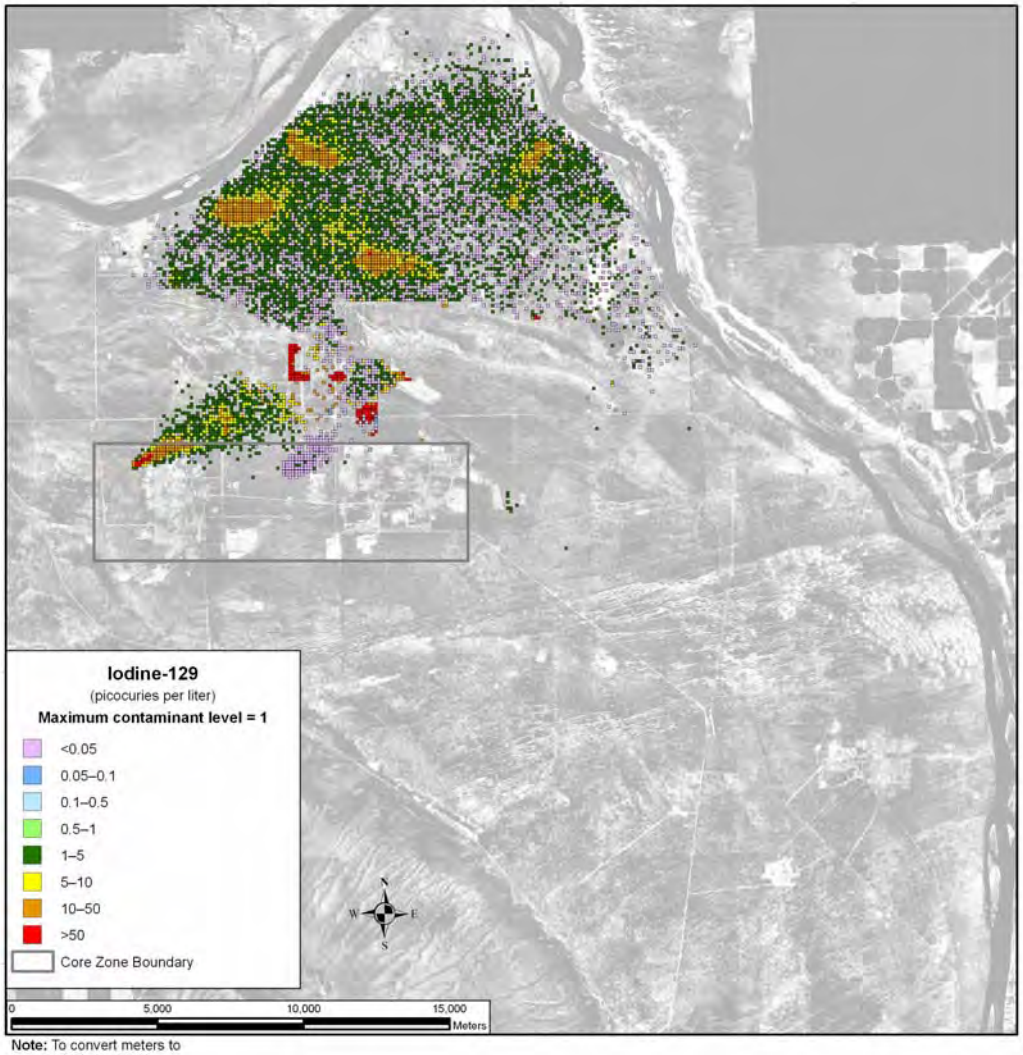


Figure 5–802. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890, (see Figure 5–803), there is a high-concentration plume of iodine-129 stretching northeast of IDF-West and a low-concentration plume stretching north from the RPPDF and through Gable Gap. Four separate high-concentration areas have also formed north of Gable Mountain and Gable Butte. By CY 7140, (see Figure 5–804) the plumes from IDF-West and the RPPDF have dissipated, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume remain close to the benchmark. Figure 5–805 shows concentration distributions at CY 11,885. Technetium-99 (see Figures 5–806 through 5–808) shows a similar spatial distribution, but has higher concentrations in the plume from IDF-East and lower concentrations in the plume from IDF-West. Chromium (see Figures 5–809 through 5–811), and nitrate (see Figures 5–812 through 5–814) show similar spatial distributions at selected times, but have consistently lower concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).



Note: To convert meters to feet, multiply by 3.281

Figure 5–803. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

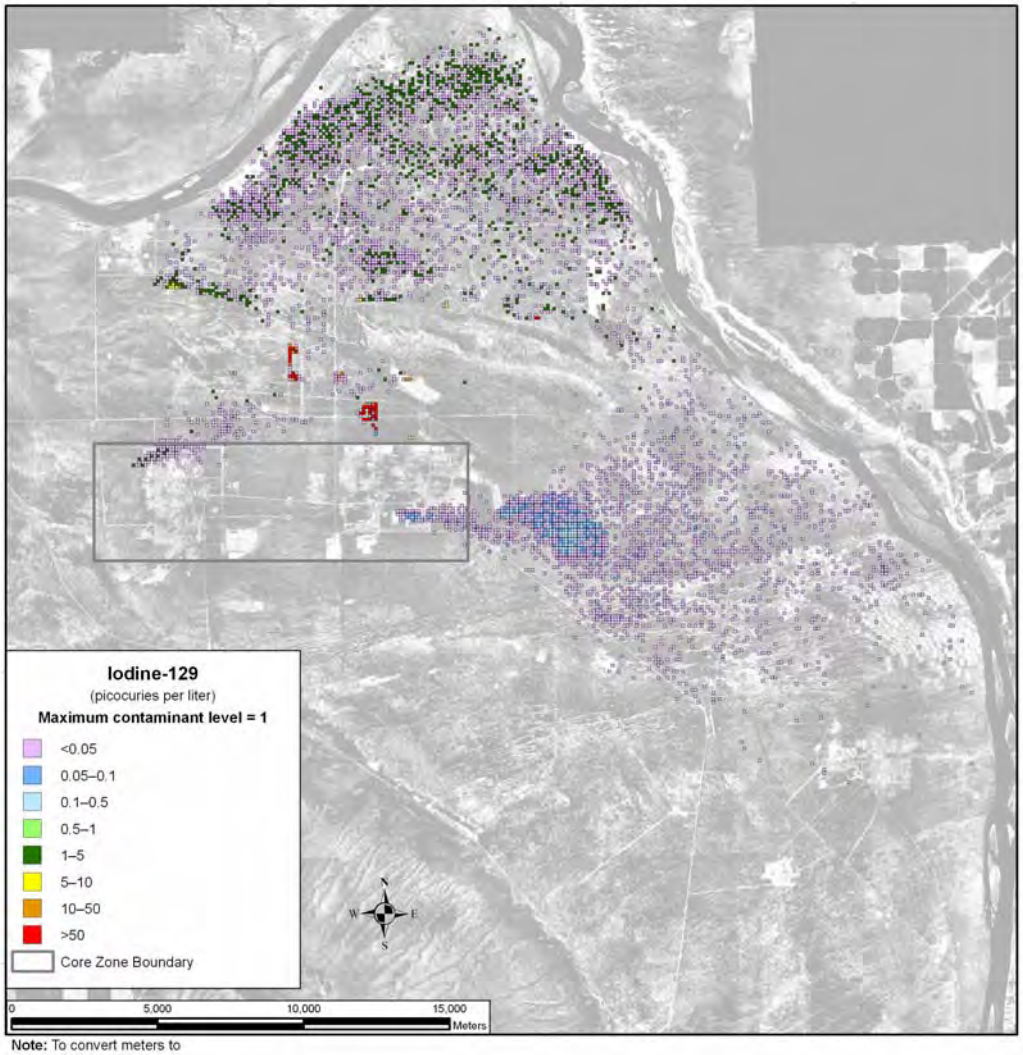


Figure 5–804. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

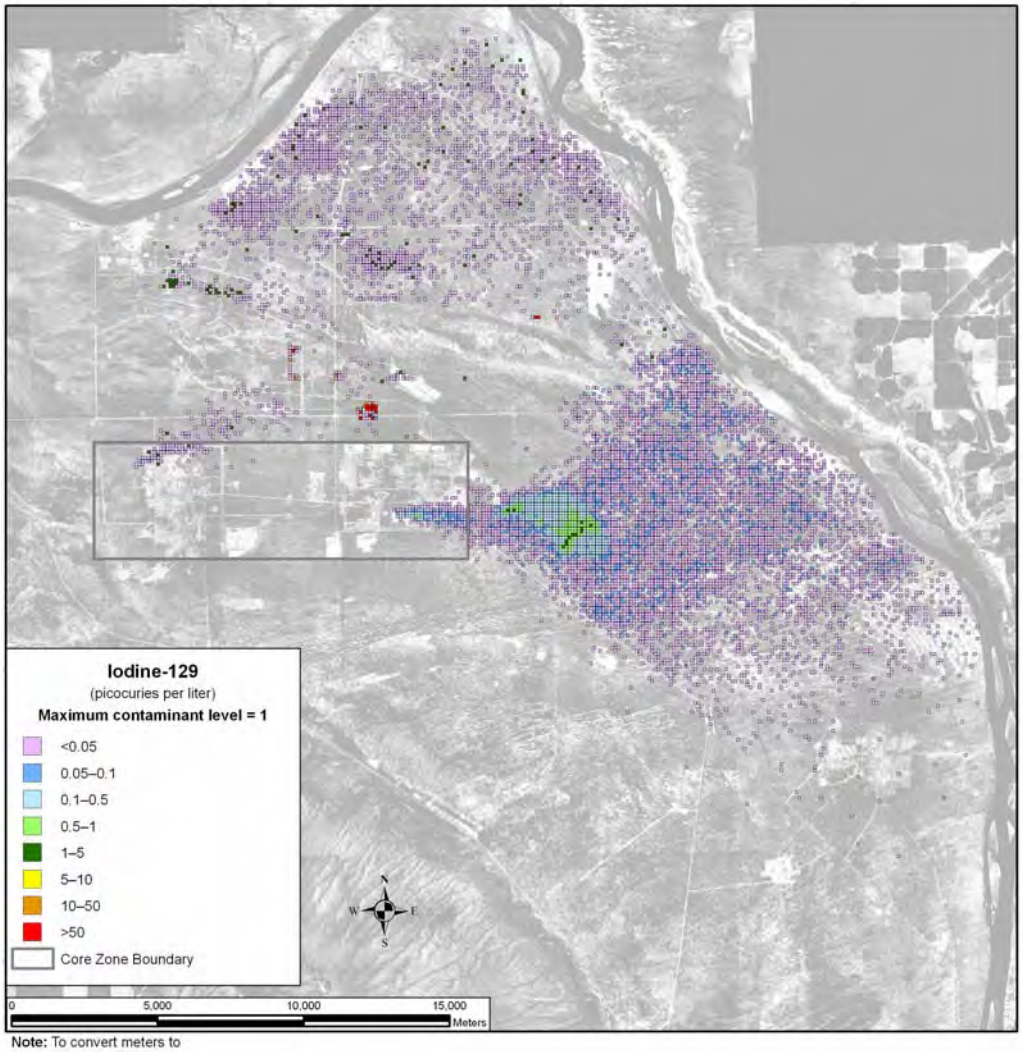


Figure 5–805. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

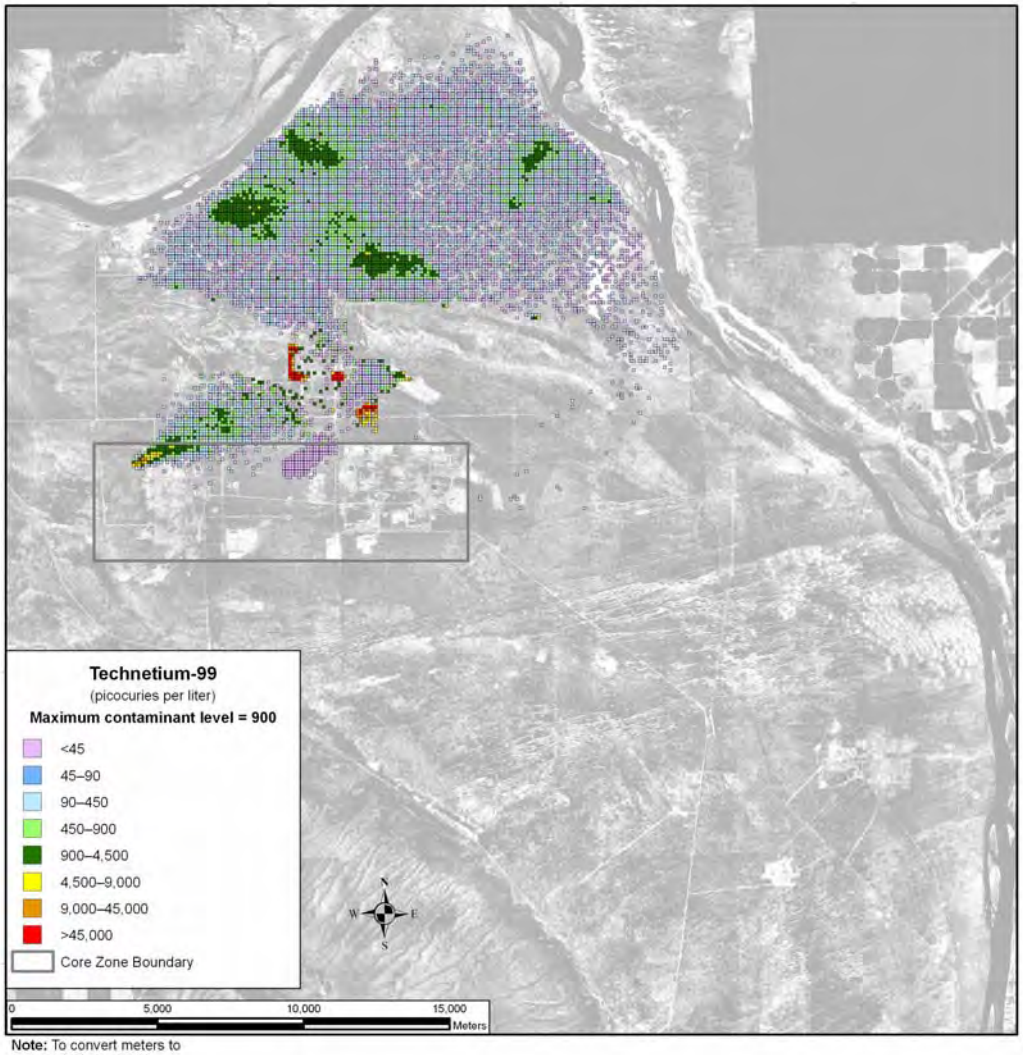


Figure 5–806. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

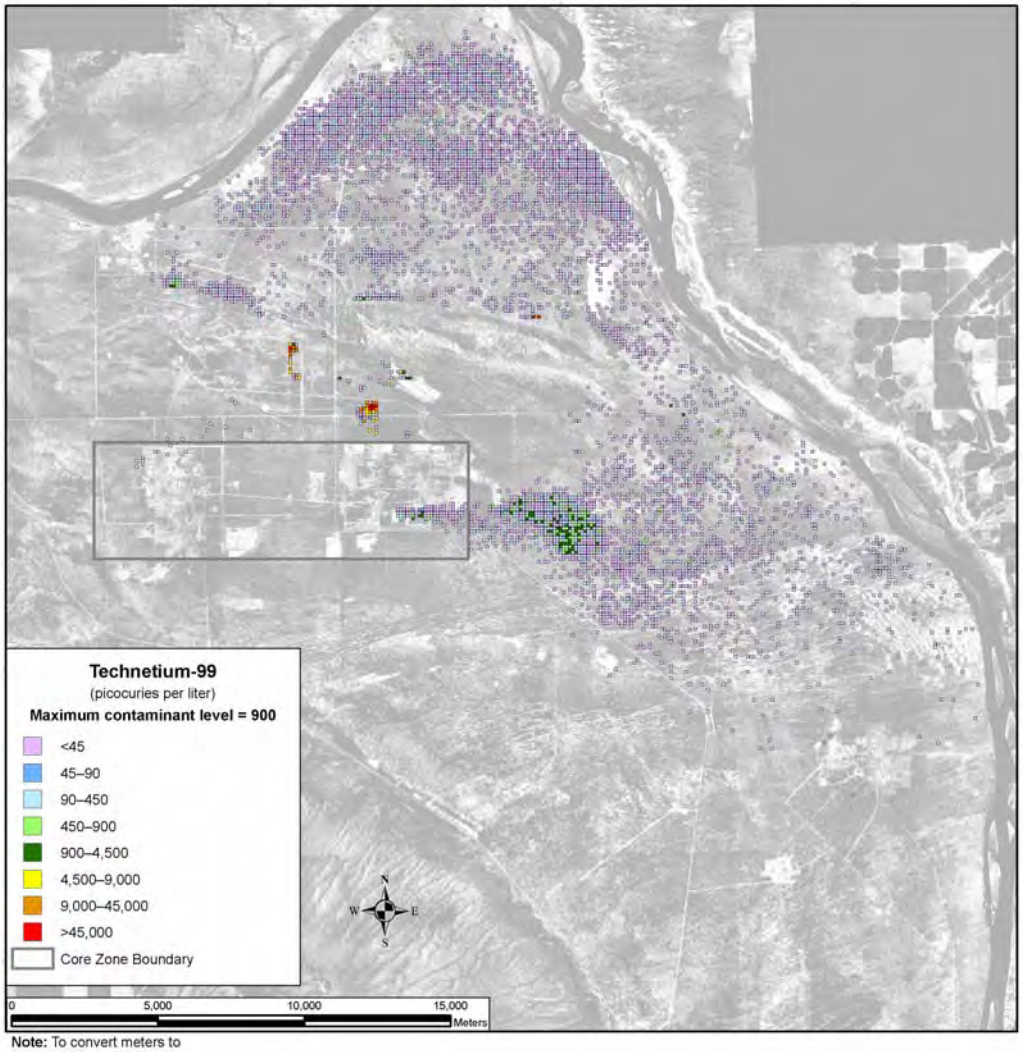


Figure 5–807. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

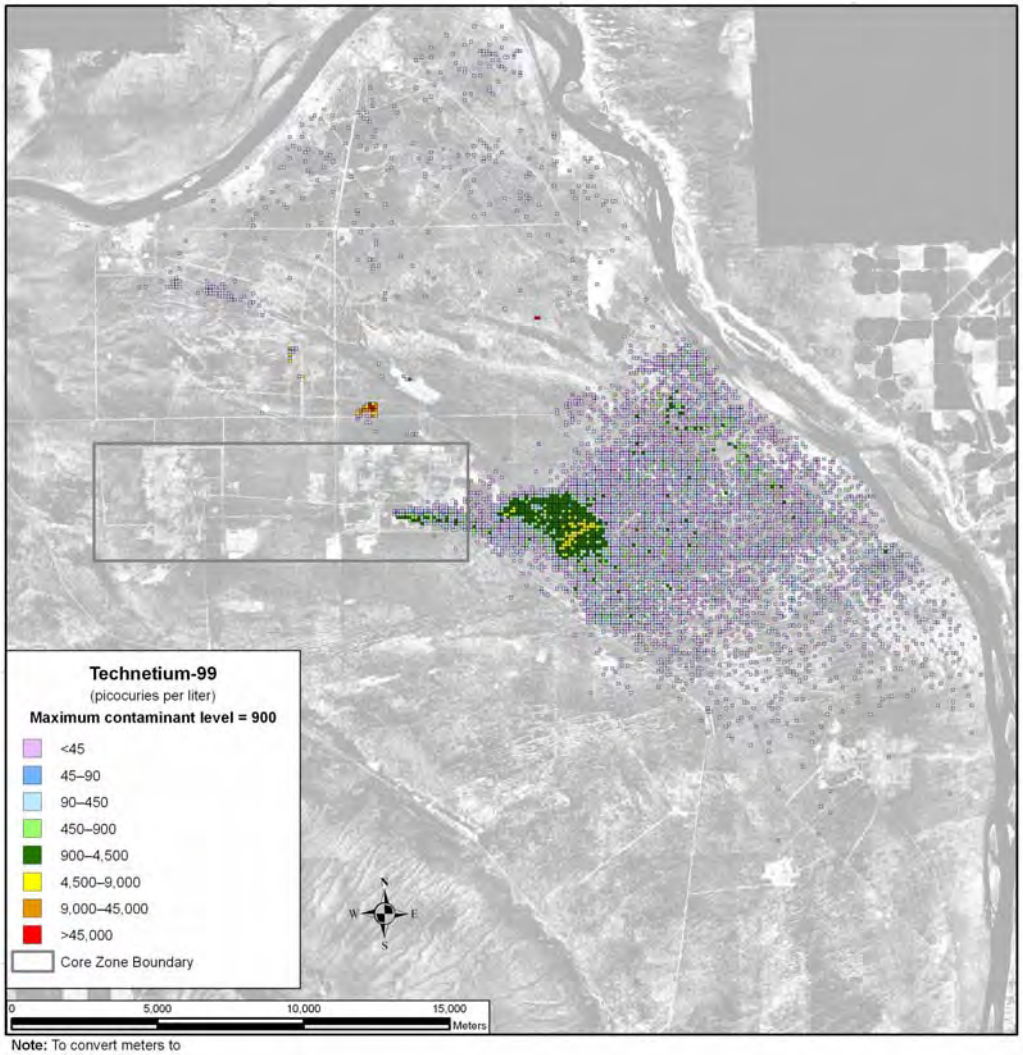


Figure 5–808. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

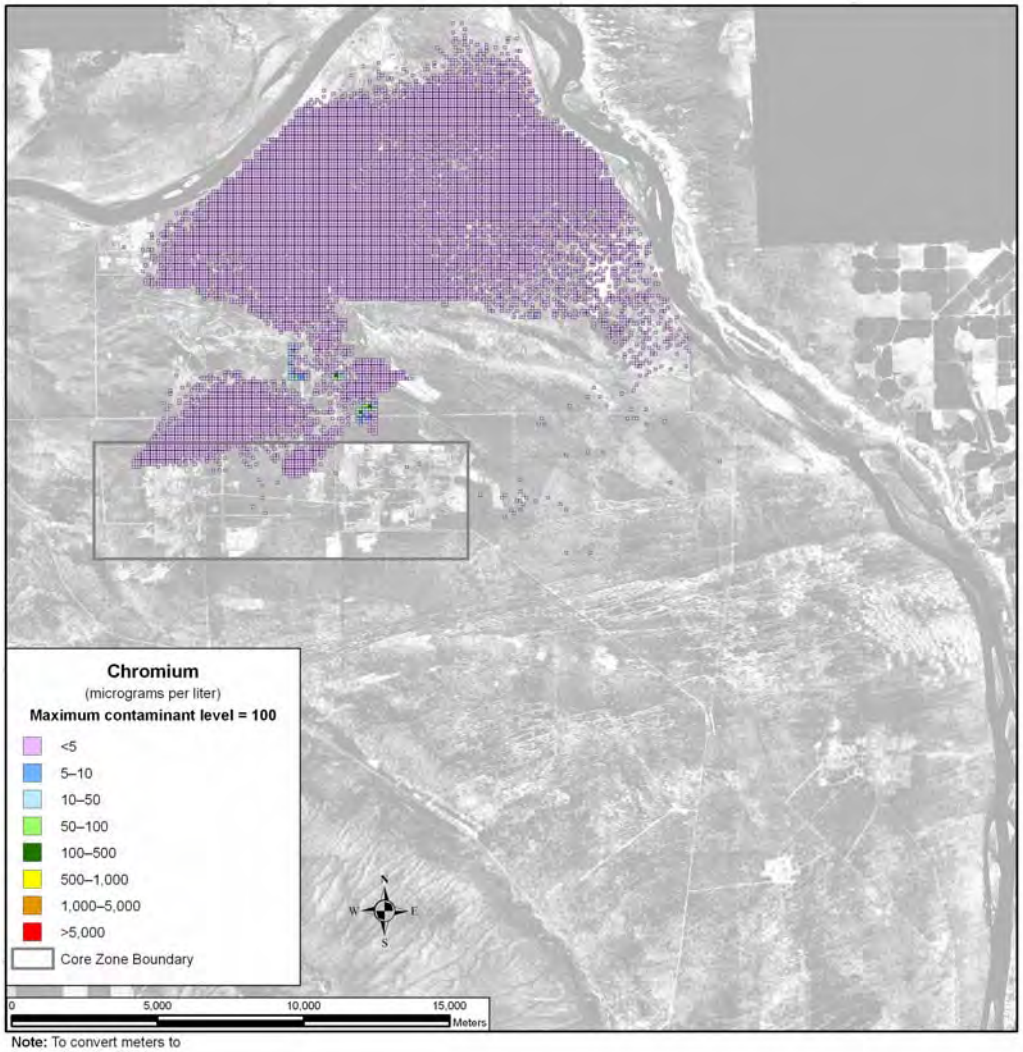
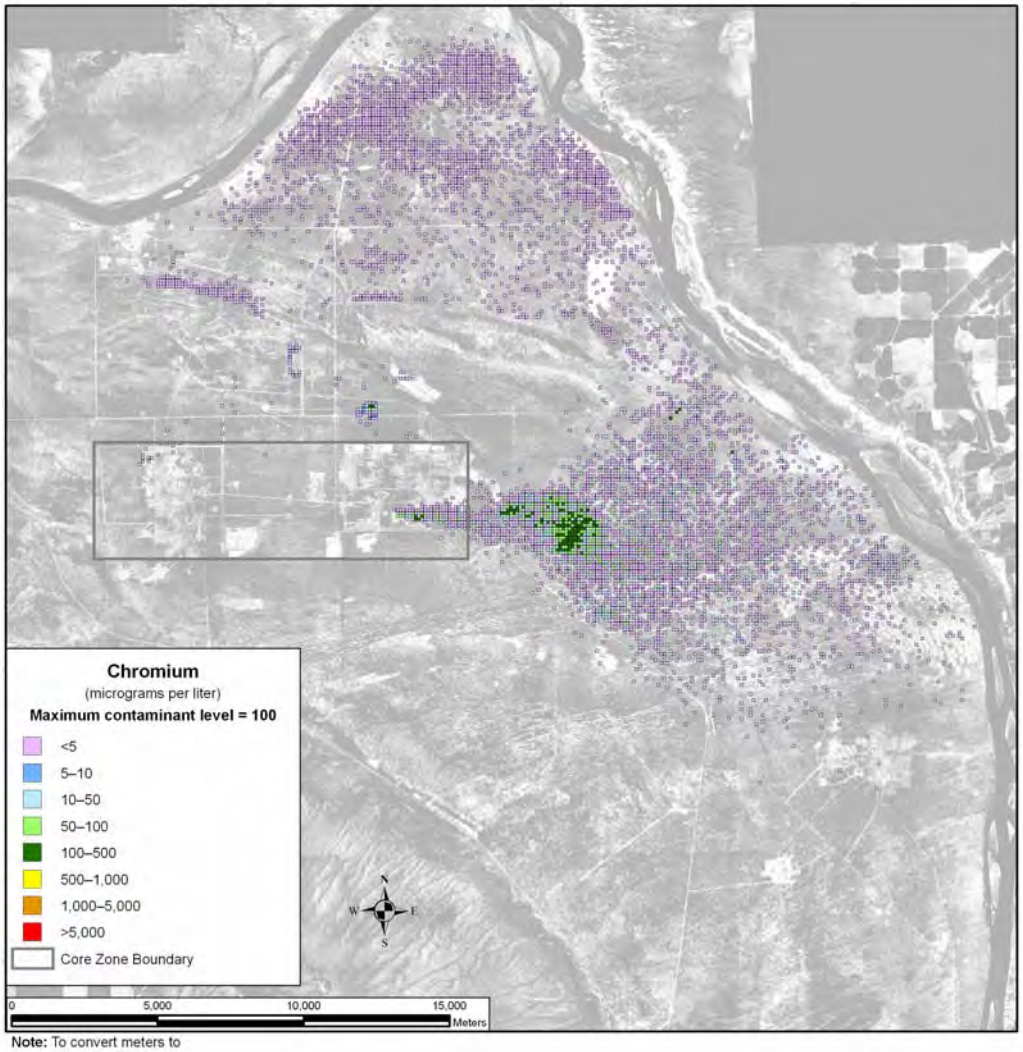


Figure 5–809. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–810. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

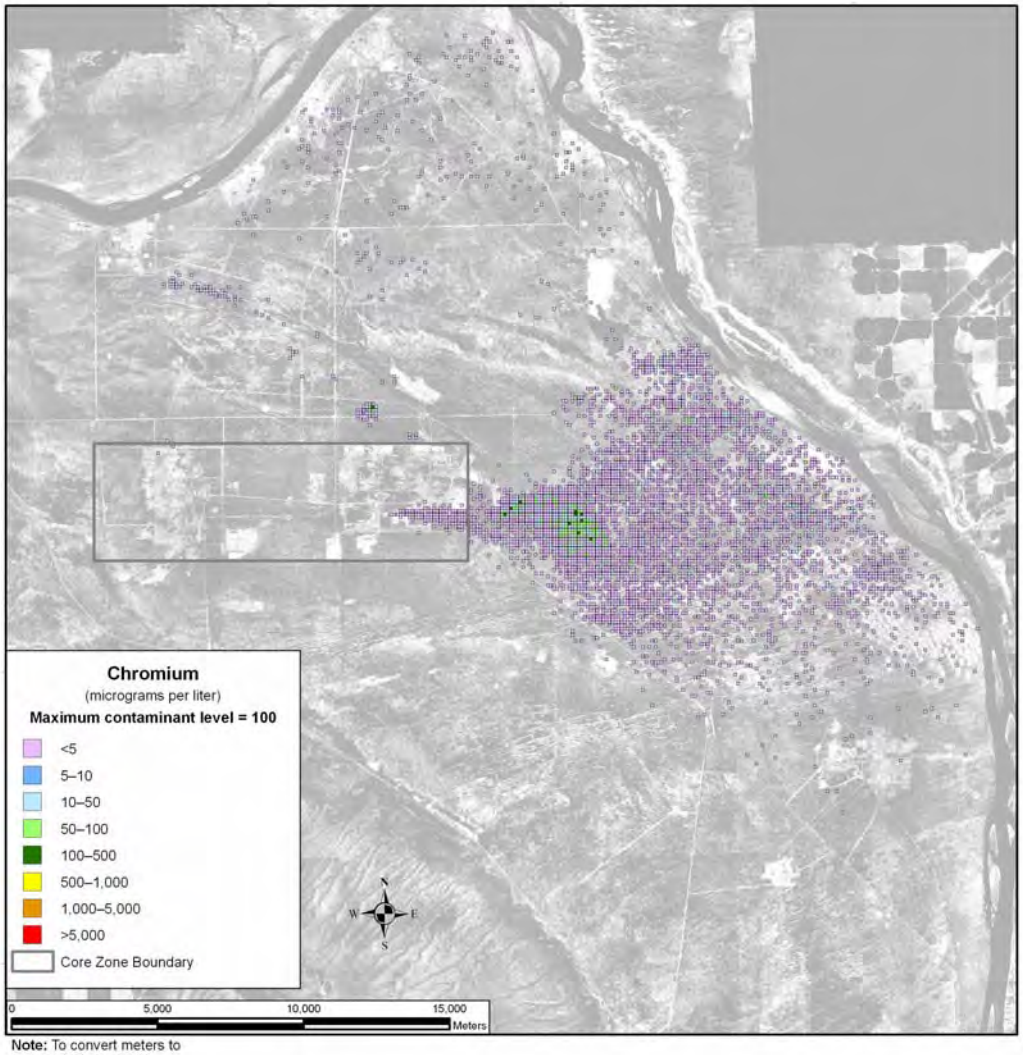


Figure 5–811. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

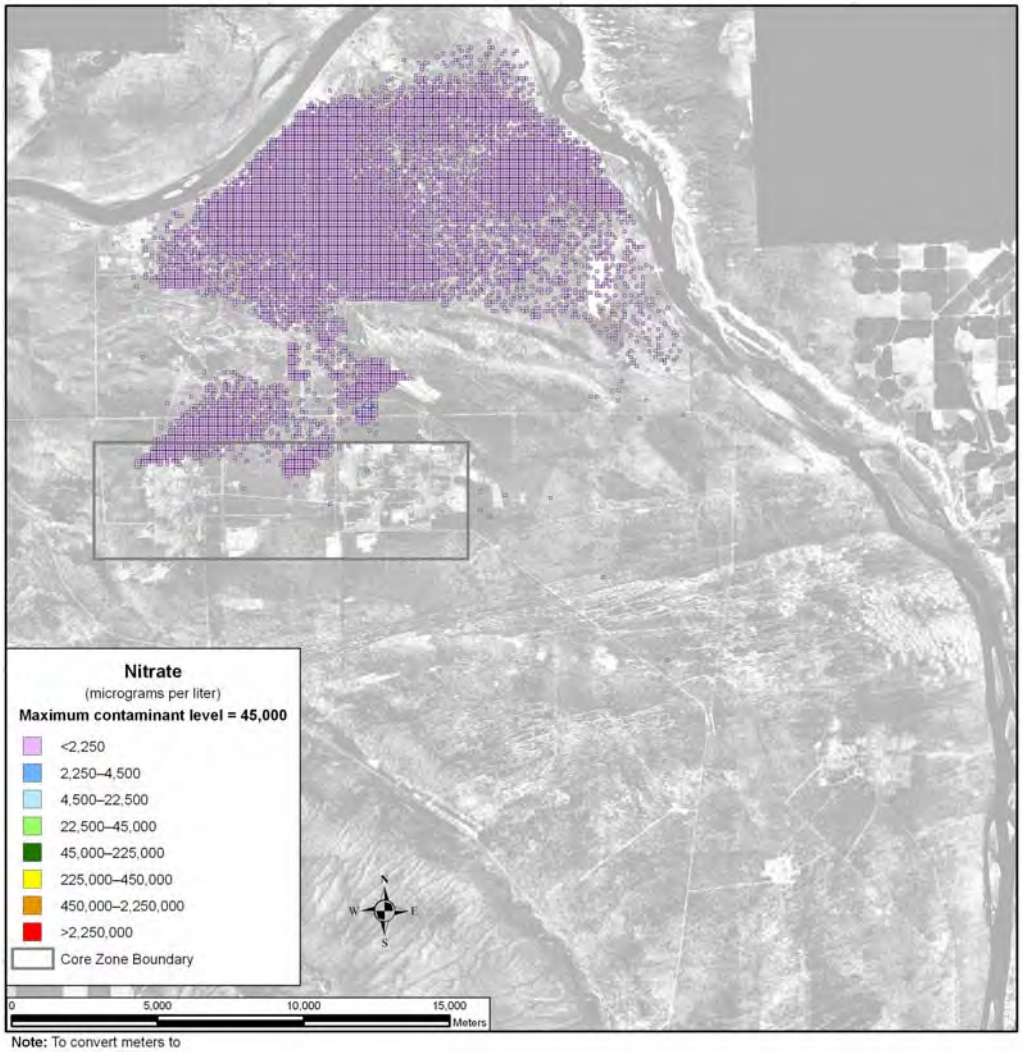


Figure 5–812. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

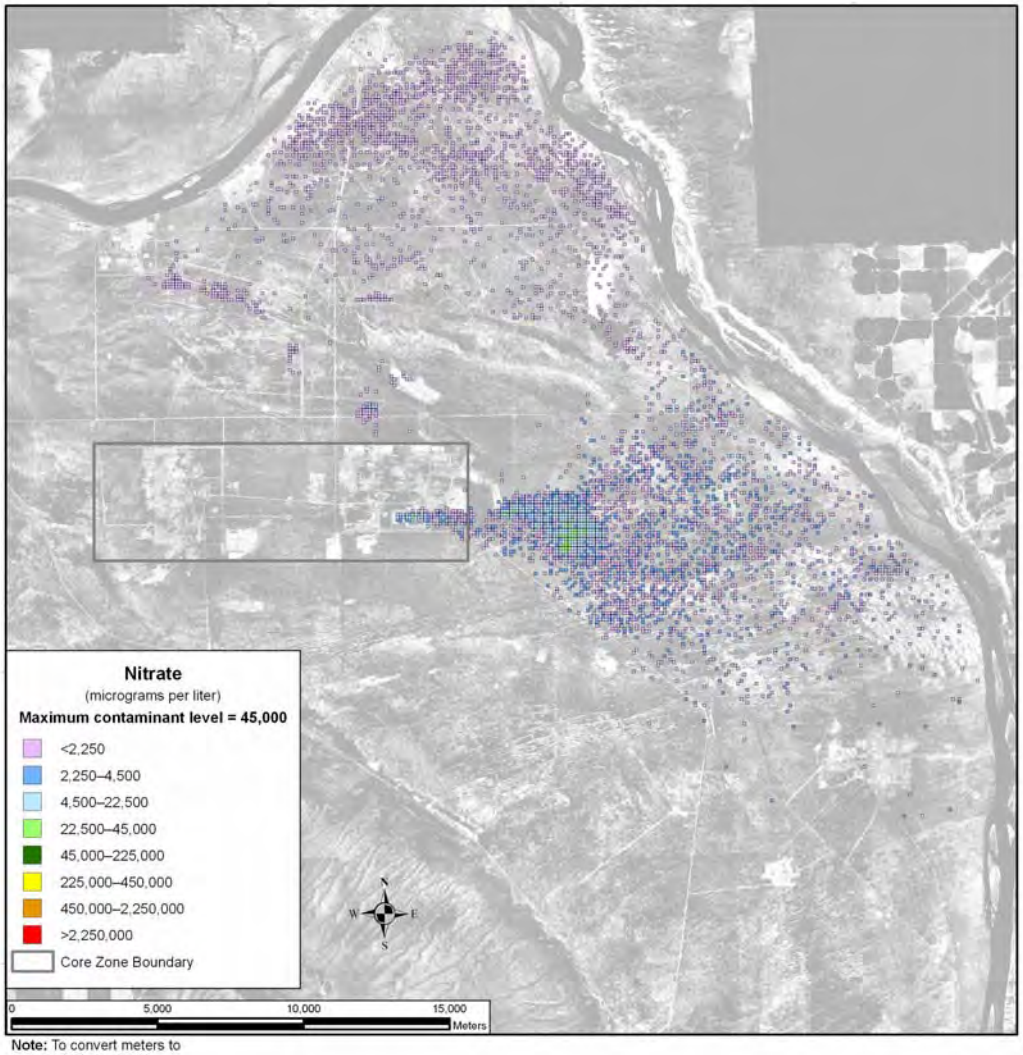


Figure 5–813. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

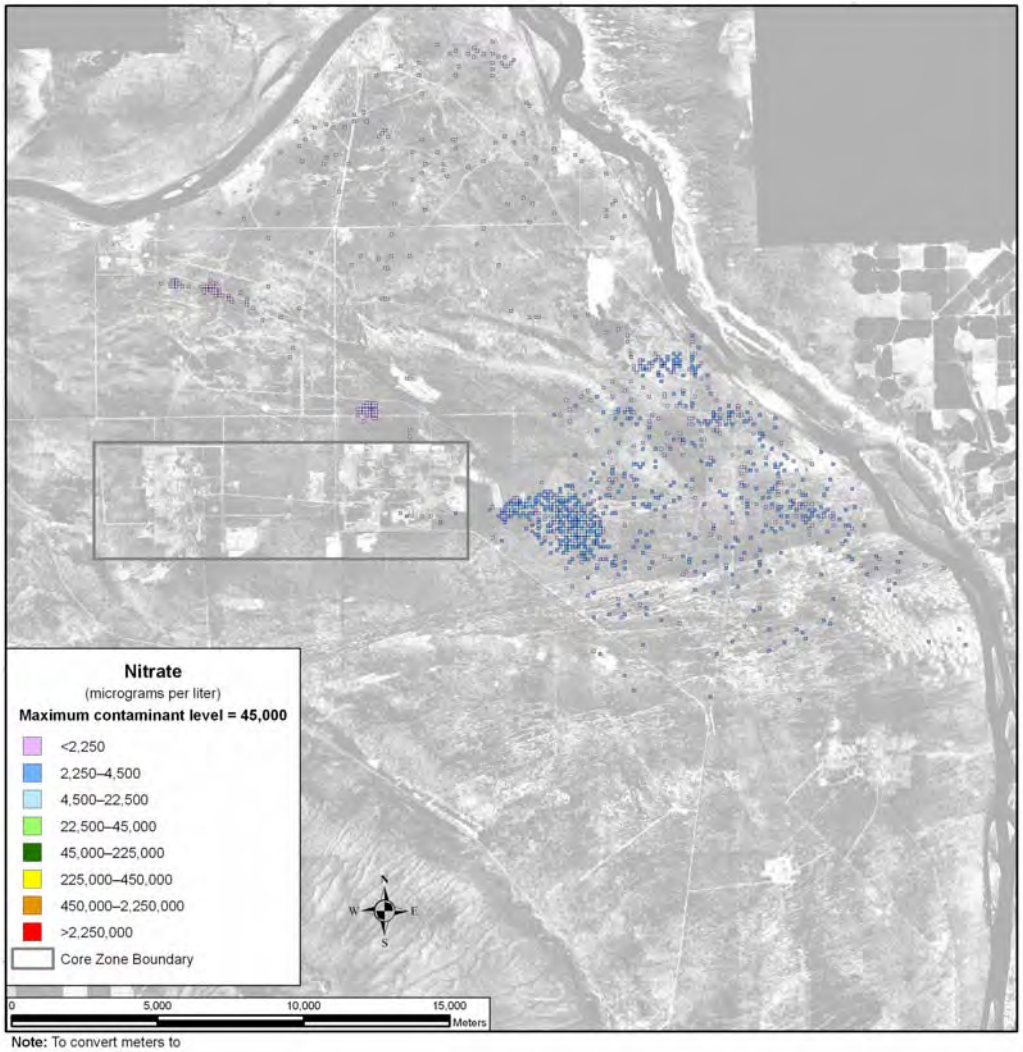


Figure 5–814. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium and uranium-238 show a different spatial distribution over time. They are not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, there is a uranium-238 plume extending northeast from IDF-West through Gable Gap (see Figure 5–815). A total uranium plume extends through Gable Gap from the RPPDF (see Figure 5–816). Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.

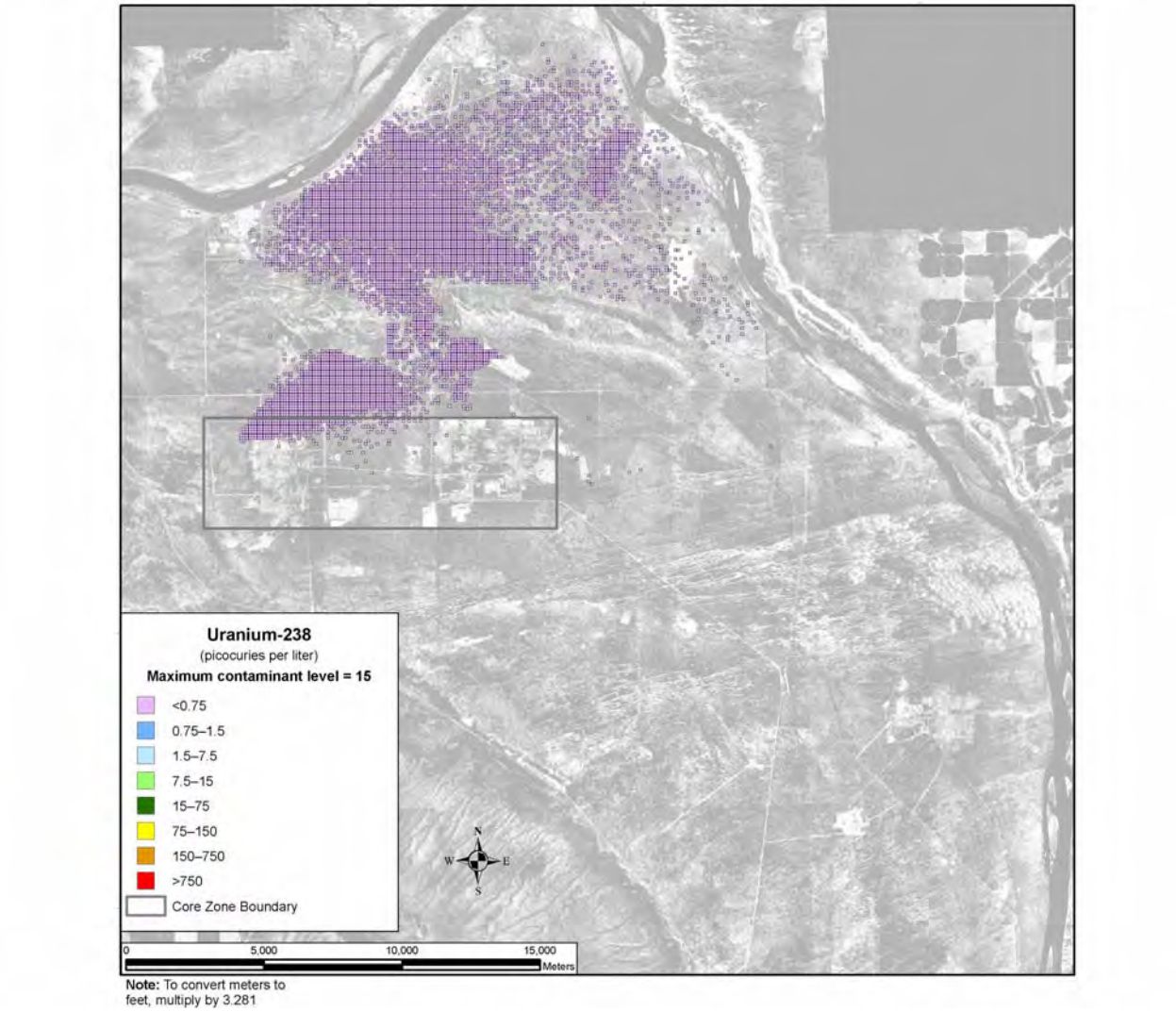


Figure 5–815. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

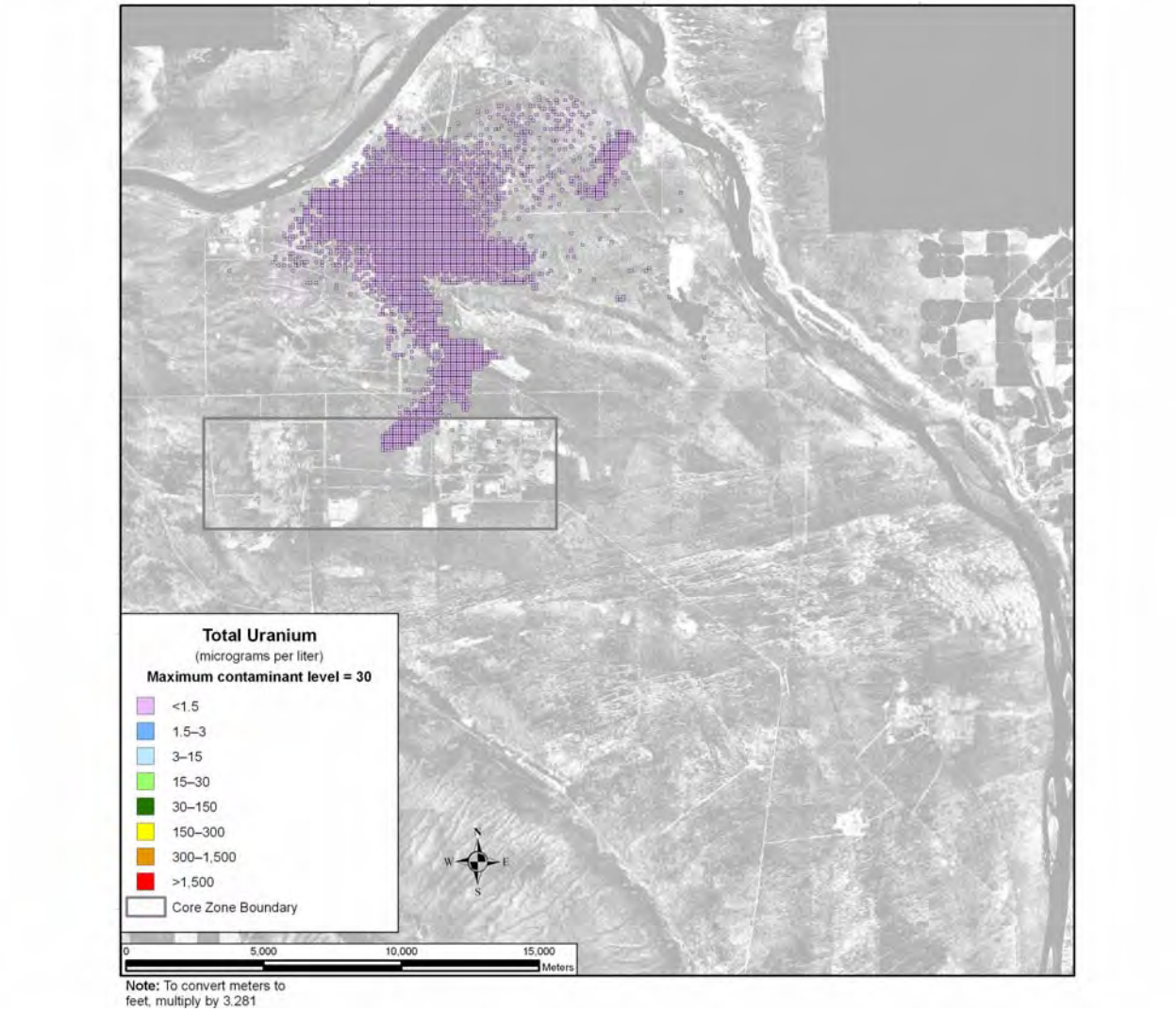


Figure 5–816. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, in general, discharges from IDF-West are the predominant contributors. Discharges from IDF-East and the RPPDF are secondary contributors.

Concentrations of iodine-129 and technetium-99 show a sharp rise and fall between CY 2940 and CY 4940 that exceeds the benchmark by an order of magnitude or slightly more. Chromium and nitrate show a similar rise and fall, but both remain below their respective benchmarks. For all of the conservative tracers, concentrations at the Core Zone Boundary remain within an order of magnitude of the benchmark concentration during the last 5,000 years of the period of analysis. Concentrations at the Columbia River nearshore are slightly lower, but within an order of magnitude of the concentrations at the Core Zone Boundary. The intensities and areas of these groundwater plumes stabilize around CY 6940.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the benchmark at the Core Zone Boundary and the Columbia River nearshore throughout the simulation. The peak intensity and area of the contamination plume is near the end of the period of analysis.

5.3.1.3.1.4 Disposal Group 1, Subgroup 1-D

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-D covers disposal of waste generated under Tank Closure Alternative 3C and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Summaries of the proposed actions and timelines for Waste Management Alternative 3 are provided in Chapter 2, Section 2.5.

IDF-East has five subtotals that represent the releases from ILAW glass, steam reforming waste, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, as follows:

- The disposal period was assumed to start with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other

COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D (IDF-East, IDF-West, and RPPDF releases), in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-EAST AREA INTEGRATED DISPOSAL FACILITY

Figure 5–817 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–818, the chemical hazard drivers. The inventories in the five waste forms are a major factor in the release quantities to the vadose zone. The predominant sources of technetium-99 are steam reforming waste (greater than 99 percent) and chromium (greater than 99 percent). The predominant sources of iodine-129 are steam reforming (71 percent) and ETF-generated secondary waste (29 percent) forms. The predominant source of nitrate (greater than 99 percent) is ETF-generated secondary waste. No boron or fluoride is released from IDF-East.

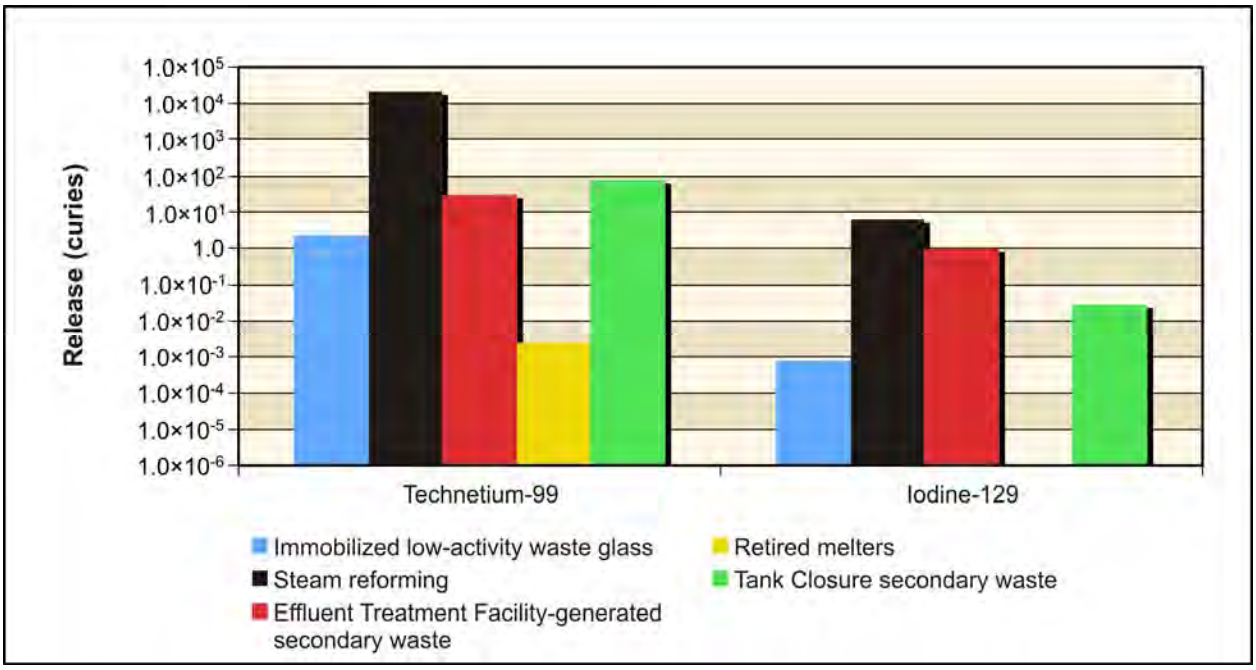


Figure 5–817. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

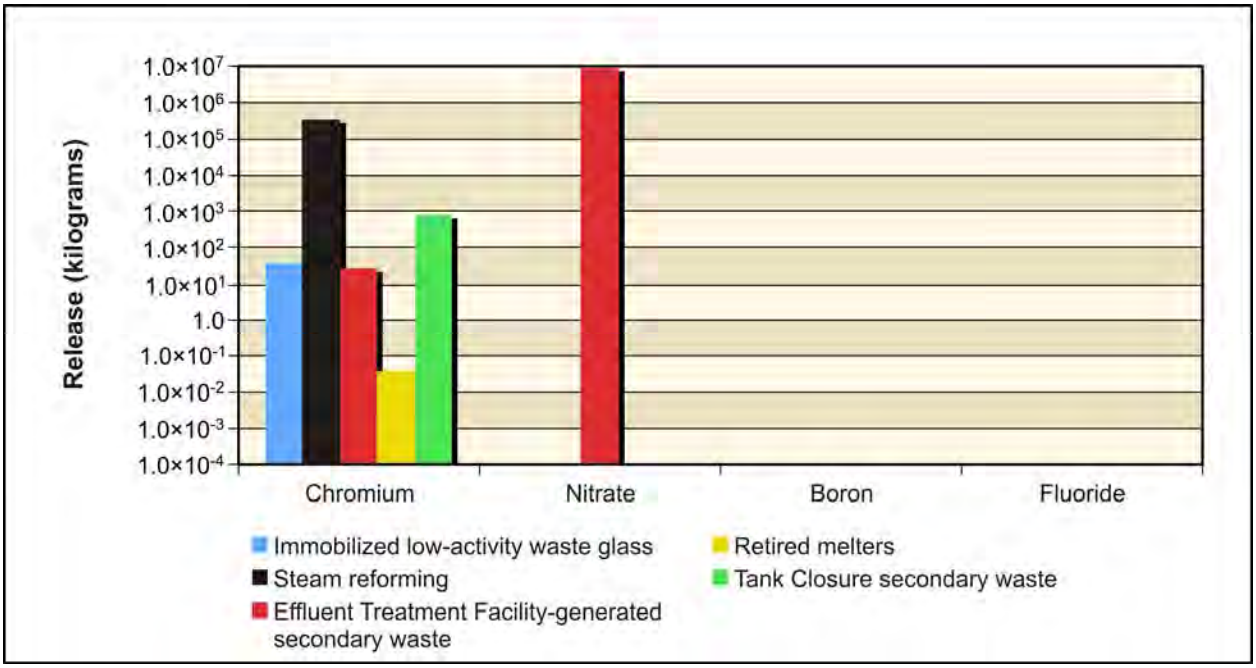


Figure 5–818. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–819 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–820, the chemical hazard drivers. In addition to the waste inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the vadose zone technetium-99 (97 percent) and iodine-129 (83 percent) and essentially all (greater than 99 percent) of the chromium and nitrate are released to groundwater during the period of analysis.

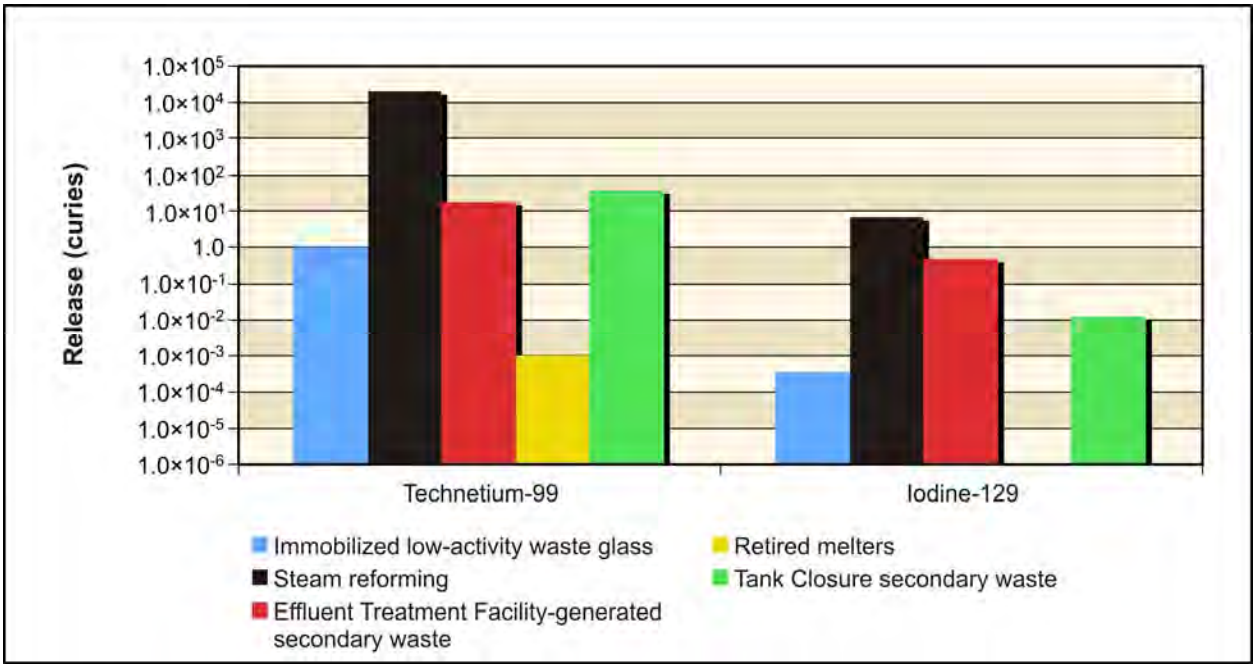


Figure 5–819. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

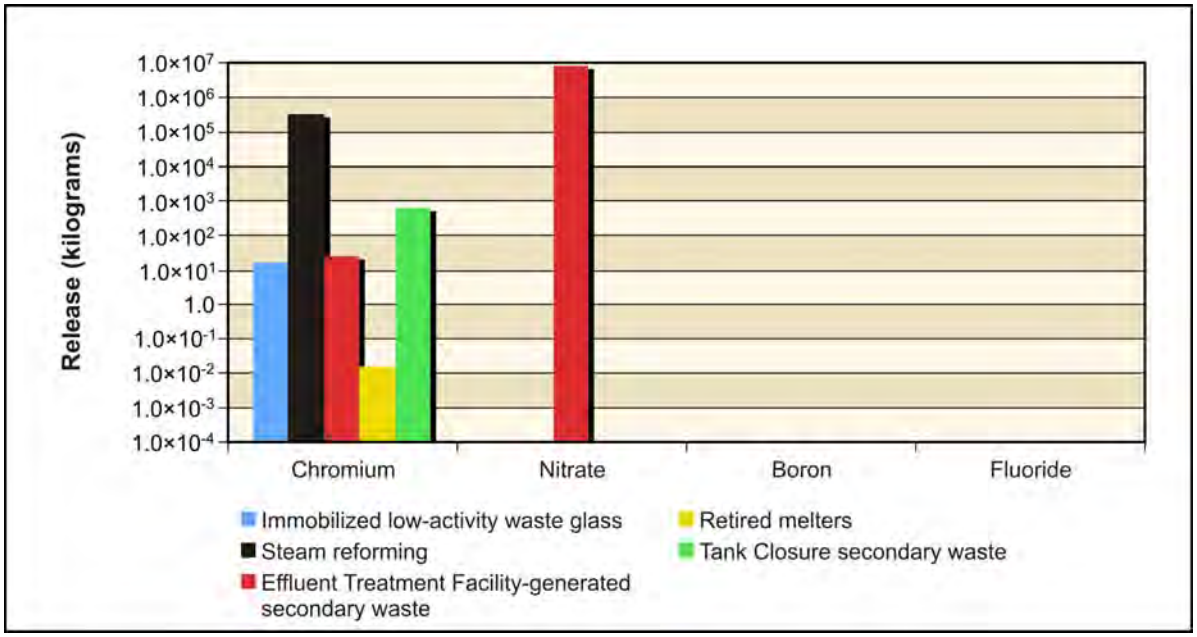


Figure 5–820. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–821 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–822, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially all of the groundwater technetium-99 (97 percent) and iodine-129 (97 percent), chromium (97 percent), and nitrate (99 percent) are released to the Columbia River.

Overall, almost all of the IDF-East vadose zone technetium-99 (95 percent), chromium (96 percent), and nitrate (98 percent), and most of the iodine-129 (80 percent), reached the Columbia River during the period of analysis.

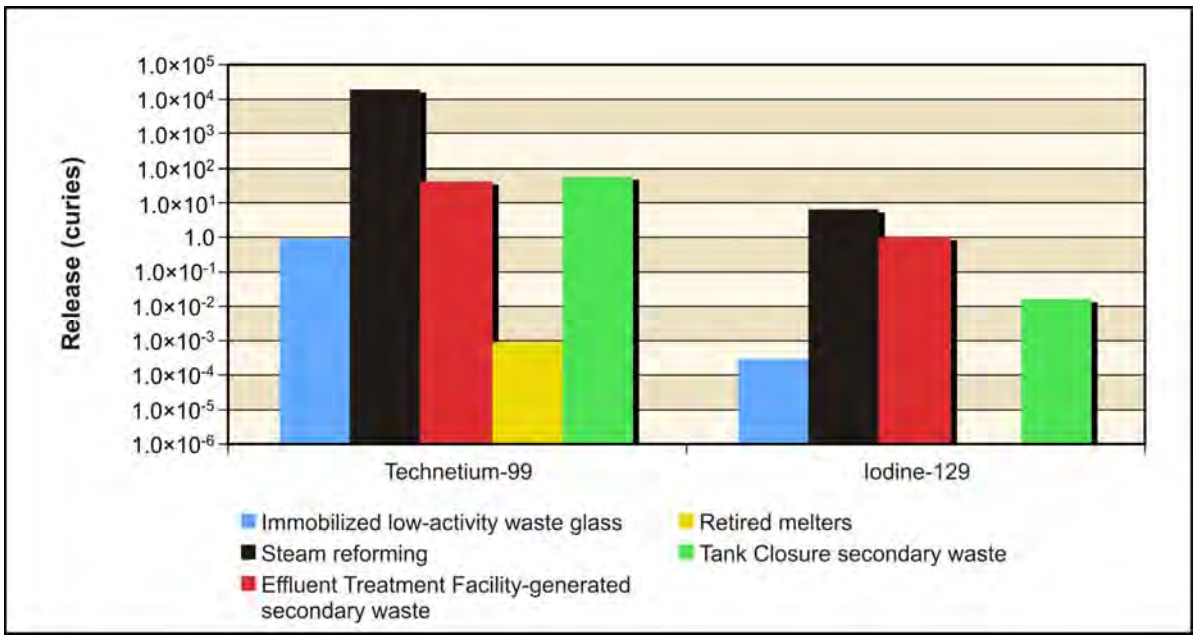


Figure 5–821. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

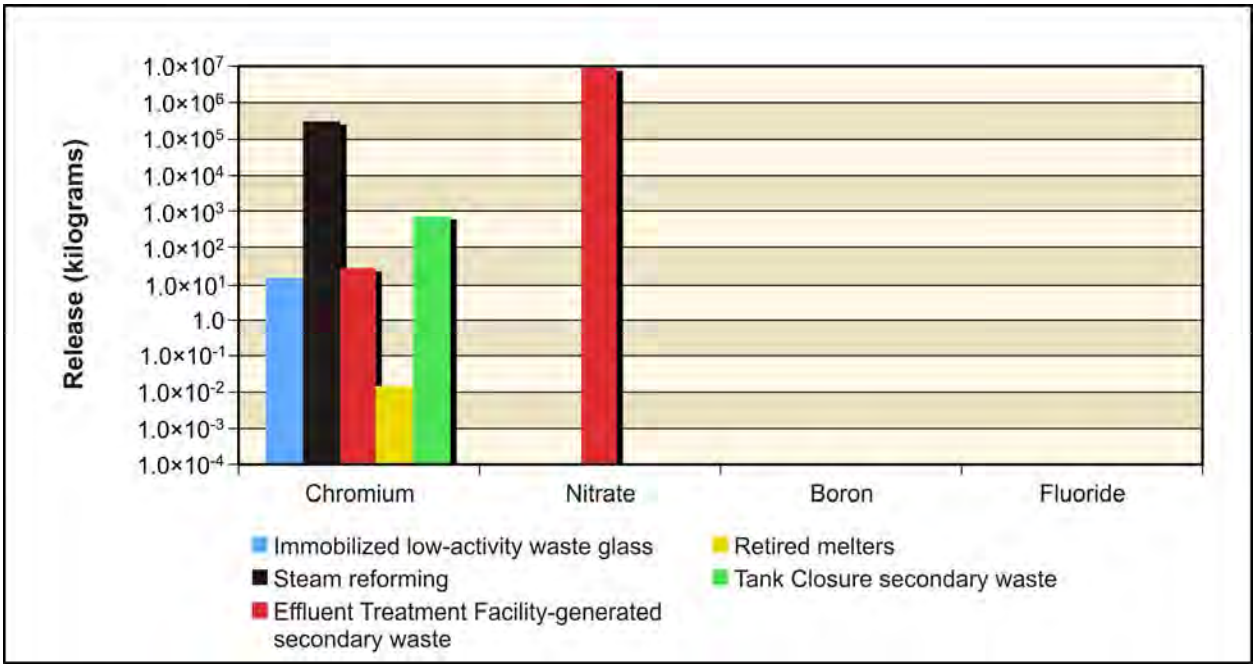


Figure 5–822. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-WEST AREA INTEGRATED DISPOSAL FACILITY

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste.

Figure 5–823 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–824, the chemical hazard drivers. The inventories in the three waste forms are a major factor in the release quantities to the vadose zone. The predominant source of technetium-99 (greater than 99 percent) and iodine-129 (greater than 99 percent) is offsite-generated waste released to the vadose zone. Essentially all (greater than 99 percent) of the nitrate, boron, and fluoride that are released to the vadose zone are from waste management secondary and onsite-generated waste. The chromium released to the vadose zone is from waste management secondary and onsite-generated waste (66 percent) and offsite-generated waste (34 percent).

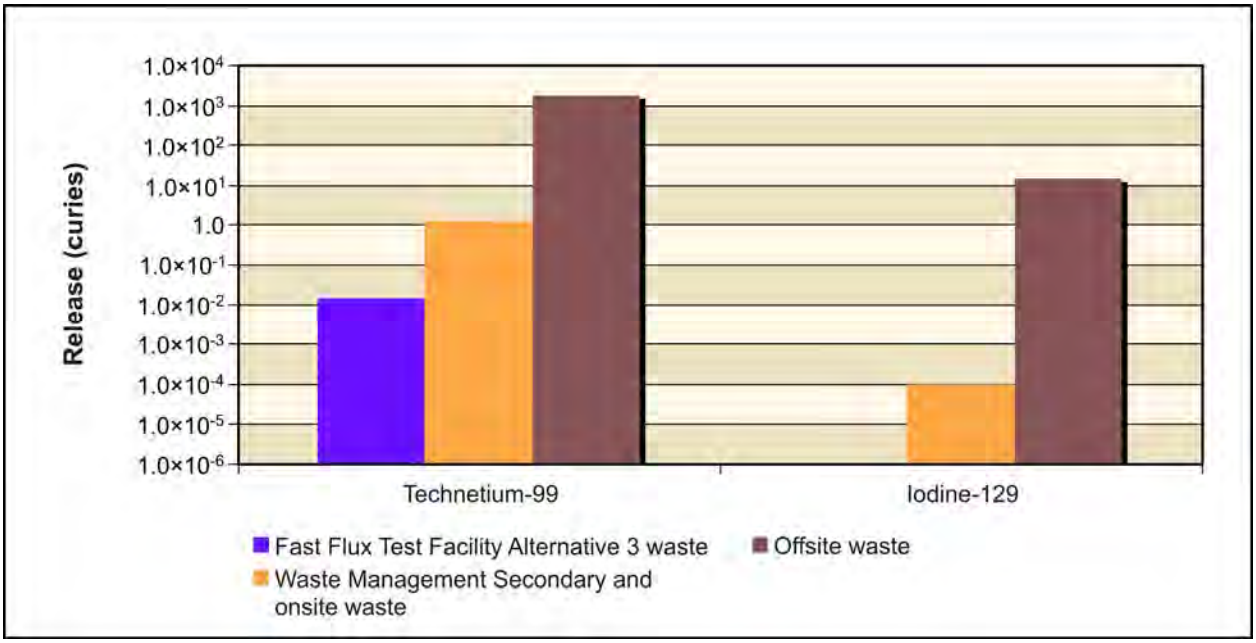


Figure 5–823. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

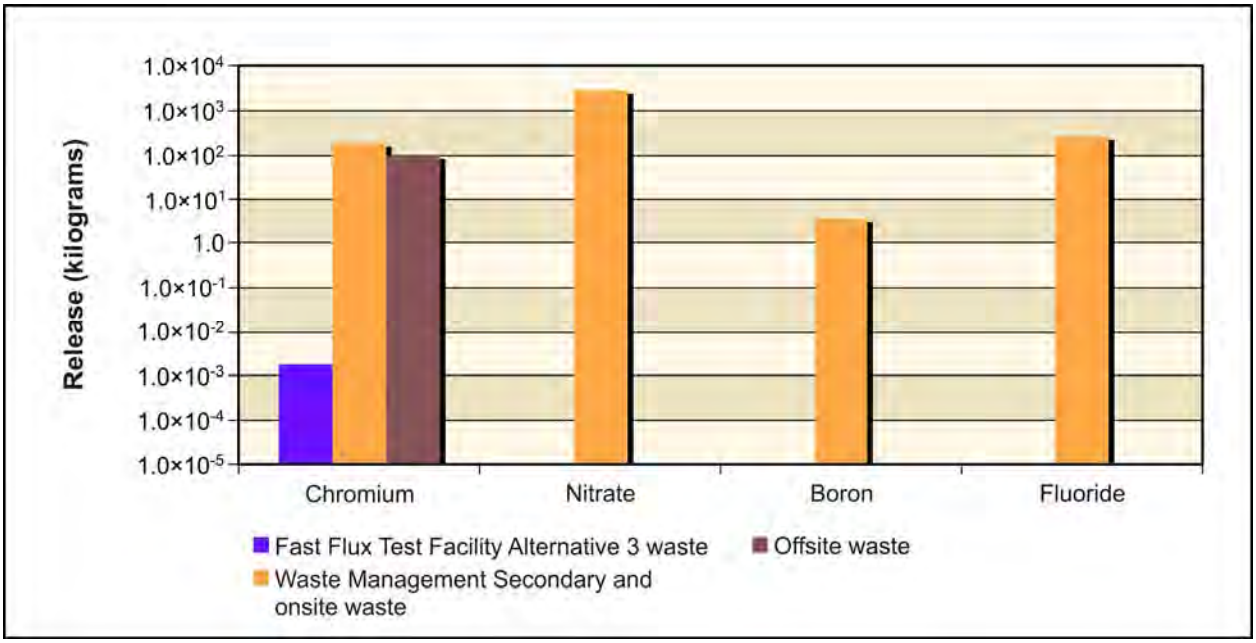


Figure 5–824. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–825 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–826, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Almost all of the vadose zone technetium-99 (98 percent), iodine-129 (99 percent), chromium (99 percent), nitrate (greater than 99 percent), boron (greater than 99 percent), and fluoride (greater than 99 percent) are released to groundwater during the period of analysis.

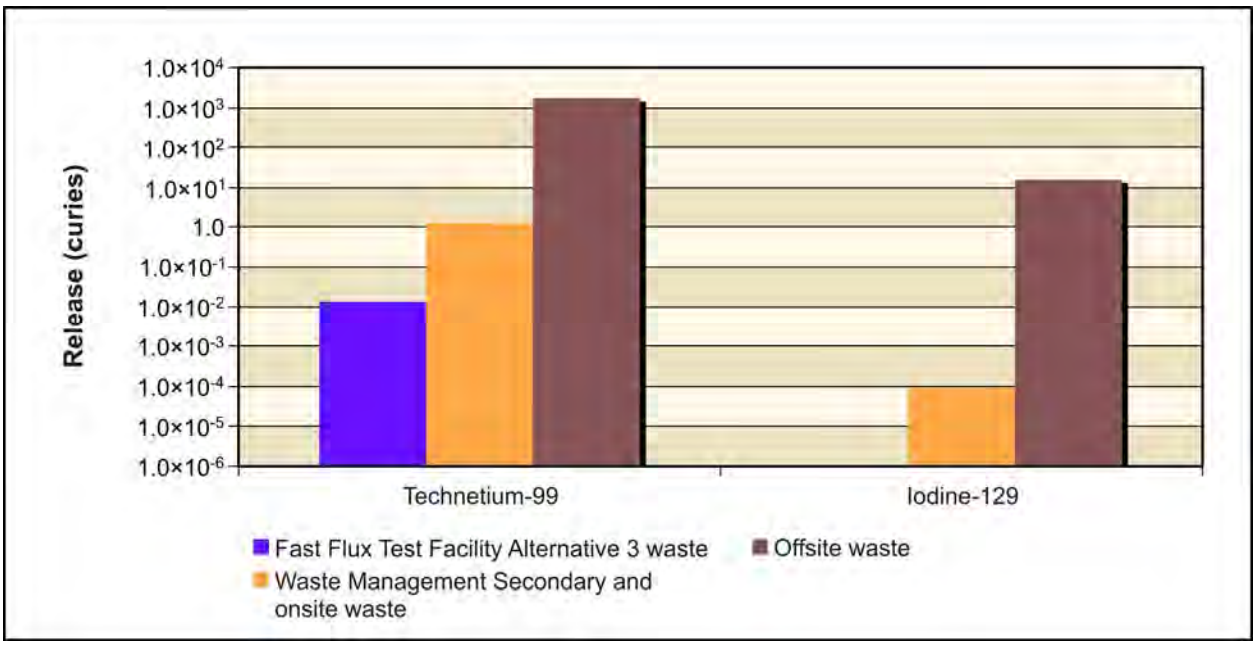


Figure 5–825. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

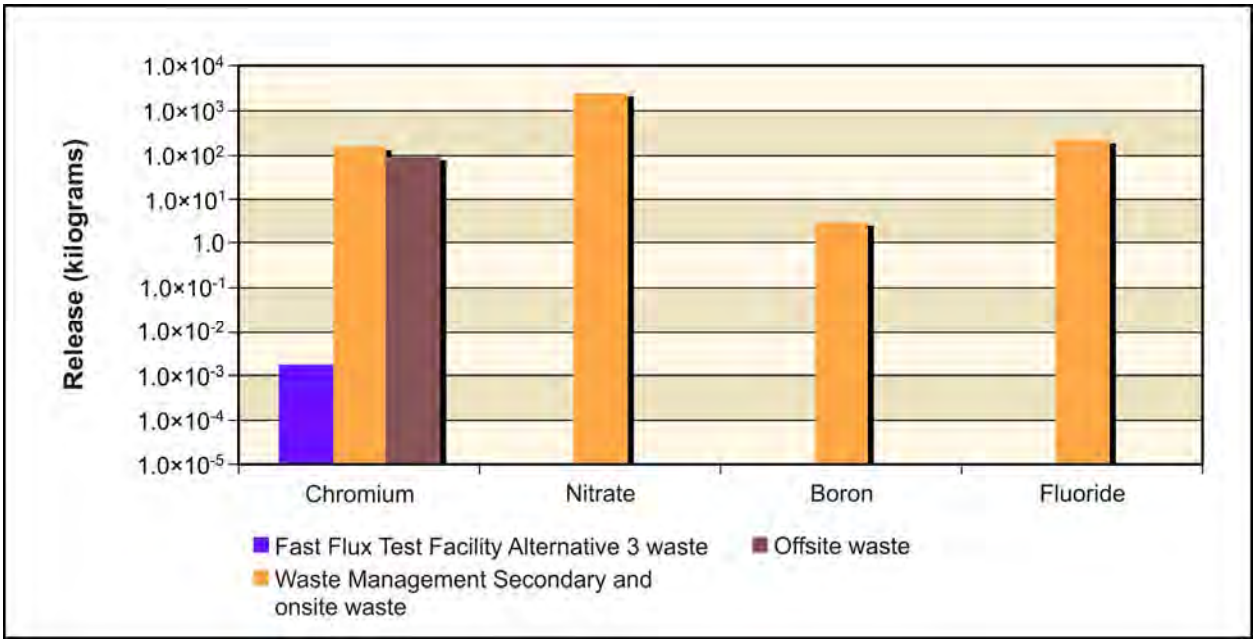


Figure 5–826. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–827 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–828, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (97–98 percent) of the IDF-West groundwater technetium-99, iodine-129, chromium, nitrate, boron, and fluoride are released to the Columbia River over the period of analysis.

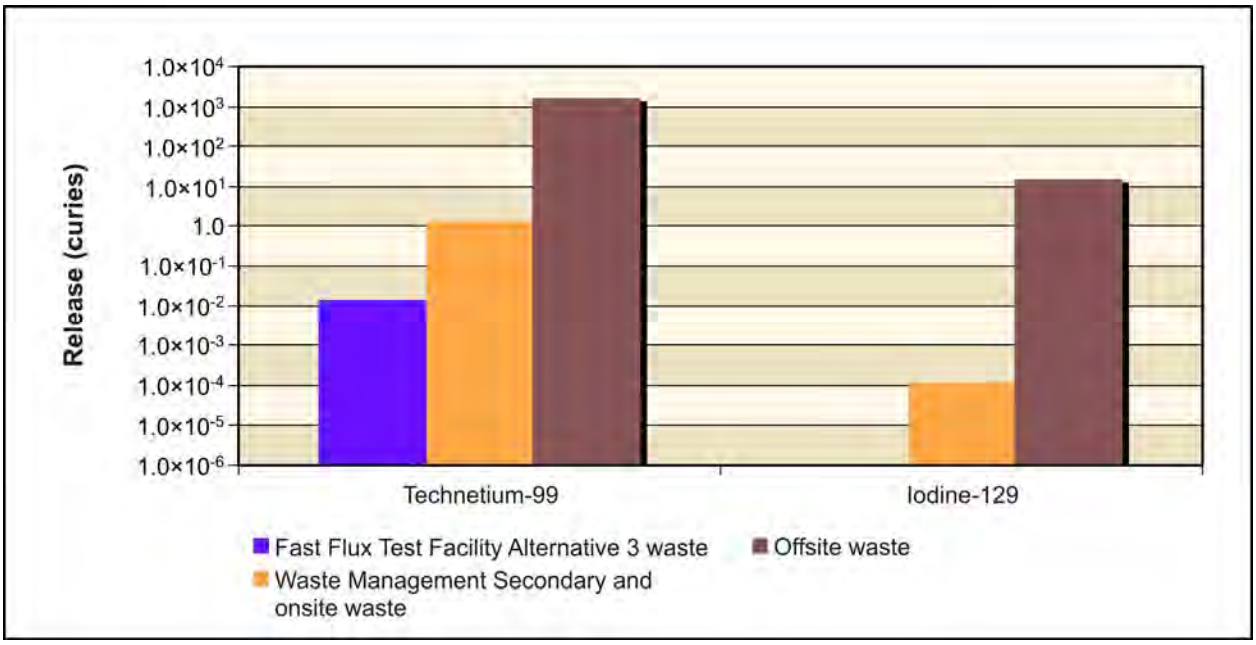


Figure 5–827. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

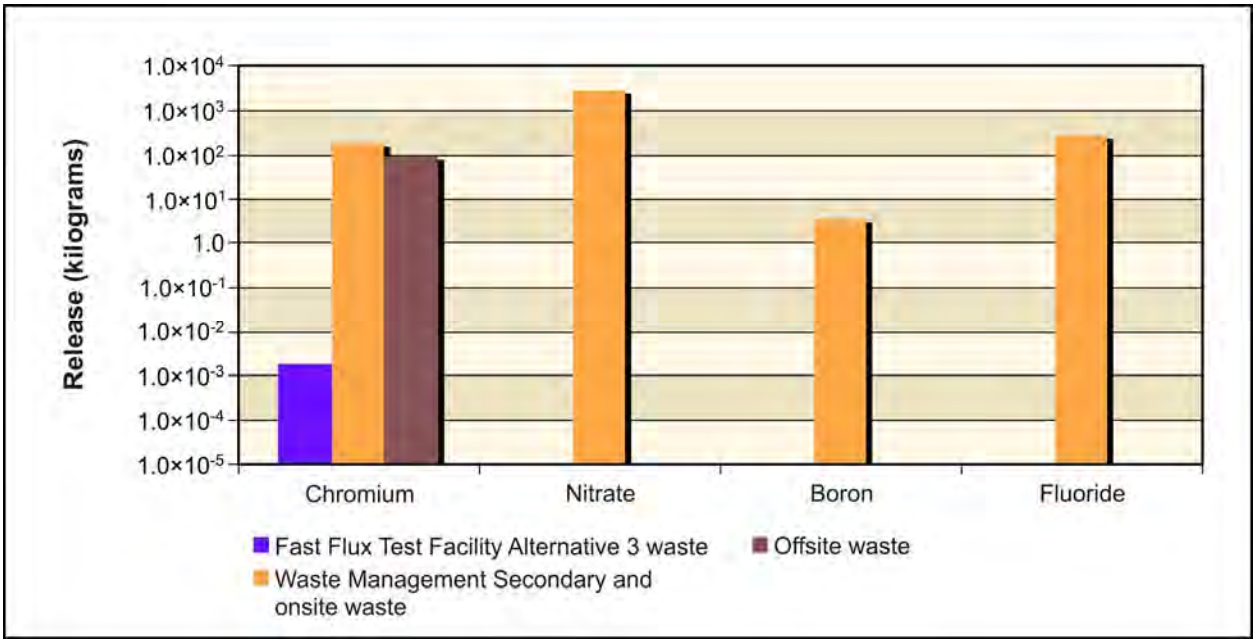


Figure 5–828. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

Overall, almost all (97–98 percent) of the IDF-West vadose zone technetium-99, iodine-129, chromium, nitrate, boron, and fluoride reached the Columbia River over the period of analysis.

RIVER PROTECTION PROJECT DISPOSAL FACILITY

Figure 5–829 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–830, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium-99 (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). No fluoride or boron is released from the RPPDF.

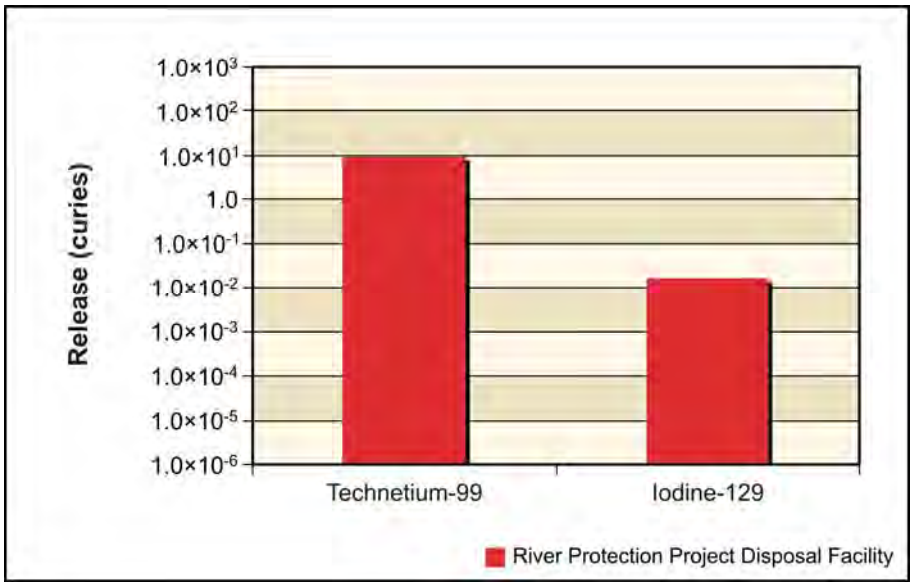


Figure 5–829. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

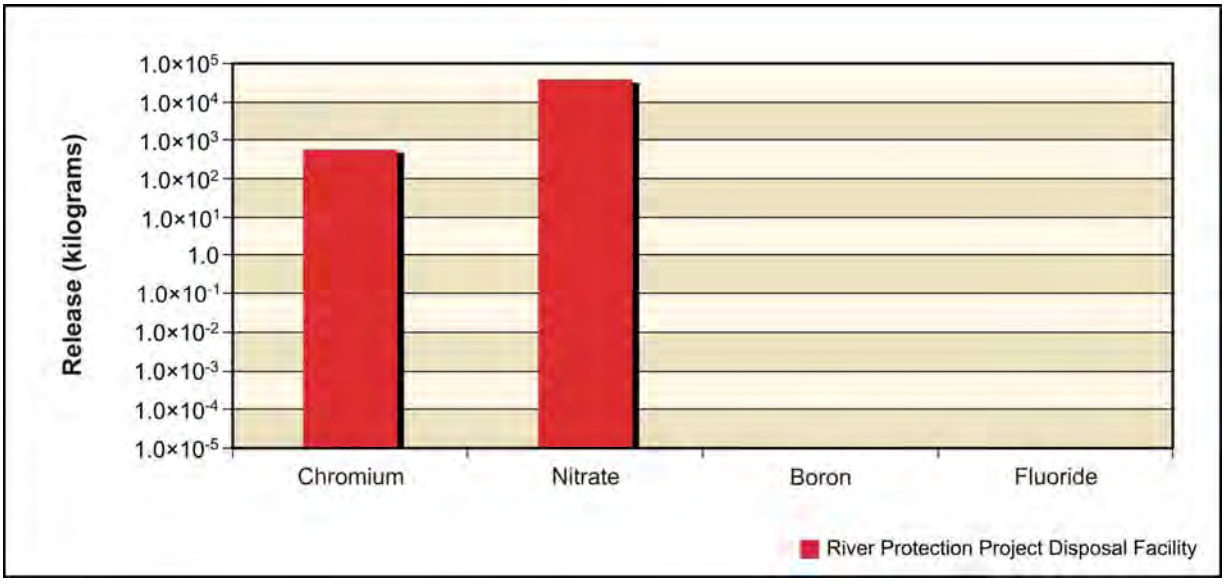


Figure 5–830. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–831 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–832, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Essentially all (99 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate are released to the groundwater.

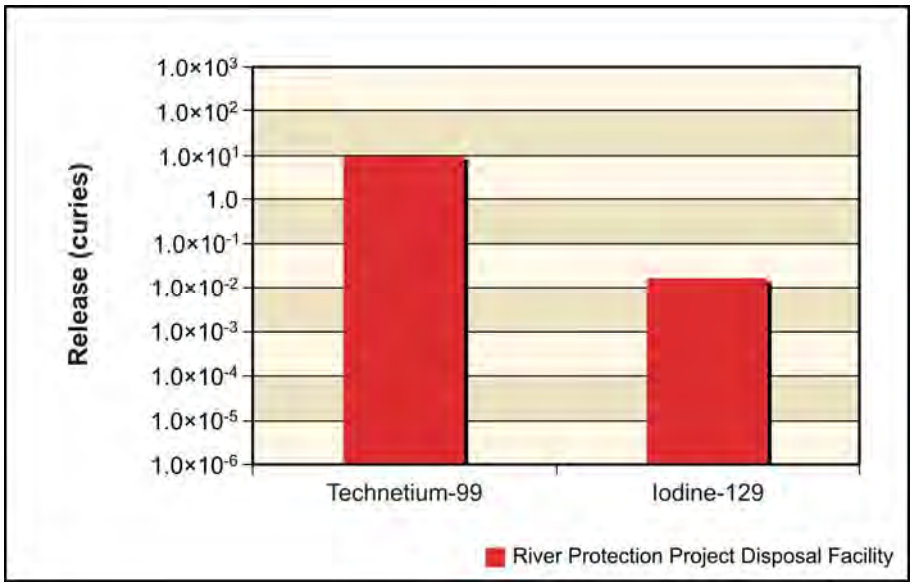


Figure 5–831. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Groundwater

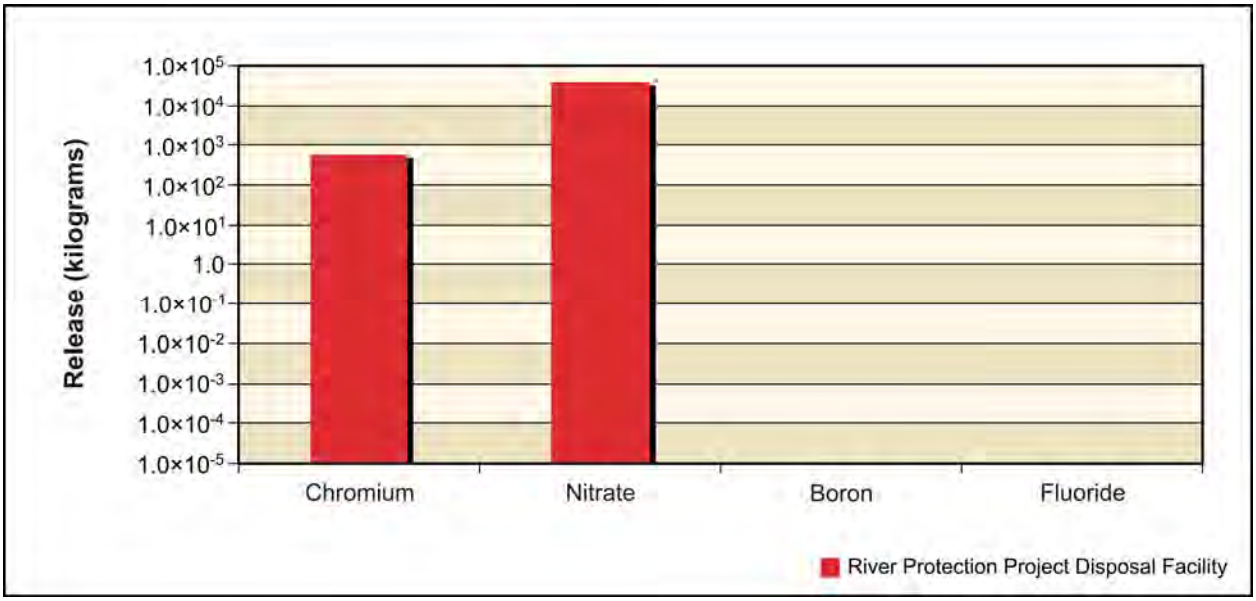


Figure 5–832. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–833 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–834, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (96 percent) of the groundwater technetium-99, iodine-129, chromium, and nitrate are released to the Columbia River.

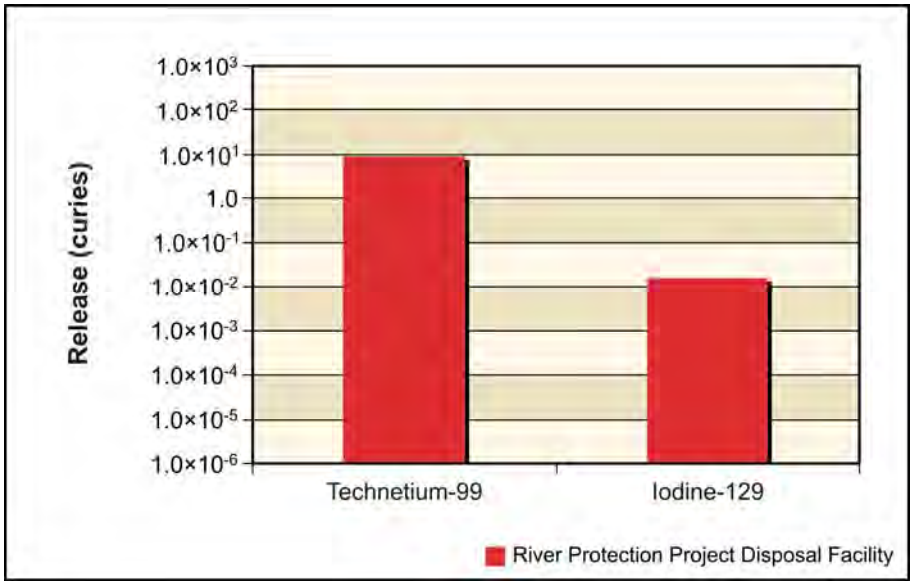


Figure 5–833. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Columbia River

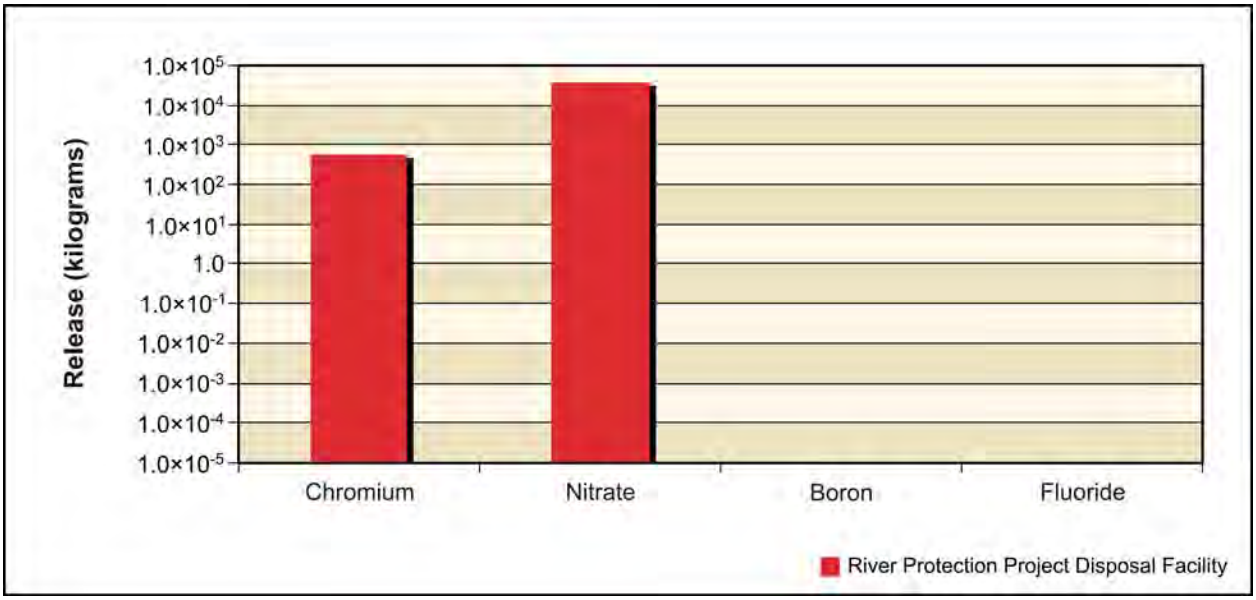


Figure 5–834. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Columbia River

Overall, most (95–96 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate reached the Columbia River during the period of analysis.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–92 shows the maximum concentrations in groundwater.

Table 5–92. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**29,200**	**20,200**	33	**24,600**	**7,450**	900
	(9032)	(3713)	(3825)	(9067)	(9206)	
Iodine-129	**11**	**173**	0.1	**60**	**8**	1
	(8514)	(3797)	(3772)	(3853)	(4729)	
Chemical in micrograms per liter						
Chromium	**436**	2	2	**174**	**116**	100
	(9071)	(3696)	(3856)	(8397)	(9878)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,500	17	149	4,970	3,320	45,000
	(7859)	(3703)	(3811)	(7269)	(7528)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–835 through 5–838 show concentration versus time for technetium-99, iodine-129, chromium, and nitrate. The releases of technetium-99 from IDF-East, IDF-West, and the RPPDF result in concentrations at the Core Zone Boundary and the Columbia River nearshore that exceed the technetium-99 benchmark concentration over two-thirds of the period of analysis (see Figure 5–835). After the post-disposal period there is a short period (1,000 years) when the Core Zone Boundary concentration exceeds the benchmark concentration. The Core Zone Boundary concentration then decreases below the benchmark concentration at levels coincident with the Columbia River nearshore. Both the Core Zone Boundary and Columbia River nearshore concentrations then increase and remain above the benchmark concentration through the end of the analysis period. The Core Zone Boundary and Columbia River nearshore concentrations never exceed the benchmark concentrations by more than one order of magnitude.

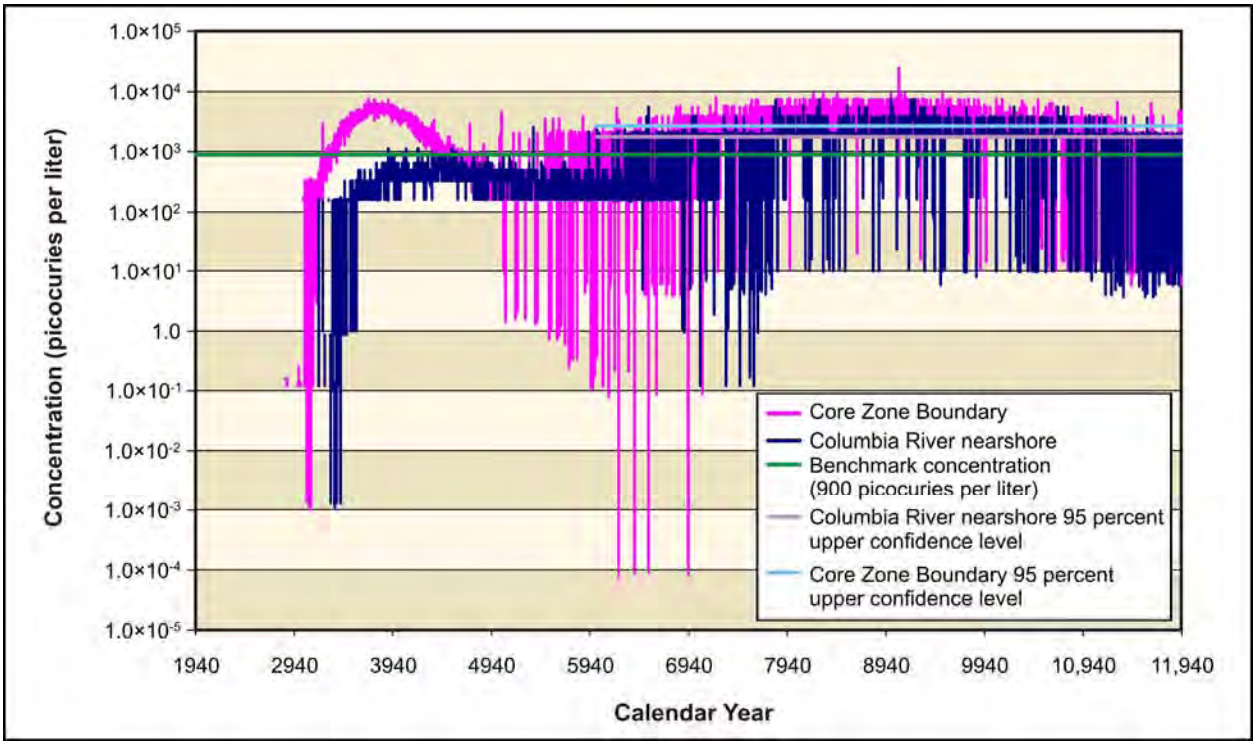


Figure 5–835. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Technetium-99 Concentration Versus Time

The iodine-129 concentrations (see Figure 5–836) at both the Core Zone Boundary and Columbia River nearshore have a similar time versus concentration profile as technetium-99 except that the Core Zone Boundary and Columbia River nearshore concentrations never fall below the iodine-129 benchmark concentration. The initial Core Zone Boundary iodine-129 peak is between one and two orders of magnitude of the benchmark concentration, but then drops to a level coincident with the Columbia River nearshore concentration. After the initial Core Zone Boundary iodine-129 peak, the concentrations at both the Core Zone Boundary and the Columbia River nearshore remain less than one order of magnitude above the benchmark concentration.

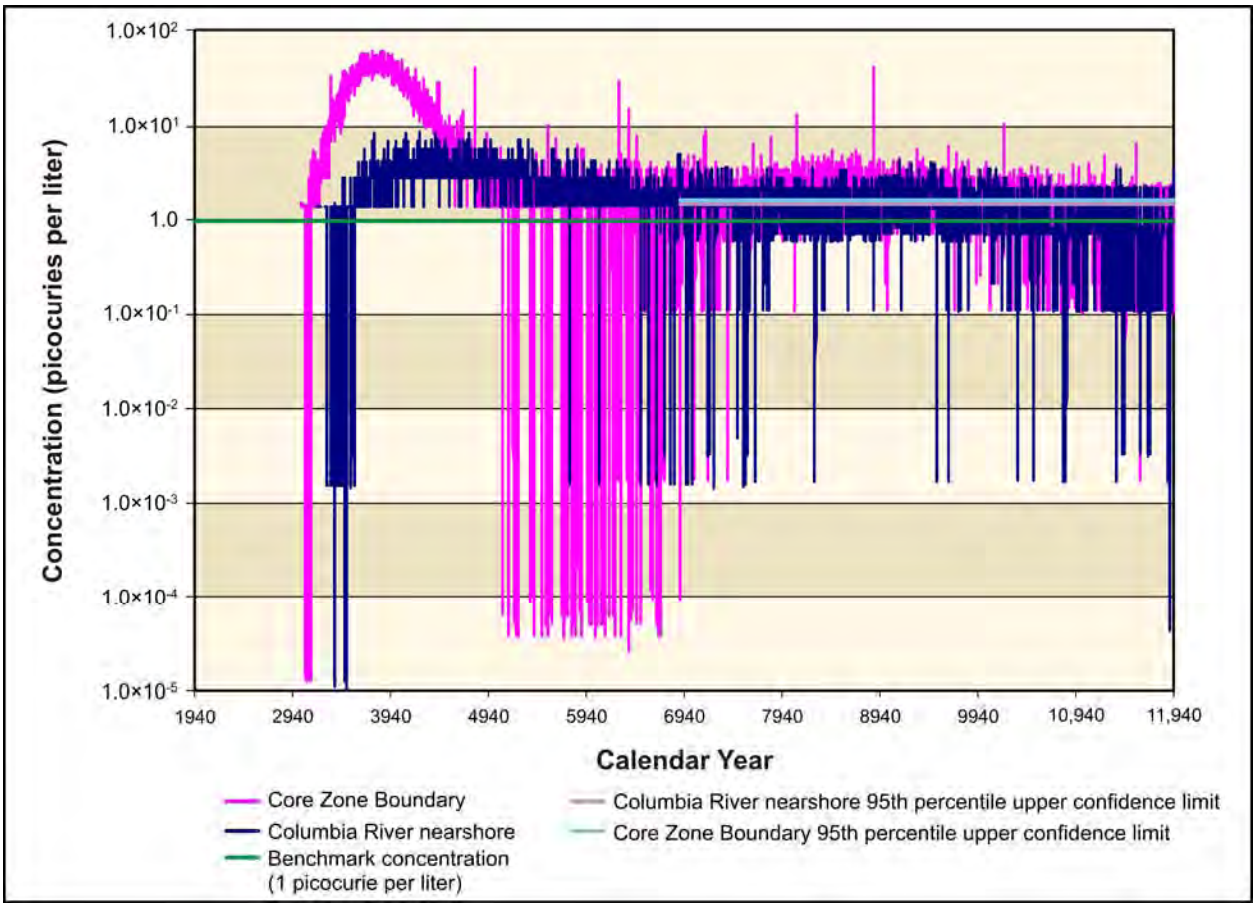


Figure 5–836. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Iodine-129 Concentration Versus Time

The time versus concentration profiles for chromium and nitrate (see Figures 5–837 and 5–838) also show initial peaks for their Core Zone Boundary concentrations. However, unlike technetium-99 and iodine-129, these peaks are less than the concentrations that are reached at later times. Both chromium and nitrate gradually increase through the latter half of the analysis period and then show a decline that continues through the end of the analysis period. The chromium concentrations (at the Core Zone Boundary and Columbia River nearshore) both approach the benchmark concentration, but appear never to exceed it. The nitrate concentrations are always at least one order of magnitude less than the benchmark concentration.

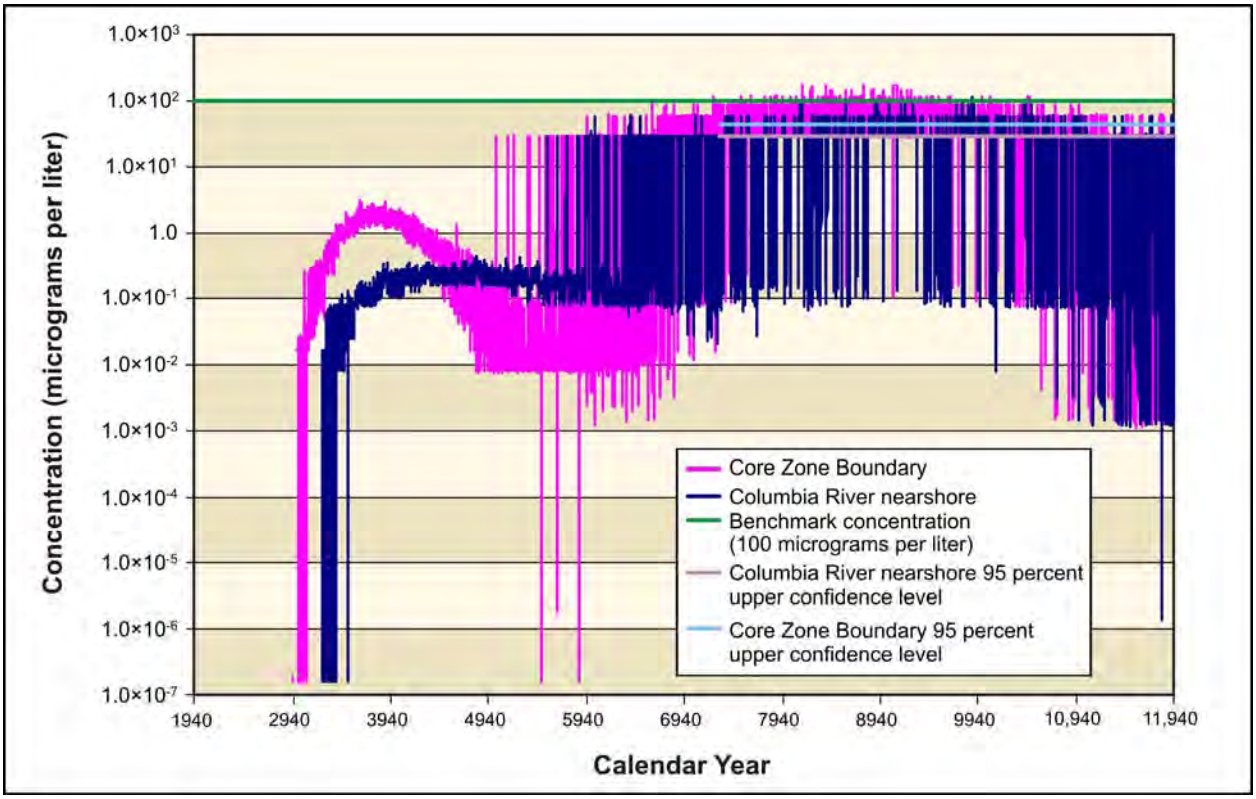


Figure 5–837. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chromium Concentration Versus Time

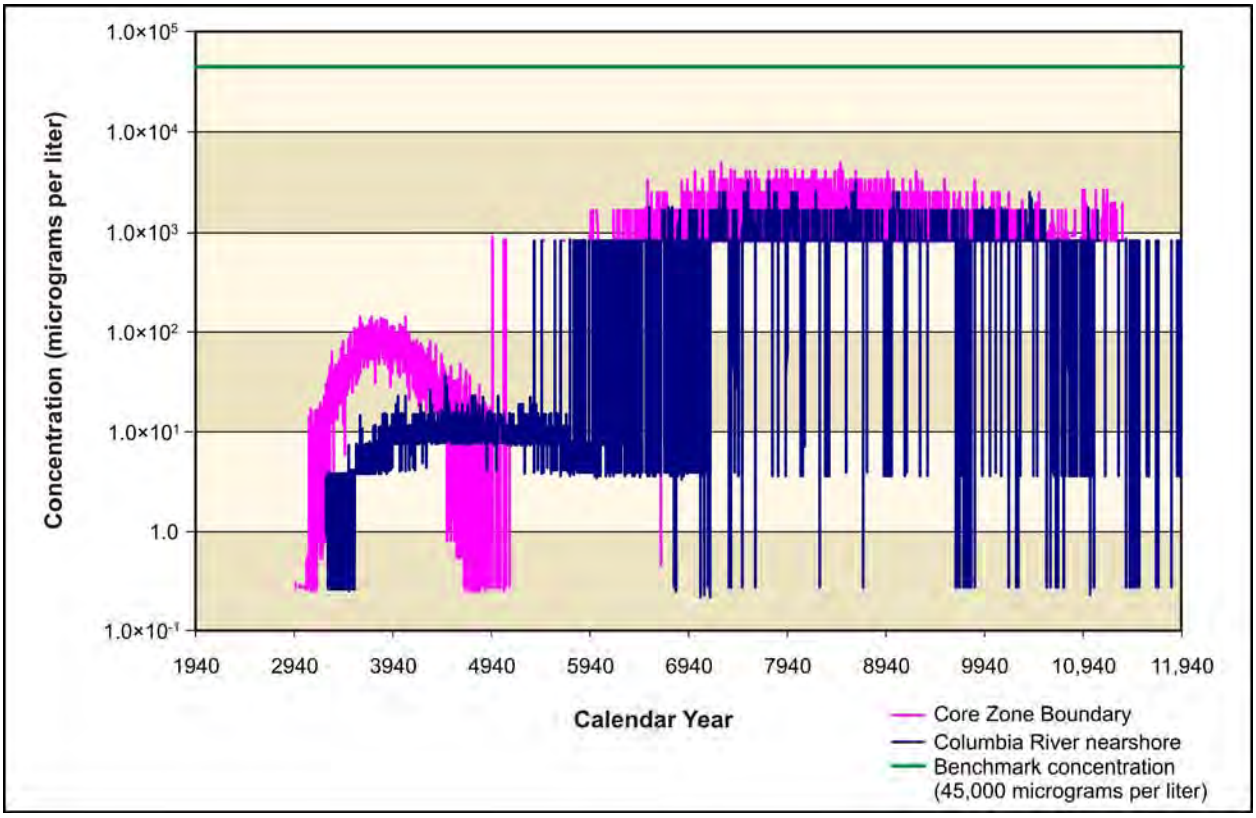


Figure 5–838. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Nitrate Concentration Versus Time

Figures 5–839 and 5–840 show concentration versus time for uranium-238 and total uranium. Because uranium-238 and total uranium move slowly through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are always lower than the benchmark concentrations over the period of analysis. Both uranium-238 (see Figure 5–839) and total uranium (see Figure 5–840) show increasing concentrations in the Core Zone that continue through the end of the analysis period. Over this analysis period, concentrations of uranium-238 at the Core Zone Boundary are at least two orders of magnitude less than the benchmark concentration, while the total uranium is at least seven orders of magnitude below its benchmark concentration. The concentrations at the Columbia River nearshore are much smaller and appear to occur significantly later than the Core Zone Boundary concentrations. The trend for uranium-238 and total uranium shows a continuing increase through the end of the analysis period.

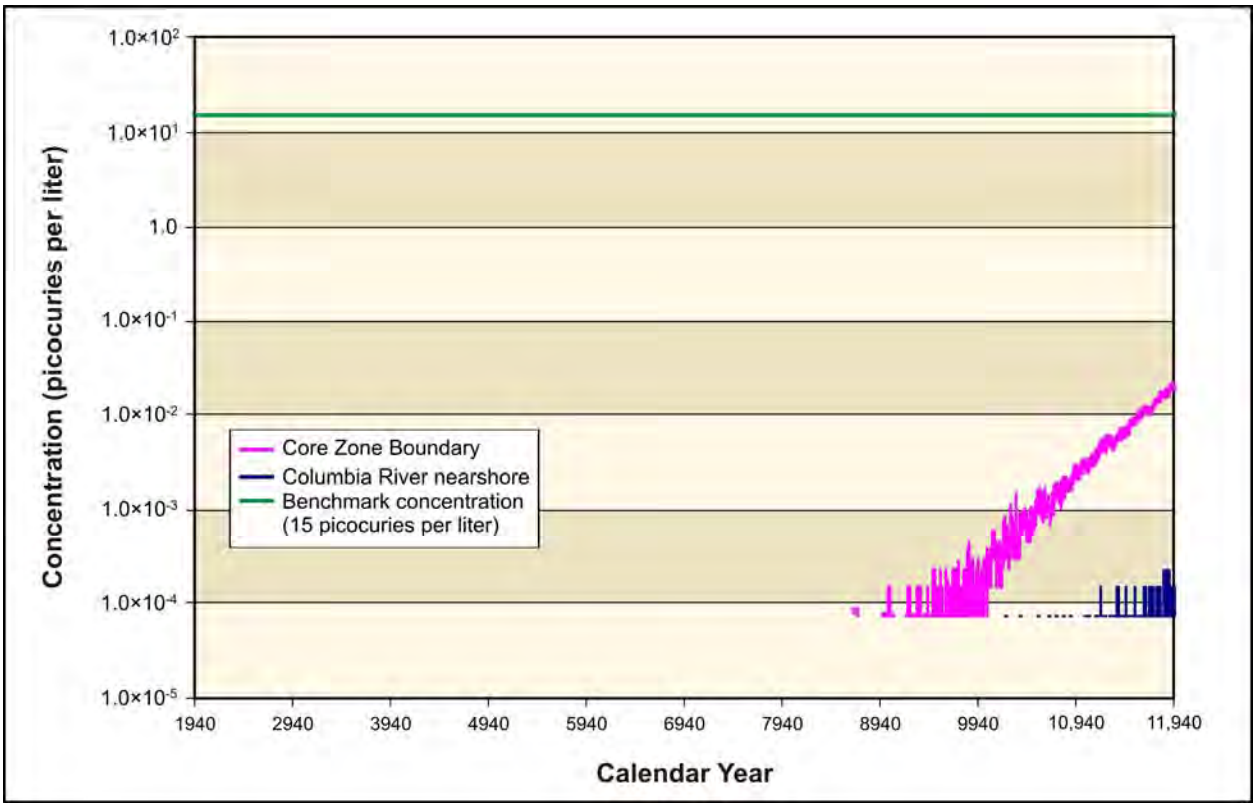


Figure 5–839. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Uranium-238 Concentration Versus Time

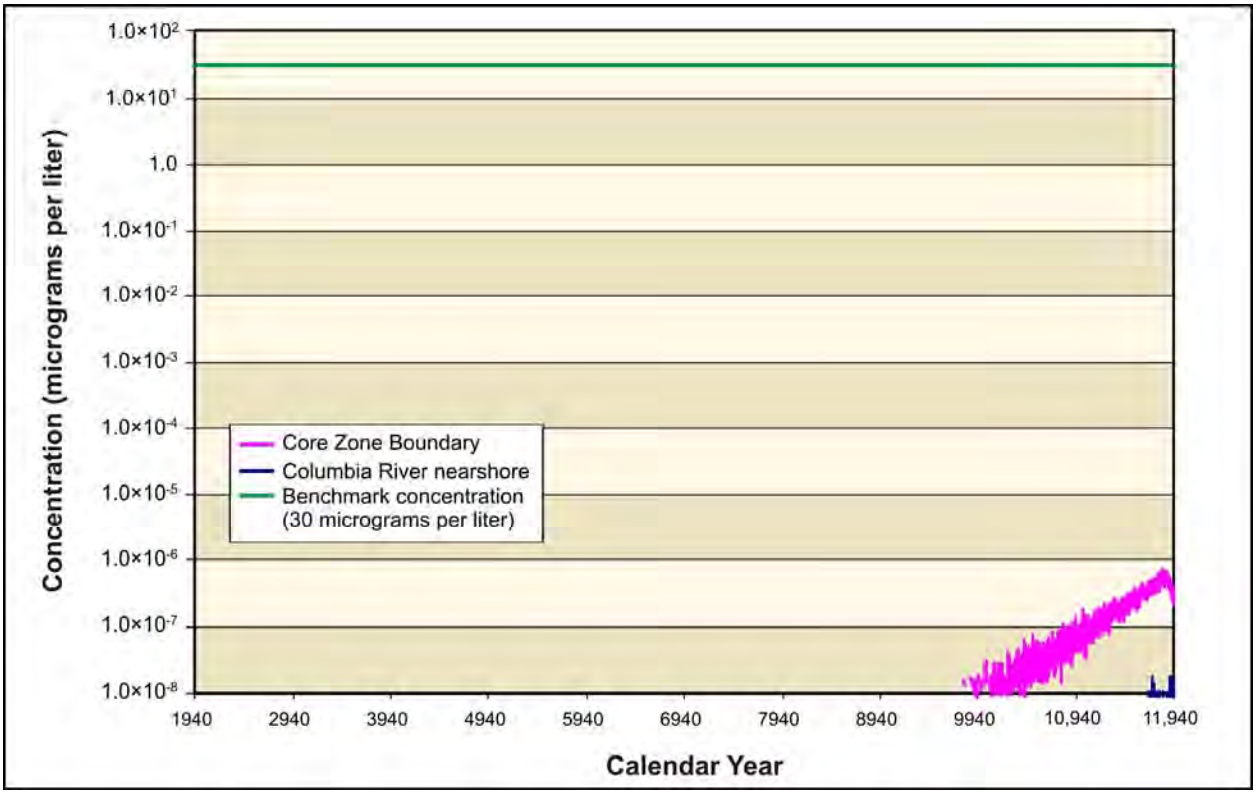


Figure 5–840. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–841 through 5–852 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. These data show the groundwater releases from the RPPDF and IDF-West that extend north from within the Core Zone to the Columbia River. The IDF-East groundwater releases extend east from within the Core Zone to the Columbia River. The RPPDF and IDF-West releases remain in a fairly narrow channel (Gable Gap) until about halfway to the Columbia River nearshore boundary. The releases then spread out over the northern tip area of Hanford. The IDF-East releases remained in a relatively narrow channel until they reached about the one-quarter distance point to the Columbia River, where the releases spread out and continued to the Columbia River nearshore boundary.

Figure 5–841 (CY 3890) shows the technetium-99 release from IDF-West and the RPPDF in CY 3890. This spatial distribution shows that technetium-99 exceeds the benchmark concentration within the Core Zone (due to the IDF-West release) and in several areas close to the Columbia River nearshore. There are also several small areas with very high concentrations of technetium-99 (several orders of magnitude

larger than the benchmark concentration) just north of the Core Zone Boundary. Figure 5–842 shows that the technetium-99 release from IDF-West and the RPPDF has largely dissipated by CY 7140 and only exists in areas close to the Columbia River nearshore at concentrations at least one order of magnitude lower than the benchmark concentration. This figure also shows a technetium-99 release distribution from IDF-East. There are significant areas where technetium-99 approaches or exceeds the benchmark concentration. Figure 5–843 shows that the IDF-West and RPPDF groundwater technetium-99 is almost completely dissipated in CY 11,885. A very small pocket of high concentration remains north of the Core Zone Boundary. At CY 11,885, technetium-99 has continued to move to the Columbia River. There are several areas where the IDF-East release still approaches or exceeds the benchmark concentration within one order of magnitude.

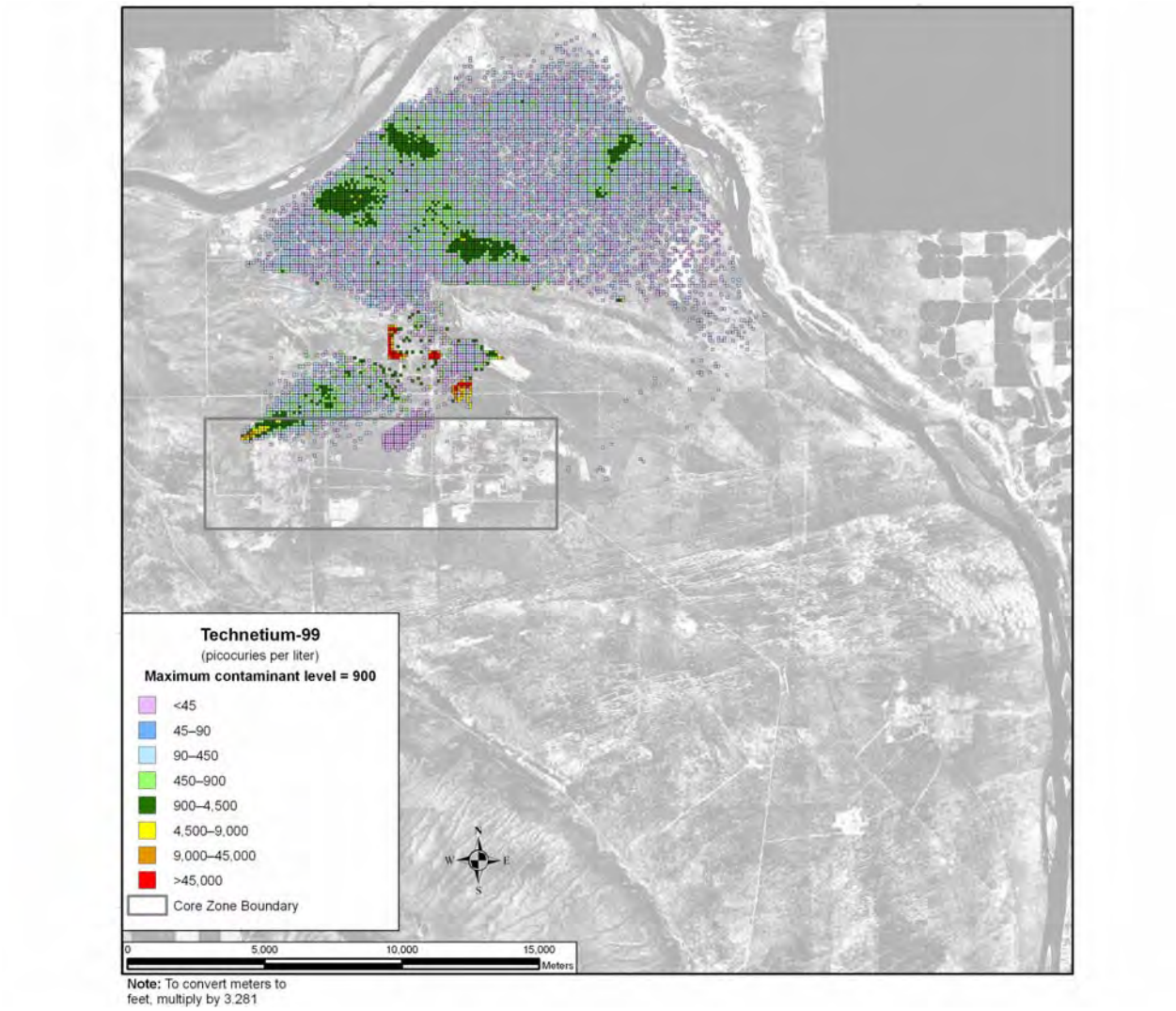


Figure 5–841. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 3890

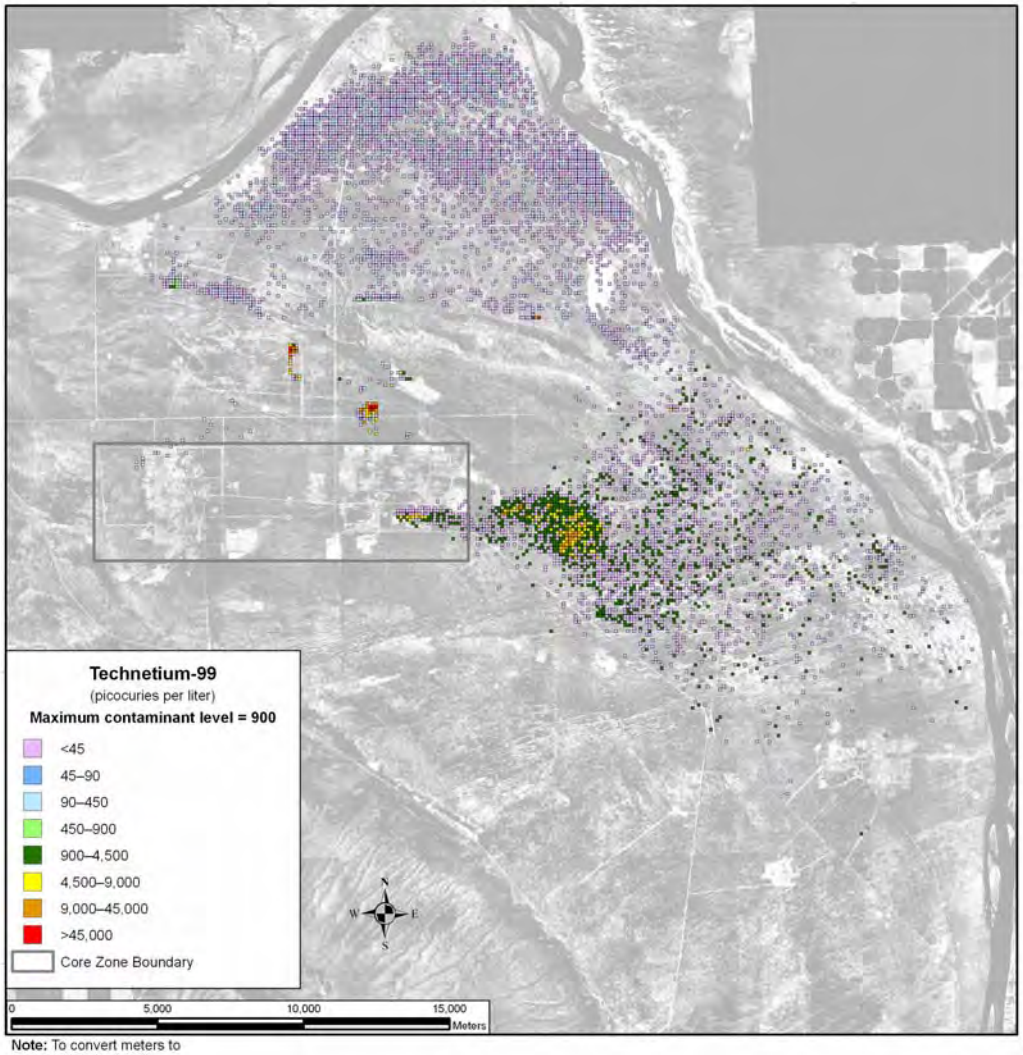


Figure 5–842. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 7140

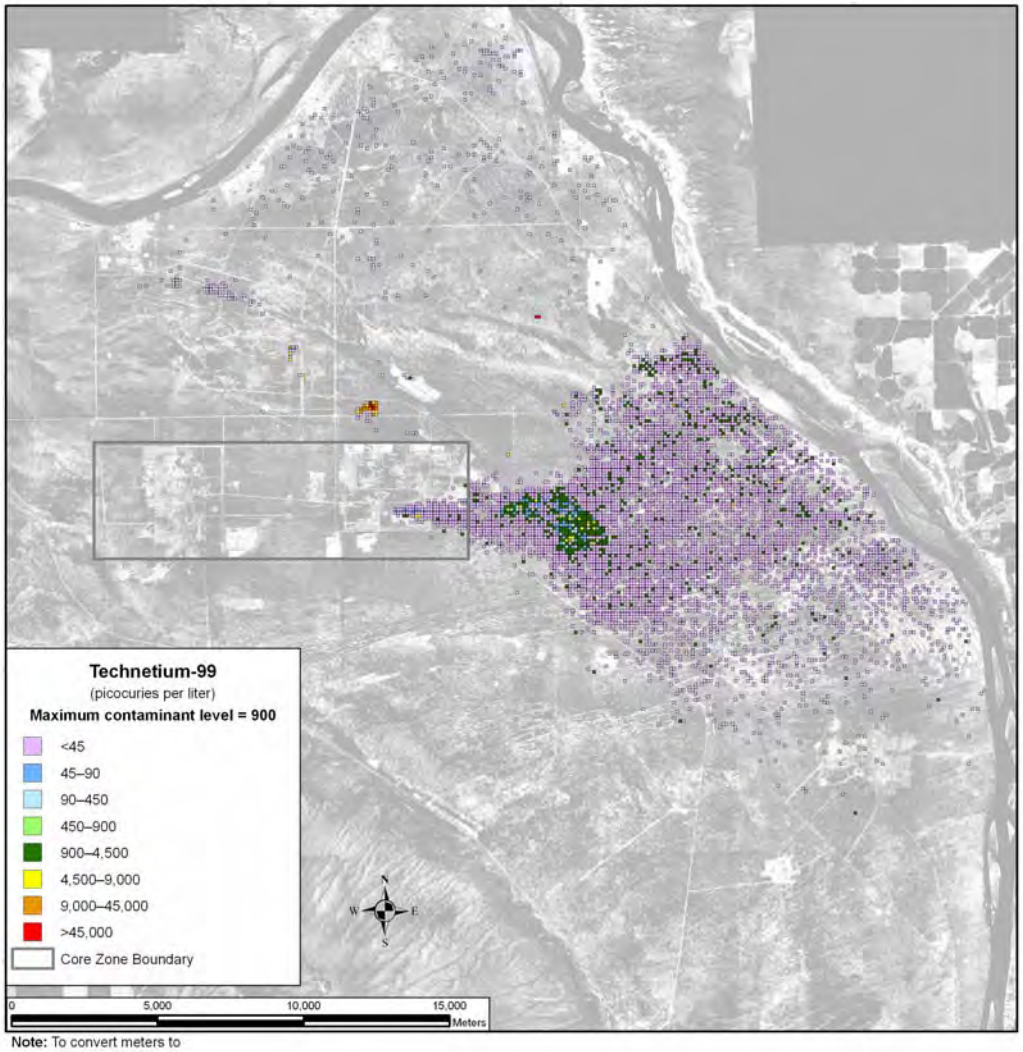


Figure 5–843. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 11,885

Figures 5–844 through 5–846 show iodine-129 released at IDF-East, IDF-West, and the RPPDF; the time and spatial distributions of this release are very similar to the technetium-99 release. However, the CY 3890 iodine-129 release (see Figure 5–844) shows significantly higher iodine-129 concentrations compared to benchmark concentrations than the technetium-99 release. The areas of high concentrations are in approximately the same locales but have relatively higher concentrations. By CY 7140 (see Figure 5–845), concentrations of IDF-West and RPPDF iodine-129 have significantly dissipated, but there are areas where concentrations are equal to or above the benchmark concentration. The CY 11,885 IDF-East iodine-129 (see Figure 5–846) shows a continuing iodine-129 distribution with areas that have concentrations that approach or exceed the benchmark concentration.

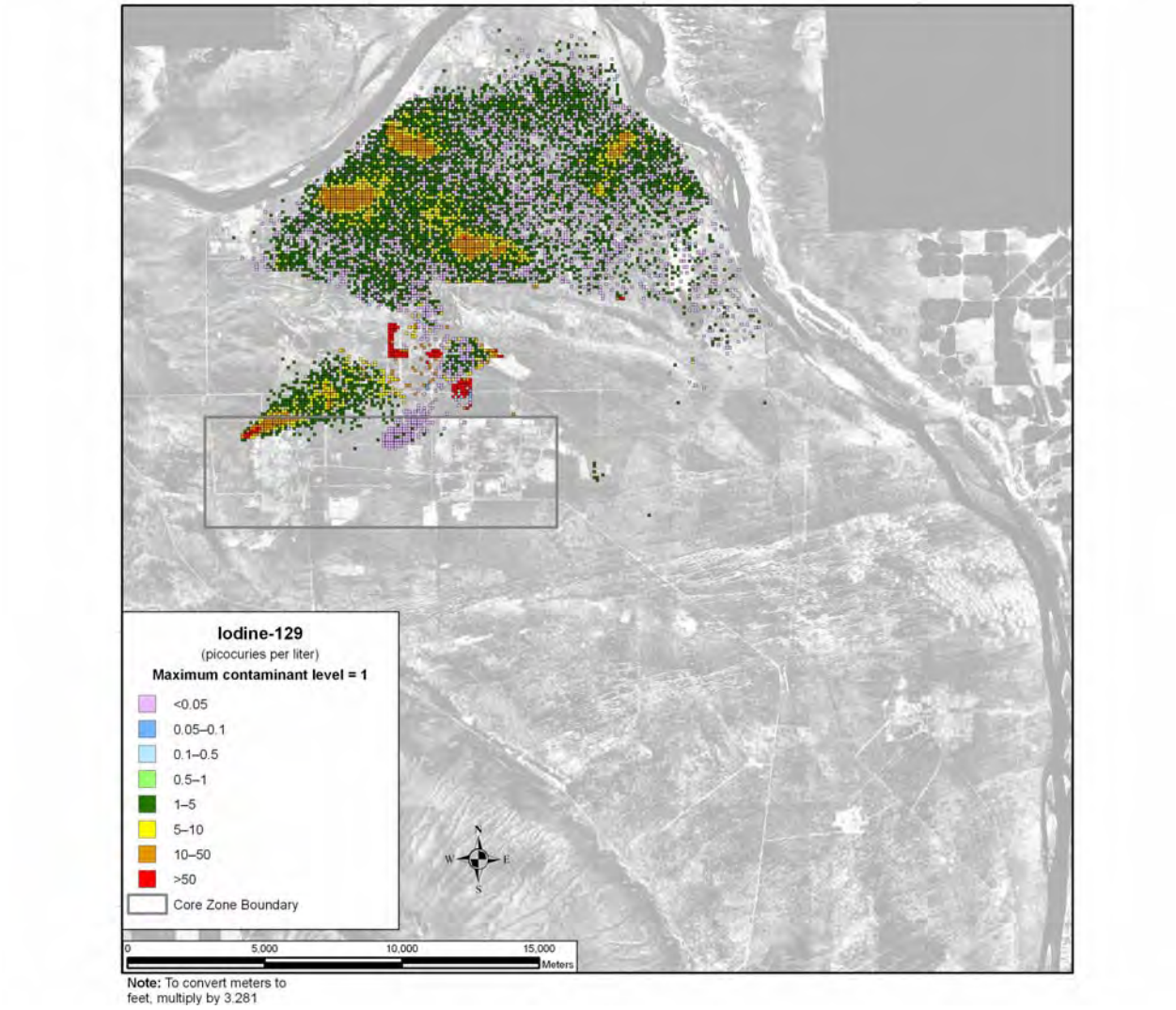


Figure 5–844. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 3890

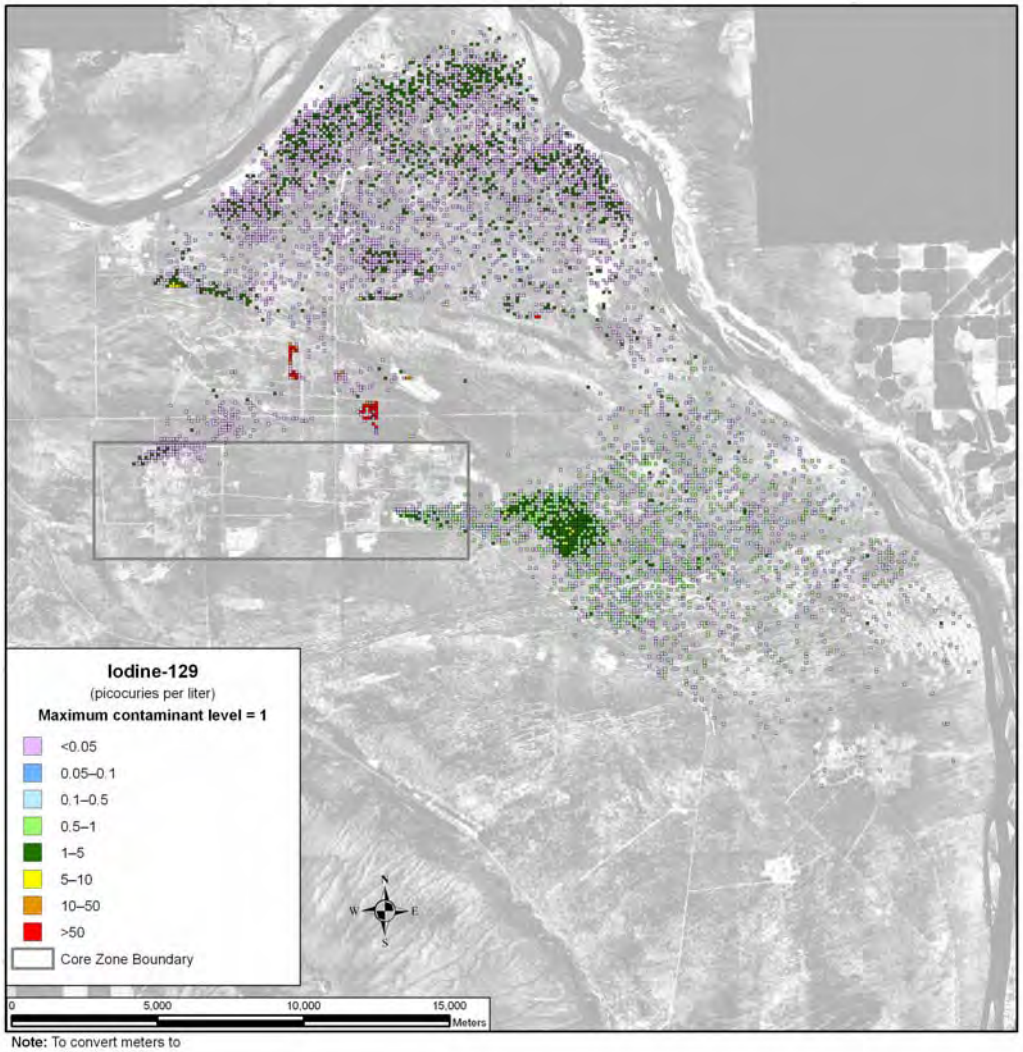


Figure 5–845. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 7140

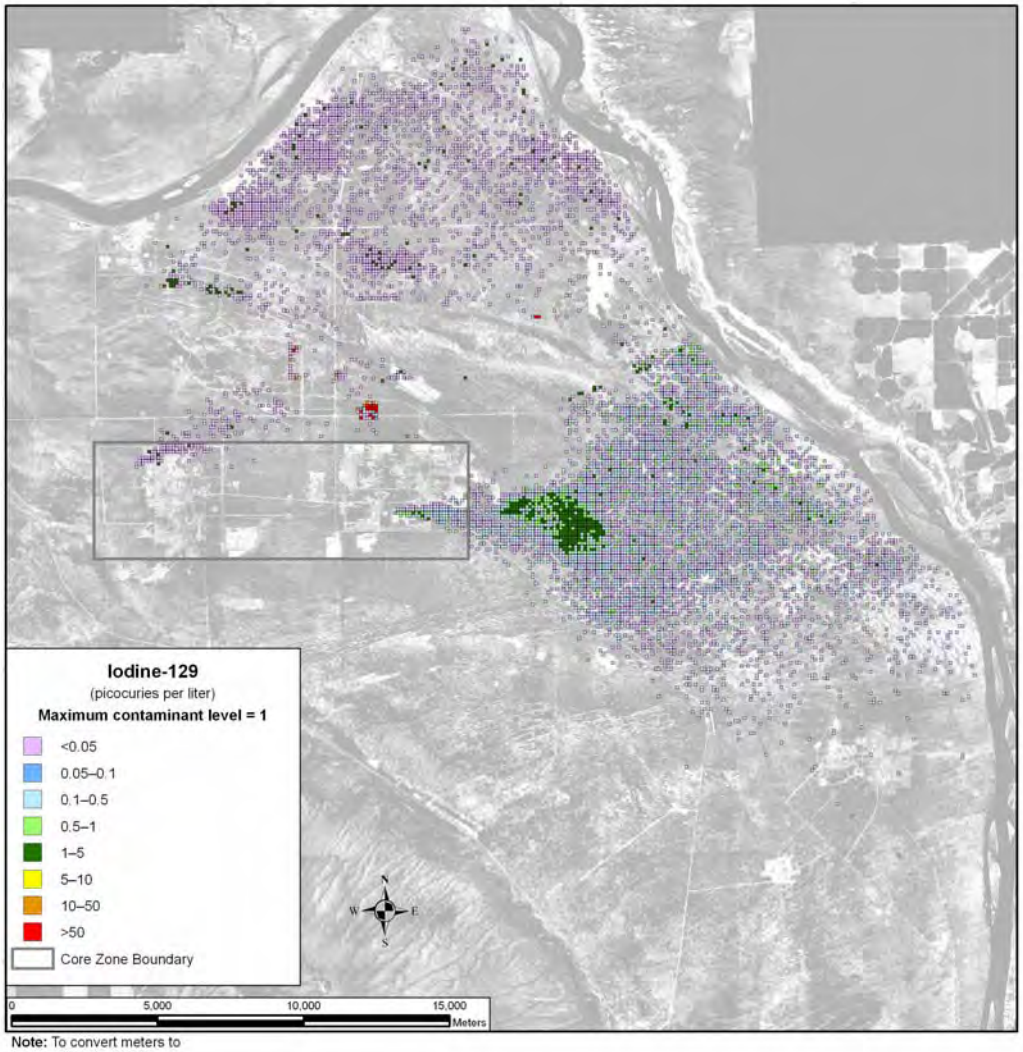


Figure 5–846. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 11,885

The IDF-East, IDF-West, and RPPDF nitrate releases, shown in Figures 5–847 through 5–849, show time and spatial distributions similar to the released technetium-99 and iodine-129. These show nitrate concentrations are below benchmark concentrations, with the exception of a very small area just north of the Core Zone Boundary. By CY 11,885, almost all of the groundwater nitrate has dissipated.

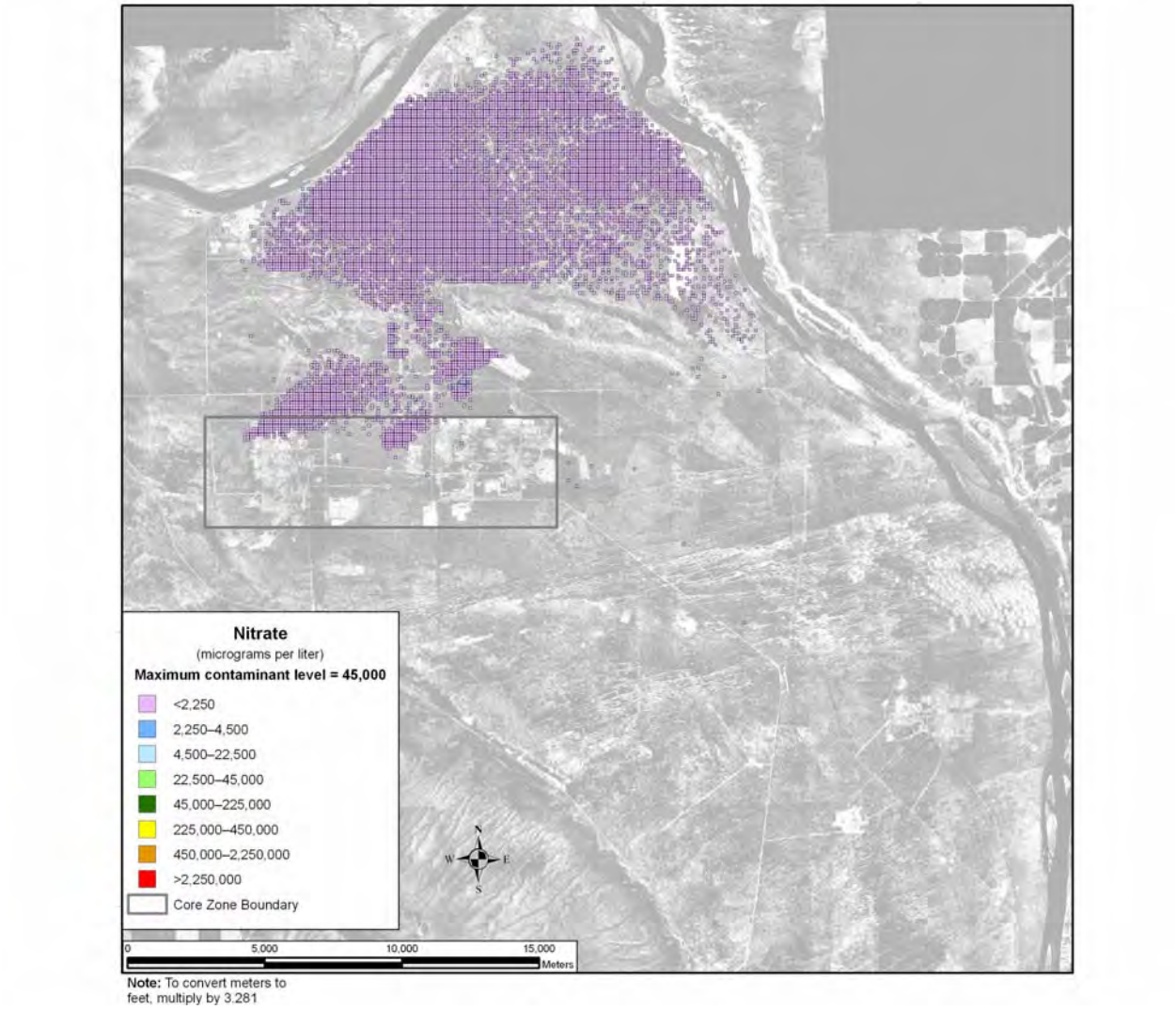


Figure 5–847. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 3890

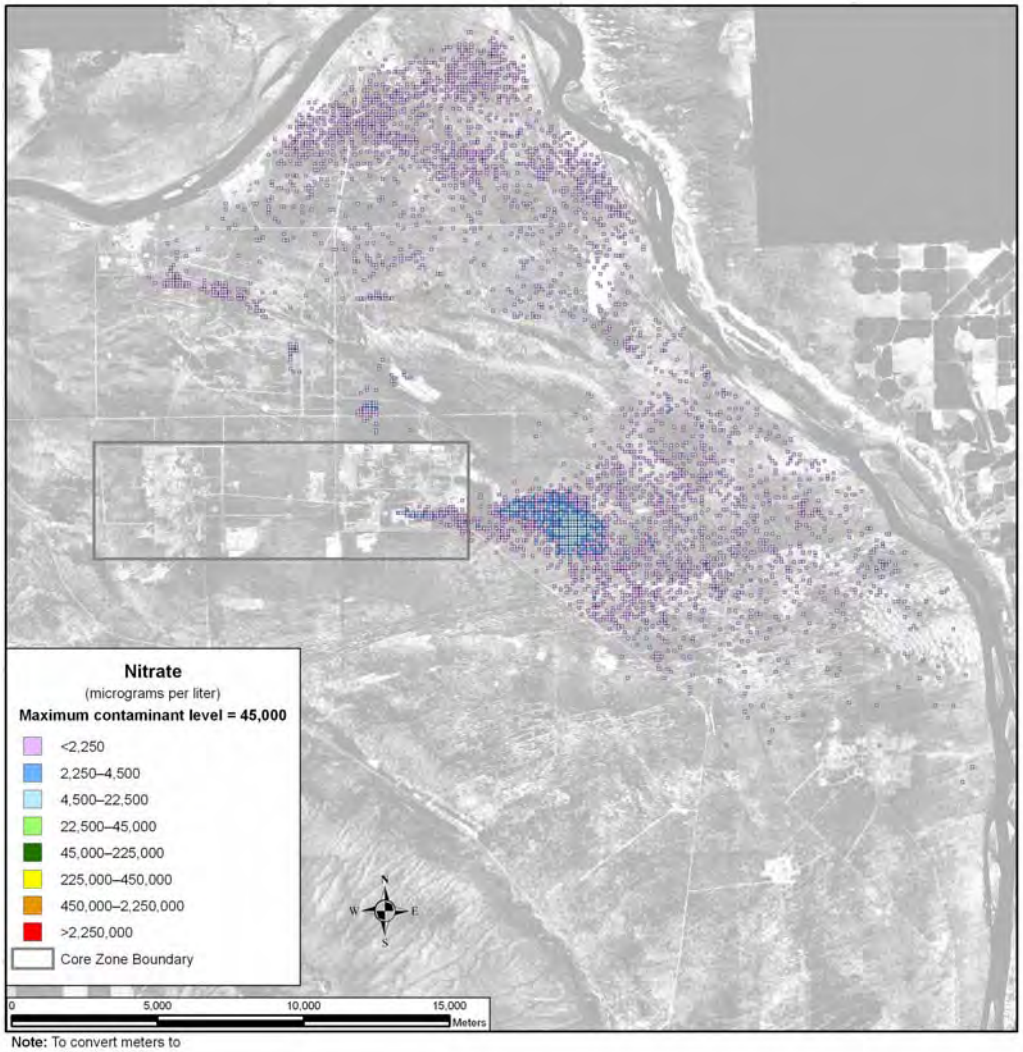


Figure 5–848. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 7140

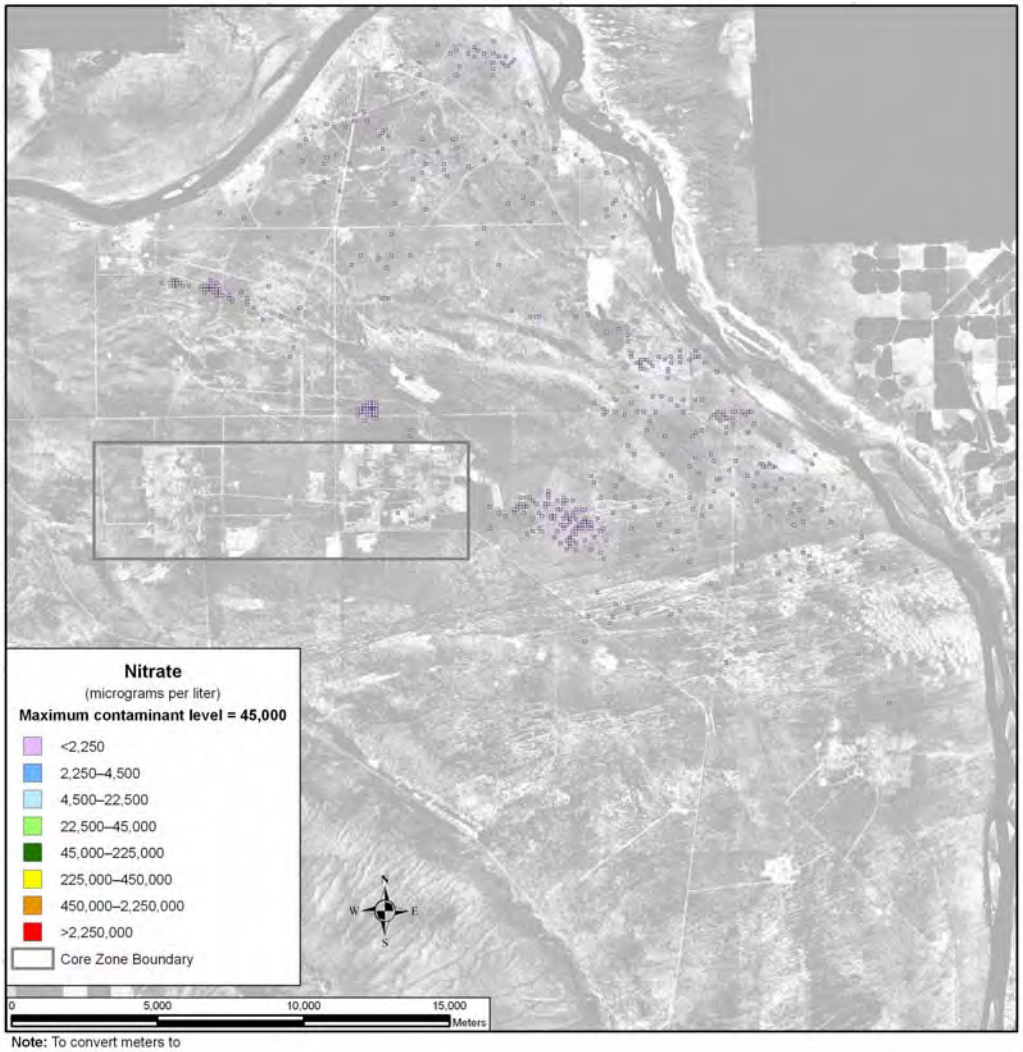


Figure 5–849. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 11,885

The CY 3890 and CY 7140 chromium releases in Figures 5–850 and 5–851 are nearly identical to the respective nitrate releases. Chromium concentrations appear to approach the benchmark concentration in the same locale as nitrate. By CY 11,885 (see Figure 5–852), the chromium release has dissipated, but a significant a amount of chromium remains distributed between IDF-East and the Columbia River nearshore. Chromium released from IDF-West and the RPPDF has almost totally dissipated.

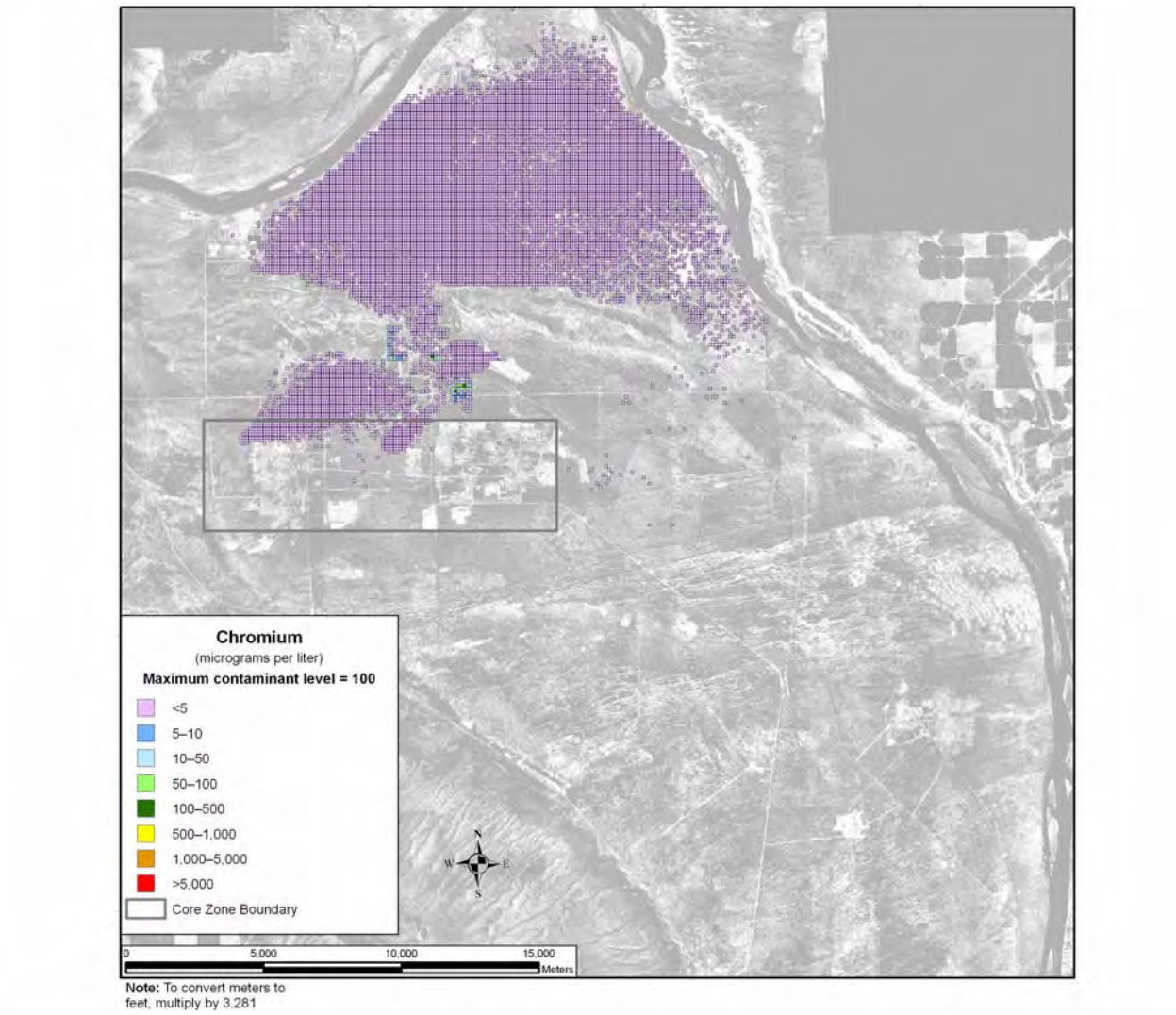


Figure 5–850. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 3890

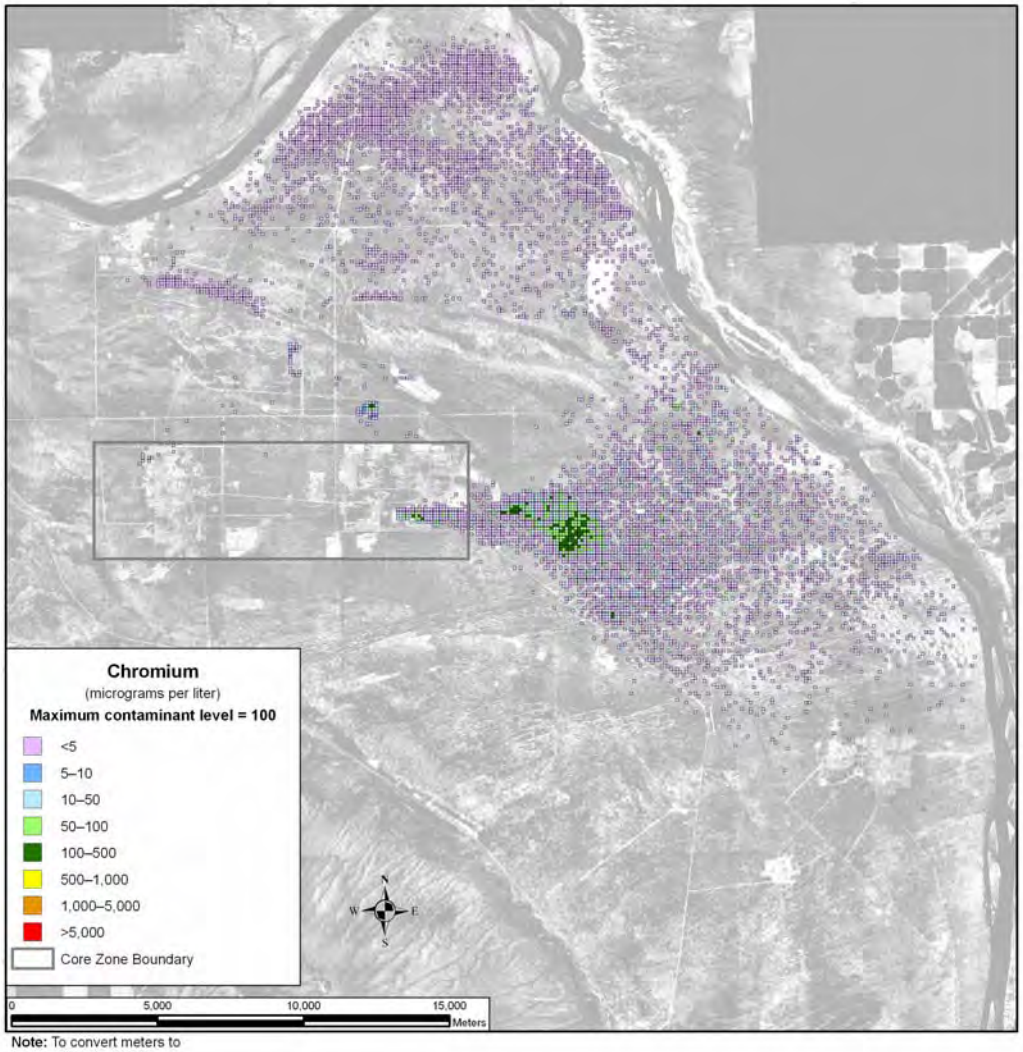


Figure 5–851. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 7140

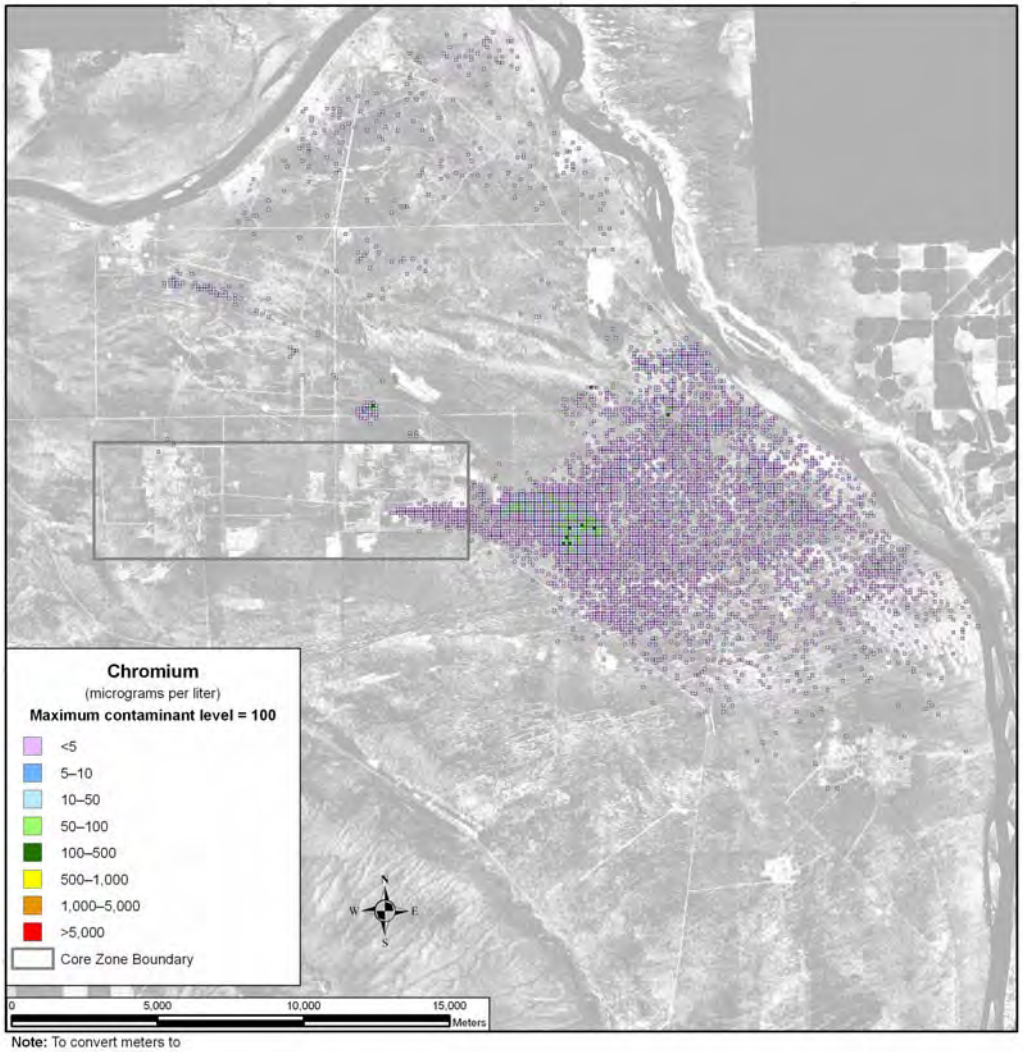


Figure 5–852. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 11,885

The uranium-238 and total uranium spatial distributions in Figures 5–853 and 5–854 (both CY 11,885) show a uranium-238 plume from IDF-West and a total uranium plume from the RPPDF. There are no uranium-238 or total uranium releases from IDF-East. The uranium-238 and total uranium releases are distributed in the same locales as the other releases from these sites. The concentrations in both releases remain well below the respective uranium-238 and total uranium benchmark concentrations. The data show retardation with similar distributions and concentrations extending from the release sites to the Columbia River nearshore.

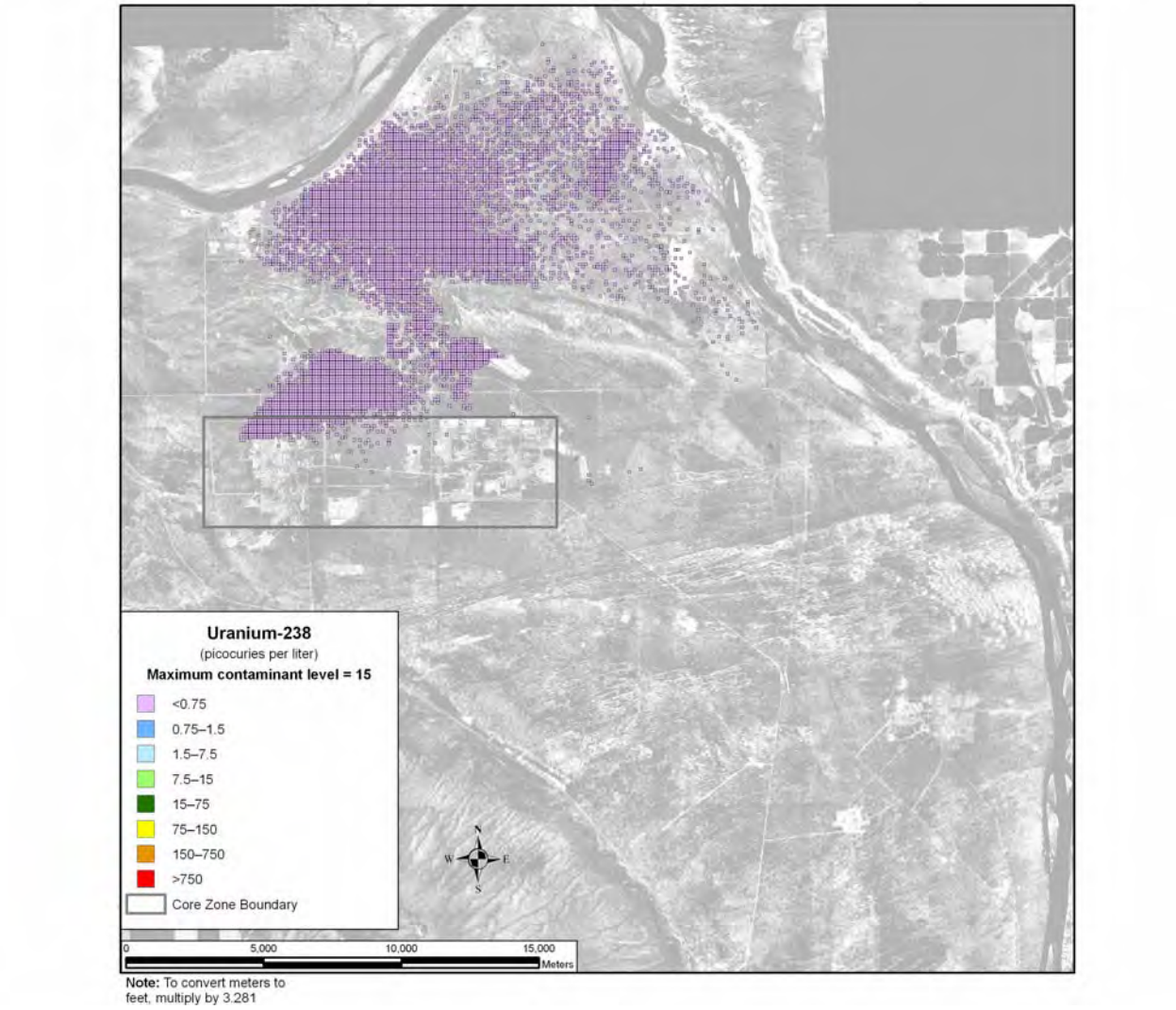


Figure 5–853. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Uranium-238 Concentration During the Calendar Year 11,885

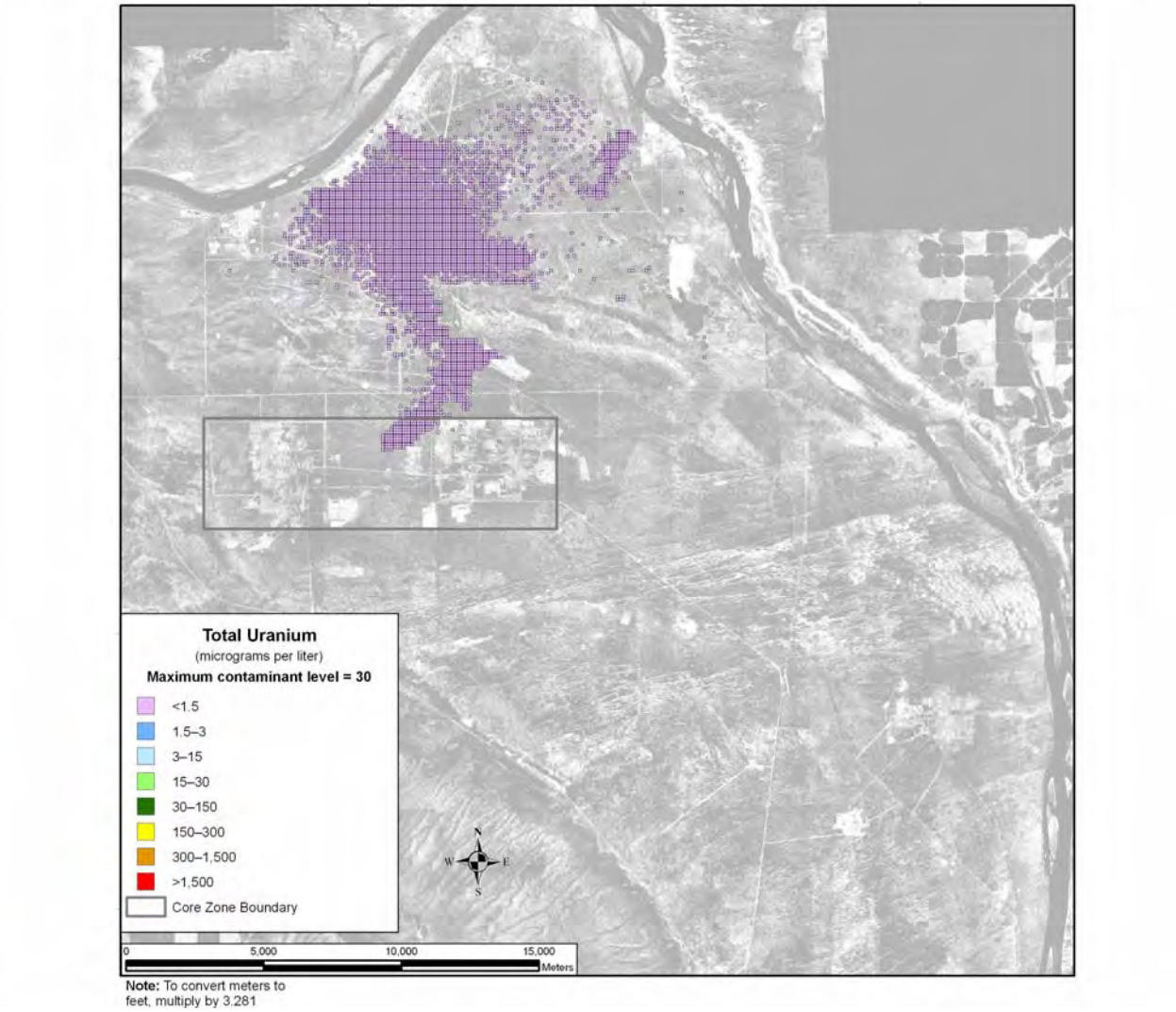


Figure 5–854. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Total Uranium Concentration During the Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, in general, the inventory remaining at IDF-West are predominant contributors. The releases from IDF-East and the RPPDF are secondary contributors.

By the end of this period of analysis (CY 11,885), the chromium and nitrate distributions have largely dispersed below their benchmark concentrations. A significant spatial distribution of technetium-99 and iodine-129 remain. Most of the distribution area has concentrations below benchmark levels, but there are some small areas where technetium-99 and iodine-129 concentrations exceed the benchmark levels at CY 11,885. The released iodine-129, which occurs at higher concentration levels relative to its benchmark than technetium-99, dissipates much more quickly than technetium-99.

For uranium-238 and total uranium, their relatively, limited mobility is an important factor governing the time-frames and scale of groundwater impacts. The concentrations of these retarded species do not exceed their benchmark levels at the Core Zone Boundary or Columbia River nearshore over this period

of analysis. However, the spatial distributions of both uranium-238 and total uranium exist through the end of the analysis period (CY 11,885). Although the concentrations of uranium-238 and total uranium are both 2 orders of magnitude smaller than either benchmark concentrations during this analysis period, the trend appears to show a continuing increase through the end of the analysis period.

5.3.1.3.1.5 Disposal Group 1, Subgroup 1-E

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E covers disposal of waste generated under Tank Closure Alternative 3C, FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Tank closure waste would be converted to IHLW, ILAW glass, bulk vitrification glass, and cast stone waste.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period would start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, nitrate, and acetonitrile.

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrate, and acetonitrile) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, (IDF-East, IDF-West, and RPPDF releases), in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–855 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–856, the chemical hazard drivers. The inventories in the six waste forms are a major factor in the release quantities to the vadose zone. The predominant source of vadose zone technetium-99 is cast stone waste (94 percent), with the remainder coming from bulk vitrification glass (5 percent) and tank closure secondary waste (1 percent). The vadose zone iodine-129 is from ETF-generated secondary waste (75 percent) and cast stone waste (23 percent), as well as tank closure secondary waste (2 percent). The predominant source of chromium (greater than 99 percent) and acetonitrile (greater than 99 percent) is cast stone waste. The sources of nitrate release to the vadose zone are cast stone waste (84 percent) and ETF-generated secondary waste (greater than 16 percent). No boron or fluoride is released from IDF-East.

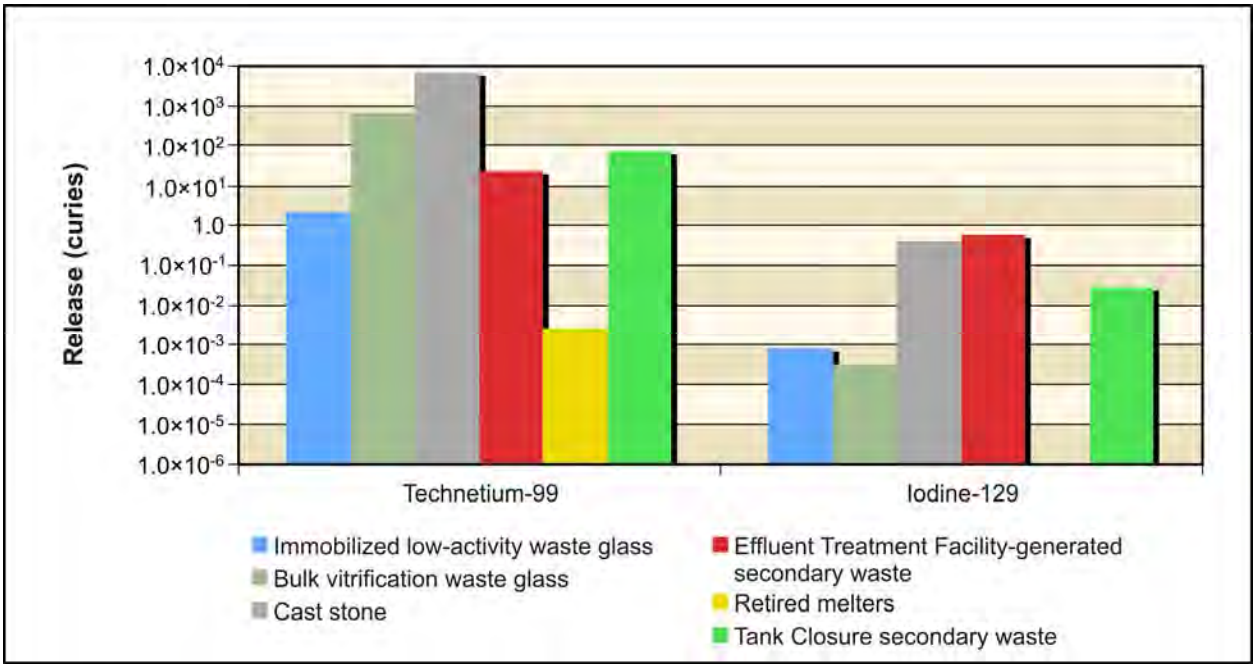


Figure 5–855. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

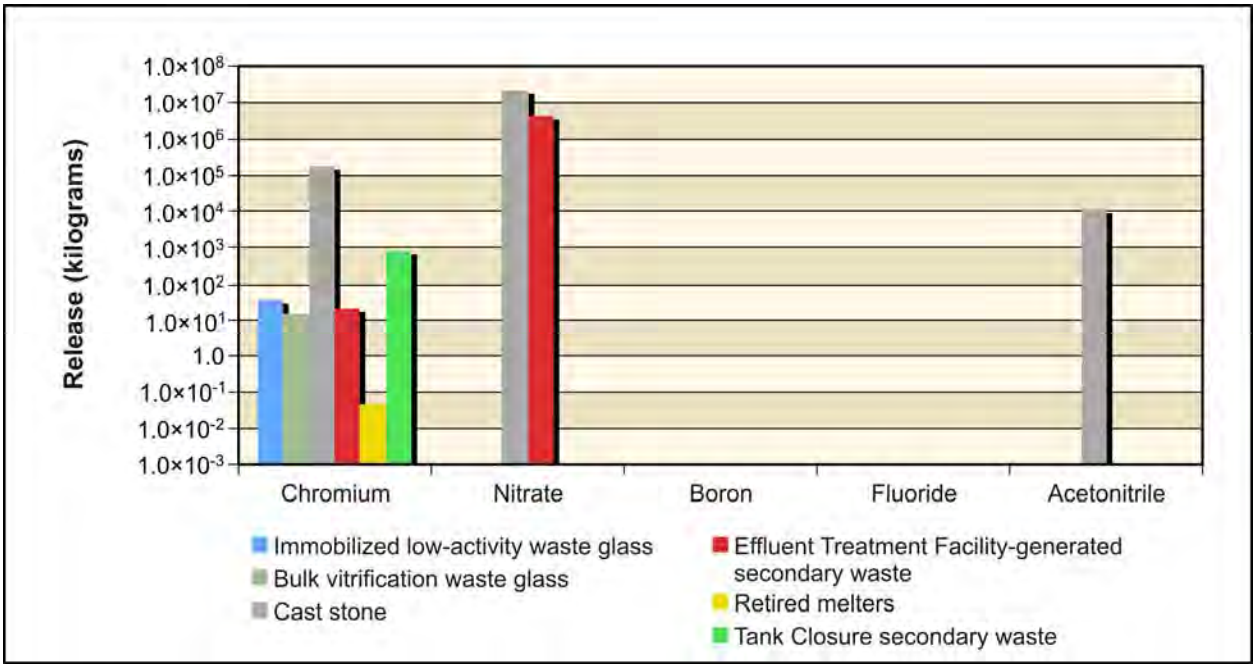


Figure 5–856. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–857 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–858, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. The vadose zone releases some technetium-99 (46 percent) and iodine-129 (43 percent) to the groundwater. Nearly all (99 percent) of the vadose zone chromium, nitrate, and acetonitrile are released to the groundwater.

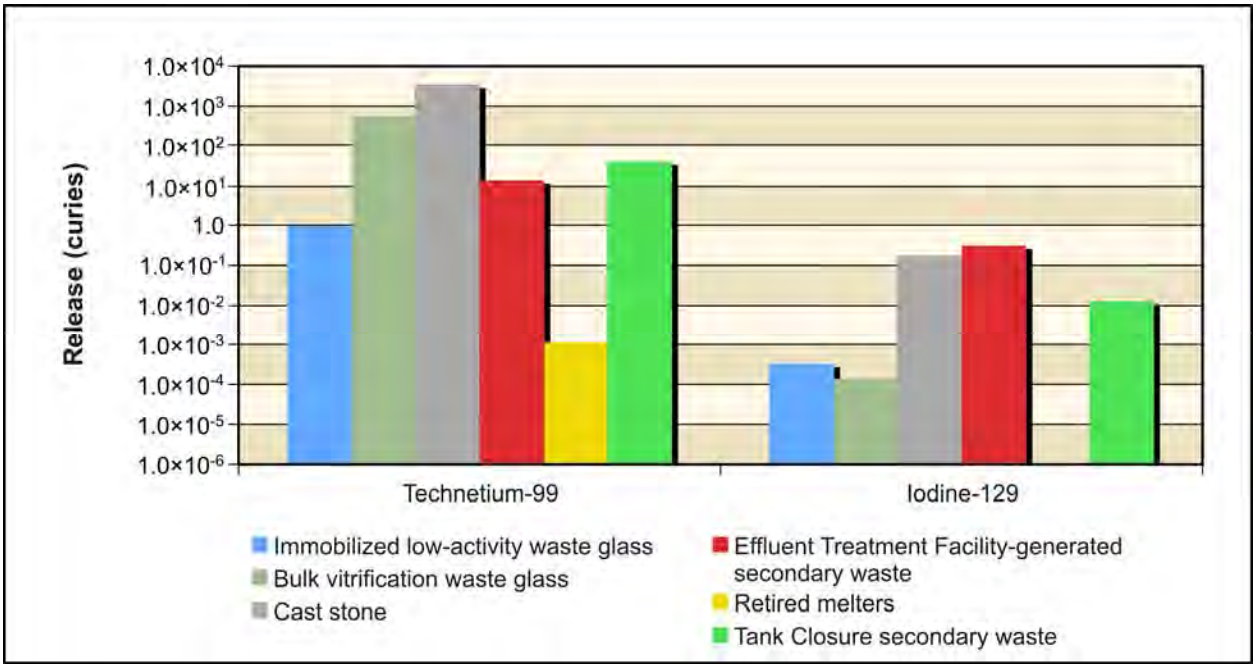


Figure 5–857. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

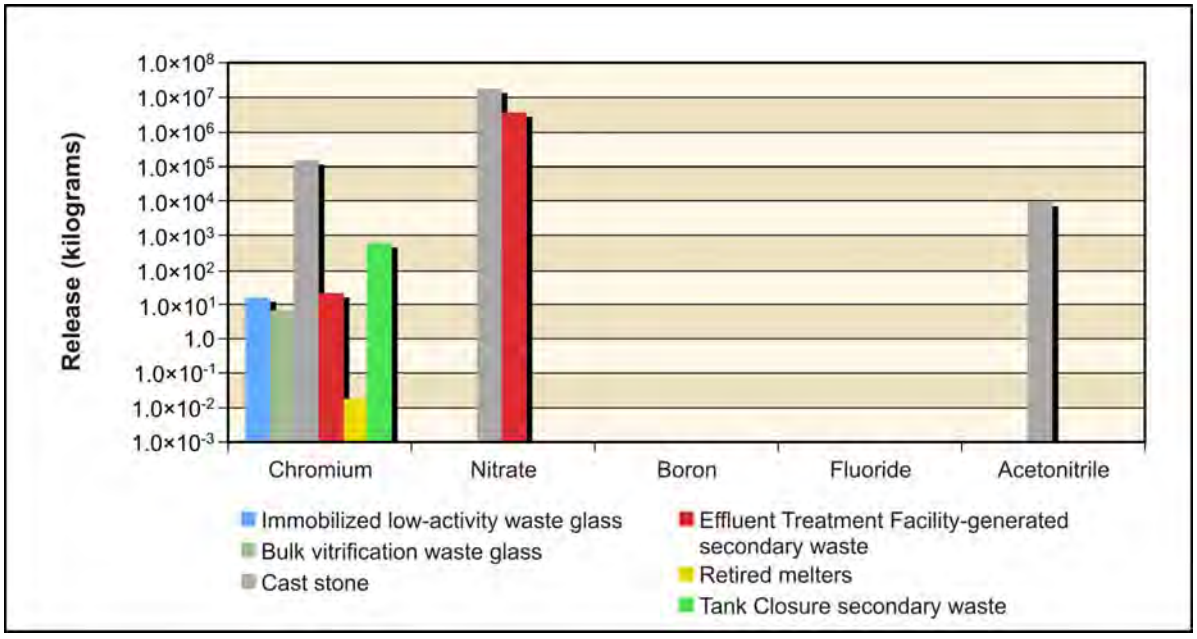


Figure 5–858. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–859 shows the estimated release at the Columbia River for the radiological risk drivers and Figure 5–860, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. The groundwater releases most of its iodine-129 (90 percent), chromium (97 percent), nitrate (98 percent), and acetonitrile (97 percent) to the Columbia River. Some vadose zone technetium-99 (68 percent) is also released.

Overall, most of the IDF-East vadose zone chromium (96 percent), nitrate (97 percent), and acetonitrile (96 percent) and some of the vadose zone technetium-99 (31 percent) and iodine-129 (39 percent) reach the Columbia River over the period of analysis.

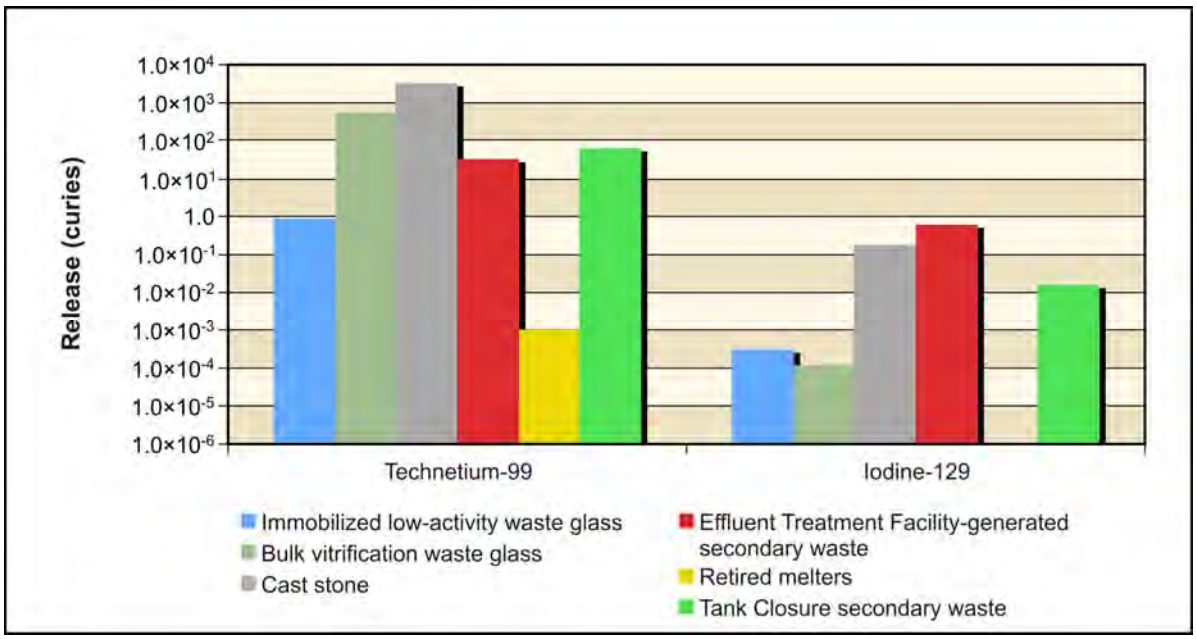


Figure 5–859. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

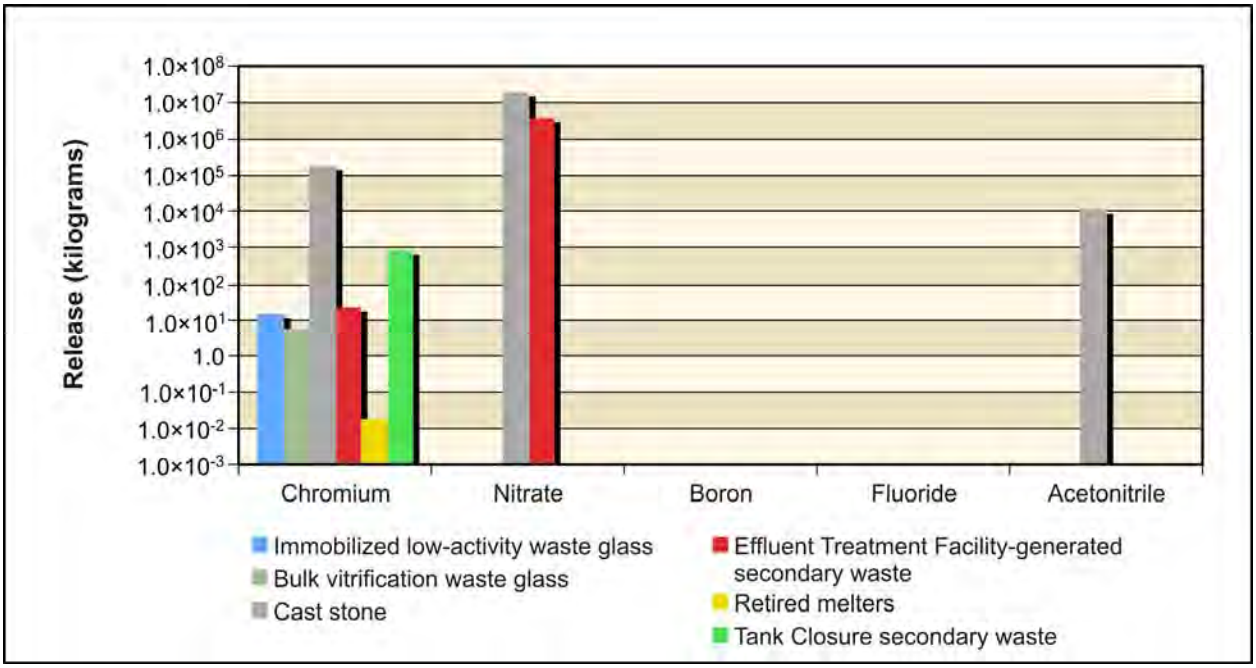


Figure 5–860. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary, and onsite- and offsite-generated waste.

Figure 5–861 shows the release to the vadose zone for the radiological risk drivers and Figure 5–862, the chemical hazard drivers. The inventories in the three waste forms are a major factor in the release quantities to the vadose zone. Offsite-generated waste is the predominate source of the technetium-99 (greater than 99 percent) and iodine-129 (greater than 99 percent) released to the vadose zone. Essentially all (greater than 99 percent) of the nitrate, boron, and fluoride that is released to the vadose zone is from waste management secondary and onsite-generated waste. Chromium released to the vadose zone is from waste management secondary and onsite-generated waste, (66 percent) and offsite-generated waste (34 percent). No acetonitrile is released from IDF-West.

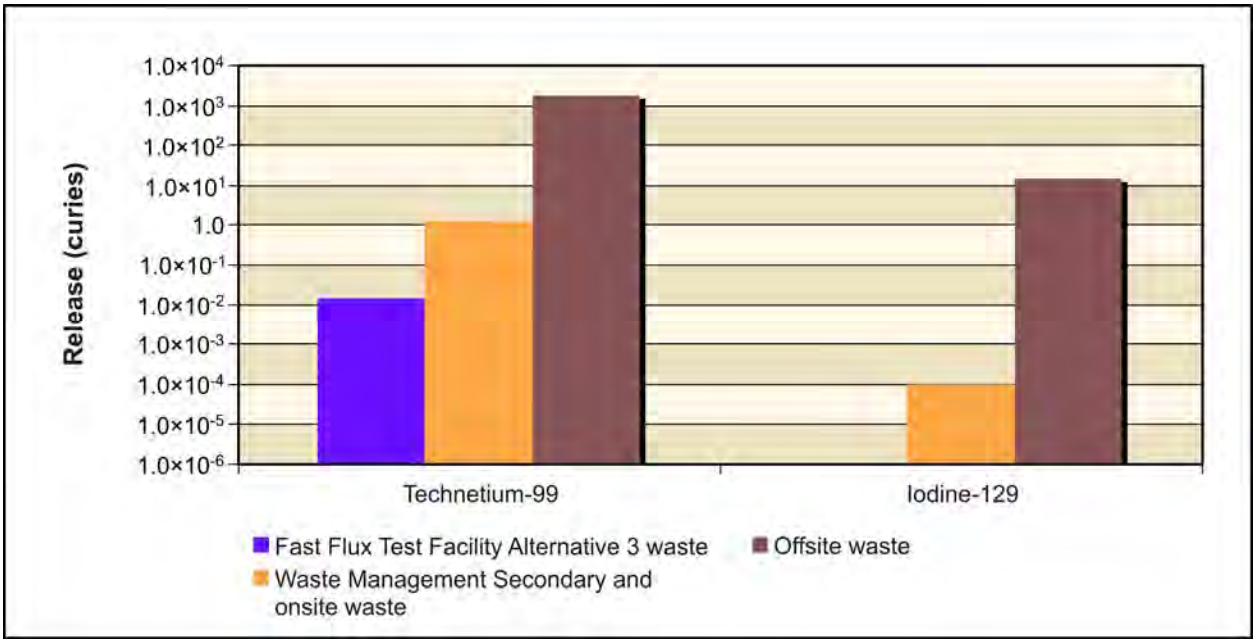


Figure 5–861. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

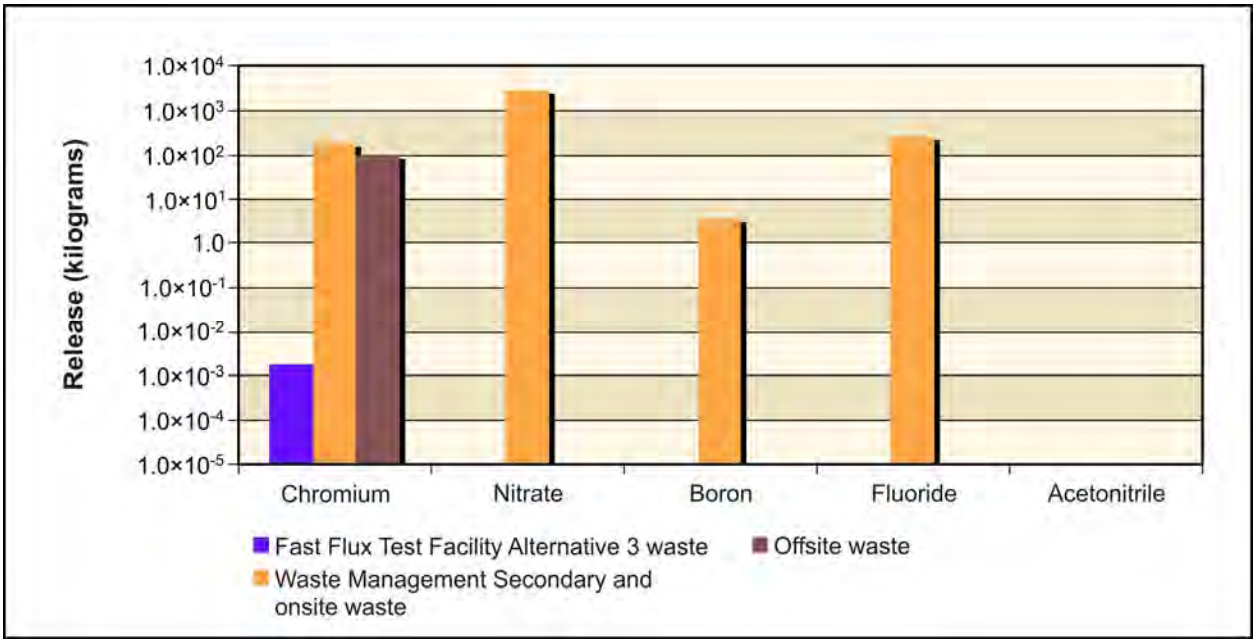


Figure 5–862. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–863 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–864, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the IDF-West vadose zone technetium-99 (98 percent), iodine-129 (99 percent), chromium (99 percent), nitrate (greater than 99 percent), boron (greater than 99 percent), and fluoride (greater than 99 percent) are released to the groundwater during the period of analysis.

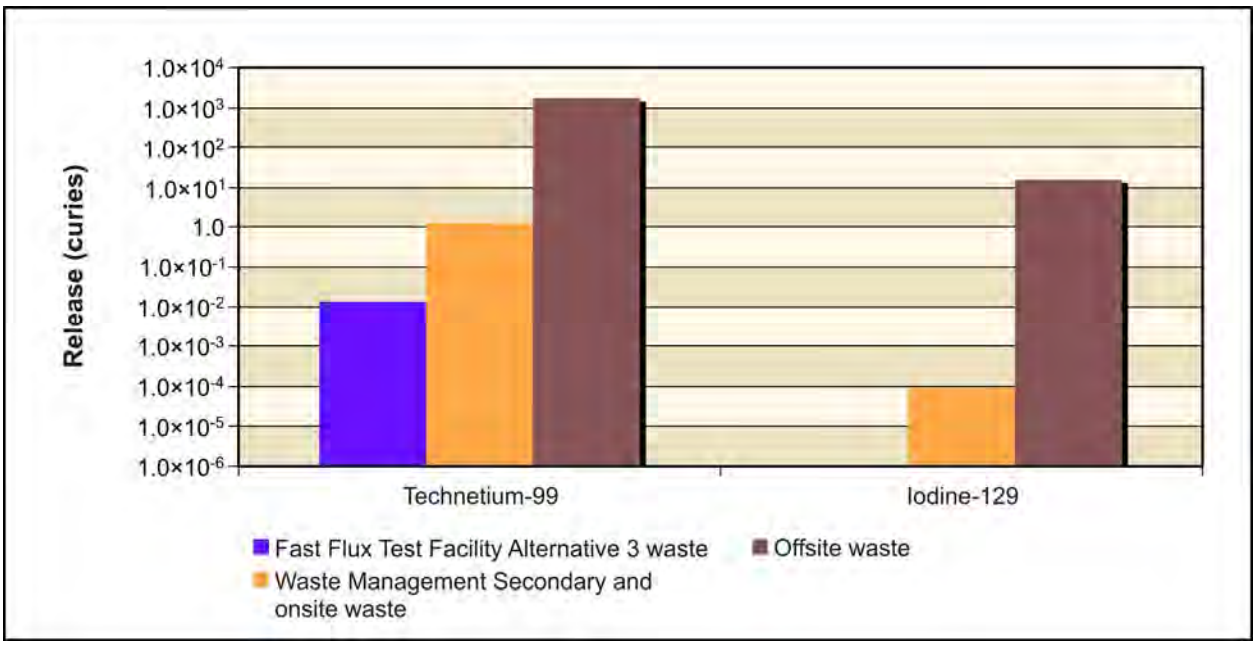


Figure 5–863. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

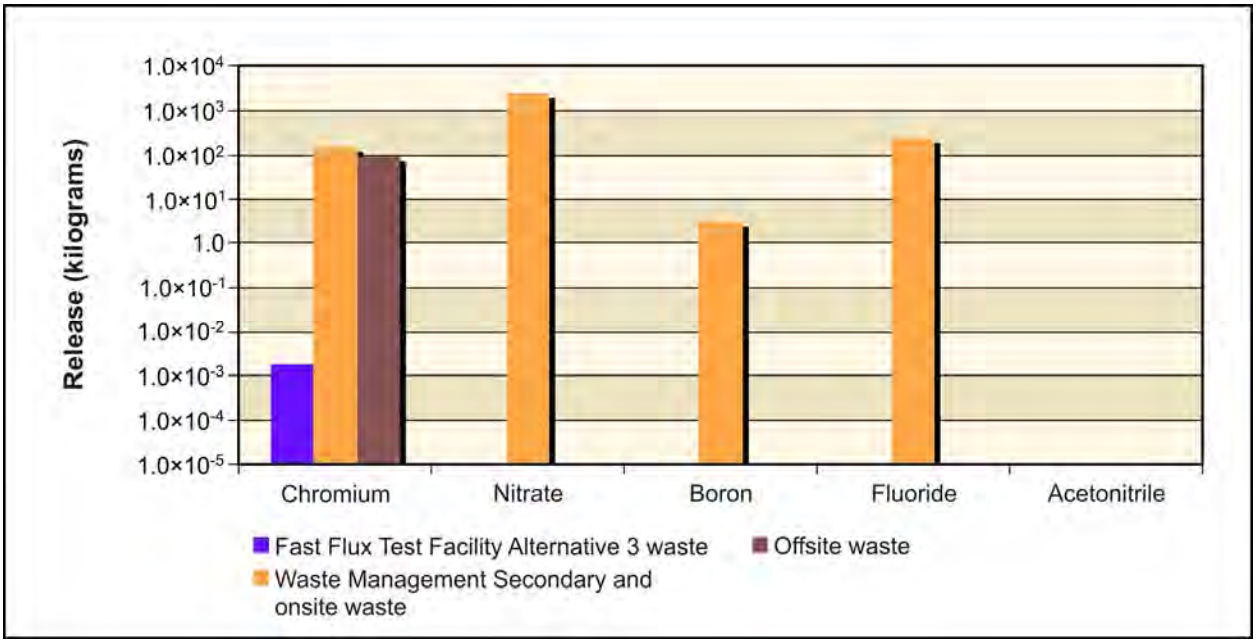


Figure 5–864. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–865 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–866, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (97–98 percent) of the IDF-West groundwater technetium-99, iodine-129, chromium, nitrate, boron, and fluoride are released to the Columbia River over the period of analysis.

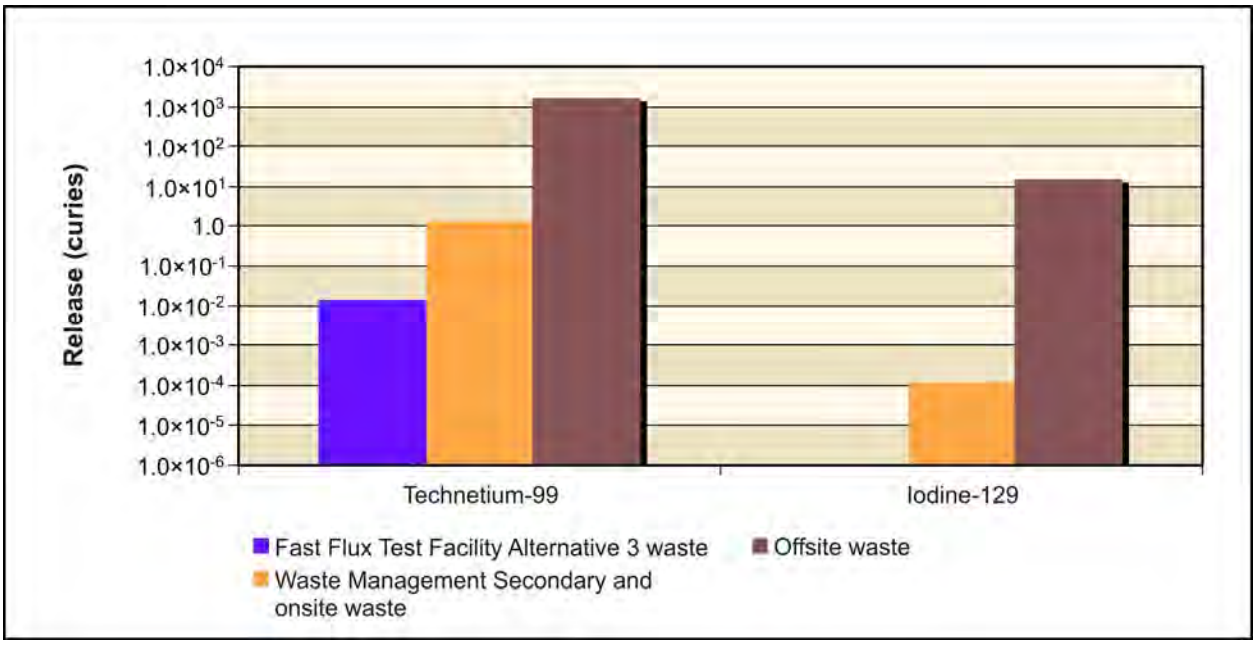


Figure 5–865. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

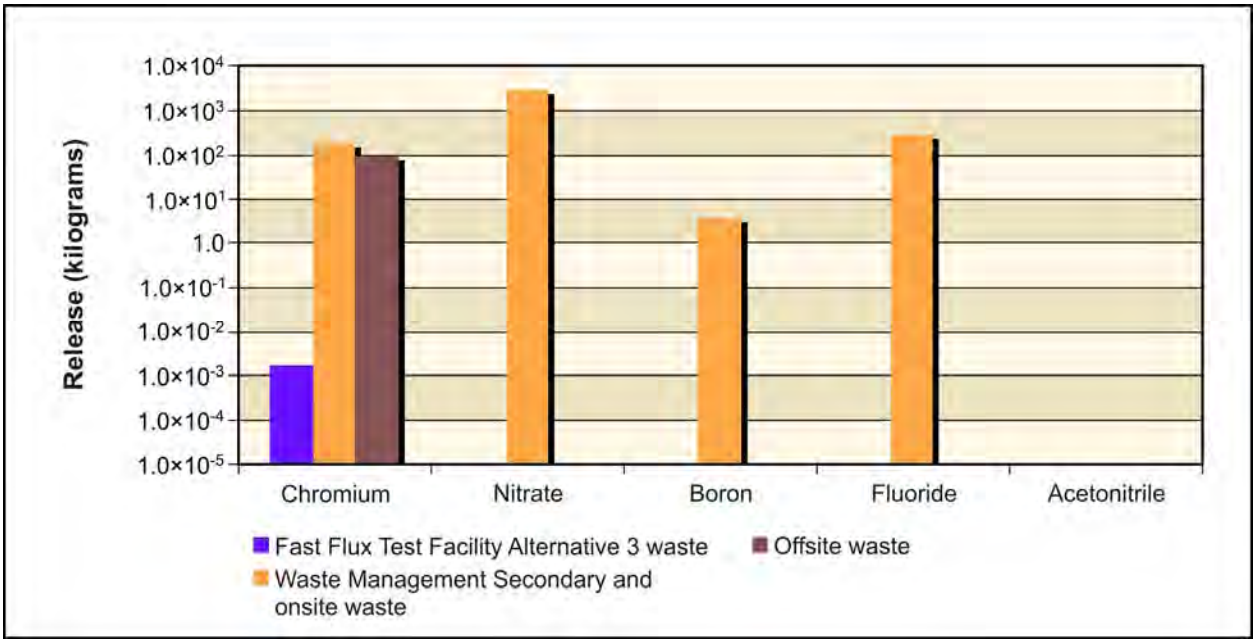


Figure 5–866. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

Overall, most (96-98 percent) of the IDF-West vadose zone technetium-99, iodine-129, chromium, nitrate, boron, and fluoride reach the Columbia River over the period of analysis.

River Protection Project Disposal Facility

Figure 5–867 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–868, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). No fluoride, boron, or acetonitrile is released from the RPPDF.

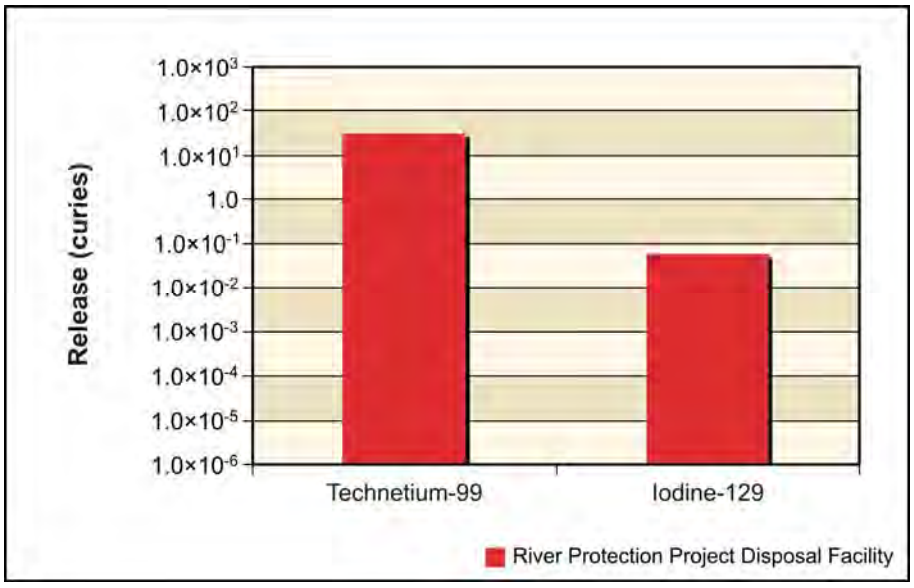


Figure 5–867. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

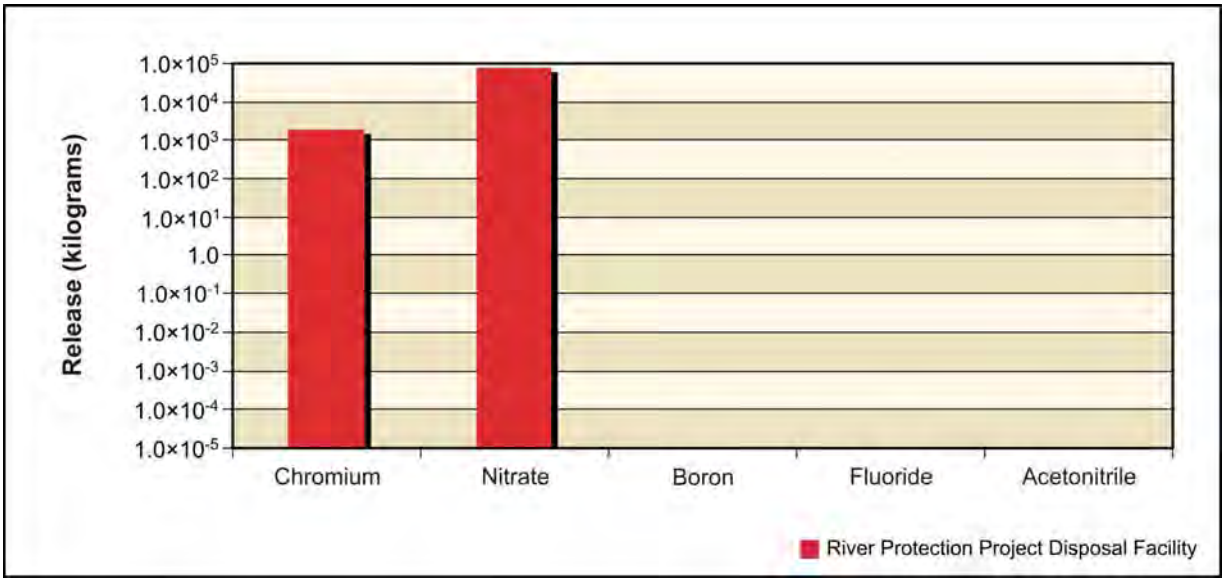


Figure 5–868. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–869 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–870, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Essentially all (99 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate are released to the groundwater.

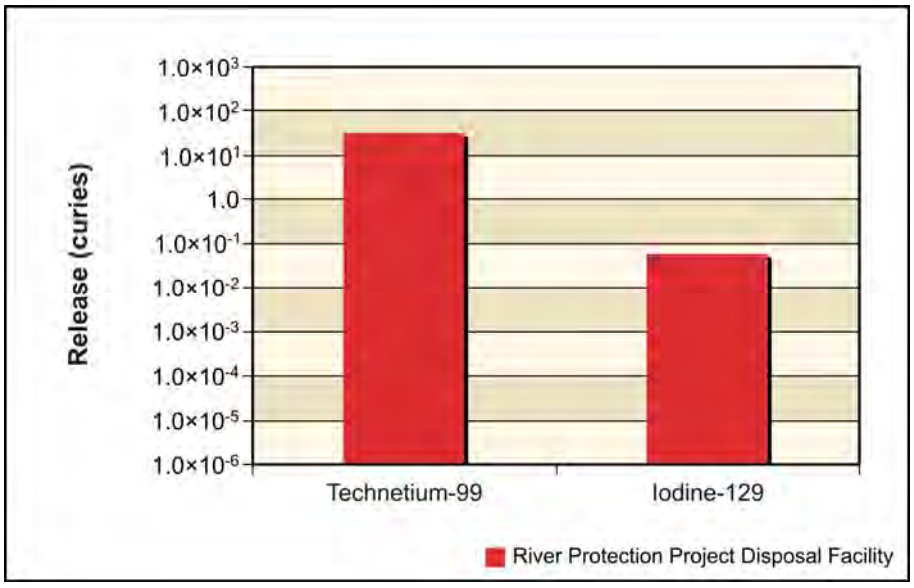


Figure 5–869. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Groundwater

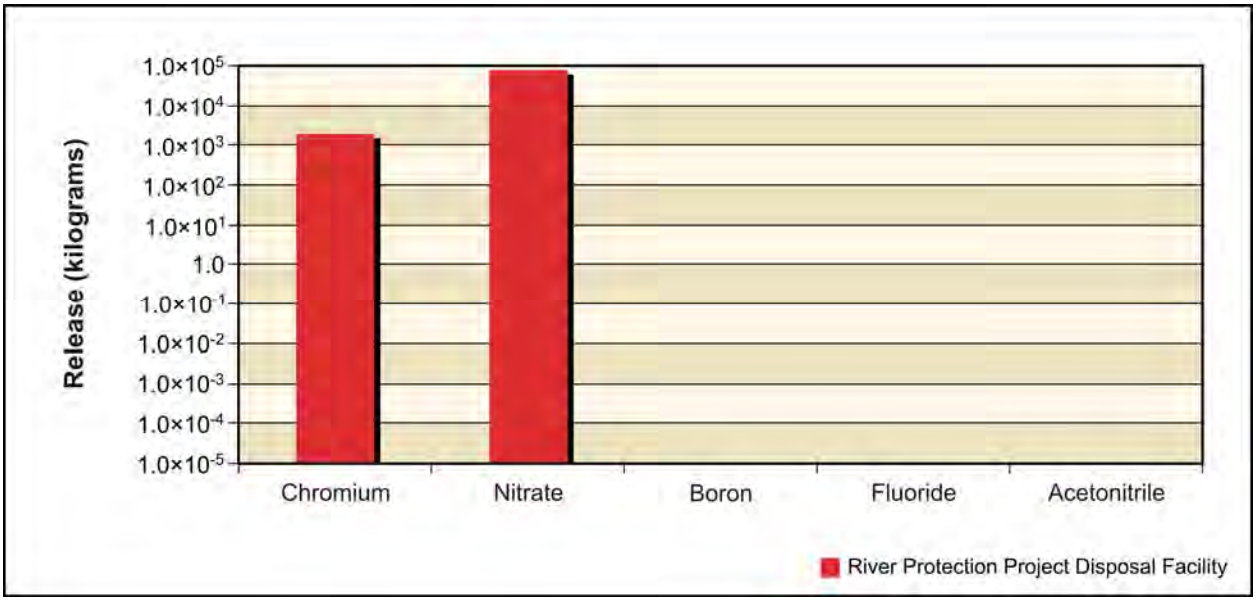


Figure 5–870. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–871 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–872, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (96 percent) of the groundwater technetium-99, iodine-129, chromium, and nitrate are released to the Columbia River.

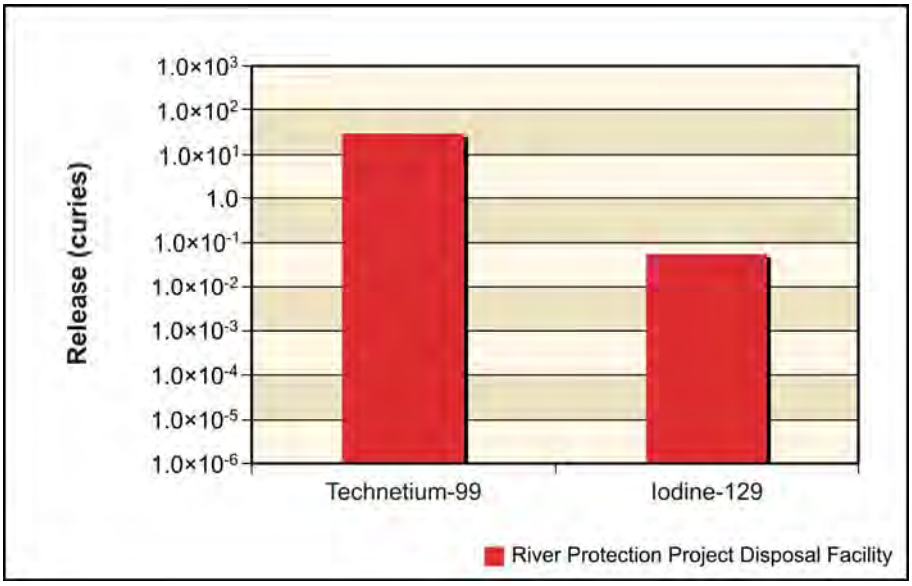


Figure 5–871. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Columbia River

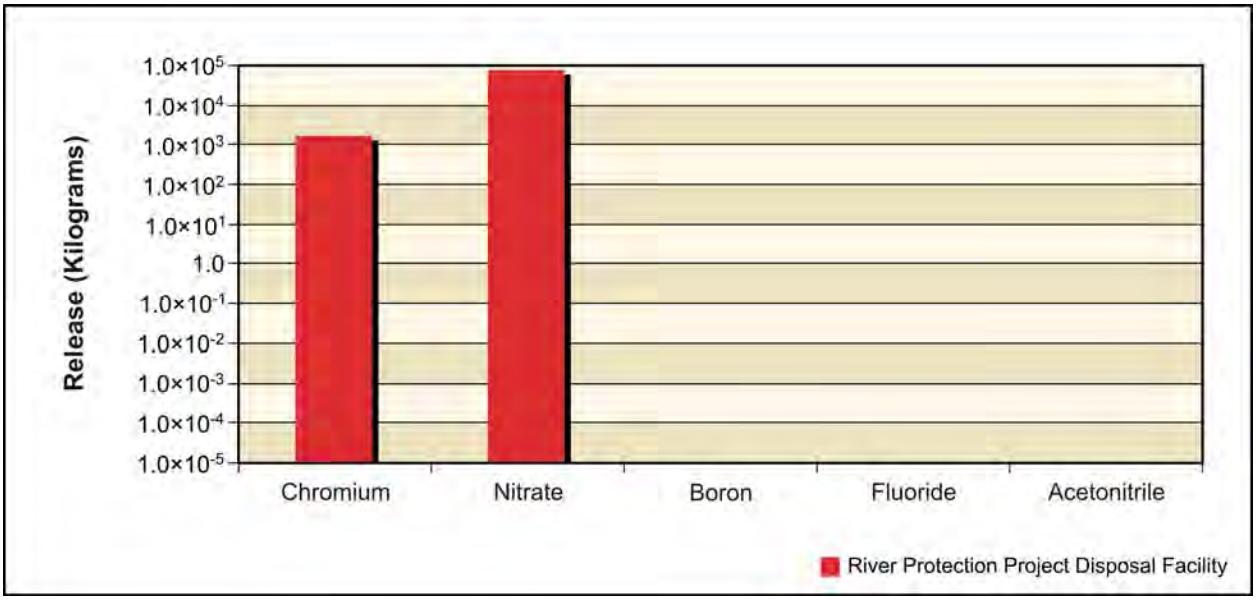


Figure 5–872. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Columbia River

Overall, most (95–96 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate reached the Columbia River during the period of analysis.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–93 shows the maximum concentrations in groundwater.

Table 5–93. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**5,640**	**20,200**	103	**7,600**	**2,030**	900
	(9826)	(3713)	(3822)	(3690)	(8117)	
Iodine-129	**1**	**173**	0.2	**60**	**8**	1
	(11,228)	(3797)	(3940)	(3853)	(4728)	
Chemical in micrograms per liter						
Chromium	**223**	2	6	96	64	100
	(9069)	(3696)	(3804)	(8643)	(8079)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	29,000	17	229	13,900	6,380	45,000
	(9330)	(3703)	(4042)	(8994)	(8673)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–873 through 5–876 show concentration versus time for technetium-99, iodine-129, chromium, and nitrate, respectively. The releases of technetium-99 from IDF-East, IDF-West, and the RPPDF result in concentrations at the Core Zone Boundary and the Columbia River nearshore that exceed the technetium-99 benchmark concentration over part of the period of analysis (see Figure 5–873). There is a relatively narrow technetium-99 increase after the post-disposal period, when the Core Zone Boundary concentration exceeds the benchmark concentration for about 1,000 years. The peak, at about CY 3800, is less than one order of magnitude greater than the benchmark concentration. The Core Zone Boundary technetium-99 concentration then drops below the benchmark concentration to a level about equal to the Columbia River nearshore concentration. After a slight increase, both the Core Zone Boundary and the Columbia River nearshore technetium-99 concentrations remain at about the benchmark concentration level through the remainder of the period of analysis (CY 11,940).

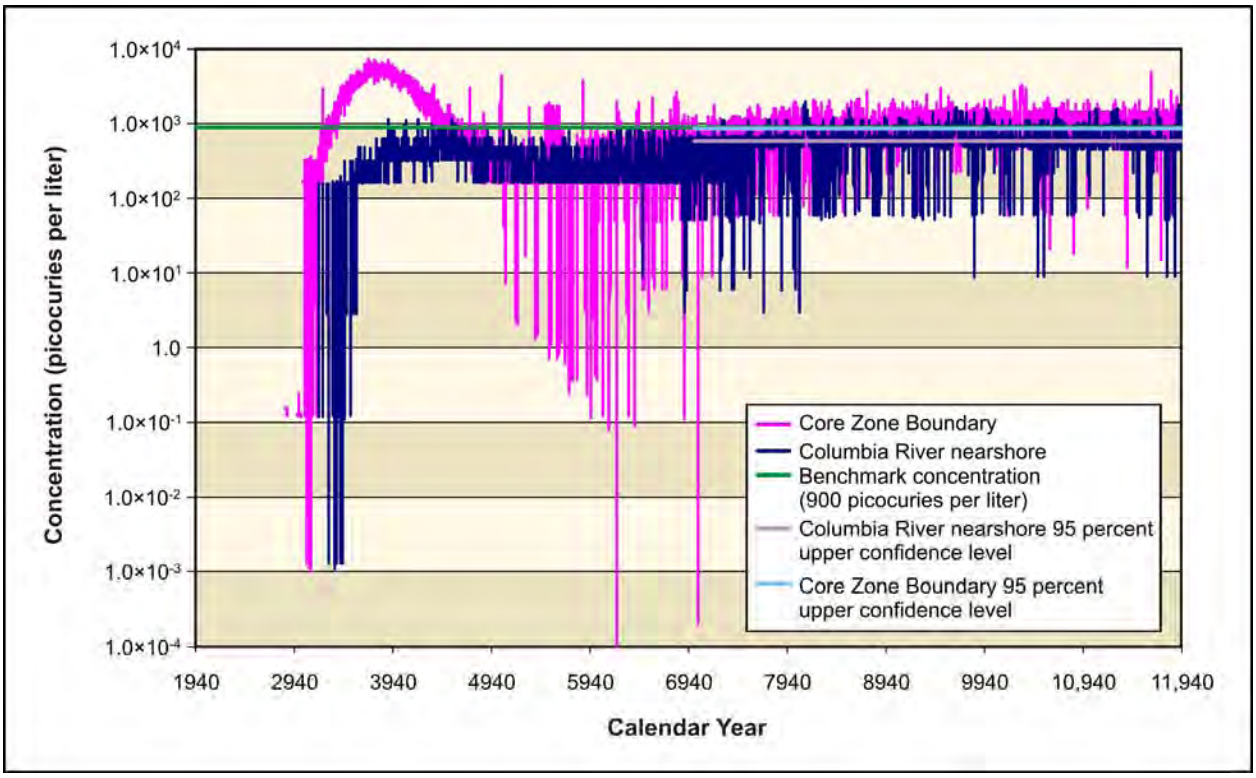


Figure 5–873. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Technetium-99 Concentration Versus Time

The iodine-129 concentration versus time (see Figure 5–874) shows a similar response at the Core Zone Boundary and the Columbia River nearshore. The iodine-129 peak at CY 3800 is less than two orders of magnitude greater than the benchmark concentration. The iodine-129 then decreases to the benchmark concentration level and remains at about the benchmark concentration level at both the Core Zone Boundary and Columbia River nearshore through the remainder of this period of analysis (CY 11,940).

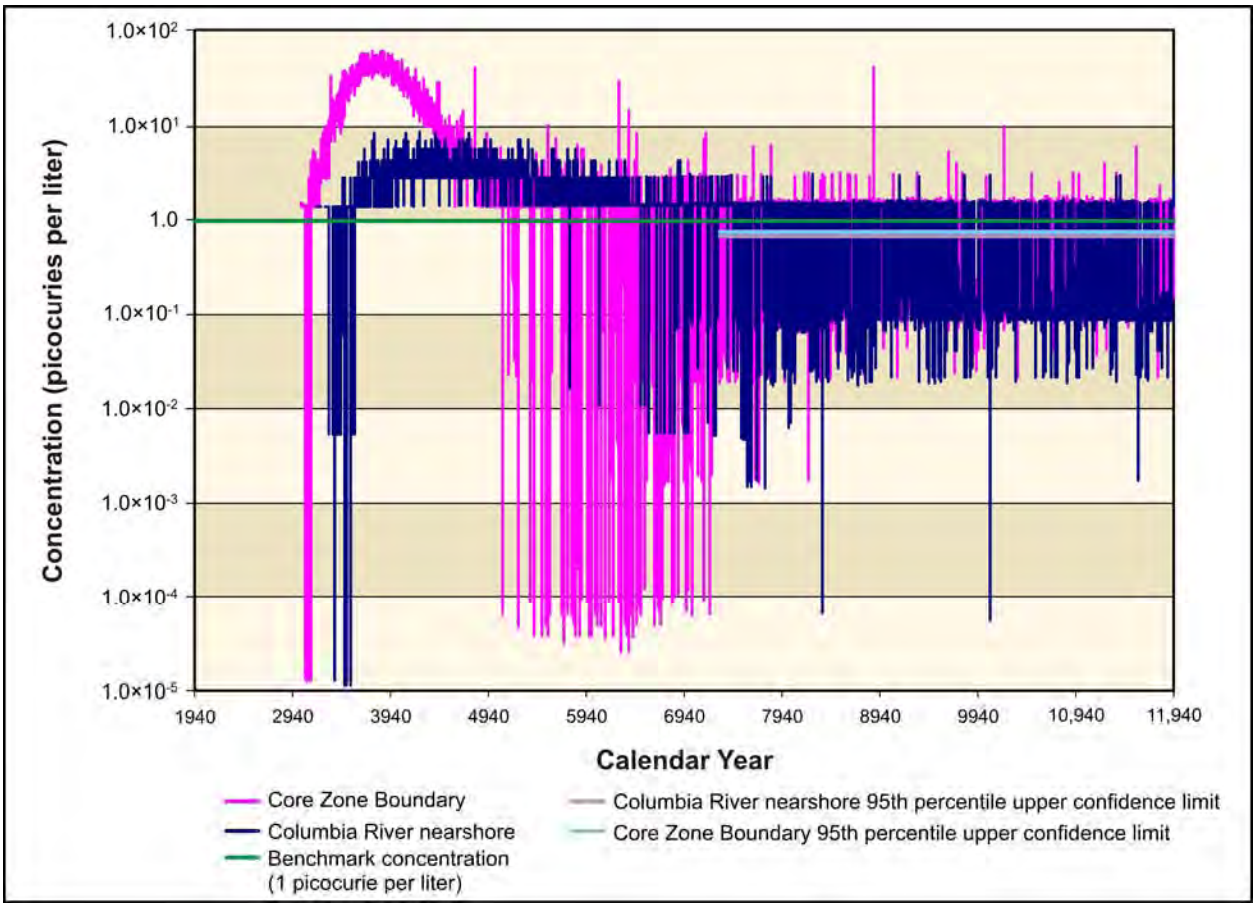


Figure 5–874. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Iodine-129 Concentration Versus Time

Figures 5–875 and 5–876 also show an initial increase in the Core Zone Boundary chromium and nitrate, followed by a second, broader increase period that peaks at about the two-thirds point of the analysis period. The chromium concentrations approach the benchmark concentration during the latter half of the analysis period, but then decline; the CY 11,940 concentrations are just under the benchmark concentration. The chromium concentrations are always less than the benchmark concentrations through the end of the analysis period. The nitrate concentration is always less than one order of magnitude from the benchmark concentration throughout the period of analysis at both the Core Zone Boundary and Columbia River nearshore.

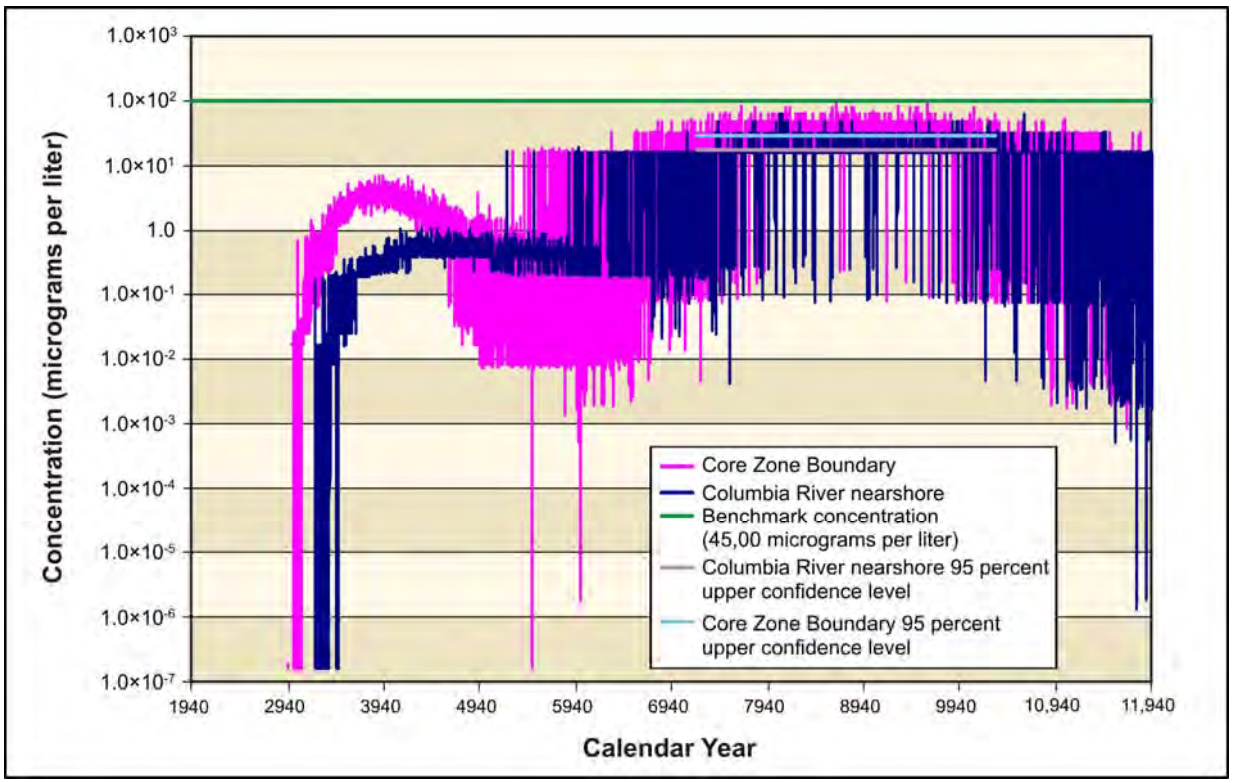


Figure 5–875. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chromium Concentration Versus Time

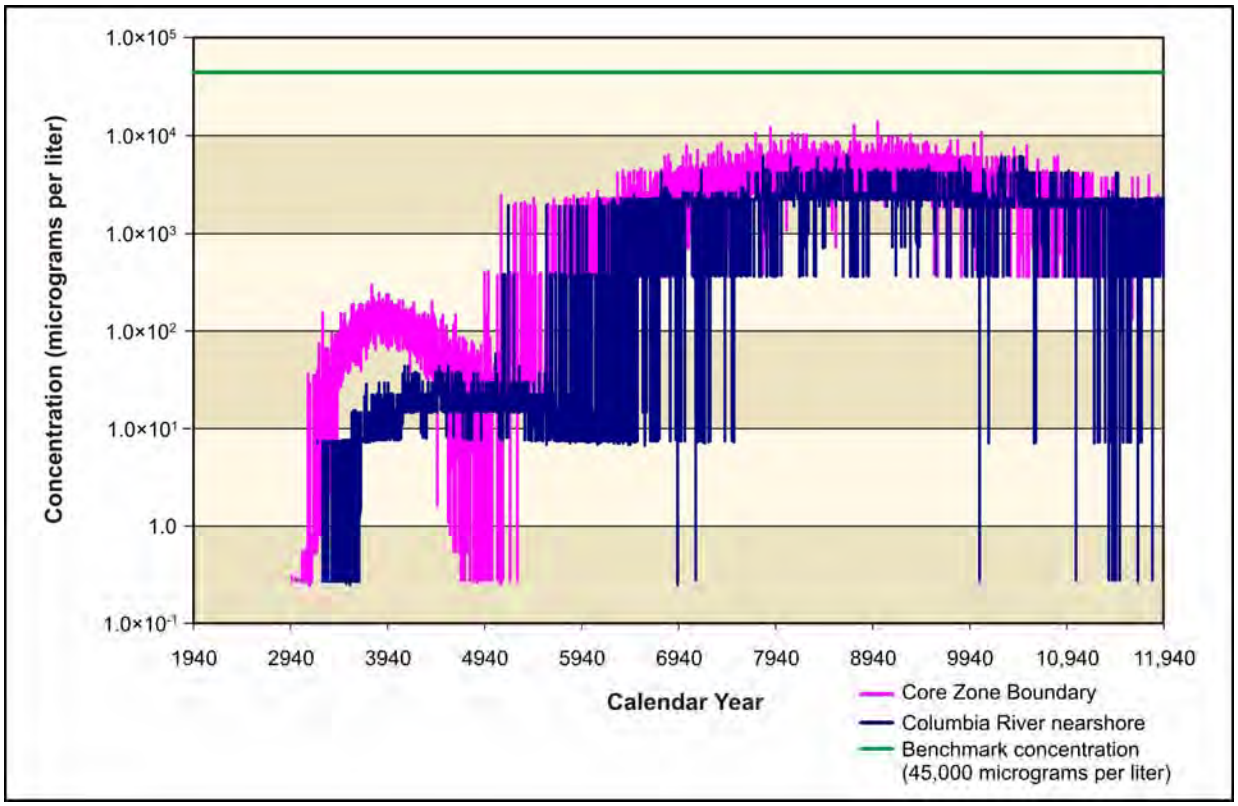


Figure 5–876. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Nitrate Concentration Versus Time

Figures 5–877 and 5–878 show concentration versus time for uranium-238 and total uranium, respectively. Because uranium-238 and total uranium move slowly through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations at the Core Zone Boundary and the Columbia River nearshore that are always significantly lower than the benchmark concentrations. Toward the latter half of the period of analysis, both the uranium-238 (see Figure 5–877) and total uranium (see Figure 5–878) concentrations at the Core Zone Boundary and Columbia River nearshore increase. The Core Zone Boundary uranium-238 is at least two orders of magnitude less than the benchmark concentration at the end of the period of analysis (CY 11,940). The concentration at the Columbia River nearshore is even smaller (by about six orders of magnitude). The total uranium concentration at the Core Zone Boundary and the Columbia River nearshore shows a similar response, but the maximum levels of total uranium are always at least six orders of magnitude less than the total uranium benchmark concentration.

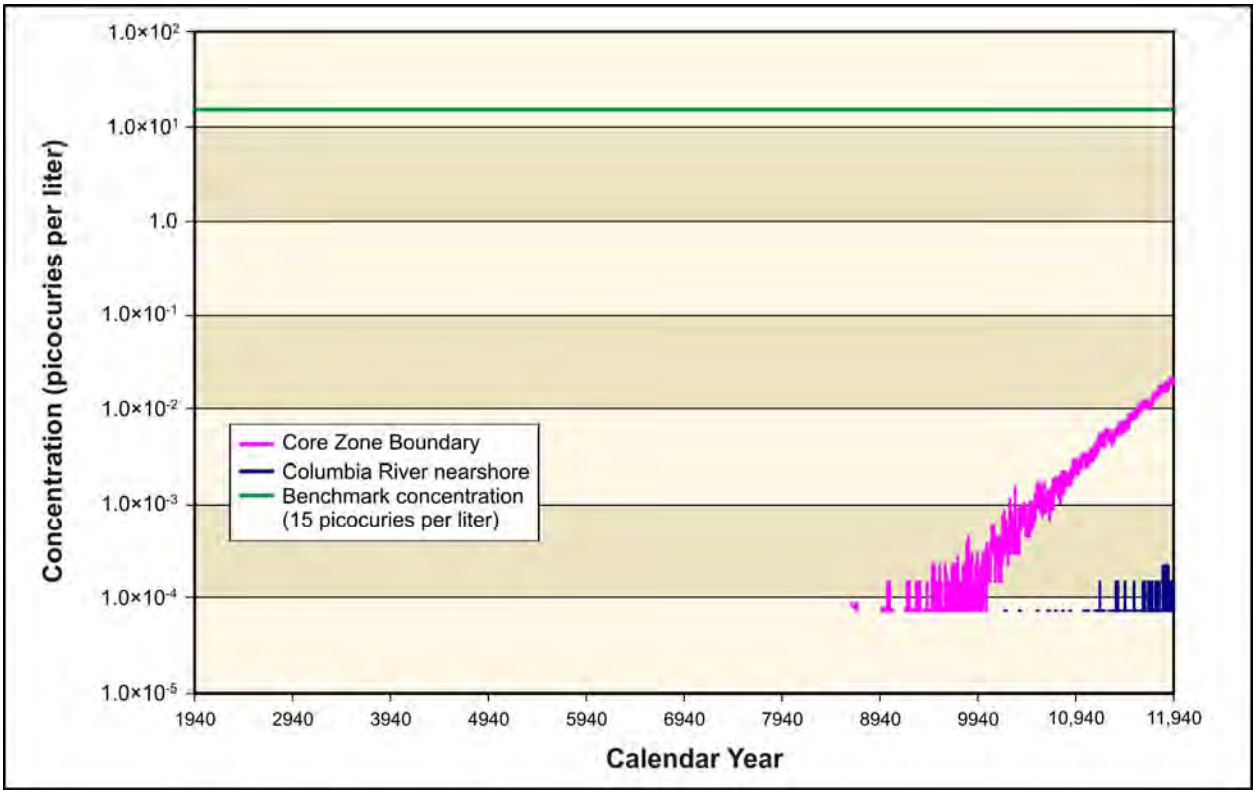


Figure 5–877. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Uranium-238 Concentration Versus Time

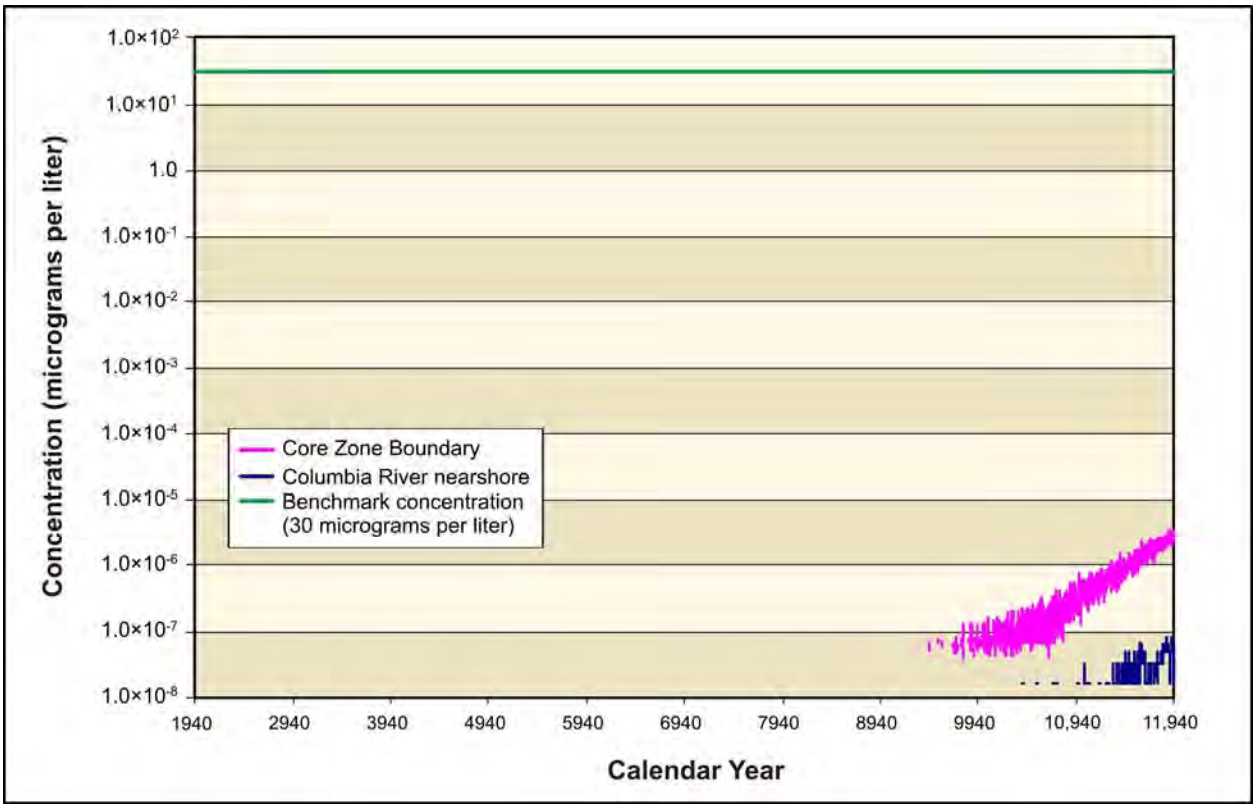


Figure 5–878. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–879 through 5–890 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. Figures 5–891 and 5–892 show the concentration distribution for uranium-238 and total uranium at CY 11,885. These data show the groundwater releases from the RPPDF and IFD-West that extend north from within the Core Zone to the Columbia River. These concentration distributions show that the releases of technetium-99, iodine-129, nitrate, and chromium occur significantly earlier at the RPPDF and IDF-West than the same releases at IDF-East. The RPPDF and IDF-West releases remain in a fairly narrow channel (Gable Gap) until about halfway to the Columbia River nearshore. The releases then spread out over the northern tip area of Hanford. The IDF-East releases remained in a relatively narrow channel until they reached about the one-quarter distance point to the Columbia River, where the releases spread out and continued to the Columbia River nearshore.

Figure 5–879 shows the technetium-99 release from IDF-West and the RPPDF in CY 3890. This spatial distribution shows that the technetium-99 exceeds the benchmark concentration within the Core Zone (due to the IDF-West release) and in several areas close to the Columbia River nearshore. There are several small areas with very high concentrations of technetium-99 (several orders of magnitude larger than the benchmark concentration) just north of the Core Zone Boundary. Figure 5–880 shows that the technetium-99 release from IDF-West and the RPPDF has dissipated by CY 7140 and only exists in areas close to the Columbia River nearshore at concentrations at least one order of magnitude lower than the benchmark concentration. This figure also shows a technetium-99 release distribution from IDF-East. This shows significant areas where the technetium-99 approaches or exceeds the benchmark concentration. Figure 5–881 shows the continued dissipation of the IDF-West and RPPDF groundwater technetium-99 in CY 11,885. In contrast, in CY 11,885, the IDF-East technetium-99 distribution has continued to spread toward the Columbia River. At CY 11,885, significant areas exist where the technetium-99 concentrations from the IDF-East release still exceed the benchmark concentration; levels are at least one order of magnitude larger than the benchmark concentration in parts of these areas.

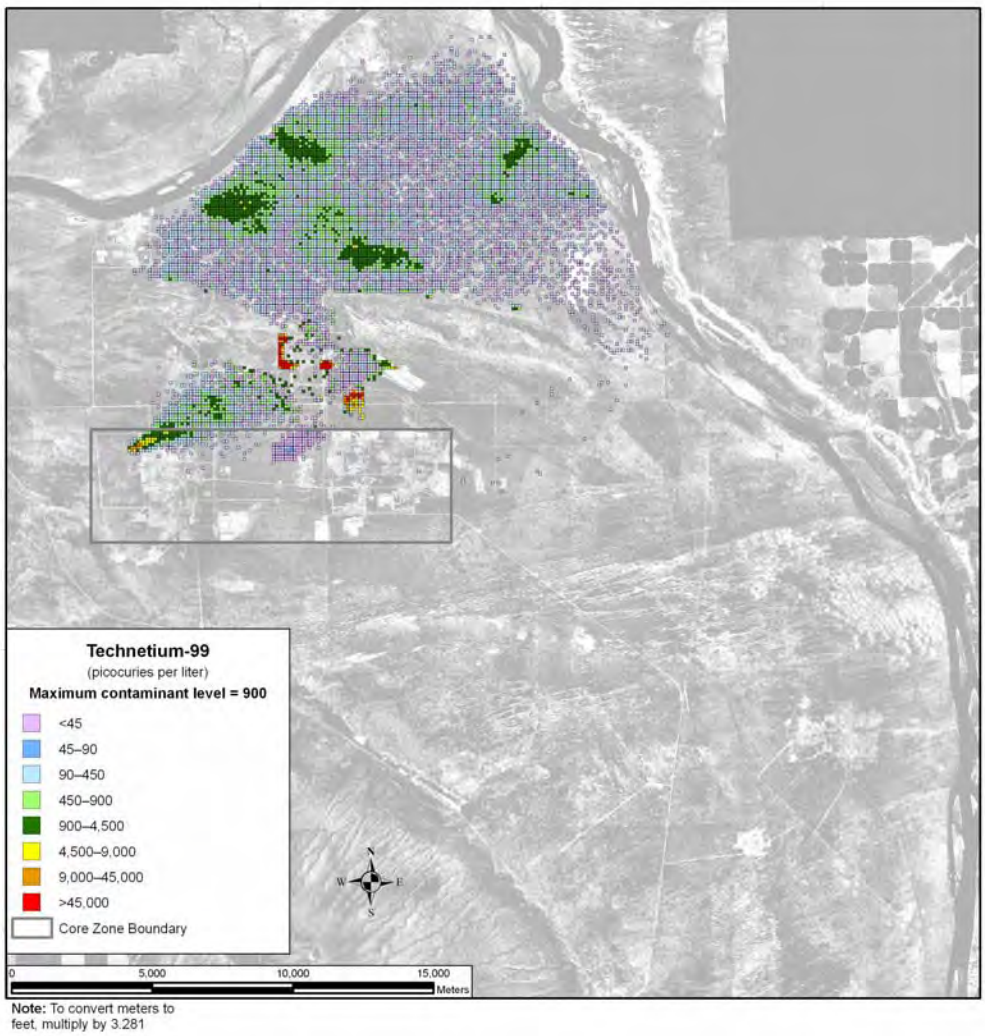


Figure 5–879. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

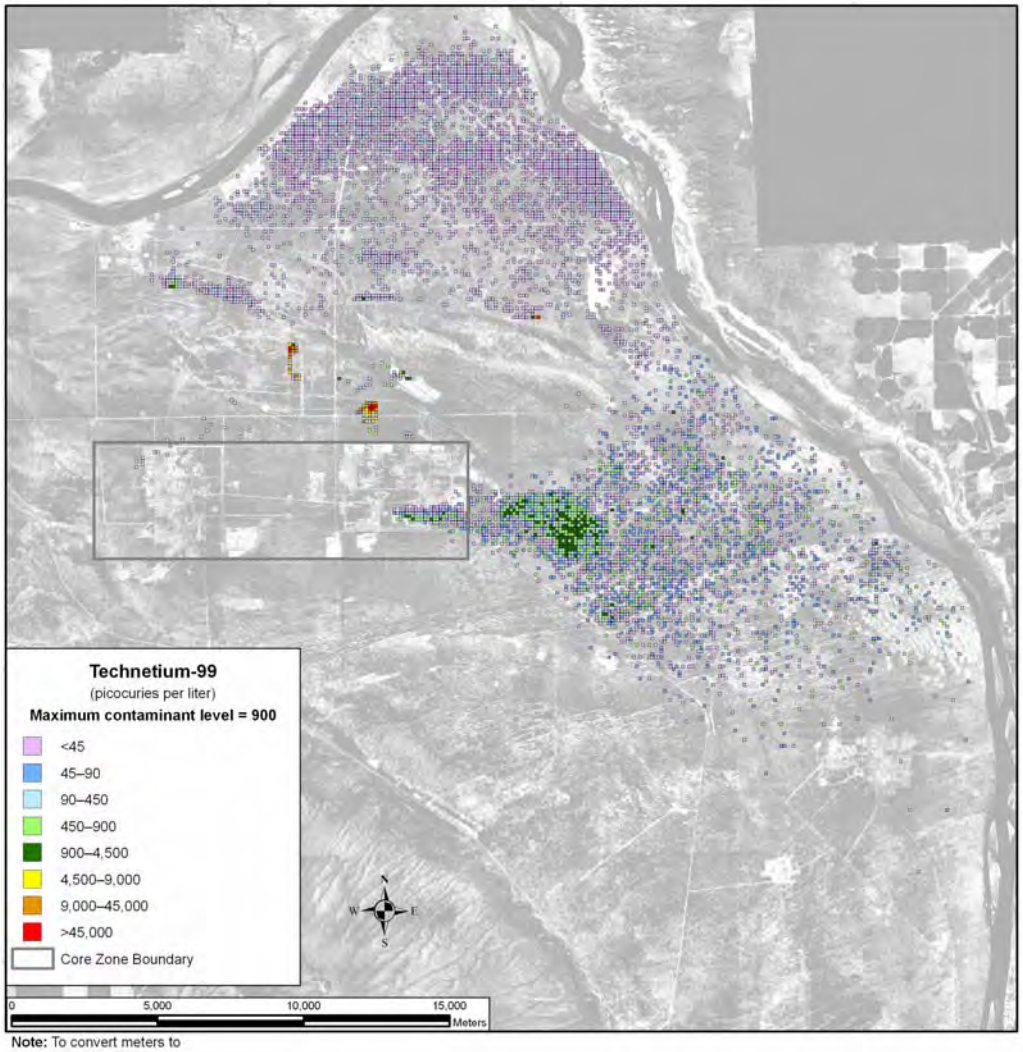


Figure 5–880. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

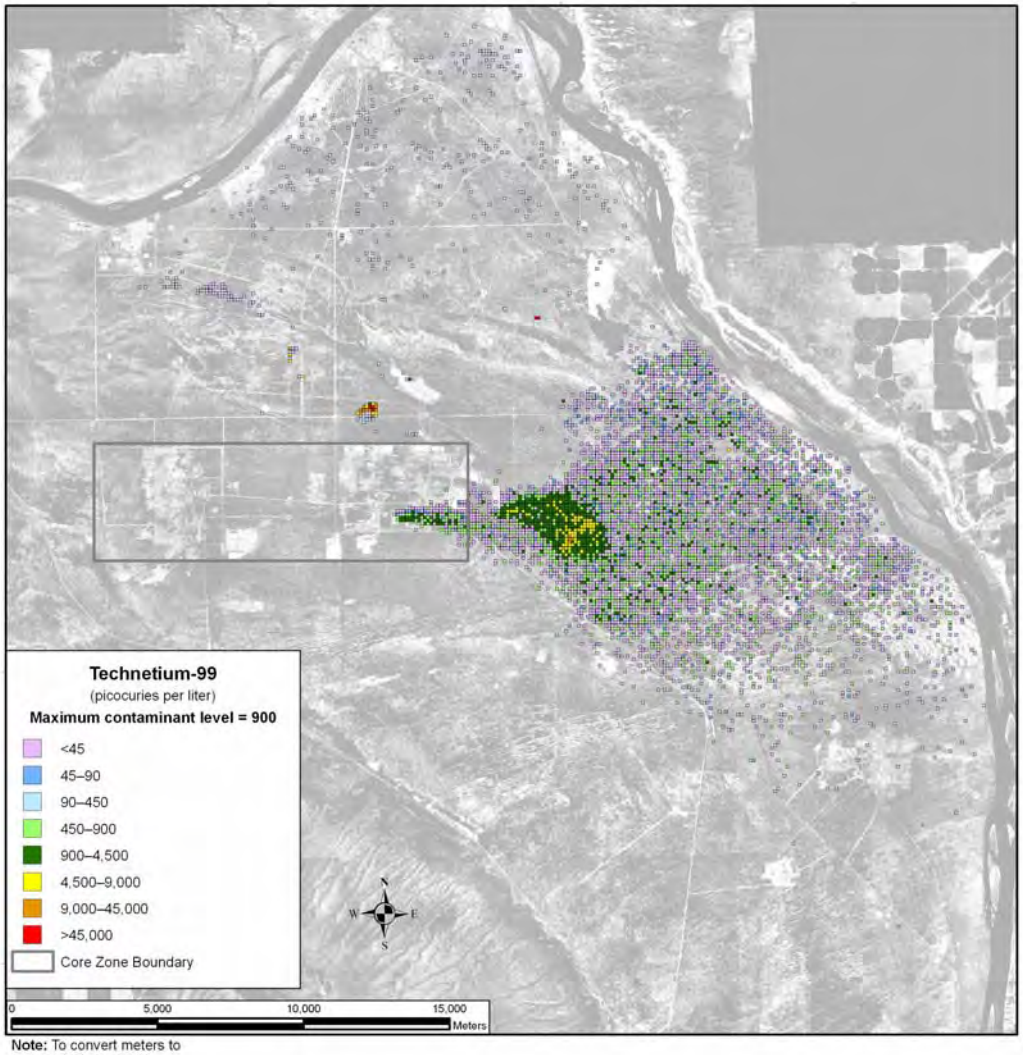


Figure 5–881. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

Figures 5–882 through 5–884 show iodine-129 released from IDF-East, IDF-West, and the RPPDF with a spatial distribution very similar to the technetium-99 release. However, the CY 3890 iodine-129 release (see Figure 5–882) shows higher relative concentrations (compared with the benchmark concentration) than the technetium-99 release. The areas of high concentrations are in the same locales, but these areas have levels that exceed the benchmark concentration by at least one order of magnitude. The iodine-129 released from IDF-West and the RPPDF has significantly dissipated by CY 7140 (see Figure 5–883). The IDF-West iodine-129 release shows less area in which concentrations are at or above the benchmark concentration than the technetium-99 release. The iodine-129 released from IDF-East in CY 11,885 (see Figure 5–884) shows the same relative spatial distribution as technetium-99, but the areas that approach or exceed the benchmark concentration are significantly smaller.

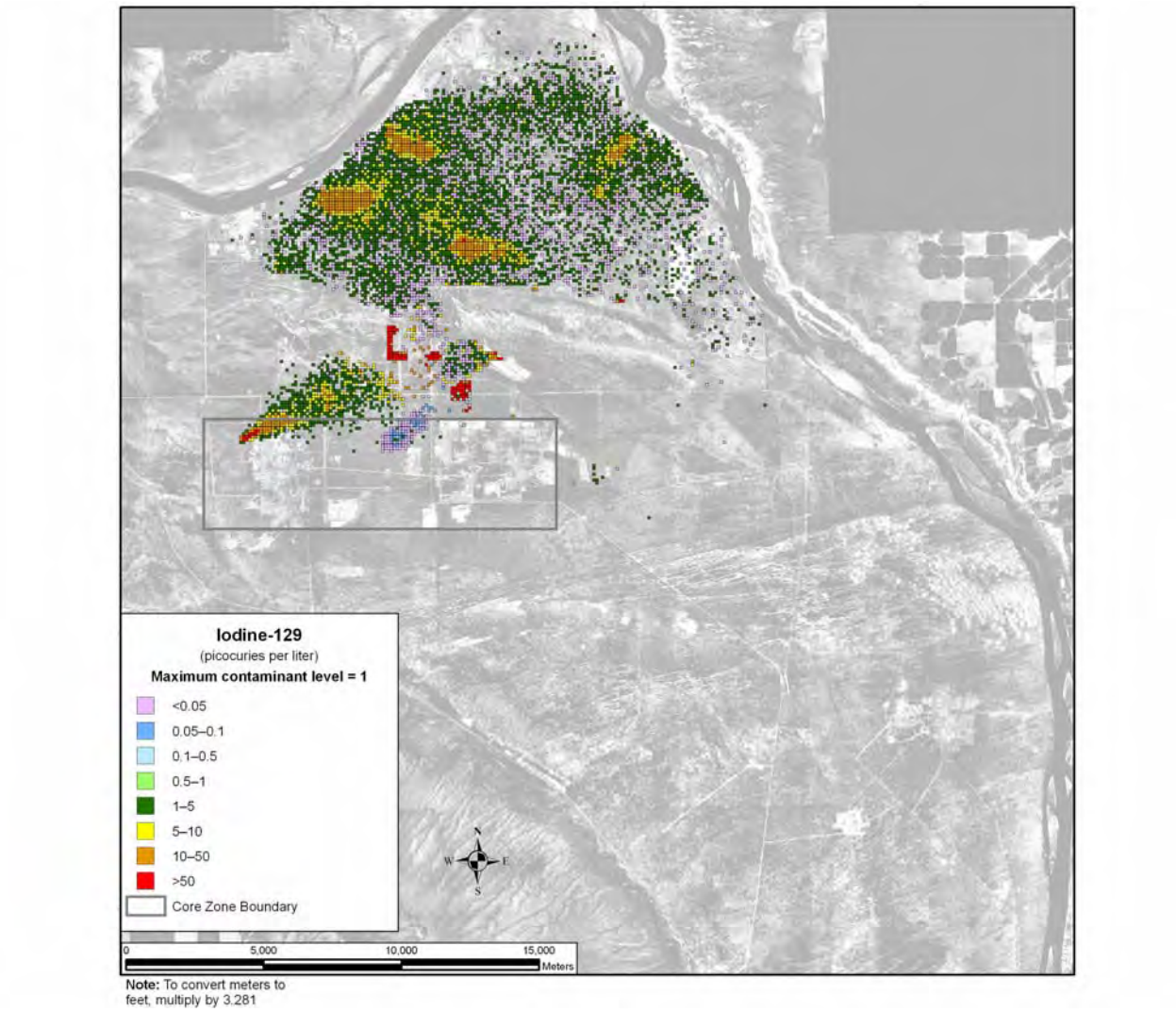


Figure 5–882. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

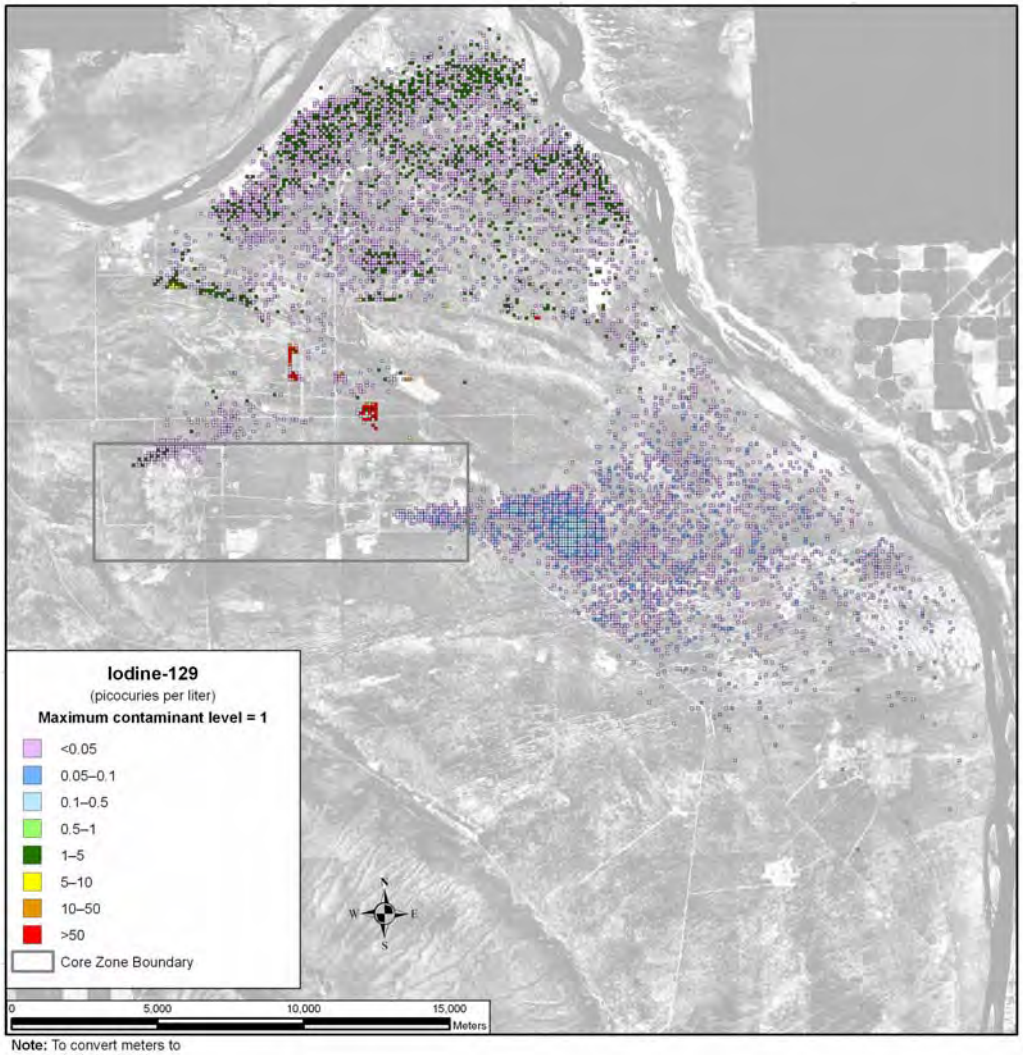


Figure 5–883. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

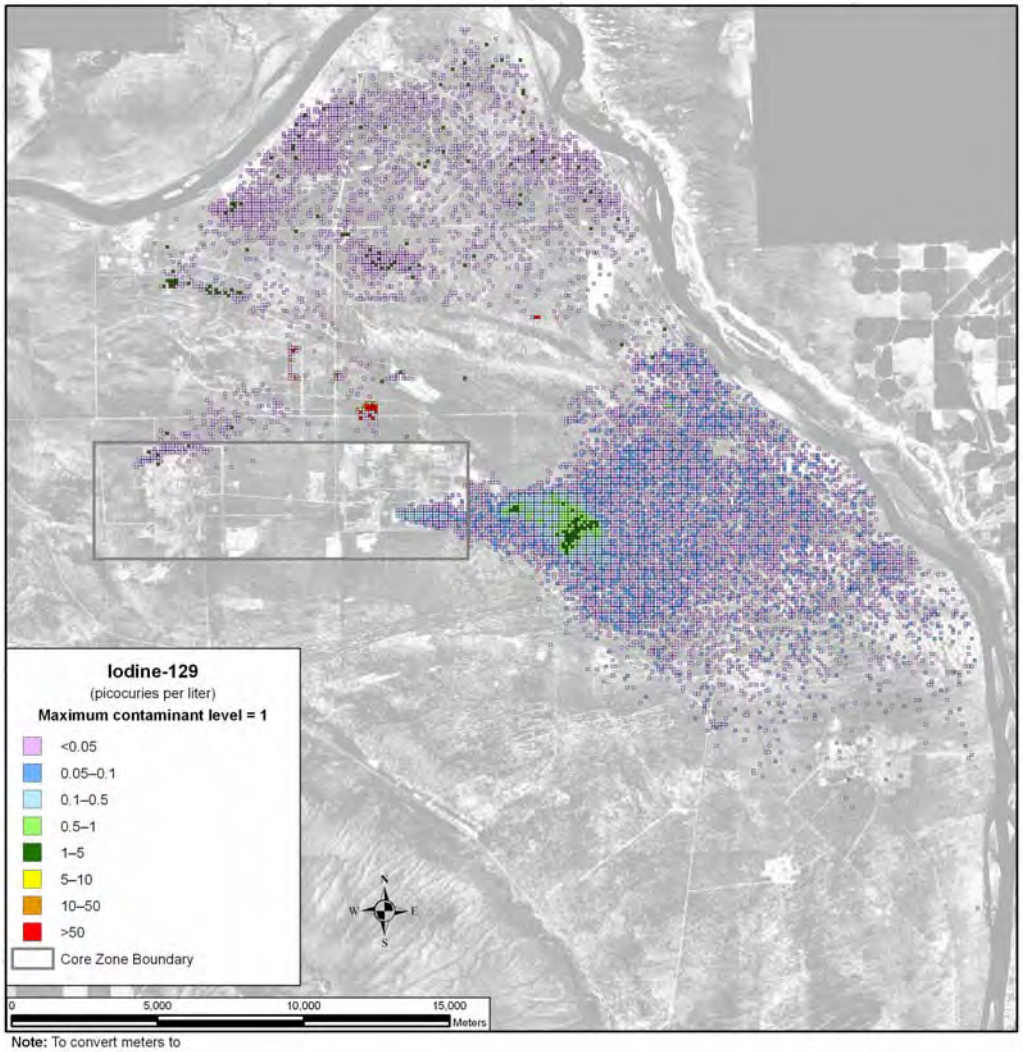


Figure 5–884. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

The IDF-East, IDF-West, and RPPDF nitrate releases, shown in Figures 5–885 through 5–887, show time and spatial distributions similar to the technetium-99 and iodine-129 releases. However, because the inventory of nitrate is lower than that of technetium-99 and iodine-129, concentrations of nitrate in these distributions are significantly less than the nitrate benchmark concentration. By CY 11,885, most of the groundwater nitrate has dissipated.

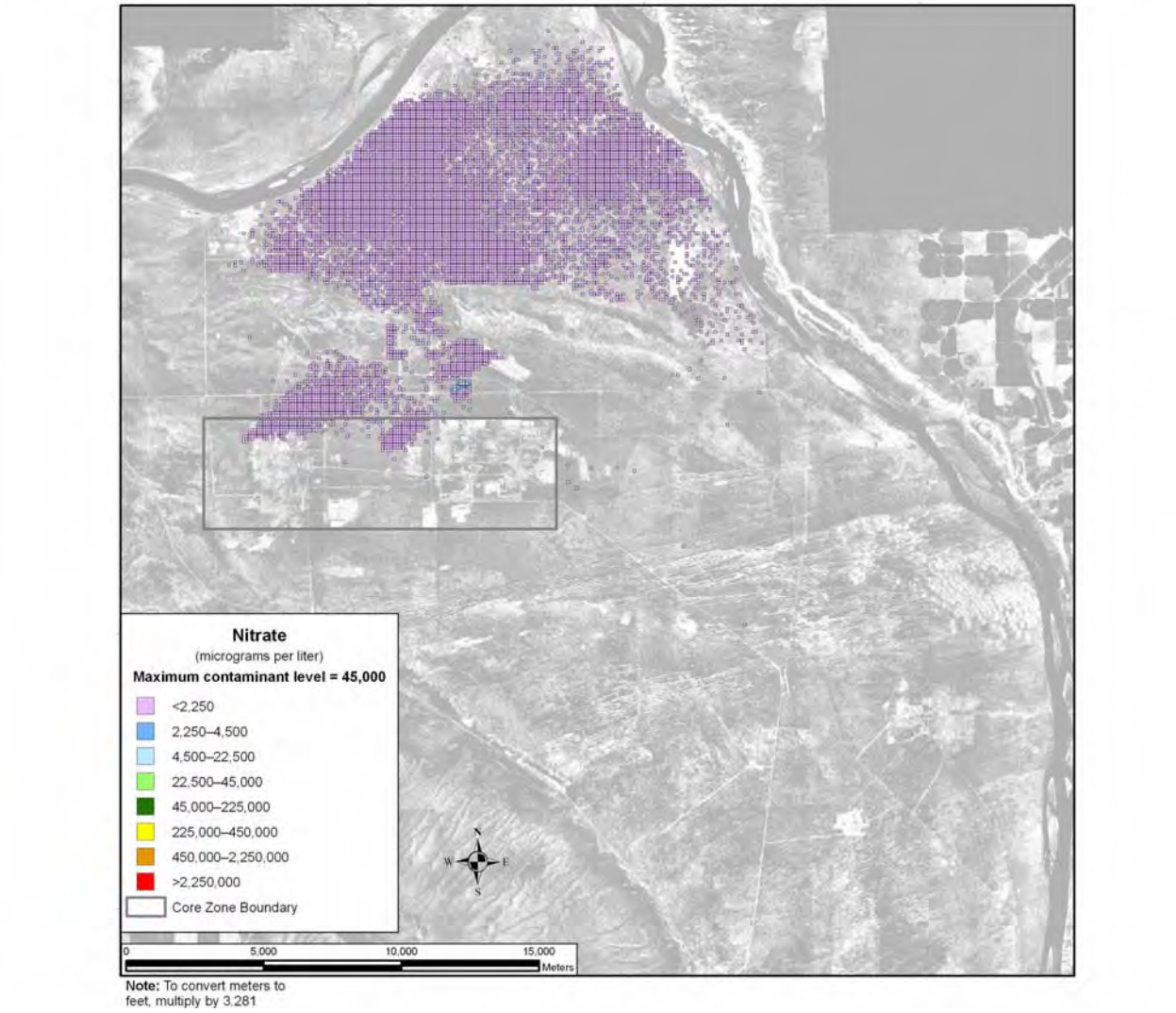


Figure 5–885. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

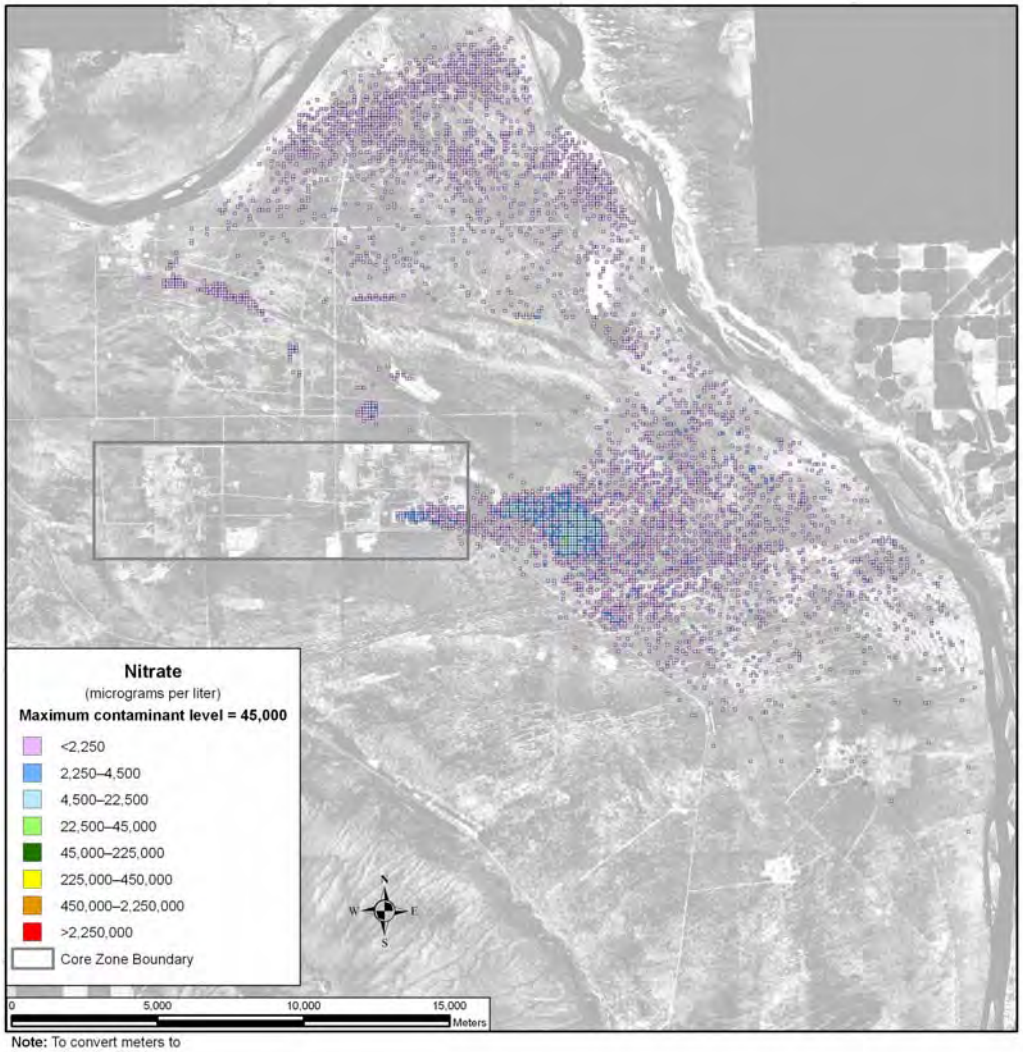


Figure 5–886. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

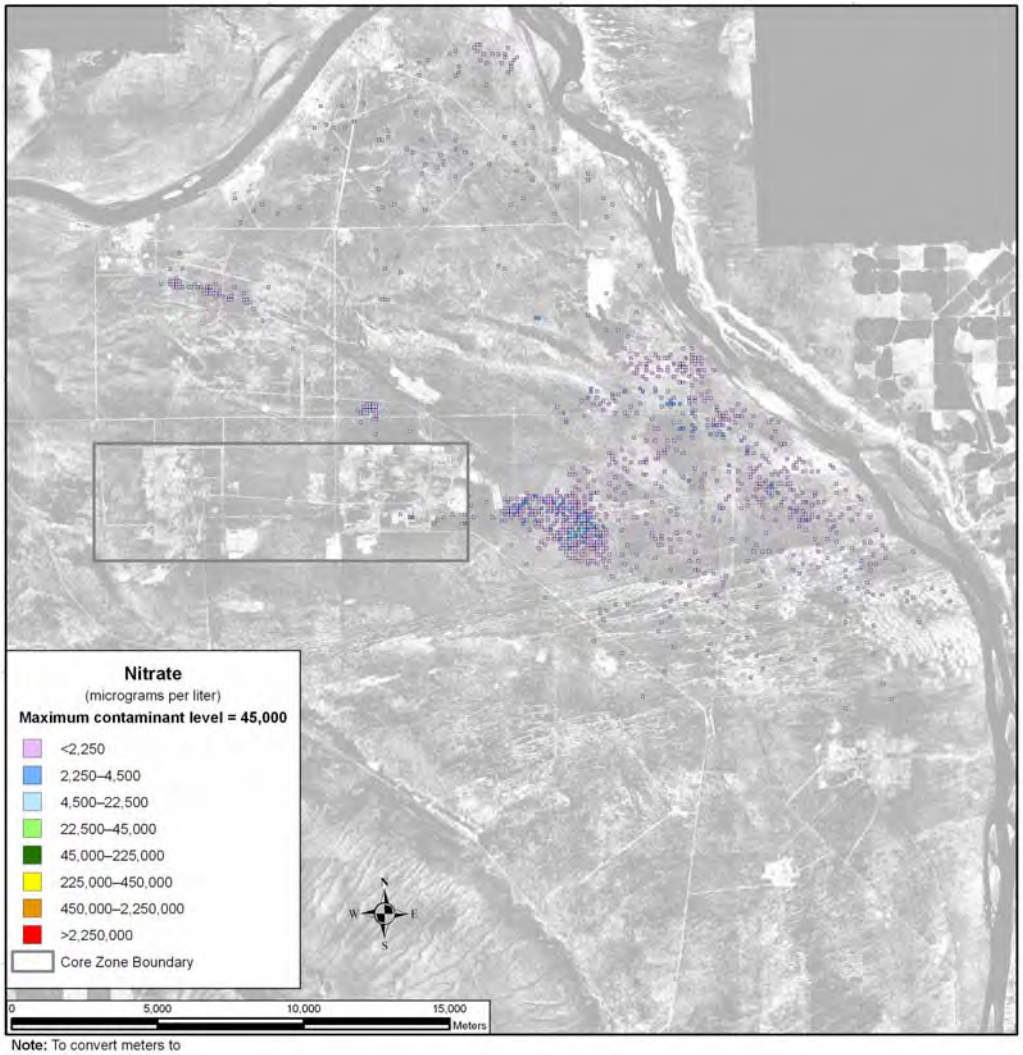


Figure 5–887. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

The initial chromium release time and spatial patterns in CY 3890 are nearly identical to the IDF-West and RPPDF nitrate releases (see Figure 5–888). There are several small areas where the chromium concentration approaches or exceeds its benchmark concentration. Most of the chromium released from IDF-West and the RPPDF has dissipated to the Columbia River by CY 7140 (see Figure 5–889). This also shows a significant chromium distribution from IDF-East with small areas that exceed benchmark concentrations. By CY 11,885 the IDF-West and RPPDF chromium is essentially dissipated (see Figure 5–890). However, there is a significant distribution of chromium that extends from the IDF-East release site to the Columbia River. Most of the distribution is well below benchmark concentrations.

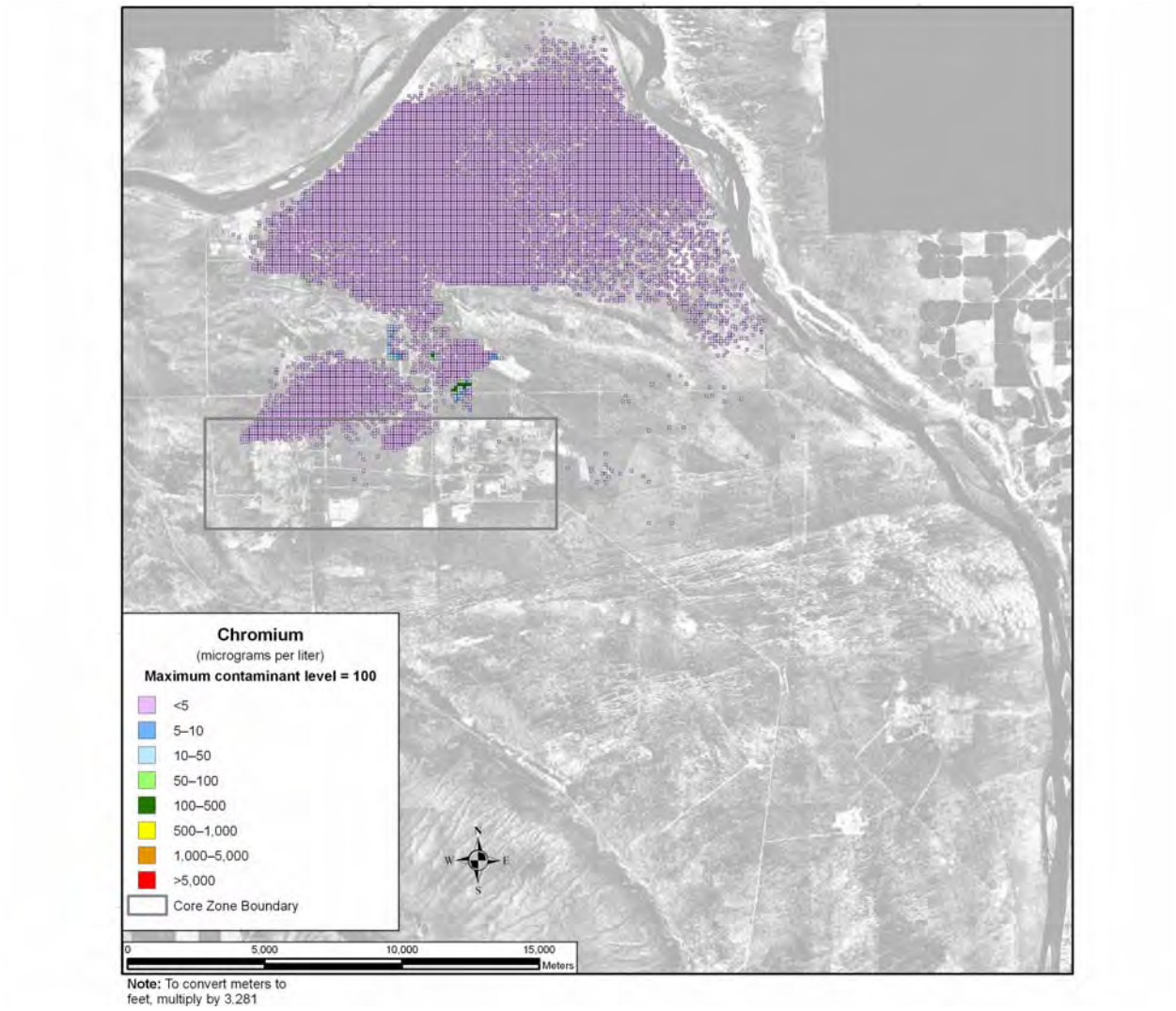


Figure 5–888. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

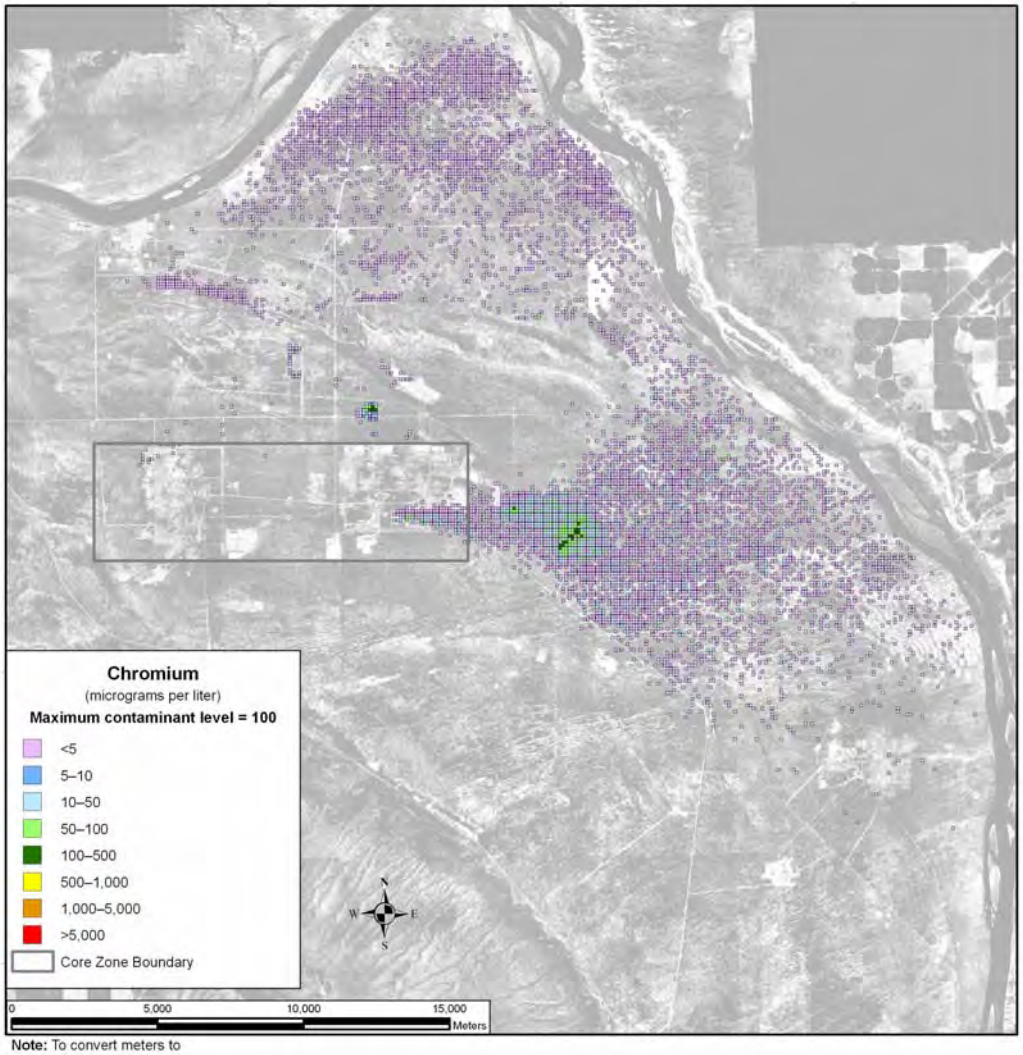


Figure 5–889. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

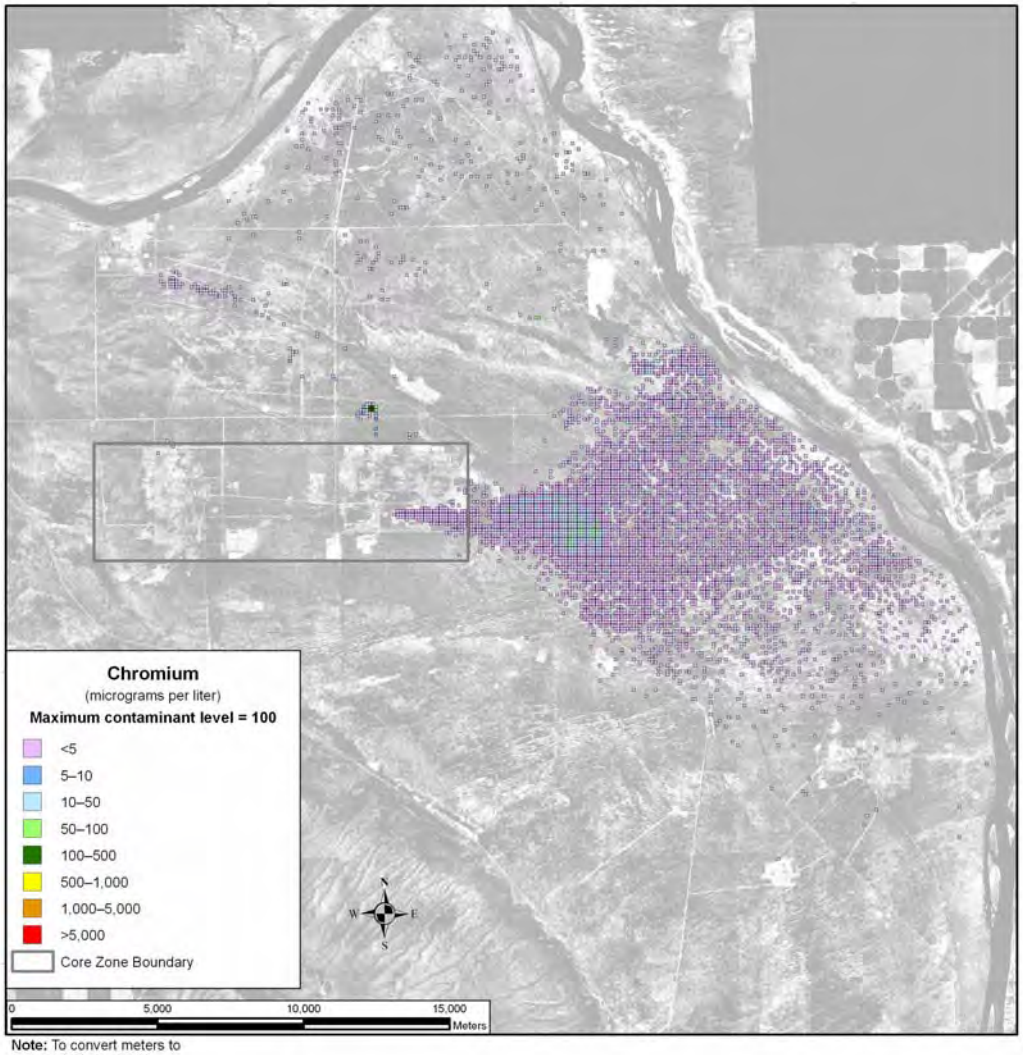


Figure 5–890. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

The uranium-238 and total uranium spatial distributions in Figures 5–891 and 5–892 (both CY 11,885) show a uranium-238 plume from IDF-West and a total uranium plume from the RPPDF. There are no uranium-238 or total uranium releases from IDF-East. The uranium-238 and total uranium concentrations in both releases remain well below their respective benchmark concentrations over the period of analysis. The data show uranium-238 and total uranium retardation with similar distributions and concentrations extending from the release sites to the Columbia River nearshore.

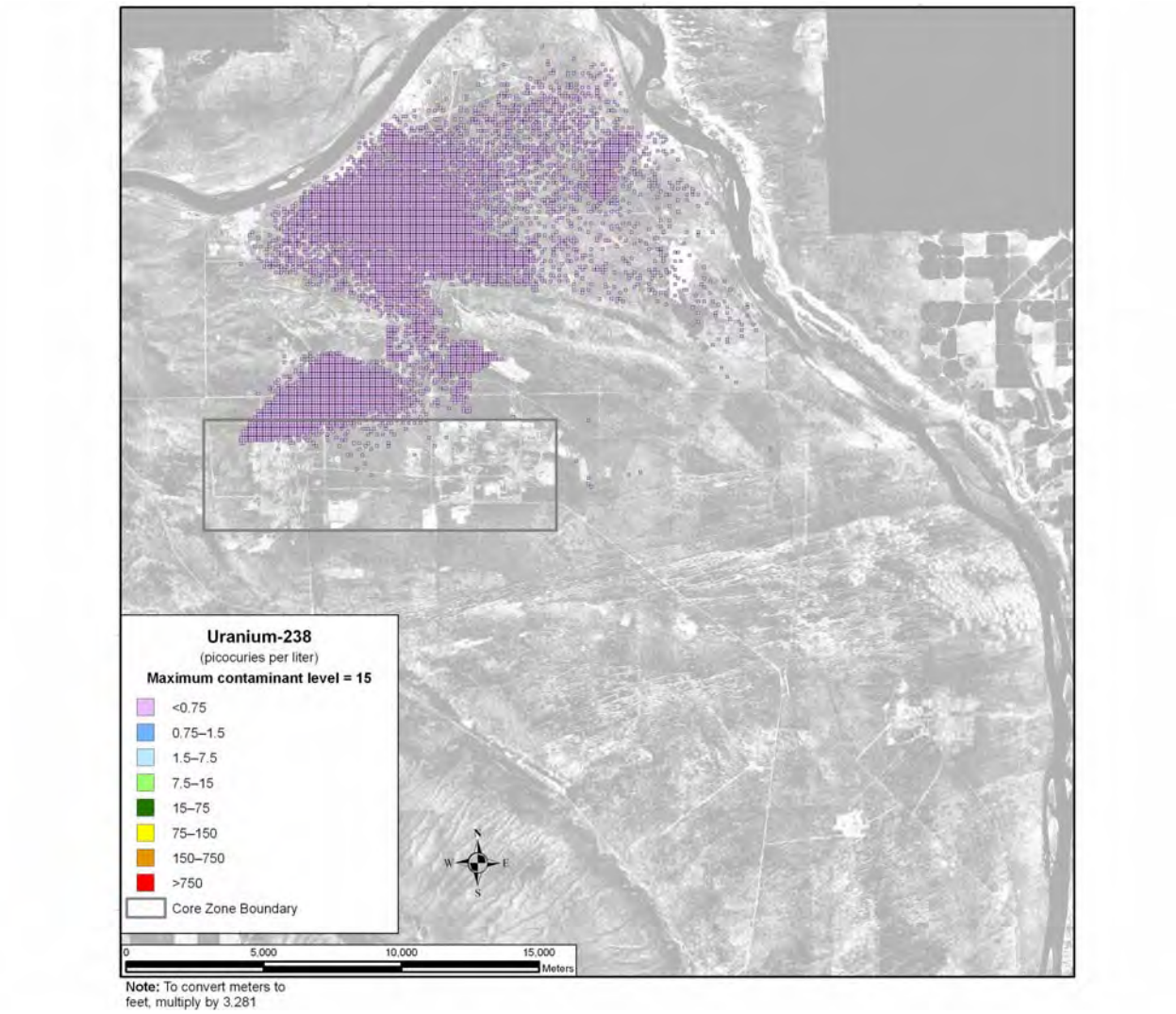


Figure 5–891. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

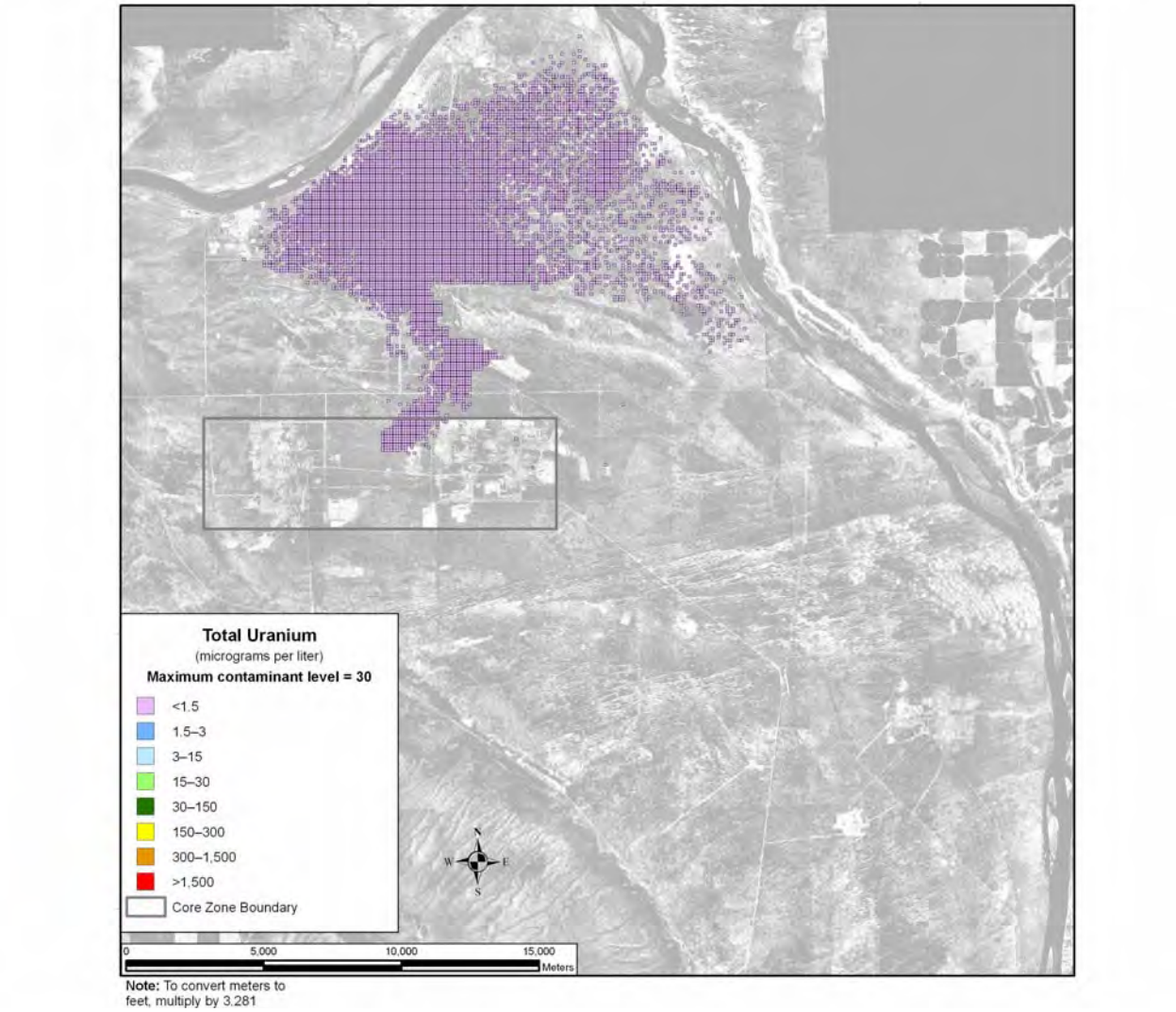


Figure 5–892. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, in general, the inventories remaining at IDF-East, IDF-West, and the RPPDF, which are available for release to the environment at the start of the post-disposal period, are predominant contributors. The releases from IDF-West and the RPPDF occur earlier and dissipate earlier than releases from IDF-East.

By the end of this analysis period (CY 11,885), the chromium and nitrate distributions have largely dispersed below their benchmark concentrations. A significant spatial distribution of technetium-99 and iodine-129 remain. Most of the distribution area has concentrations below benchmark levels, but there are some small areas in which technetium-99 and iodine-129 concentrations exceed benchmark levels at CY 11,885. The released iodine-129, which occurs at higher concentration levels relative to its benchmark than technetium-99, dissipates much more quickly than technetium-99.

Uranium-238 and total uranium's relatively limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed

their benchmark levels at the Core Zone Boundary or Columbia River nearshore over this period of analysis. However, the spatial distributions of both uranium-238 and total uranium exist through the end of the analysis period (CY 11,885). Although the concentrations of uranium-238 and total uranium are both two orders of magnitude smaller than either benchmark concentration during this analysis period, the trend appears to show a continuing increase through the end of the analysis period.

5.3.1.3.1.6 Disposal Group 1, Subgroup 1-F

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F covers disposal of waste generated under Tank Closure Alternative 5 and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Tank closure waste would be converted to IHLW, ILAW glass, bulk vitrification glass, cast stone waste, and sulfate grout.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and IDF-West would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts, IDF-East and IDF-West are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F. Full results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, nitrate, and acetonitrile.

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrite, and acetonitrile) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone

Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F (IDF-East, and IDF-West releases), in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–893 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–894, the chemical hazard drivers. The inventories in the seven waste forms are a major factor in the release quantities to the vadose zone. Cast stone waste is the predominant vadose zone source for technetium (83 percent), with the remainder coming largely from bulk vitrification glass (12 percent) and some from tank closure secondary waste (4 percent) and ETF-generated secondary waste (1 percent). The vadose zone iodine-129 is from the ETF-generated secondary waste (90 percent) and cast stone waste (7 percent) with some from tank closure secondary waste (3 percent). Sulfate grout is the predominant vadose zone source of chromium (78 percent) with some from cast stone (22 percent). Acetonitrile (greater than 99 percent) is from cast stone waste. The nitrate is from ETF-generated secondary waste (57 percent) and cast stone waste (43 percent). No boron or fluoride is released from IDF-East.

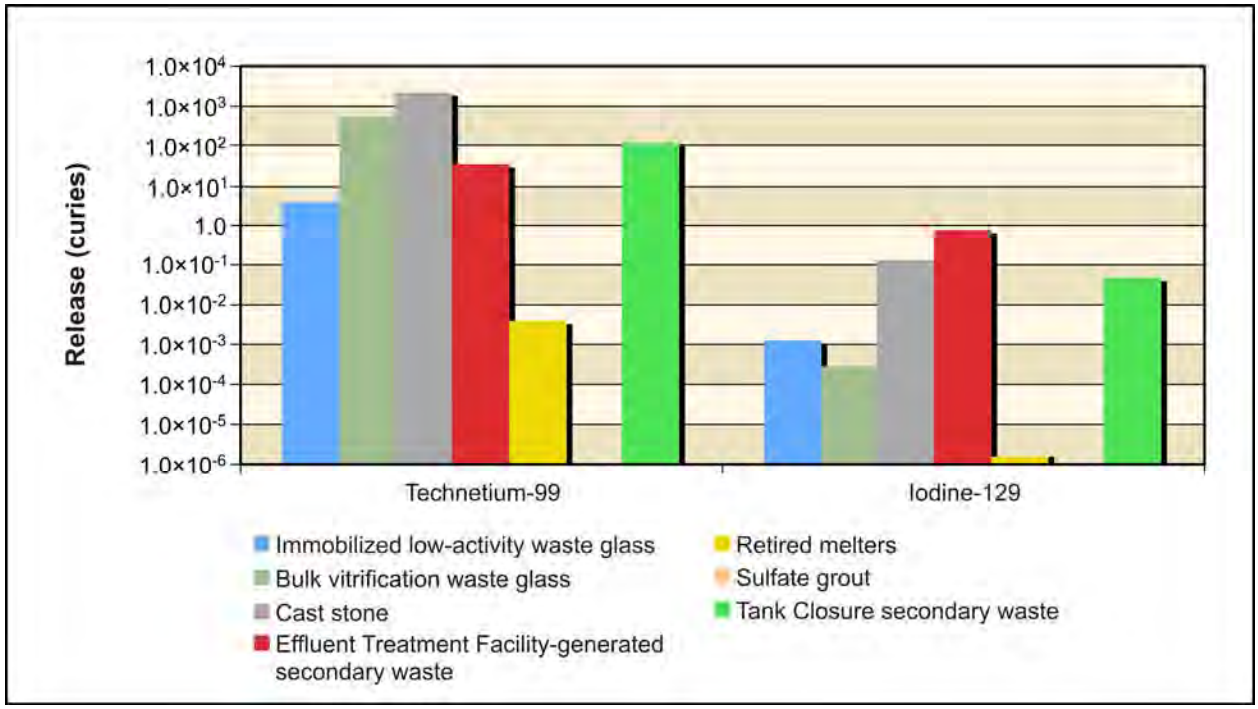


Figure 5–893. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

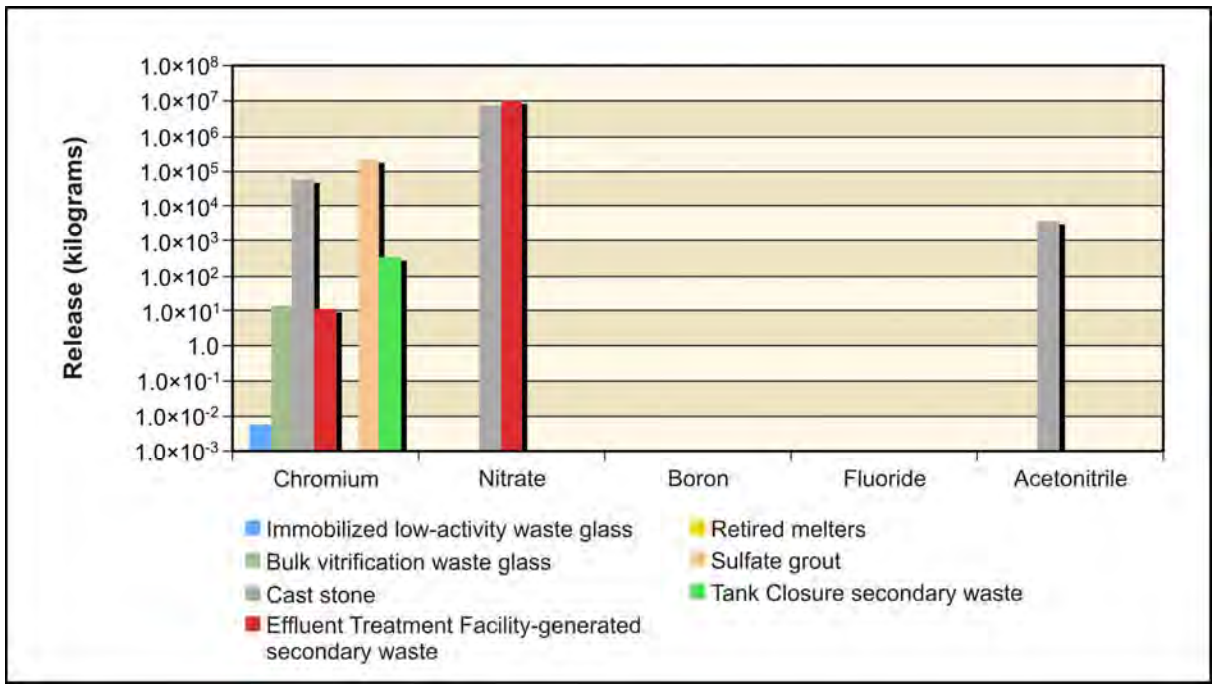


Figure 5–894. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–895 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–896, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. The vadose zone releases some technetium-99 (50 percent) and iodine-129 (43 percent) to the groundwater. Nearly all (99 percent) of the vadose zone chromium, nitrate, and acetonitrile are released to the groundwater.

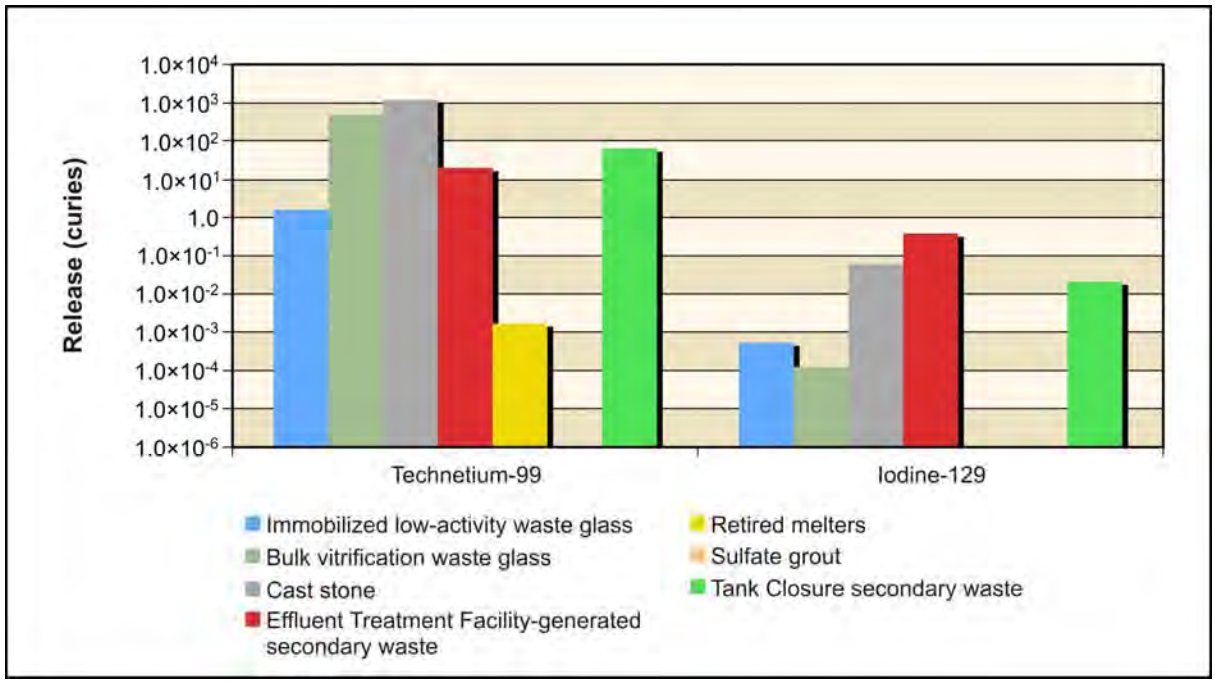


Figure 5–895. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

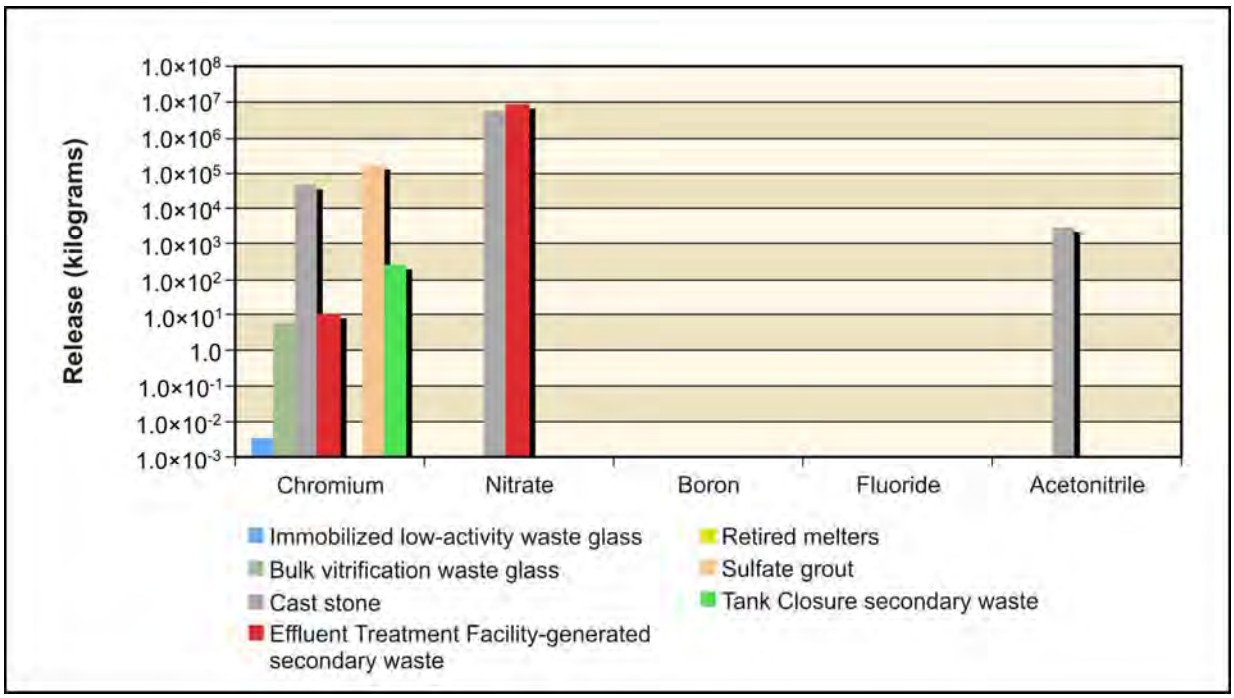


Figure 5–896. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–897 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–898, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. The groundwater releases most of its technetium-99 (92 percent), iodine-129 (90 percent), chromium (96 percent), nitrate (97 percent), and acetonitrile (96 percent) to the Columbia River.

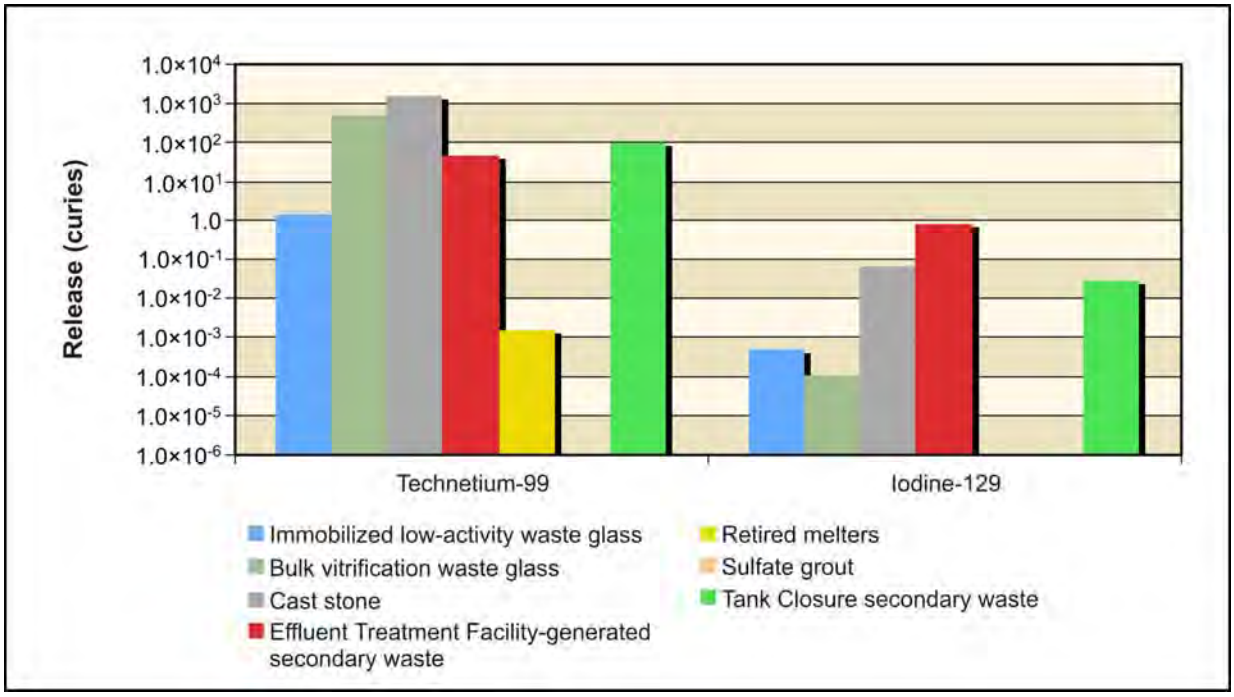


Figure 5–897. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

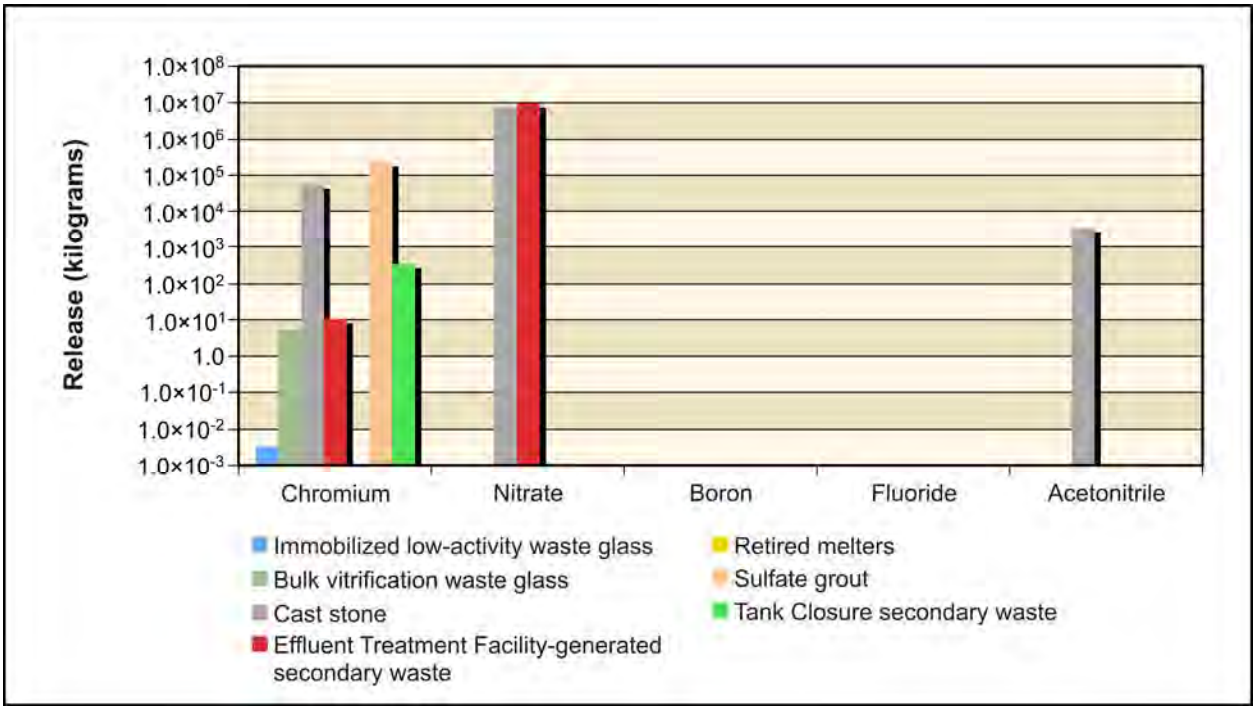


Figure 5–898. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Overall, almost all of the IDF-East vadose zone chromium (96 percent), nitrate (97 percent), and acetonitrile (96 percent), as well as some of the vadose zone technetium-99 (46 percent) and iodine-129 (39 percent), reached the Columbia River over the period of analysis.

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases of FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste.

Figure 5–899 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–900, the chemical hazard drivers. The inventories in the three waste forms are a major factor in the release quantities to the vadose zone. The predominant source of technetium-99 (greater than 99 percent) and iodine-129 (greater than 99 percent) released to the vadose zone is offsite-generated waste. Essentially all (greater than 99 percent) of the nitrate, boron, and fluoride that are released to the vadose zone are from waste management secondary and onsite-generated waste. The chromium released to the vadose zone is from waste management secondary and onsite-generated waste (66 percent) and offsite-generated waste (34 percent). No acetonitrile is released from IDF-West.

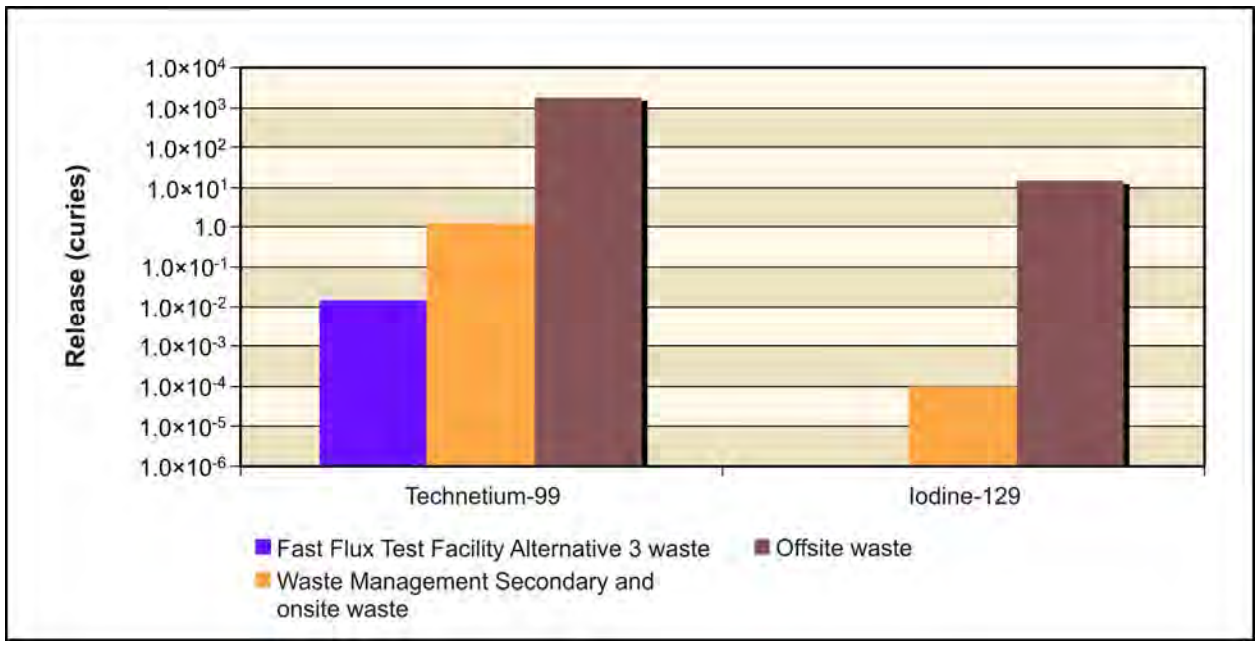


Figure 5–899. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

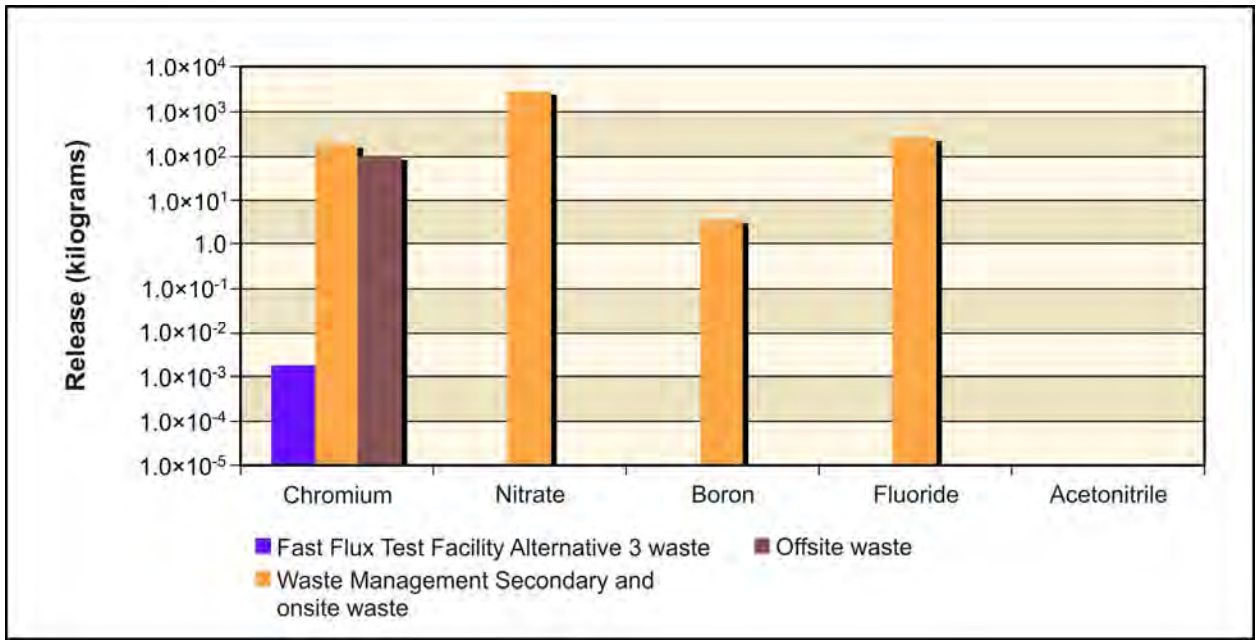


Figure 5–900. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–901 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–902, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the IDF-West vadose zone technetium-99 (98 percent), iodine-129 (99 percent), chromium (99 percent), nitrate (greater than 99 percent), boron (greater than 99 percent), and fluoride (greater than 99 percent) are released to the groundwater during the period of analysis.

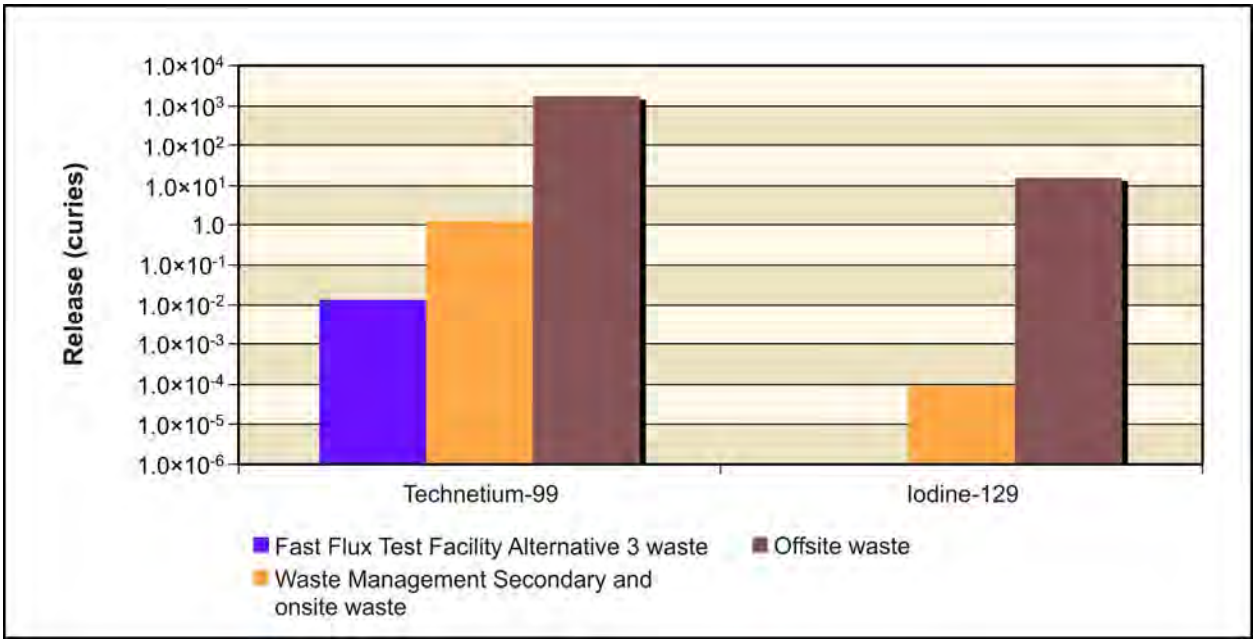


Figure 5–901. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

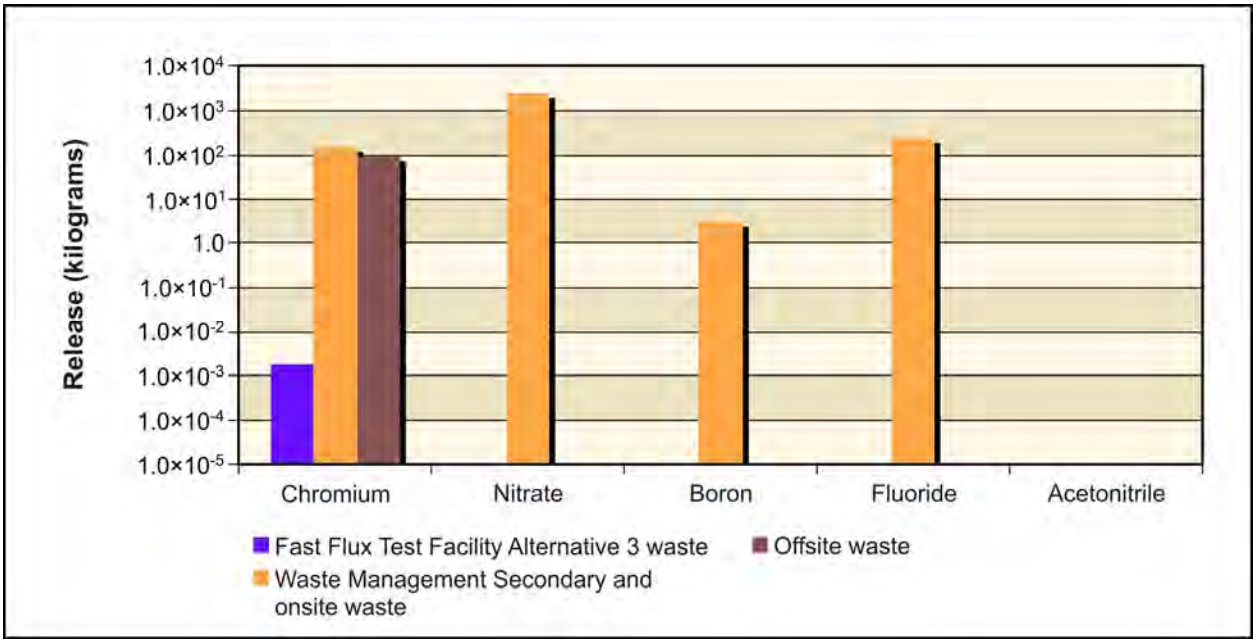


Figure 5–902. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–903 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–904, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (97–98 percent) of the IDF-West groundwater technetium-99, iodine-129, chromium, nitrate, boron, and fluoride are released to the Columbia River over the period of analysis.

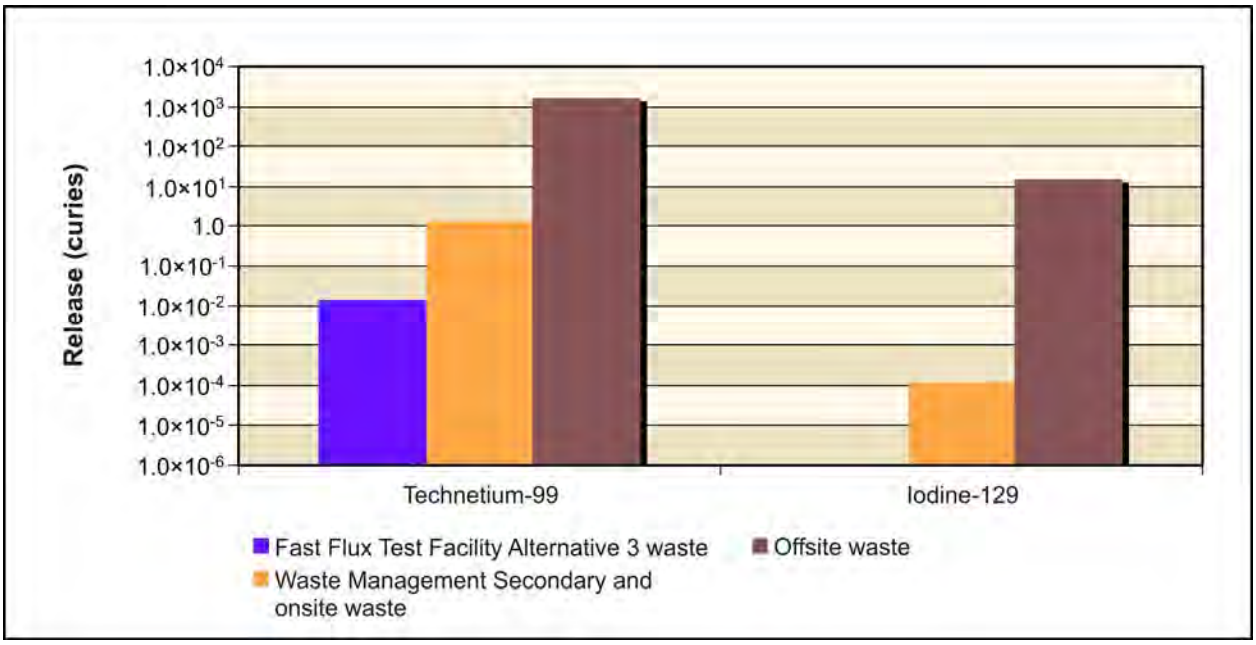


Figure 5–903. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

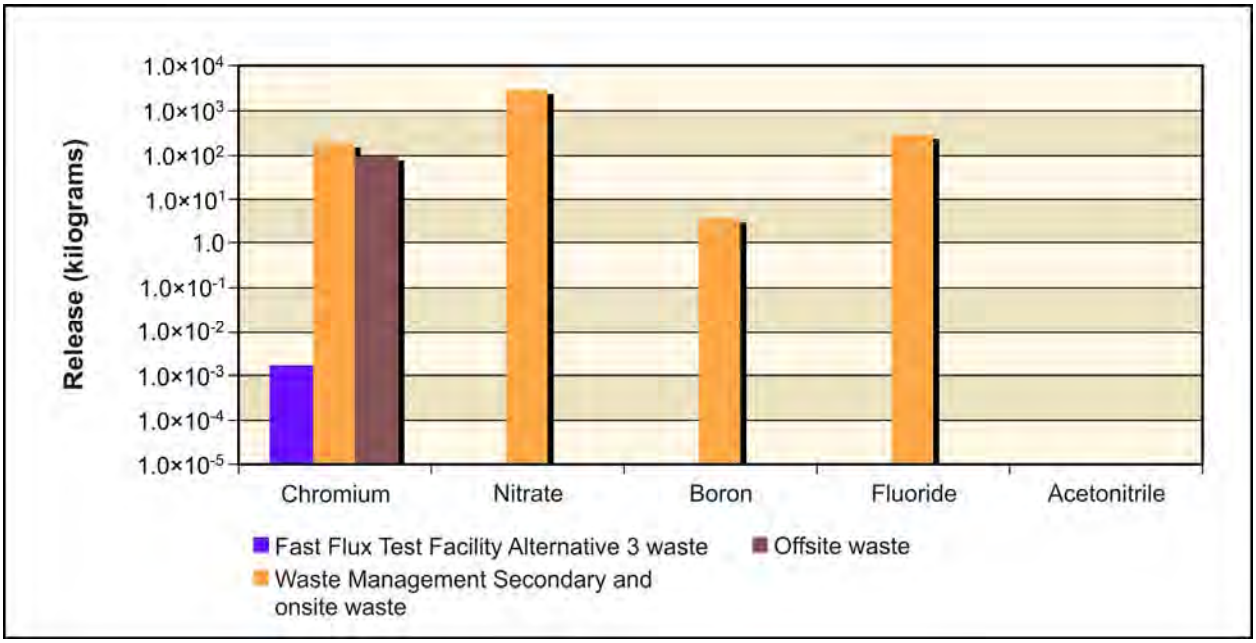


Figure 5–904. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

Overall, most (96–98 percent) of the IDF-West vadose zone technetium-99, iodine-129, chromium, nitrate, boron, and fluoride reached the Columbia River over the period of analysis.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–94 shows maximum concentrations in groundwater.

Table 5–94. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide picocuries per liter						
Technetium-99	**2,390**	**20,200**	N/A	**7,540**	**1,130**	900
	(9701)	(3713)		(3690)	(4528)	
Iodine-129	**1**	**173**	N/A	**60**	**8**	1
	(11,711)	(3797)		(3853)	(4729)	
Chemical in microgram per liter						
Acetonitrile	5	0	N/A	2	1	100
	(8475)	(1940)		(9519)	(8575)	
Chromium	**335**	2	N/A	**148**	**110**	100
	(8735)	(3696)		(8764)	(8819)	
Fluoride	0	1	N/A	1	0	4,000
	(1940)	(3684)		(3907)	(4555)	
Nitrate	21,400	17	N/A	7,420	4,560	45,000
	(8448)	(3703)		(8887)	(8787)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

Figures 5–905 through 5–908 show concentration versus time for technetium-99, iodine-129, chromium, and nitrate. Figure 5–905 shows that, at the onset of the releases from IDF-East and IDF-West, there is a technetium-99 release peak (lasting 1,000 years) at the Core Zone Boundary. The Core Zone Boundary technetium-99 concentration then decreases below the benchmark concentration to a level coincident with the Columbia River nearshore concentration. The Columbia River nearshore technetium-99 concentration never exceeds the benchmark concentration. Both the Core Zone Boundary and the Columbia River nearshore continue with concentrations below the benchmark level (within one order of magnitude) through the end of this analysis period (CY 11,940).

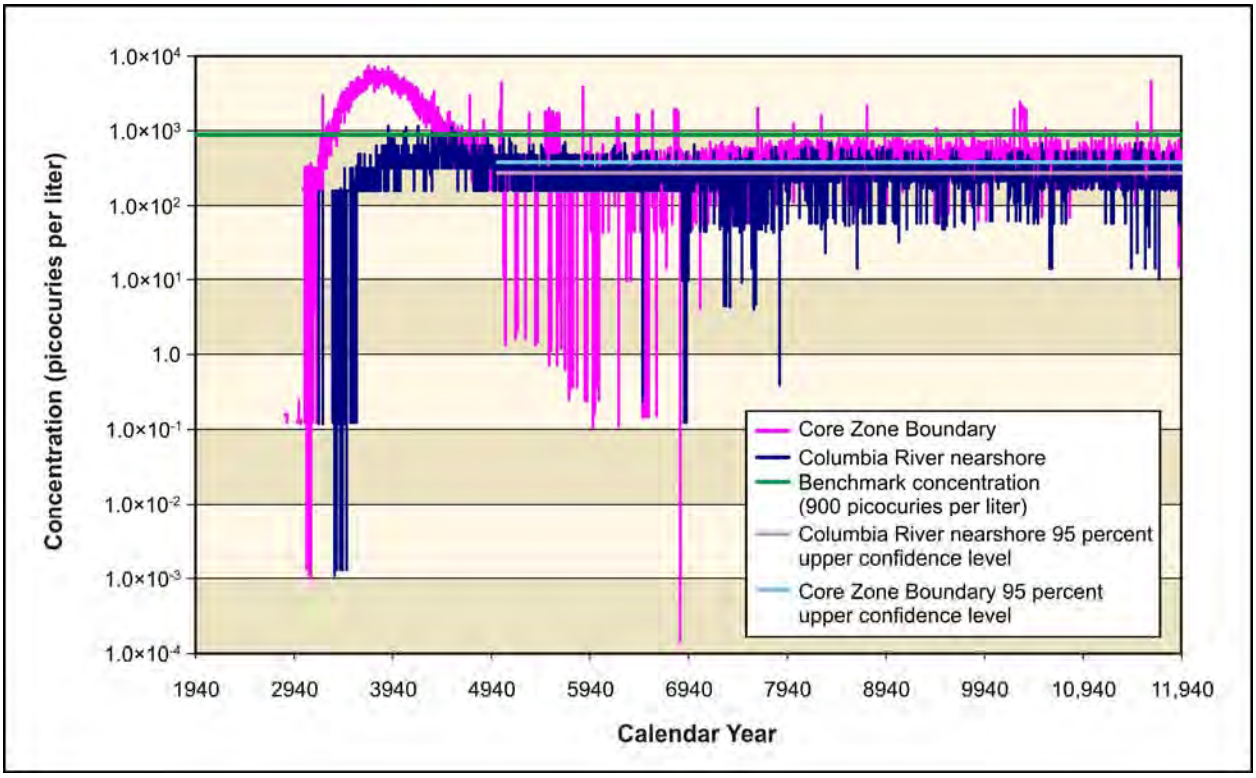


Figure 5–905. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Technetium-99 Concentration Versus Time

The Core Zone Boundary and the Columbia River nearshore both show similar concentration peaks at the onset of the iodine-129 release (see Figure 5–906). The Core Zone Boundary concentration peaks between one and two orders of magnitude above the benchmark concentration. The Columbia River nearshore concentration peaks just above the benchmark concentration, but below one order of magnitude. Both concentrations then continue on a slow decline that brings them nearly coincident with the benchmark concentration for the last half of the analysis period.

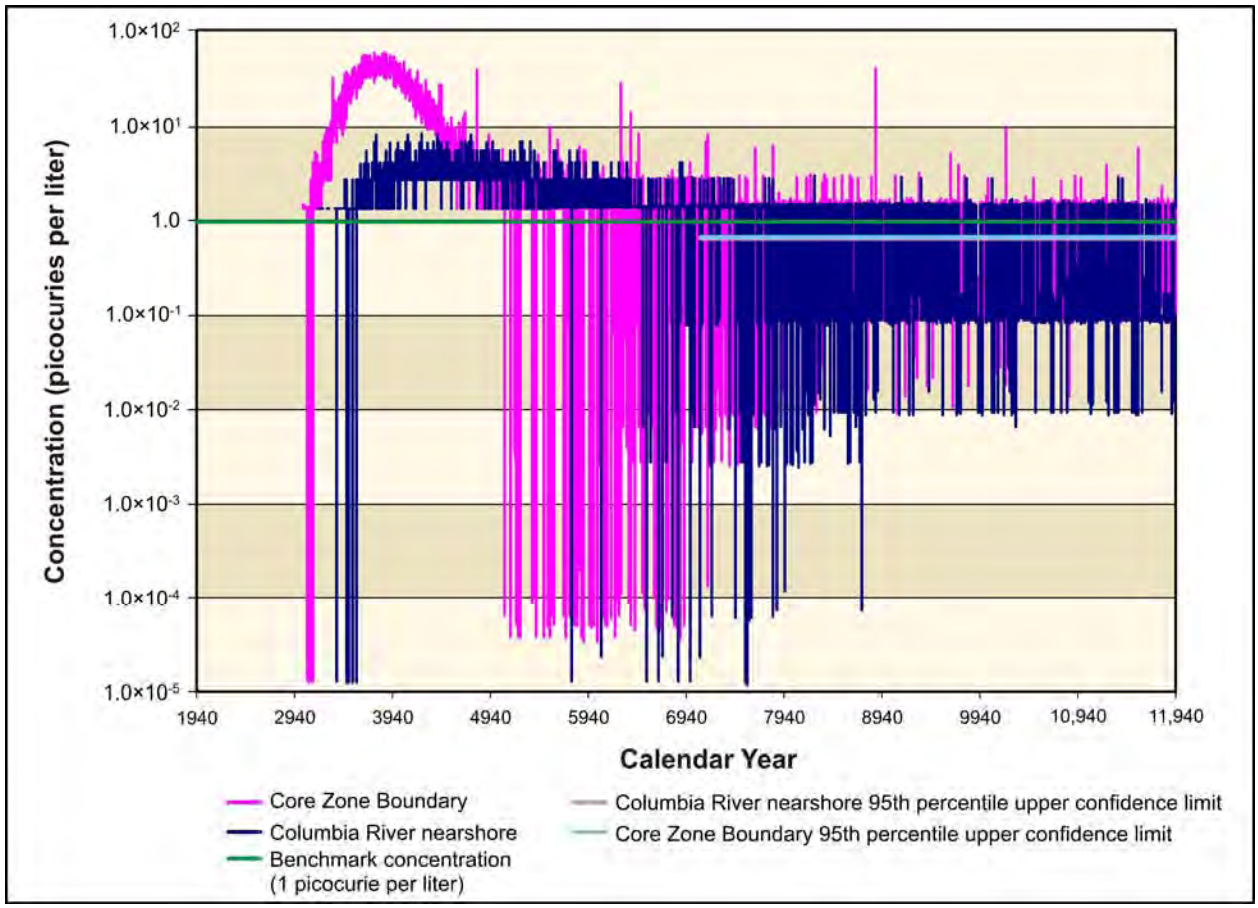


Figure 5–906. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Iodine-129 Concentration Versus Time

Figures 5–907 and 5–908 also show an initial increase in the Core Zone Boundary chromium and nitrate, followed by a second, broader increase that extends over about two-thirds of the analysis period. The nitrate concentrations are always less than one order of magnitude from the benchmark concentration. The chromium concentrations (at the Core Zone Boundary and Columbia River nearshore) approach within one order of magnitude of the benchmark concentration for most of the analysis period. Note that the actual time periods of exceedance associated with the peak values (listed in Table 5–94) are extremely limited and the 95th percentile upper confidence limit on chromium concentrations are within an order of magnitude below the benchmark concentrations.

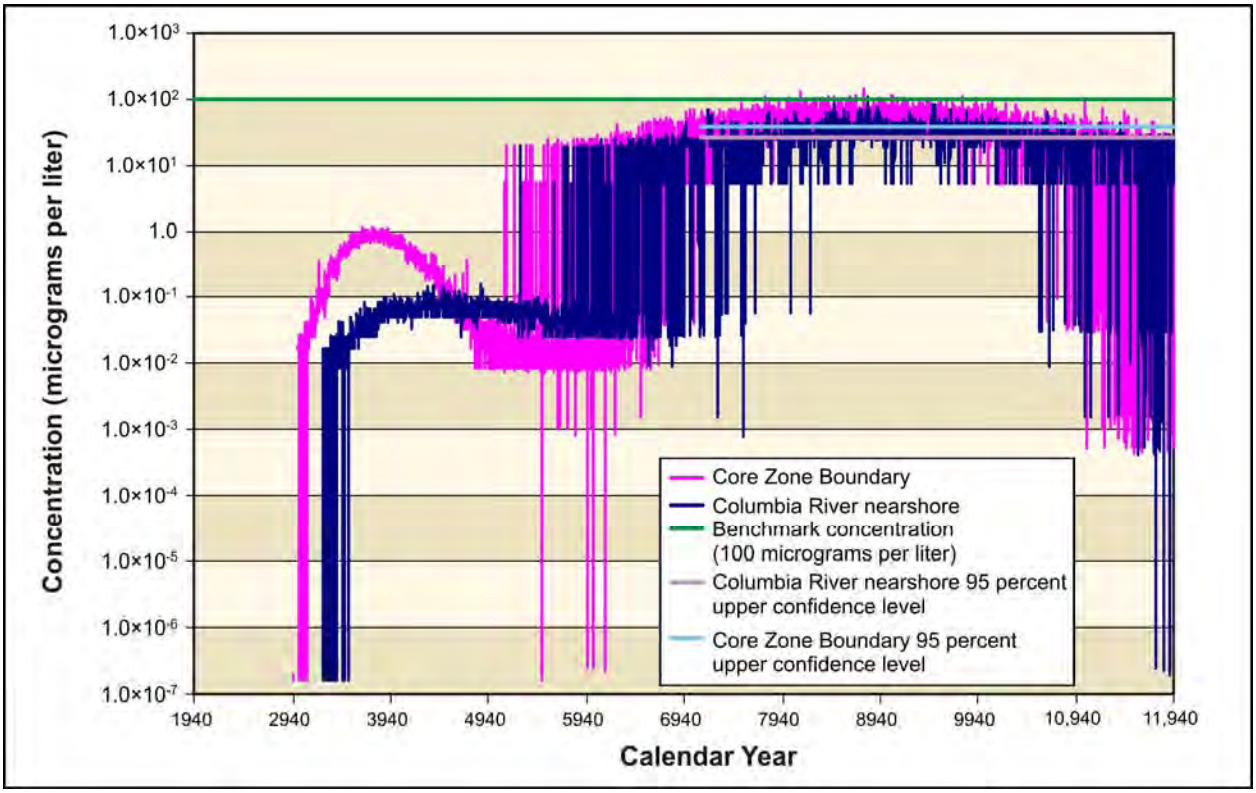


Figure 5–907. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chromium Concentration Versus Time

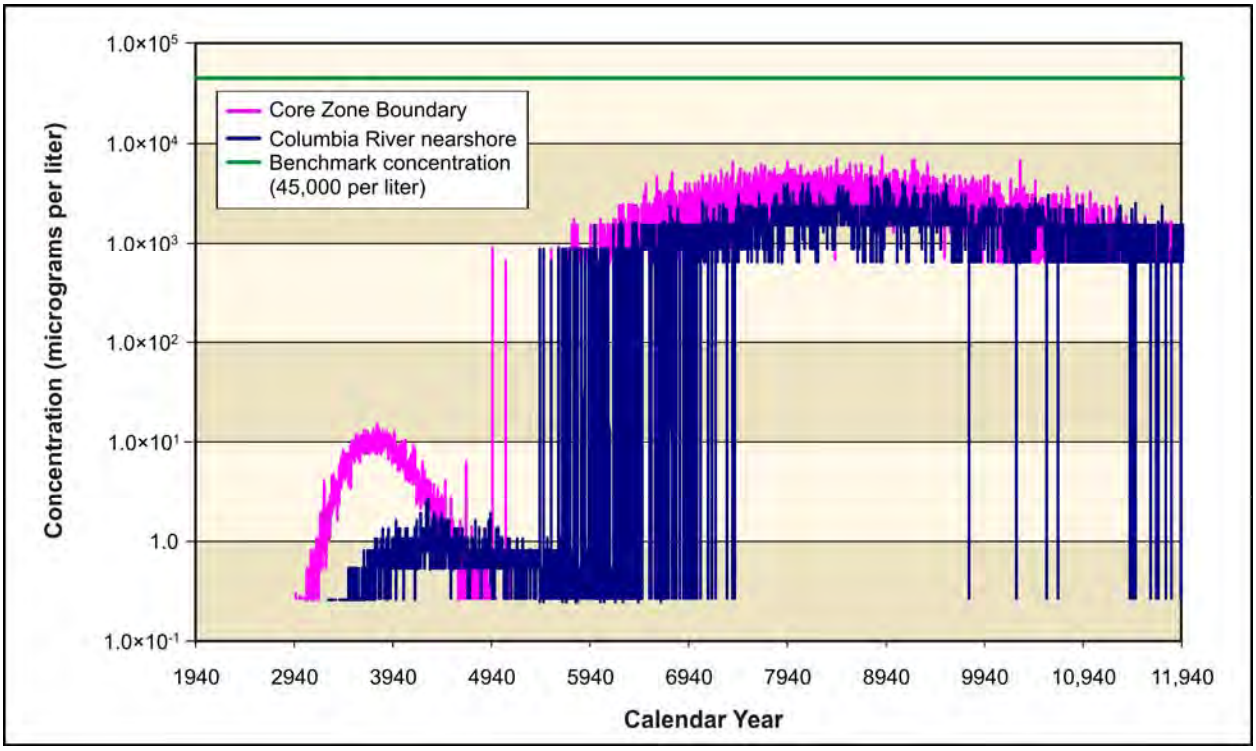


Figure 5–908. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Nitrate Concentration Versus Time

Figure 5–909 shows Core Zone Boundary and Columbia River nearshore concentrations versus time for uranium-238. There is no significant total uranium release. The data show that total uranium never approaches within nine orders of magnitude of the total uranium benchmark concentration. Figure 5–909 shows that, during the latter third of the analysis period, the uranium-238 concentrations at both the Core Zone Boundary and the Columbia River nearshore are increasing. The concentration at the Core Zone Boundary is at least three orders of magnitude below the benchmark concentration at the end of the analysis period. The concentration at the Columbia River nearshore is even smaller. The data do show that this uranium-238 rate of increase is significant and that it extends through the end of the analysis period (CY 11,885).

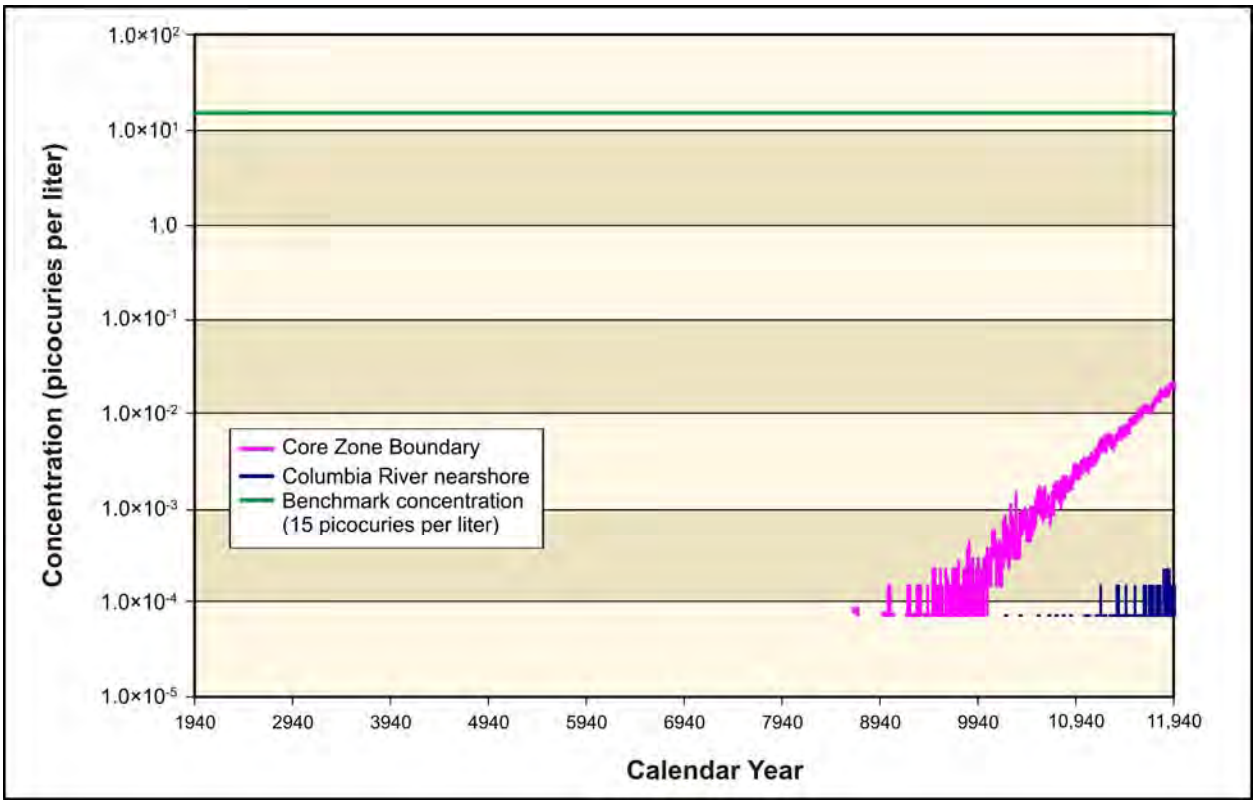


Figure 5–909. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Uranium-238 Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated the by faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–910 through 5–921 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. The groundwater releases from IDF-West extend north from the release site within the Core Zone to the Columbia River nearshore, with the distribution

remaining in a fairly narrow channel (Gable Gap) until about halfway to the Columbia River nearshore. The IDF-East releases remained in a relatively narrow channel until they reached about the one-quarter distance point to the Columbia River, where they broadened and continued to the Columbia River nearshore. For technetium-99, iodine-129, nitrate, and chromium, the IDF-West releases occur earlier and dissipate sooner than those from IDF-East. Figure 5–922 shows the concentration distribution for IDF-East uranium-238 at CY 11,885 which creates a similar release distribution.

Figure 5–910 shows that the technetium-99 release from IDF-West exceeds its benchmark concentration within the Core Zone and in several areas near to the Columbia River nearshore in CY 3890. There are also several small areas with very high technetium-99 concentrations (several orders of magnitude larger than the benchmark) just north of the Core Zone Boundary. This figure shows no technetium-99 from IDF-East at this time. Figure 5–911 shows that the IDF-West technetium-99 has mostly dissipated by CY 7140 with the exception of several small pockets north of the Core Zone Boundary where the technetium-99 concentration is greater than the benchmark concentration. The technetium-99 IDF-East release is shown with concentrations that are mostly lower than the technetium-99 benchmark concentration. Figure 5–912 shows that the IDF-West groundwater technetium-99 continues to dissipate in CY 11,885, in contrast to the IDF-East technetium-99 distribution, which continues to spread toward the Columbia River with peak concentrations that approach or exceed benchmark concentrations in an area east of the Core Zone Boundary. Most of the technetium-99 distribution is at least one order of magnitude below its benchmark concentration between IDF-East and the Columbia River nearshore.

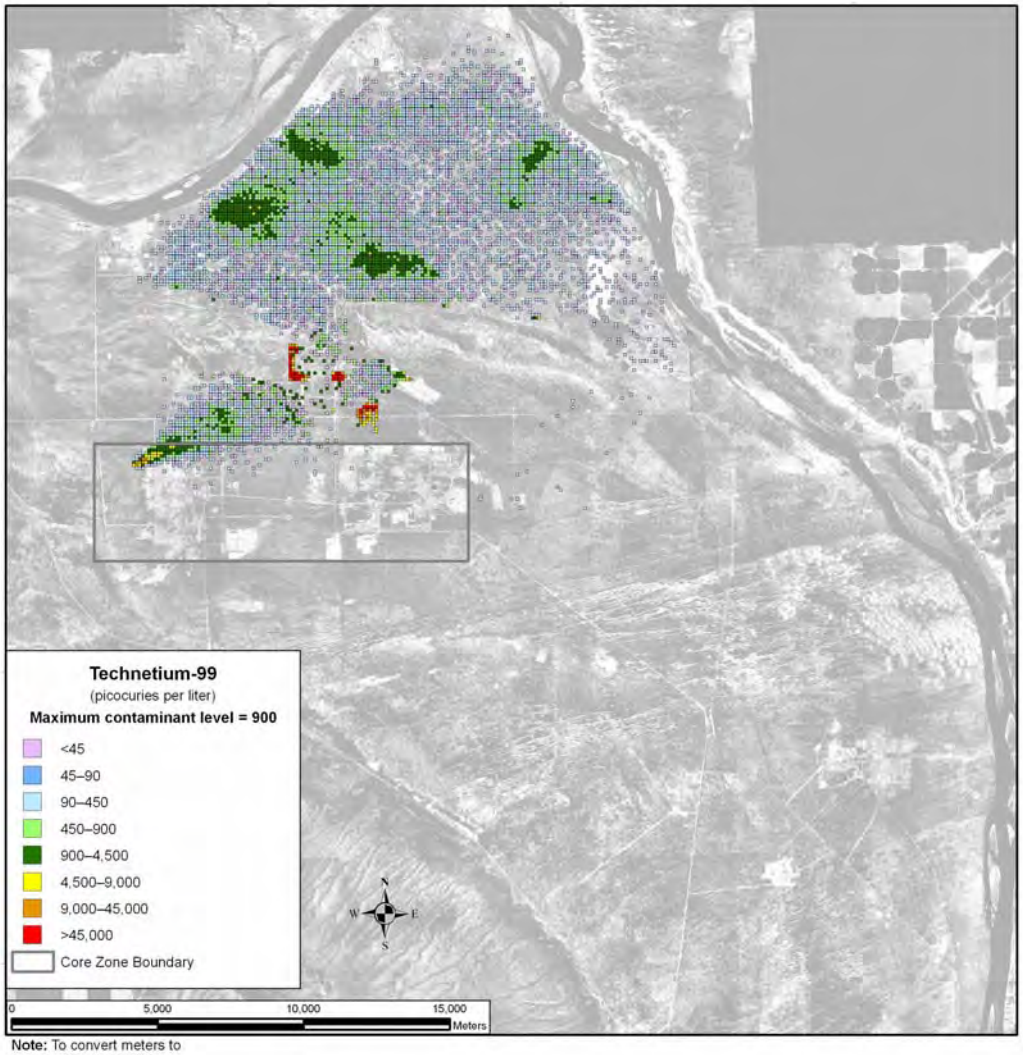


Figure 5–910. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

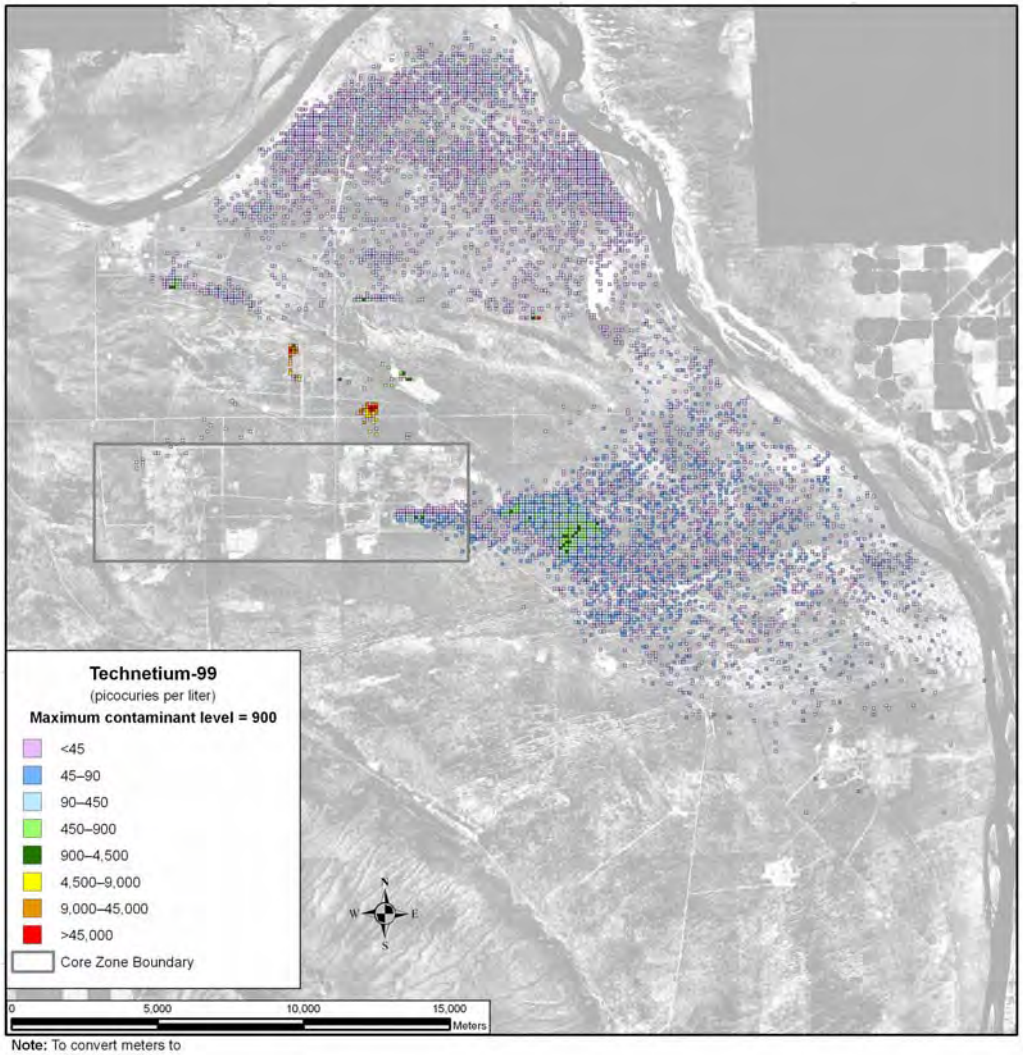


Figure 5–911. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

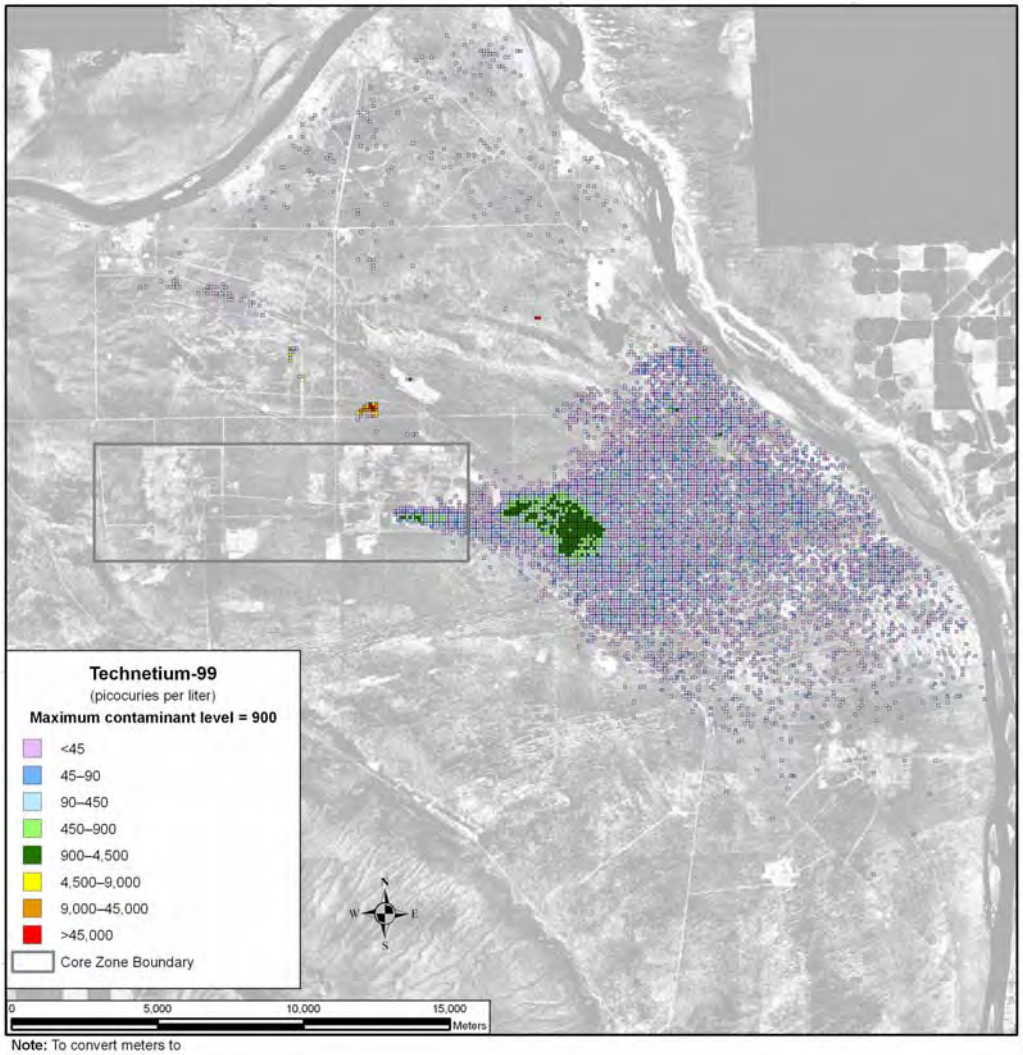


Figure 5–912. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

Figures 5–913 through 5–915 show iodine-129 released from IDF-East and IDF-West with a spatial distribution very similar to the technetium-99 release. However, the CY 3890 iodine-129 release (see Figure 5–913) shows higher relative concentrations (compared with the benchmark concentration) than the technetium-99 release. The areas of high concentrations are in the same locales, but these areas have levels that exceed the benchmark concentration by at least one order of magnitude. No iodine-129 is released from IDF-East at this time. By CY 7140, the IDF-West iodine-129 release has significantly dissipated (see Figure 5–914); only small areas remain where iodine-129 is at or above its benchmark concentration. This shows the onset of the IDF-East iodine-129 release. By CY 11,885 (see Figure 5–915), the IDF-East iodine-129 distribution has significantly increased in size and concentration. Several small areas east of the Core Zone Boundary show concentrations at or above benchmark levels.

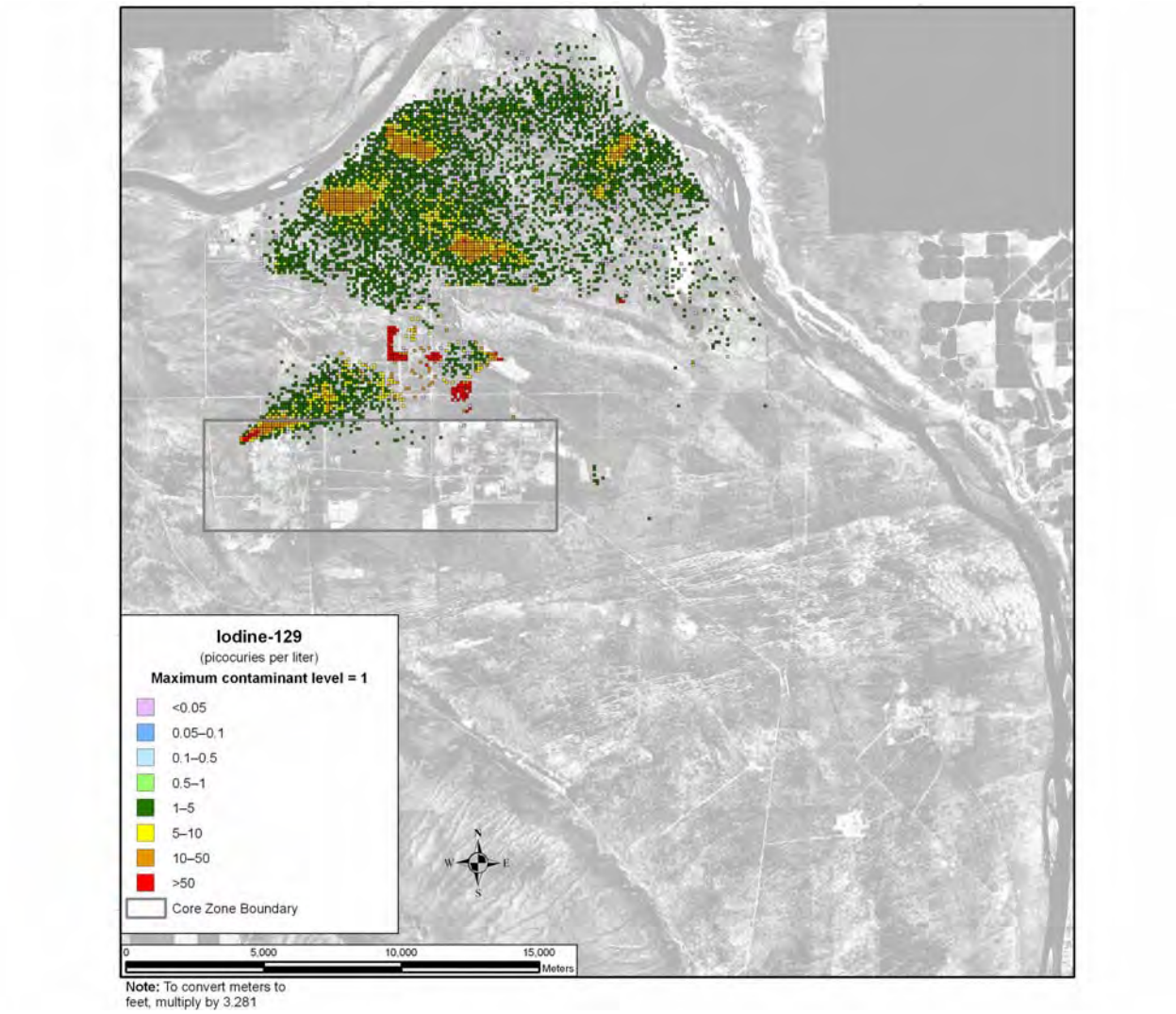


Figure 5–913. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

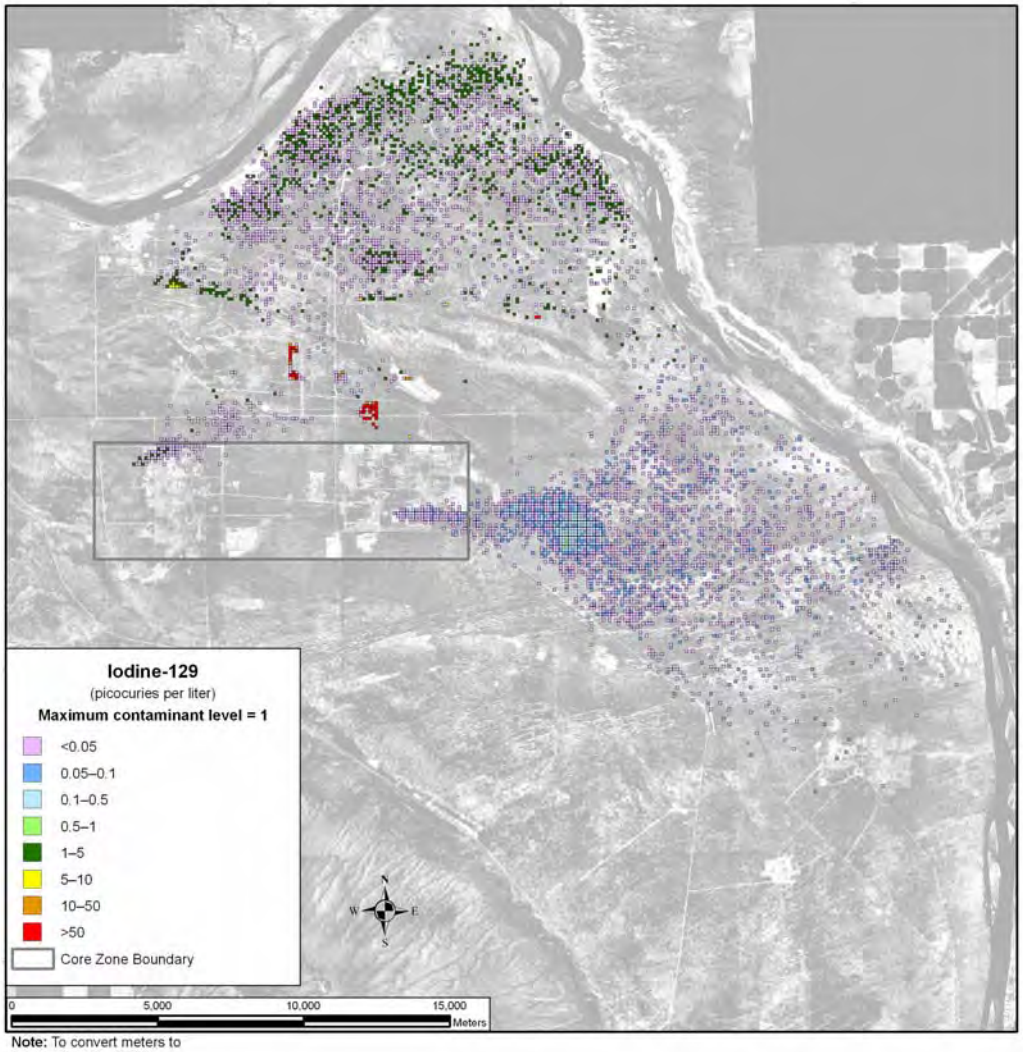


Figure 5–914. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

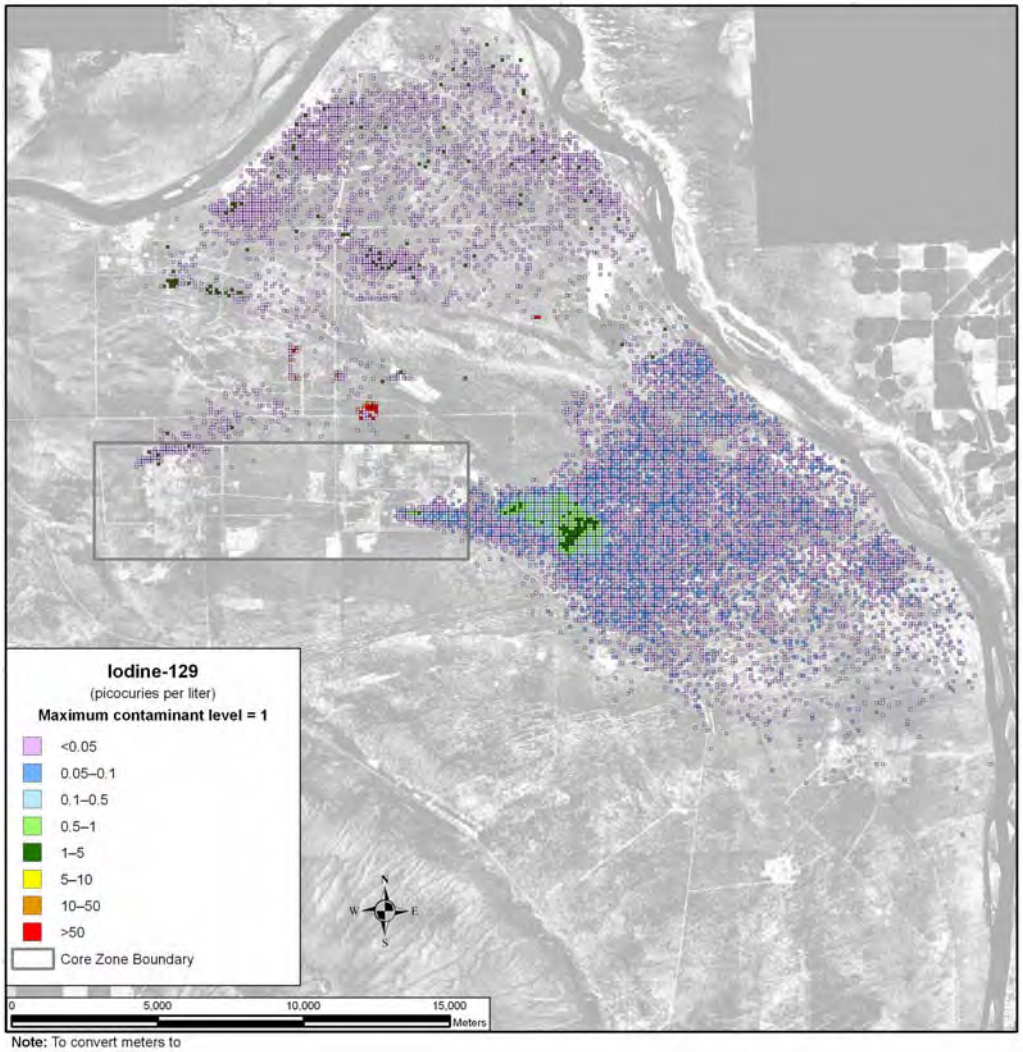


Figure 5–915. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

The IDF-East and IDF-West nitrate releases, shown in Figures 5–916 through 5–918, show time and spatial distributions similar to the technetium-99 and iodine-129 released. However, the IDF-East nitrate release never approaches benchmark concentrations and dissipates significantly by CY 7140 (almost nothing is showing at CY 11,885). The IDF-East nitrate release occurs later and does not appear in the CY 3890 data (see Figure 5–916). By CY 7140 (see Figure 5–917), the IDF-East nitrate release has reached the Columbia River. By CY 11,885 (see Figure 5–918), the nitrate has dissipated significantly and concentrations have fallen well below the benchmark concentration.

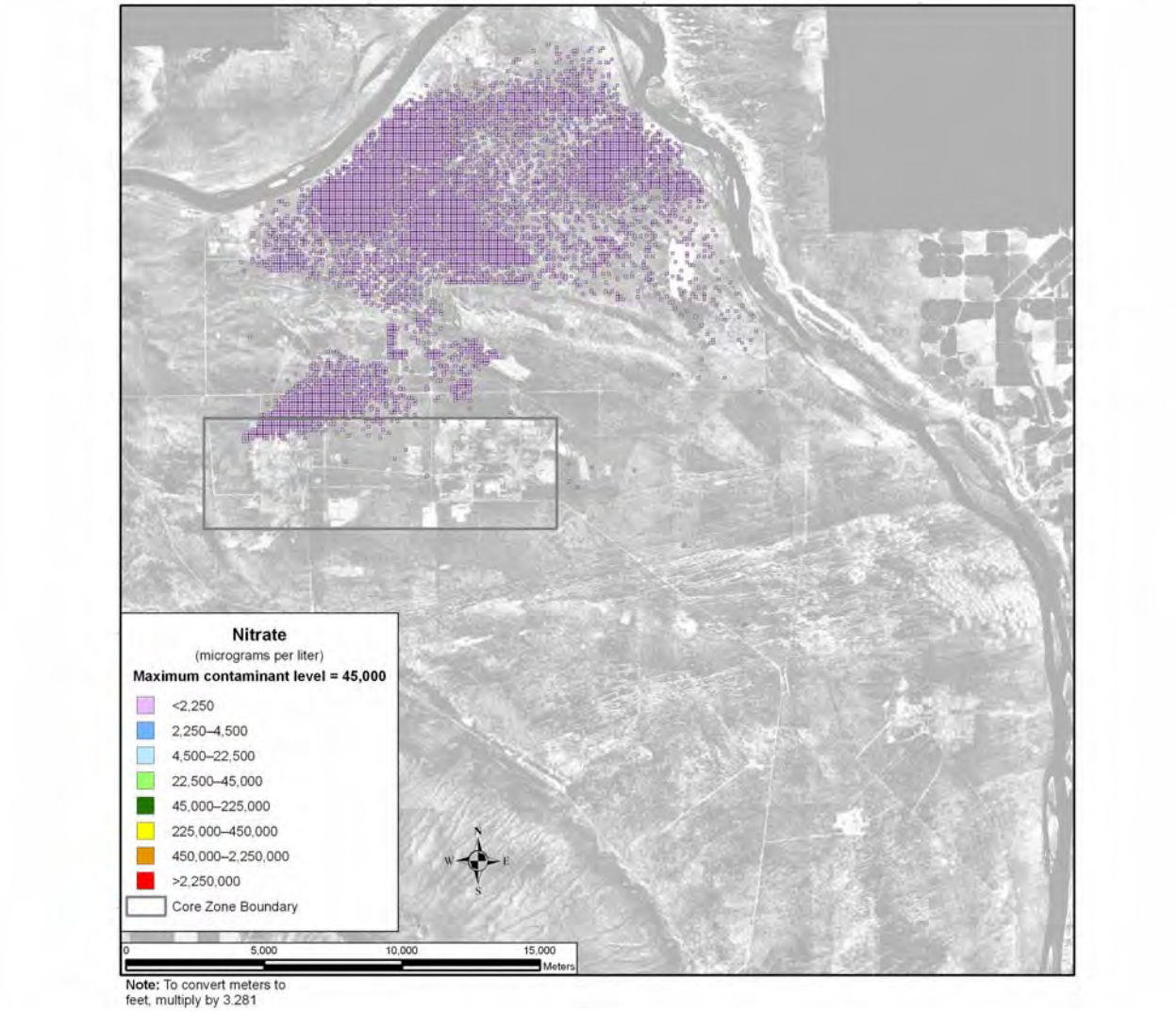


Figure 5–916. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

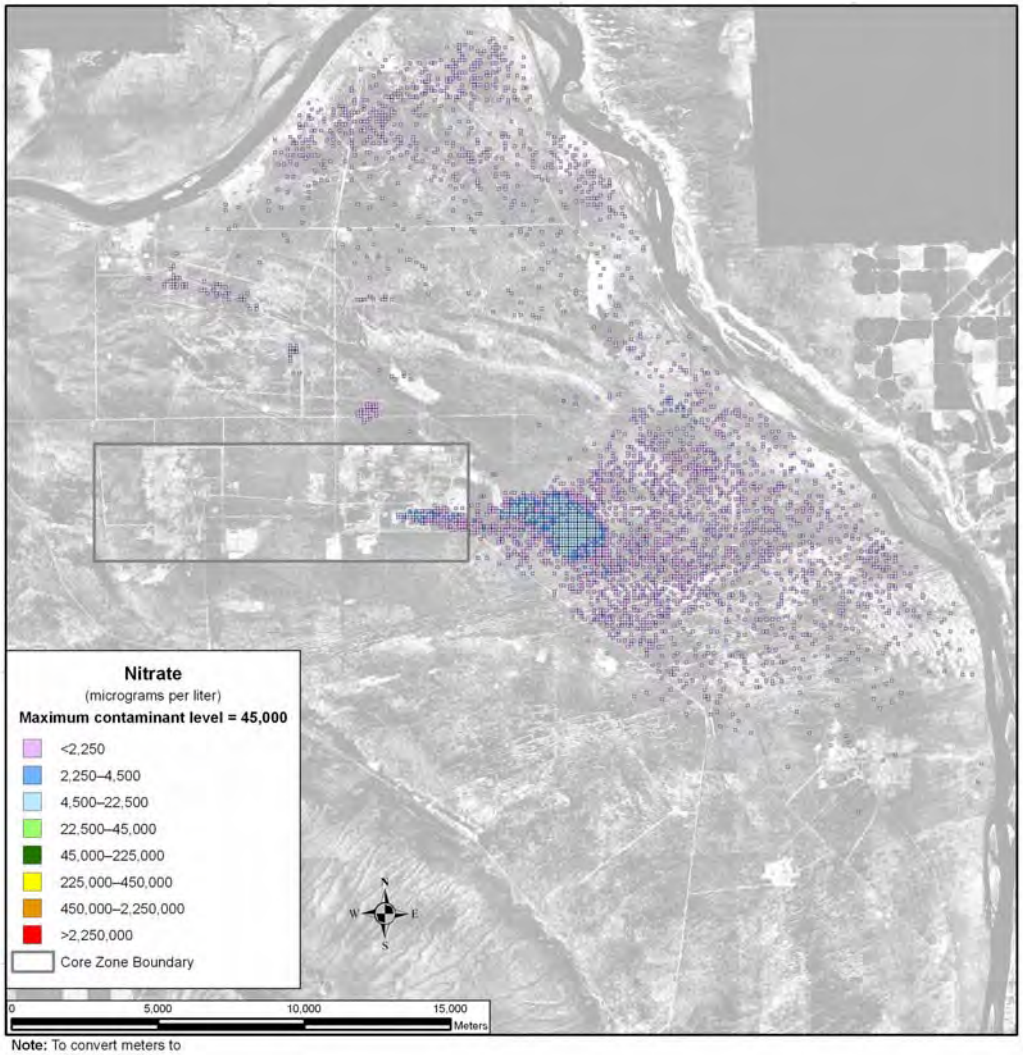


Figure 5–917. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

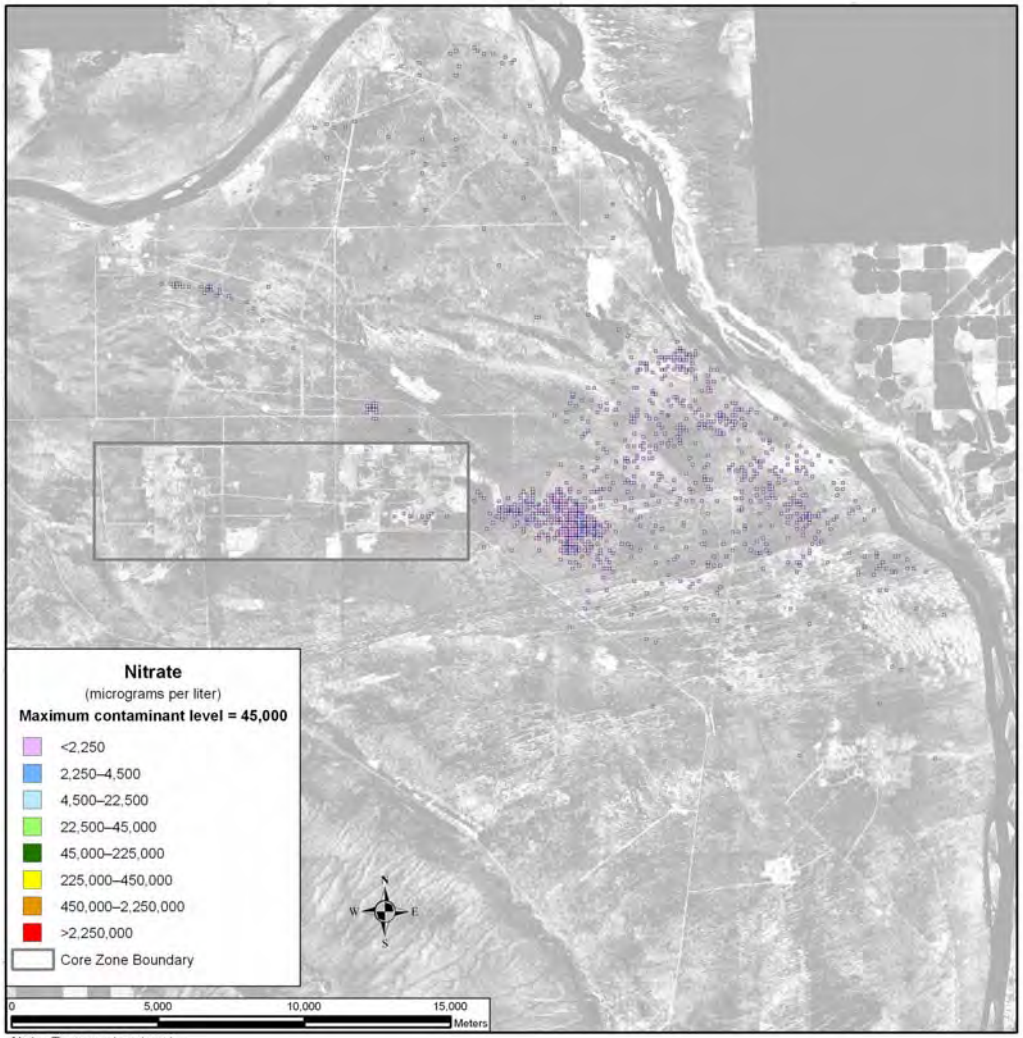


Figure 5–918. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

The initial chromium release time and spatial patterns at CY 3890 in (see Figure 5–919) are nearly identical to the IDF-West nitrate release. The chromium concentrations at CY 3890 are several orders of magnitude below the benchmark level. By CY 7140, most of this low-concentration IDF-West chromium has dissipated to the Columbia River (see Figure 5–920). By CY 7140, there is a significant chromium distribution from IDF-East, with small areas that exceed benchmark concentrations. By CY 11,885 (see Figure 5–921), the IDF-West chromium is essentially dissipated. The IDF-East chromium release extends from the release site to the Columbia River, but with concentrations that are well below the chromium benchmark concentration.

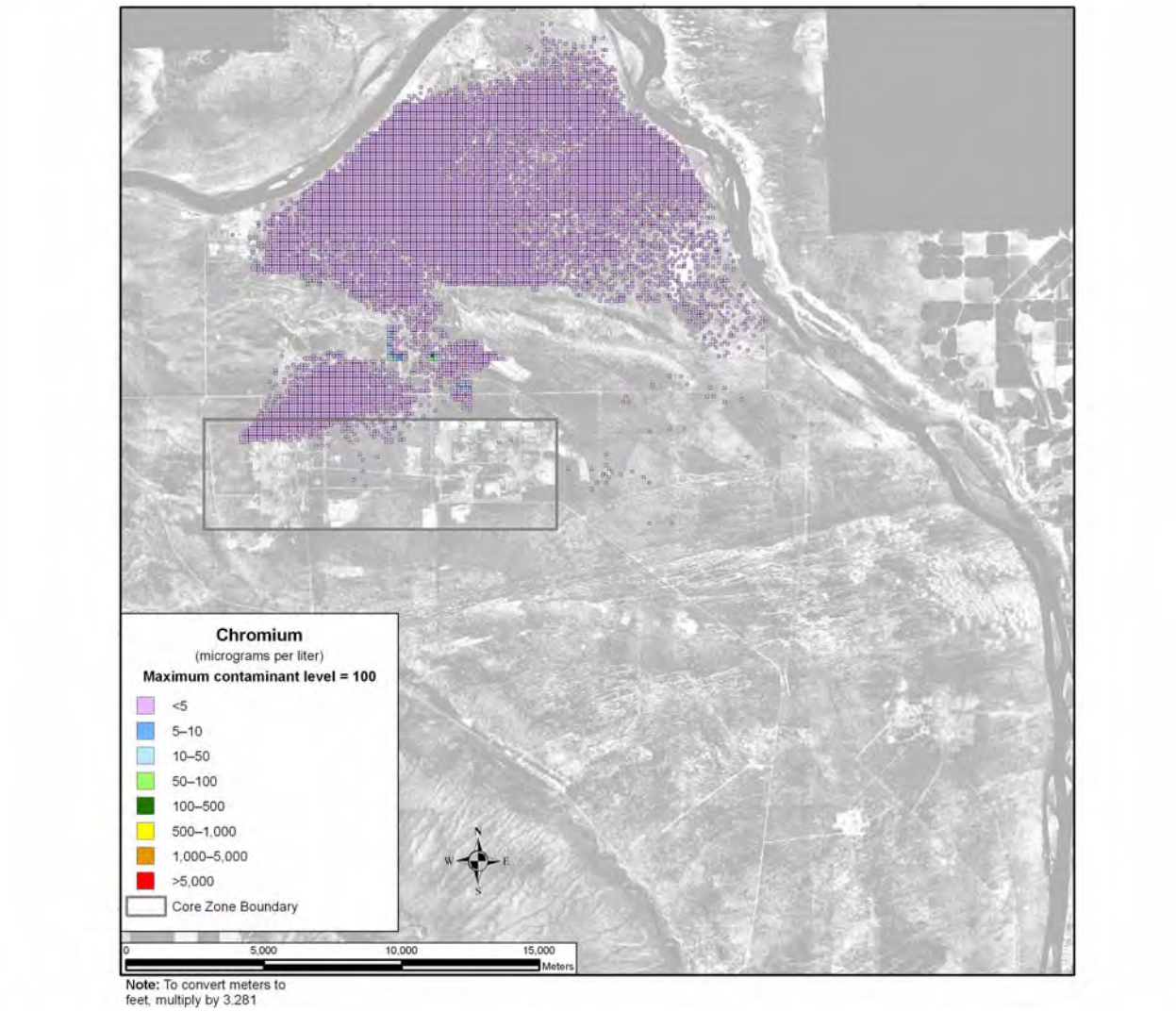


Figure 5–919. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

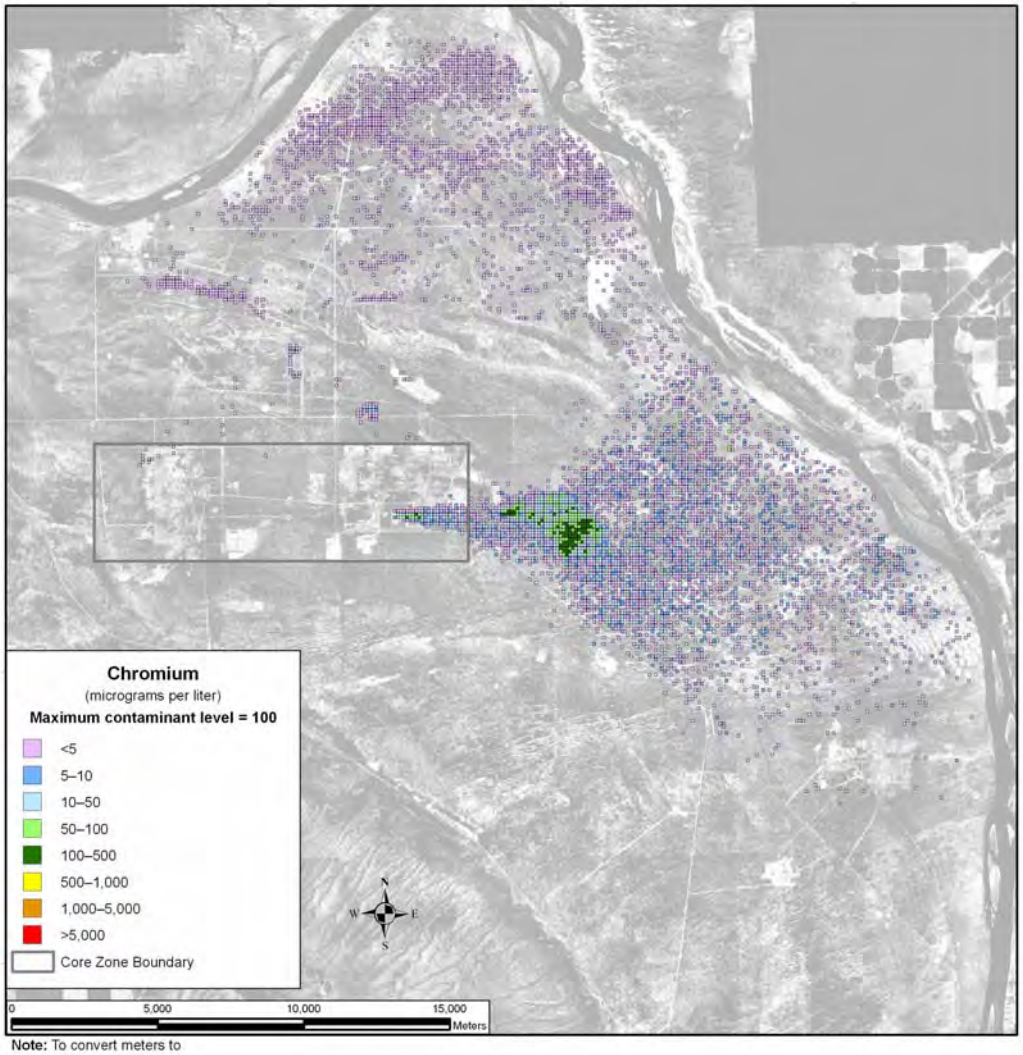


Figure 5–920. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

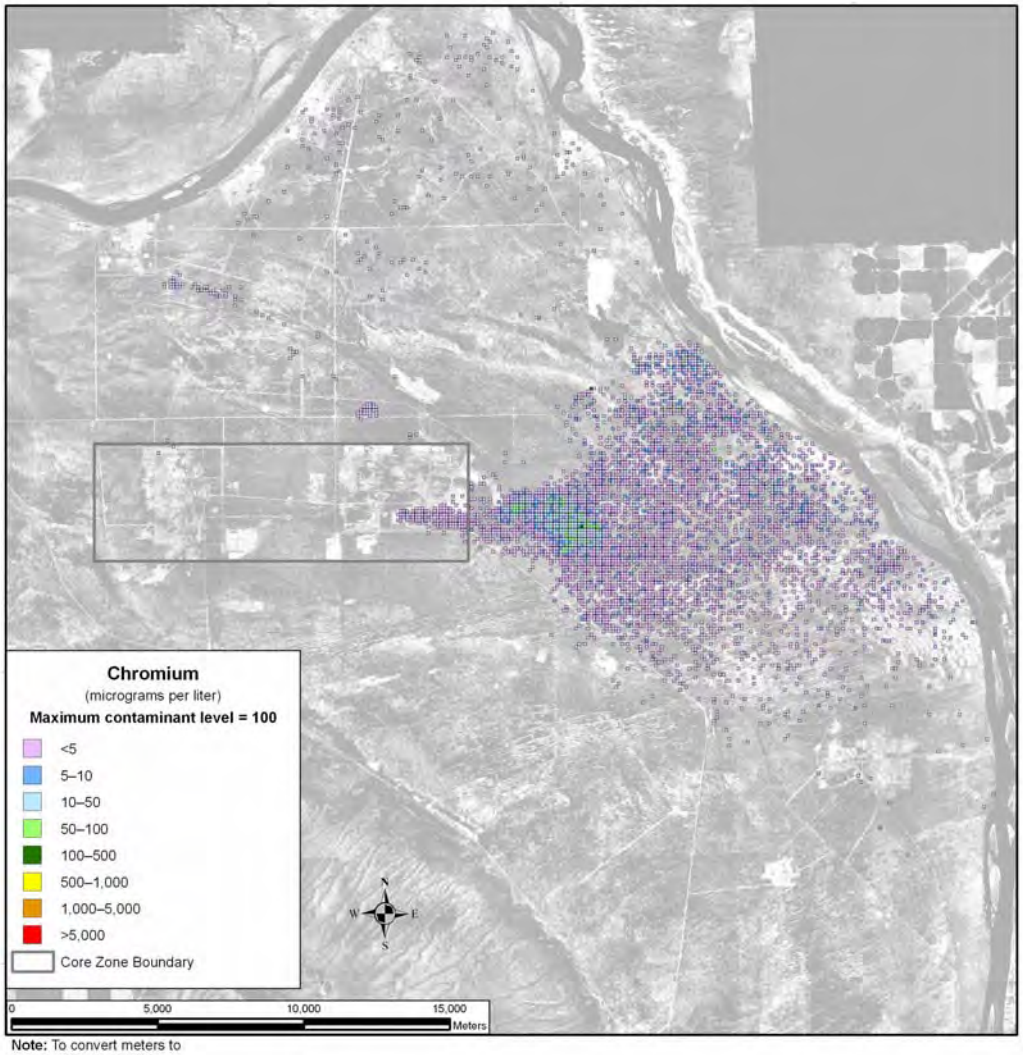


Figure 5–921. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

Figure 5–922 shows an IDF-West uranium-238 release at CY 11,885. No uranium-238 is released from IDF-East. The uranium-238 concentration in the distribution is well below its benchmark concentration. The data show retardation that resulted in a fairly homogenous concentration extending from the release site to the Columbia River nearshore.

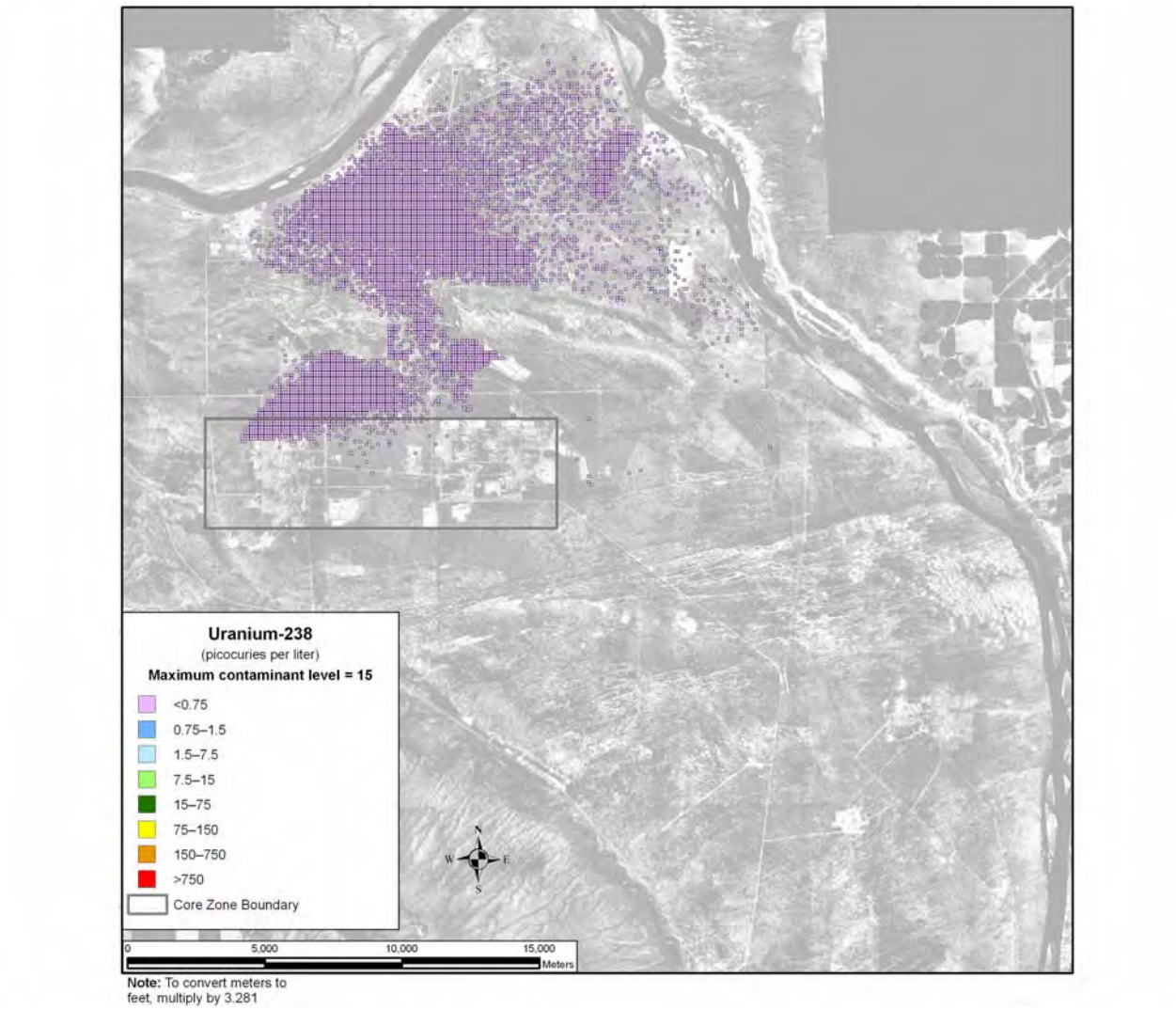


Figure 5–922. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, in general, the inventory remaining at IDF-East, IDF-West, and the RPPDF, that are available for release to the environment at the start of the post-disposal period are predominant contributors. The releases from IDF-West and the RPPDF are earlier and dissipate earlier than releases from IDF-East.

By the end of this analysis period (CY 11,885), the chromium and nitrate distributions have largely dispersed below their benchmark concentrations. A significant spatial distribution of technetium-99 and iodine-129 remains. Most of the distribution area has concentrations below benchmark levels, but there are some small areas in which technetium-99 and iodine-129 concentrations exceed benchmark levels at

CY 11,885. The released iodine-129, which occurs at higher concentration levels relative to its benchmark than technetium-99, dissipates much quicker than technetium-99.

Uranium-238's relatively limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of this retarded species do not exceed the benchmark levels at the Core Zone Boundary or Columbia River nearshore over this period of analysis. However, the spatial distributions of uranium-238 exist through the end of the analysis period (CY 11,885). Although the concentrations of uranium-238 are two orders of magnitude smaller than its benchmark concentration during this analysis period, the trend appears to show a continuing increase in concentrations through the end of the analysis period.

5.3.1.3.1.7 Disposal Group 1, Subgroup 1-G

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G covers disposal of wastes generated during Tank Closure Alternative 6C, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste. Tank closure waste would be converted to IHLW and ILAW glass. The ILAW glass would be stored on site as HLW pending disposition.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continues through CY 2050, when the disposal facilities will be operationally closed. During the disposal period the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2051 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G. Full results for all 40 COPCs are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk.

The chemical hazard drivers above account for 100 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G.

The COPC drivers that are discussed in detail in this section fall into two categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over six orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–923 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–924, the chemical hazard drivers. Two subtotals are plotted, representing releases from ETF-generated secondary waste and tank closure secondary waste. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant source for technetium-99 and chromium is tank closure secondary waste. ETF-generated secondary waste is the predominant source for iodine-129 and nitrate.

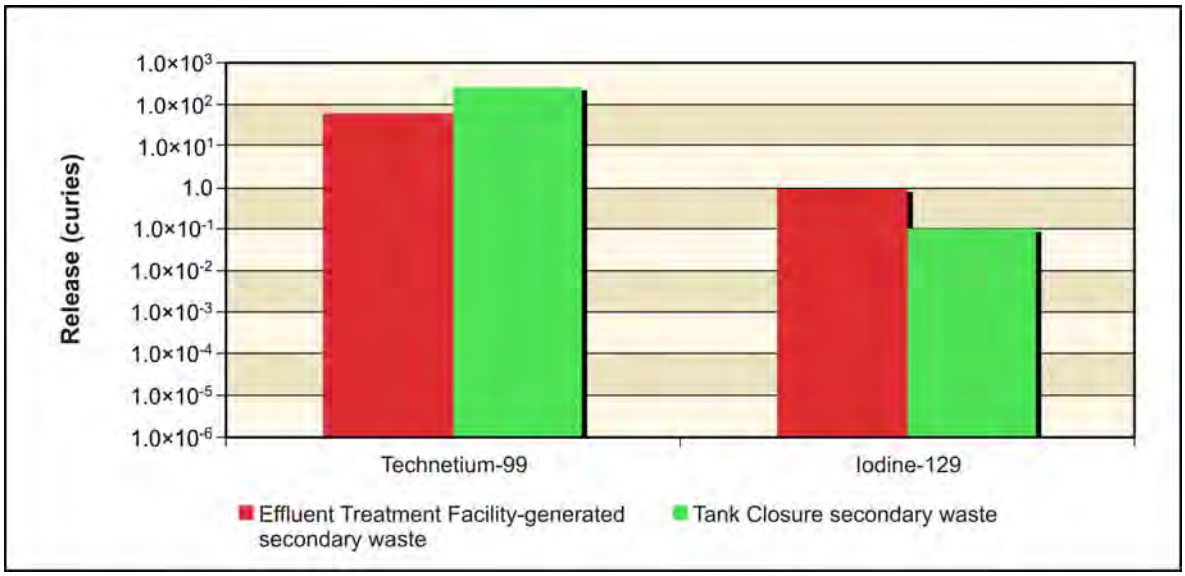


Figure 5–923. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

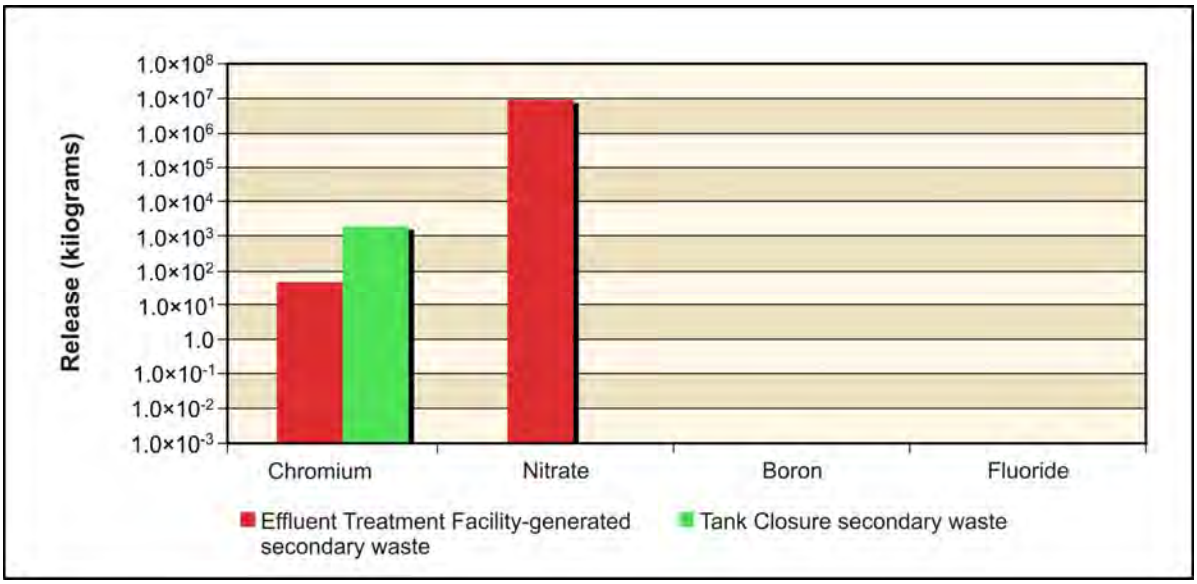


Figure 5–924. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–925 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–926, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. With the exception of technetium-99 released from ETF-generated secondary waste, of which nearly all released to the vadose zone reaches groundwater, only 40 to 50 percent of the technetium-99 and iodine-129 released to the vadose zone reaches groundwater. Nearly all chromium and nitrate released to the vadose zone reaches groundwater.

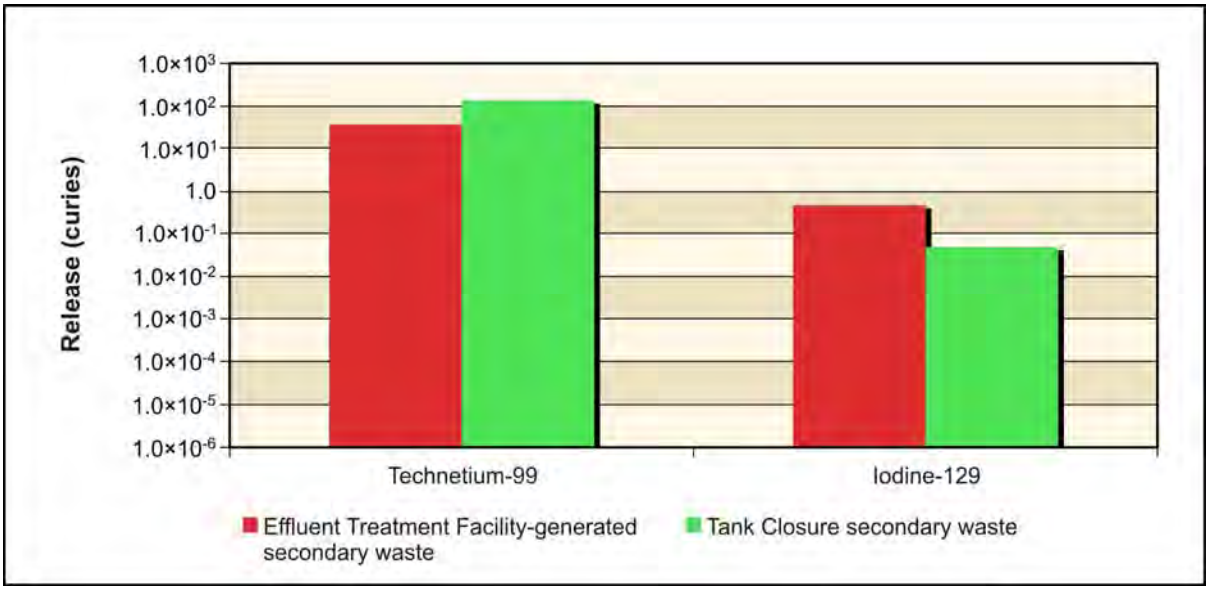


Figure 5–925. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

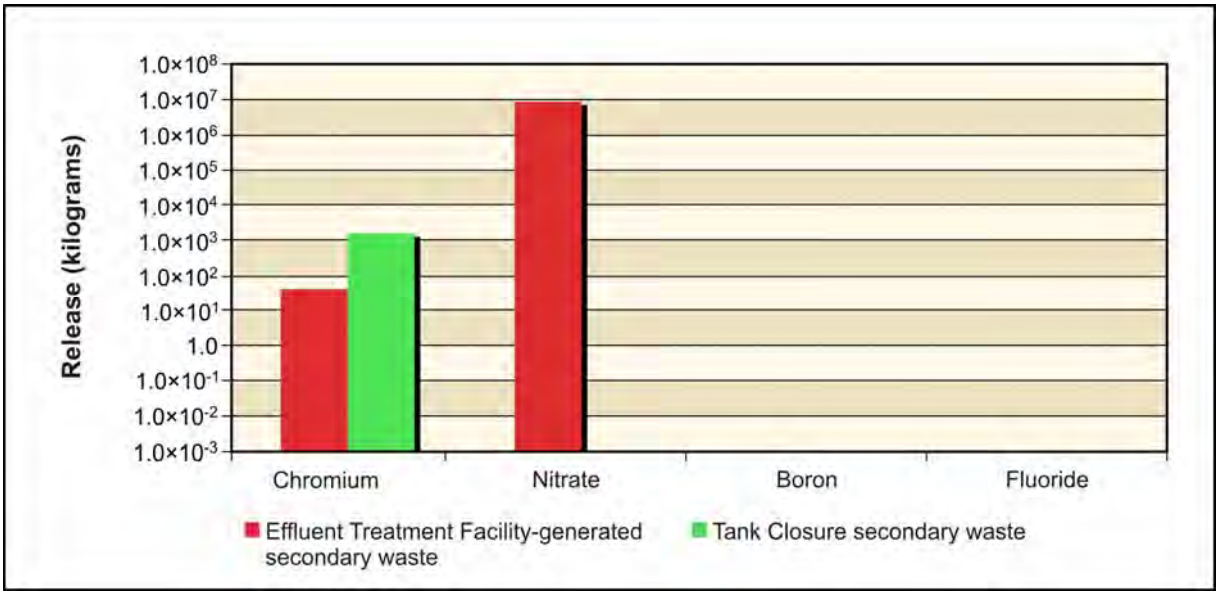


Figure 5–926. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–927 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–928, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In all cases between 90 and 100 percent of the amount released to groundwater reached the Columbia River.

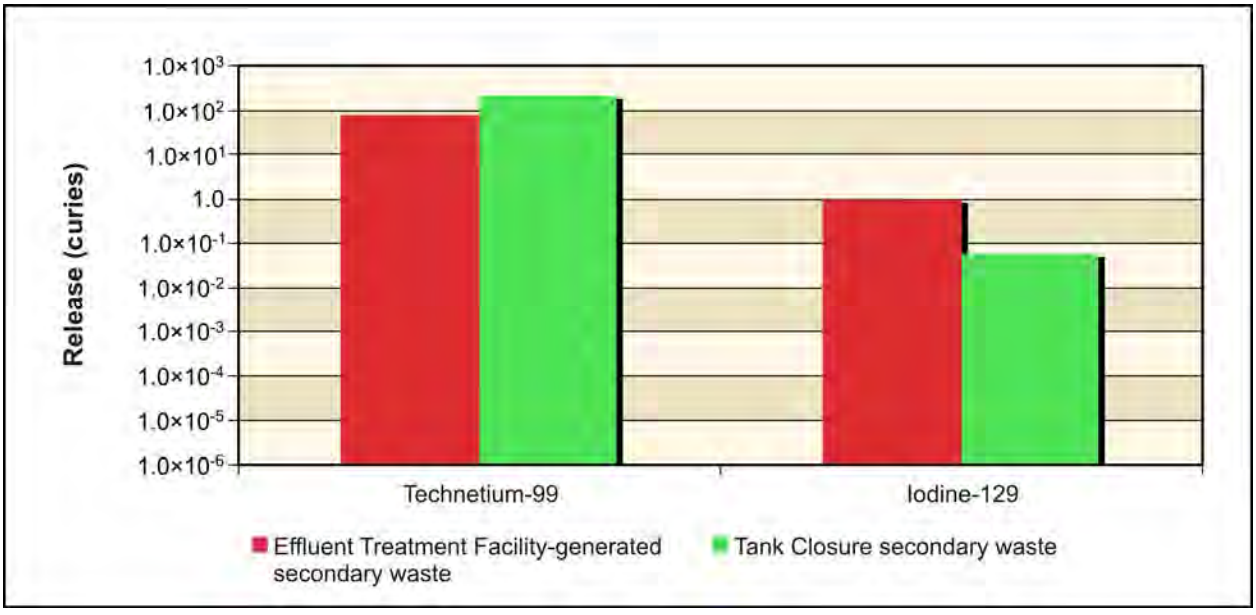


Figure 5–927. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

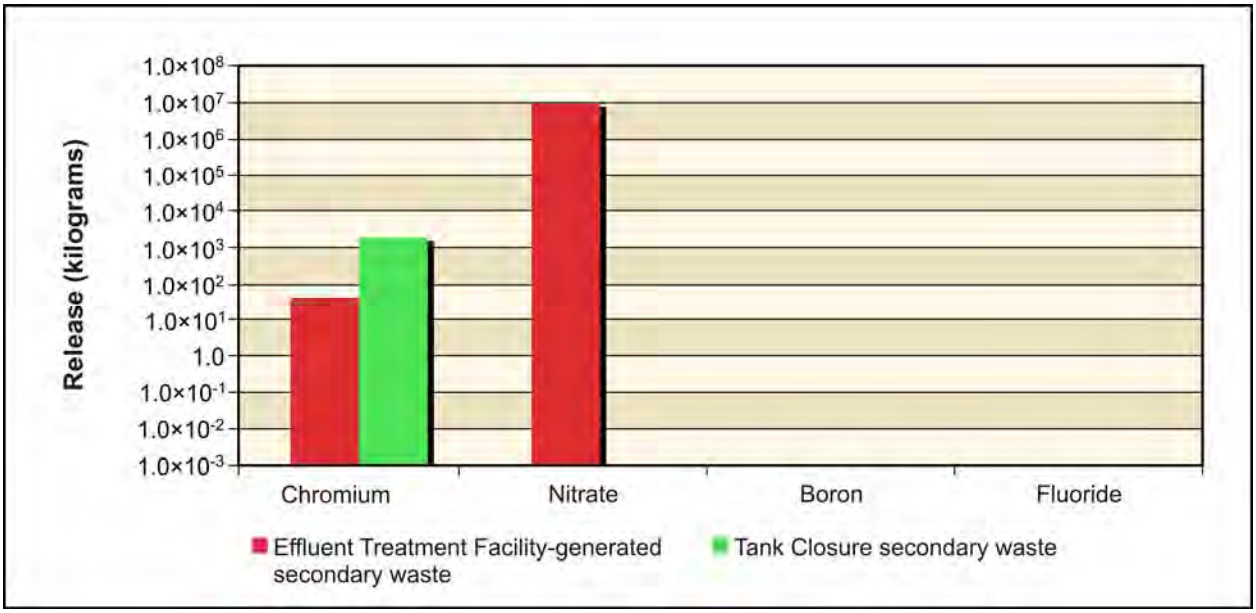


Figure 5–928. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary and onsite- and offsite-generated waste. Figure 5–929 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–930, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, boron, chromium, fluoride, and nitrate are all present at IDF-West.

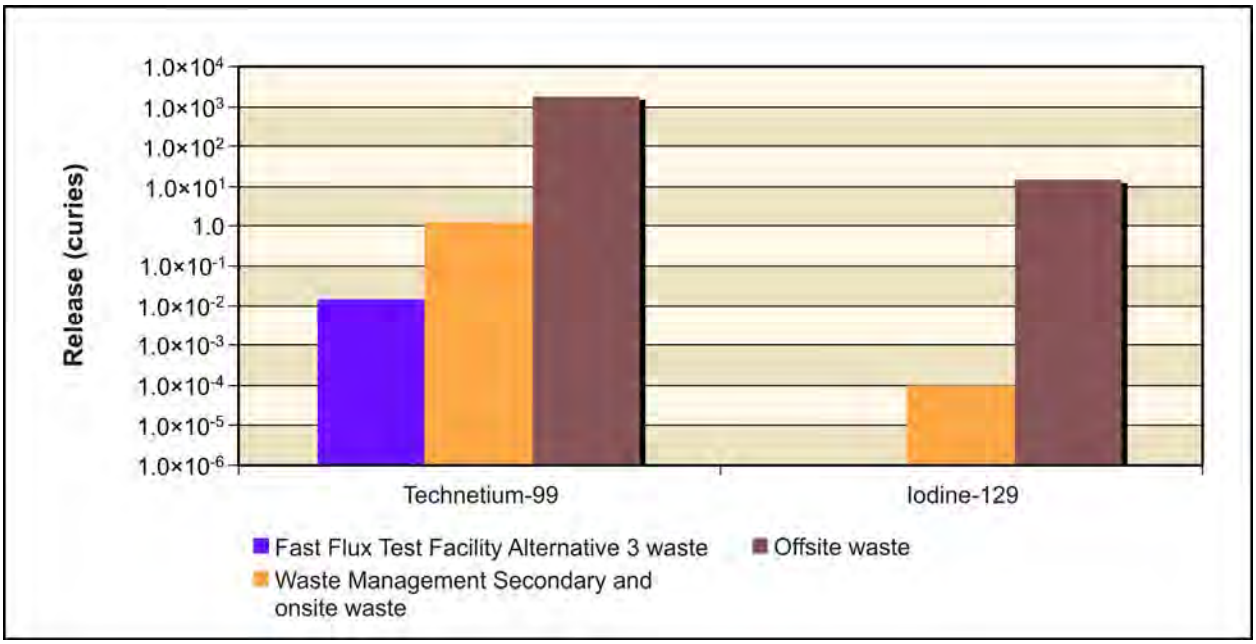


Figure 5–929. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

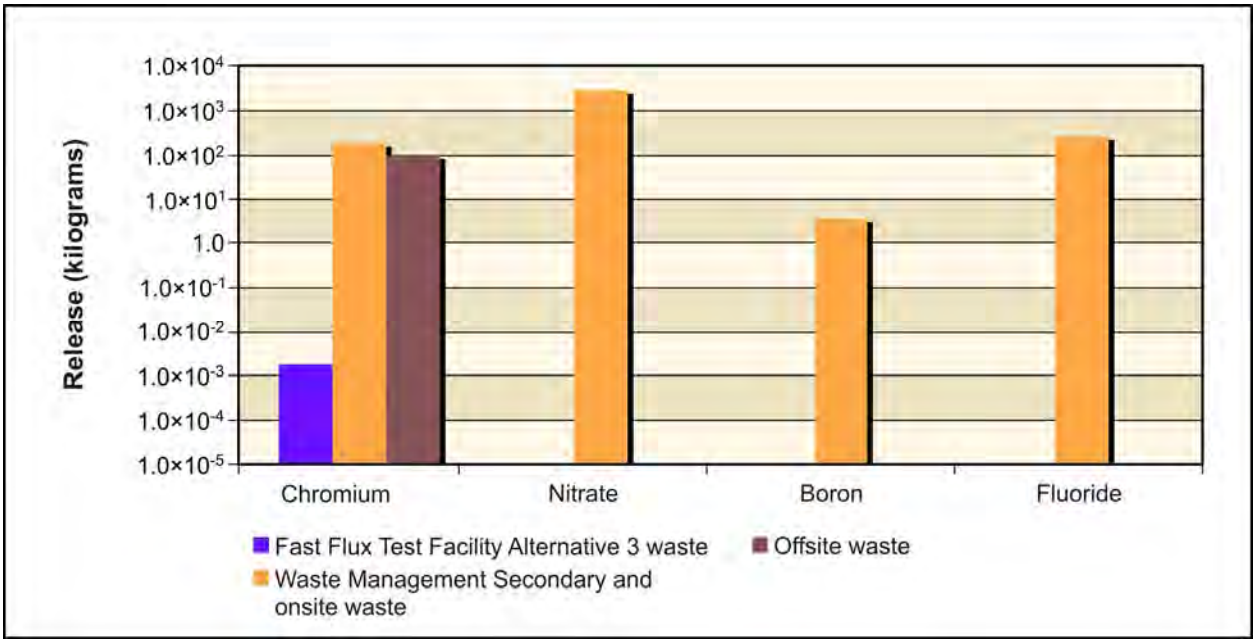


Figure 5–930. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–931 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–932, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at IDF-West behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

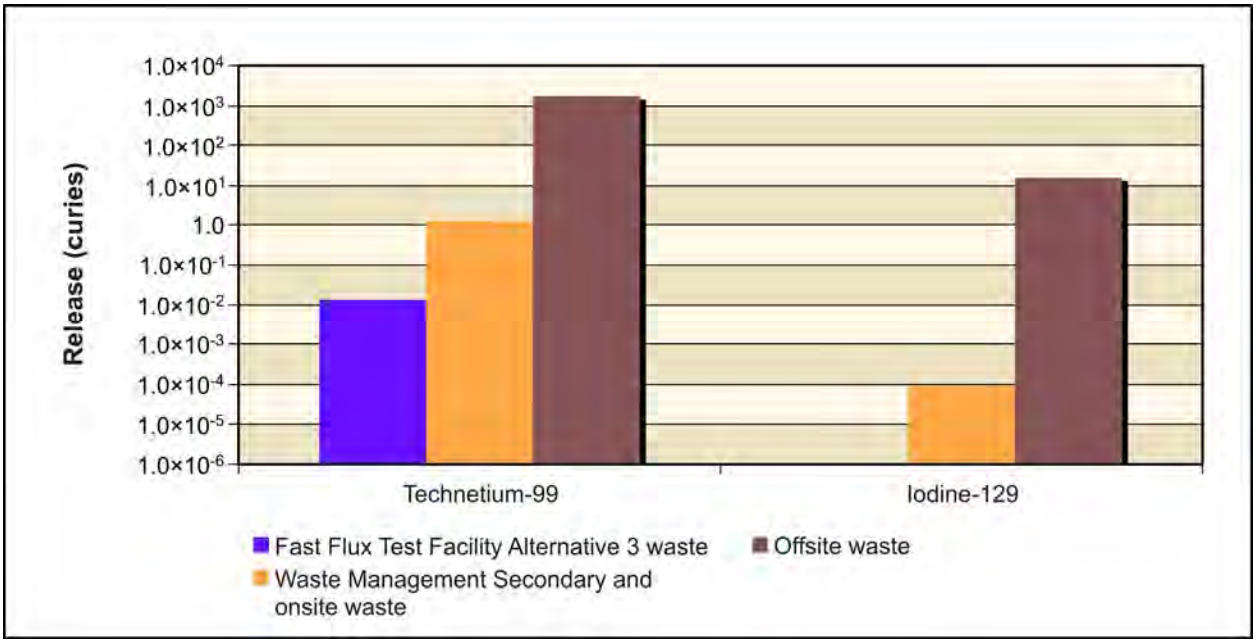


Figure 5–931. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

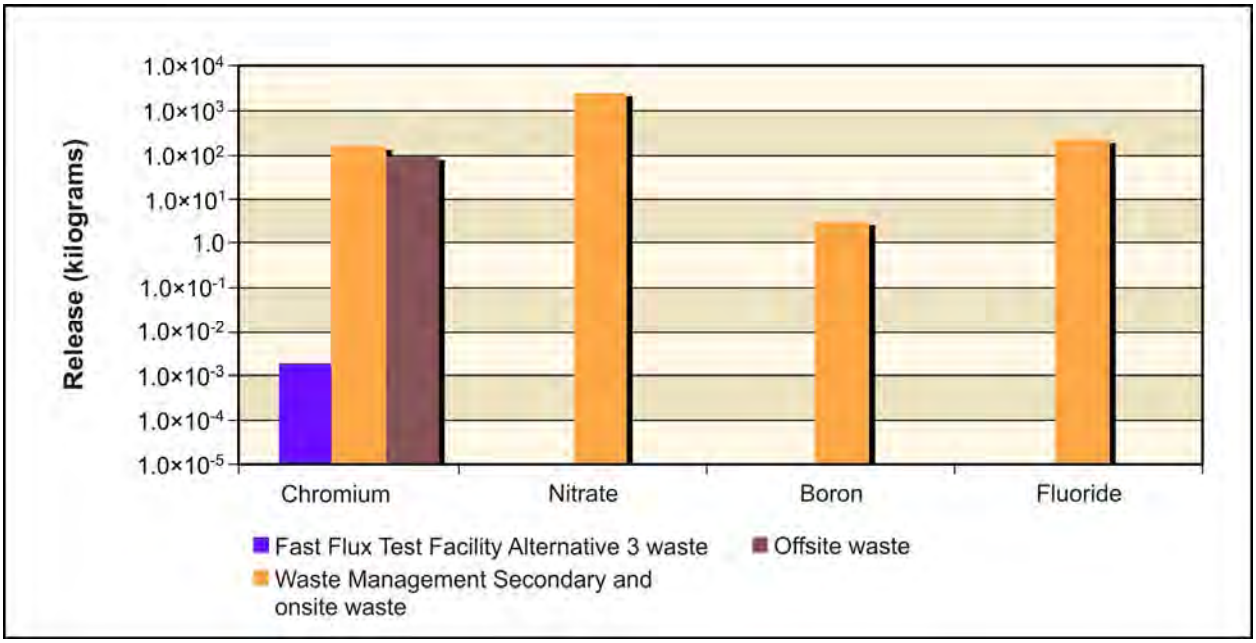


Figure 5–932. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–933 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–934, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

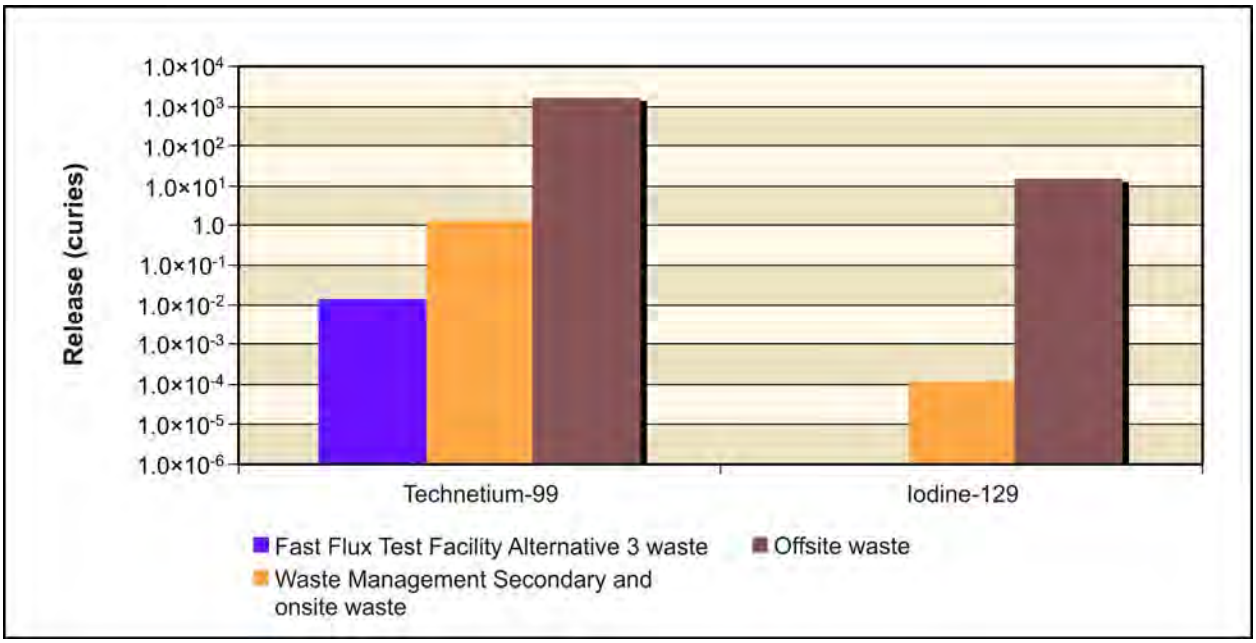


Figure 5–933. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

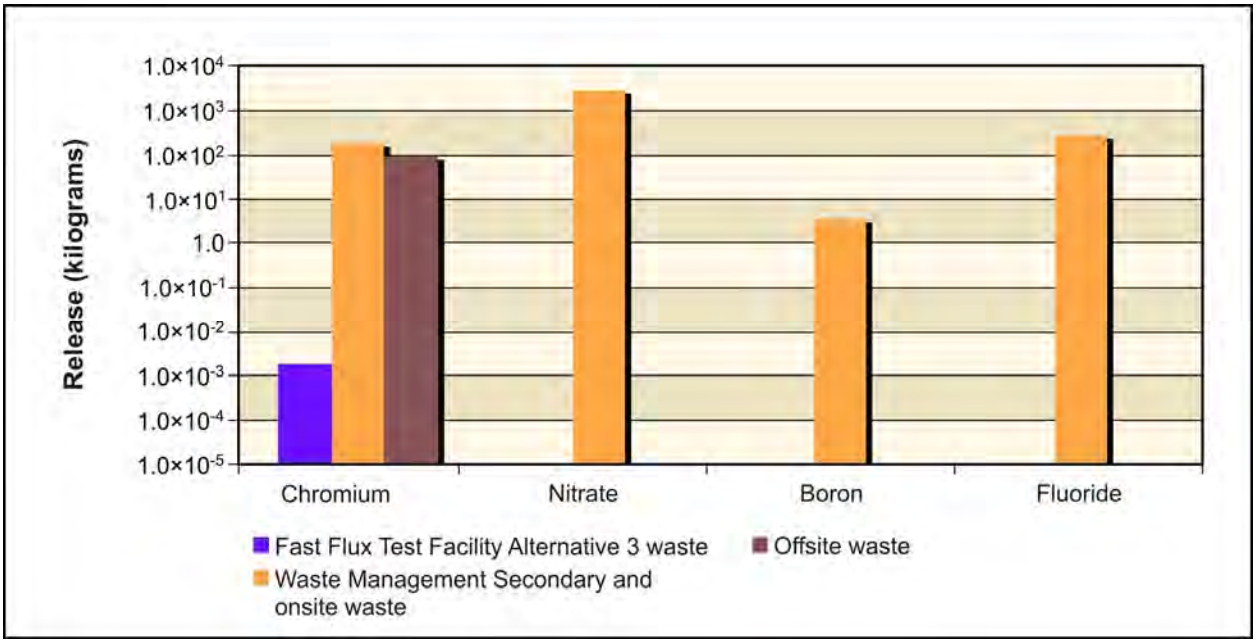


Figure 5–934. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

The RPPDF would receive lightly contaminated equipment and soils resulting from tank farm closure activities. Figure 5–935 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–936, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF.

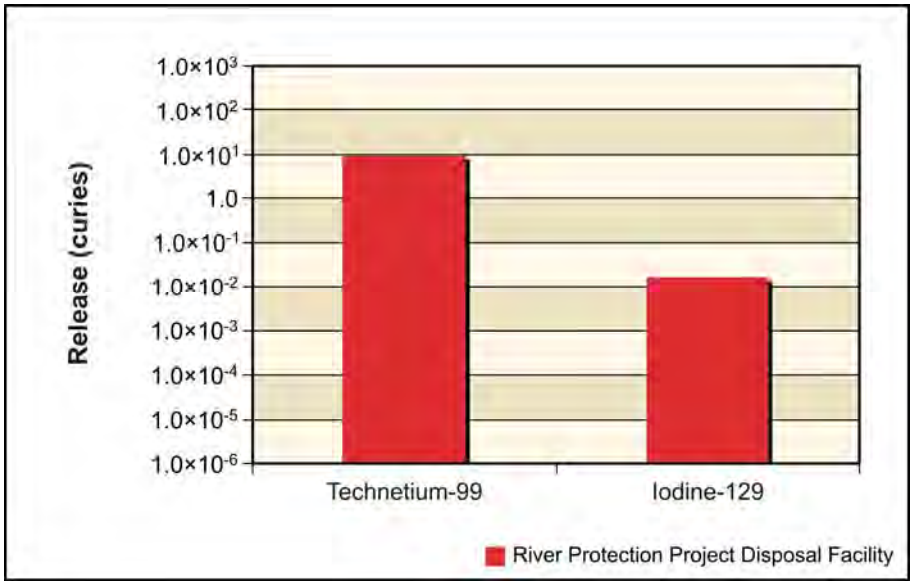


Figure 5–935. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

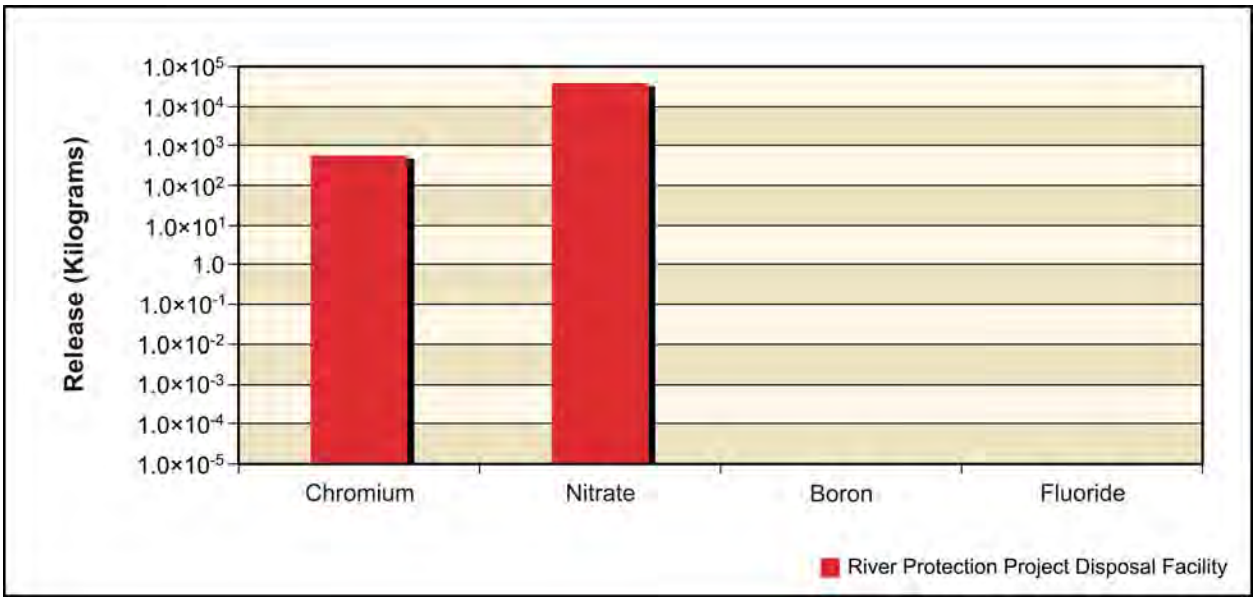


Figure 5–936. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–937 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–938, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

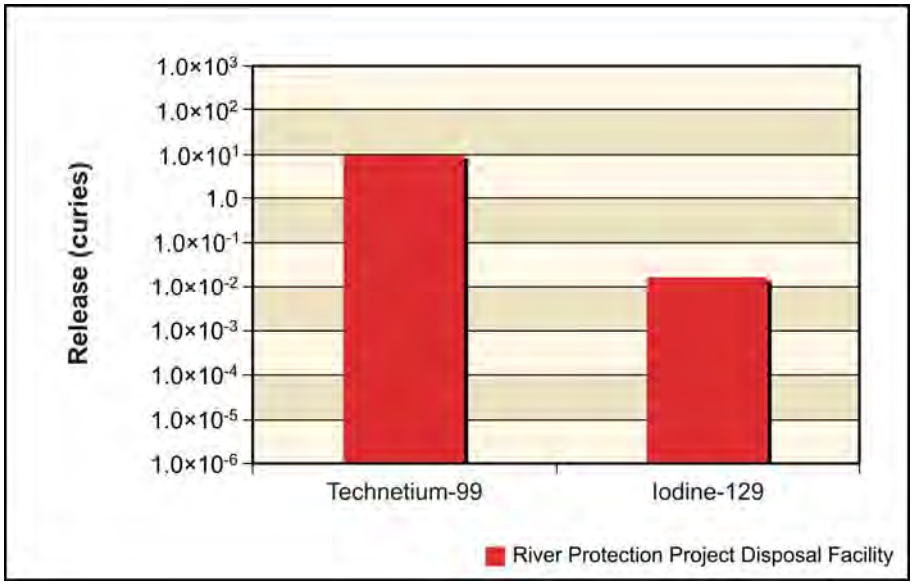


Figure 5–937. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Groundwater

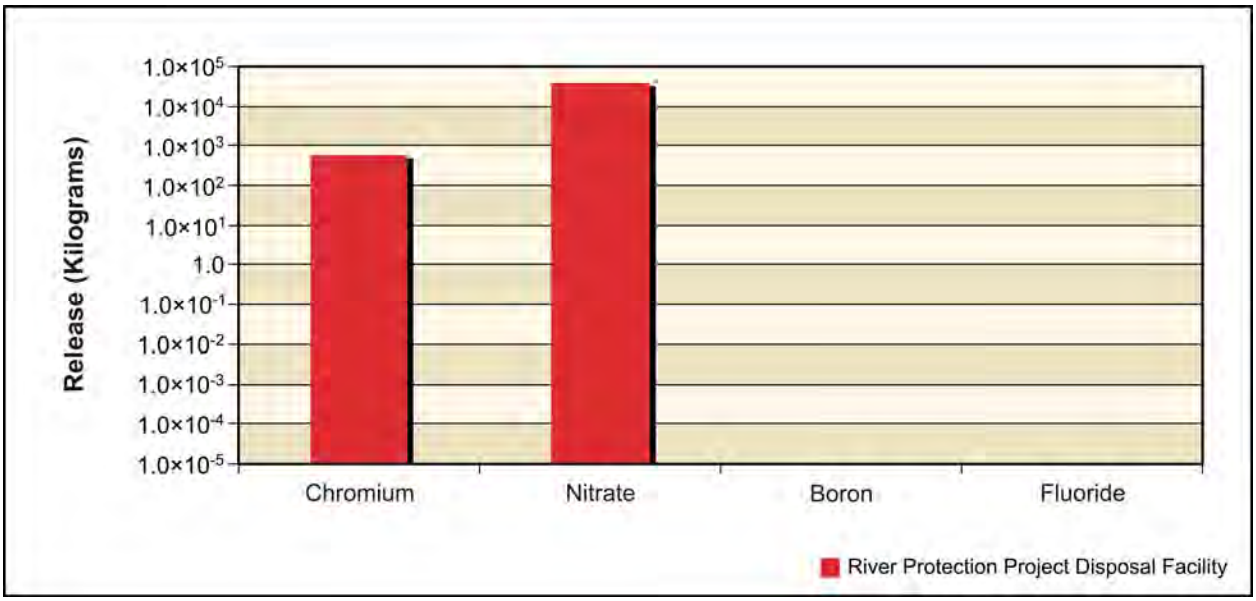


Figure 5–938. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–939 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–940, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

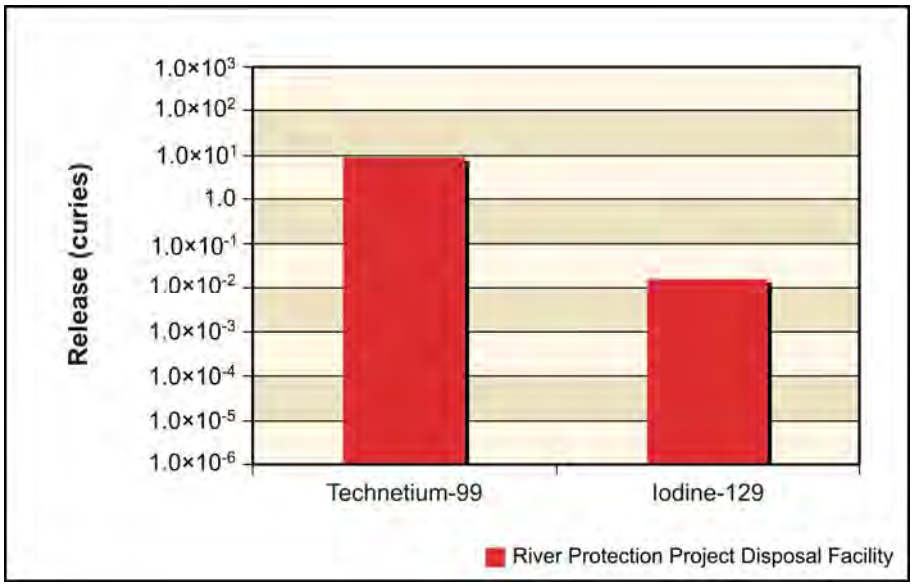


Figure 5–939. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Columbia River

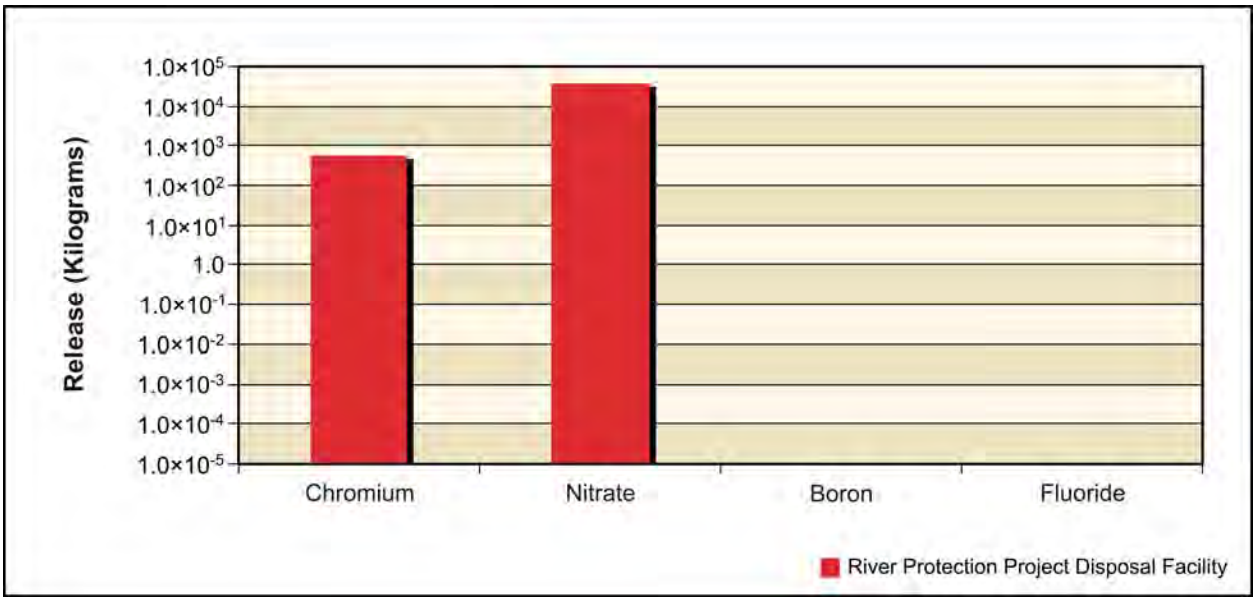


Figure 5–940. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude. Table 5–95 shows the maximum concentrations in groundwater.

Table 5–95. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	414	**20,200**	33	**7,560**	**1,130**	900
	(10032)	(3713)	(3825)	(3690)	(4528)	
Iodine-129	**1**	**173**	0.1	**60**	**8**	1
	(11,243)	(3797)	(3772)	(3853)	(4729)	
Chemical in microgram per liter						
Chromium	4	2	2	3	1	100
	(8618)	(3696)	(3856)	(3628)	(8204)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,200	17	149	5,630	2,440	45,000
	(8522)	(3703)	(3811)	(9653)	(8043)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–941 through 5–944 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, concentrations rise early in the simulation, reaching a peak around CY 3940 at about an order of magnitude above the benchmark concentration. Concentrations drop until around CY 7940, when they begin to stabilize nearly an order of magnitude below the benchmark. Iodine-129 follows a similar pattern, stabilizing slightly below the benchmark after peaking at nearly two orders of magnitude above the benchmark. Chromium concentrations at the Core Zone Boundary peak nearly two orders of magnitude below the benchmark before concentrations drop sharply. Around CY 5400, concentrations begin rising again, with a peak over two orders of magnitude below the benchmark. Nitrate has a similar two-peaked pattern, with the first peak remaining three orders of magnitude below the benchmark at the Core Zone Boundary, while the second peak is only one order of magnitude below the benchmark at the Core Zone Boundary.

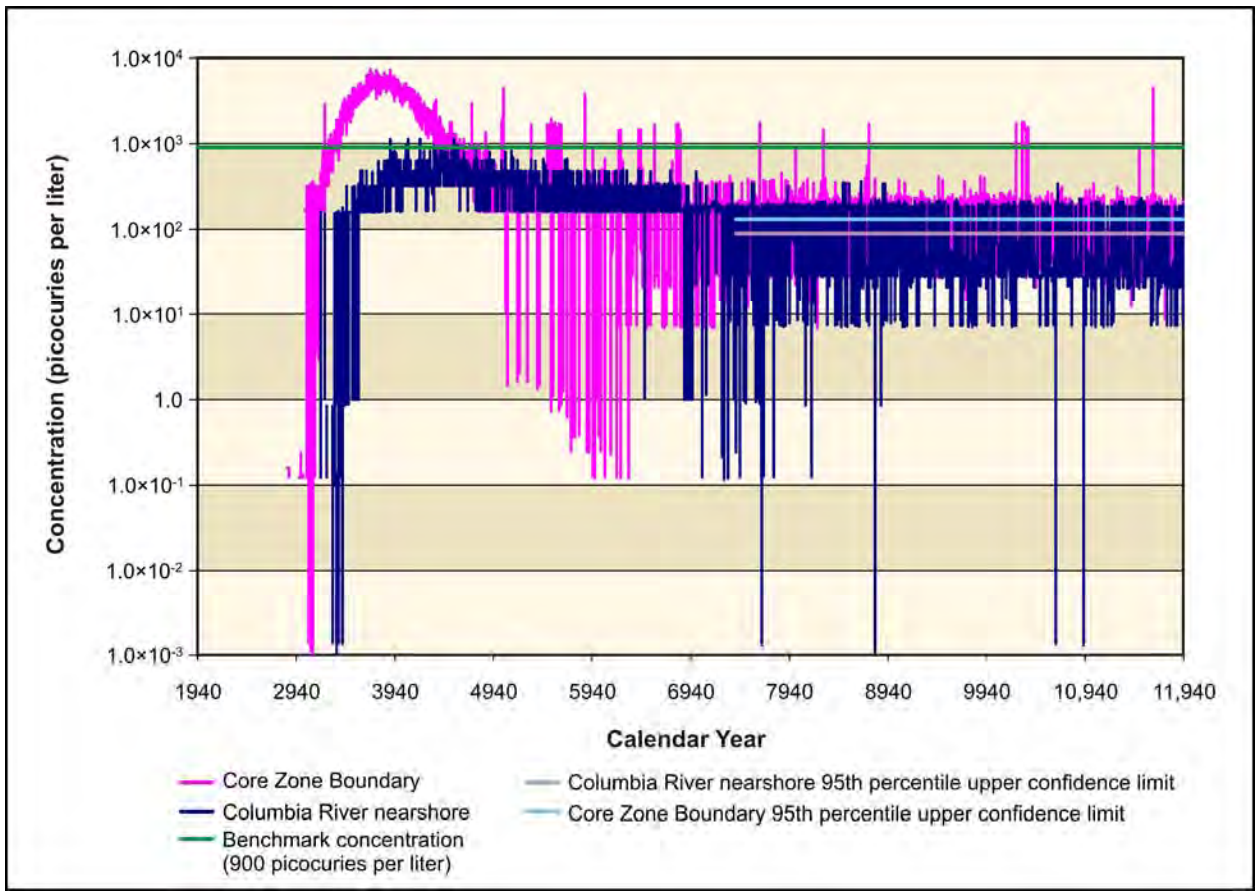


Figure 5–941. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Technetium-99 Concentration Versus Time

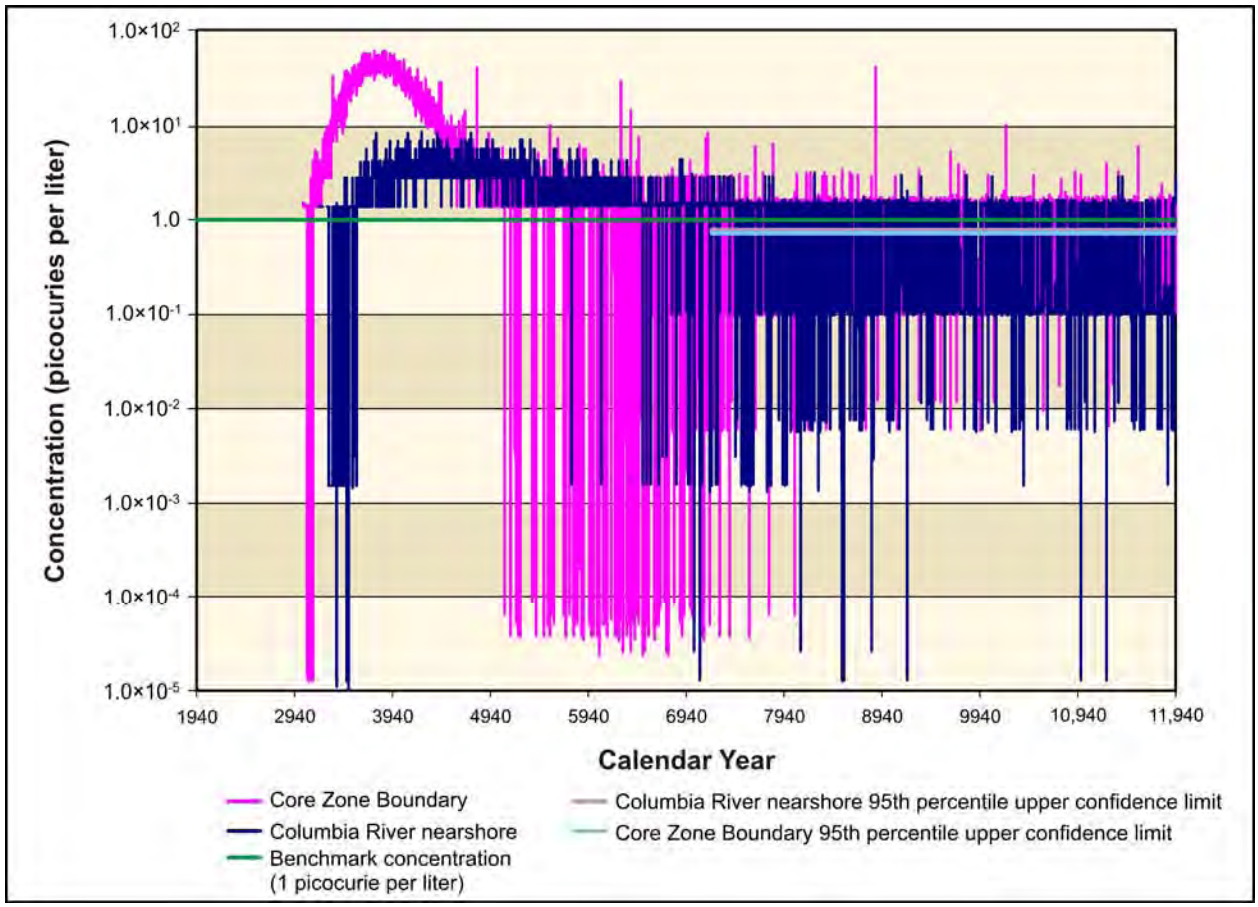


Figure 5–942. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Iodine-129 Concentration Versus Time

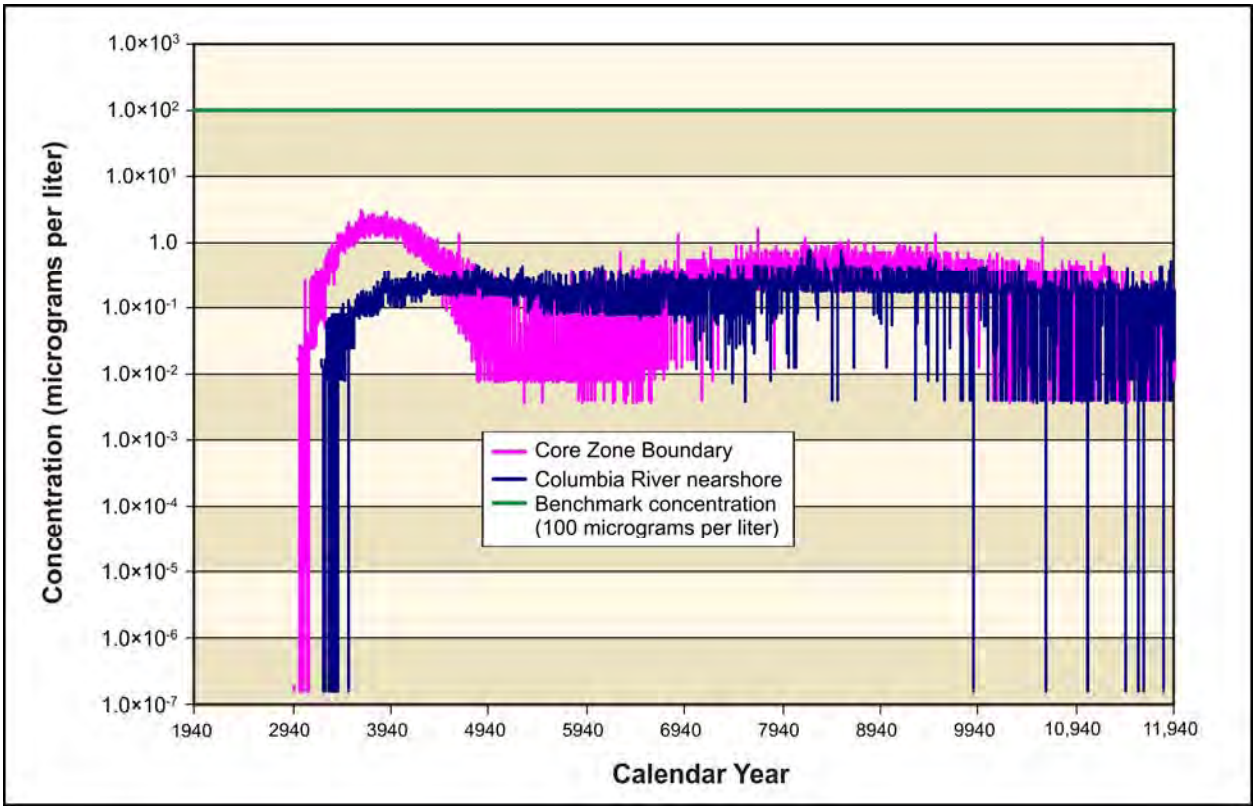


Figure 5–943. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chromium Concentration Versus Time

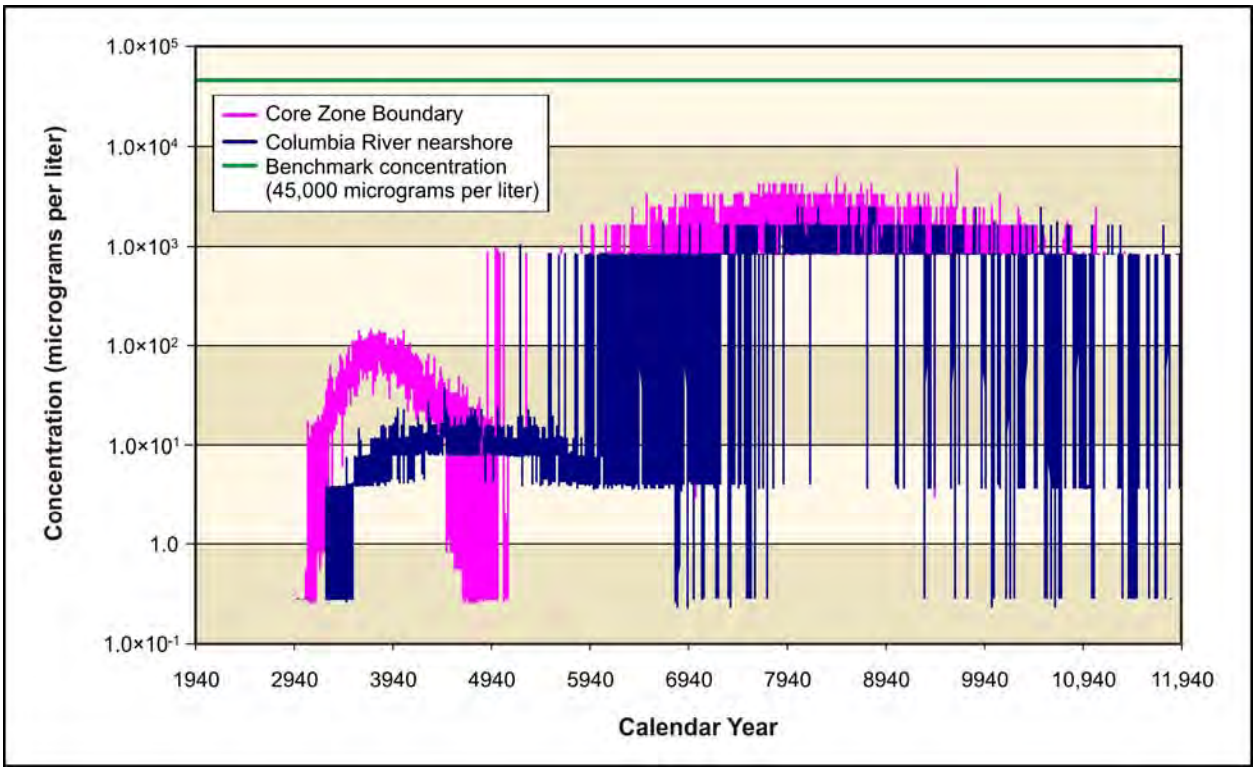


Figure 5–944. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Nitrate Concentration Versus Time

Figures 5–945 and 5–946 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of uranium, no contamination appears until CY 8940, when uranium-238 concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 remains three orders of magnitude below the benchmark throughout the simulation. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation.

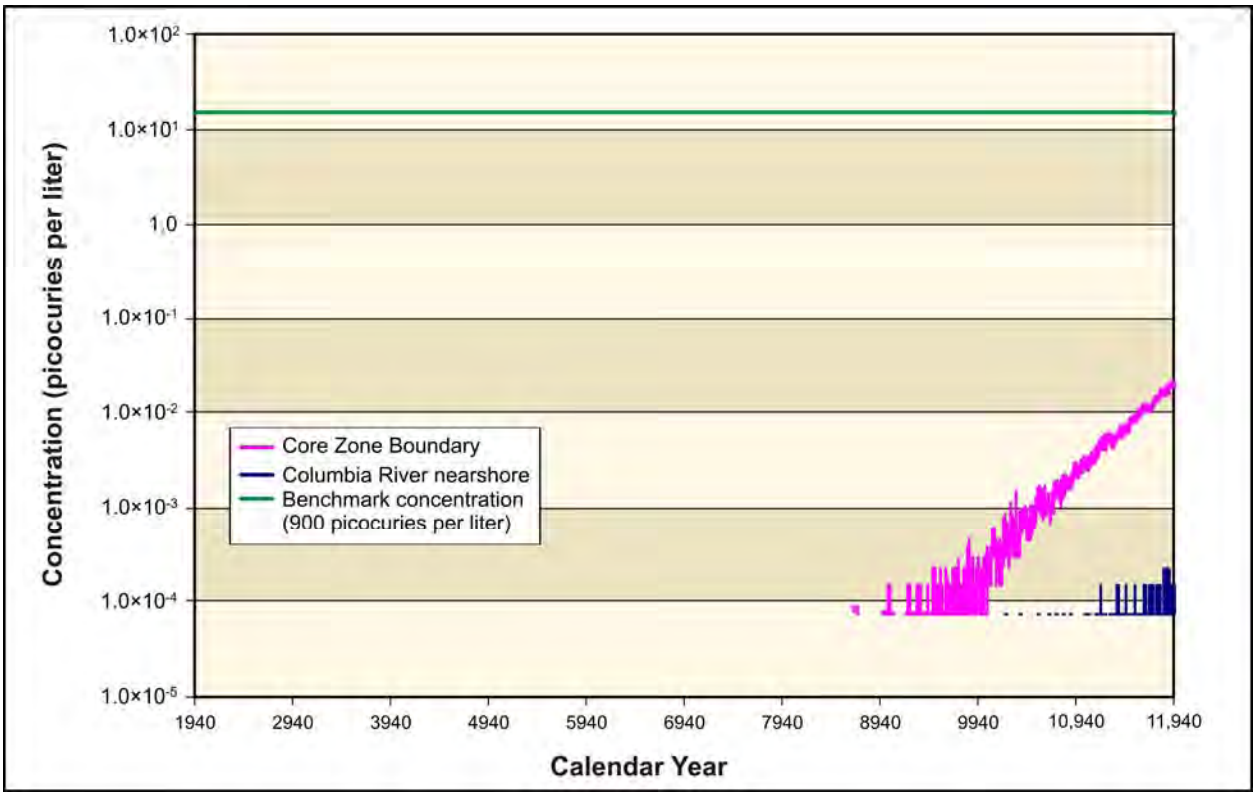


Figure 5–945. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Uranium-238 Concentration Versus Time

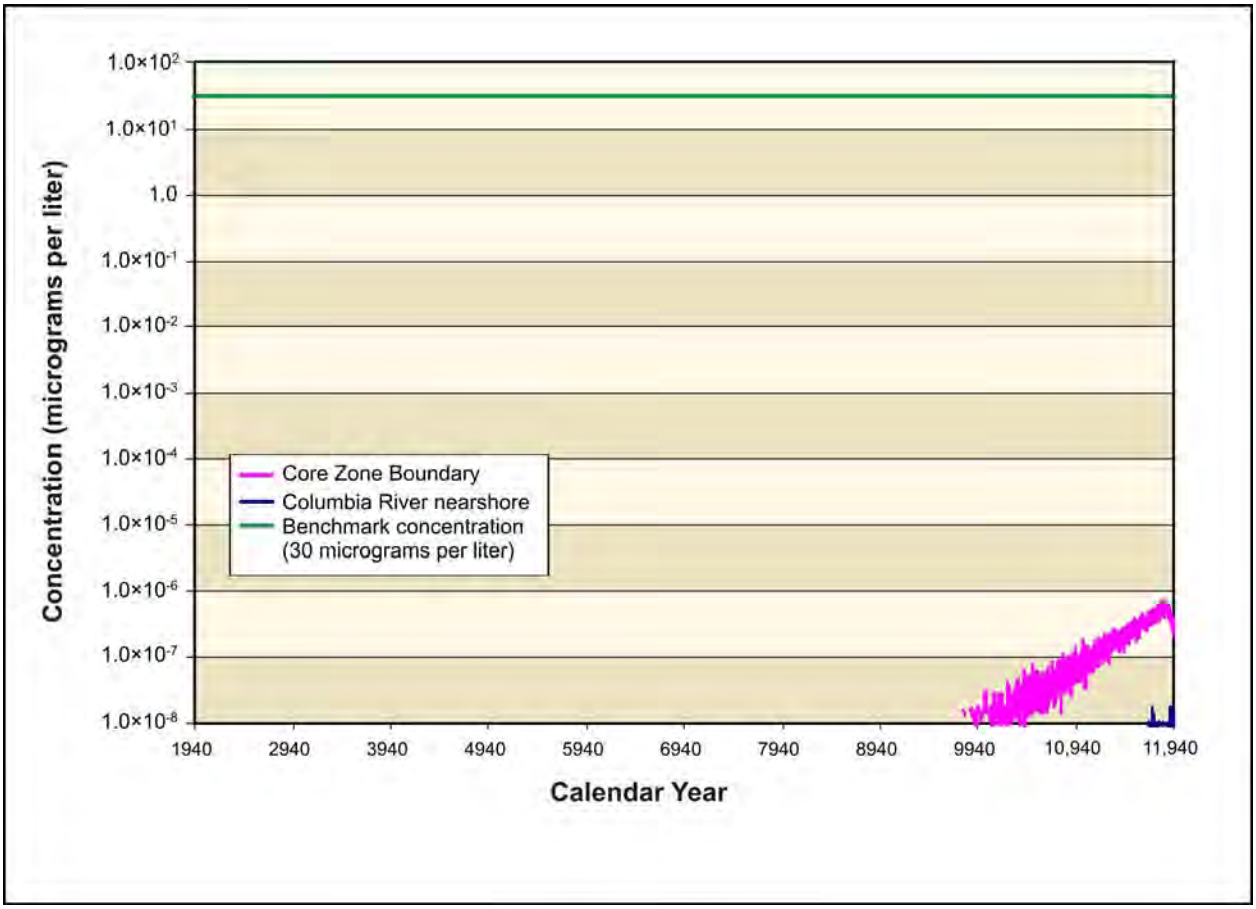


Figure 5–946. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentrations ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890 (see Figure 5–947), there is a high-concentration plume of iodine-129 stretching northeast of IDF-West, and a low-concentration plume that stretches north from the RPPDF through Gable Gap. Four separate high-concentration areas have also formed north of Gable Mountain and Gable Butte. By CY 7140 (see Figure 5–948), the plumes from IDF-West and the RPPDF have dissipated, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume remain close to the benchmark. Figure 5–949 shows the spatial concentration for iodine-129 during CY 11,885. Technetium-99 (see Figures 5–950 through 5–952) shows a similar spatial distribution, but has lower concentrations. Nitrate (see Figures 5–953 through 5–955) shows similar spatial distributions at selected times, but has consistently lower concentrations, well below the benchmark. Chromium (see Figures 5–956 through 5–958) has low-concentration plumes originating at IDF-East and the

RPPDF, but no contamination originating at IDF-West. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).

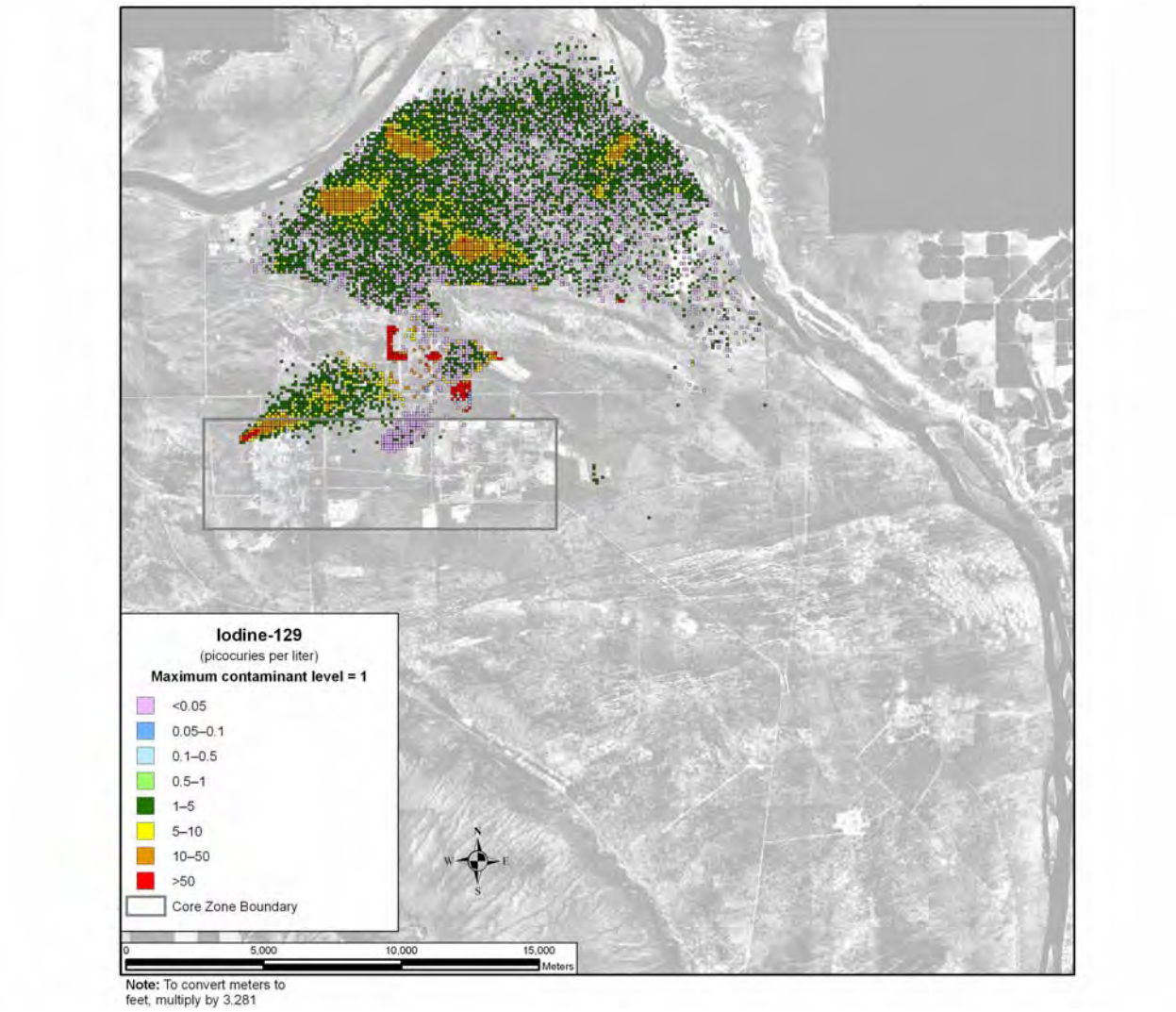


Figure 5–947. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

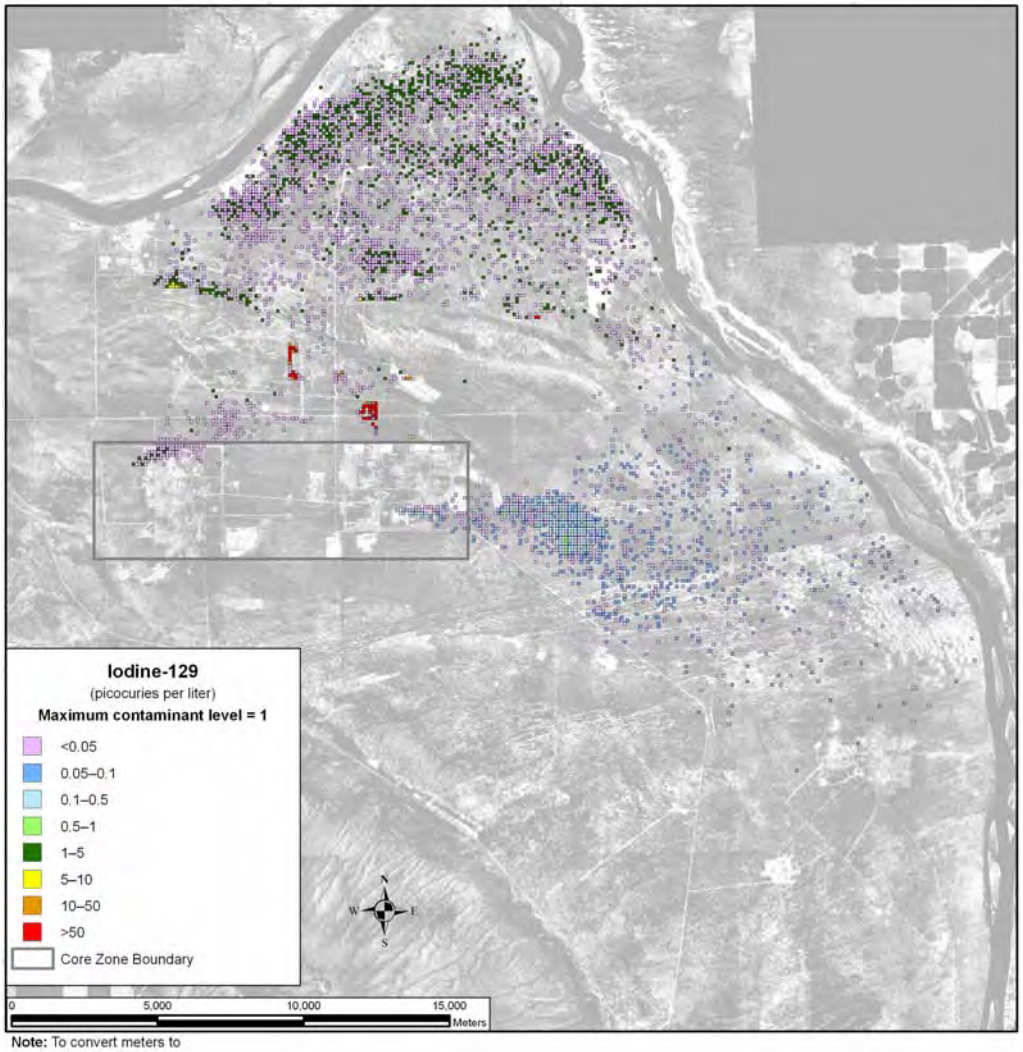


Figure 5–948. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

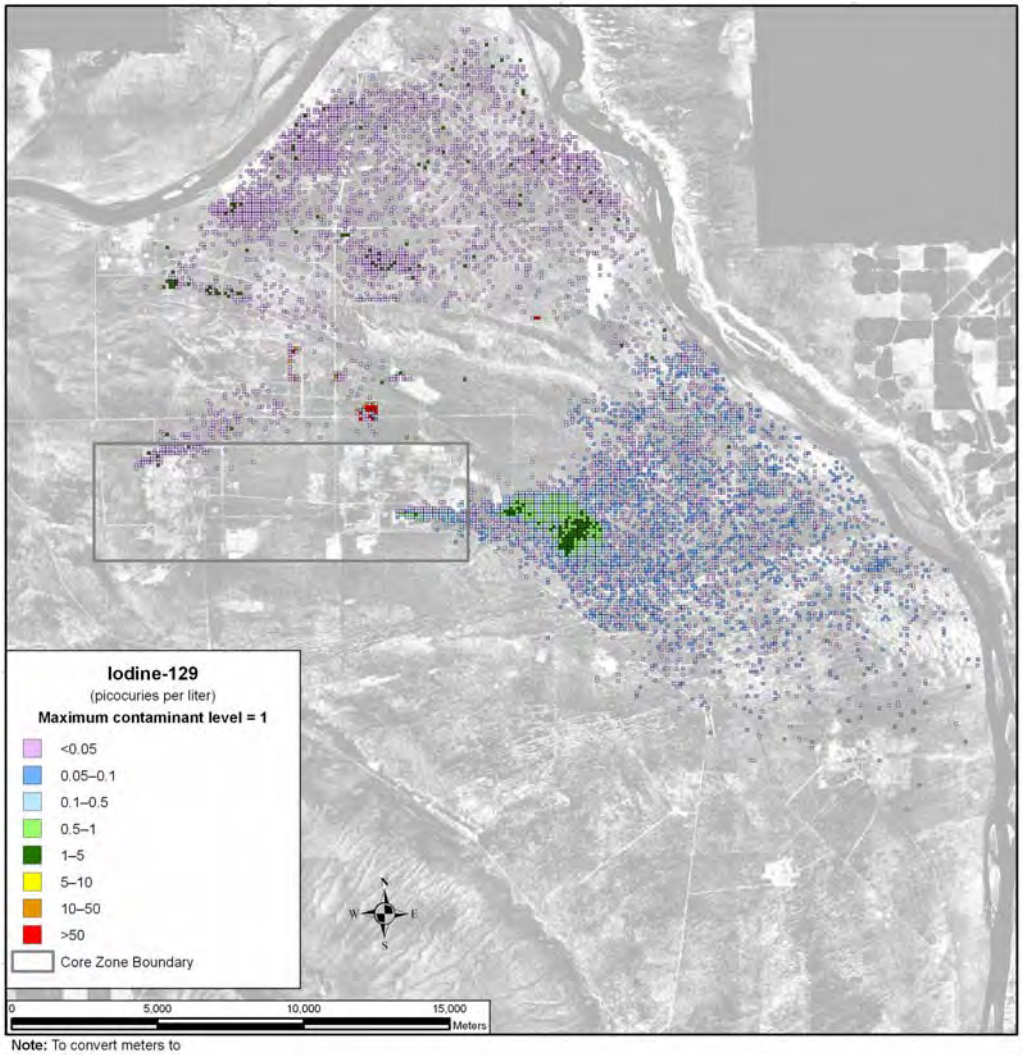


Figure 5–949. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

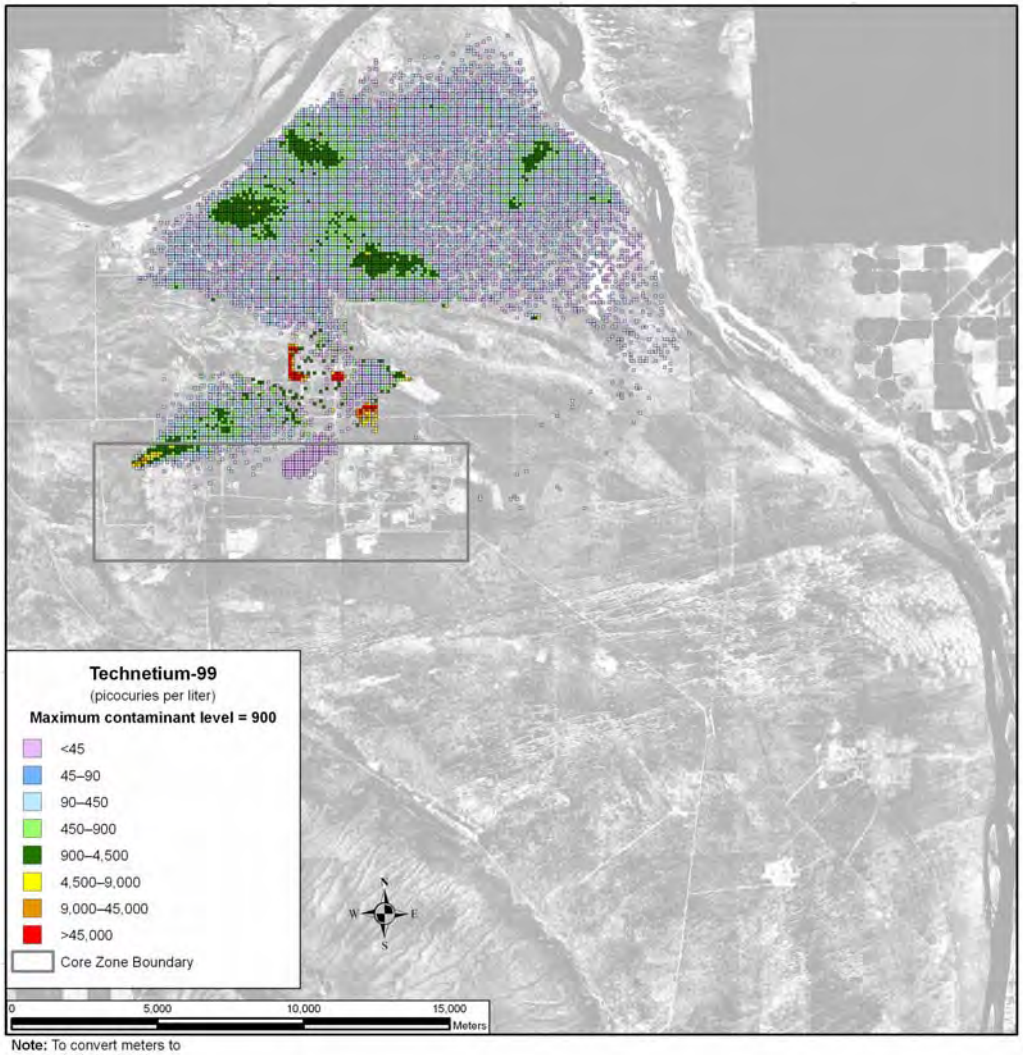


Figure 5–950. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

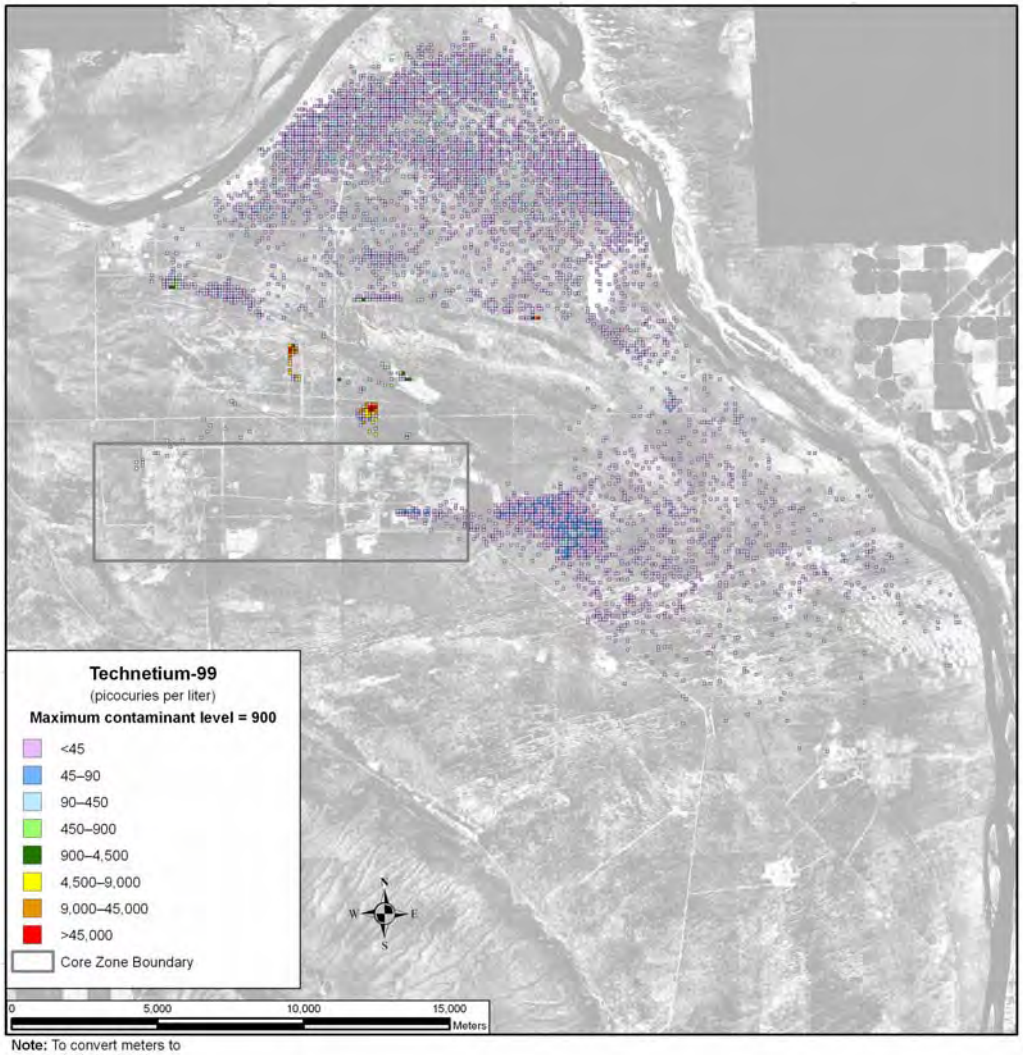


Figure 5–951. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

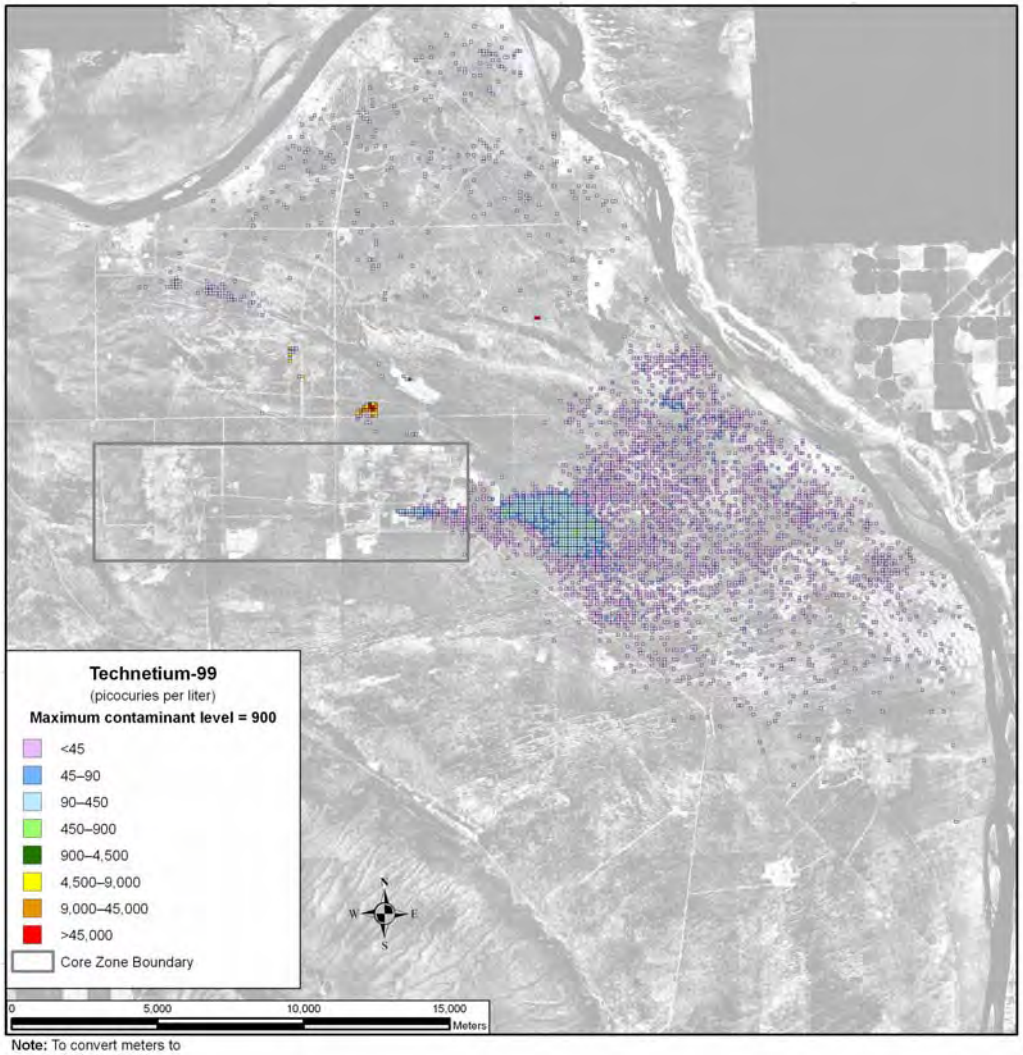


Figure 5–952. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

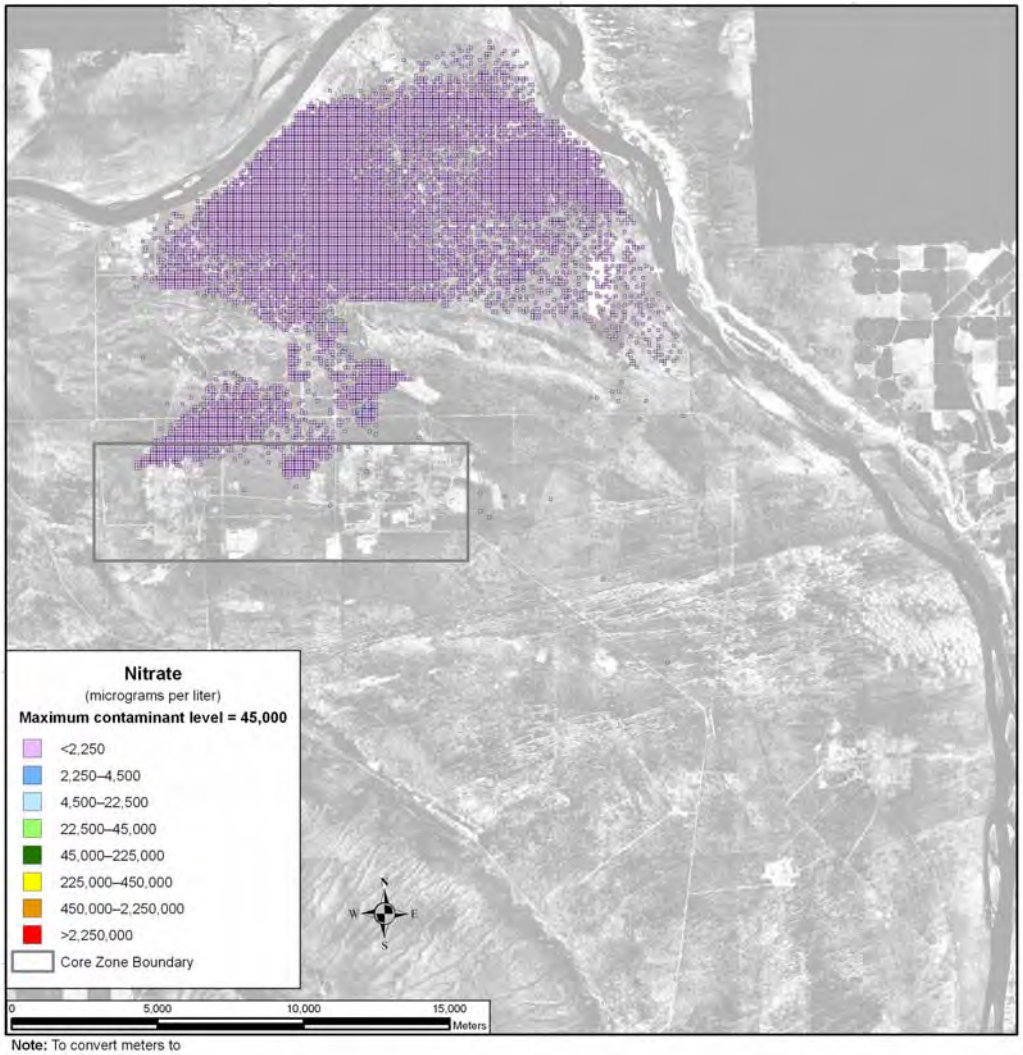


Figure 5–953. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

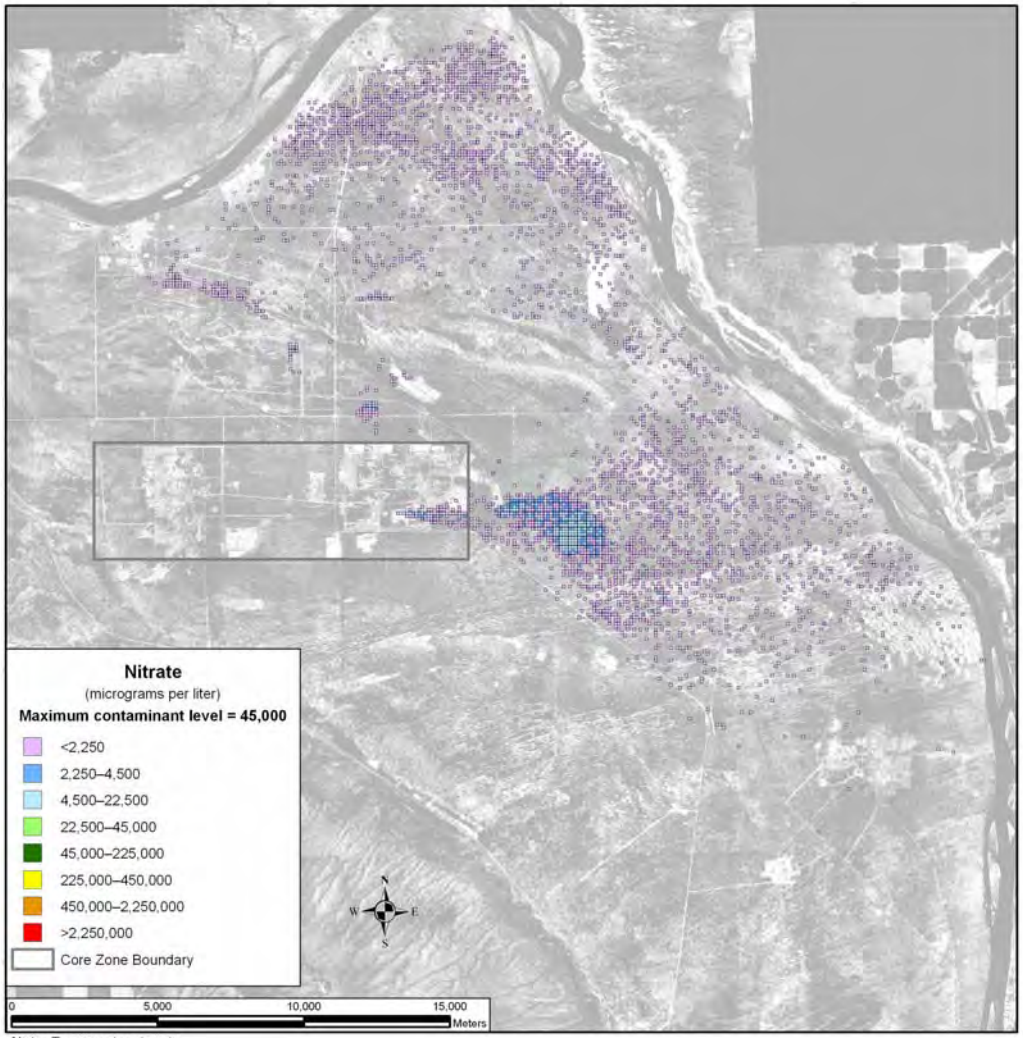


Figure 5–954. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

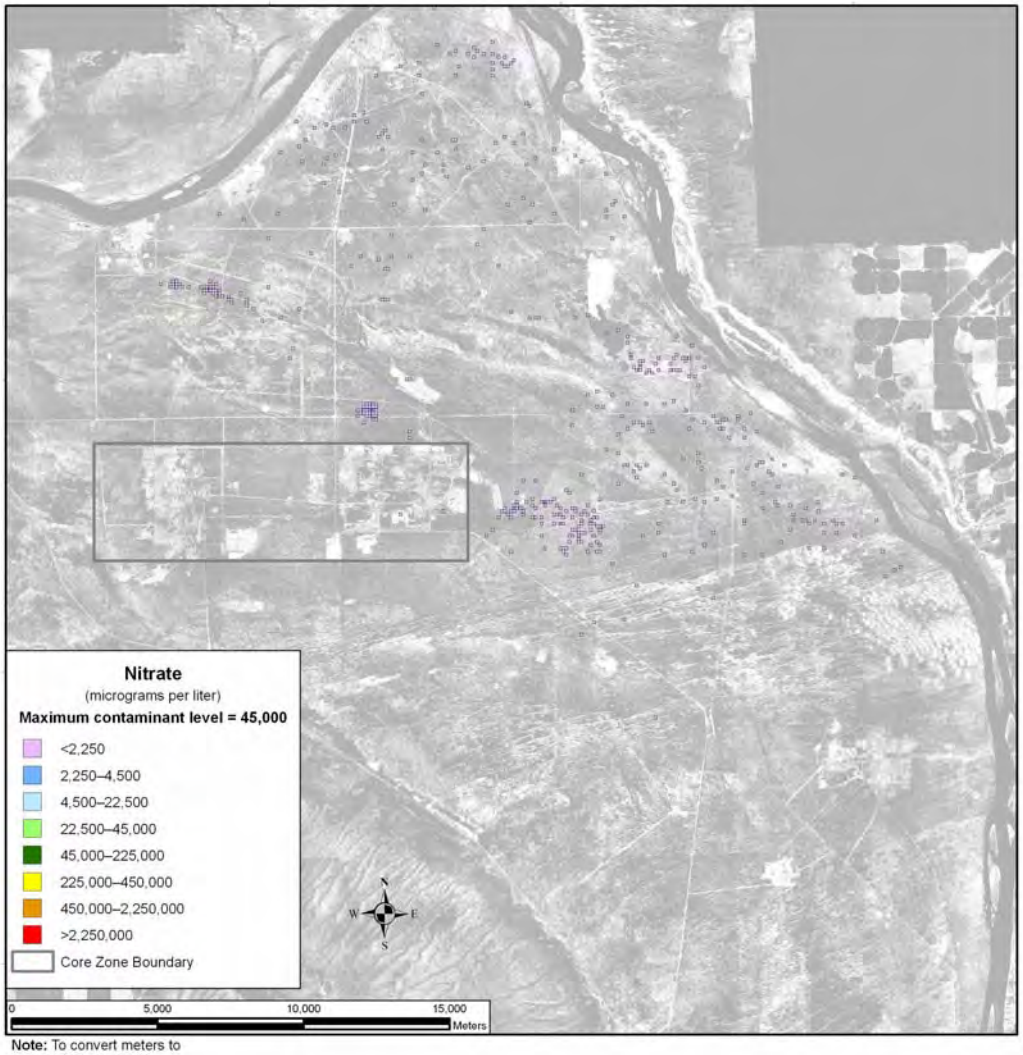


Figure 5–955. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

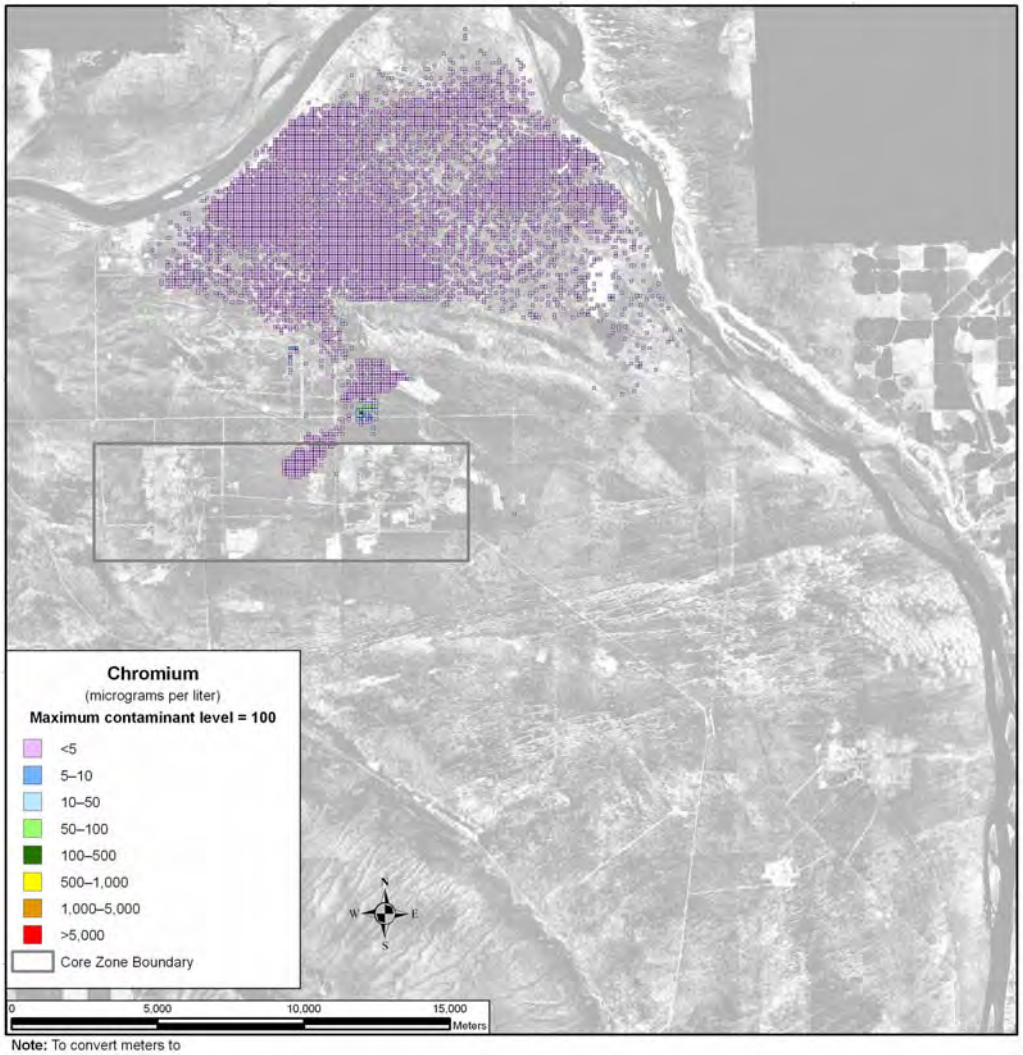


Figure 5–956. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

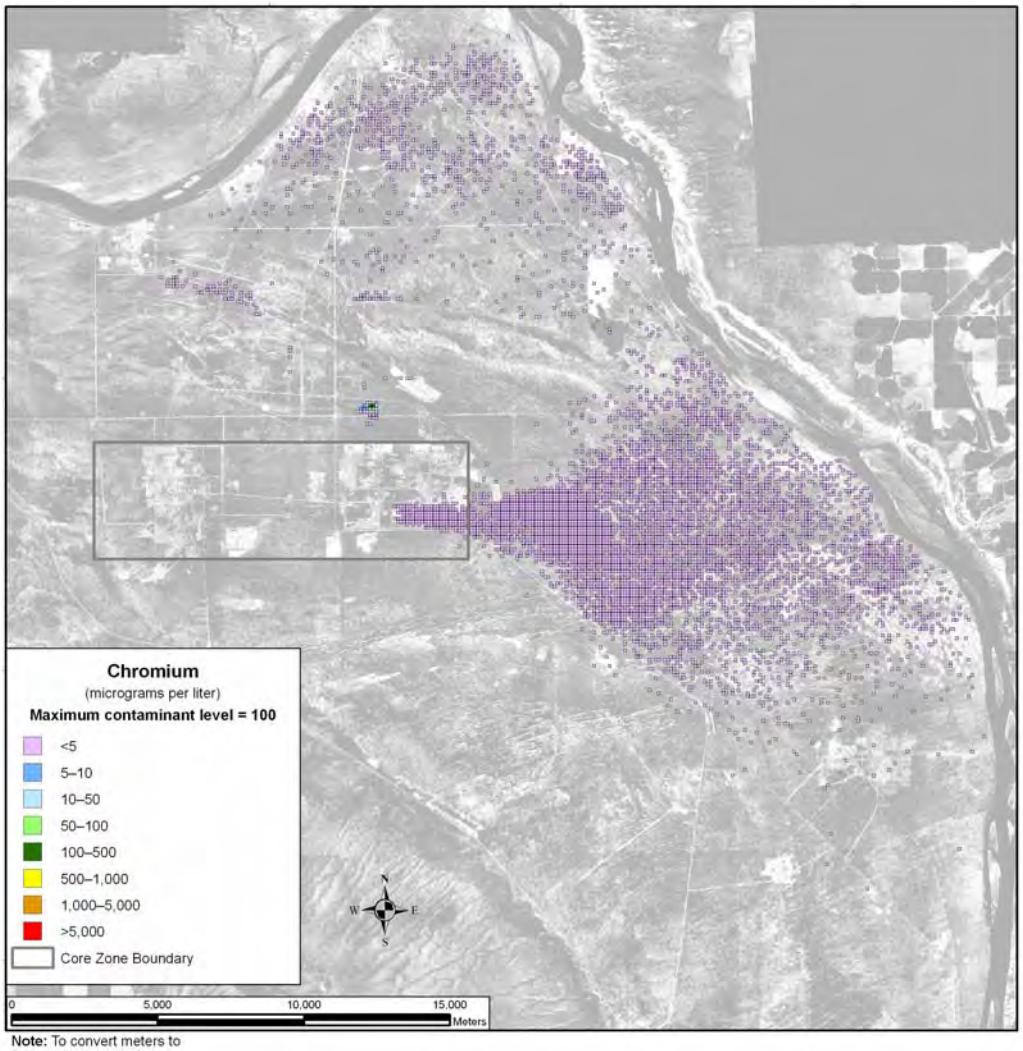


Figure 5–957. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

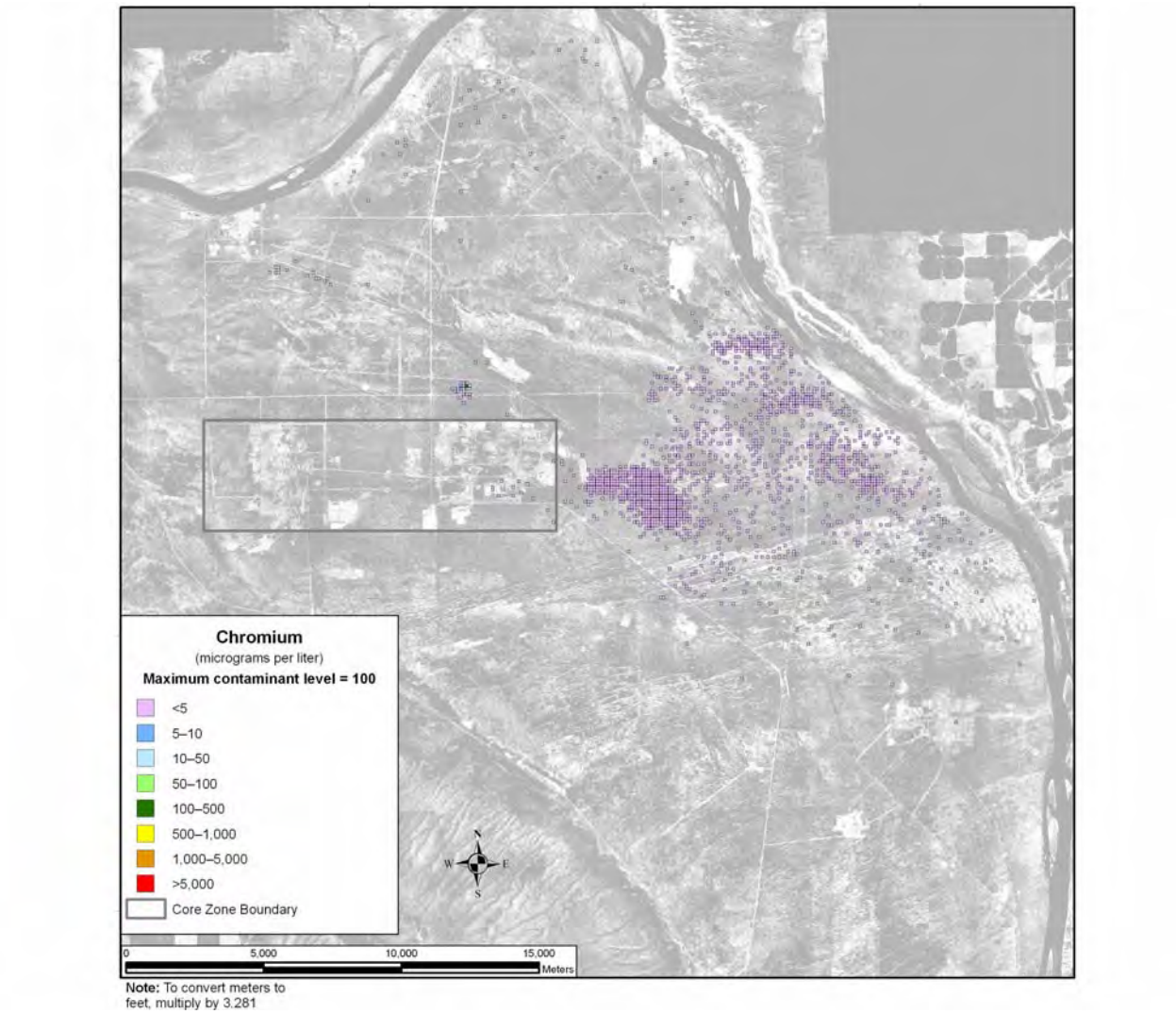


Figure 5–958. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

Total uranium and uranium-238 show a different spatial distribution over time. They are not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, a uranium-238 plume extends northeast from IDF-West through Gable Gap (see Figure 5–959). Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.

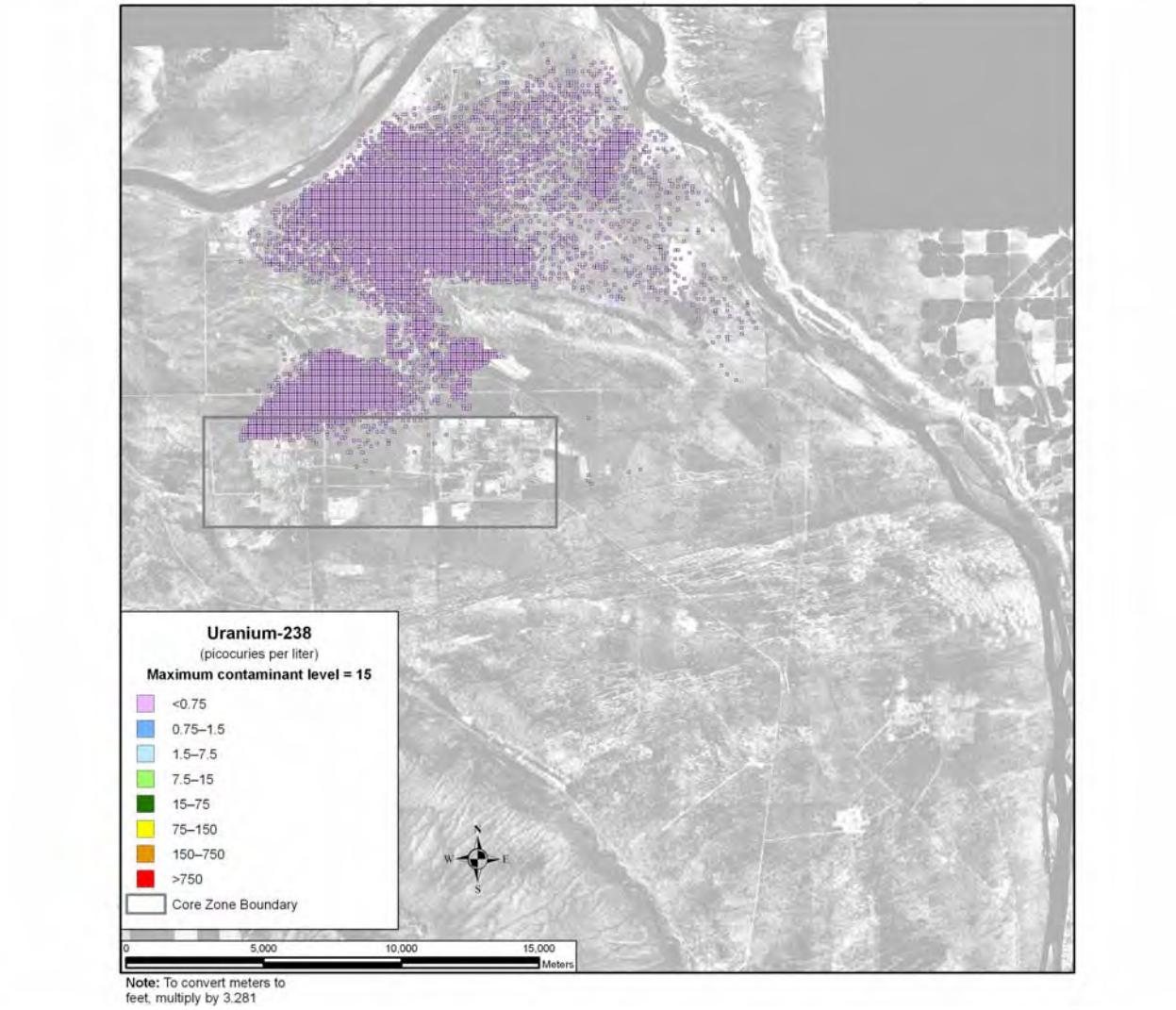


Figure 5–959. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in general, discharges from IDF-West are the predominant contributors. IDF-East and the RPPDF are secondary contributors.

Concentrations of iodine-129 and technetium-99 show a sharp rise and fall between CY 2940 and CY 4940 that exceeds the benchmark by an order of magnitude or slightly more. Concentrations of these COPCs stabilize near the benchmark concentration around CY 7940. Chromium shows a similar rise and fall but remains about two orders of magnitude below the benchmark. Nitrate has a similar rise and fall in concentrations between CY 2940 and CY 4940, followed by another rise in concentrations. This rise in concentration stabilizes around CY 6940 and is about an order of magnitude greater than the first peak, but an order of magnitude below the benchmark concentration.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the

benchmark at the Core Zone Boundary and the Columbia River nearshore throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.1.3.2 Disposal Group 2

Disposal Group 2 is characterized by operational completion dates of CY 2100 for IDF-East and the RPPDF, and CY 2050 for IDF-West. In Disposal Group 2, IDF-West has a large capacity (90,000 cubic meters [117,720 cubic yards]), IDF-East has a larger capacity (325,000 cubic meters [425,100 cubic yards]), and the RPPDF has an even larger capacity (8,370,000 cubic meters[10,947,960 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternative 2A or 6B, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

5.3.1.3.2.1 Disposal Group 2, Subgroup 2-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, includes Tank Closure Alternative 2A, FFTF Decommissioning Alternative 2 or 3, and onsite and offsite waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009 and continues through CY 2050 for IDF-West and CY 2100 for IDF-East when the disposal facilities will be operationally closed. During the disposal period, the materials in this permitted, operational facility are not available for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and IDF-West become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, IDF-East and IDF-West are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above accounts for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A (IDF-East and IDF-West), in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has four subtotals plotted representing releases from ILAW glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

Figure 5–960 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–961, the chemical hazard drivers. For all four types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source for technetium-99 and chromium is tank closure secondary waste. Iodine-129 and nitrate have ETF-generated secondary waste as the predominant source. Boron and fluoride do not exist at IDF-East.

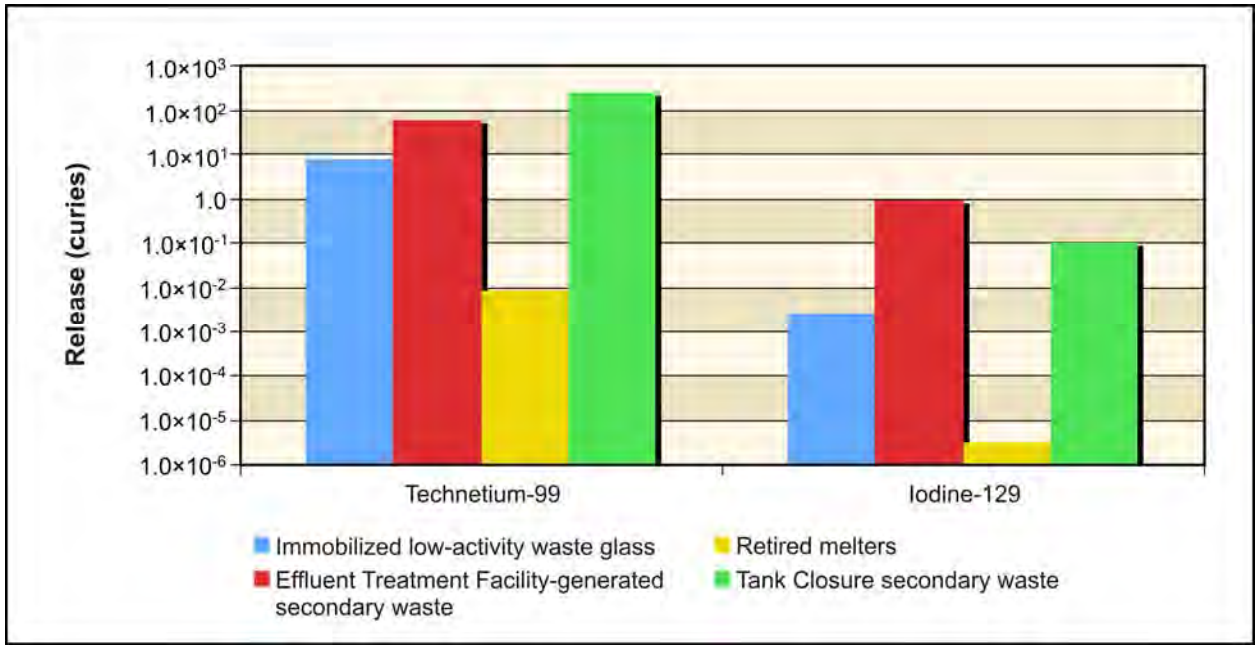


Figure 5–960. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

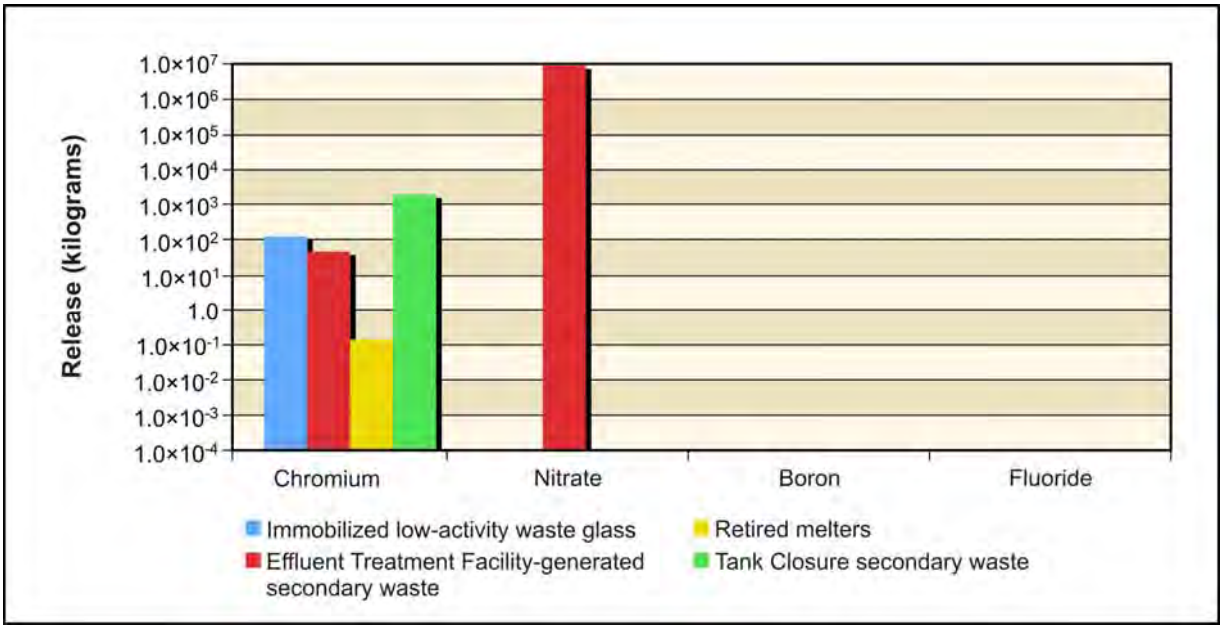


Figure 5–961. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–962 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–963, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Essentially equal" means that there is a difference of less than one order of magnitude. Overall, about 58 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches the groundwater, while approximately 100 percent of the chemical quantity (kilograms) released to the vadose zone during the period of analysis reaches the groundwater.

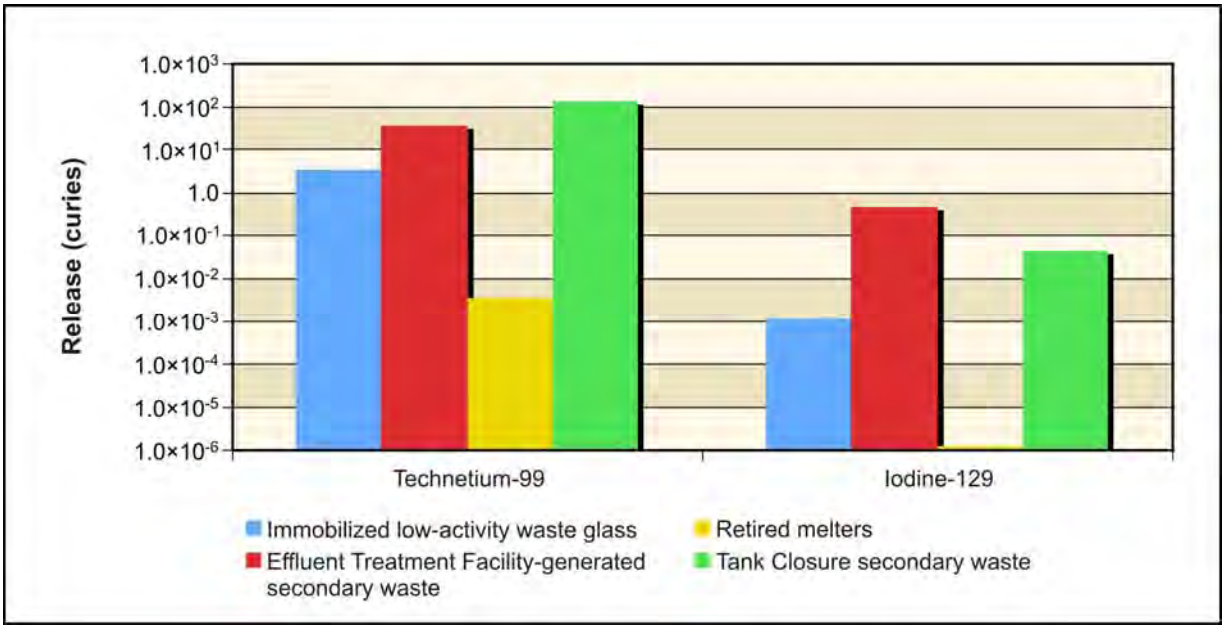


Figure 5–962. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

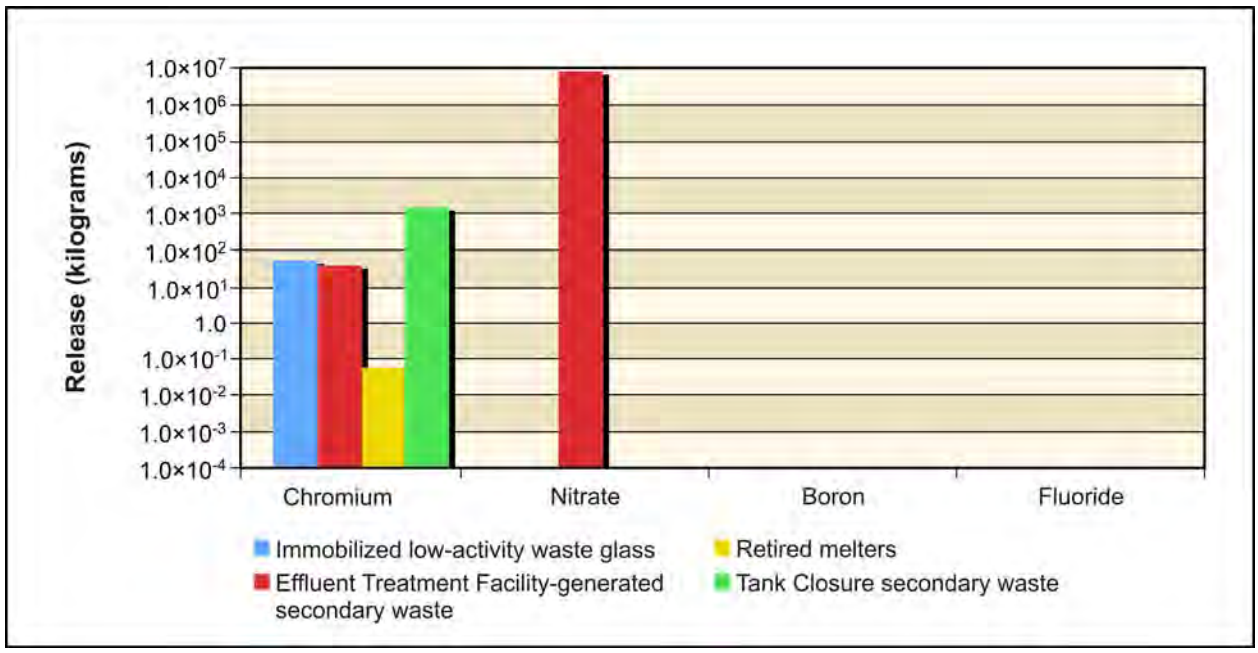


Figure 5–963. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–964 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–965, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 91 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reaches the river, while approximately 98 percent of the chemical quantity (kilograms) released to the groundwater during the period of analysis reaches the river.

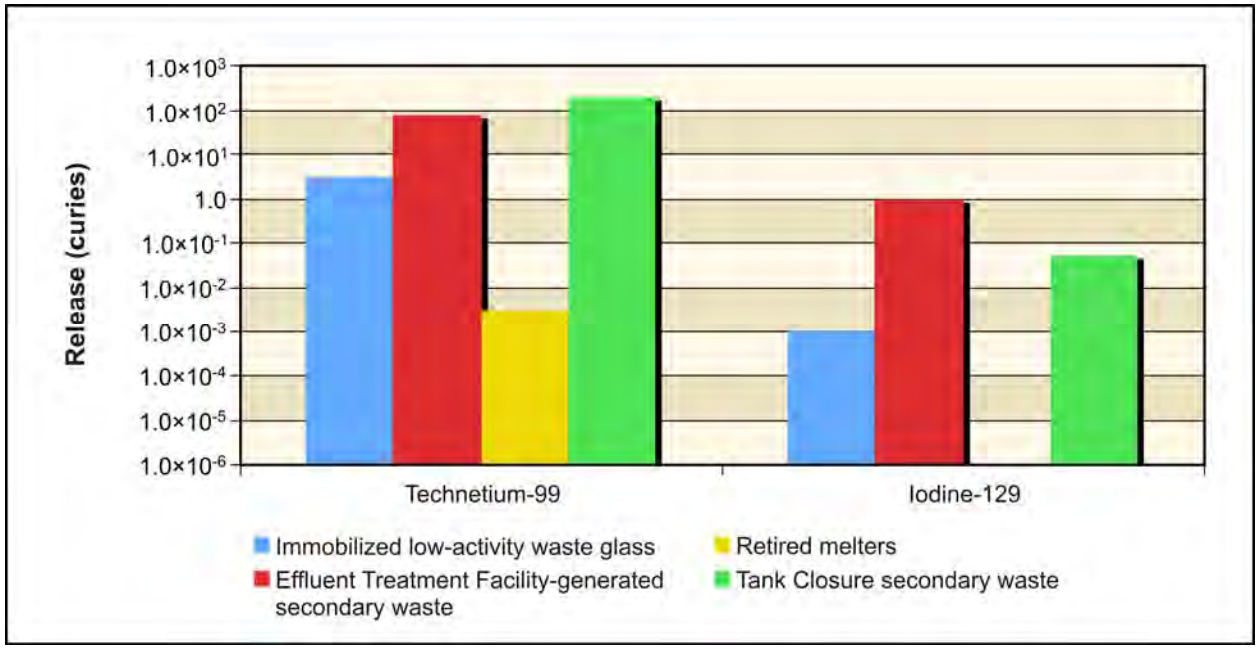


Figure 5–964. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

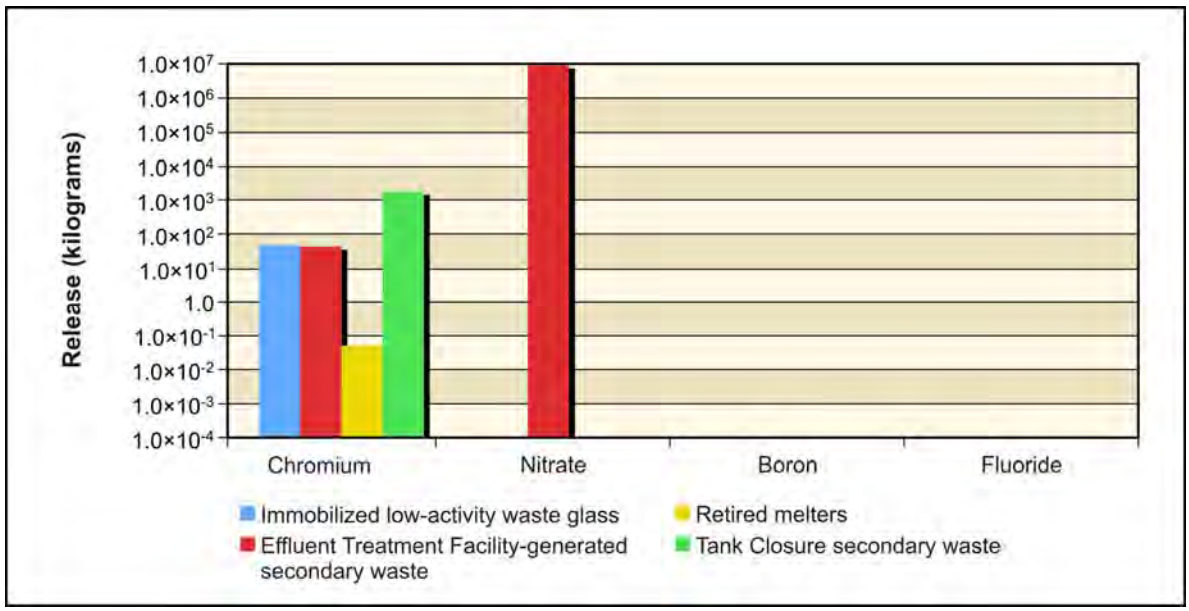


Figure 5–965. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste.

Figure 5–966 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–967, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source for technetium-99 and iodine-129 is offsite waste. For chromium, nitrate, boron, and fluoride, the predominant source is waste management secondary waste and onsite-generated waste.

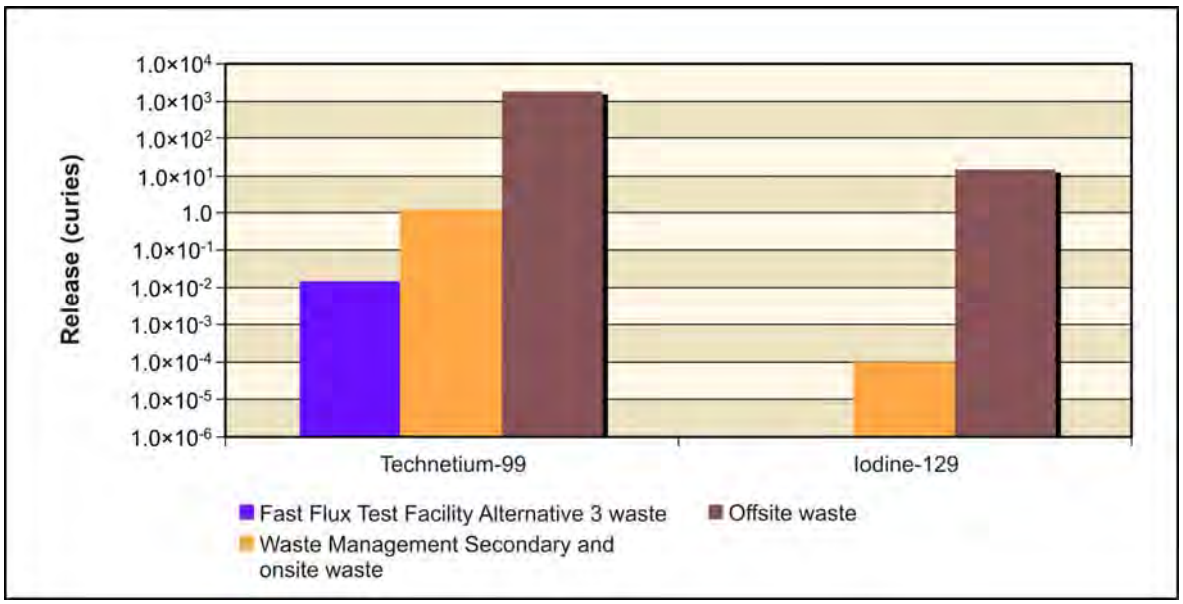


Figure 5–966. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

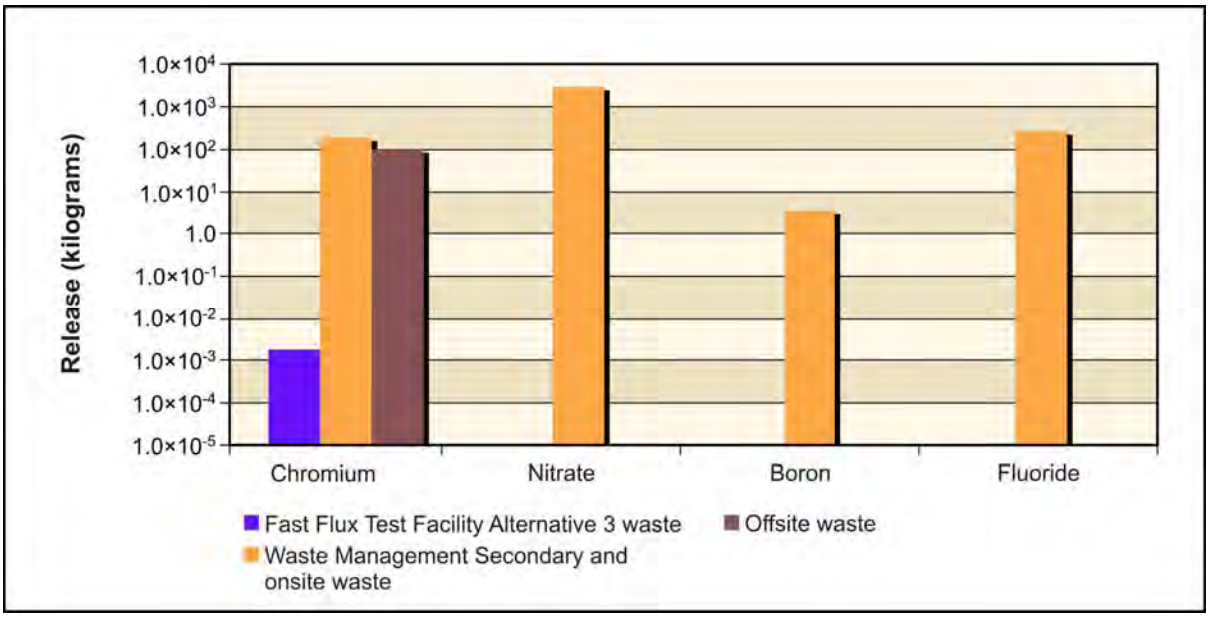


Figure 5–967. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–968 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–969, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, boron, and fluoride, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Approximately equal" means that there is a difference of less than one order of magnitude. Overall, about 98 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches groundwater, while approximately 100 percent of the chemical quantity (kilograms) released to the vadose zone during the period of analysis reaches groundwater.

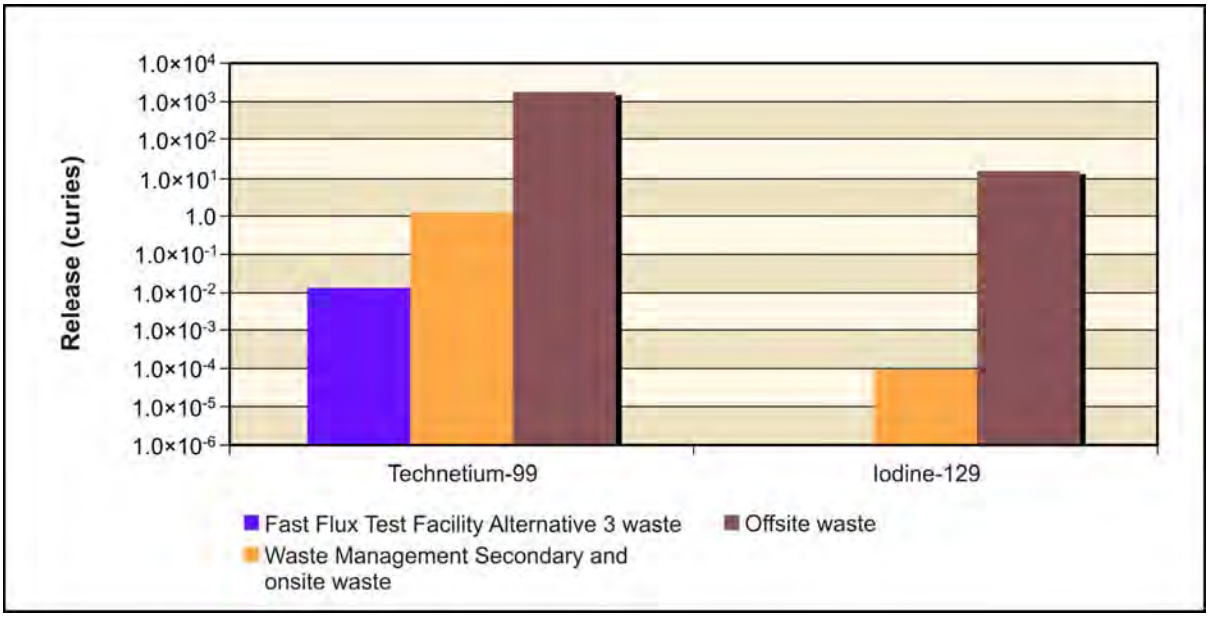


Figure 5–968. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

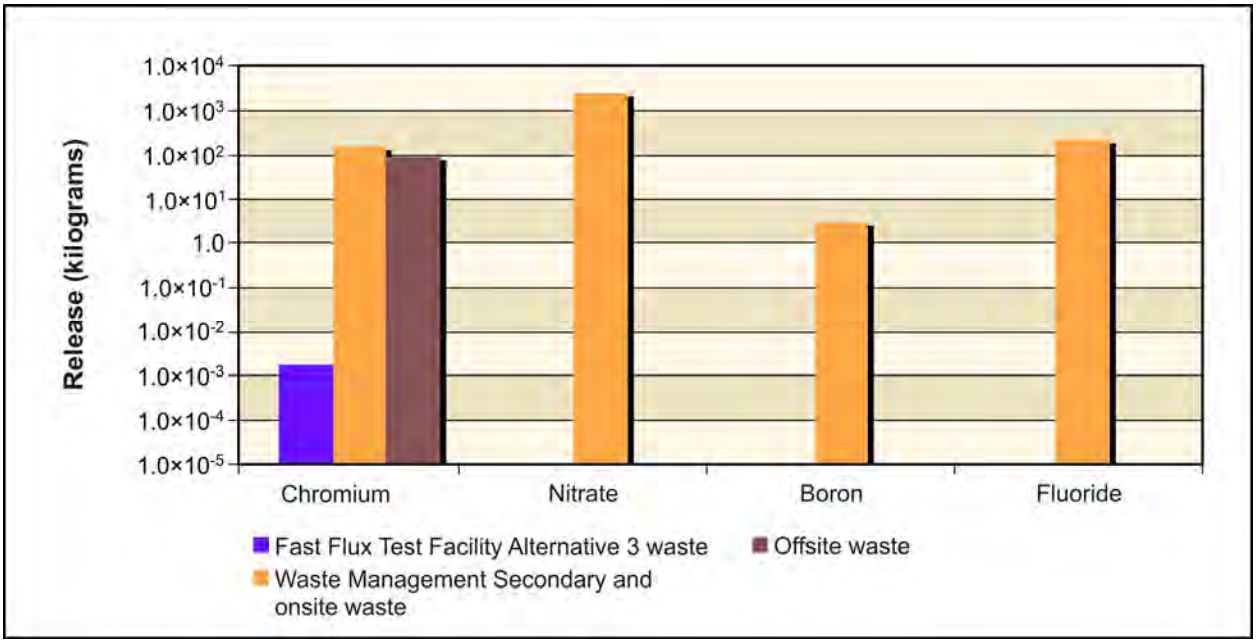


Figure 5–969. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–970 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–971, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, nitrate, boron, and fluoride, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclide amount (curies) released to groundwater during the period of analysis reaches the river while approximately 98 percent of the chemical quantity (kilograms) released to groundwater during the period of analysis reaches the river.

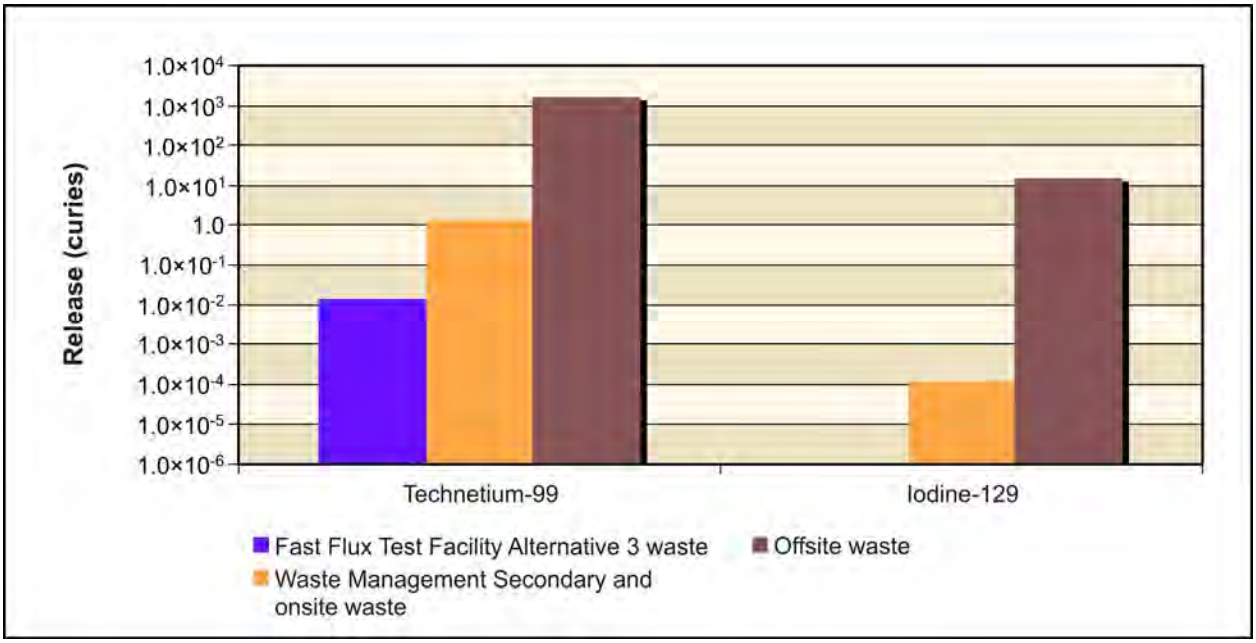


Figure 5–970. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

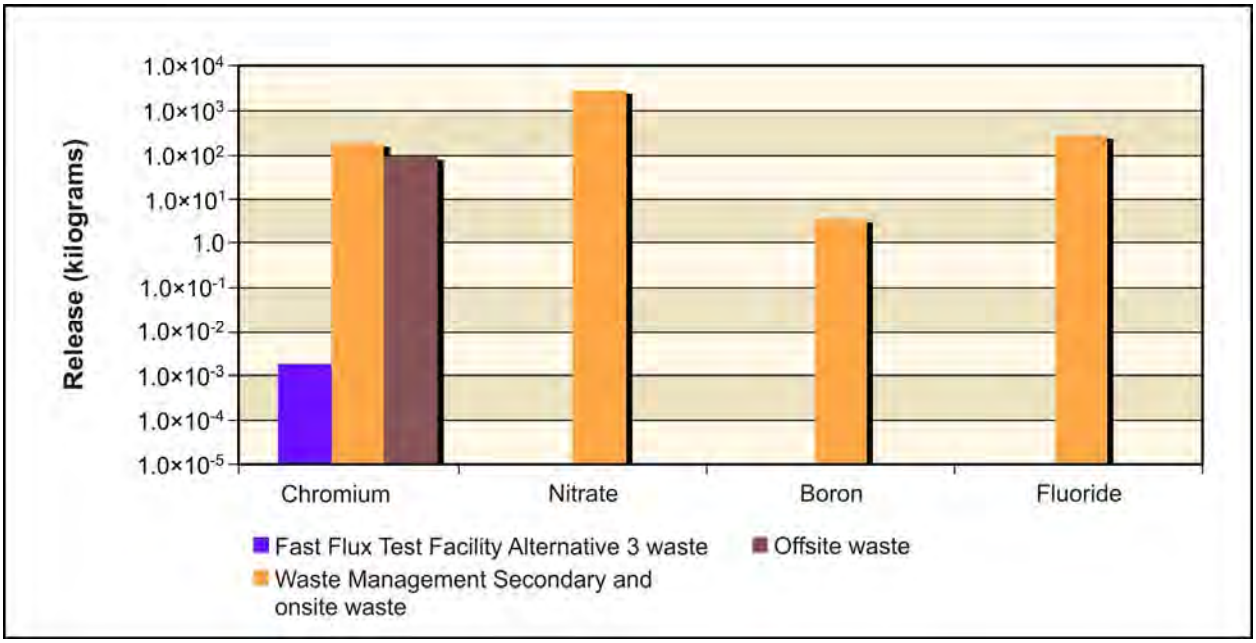


Figure 5–971. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–972 through Figure 5–975 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East and IDF-West cause groundwater concentrations of iodine-129 to exceed benchmark concentrations at the Core Zone Boundary and Columbia River nearshore by approximately one order of magnitude. Iodine-129 concentration exceeds the benchmark in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak only lasts for approximately 10 percent of the period of analysis. Technetium-99 sporadically exceeds the benchmark at the Columbia River nearshore, and the 95th percentile upper confidence limit is within an order of magnitude below the benchmark for most of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or Columbia River nearshore. Table 5–96 shows the maximum concentrations in groundwater.

Table 5–96. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	334	**20,200**	N/A	**7,540**	**1,130**	900
	(9823)	(3713)		(3690)	(4528)	
Iodine-129	**2**	**173**	N/A	**60**	**8**	1
	(10,498)	(3797)		(3853)	(4729)	
Chemical in micrograms per liter						
Chromium	3	2	N/A	2	1	100
	(9308)	(3696)		(8982)	(8353)	
Fluoride	0	1	N/A	1	0	4,000
	(1940)	(3684)		(3907)	(4555)	
Nitrate	15,500	17	N/A	5,700	4,070	45,000
	(7977)	(3703)		(7905)	(8056)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are identified in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

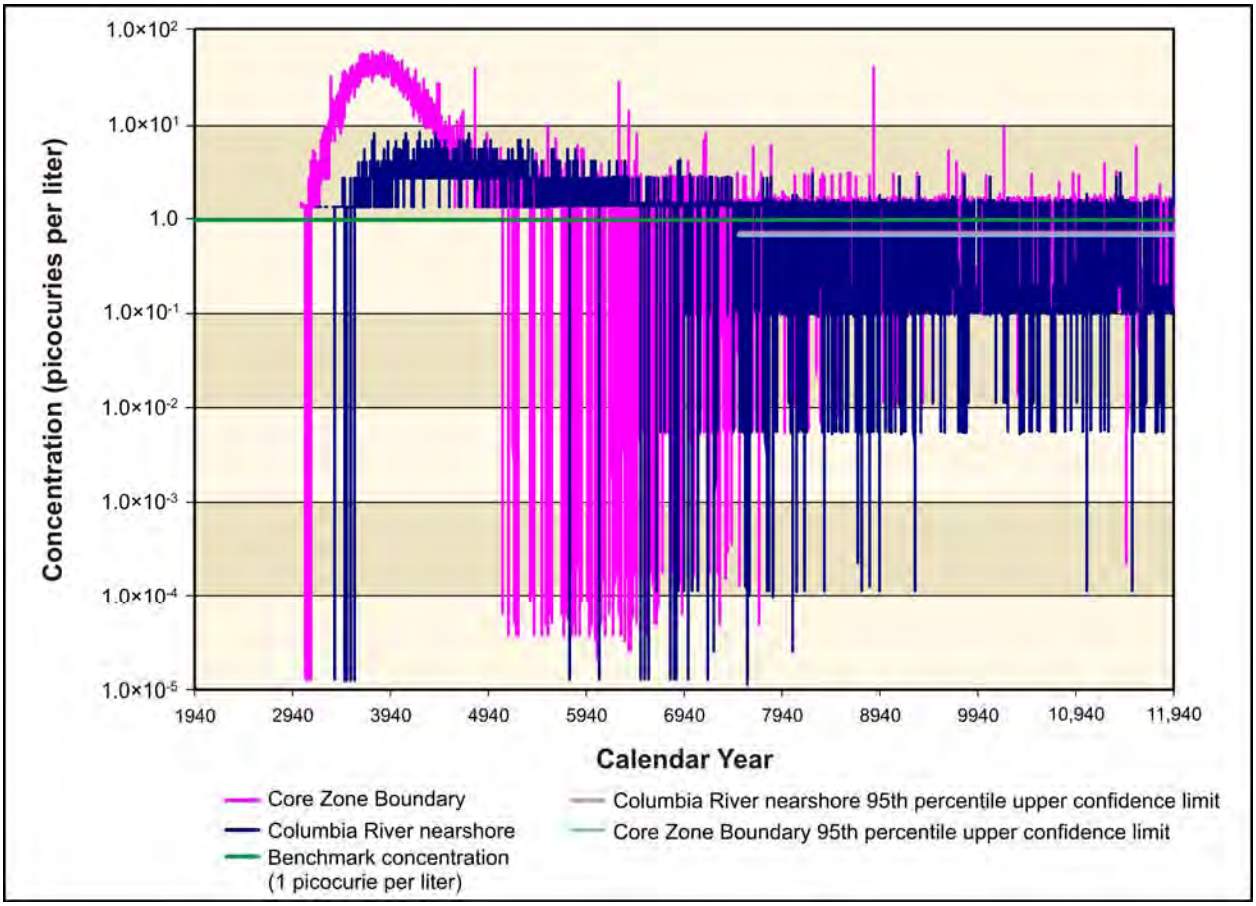


Figure 5–972. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Iodine-129 Concentration Versus Time

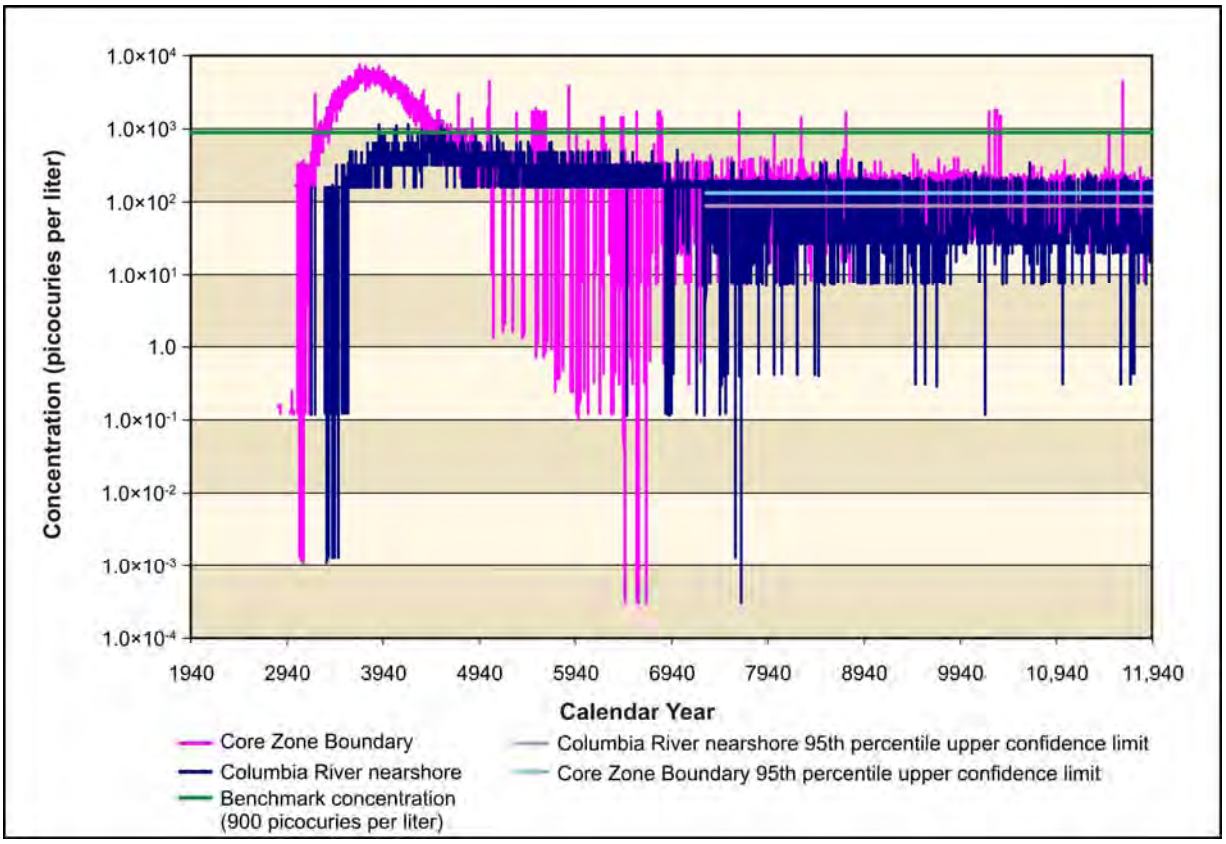


Figure 5–973. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Technetium-99 Concentration Versus Time

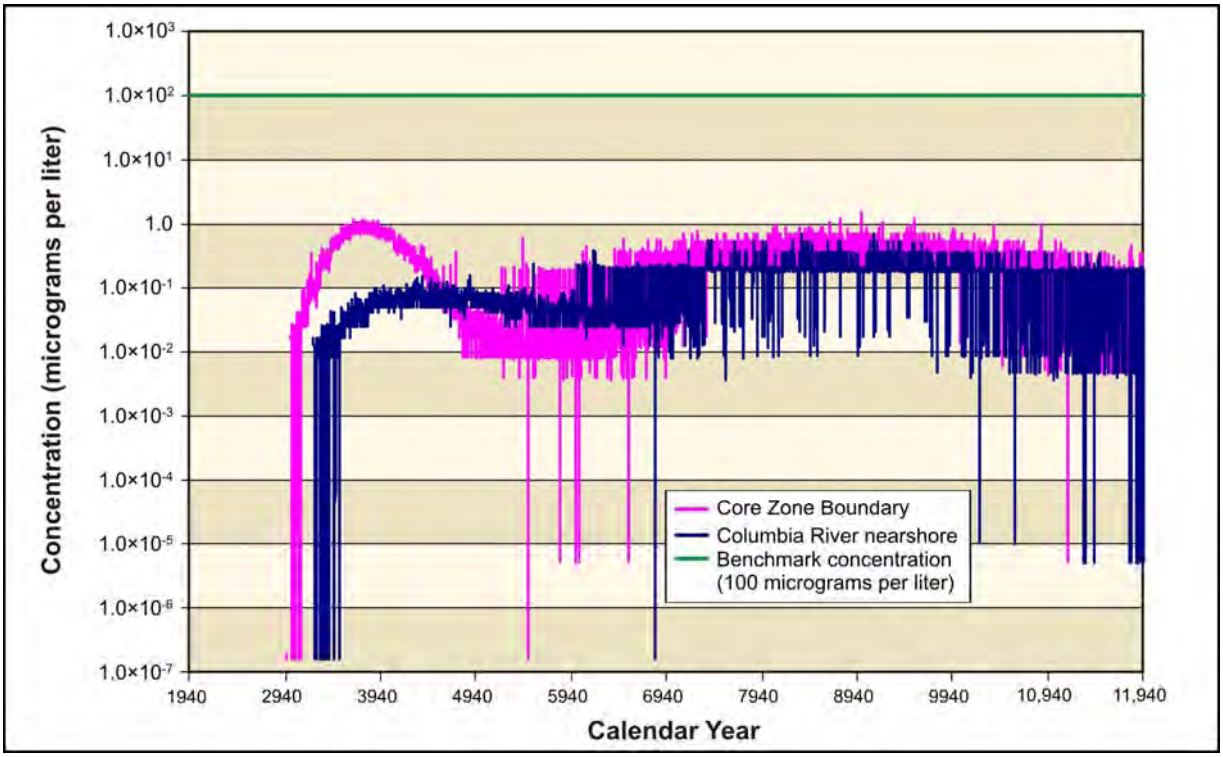


Figure 5–974. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chromium Concentration Versus Time

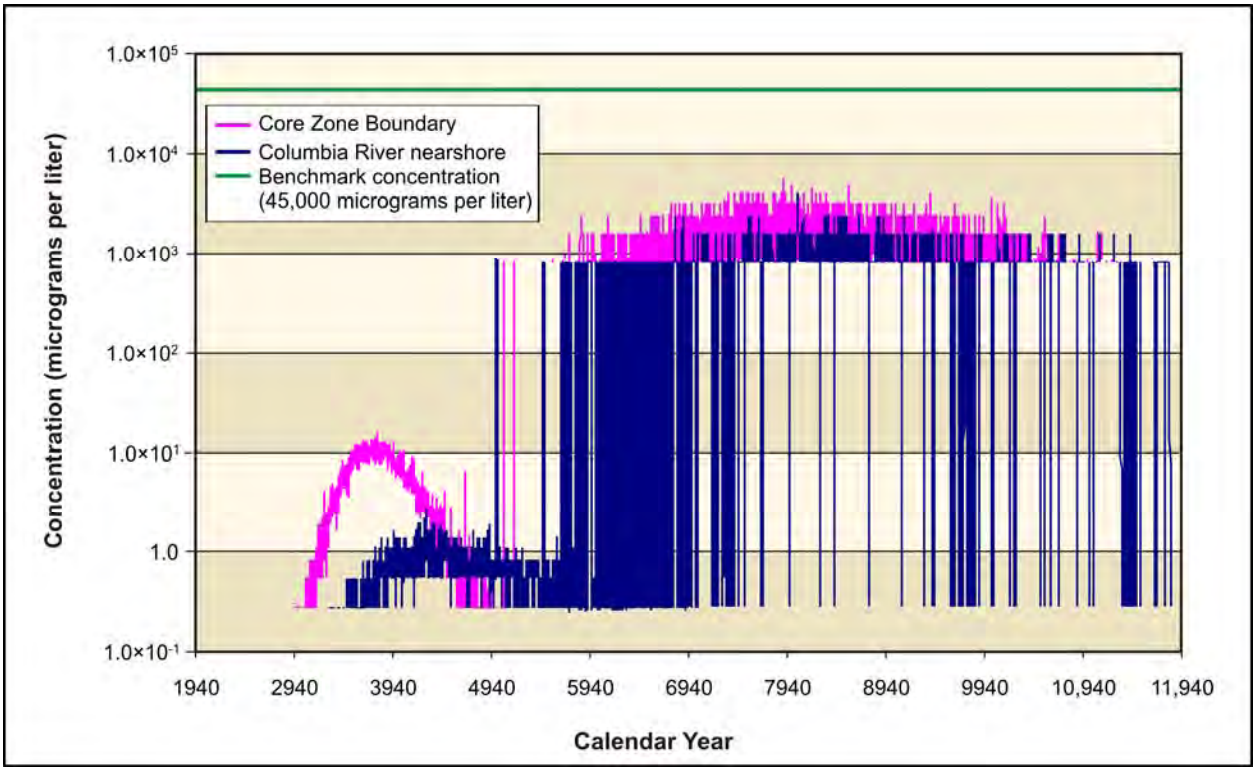


Figure 5–975. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Nitrate Concentration Versus Time

Figure 5–976 shows concentration versus time for uranium-238. Because uranium-238 moves slowly through the vadose zone, releases from IDF-East and IDF-West result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 concentrations, while very minimal, continue to rise throughout the period of analysis, but never get closer than three orders of magnitude of exceeding benchmark concentrations by the end of the period of analysis. There is no significant total uranium concentration.

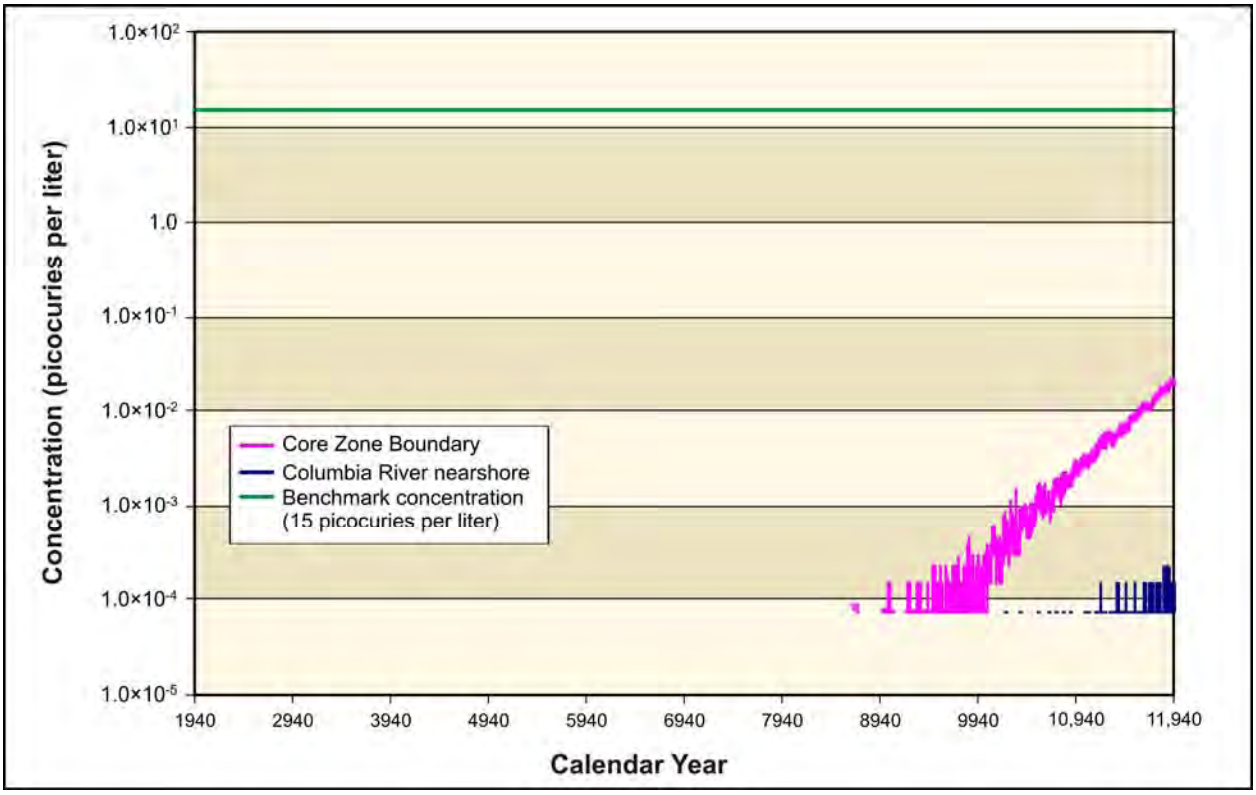


Figure 5–976. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Uranium-238 Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–977 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from IDF-West result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area eastward toward the Columbia River (see Figure 5–978). Also by CY 7140, most of the IDF-West plume continues to move north and reaches the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small isolated pockets of concentration exceeding the benchmark (see Figure 5–979). Technetium-99 (see Figures 5–980 through 5–982) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–983 through 5–985), and nitrate (see Figures 5–986 through 5–988) show similar spatial distributions at selected times, except none of them exceed the benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).

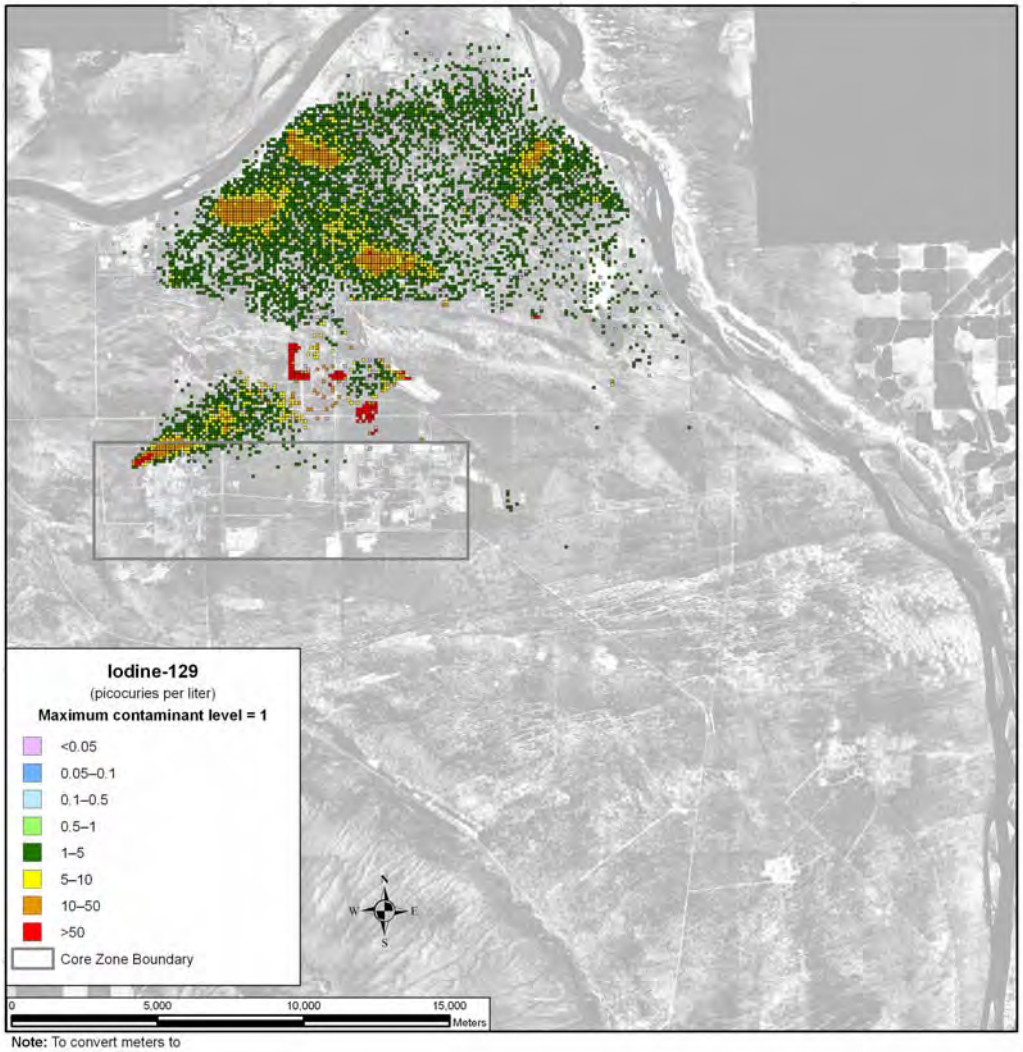


Figure 5–977. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

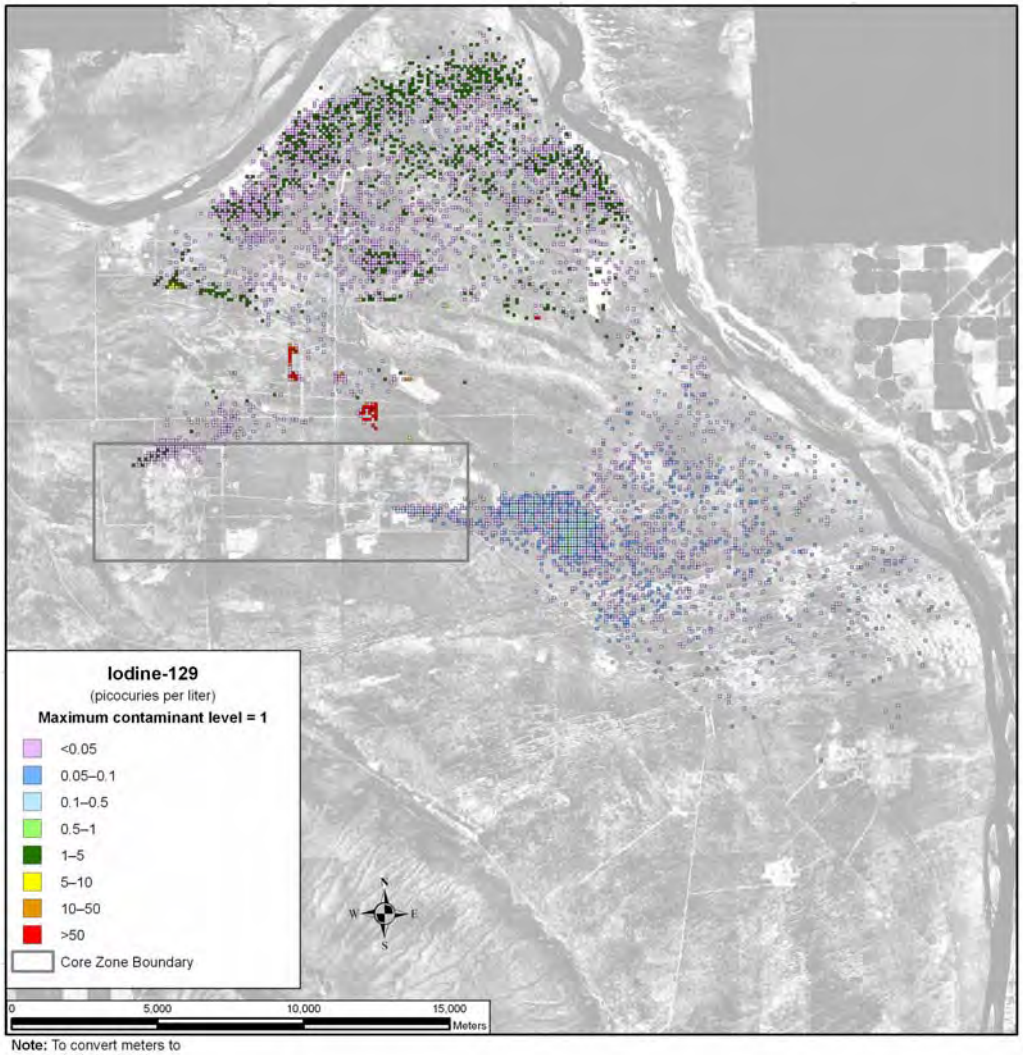


Figure 5–978. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

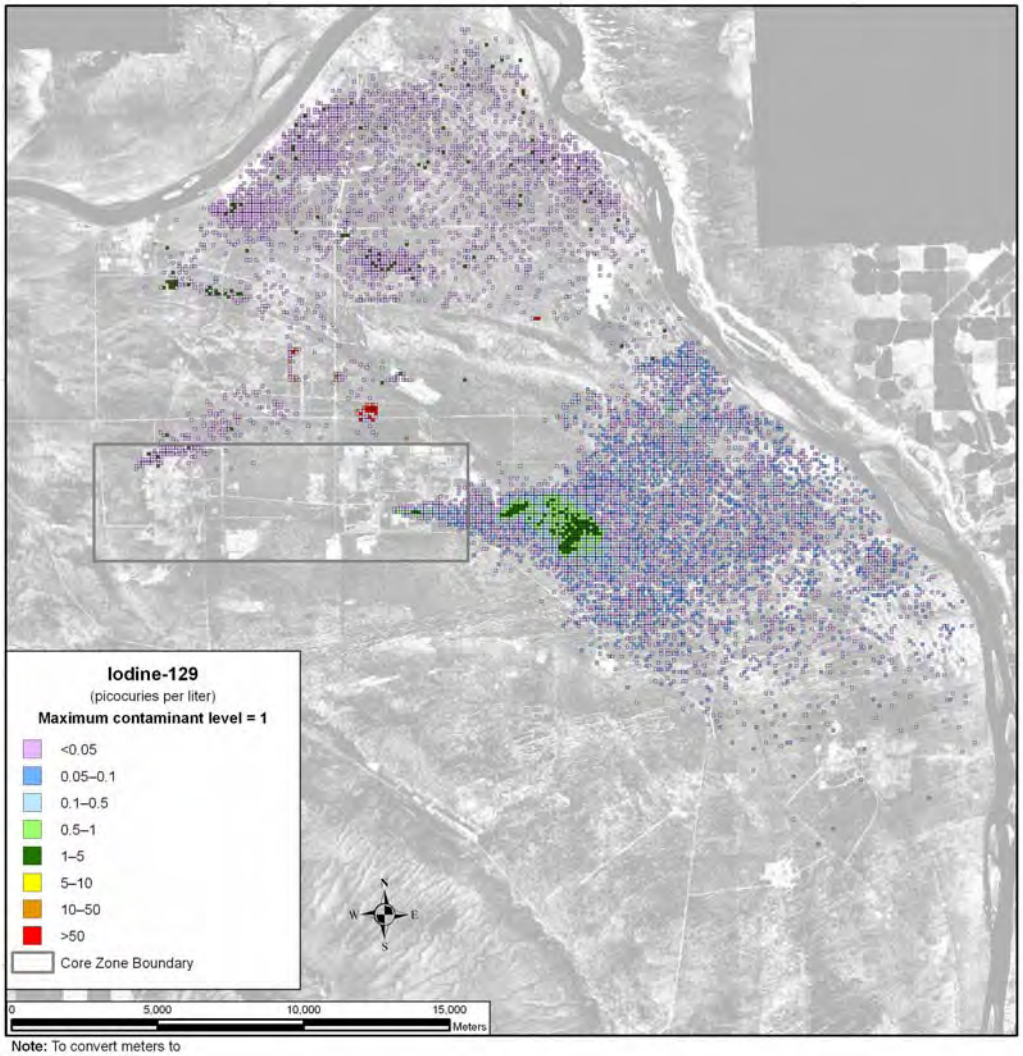


Figure 5–979. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

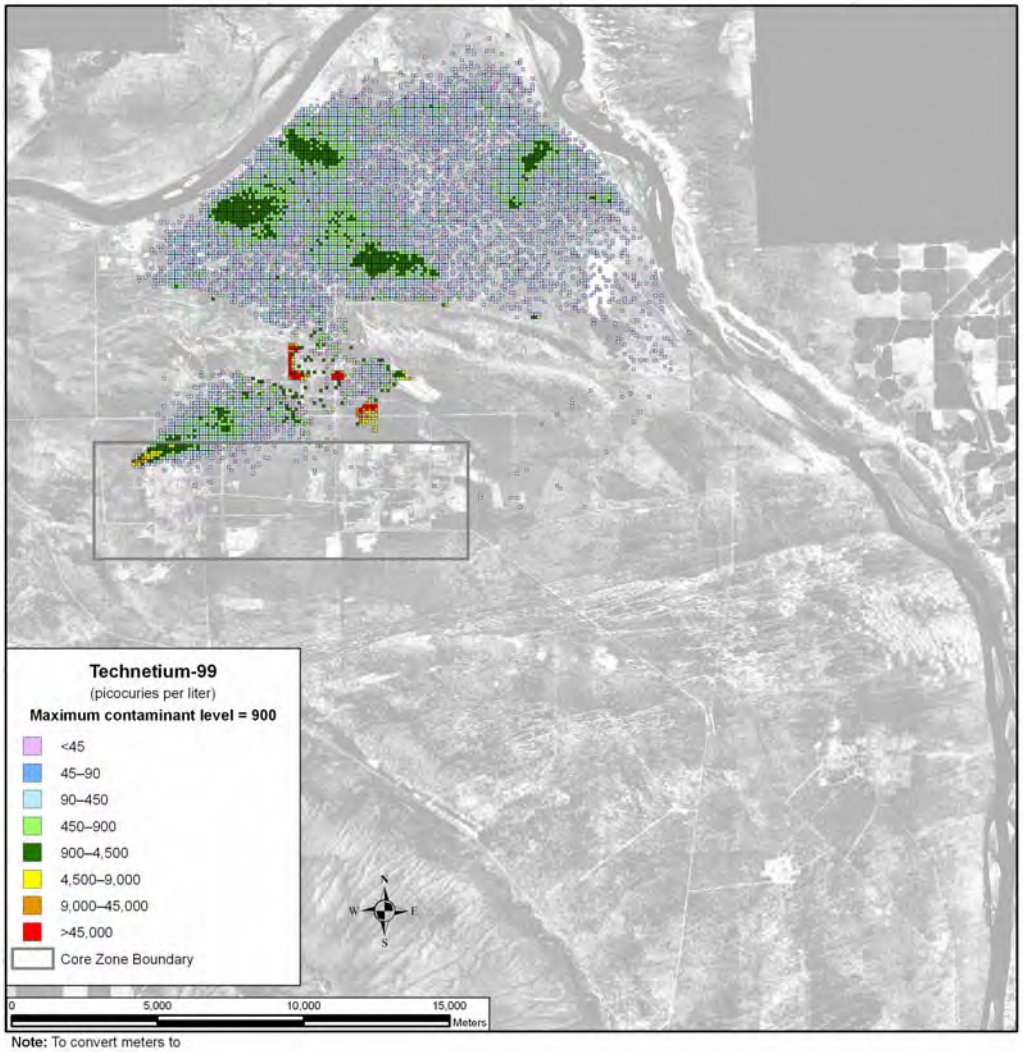


Figure 5–980. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

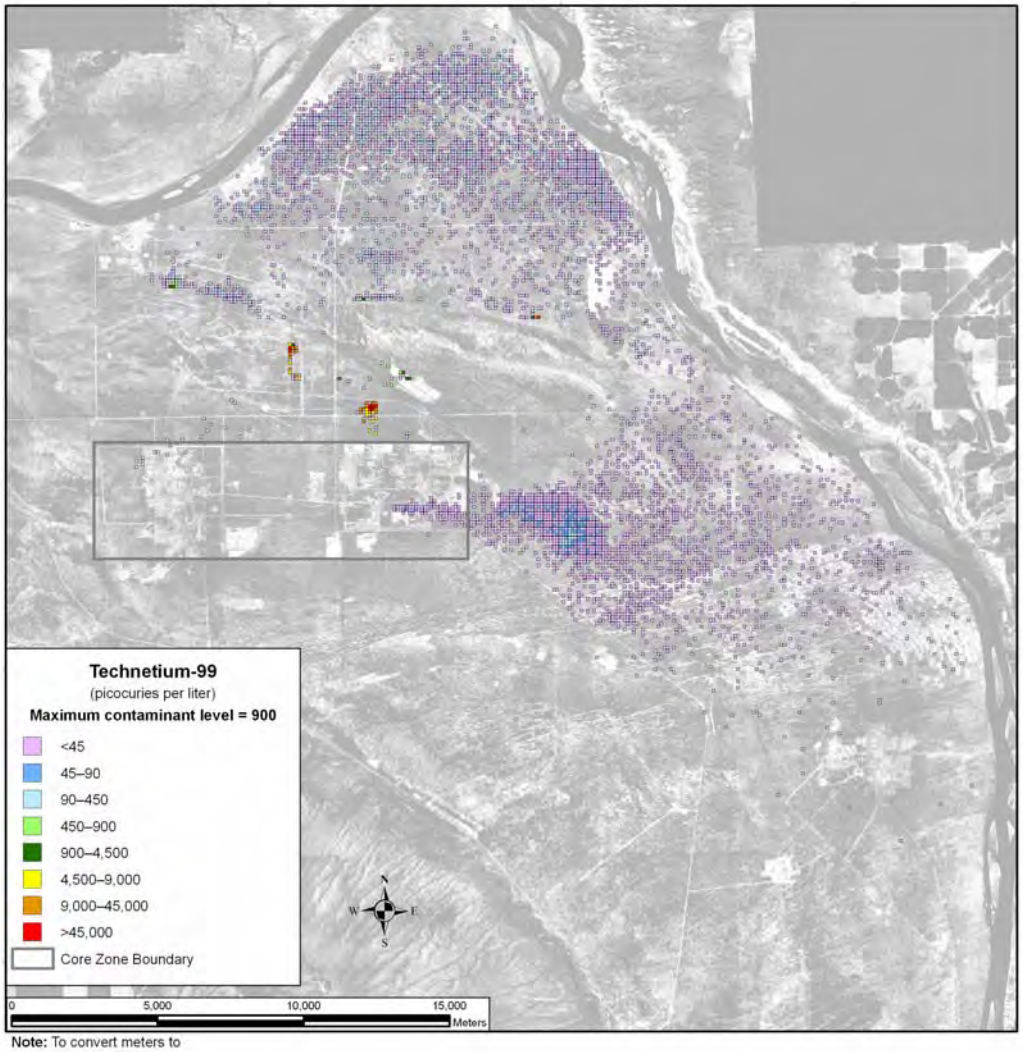


Figure 5–981. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

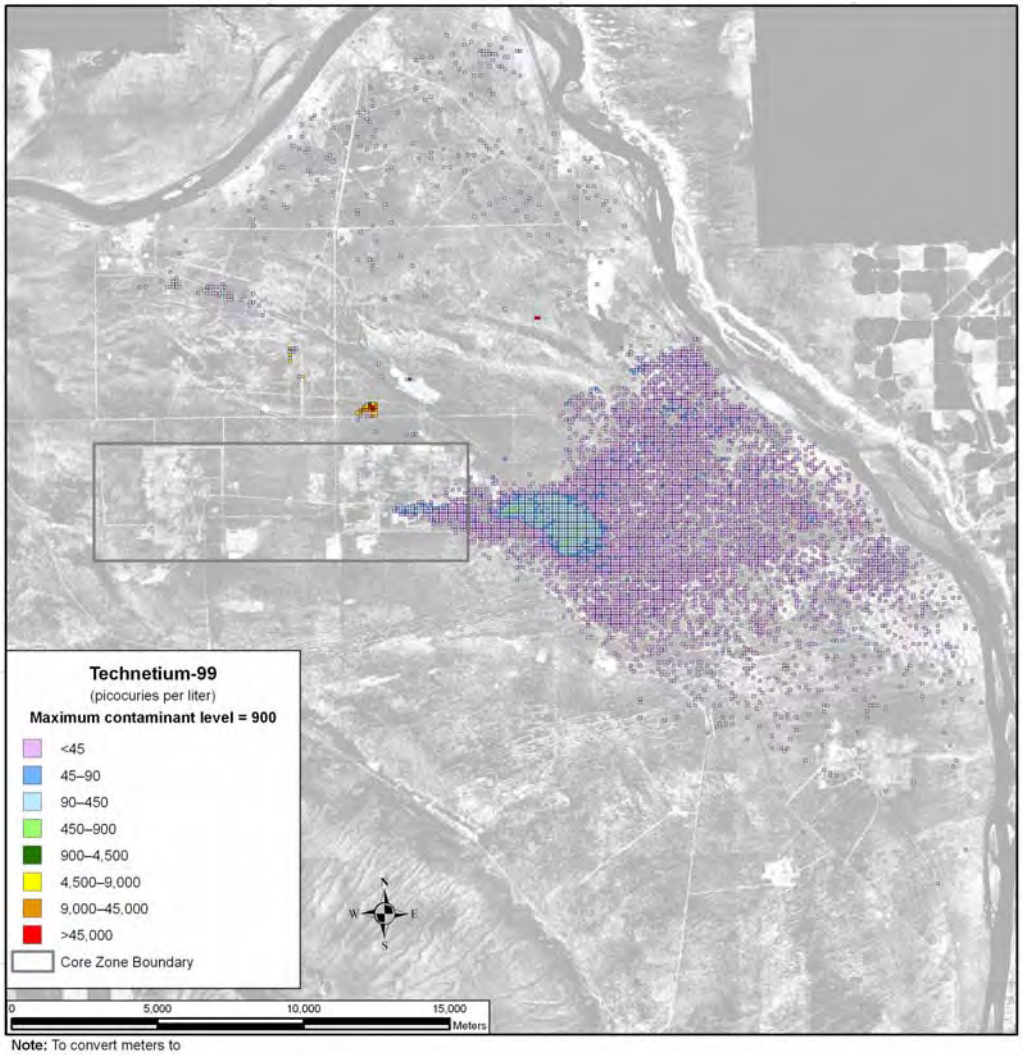


Figure 5–982. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

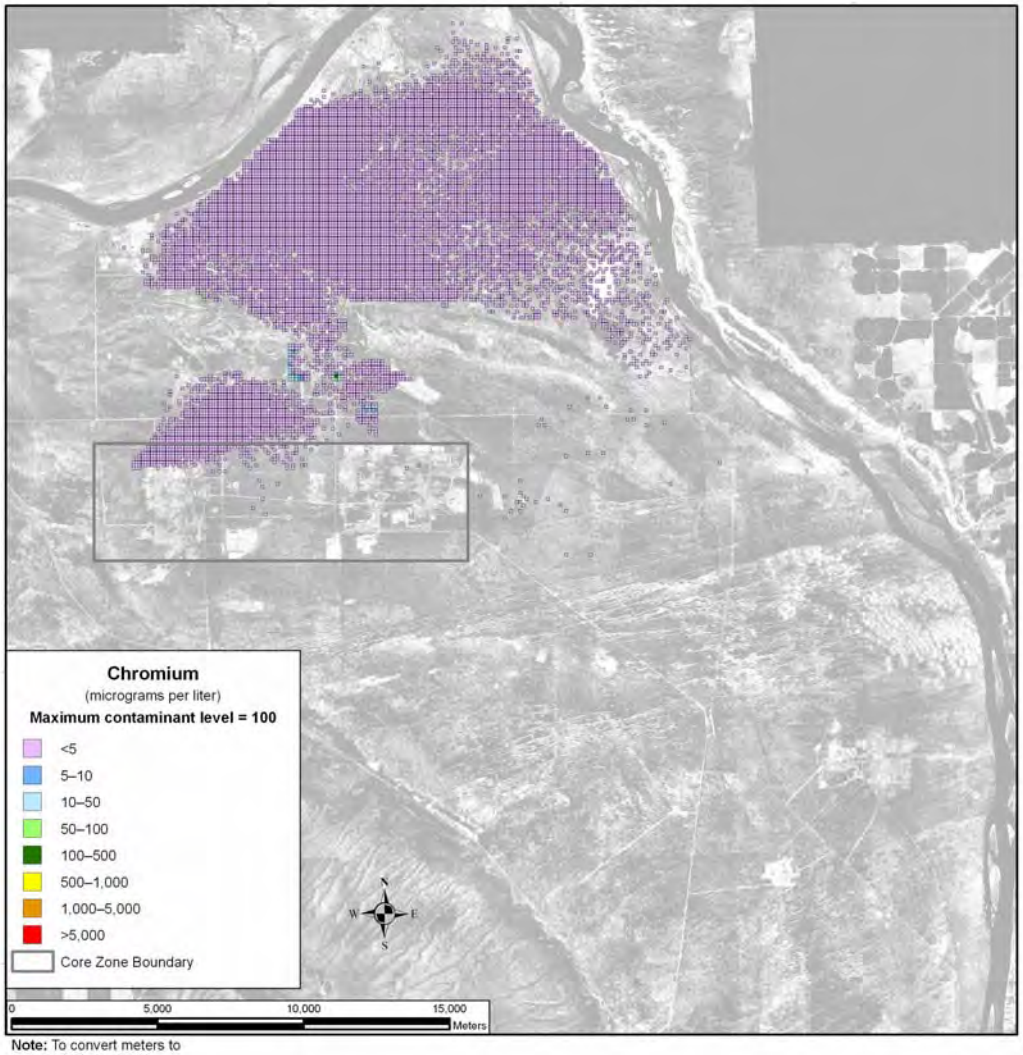


Figure 5–983. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

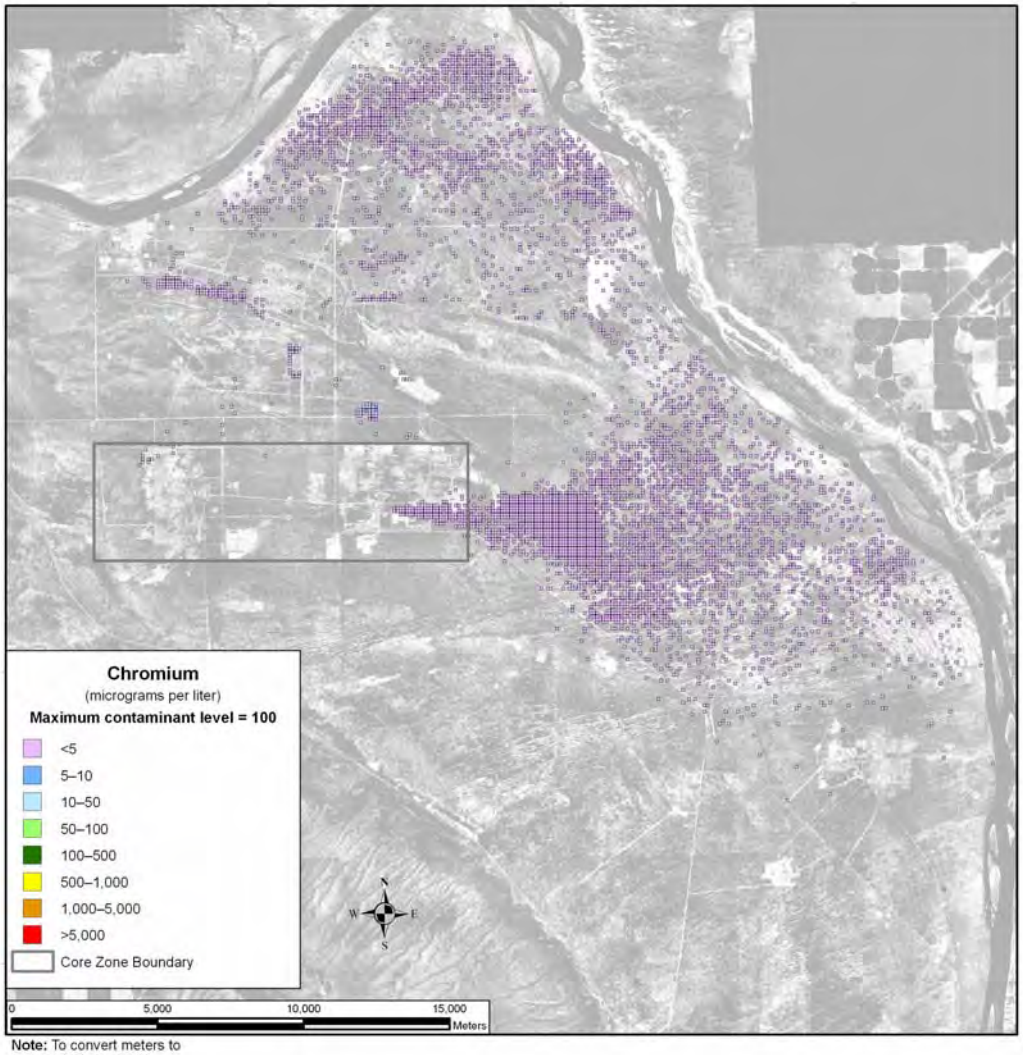


Figure 5–984. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

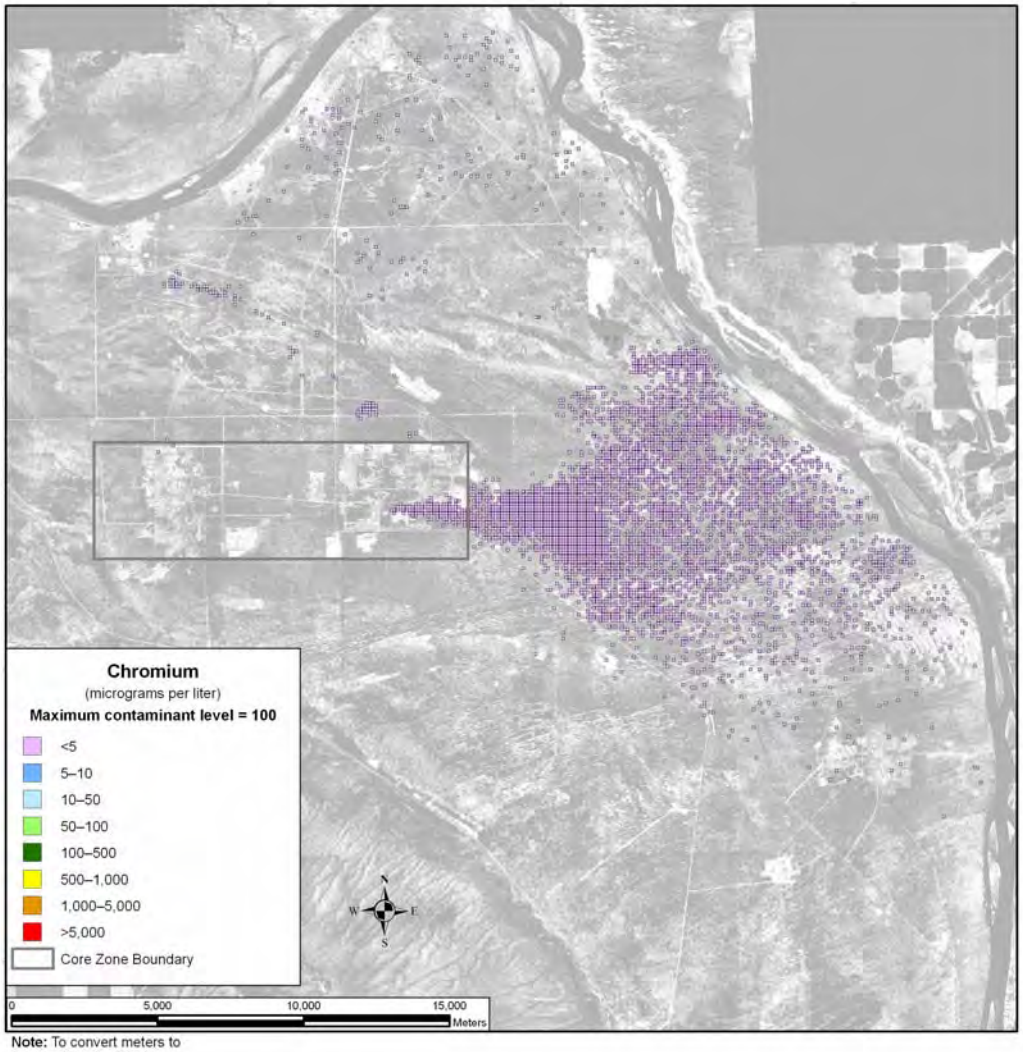


Figure 5–985. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

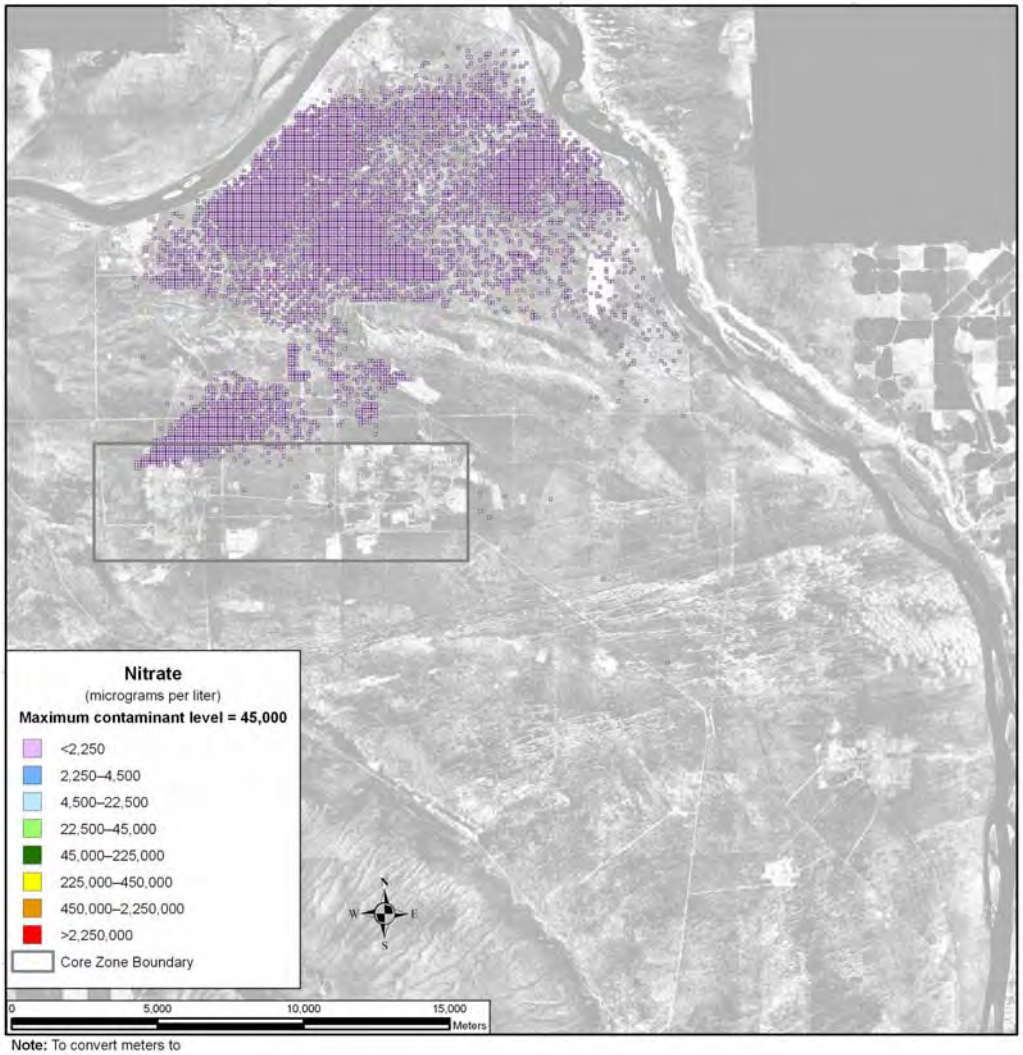


Figure 5–986. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

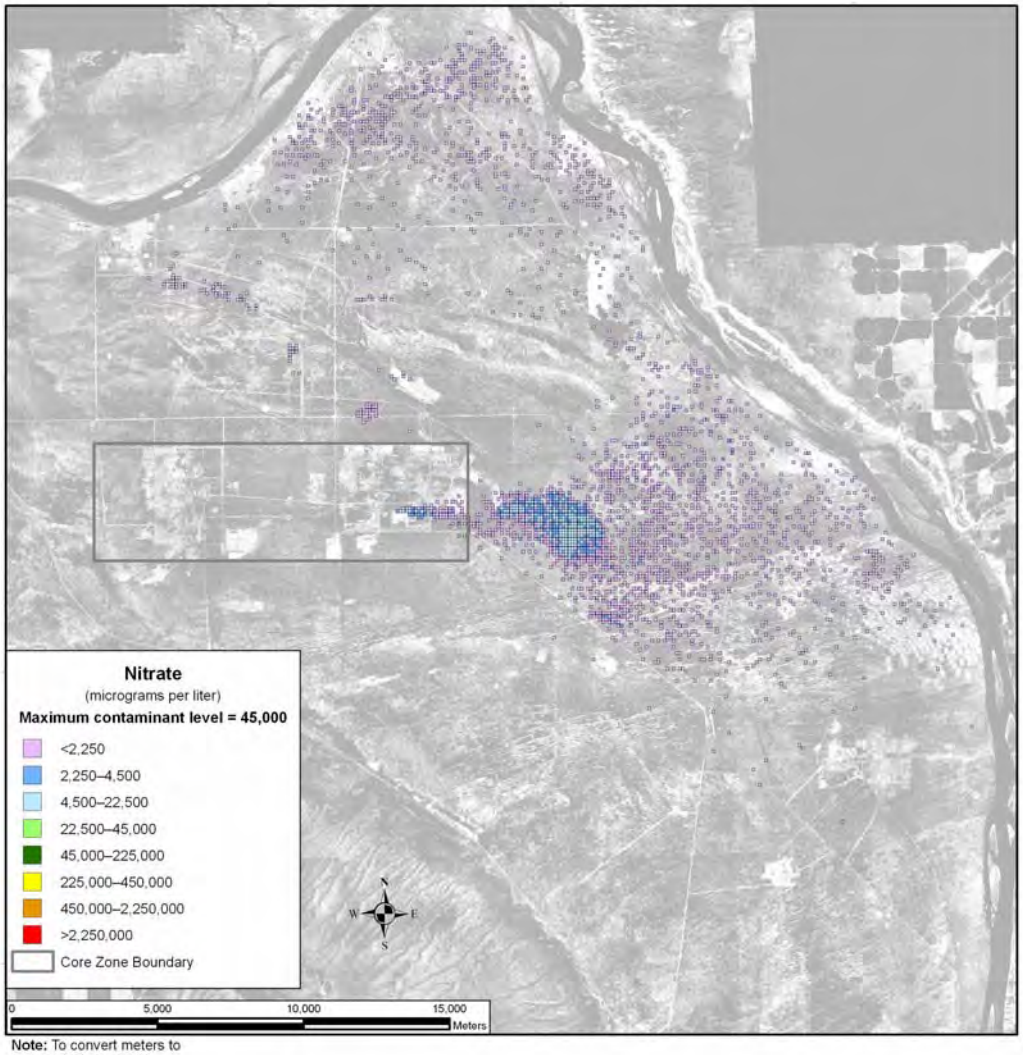


Figure 5–987. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

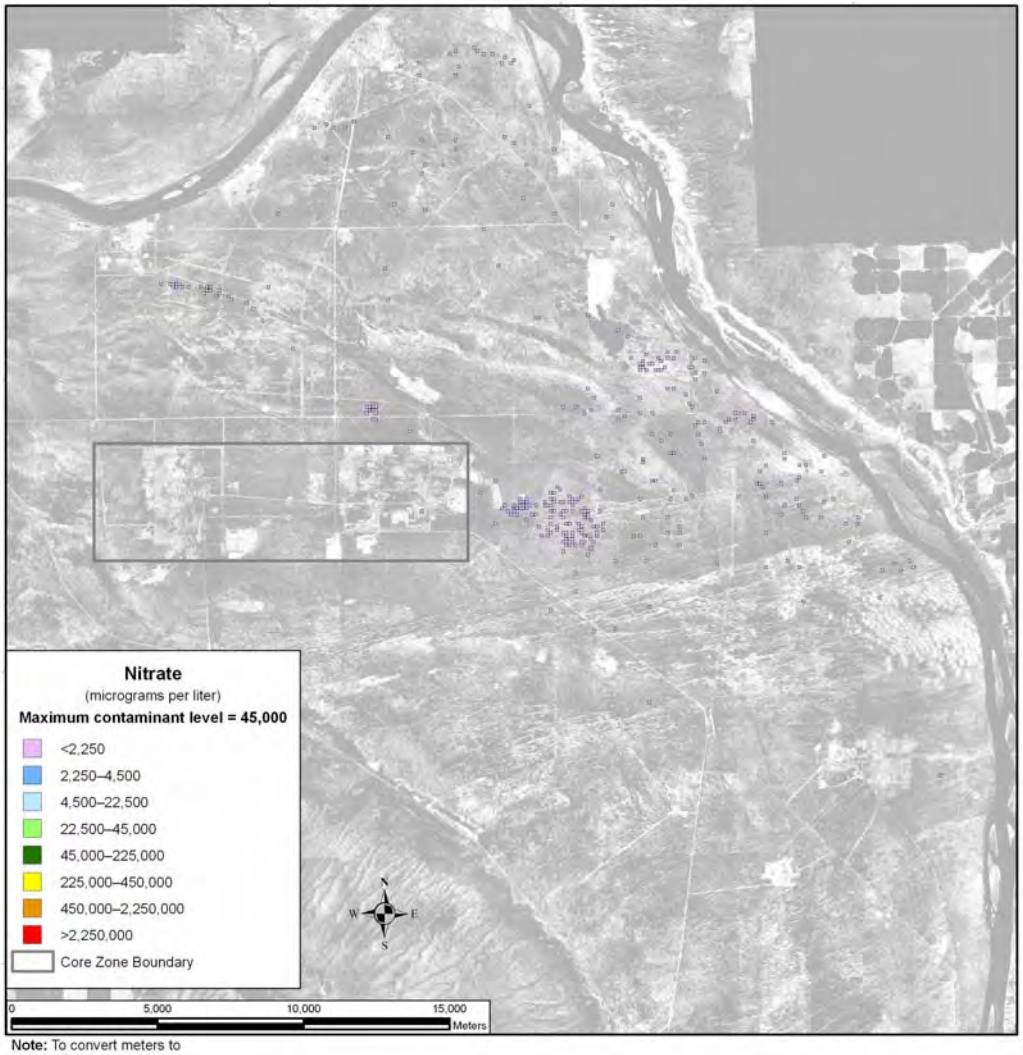


Figure 5–988. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–989 shows the distribution of uranium-238 during CY 11,885. Releases from IDF-West result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.

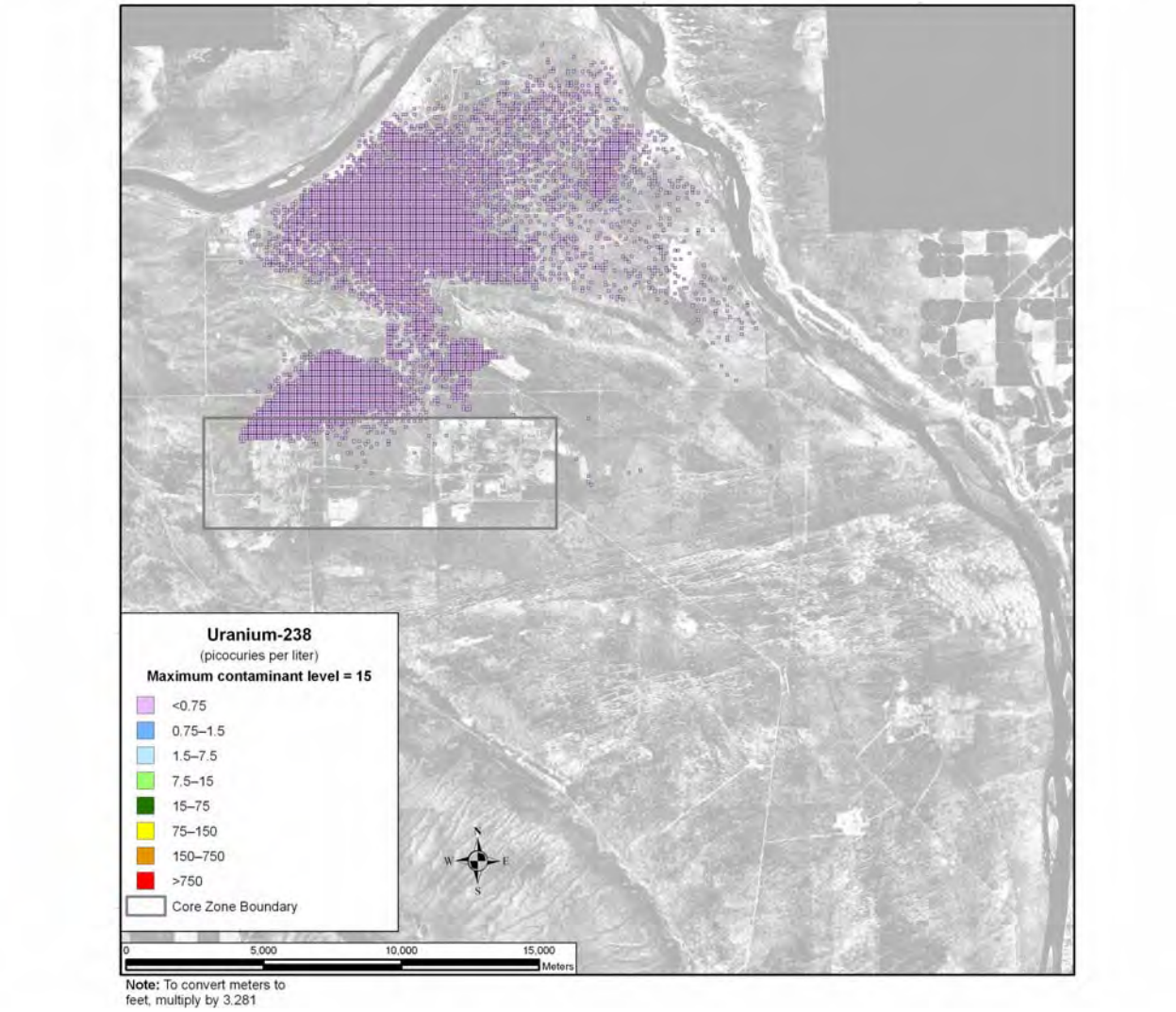


Figure 5–989. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, in general, the inventory remaining at IDF-East and IDF-West which are available for release to the environment at the start of the post-disposal period are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. The concentration at

the Columbia River nearshore is about one to two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River nearshore.

5.3.1.3.2.2 Disposal Group 2, Subgroup 2-B, Base Case

Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, is designed to show the impacts of waste disposal on IDF-East, IDF-West, and the RPPDF.

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, covers the disposal of wastes generated during Tank Closure Alternative 6B, FFTF Decommissioning Alternatives 2 or 3, and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, RPPDF in CY 2022 and continues through CY 2050 for IDF-West and CY 2100 for IDF-East and the RPPDF, when the disposal facilities will be operationally closed. During the disposal period, the materials in this permitted, operational facility are not available for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and IDF-West become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case (i.e., Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternatives 2 and 3; and onsite- and offsite-generated waste), is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, acetonitrile, chromium, and nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Subtotals are plotted as releases from three disposal facilities: IDF-West (FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- waste, and offsite-generated waste); IDF-East (PPF glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste); and the RRPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over more than 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–990 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–991, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129), the releases range over five orders of magnitude depending on the source of both radionuclides. ETF-generated secondary waste and tank closure secondary waste account for most of the releases. The release of nitrate in IDF-East is all associated with ETF-generated secondary waste. Sources of chromium include tank closure secondary waste, PPF glass, and retired melters.

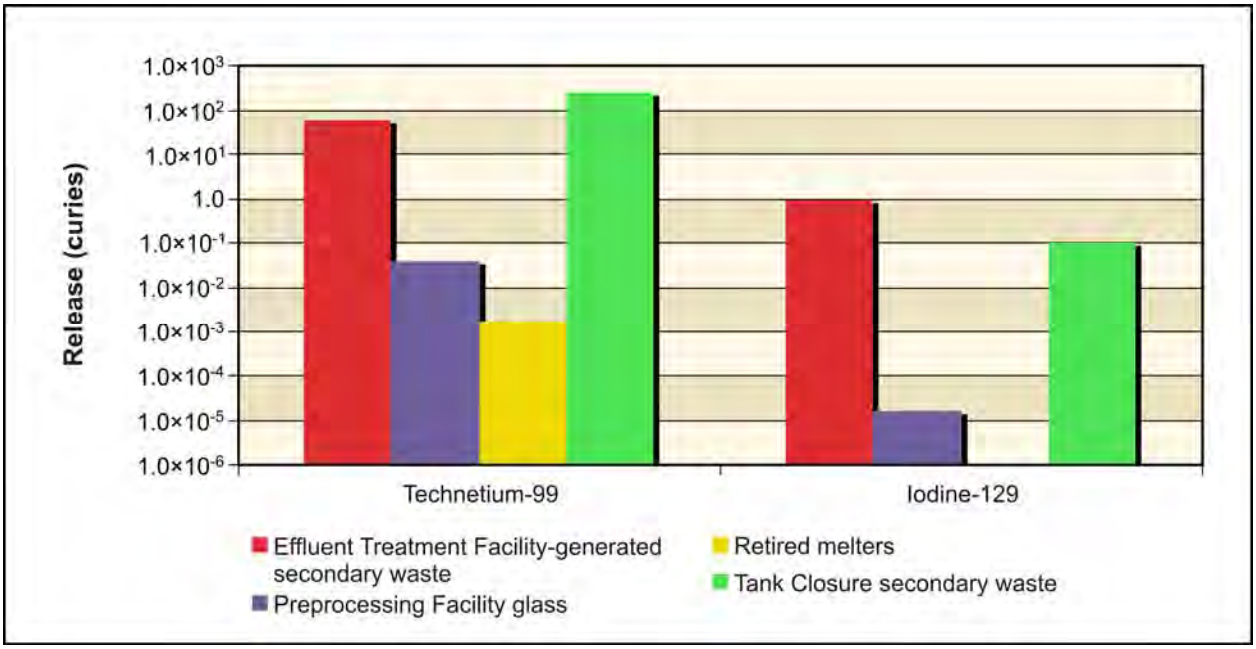


Figure 5–990. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

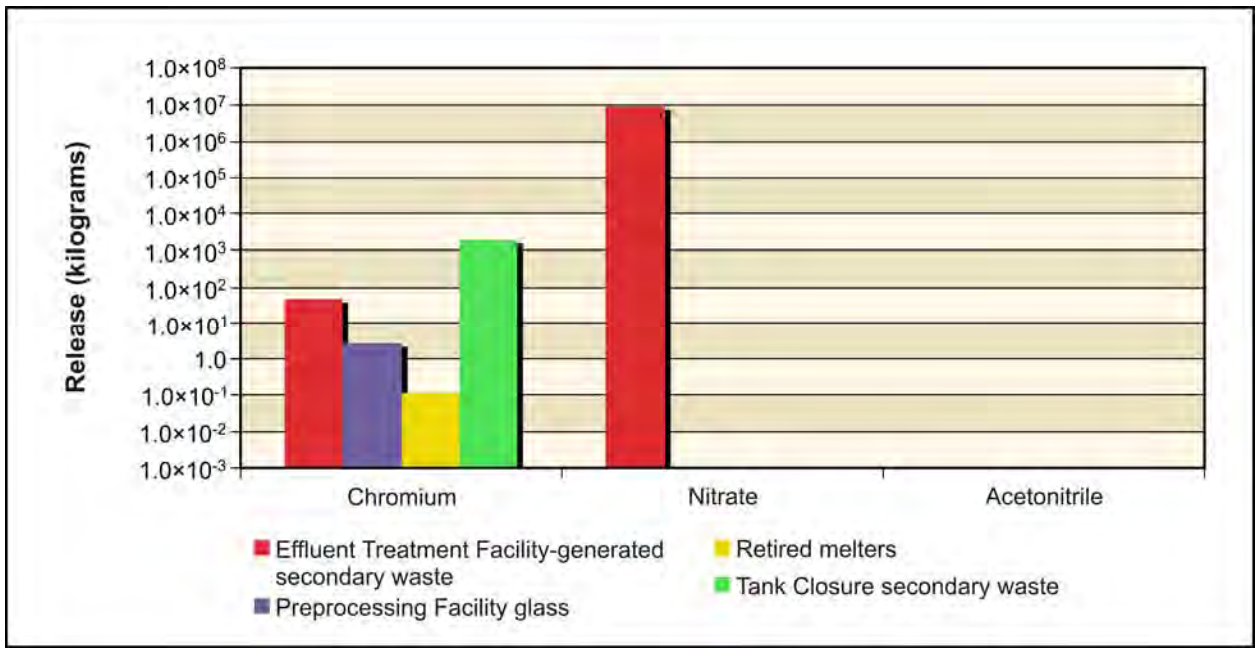


Figure 5–991. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–992 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–993, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to groundwater is essentially equal to the amount released to the vadose zone.

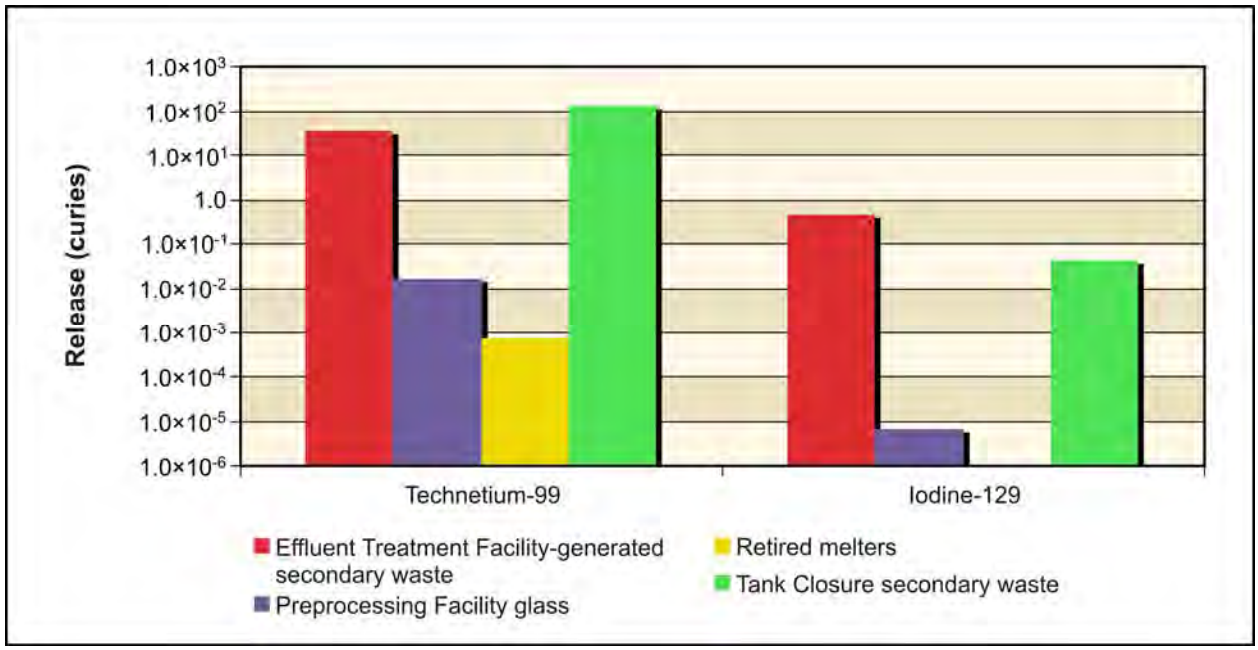


Figure 5–992. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

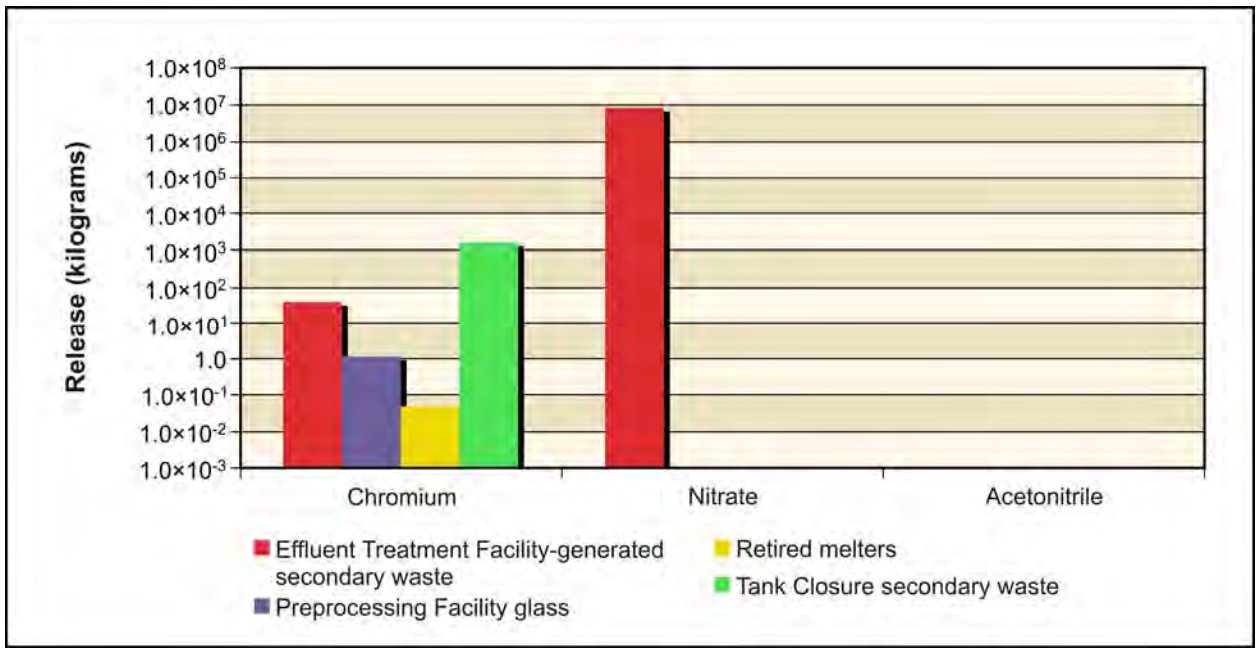


Figure 5–993. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–994 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–995, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to the Columbia River is essentially equal to the amount released to groundwater.

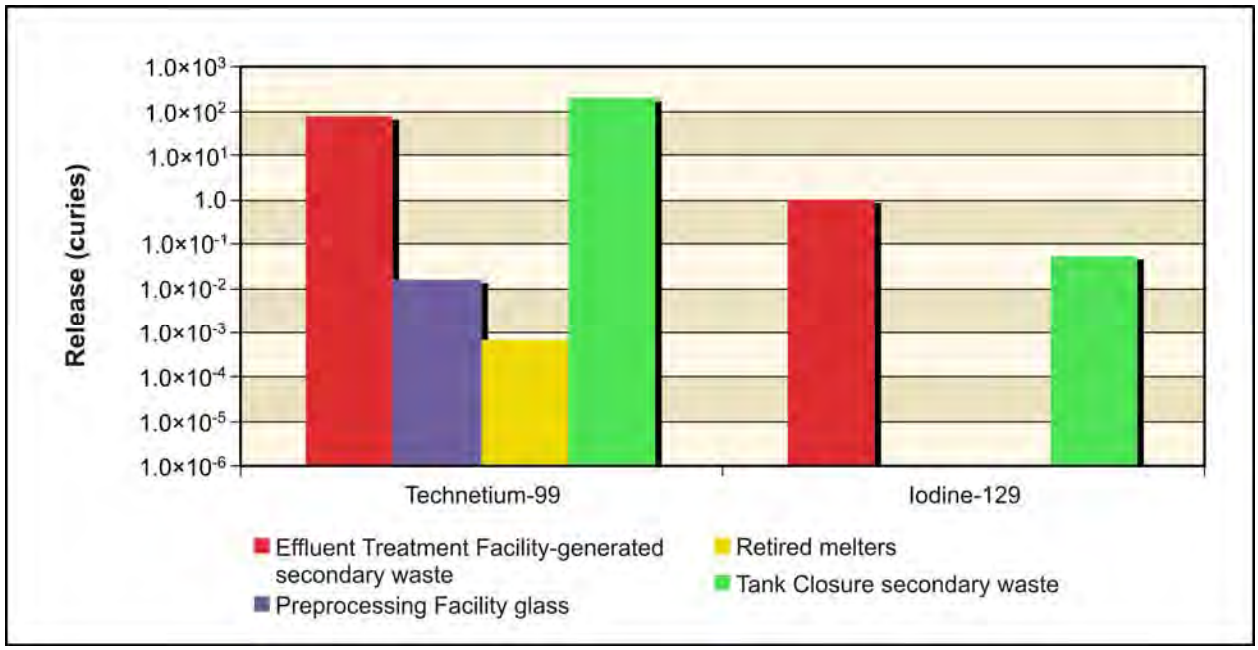


Figure 5–994. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

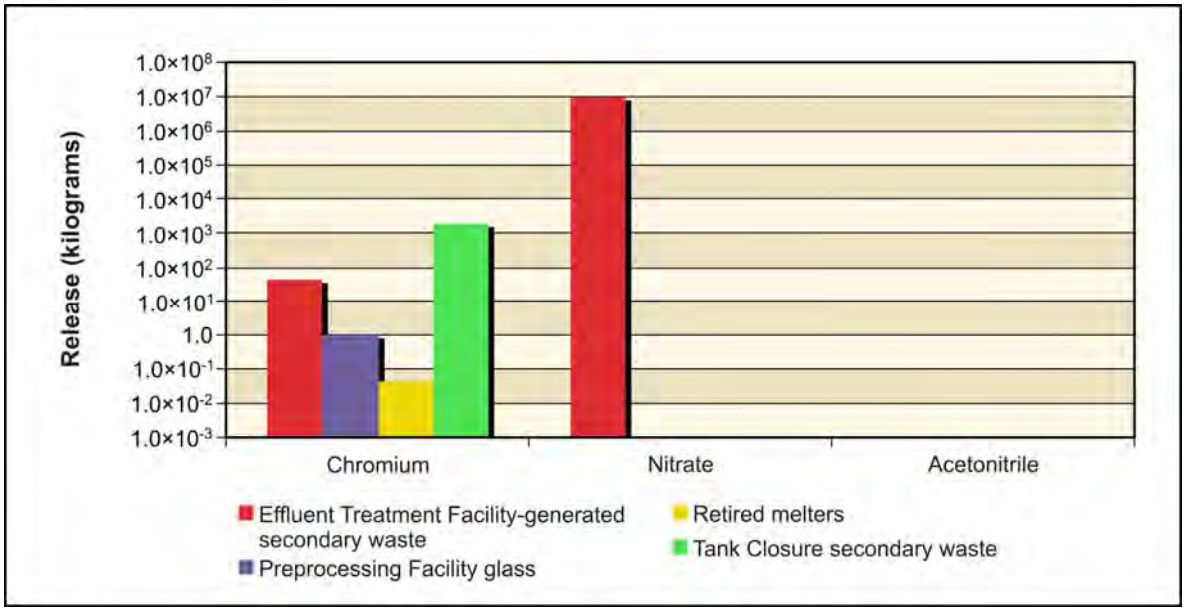


Figure 5–995. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

Figure 5–996 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–997, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129) in IDF-West, the releases range over five orders of magnitude depending on the source. Over 99 percent of the radiological waste is from offsite waste. The chromium in IDF-West and essentially all of the nitrate derive from releases associated with waste management secondary waste and onsite-generated waste. Of the chromium sources, less than 1 percent is from FFTF Decommissioning Alternative 3 waste, 66 percent is from waste management secondary waste and onsite-generated waste, and 34 percent is from offsite-generated waste.

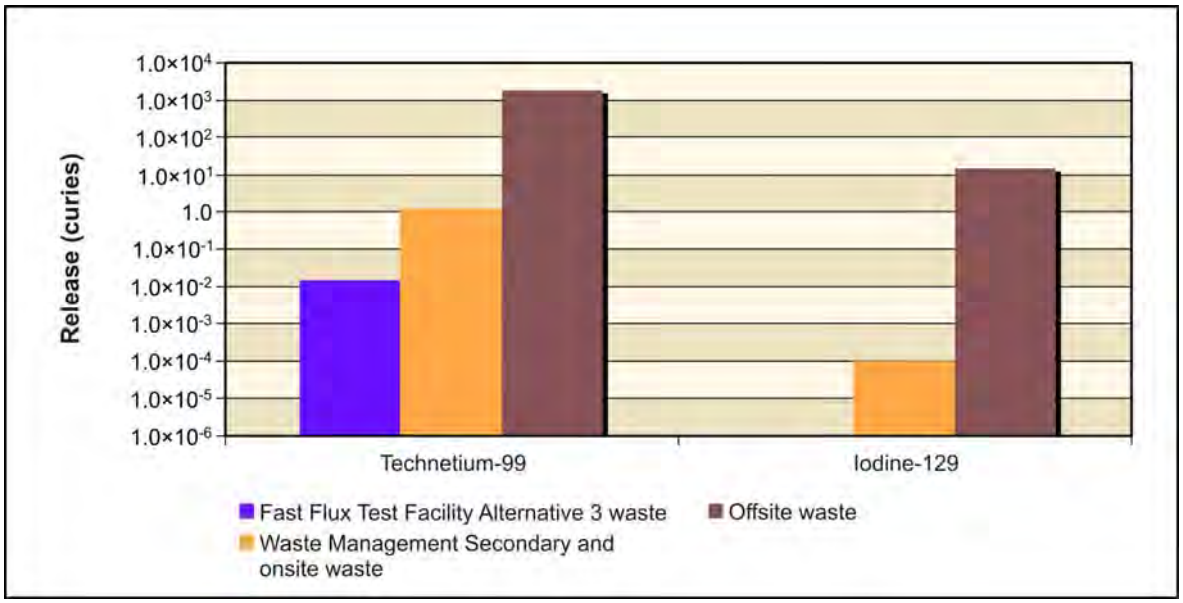


Figure 5–996. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

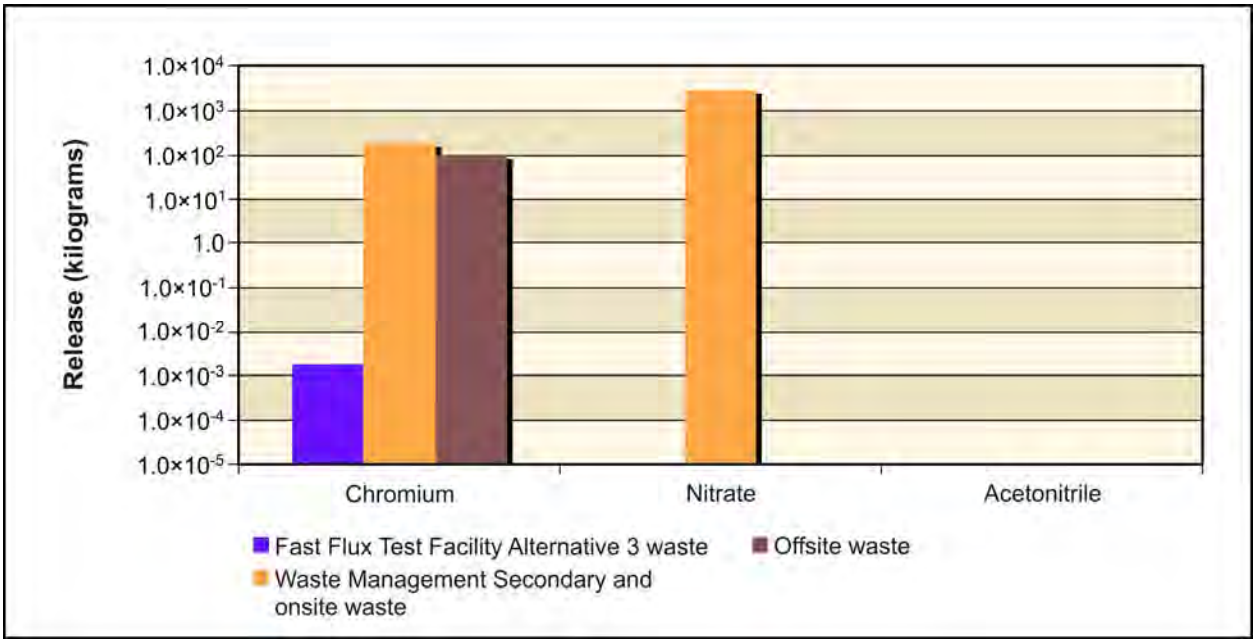


Figure 5–997. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–998 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–999, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to groundwater is essentially equal to the amount released to the vadose zone.

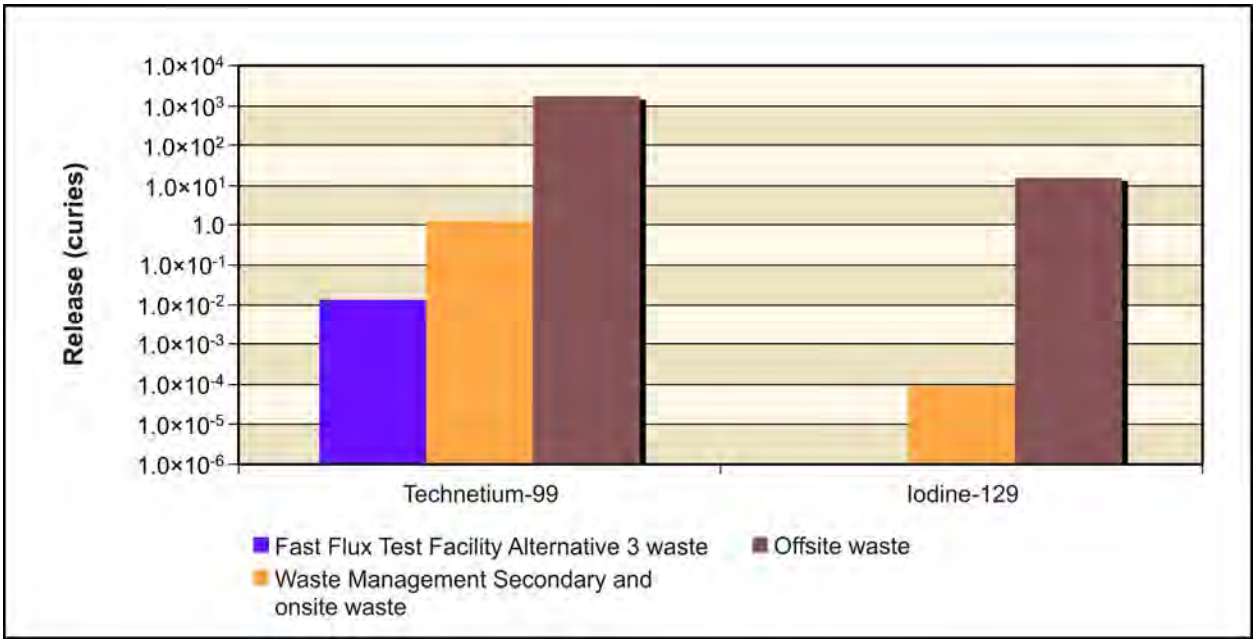


Figure 5–998. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

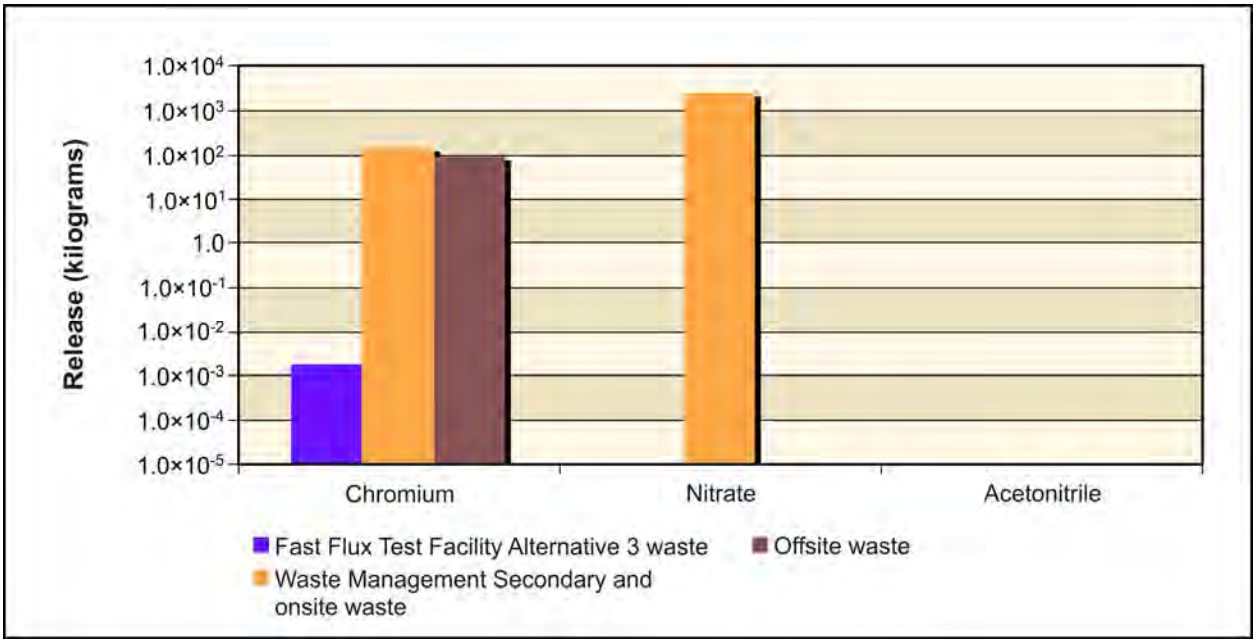


Figure 5–999. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1000 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–1001, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to the Columbia River is approximately 5 percent less than the amount released to the vadose zone.

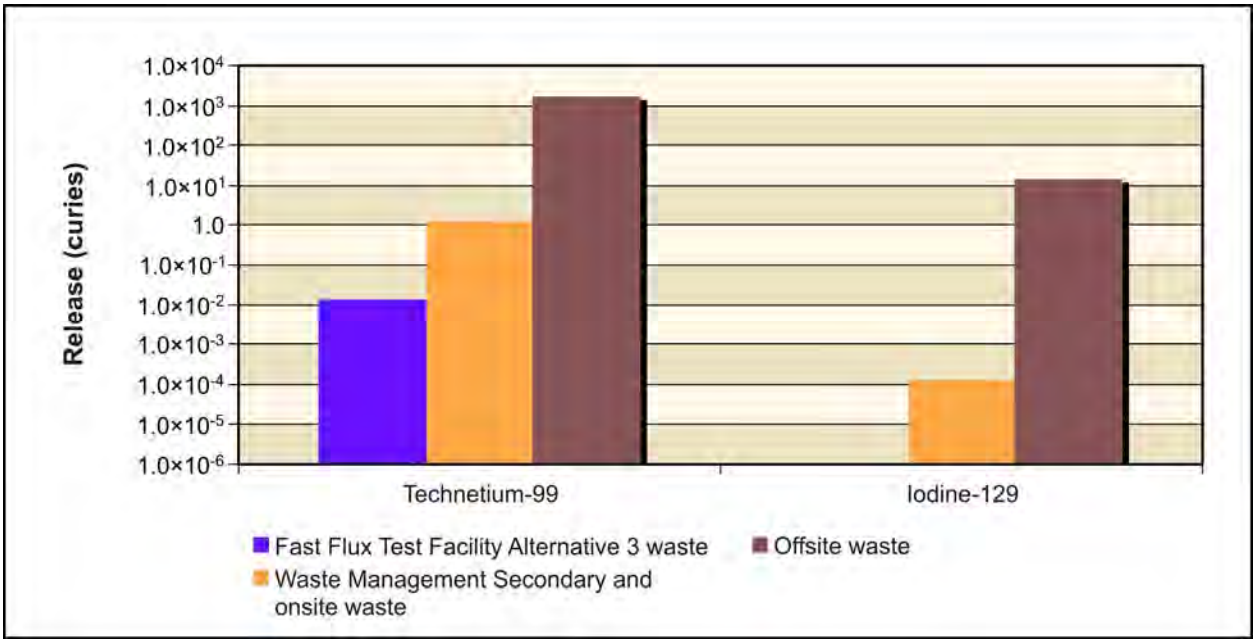


Figure 5–1000. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

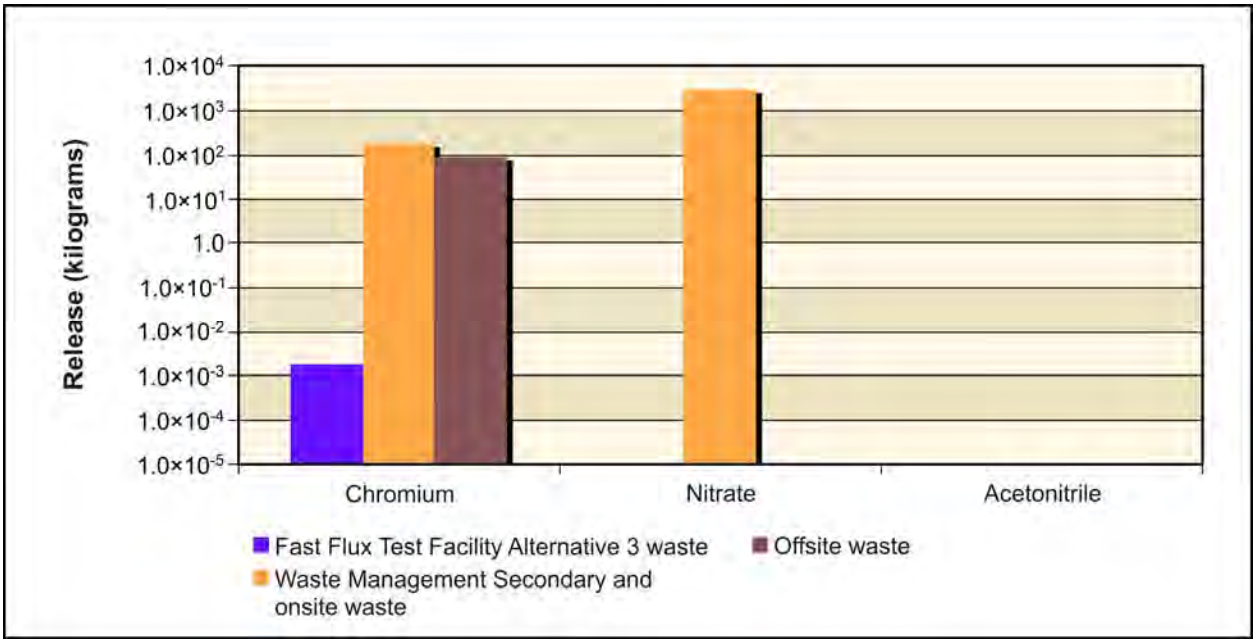


Figure 5–1001. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1002 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–1003, the chemical hazard drivers. The release of technetium-99 is more than two orders of magnitude greater than the releases of iodine-129 in the RRPDF. The chemical constituents show nitrate as the predominant COPC, its release about two orders of magnitude greater than that of chromium and five orders of magnitude greater than that of acetonitrile.

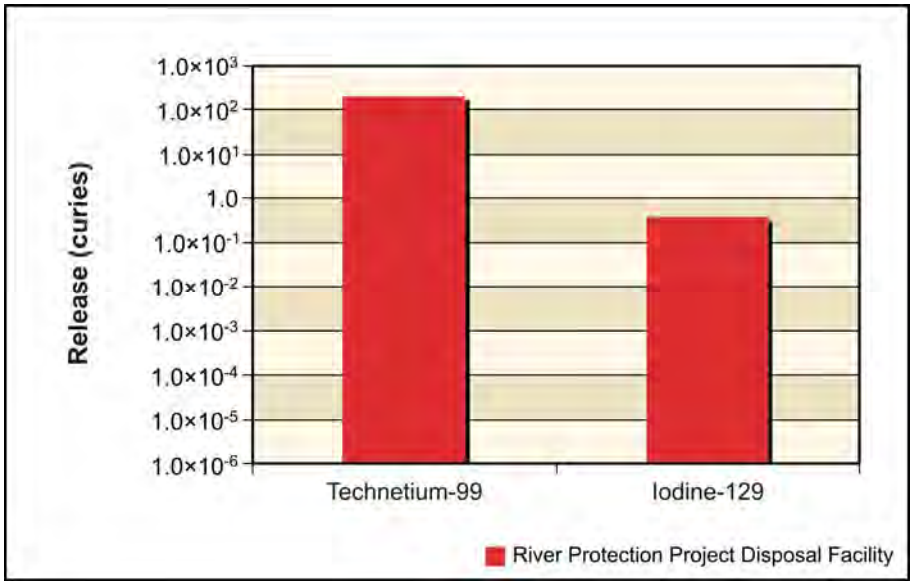


Figure 5–1002. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

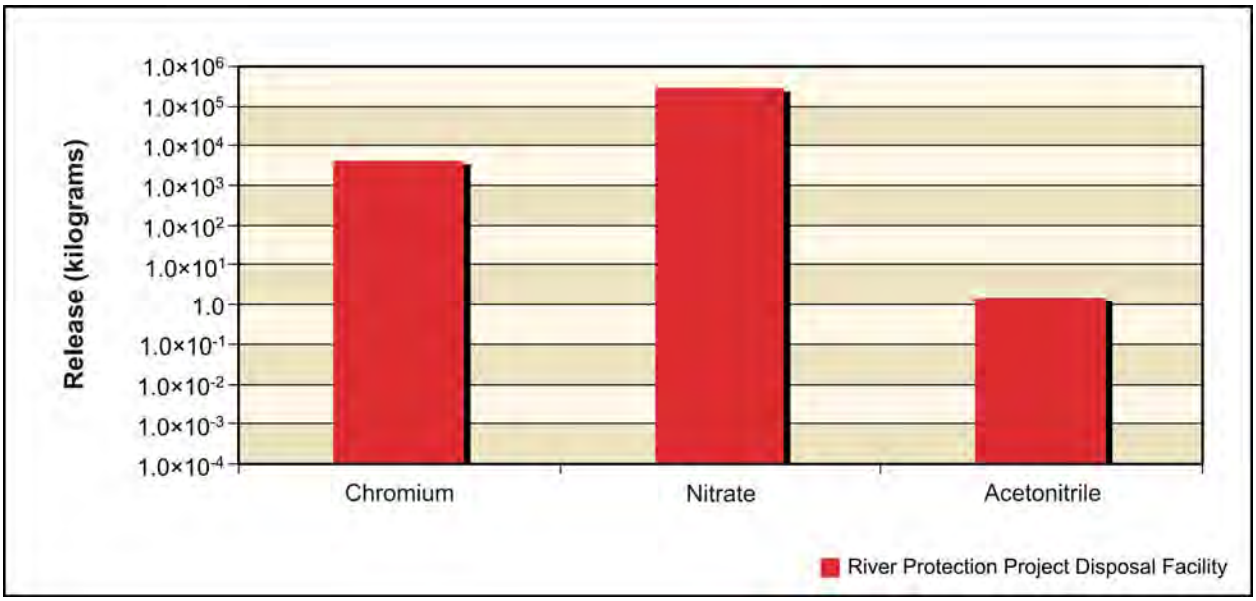


Figure 5–1003. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1004 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–1005, the chemical hazard drivers. For the conservative tracers (iodine-129, technetium-99, acetonitrile, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

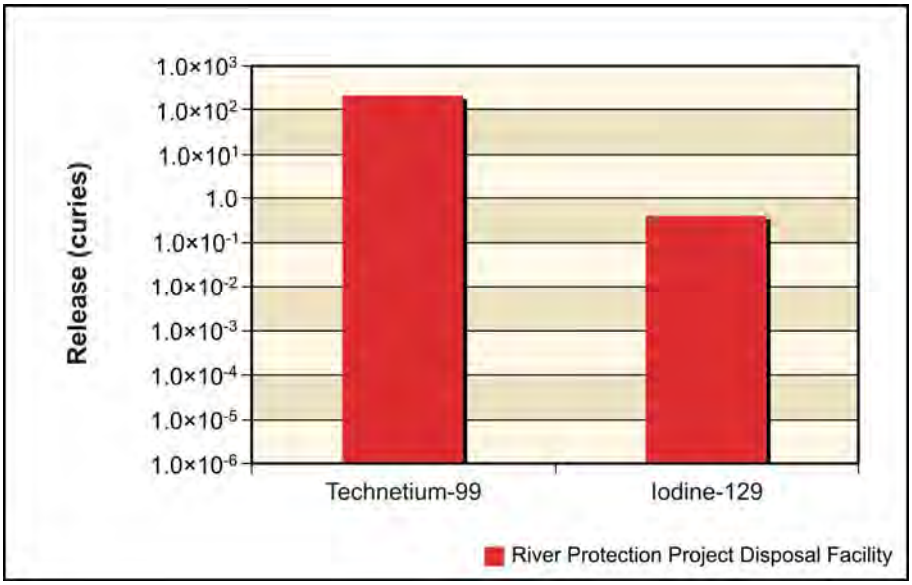


Figure 5–1004. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

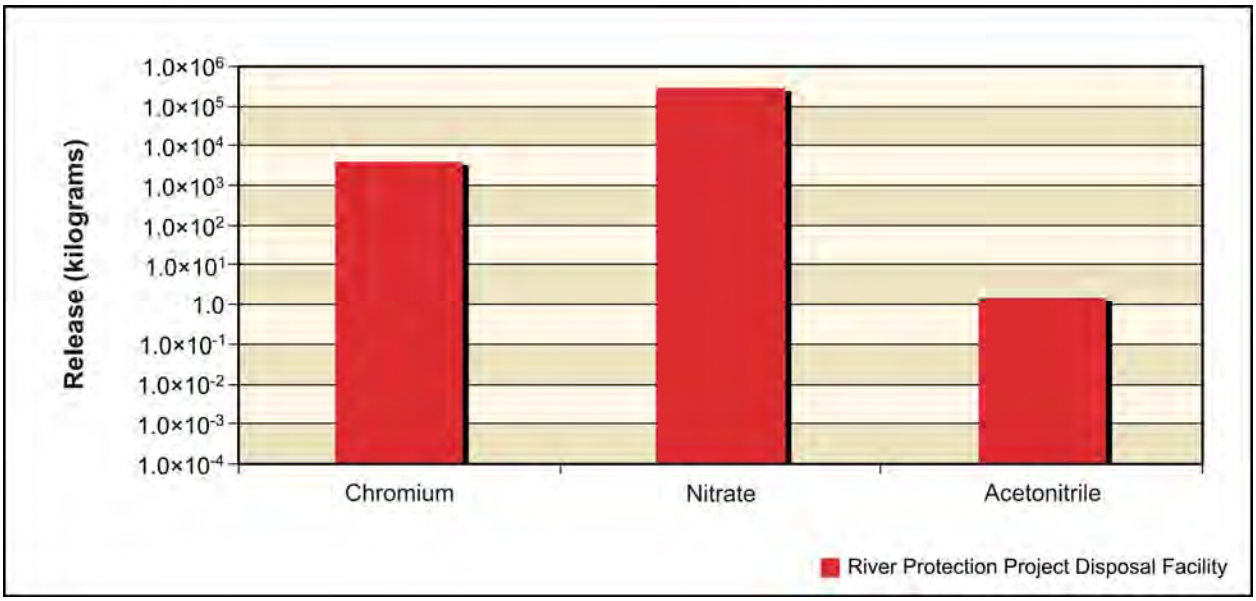


Figure 5–1005. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1006 shows the release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–1007, the chemical hazard drivers. Both figures show similar trends, as mentioned in the above paragraph, for release to the Columbia River for all COPC drivers in the RRPDF.

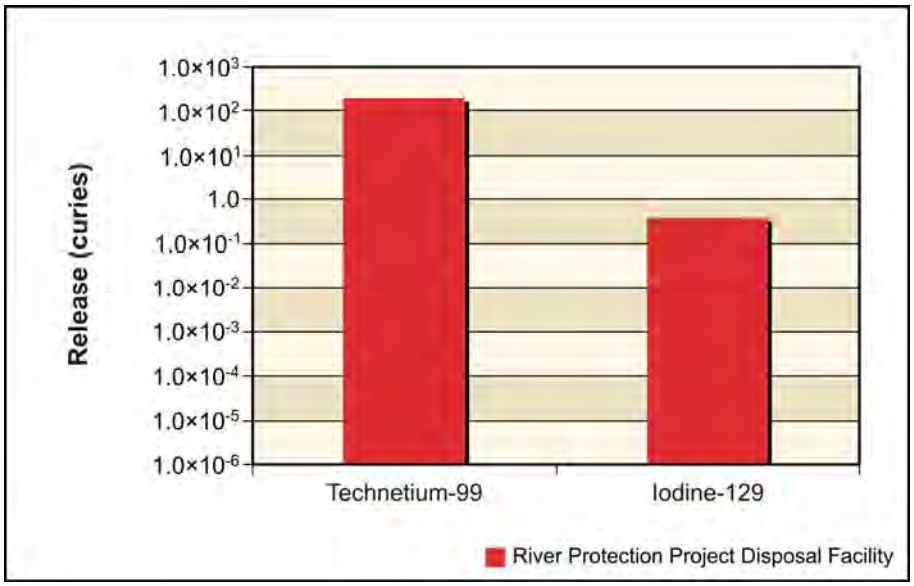


Figure 5–1006. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

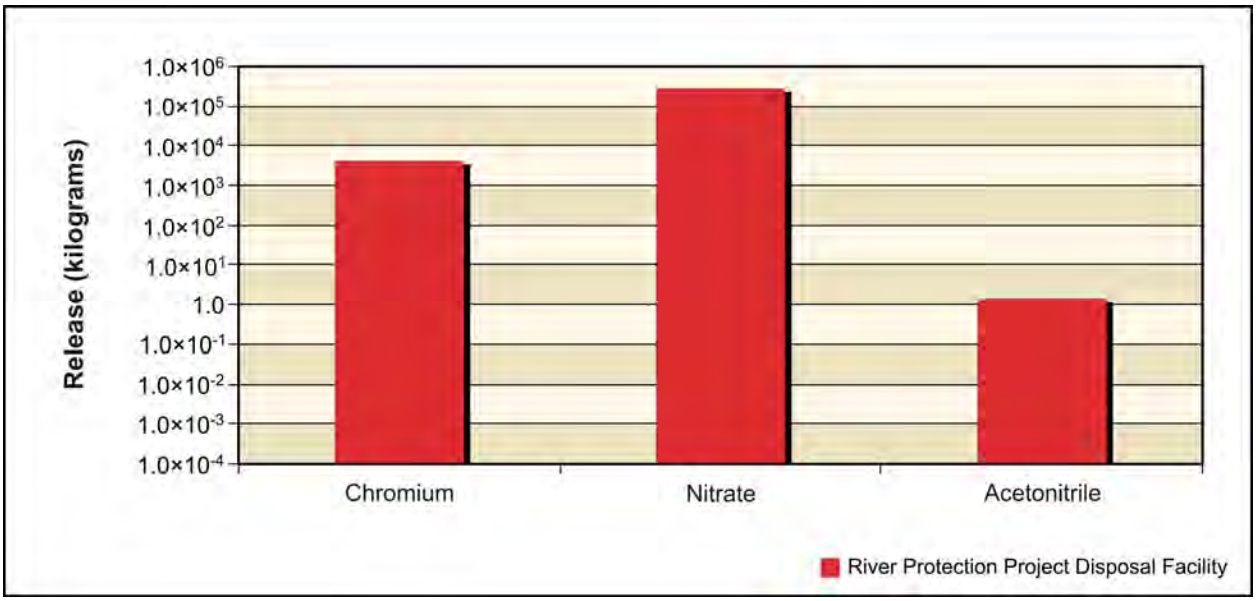


Figure 5–1007. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. Confidence intervals are calculated to show the length of time (in this case, 95 percent of the time) a concentration is likely to be at or below a given value. The confidence interval is basically a statistical aid to interpreting data presenting with a significant amount of random fluctuation (noise). In this analysis, the confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, or the concentration was near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude.

Figures 5–1008 through 5–1011 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from IDF-East, IDF-West, and the RRPDF at the Core Zone Boundary cause groundwater concentrations to exceed the benchmark for iodine-129 at CY 3500. Calculations using the confidence interval show that the iodine-129 concentrations exceed the benchmark at both the Core Zone Boundary and the Columbia River nearshore after CY 5500. The trend for technetium-99 concentrations is similar to that for iodine-129 concentrations but below the benchmark during the period of analysis. Chromium and nitrate measurements at the Core Zone Boundary and the Columbia River nearshore are below the benchmark concentrations by one to three orders of magnitude, and the concentration trends are similar to those for iodine-129 and technetium-99. Table 5–97 shows the maximum concentrations in groundwater.

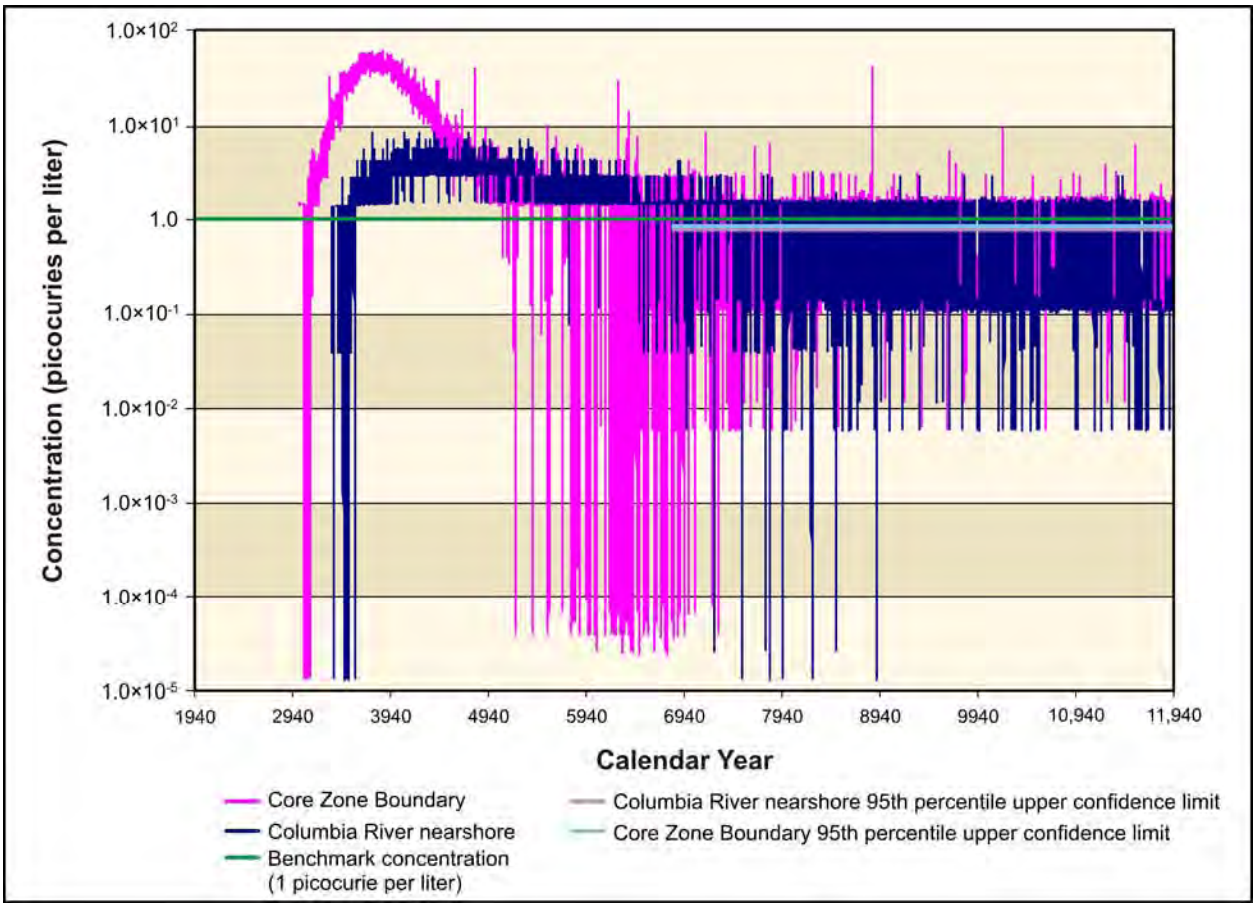


Figure 5–1008. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Iodine-129 Concentration Versus Time

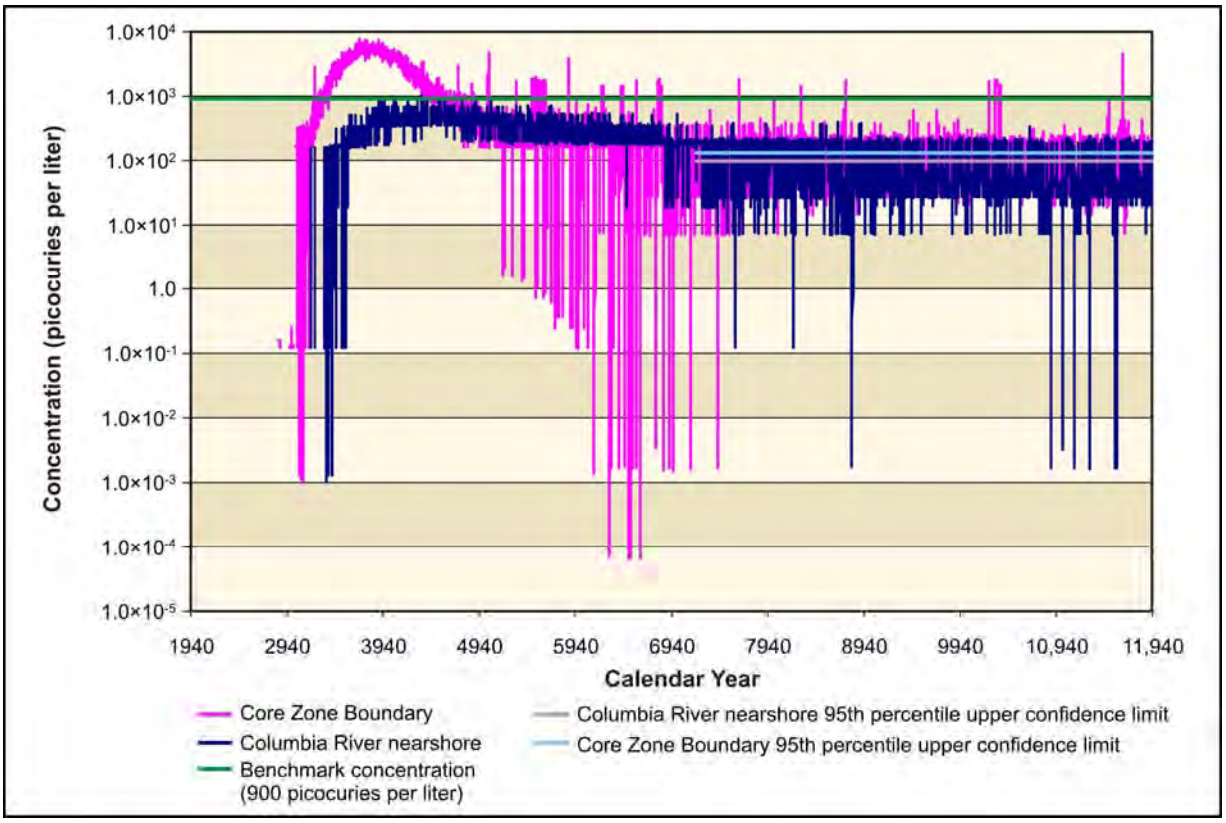


Figure 5–1009. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Technetium-99 Concentration Versus Time

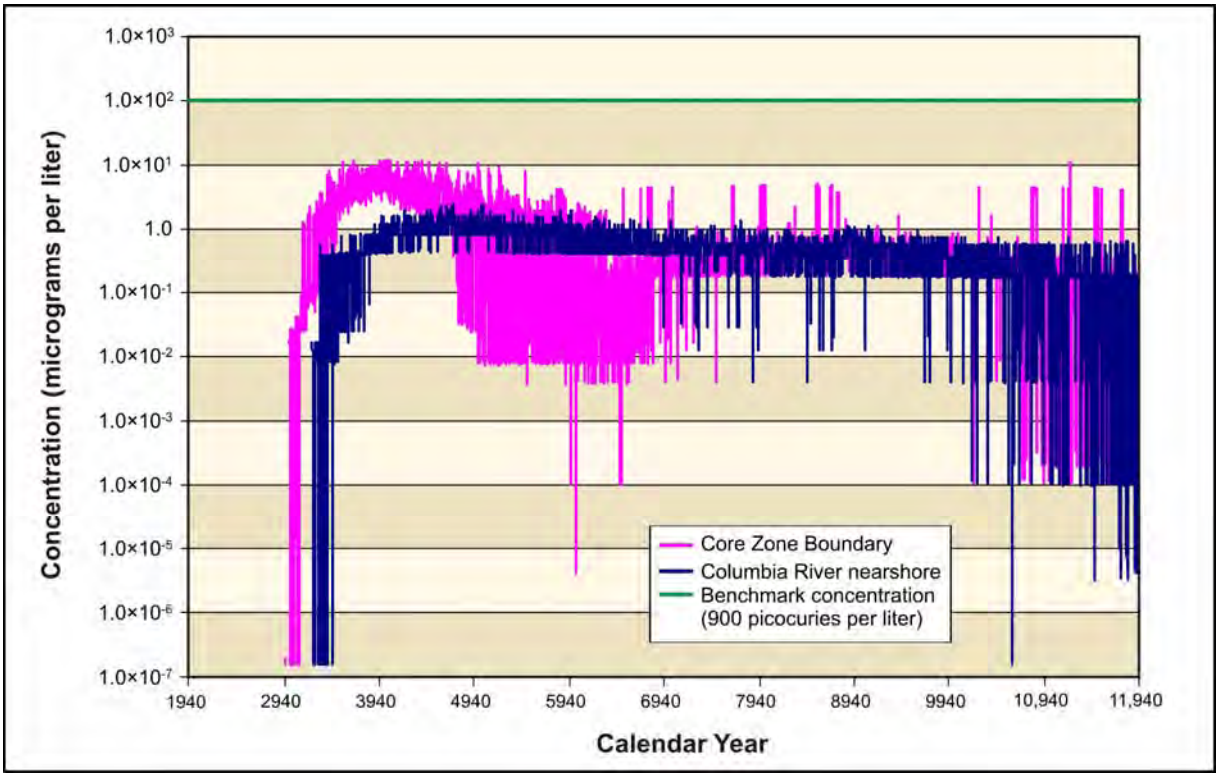


Figure 5–1010. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chromium Concentration Versus Time

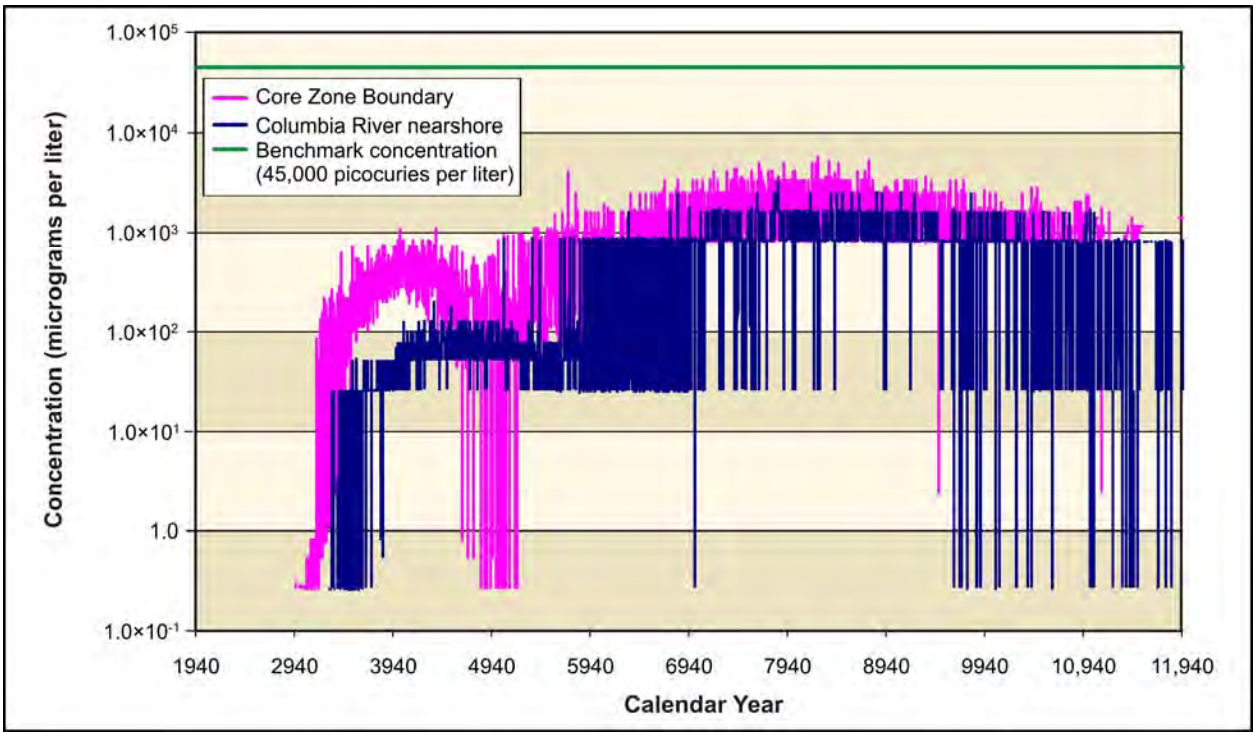


Figure 5–1011. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Nitrate Concentration Versus Time

Table 5–97. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	347	**20,200**	283	**7,750**	**1,180**	900
	(10,643)	(3713)	(3889)	(3690)	(3884)	
Iodine-129	**2**	**173**	0.5	**61**	**8**	1
	(11,363)	(3797)	(4089)	(3853)	(4392)	
Chemical in microgram per liter						
Chromium	3	2	6	12	2	100
	(8281)	(3696)	(3868)	(4042)	(4714)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	353	5,750	3,310	45,000
	(8162)	(3703)	(3996)	(8245)	(7831)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–1012 and 5–1013 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of both forms, no total uranium or uranium-238 groundwater contamination appears until roughly CY 9000. Concentrations of both total uranium and uranium-238 continue to rise until the end of the 10,000-year period of analysis, but remain at least three orders of magnitude below the benchmark for both the Core Zone Boundary and the Columbia River nearshore at the end of the period of analysis.

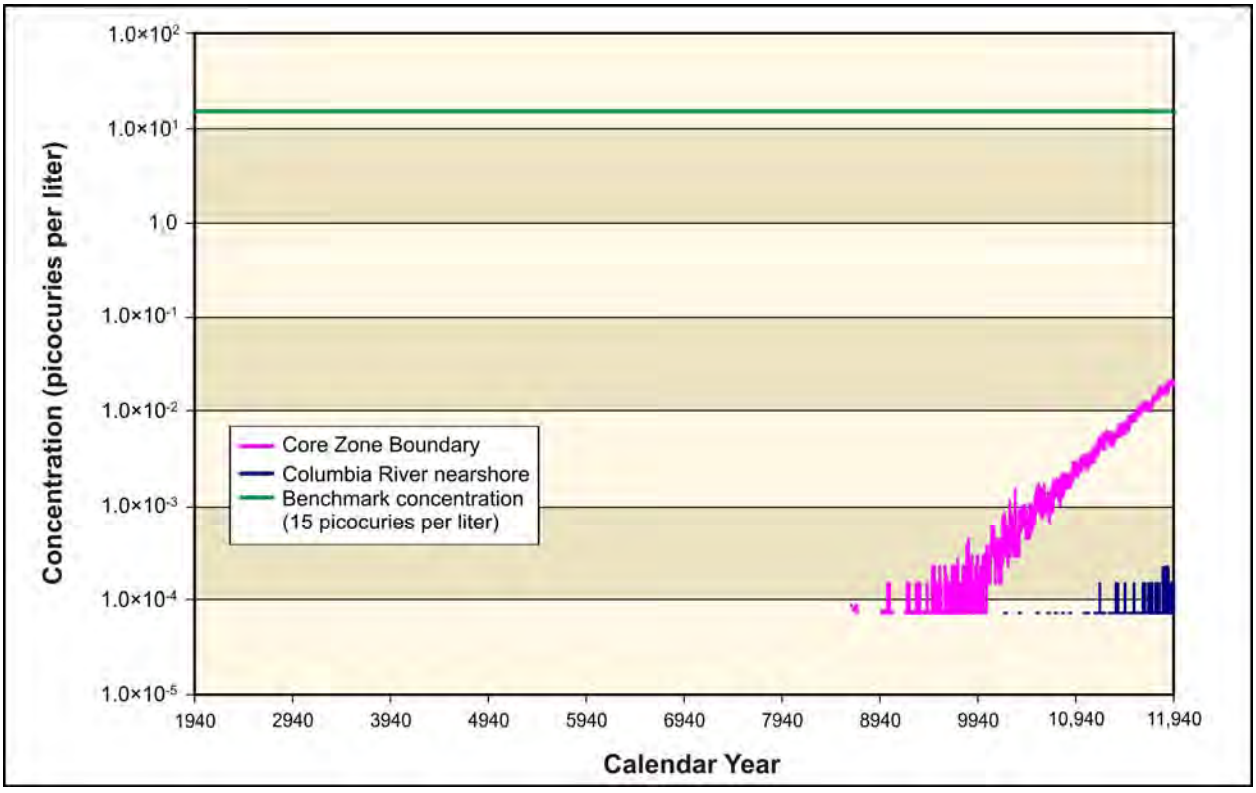


Figure 5–1012. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Uranium-238 Concentration Versus Time

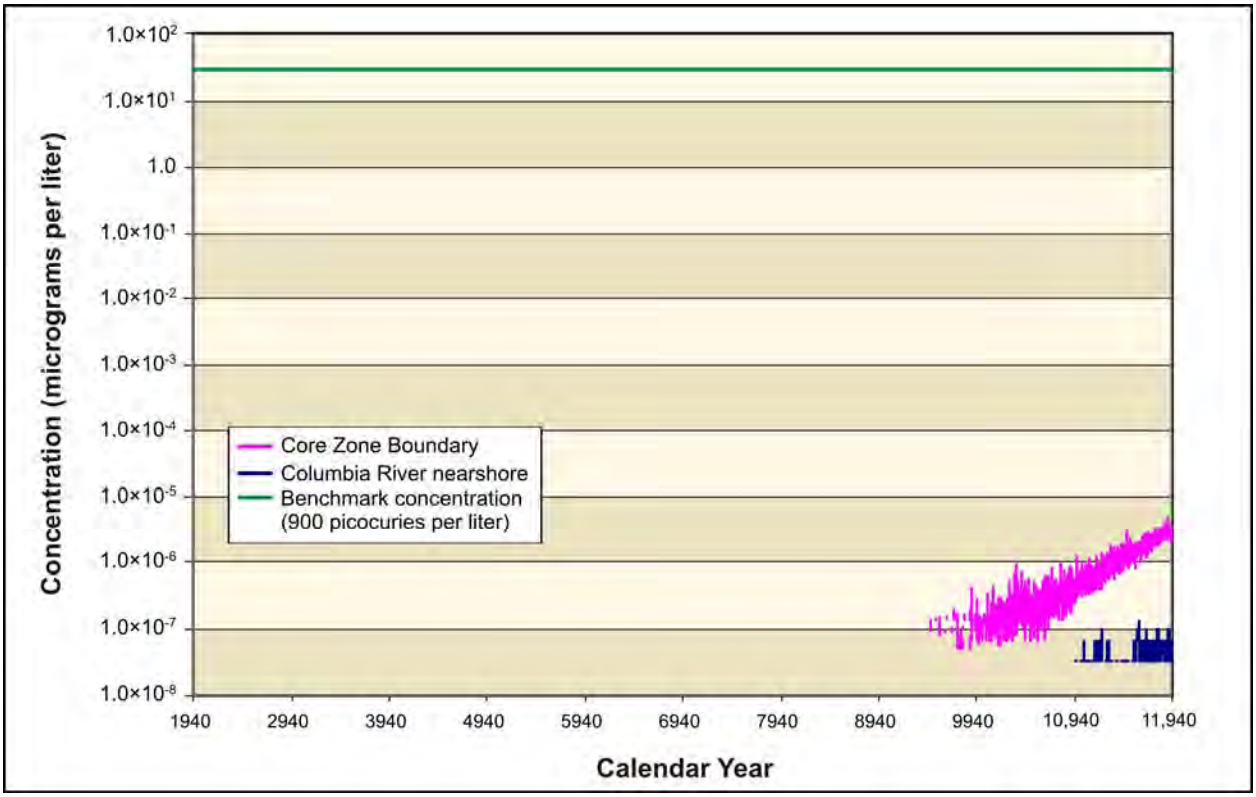


Figure 5–1013. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Total Uranium Concentration Versus

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1014 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890, when there is a concentrated plume, with concentrations many times greater than the benchmark, that stretches north from IDF-West and the RPPDF through Gable Gap. By CY 7140 (see Figure 5–1015), the plume from the RPPDF is reduced, but a new plume is beginning to form, traveling east from IDF-East. The peak concentrations in the second plume are greater than the benchmark. By CY 11,885, the plume continues to spread towards the river and the concentrations continue to increase (see Figure 5–1016). Technetium-99 (see Figures 5–1017 through 5–1019), chromium (see Figures 5–1020 through 5–1022), and nitrate (see Figures 5–1023 through 5–1025) show similar spatial distributions at selected times, but the concentrations remain lower, similar to the later plumes mentioned above. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).

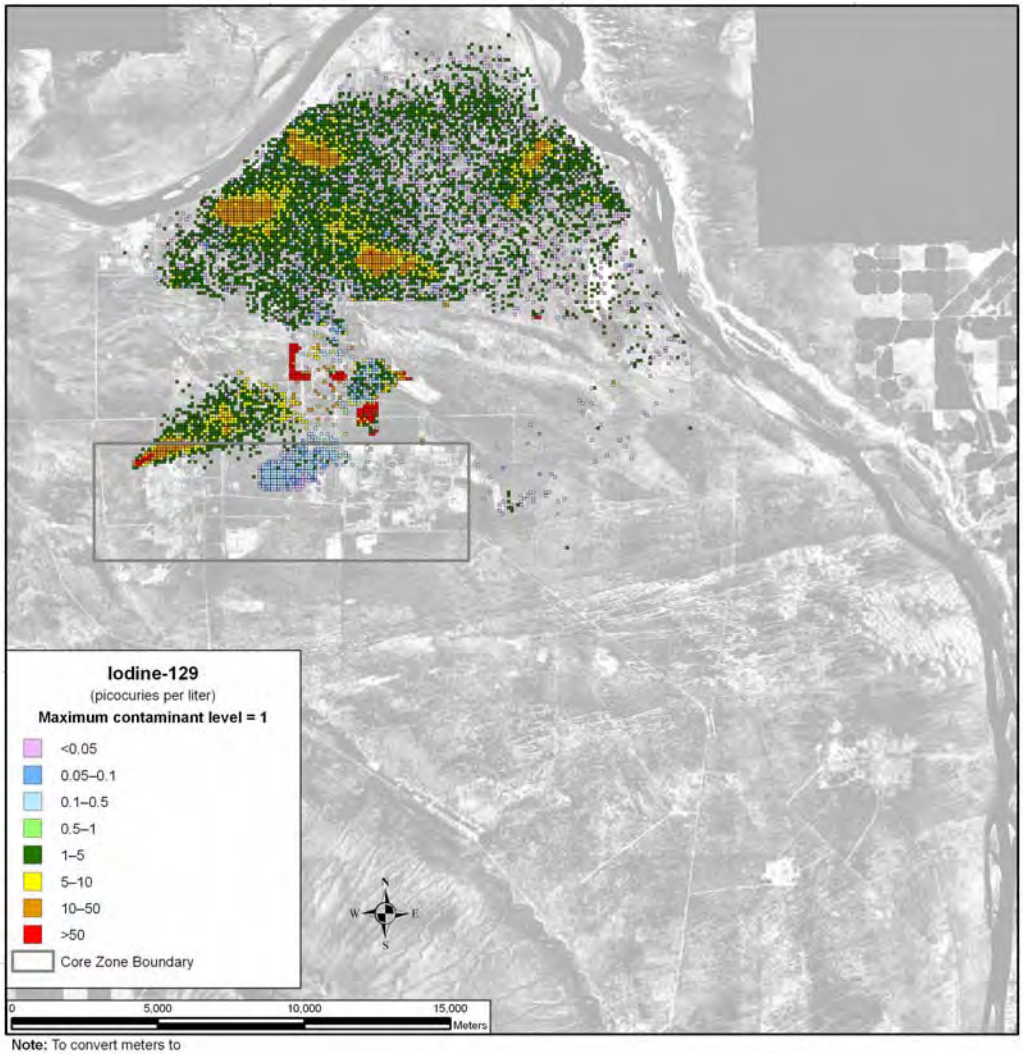


Figure 5–1014. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

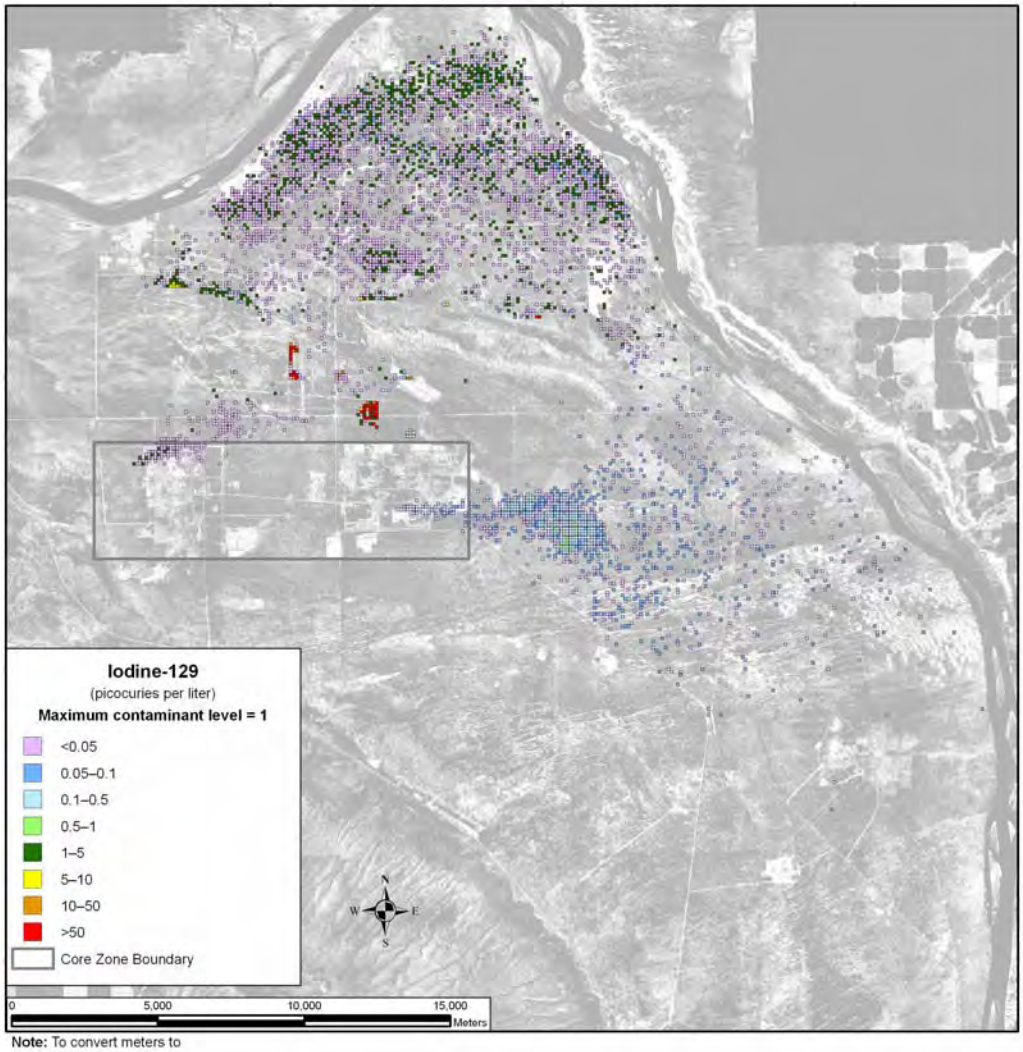
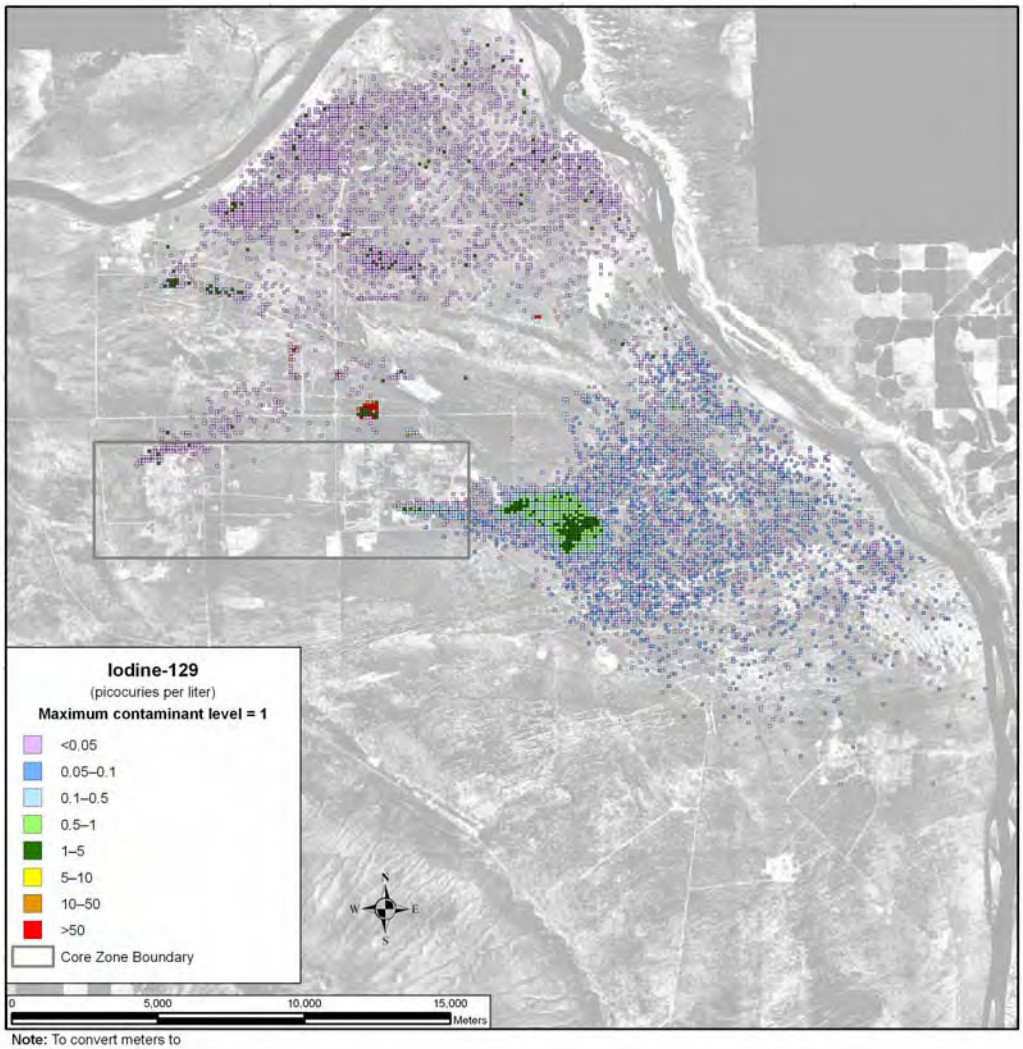
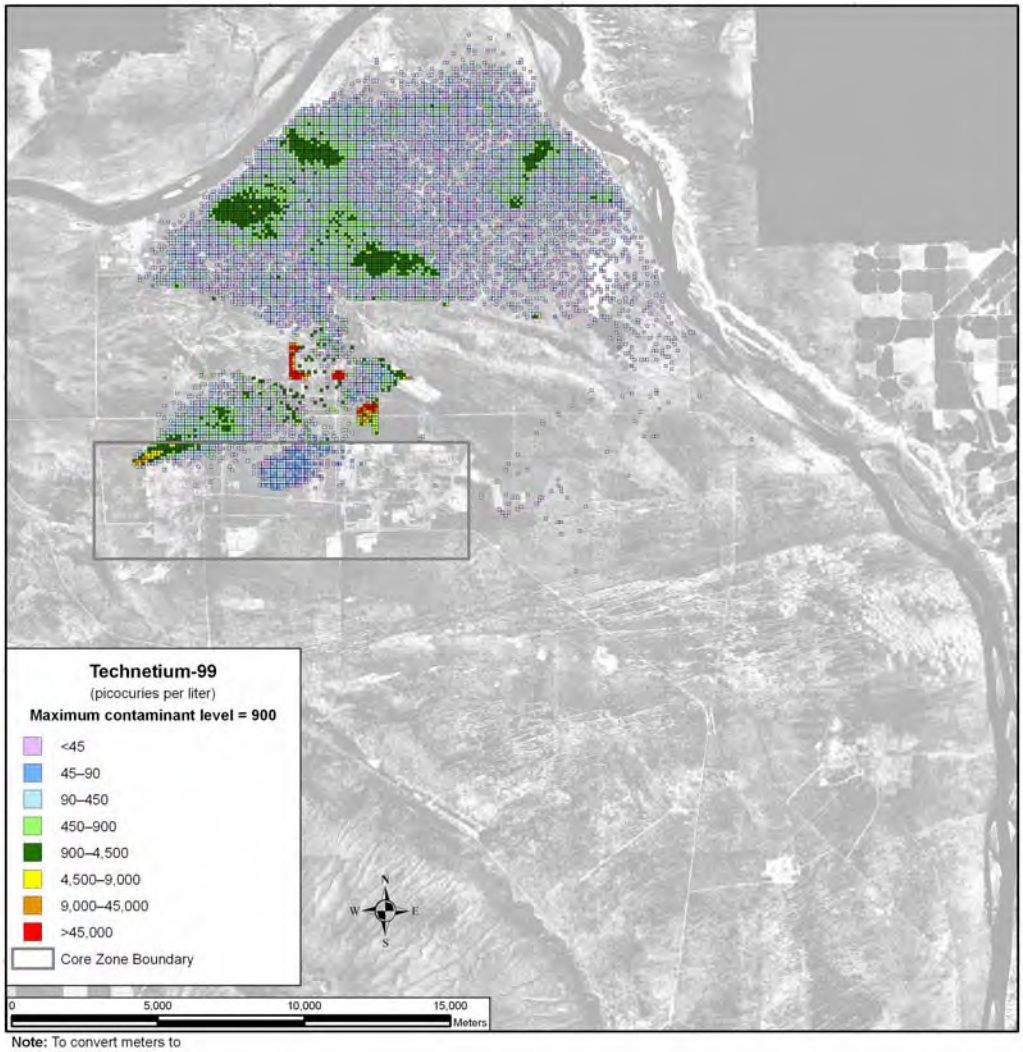


Figure 5–1015. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



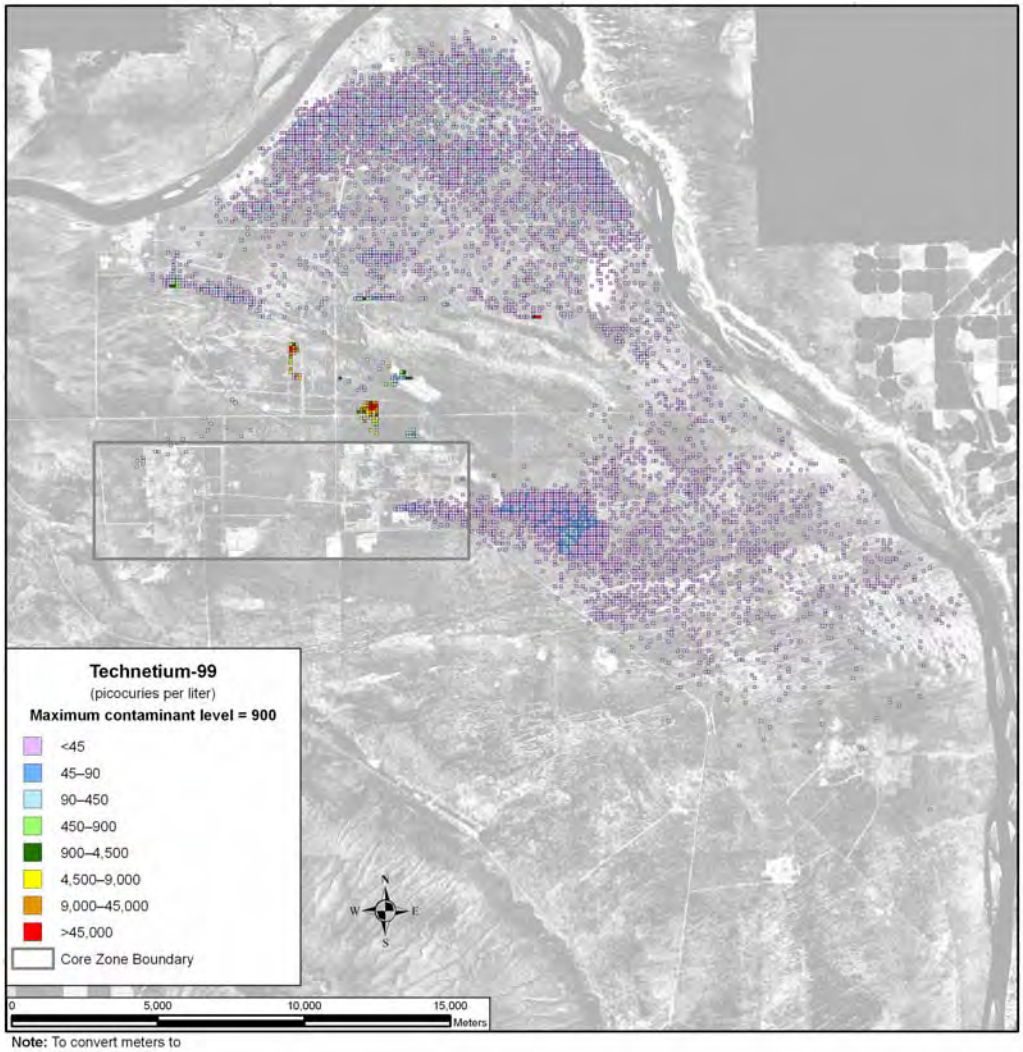
Note: To convert meters to feet, multiply by 3.281

Figure 5–1016. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–1017. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1018. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

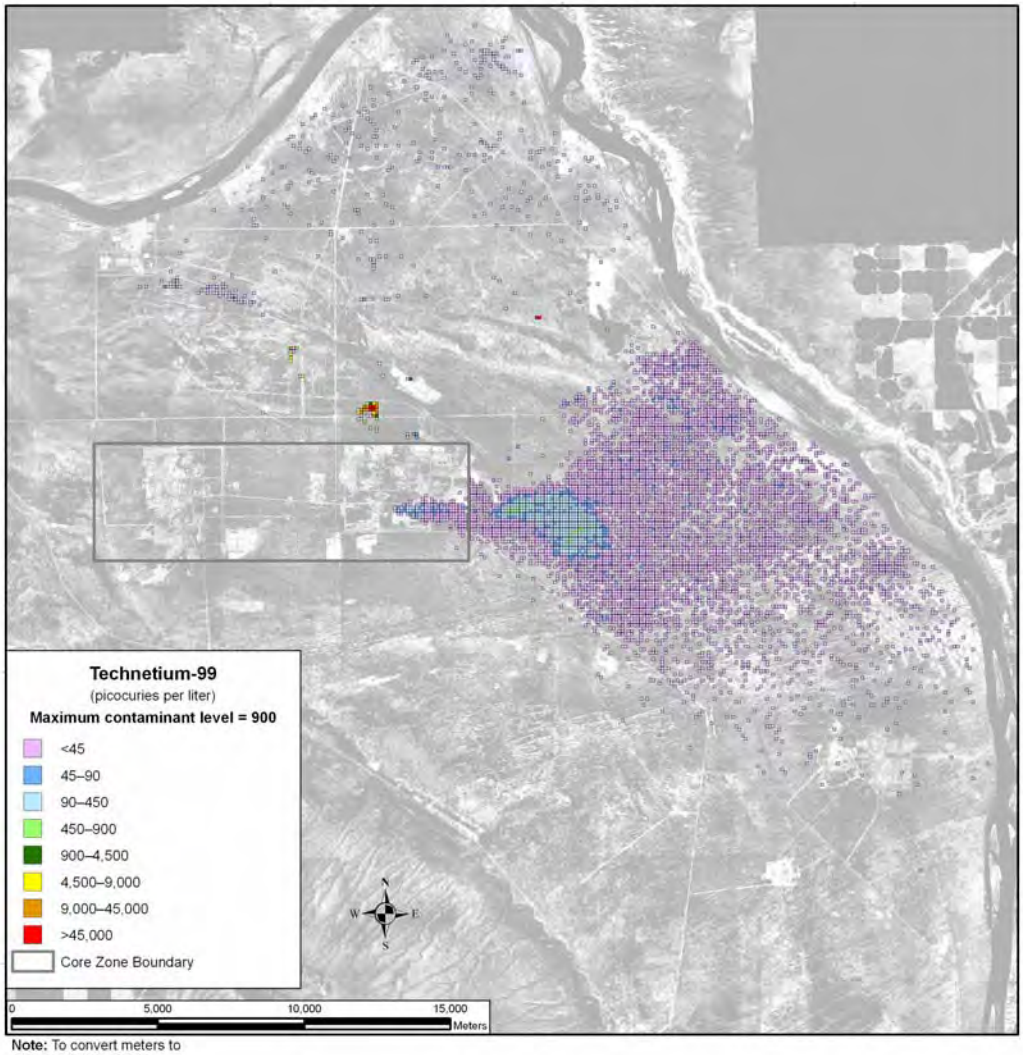


Figure 5–1019. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

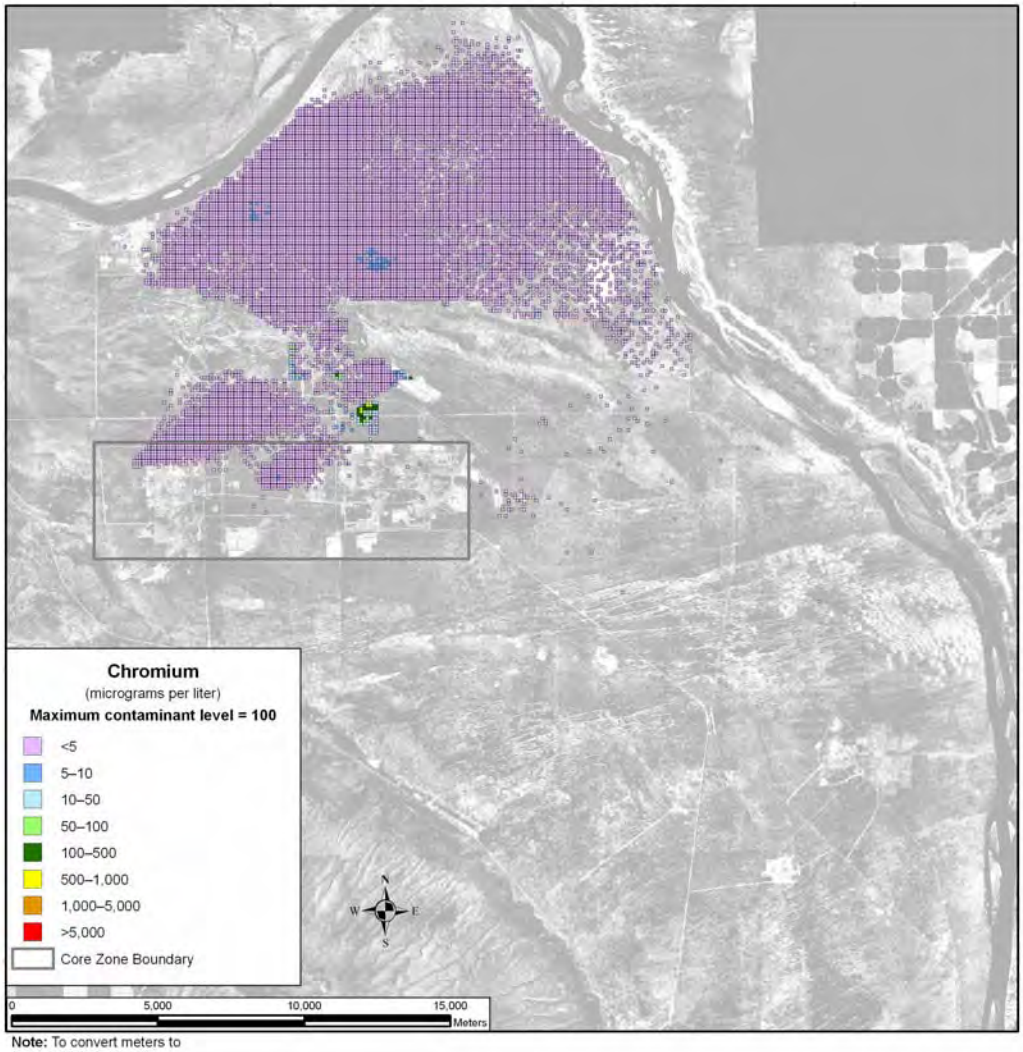


Figure 5–1020. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

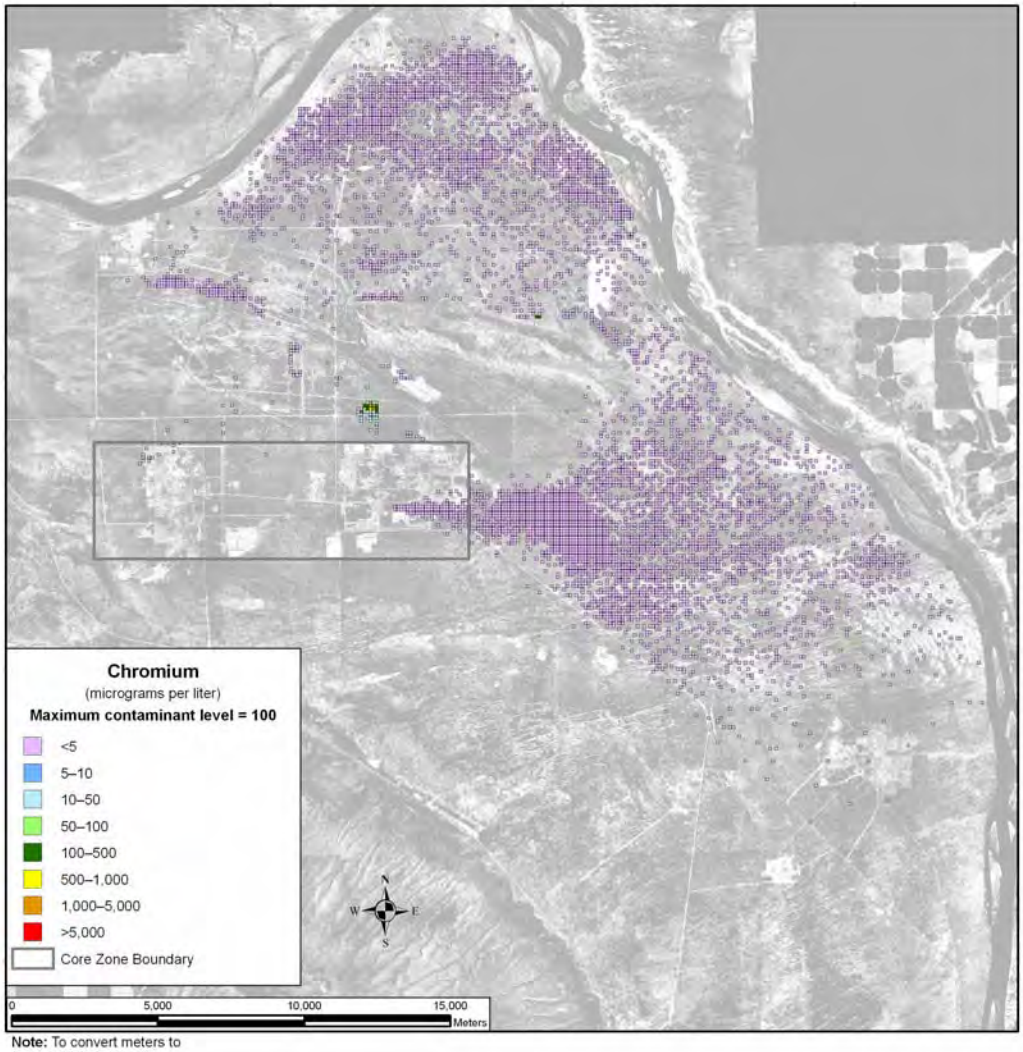


Figure 5–1021. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

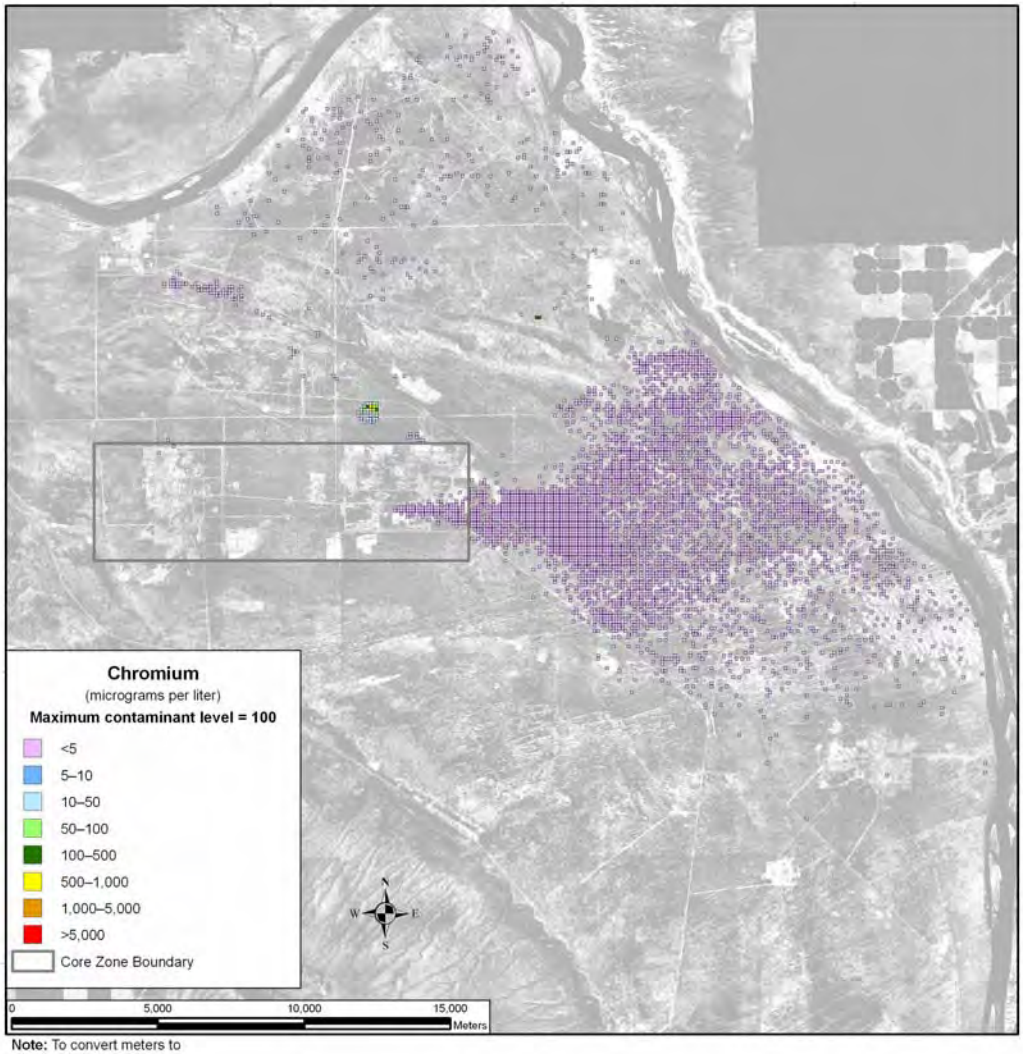


Figure 5–1022. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

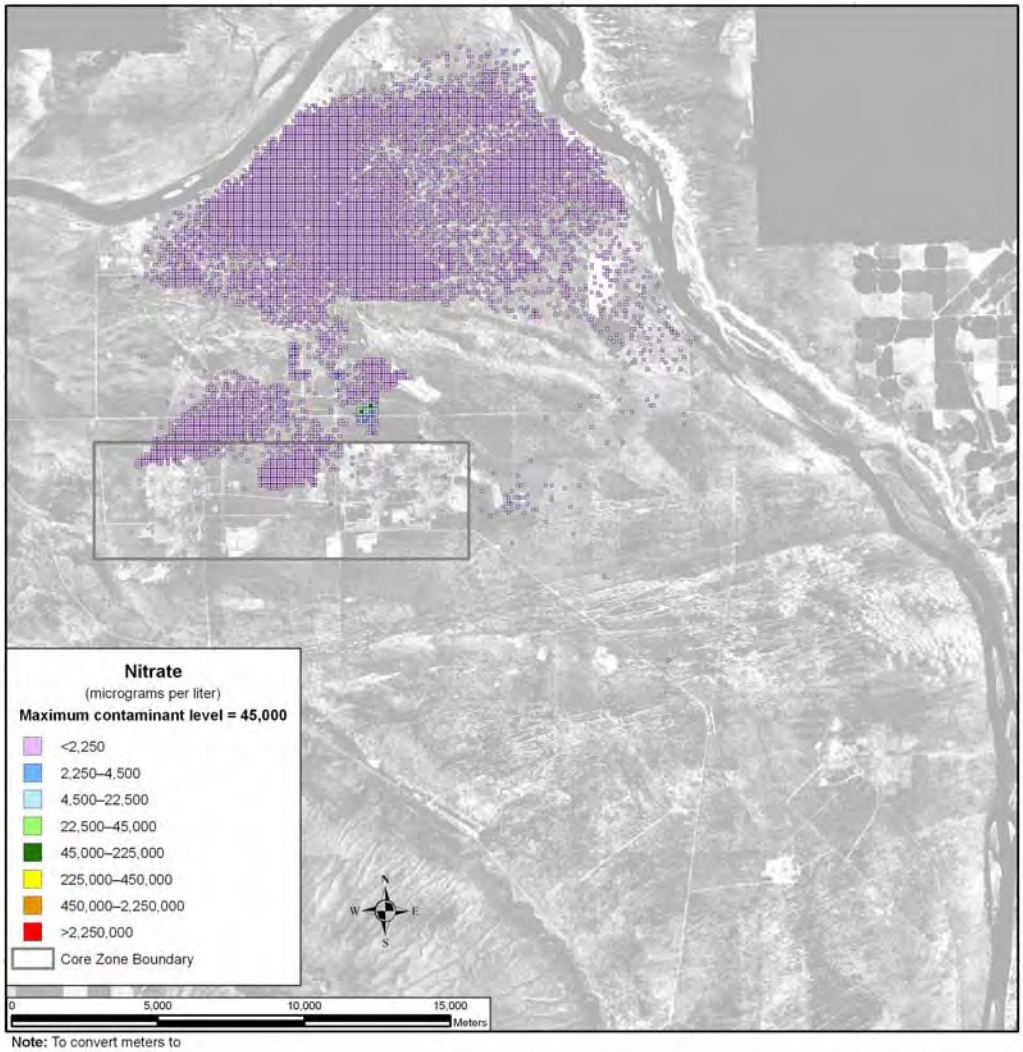


Figure 5–1023. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

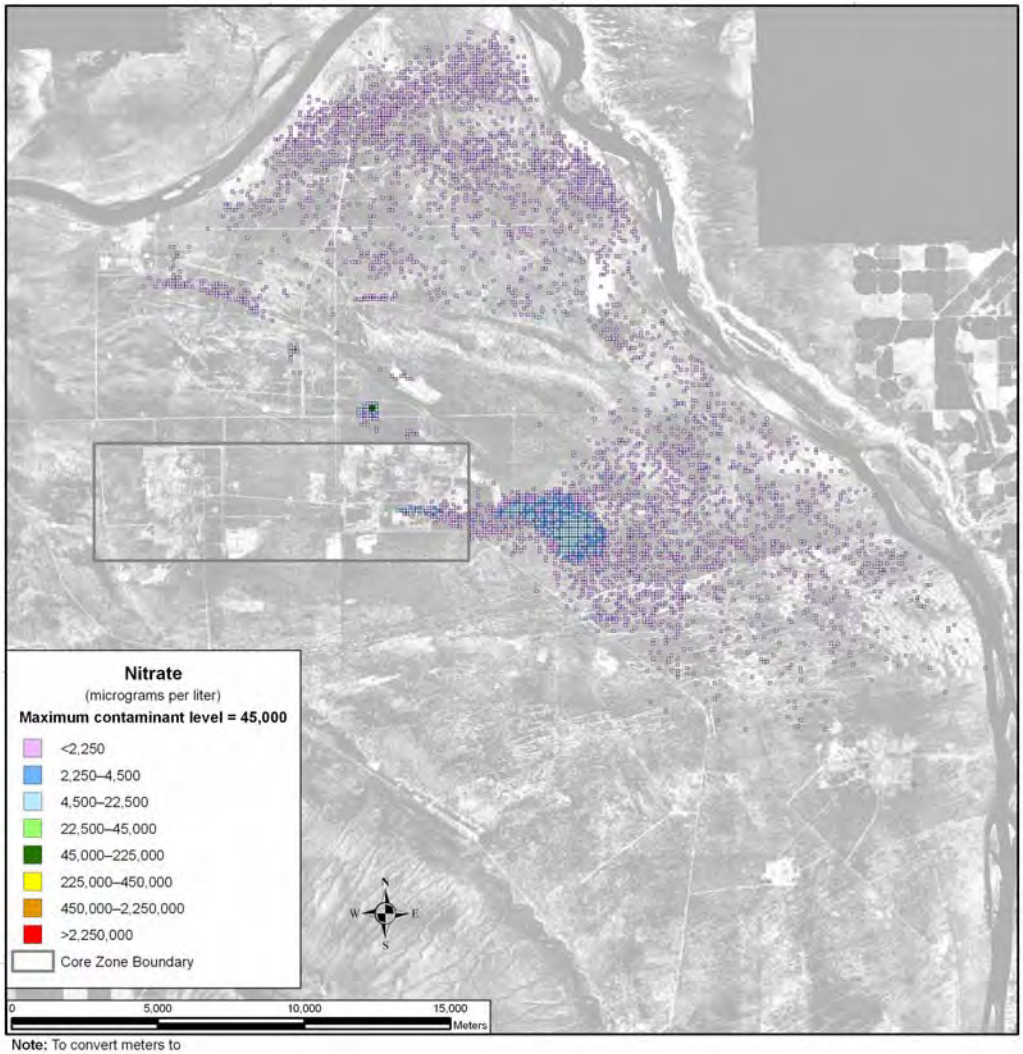


Figure 5–1024. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

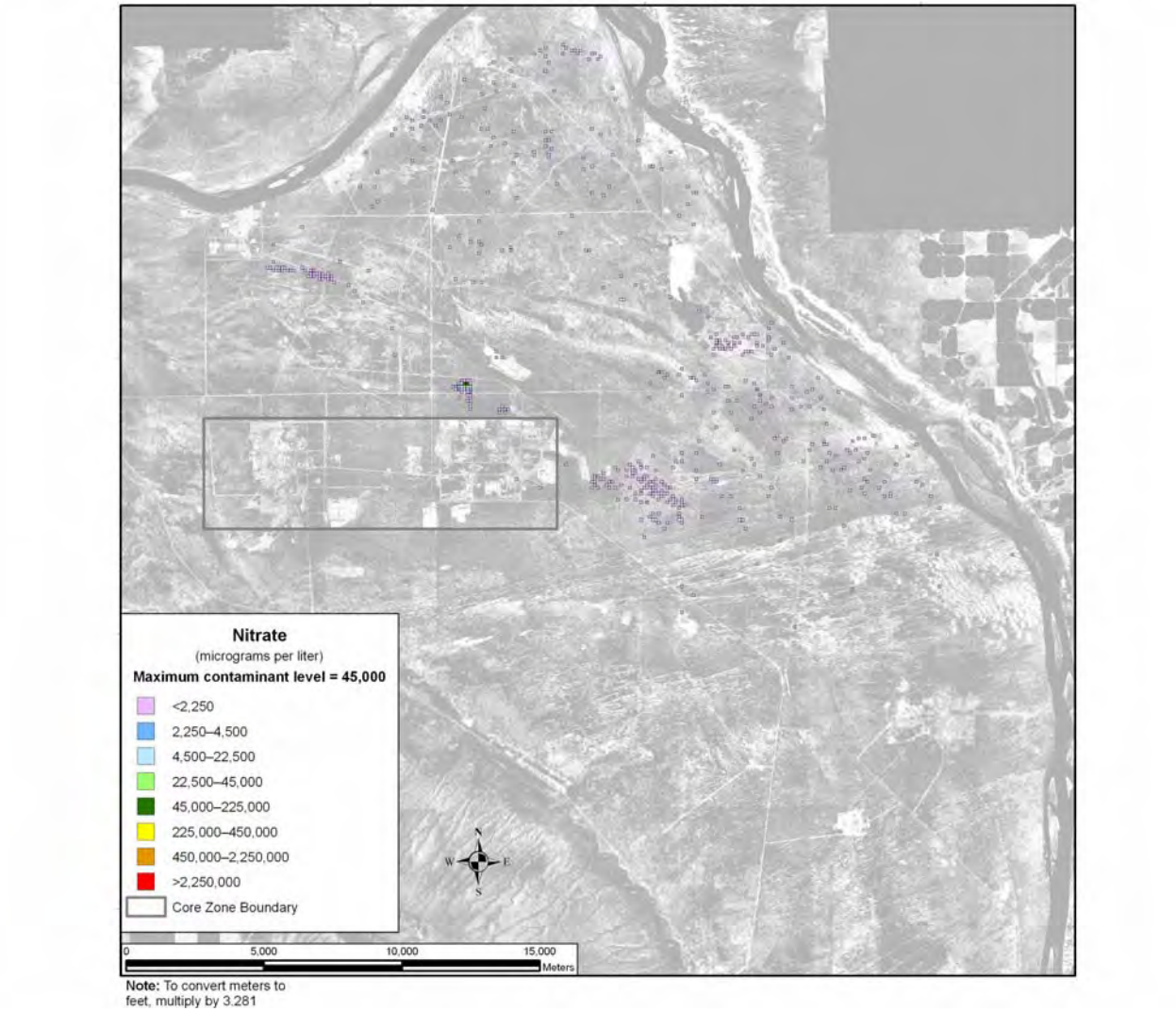


Figure 5–1025. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1026 shows the distribution of total uranium at CY 11,885. There is a low concentration plume that stretches north from IDF-West and the RPPDF through Gable Gap. Concentrations in all areas of the plume remain below one-tenth of the benchmark.

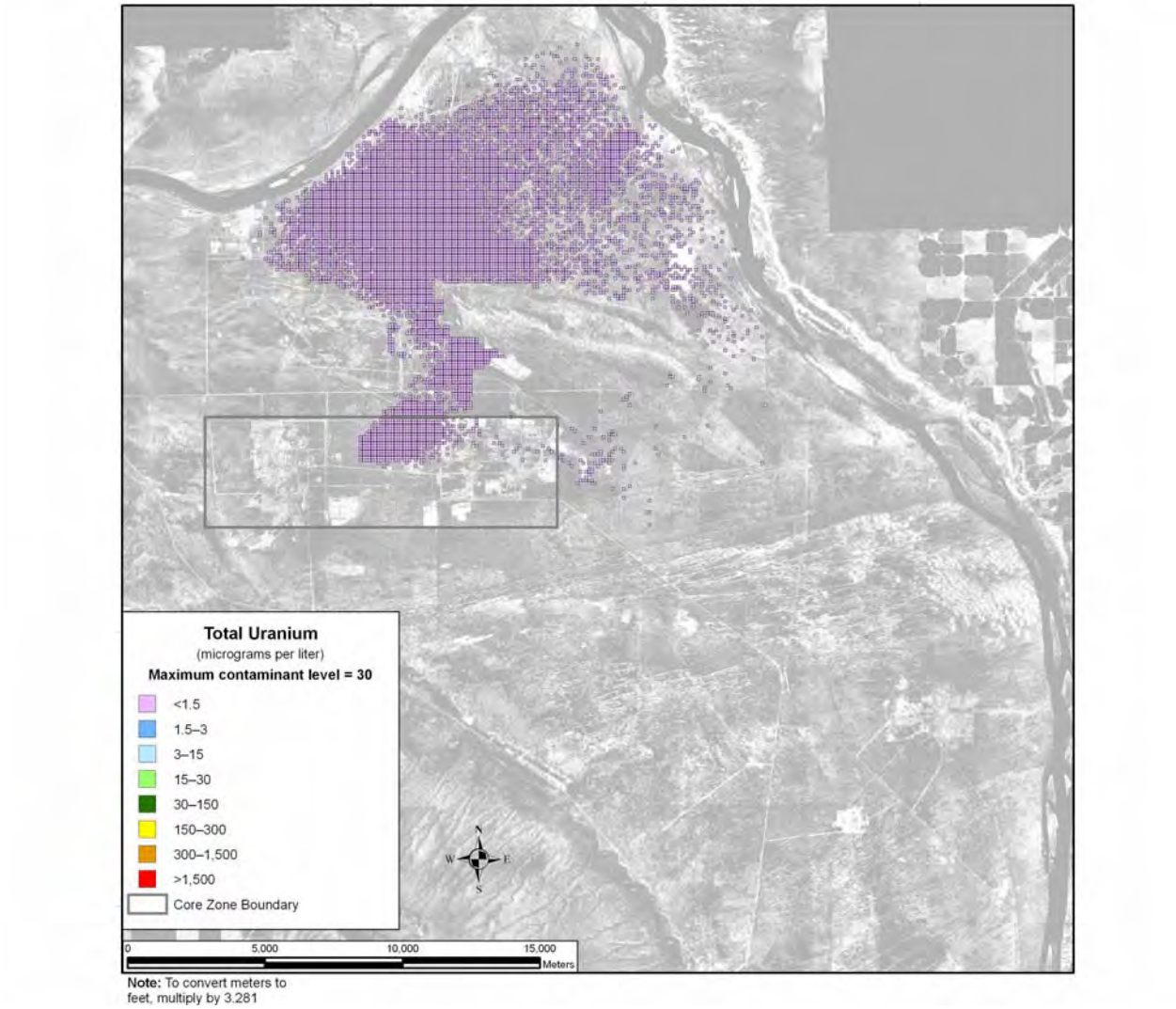


Figure 5–1026. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in general, the inventory remaining in IDF-East and IDF-West, available for release to the environment at the start of the post-disposal period, is the predominant contributor. The inventory available for release from the RRPDF during the post-disposal period is a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary exceed or approach the benchmark standards during most of the period of analysis. Concentrations at the Columbia River nearshore are about two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3500 and CY 5500.

For total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River by CY 10,000. The peak intensity and area of the contamination plume are largest near the end of the period of analysis.

5.3.1.3.2.3 Disposal Group 2, Subgroup 2-B, Option Case

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, is designed to show the impacts of waste disposal at IDF-East and the RPPDF.

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, covers the disposal of wastes generated during Tank Closure Alternatives 6B, Option Case; FFTF Decommissioning Alternatives 2 or 3; and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009 and continues through CY 2050 for IDF-West and CY 2100 for IDF-East and the RPPDF, when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, IDF-East and IDF-West are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case (i.e., Tank Closure Alternative 6B, Option Case; FFTF Decommissioning Alternatives 2 and 3; and onsite- and offsite-generated waste), is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, acetonitrile, chromium, and nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Subtotals are plotted as releases from three disposal facilities: IDF-West (FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste); IDF-East (PPF glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste); and the RRPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over more than 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–1027 shows the release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–1028, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129), the releases range over five orders of magnitude, depending on the sources of the radionuclides. ETF-generated secondary waste and tank closure secondary waste account for most of the releases. The release of nitrate in IDF-East is all associated with ETF-generated secondary waste. Chromium comes from ETF-generated secondary waste, tank closure secondary waste, PPF glass, and retired melters.

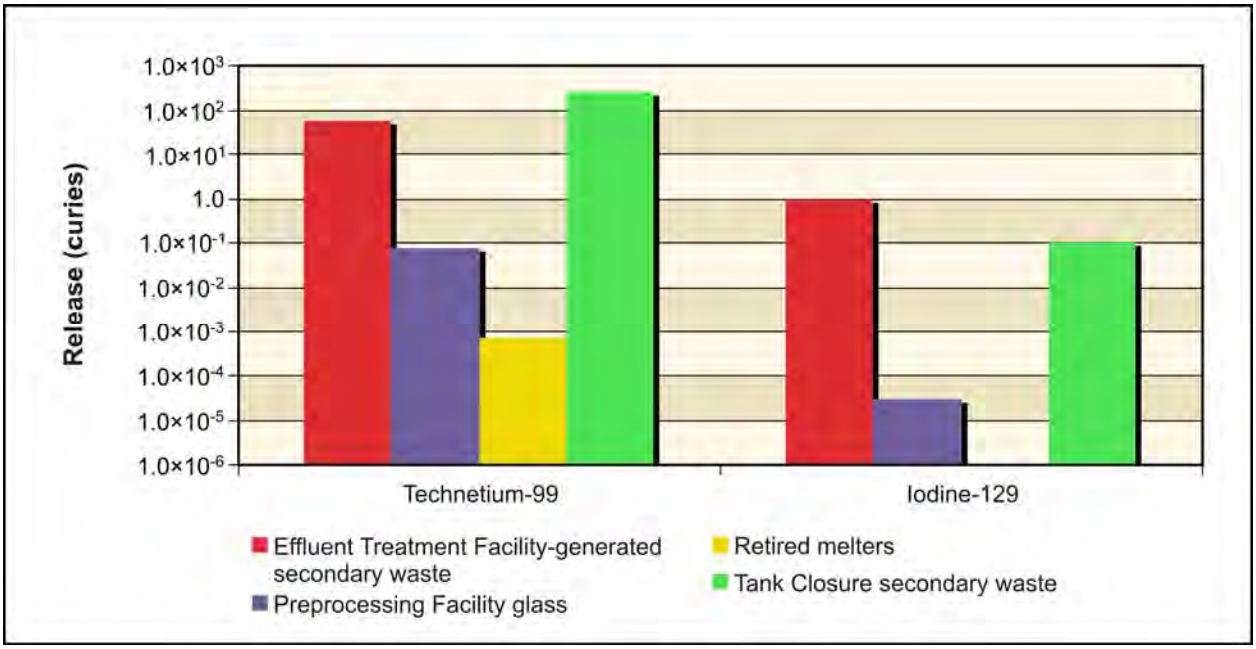


Figure 5–1027. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

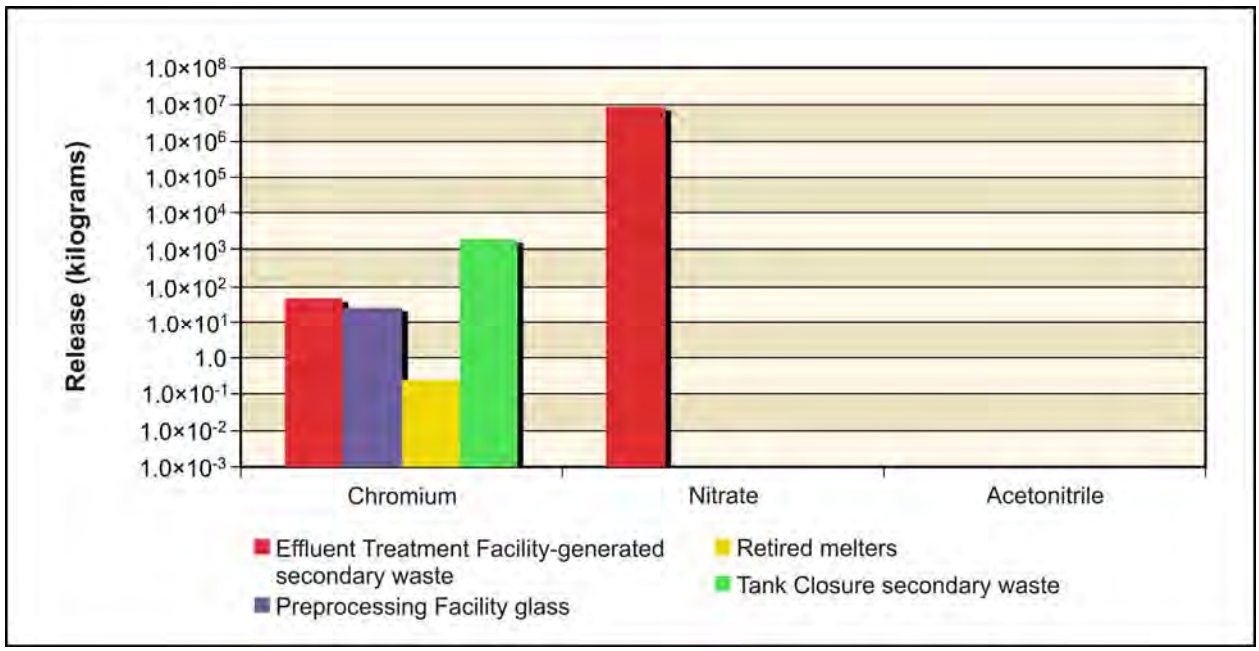


Figure 5–1028. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–1029 shows the release at IDF-East to groundwater for the radiological risk drivers and Figure 5–1030, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

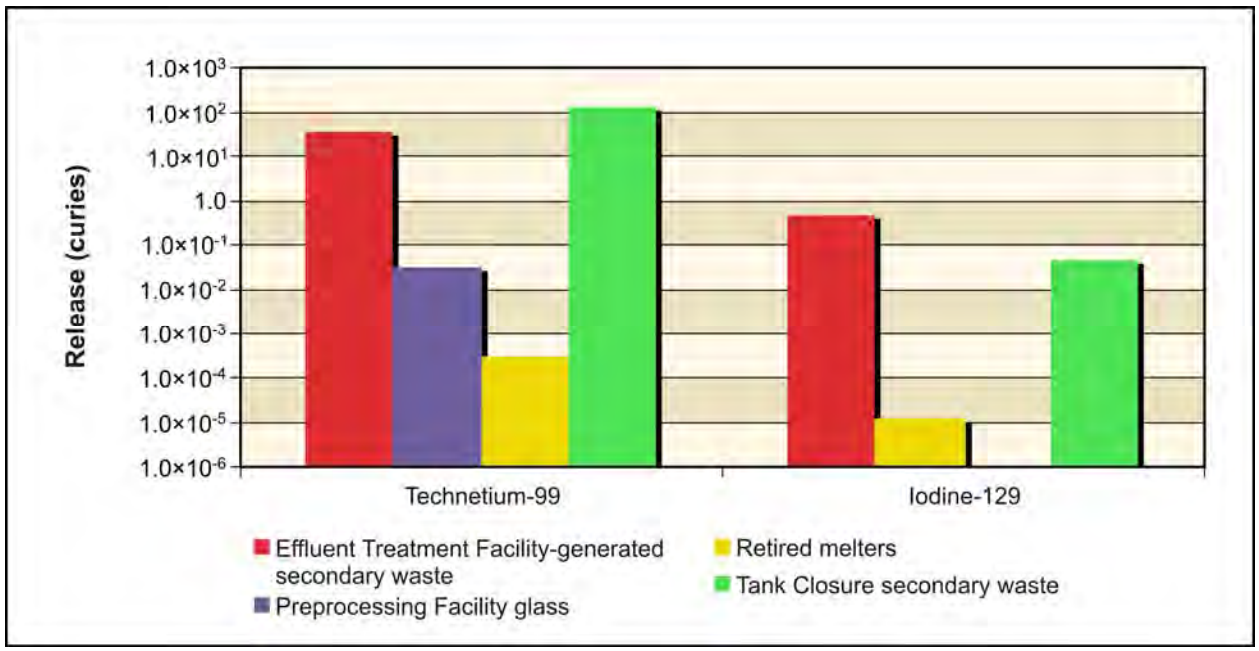


Figure 5–1029. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

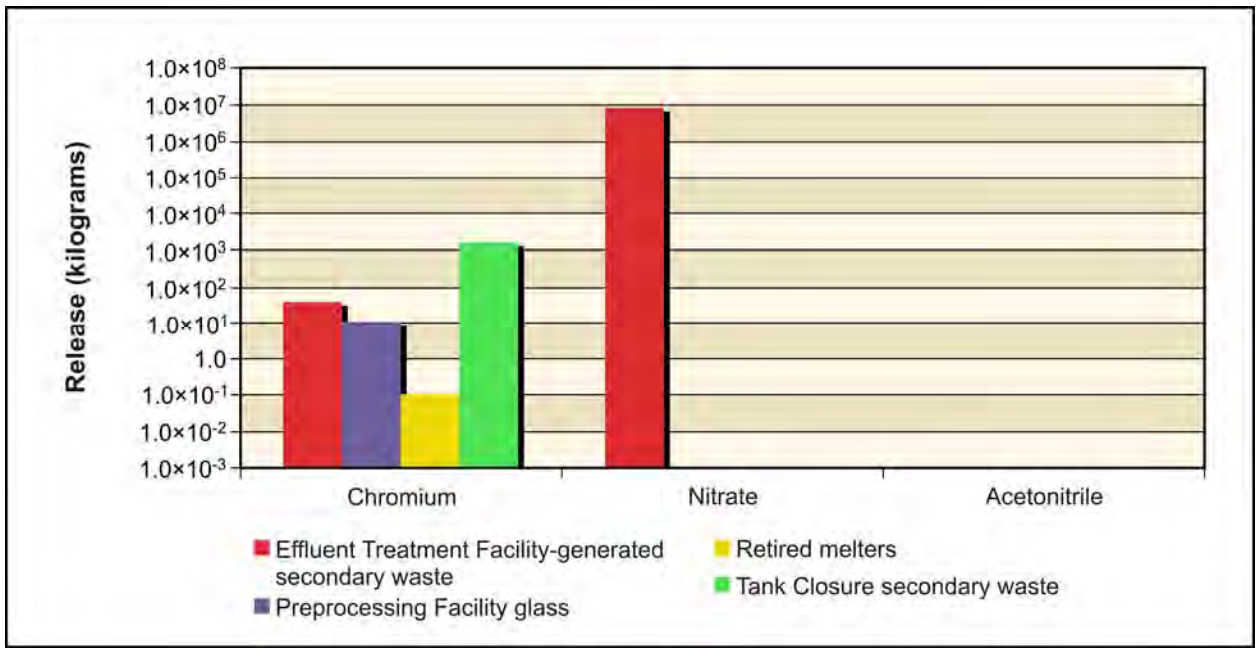


Figure 5–1030. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–1031 shows the release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–1032, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

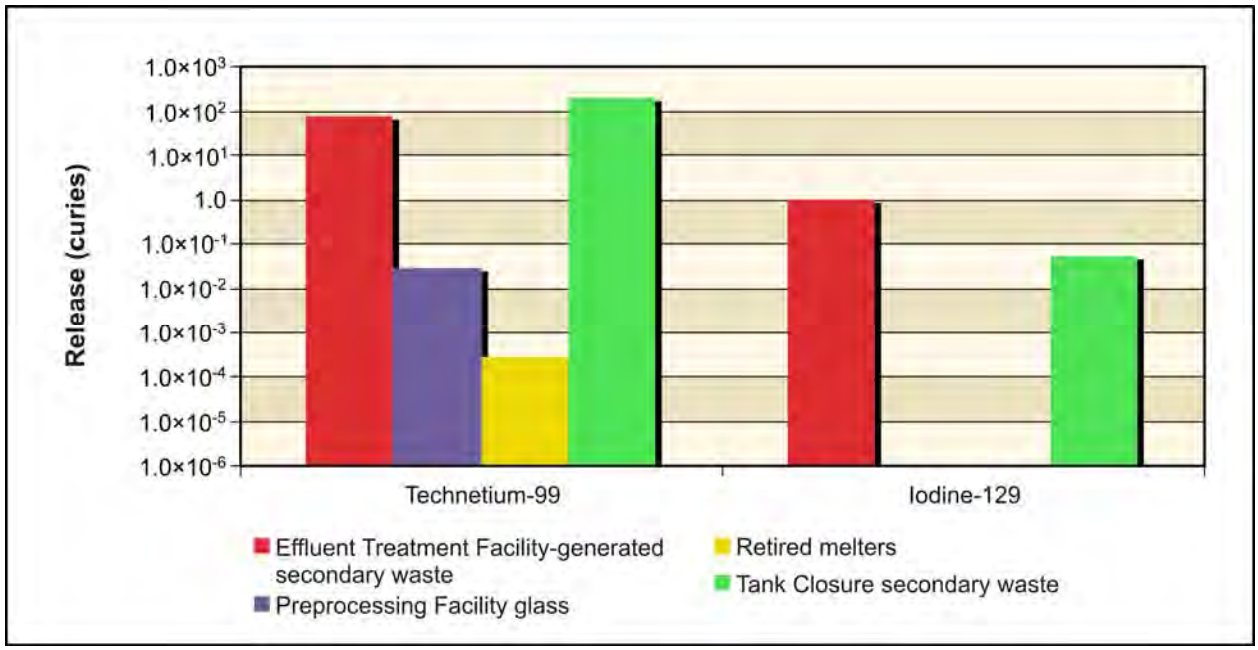


Figure 5–1031. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

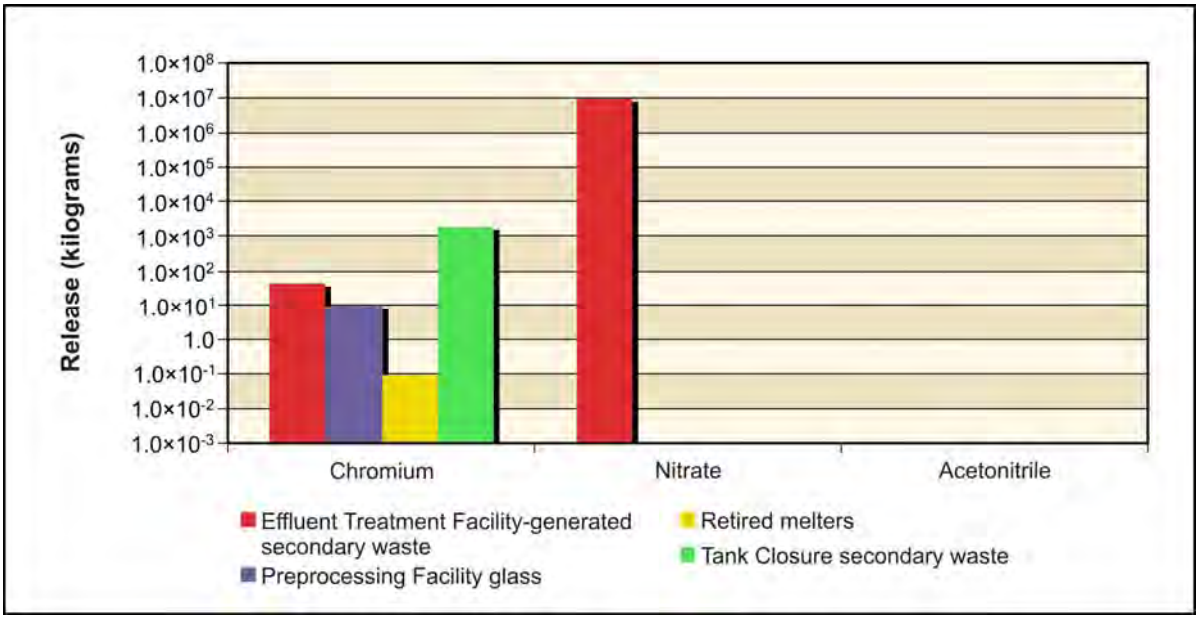


Figure 5–1032. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Figure 5–1033 shows the release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–1034, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129) in IDF-West, the releases range over five orders of magnitude depending on the source. Over 99 percent of the radiological waste is from offsite-generated waste. The chemical COPCs (chromium, and nitrate) in IDF-West, essentially all of it nitrate, have releases associated with waste management secondary waste and onsite-generated waste. Of the chromium sources, less than 1 percent is from FFTF Decommissioning Alternative 3 waste, 66 percent is from waste management secondary and onsite-generated waste, and 34 percent is from offsite-generated waste.

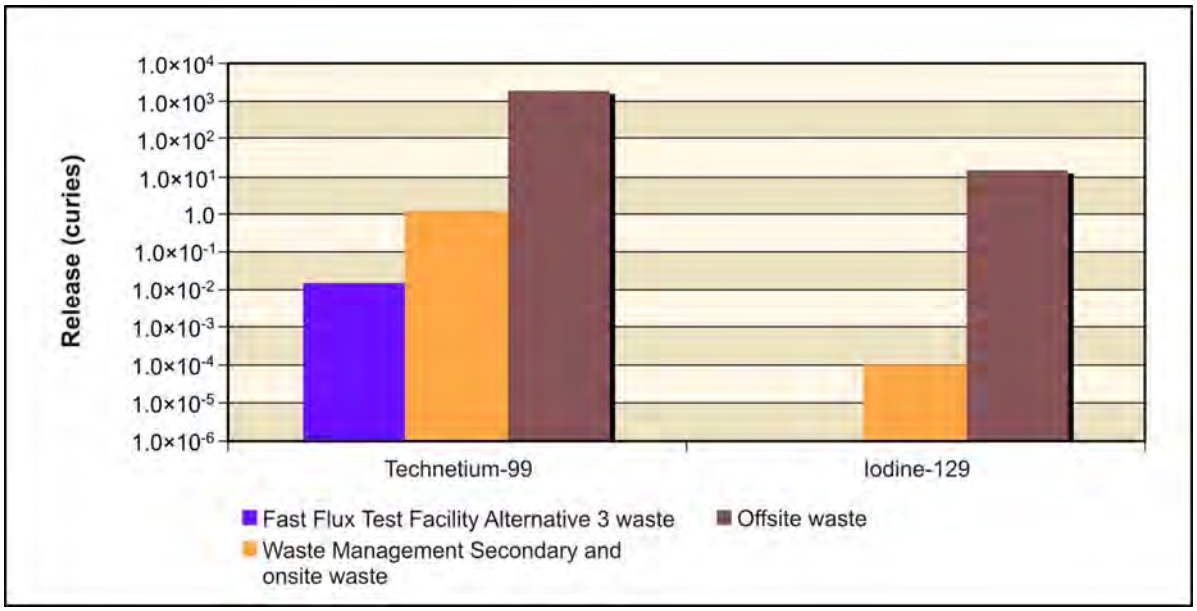


Figure 5–1033. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

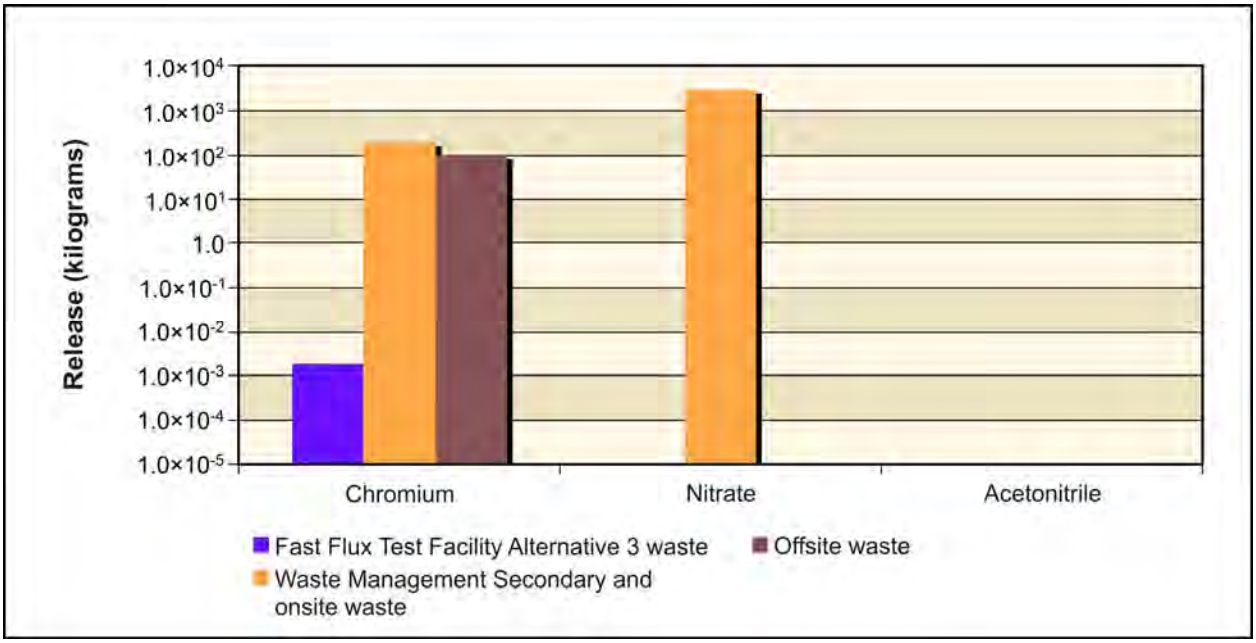


Figure 5–1034. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–1035 shows the release at IDF-West to groundwater for the radiological risk drivers and Figure 5–1036, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

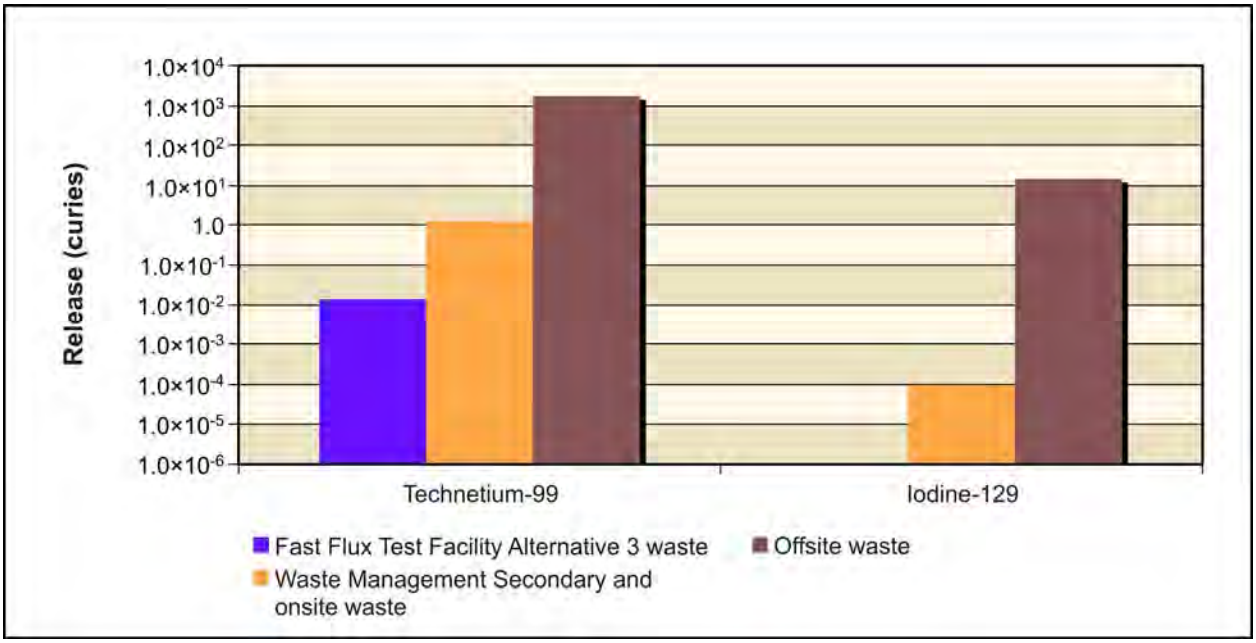


Figure 5–1035. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

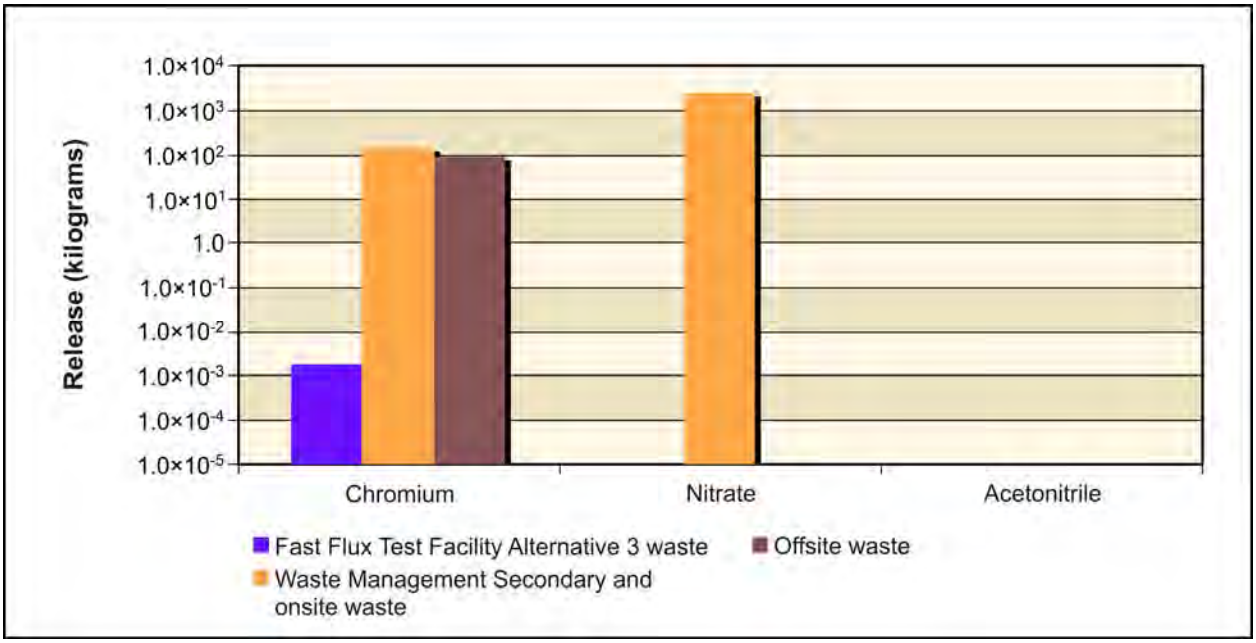


Figure 5–1036. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1037 shows the release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–1038, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is approximately 5 percent less than that released to the vadose zone.

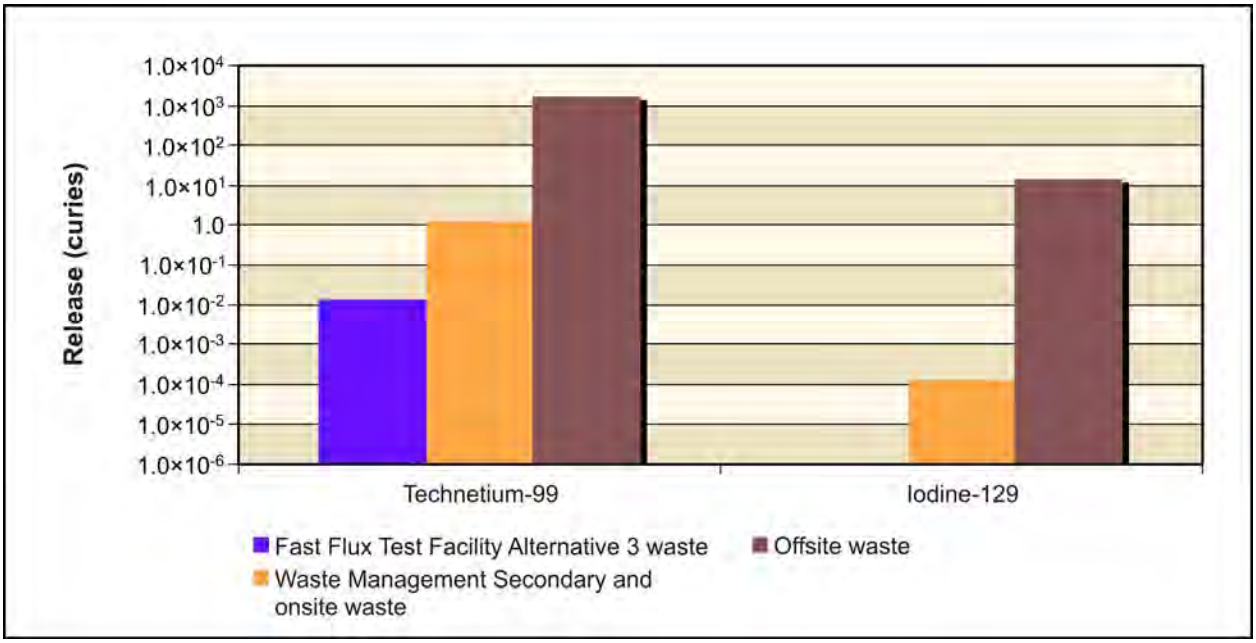


Figure 5–1037. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

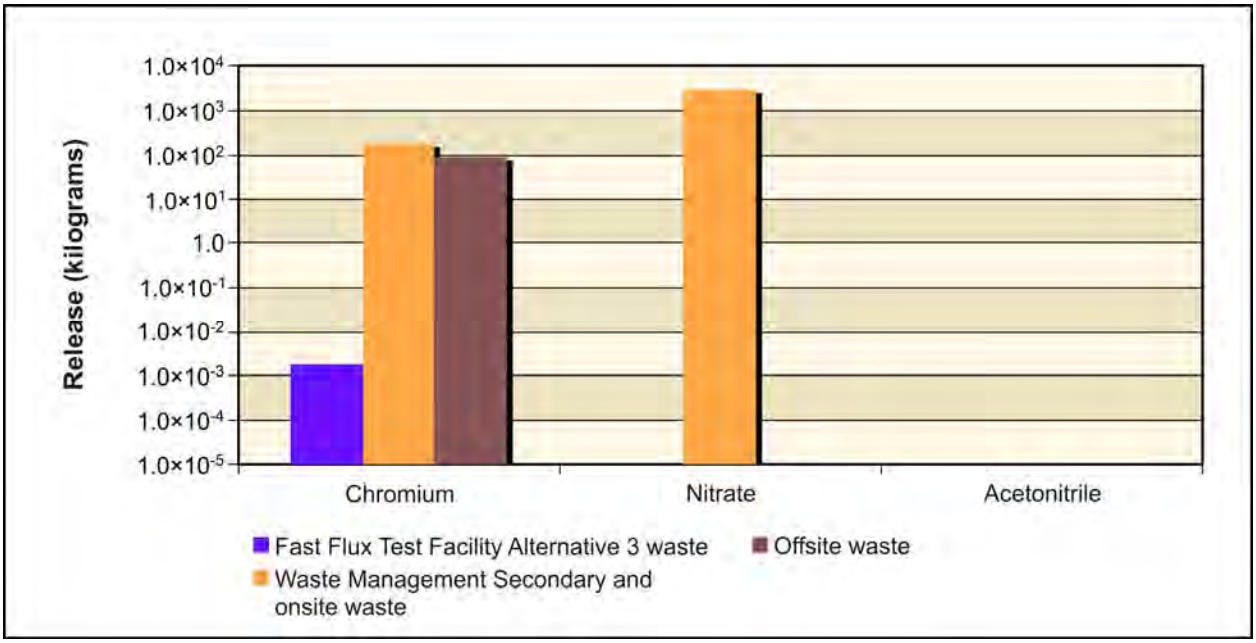


Figure 5–1038. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1039 shows the release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–1040, the chemical hazard drivers. The release of technetium-99 is more than two orders of magnitude greater than the release of iodine-129 at the RRPDF. The chemical constituents show nitrate as the predominant COPC; its release is more than two orders of magnitude greater than that of chromium and about seven orders of magnitude greater than that of acetonitrile.

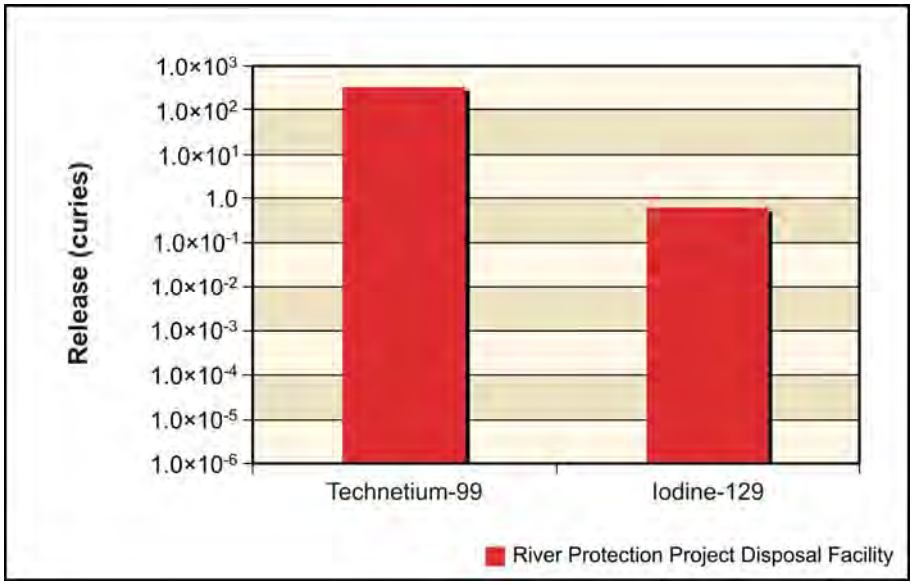


Figure 5–1039. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

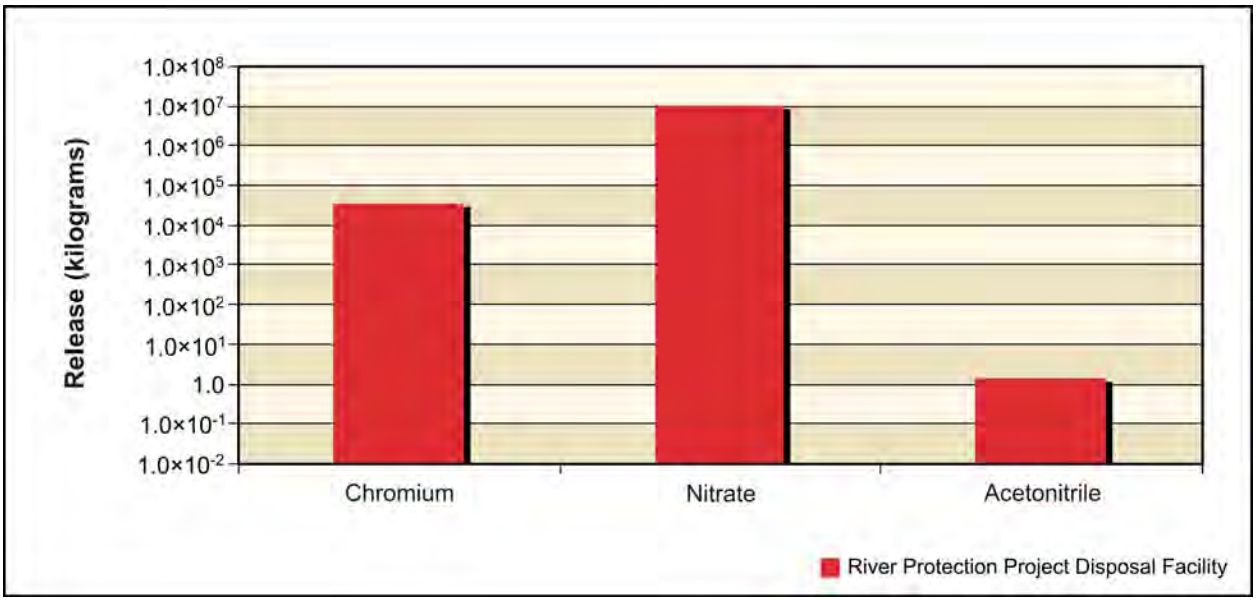


Figure 5–1040. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1041 shows the release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–1042, the chemical hazard drivers. For the conservative tracers (iodine-129, technetium-99, acetonitrile, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

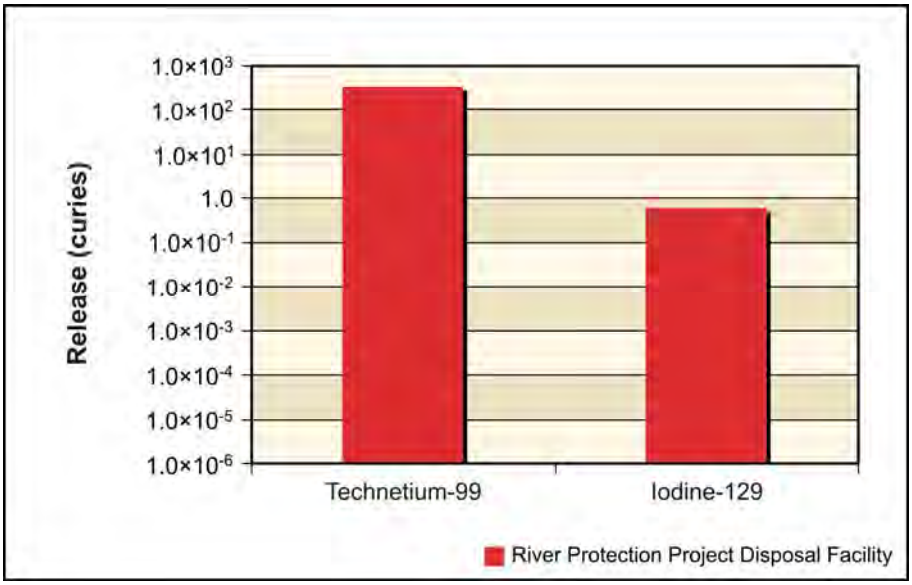


Figure 5–1041. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

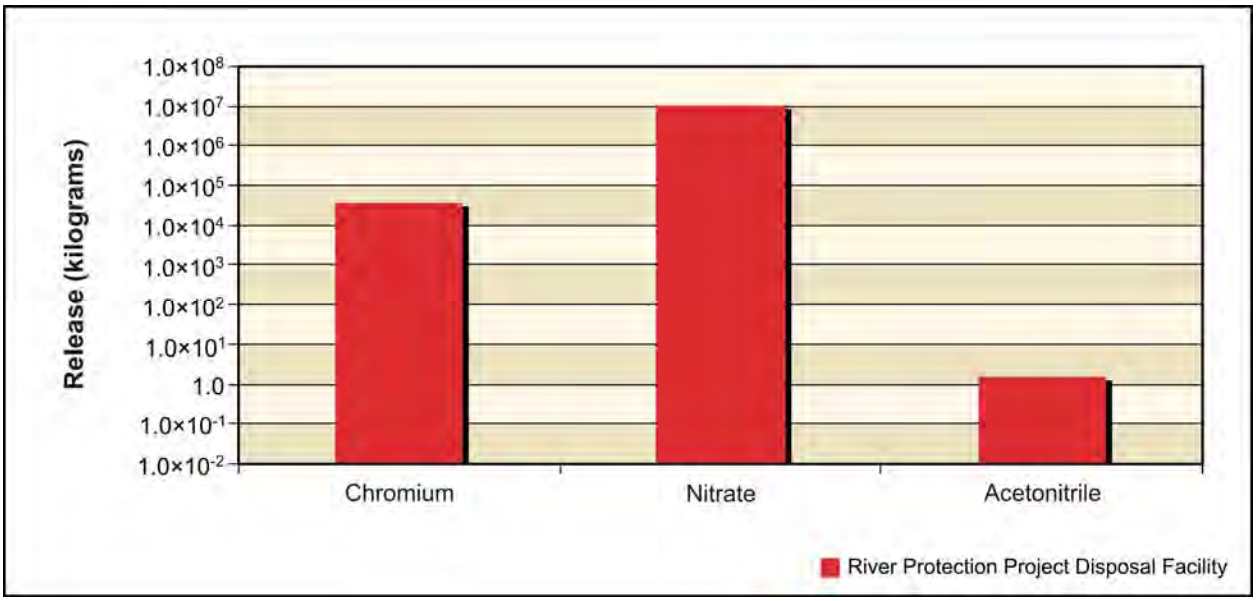


Figure 5–1042. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1043 shows the release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–1044, the chemical hazard drivers. Both figures show trends similar to those described in the above paragraph regarding the release to the Columbia River of all COPC drivers at the RRPDF.

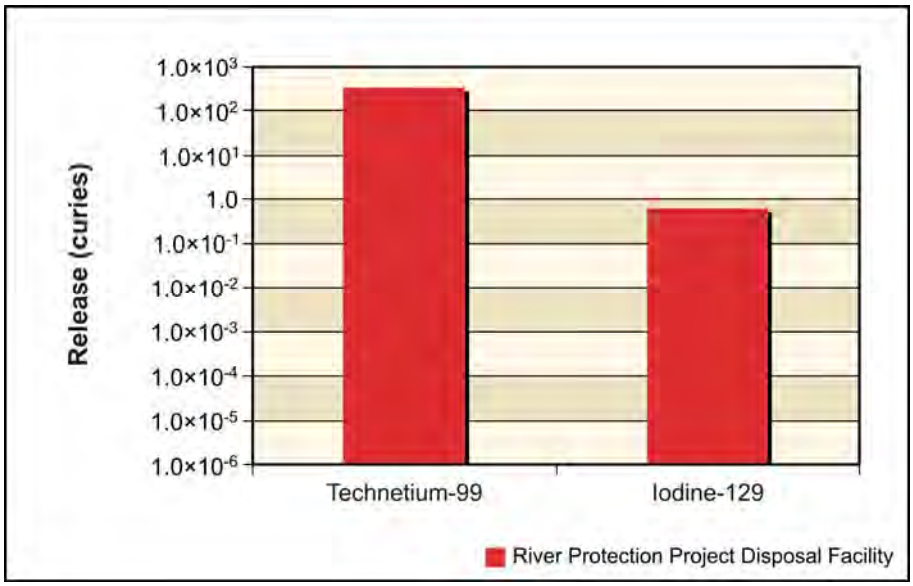


Figure 5–1043. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

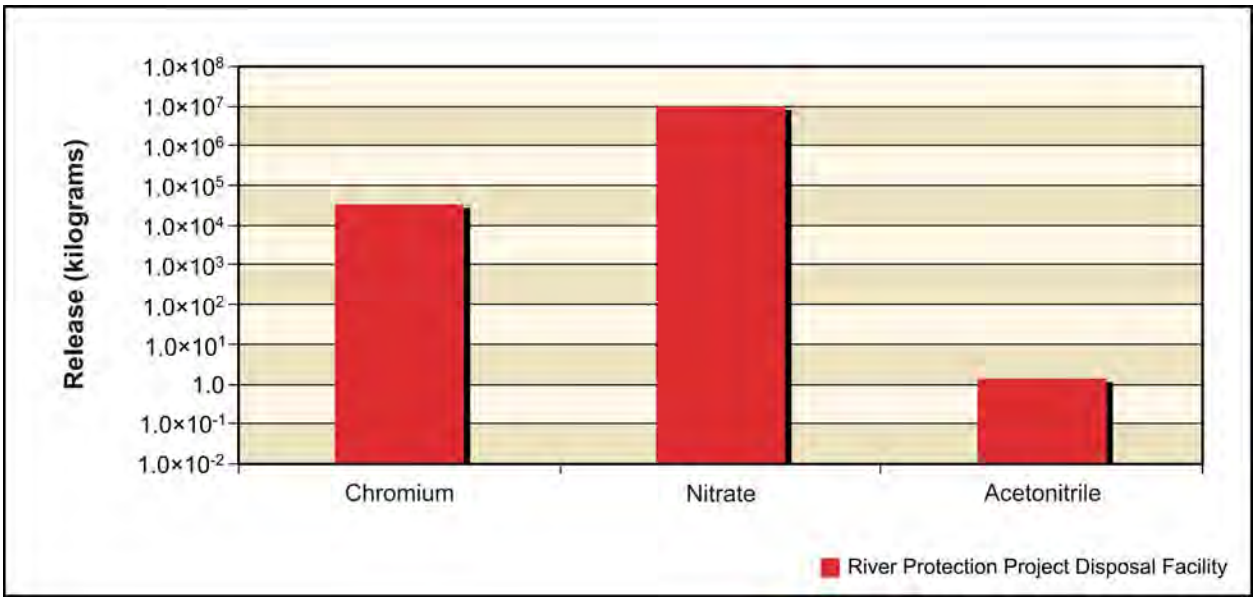


Figure 5–1044. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. Confidence intervals are calculated to show the length of time (in this case, 95 percent of the time) a concentration is likely to be at or below this value. The confidence interval is basically a statistical aid to interpreting data presenting a significant amount of random fluctuation (noise). In this analysis, the confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentration was near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude.

Figures 5–1045 through 5–1048 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from IDF-East, IDF-West, and the RPPDF at the Core Zone Boundary cause groundwater concentrations to exceed the benchmark for iodine-129 at CY 3500. Calculations using the confidence interval show that the concentrations exceed the benchmark at both the Core Zone Boundary and the Columbia River nearshore after CY 5500. The trend for technetium-99 concentrations is similar to that for iodine-129 concentrations but below the benchmark during the period of analysis. Chromium and nitrate measurements at the Core Zone Boundary and the Columbia River nearshore are below the benchmark concentrations by one to three orders of magnitude, and the concentration trends are similar to those for iodine-129 and technetium-99. Table 5–98 shows the maximum concentrations in groundwater.

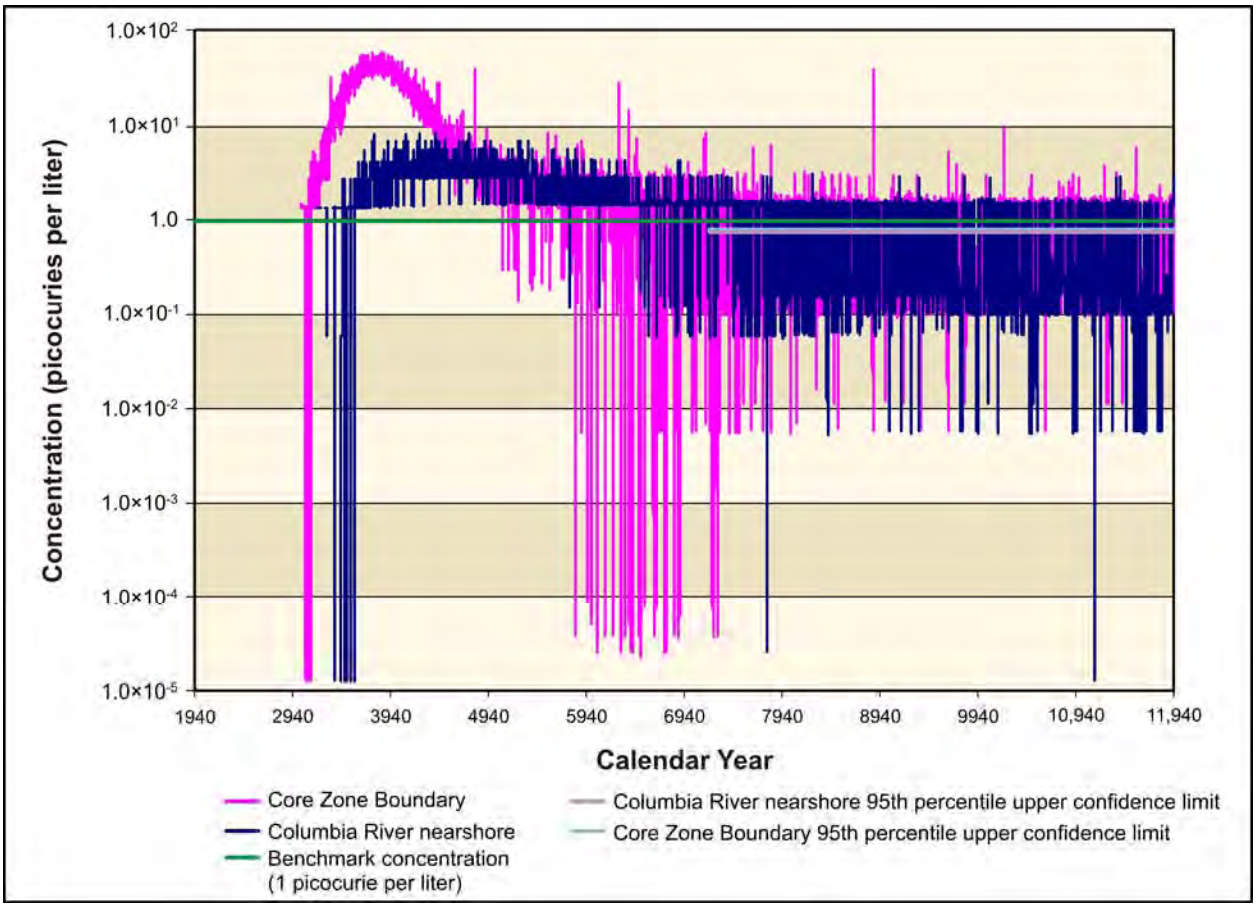


Figure 5–1045. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Iodine-129 Concentration Versus Time

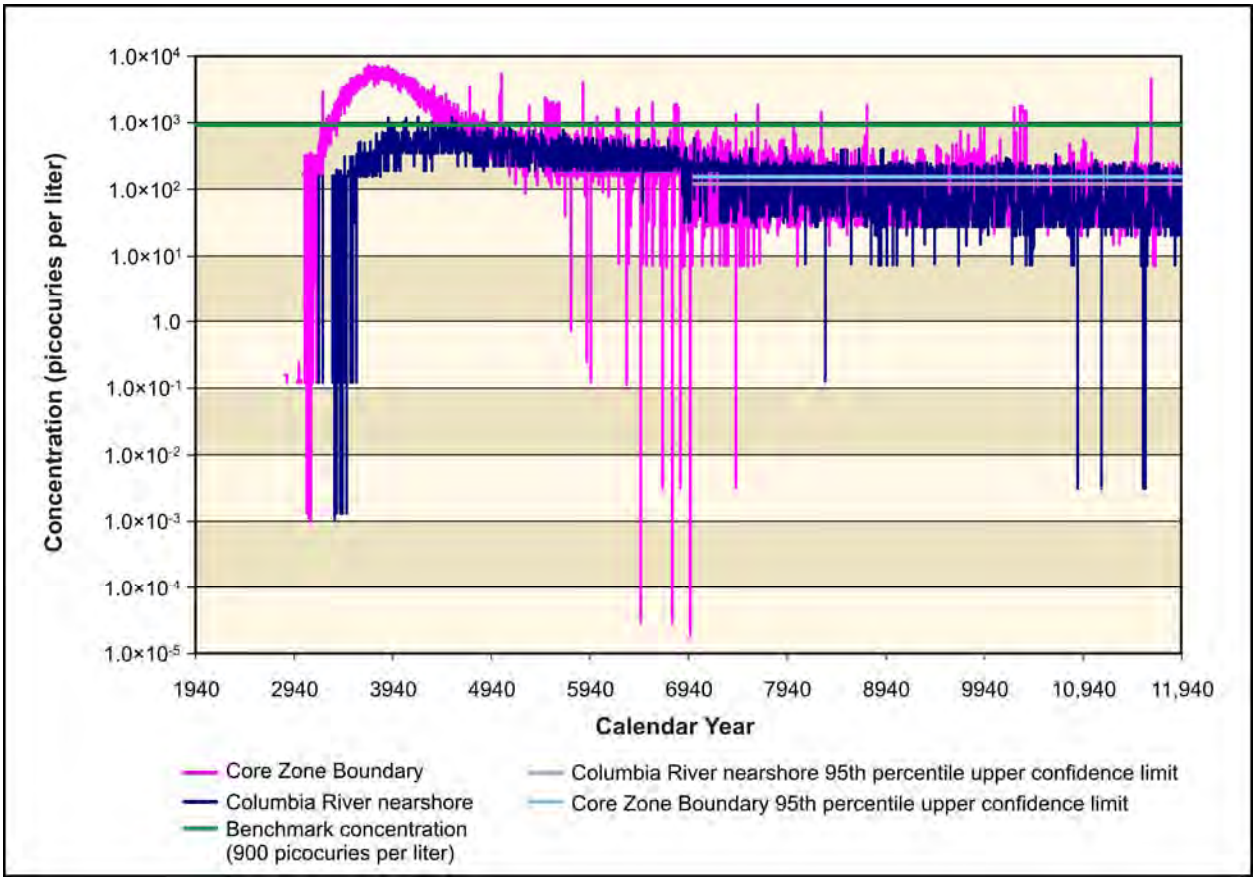


Figure 5–1046. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Technetium-99 Concentration Versus Time

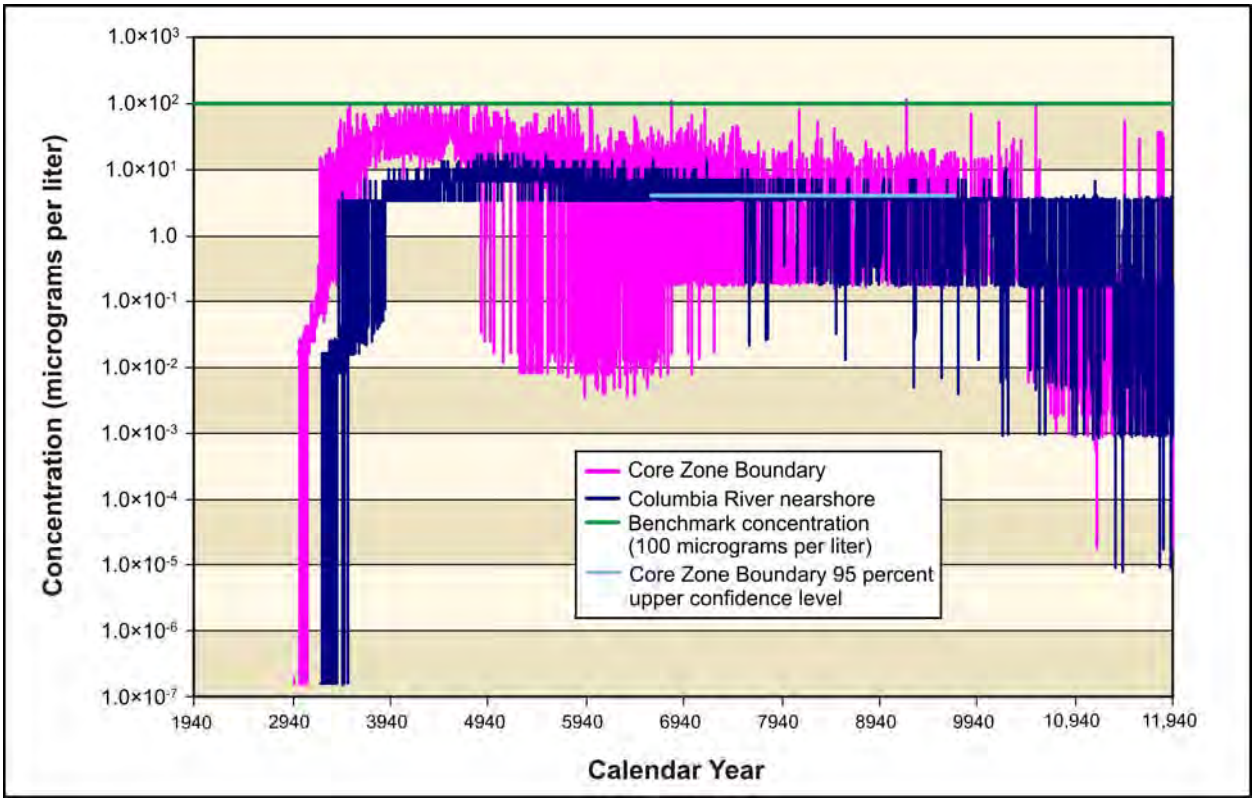


Figure 5–1047. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chromium Concentration Versus Time

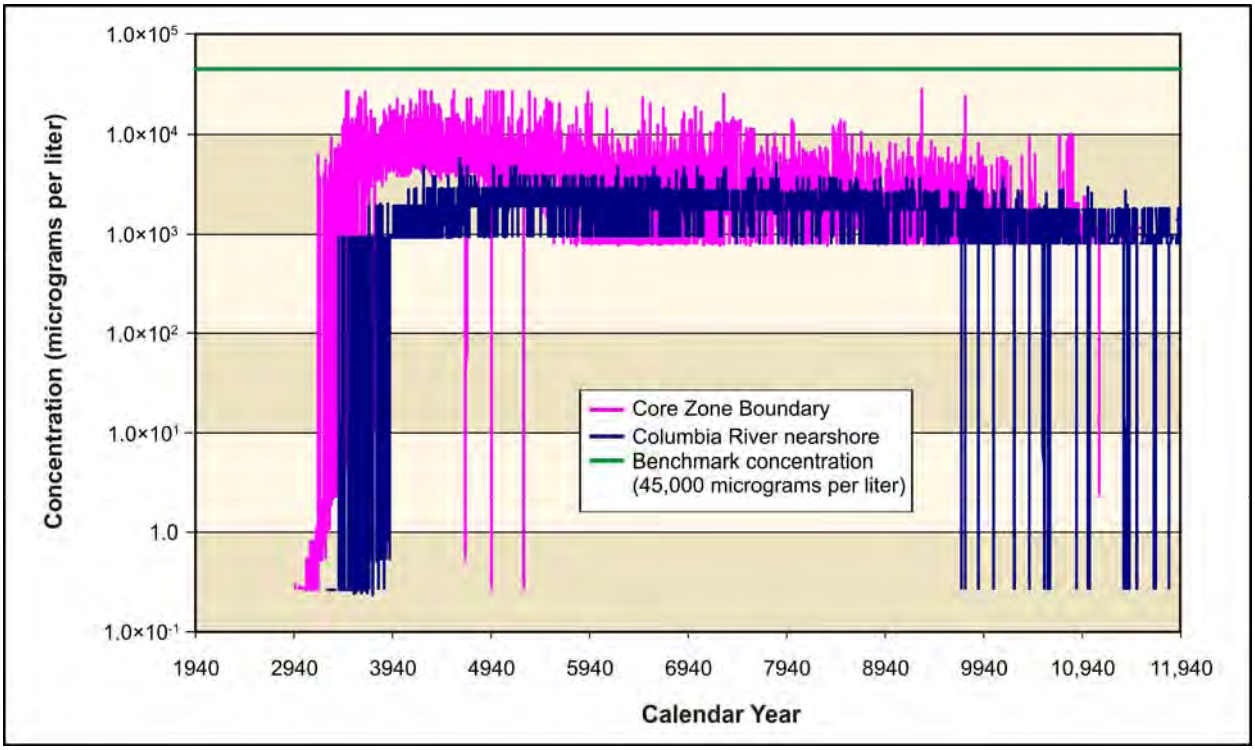


Figure 5–1048. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Nitrate Concentration Versus Time

Table 5–98. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	347	**20,200**	340	**7,590**	**1,190**	900
	(10,643)	(3713)	(4213)	(3690)	(4191)	
Iodine-129	**2**	**173**	0.6	**61**	**8**	1
	(11,363)	(3797)	(4176)	(3853)	(4392)	
Chemical in micrograms per liter						
Chromium	3	2	33	97	17	100
	(8281)	(3696)	(4118)	(10,533)	(5522)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	9,070	28,400	5,700	45,000
	(8162)	(3703)	(3962)	(9305)	(4618)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figure 5–1049 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until roughly CY 9500. Total uranium concentrations rise throughout the remainder of the period of analysis, but remain at least seven orders of magnitude lower than the benchmark concentration. Uranium-238 (see Figure 5–1050) also continues to rise after CY 9000, remaining at about two to three orders of magnitude below the benchmark at the end of the period of analysis.

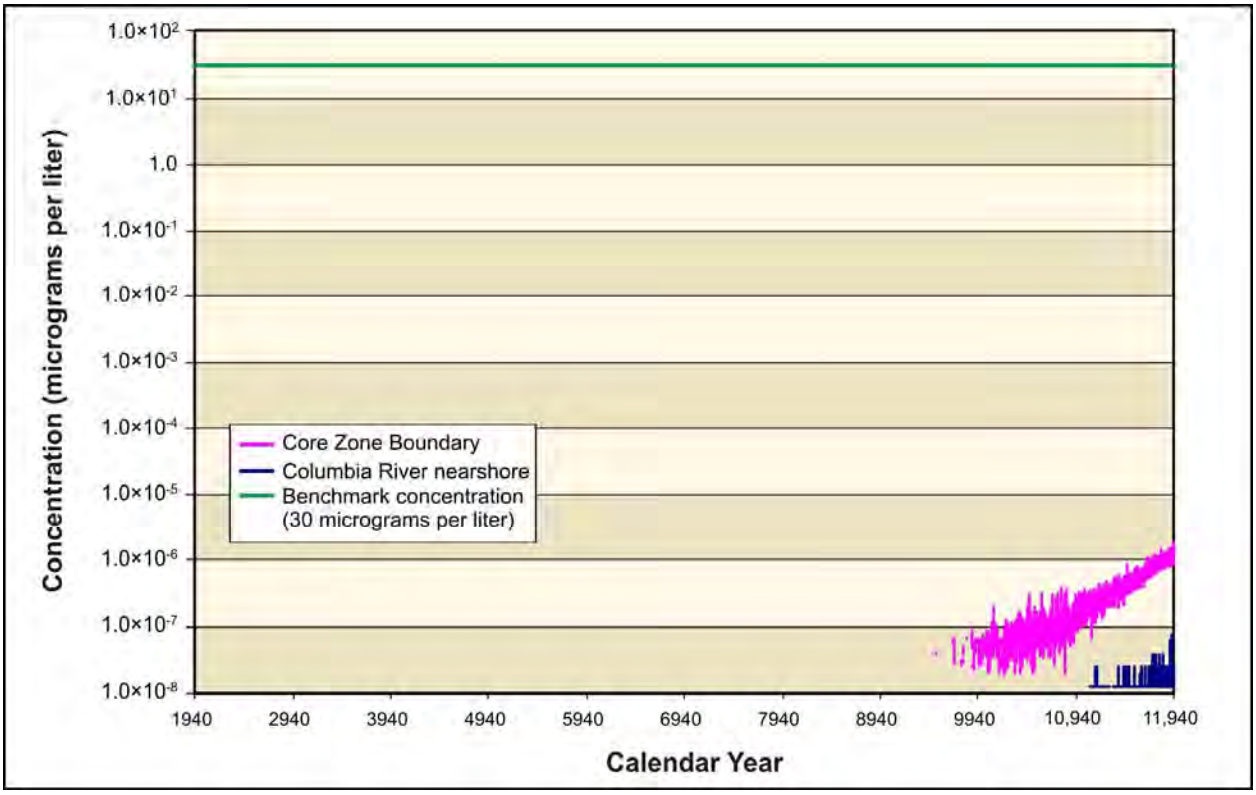


Figure 5–1049. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Total Uranium Concentration Versus Time

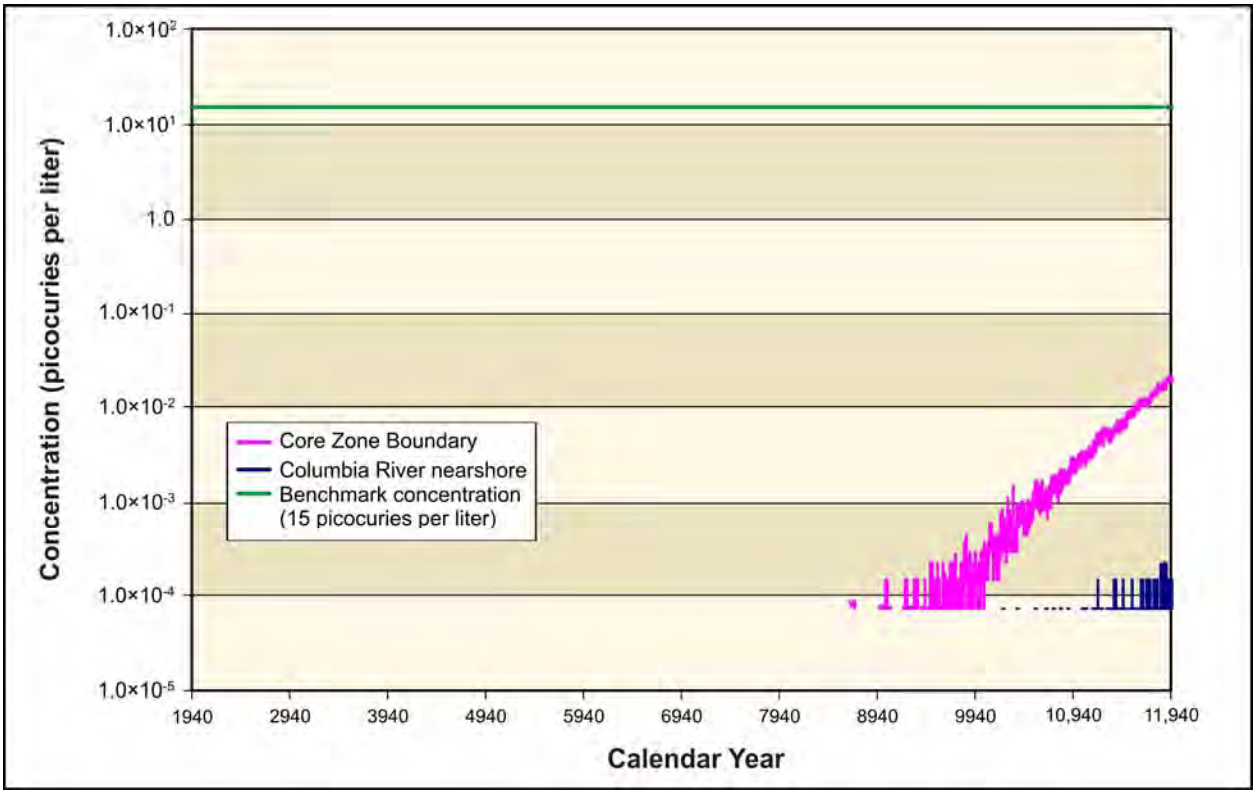


Figure 5–1050. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Uranium-238 Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations below the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1051 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890 as a concentrated plume, with concentrations many times greater than the benchmark, that stretches north from IDF-West and the RPPDF through Gable Gap. By CY 7140 (see Figure 5–1052), the plume from the RPPDF is reduced, but a new plume is beginning to form, traveling east from IDF-East. The peak concentrations in the second plume are greater than the benchmark. By CY 11,885, the plume continues to spread toward the river and the concentrations continue to increase (see Figure 5–1053). Technetium-99 (see Figures 5–1054 through 5–1056), chromium (see Figures 5–1057 through 5–1059), and nitrate (see Figures 5–1060 through 1062) show similar spatial distributions at selected times, but the concentrations remain lower, similar to the later plumes mentioned above. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).

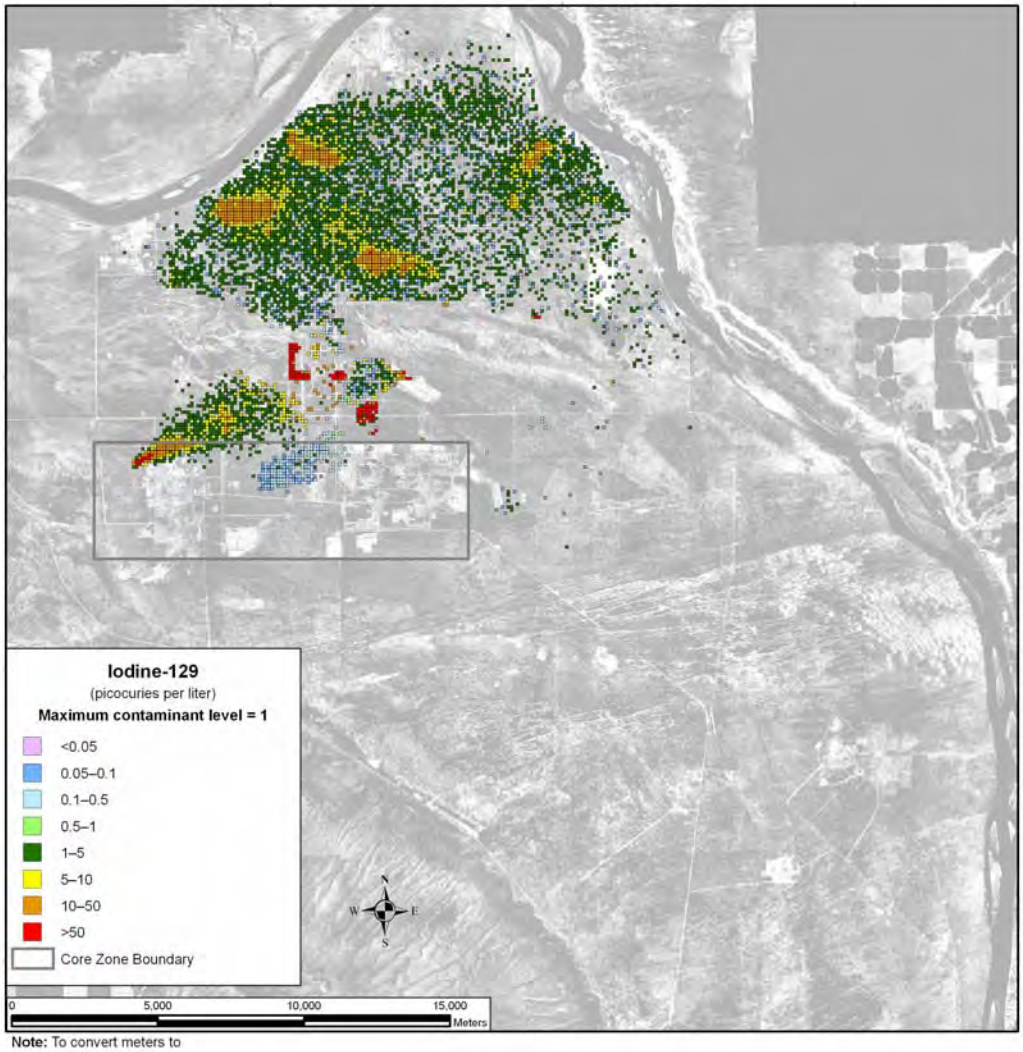


Figure 5–1051. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

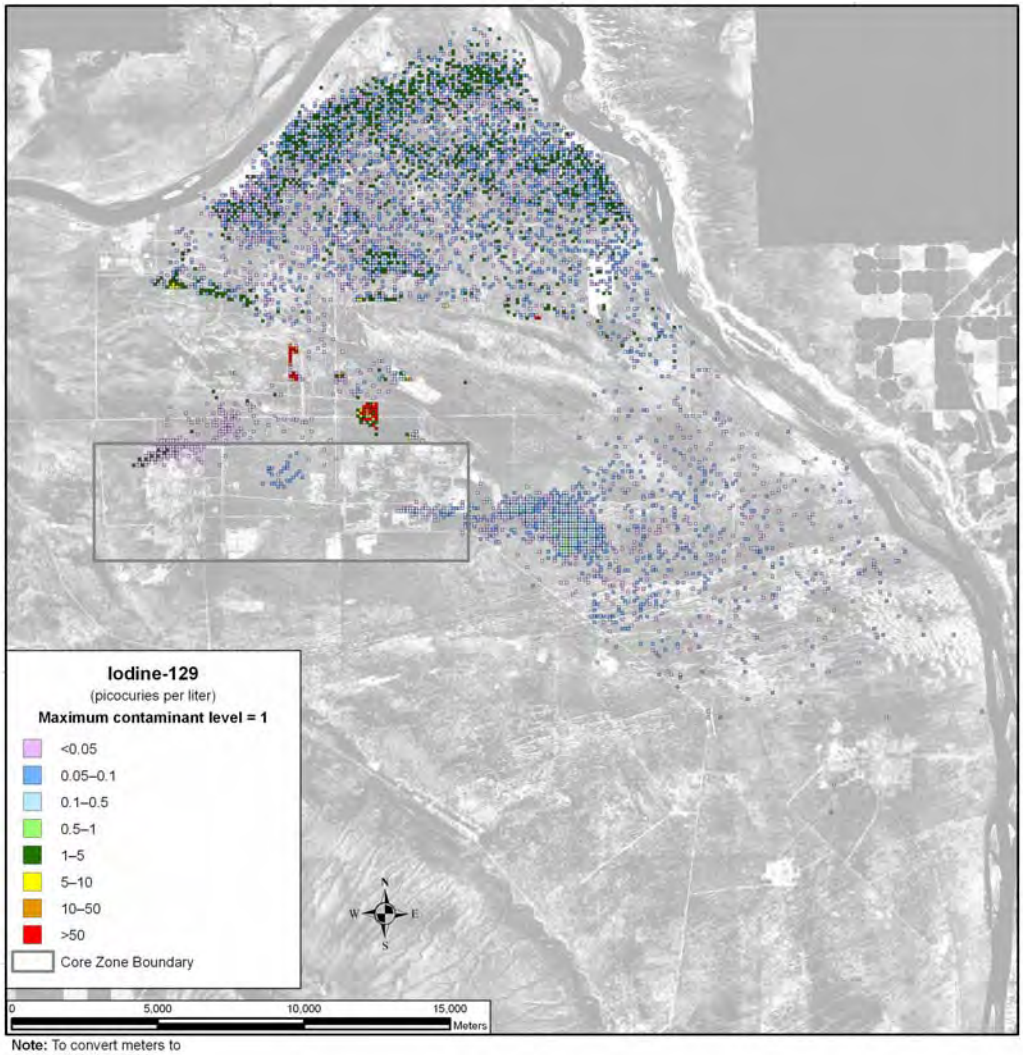


Figure 5–1052. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

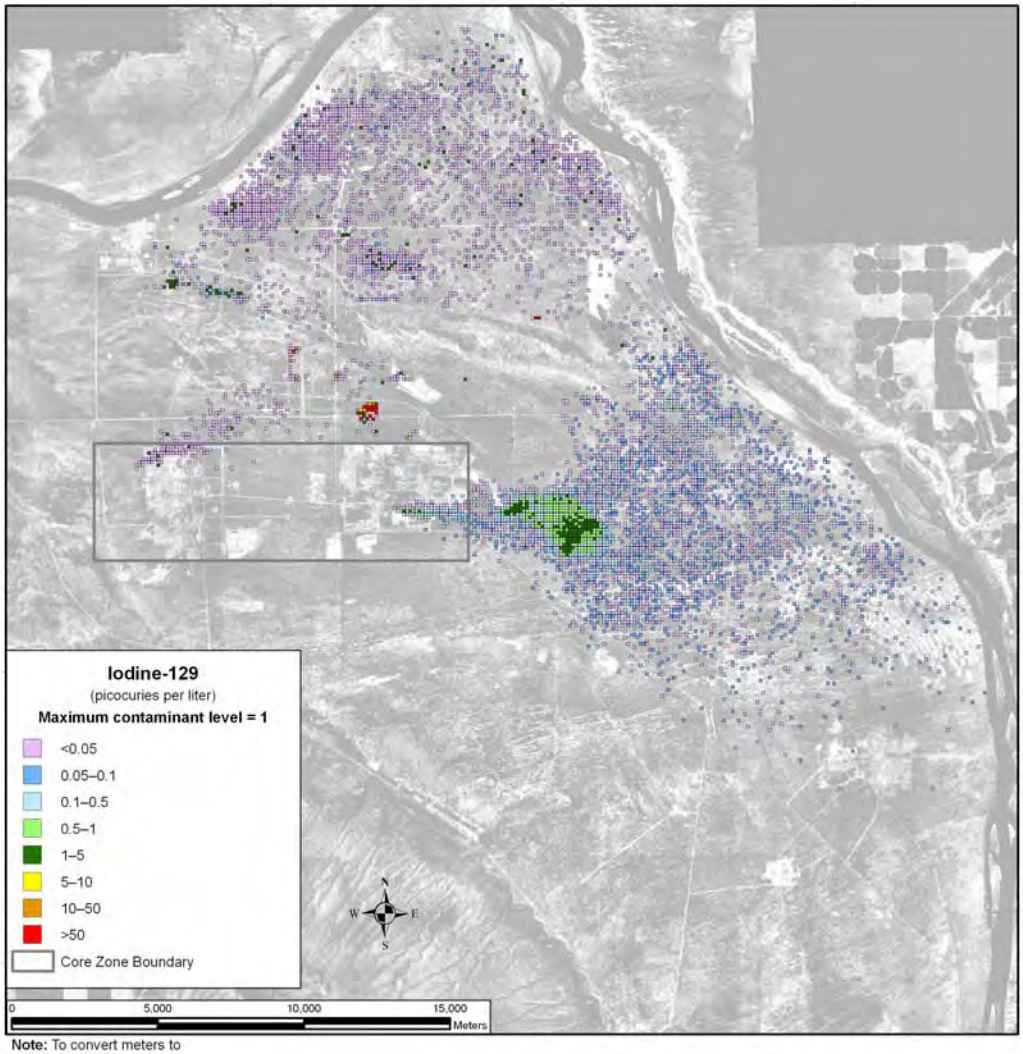


Figure 5–1053. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

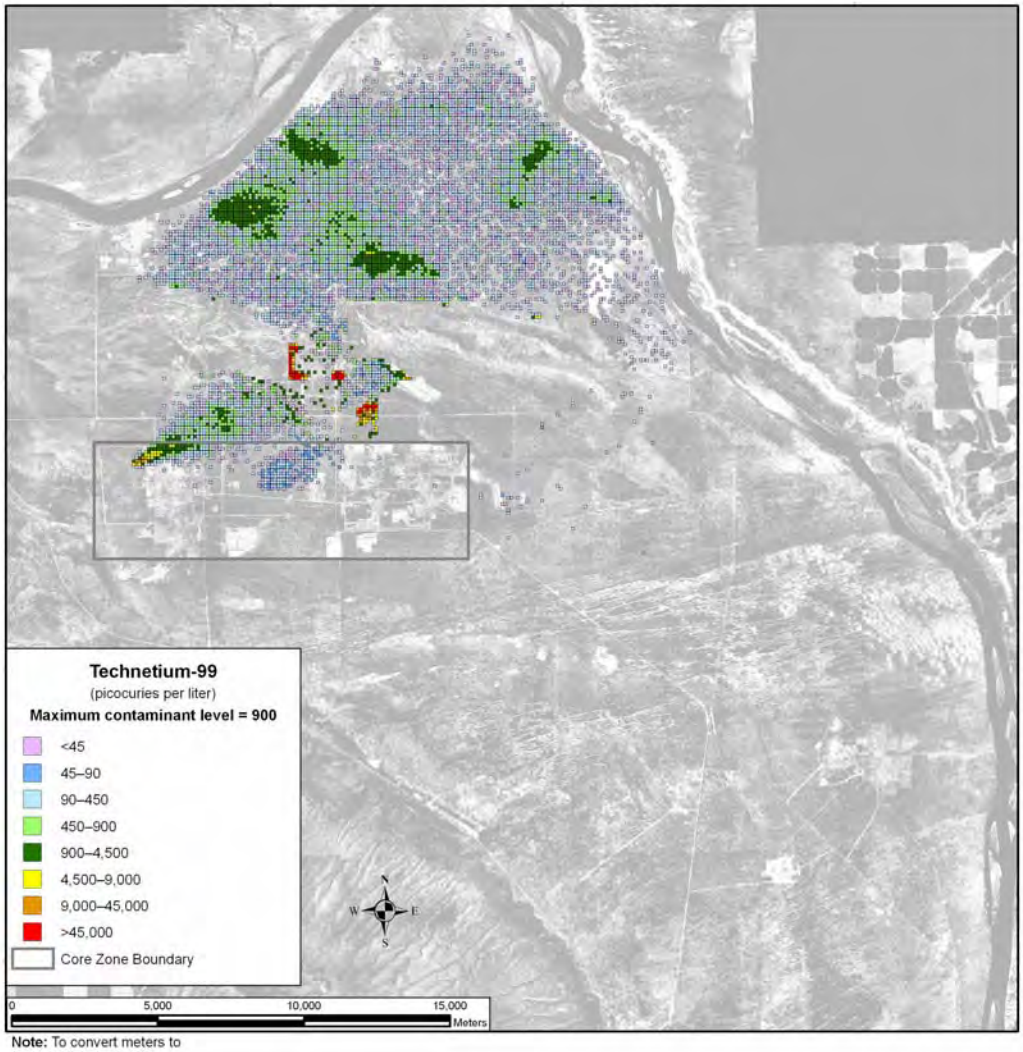


Figure 5–1054. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

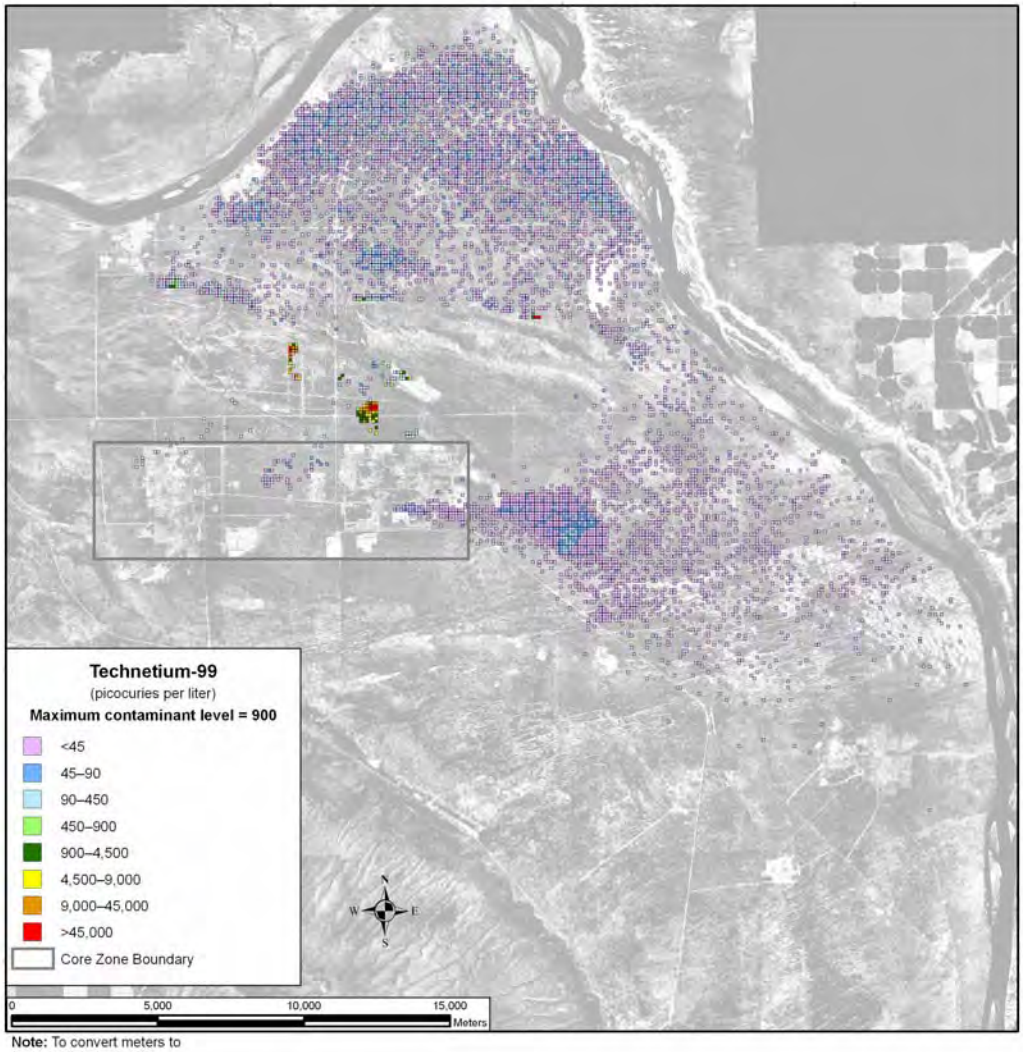
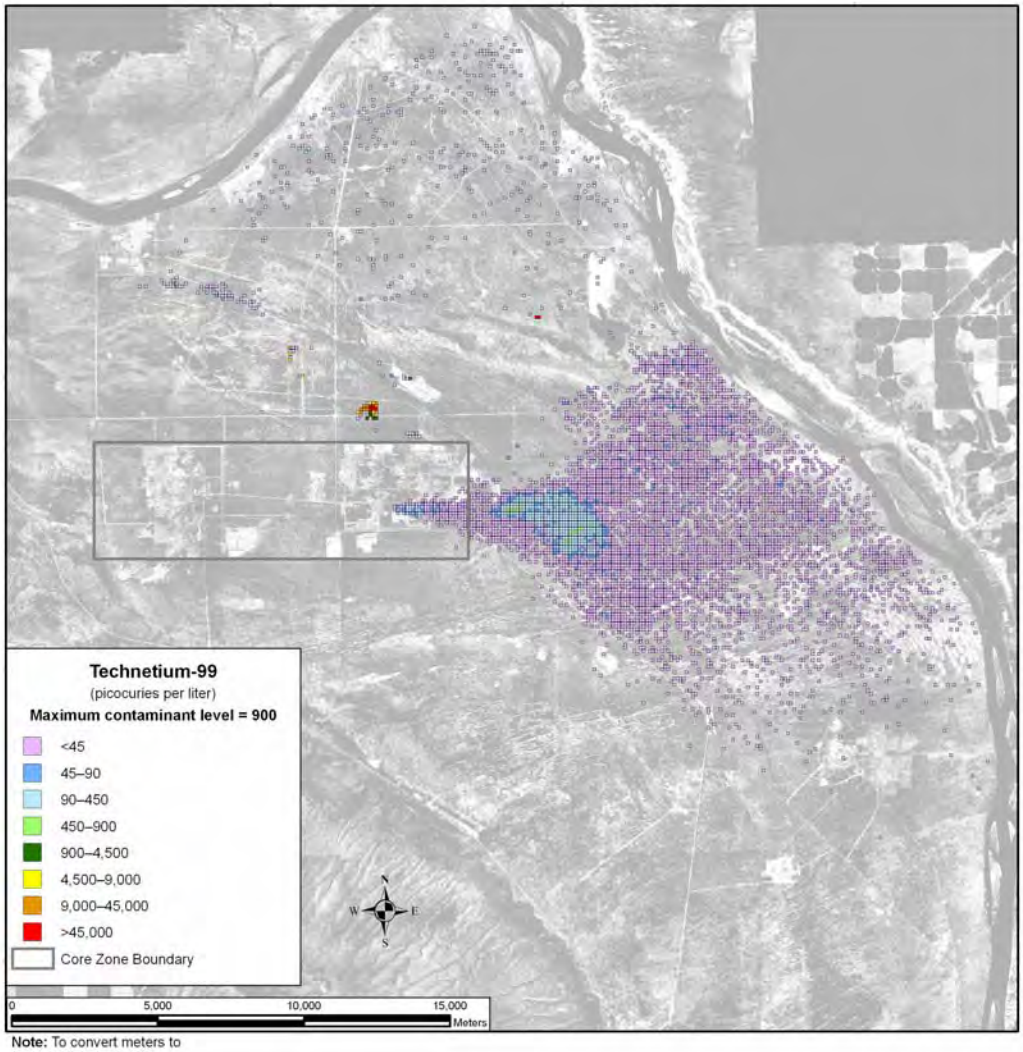


Figure 5–1055. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1056. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

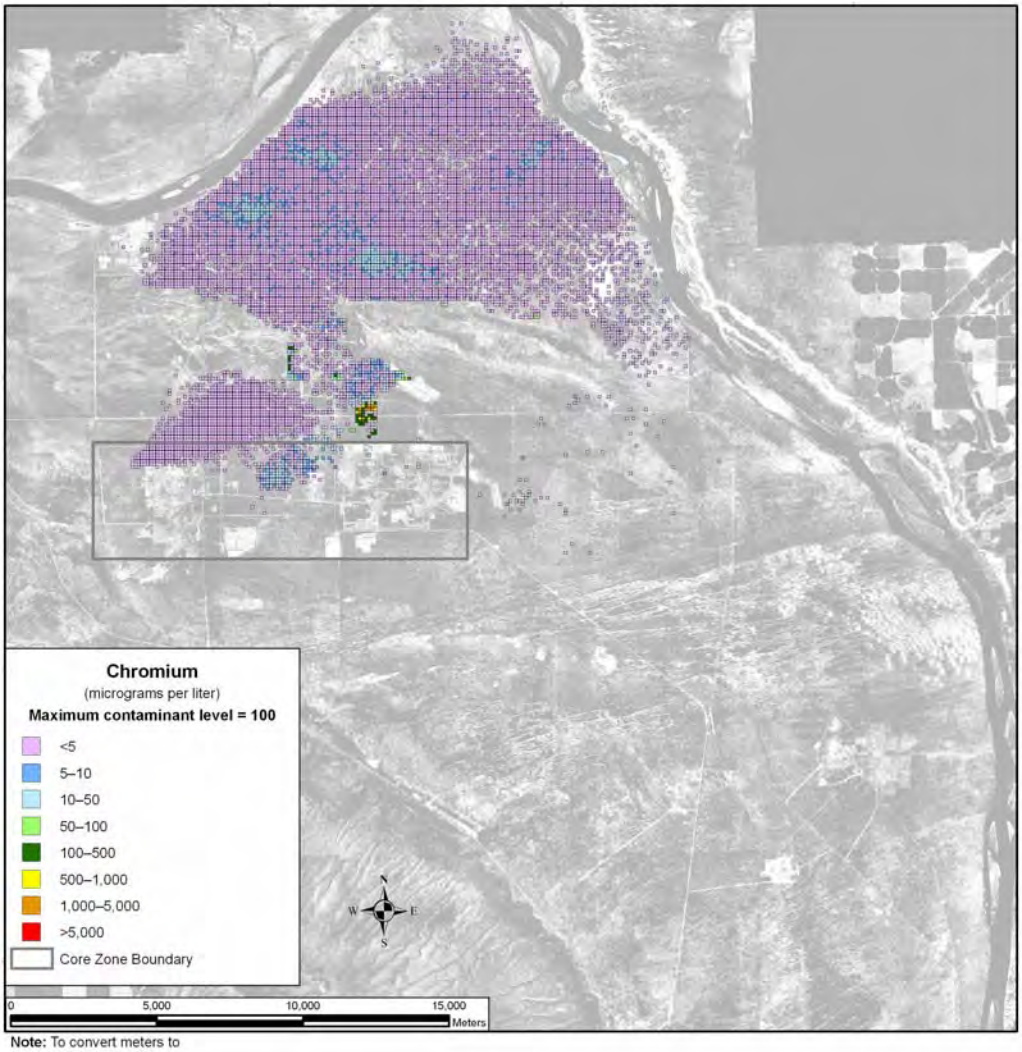


Figure 5–1057. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

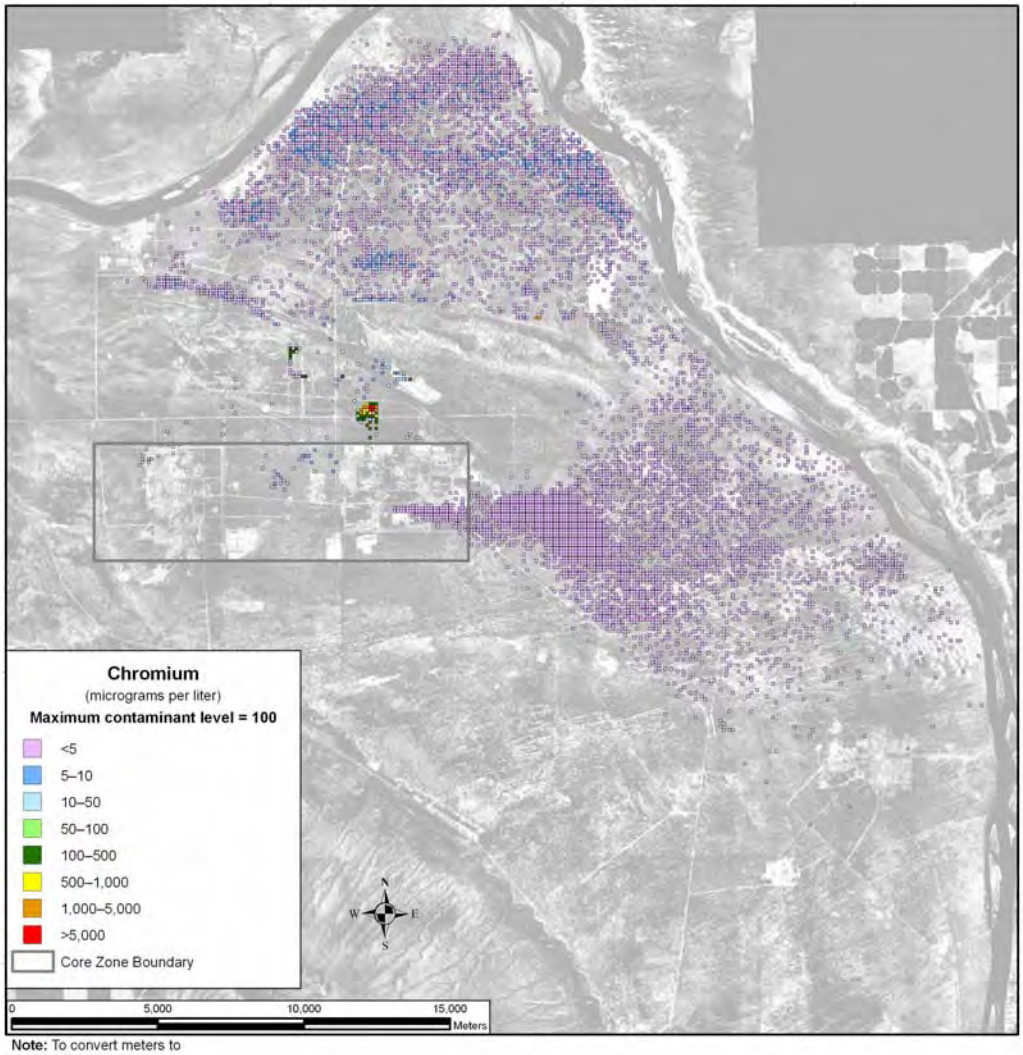


Figure 5–1058. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

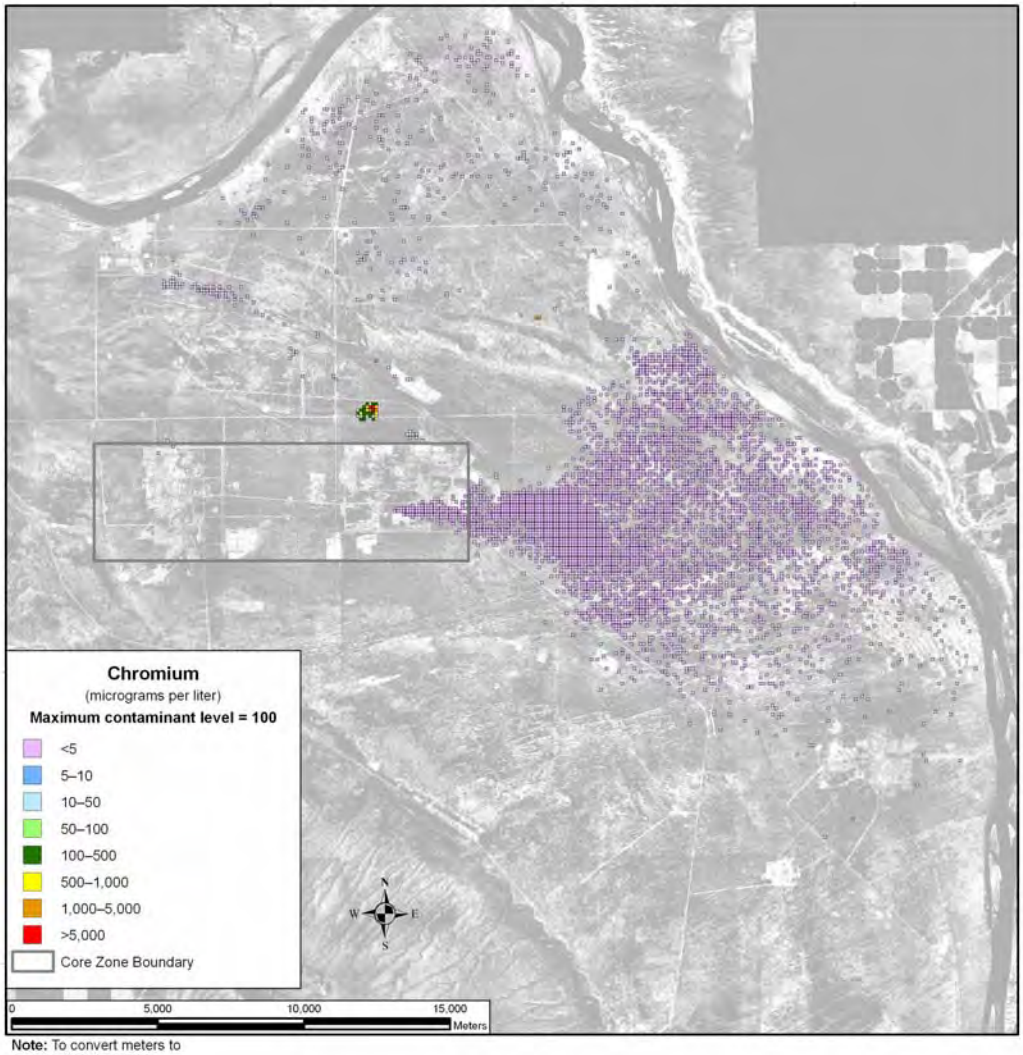


Figure 5–1059. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

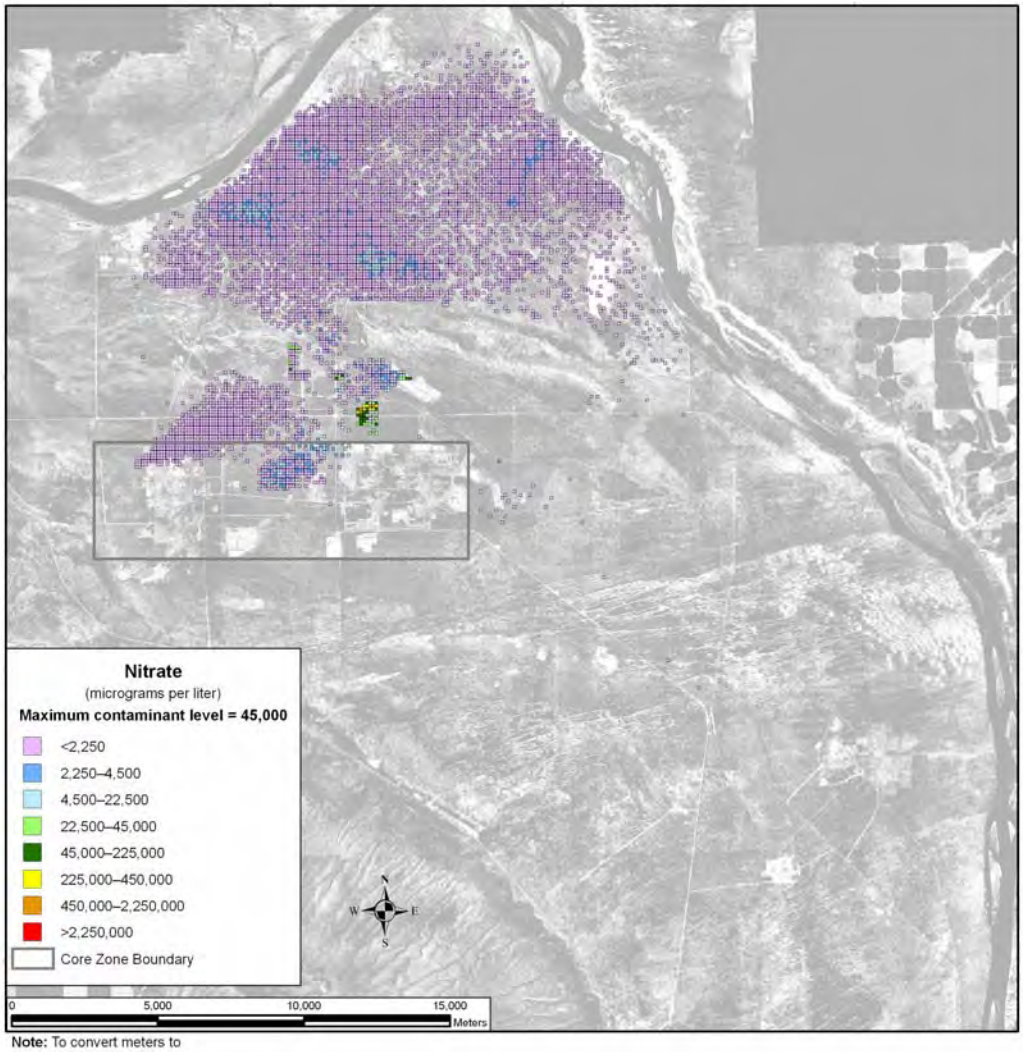


Figure 5–1060. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

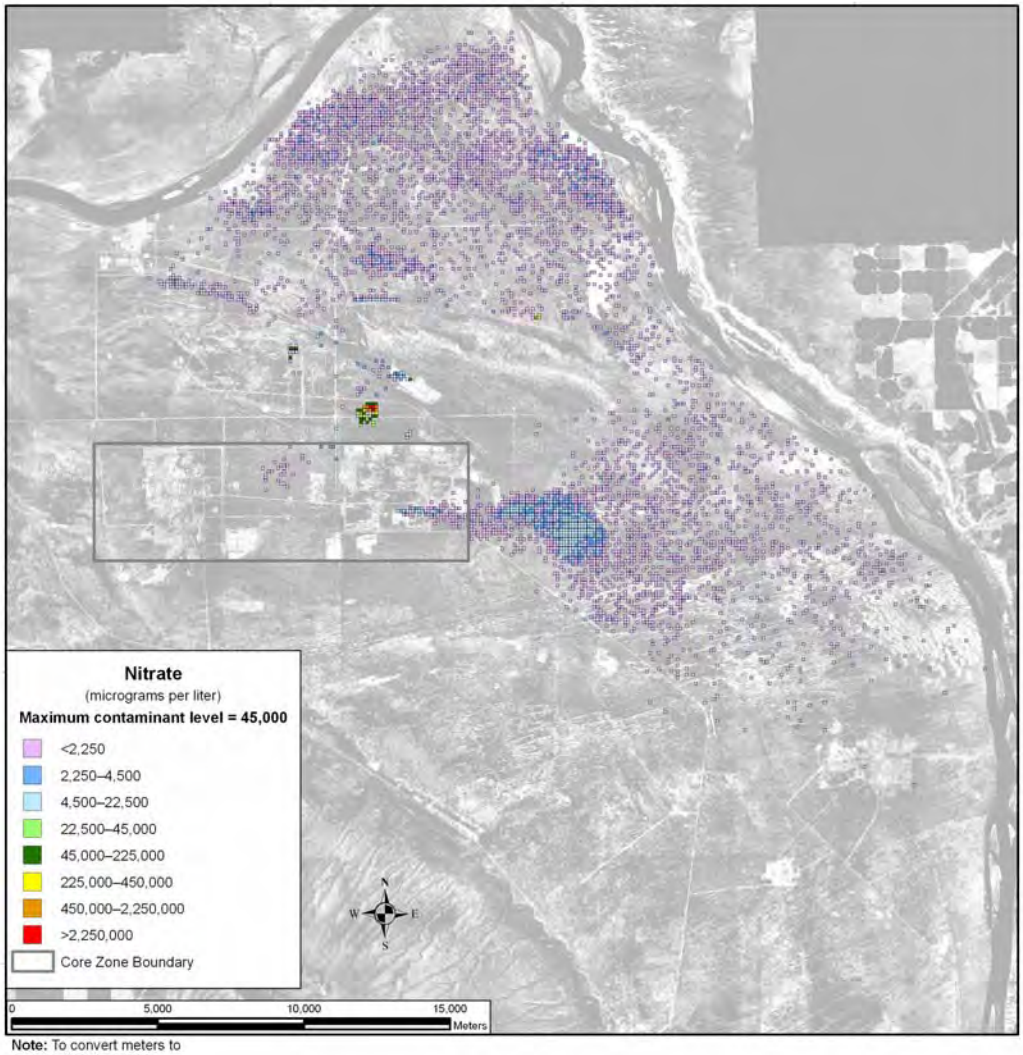


Figure 5–1061. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

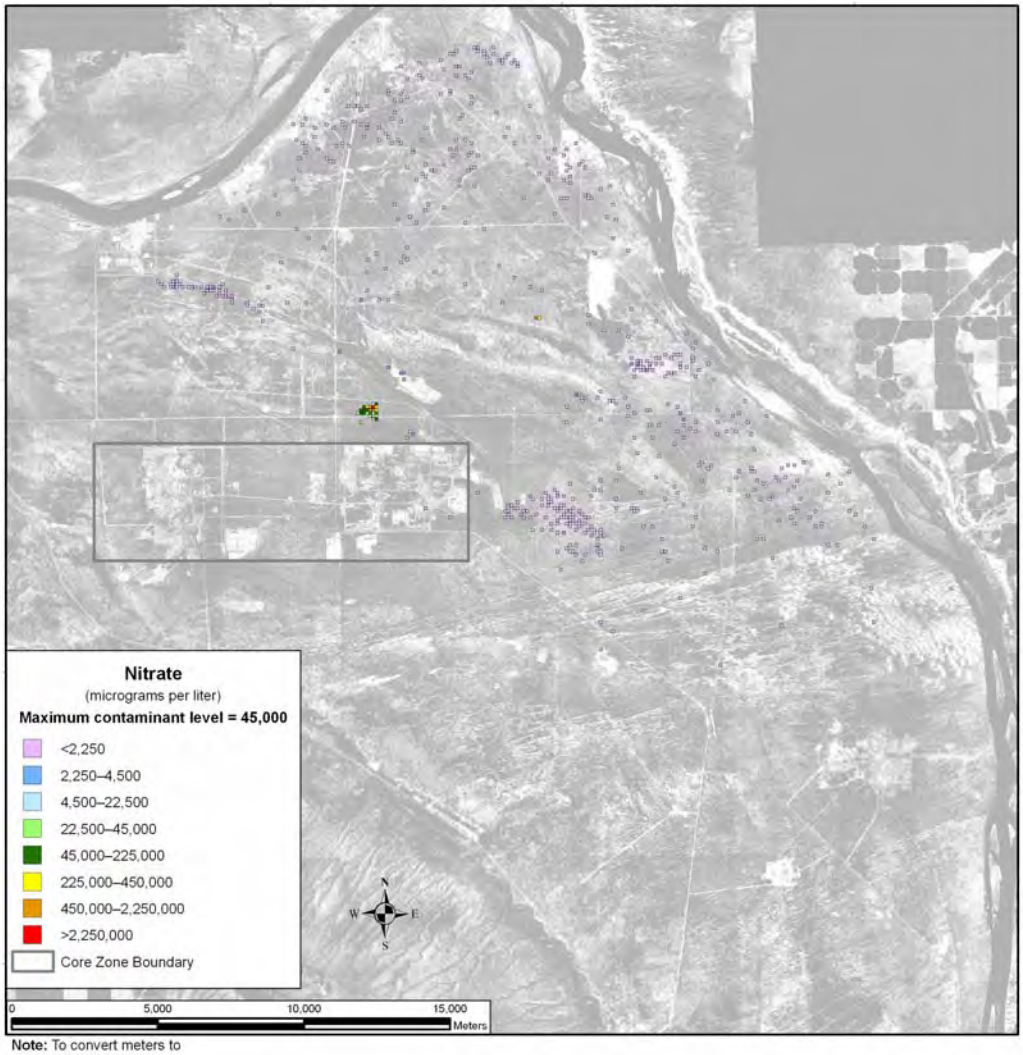


Figure 5–1062. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1063 shows the distribution of uranium-238 at CY 11,885. Figure 5–1064 shows the distribution of total uranium at CY 11,885. Both total uranium and uranium-238 show low concentration plumes that stretch north from IDF-West and the RPPDF through Gable Gap. Concentrations in all areas of the plume remain below one-tenth of the benchmark.

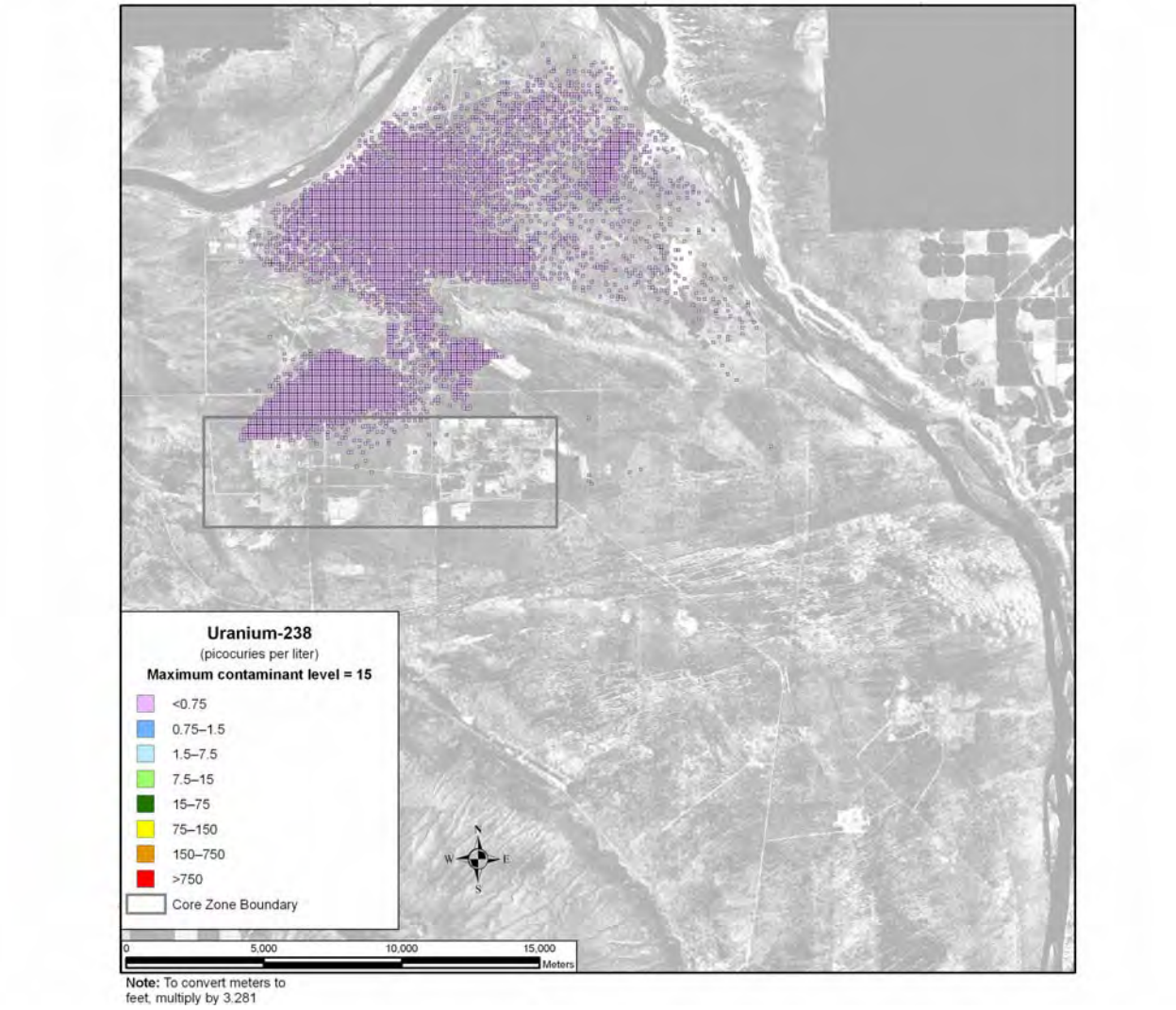


Figure 5–1063. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

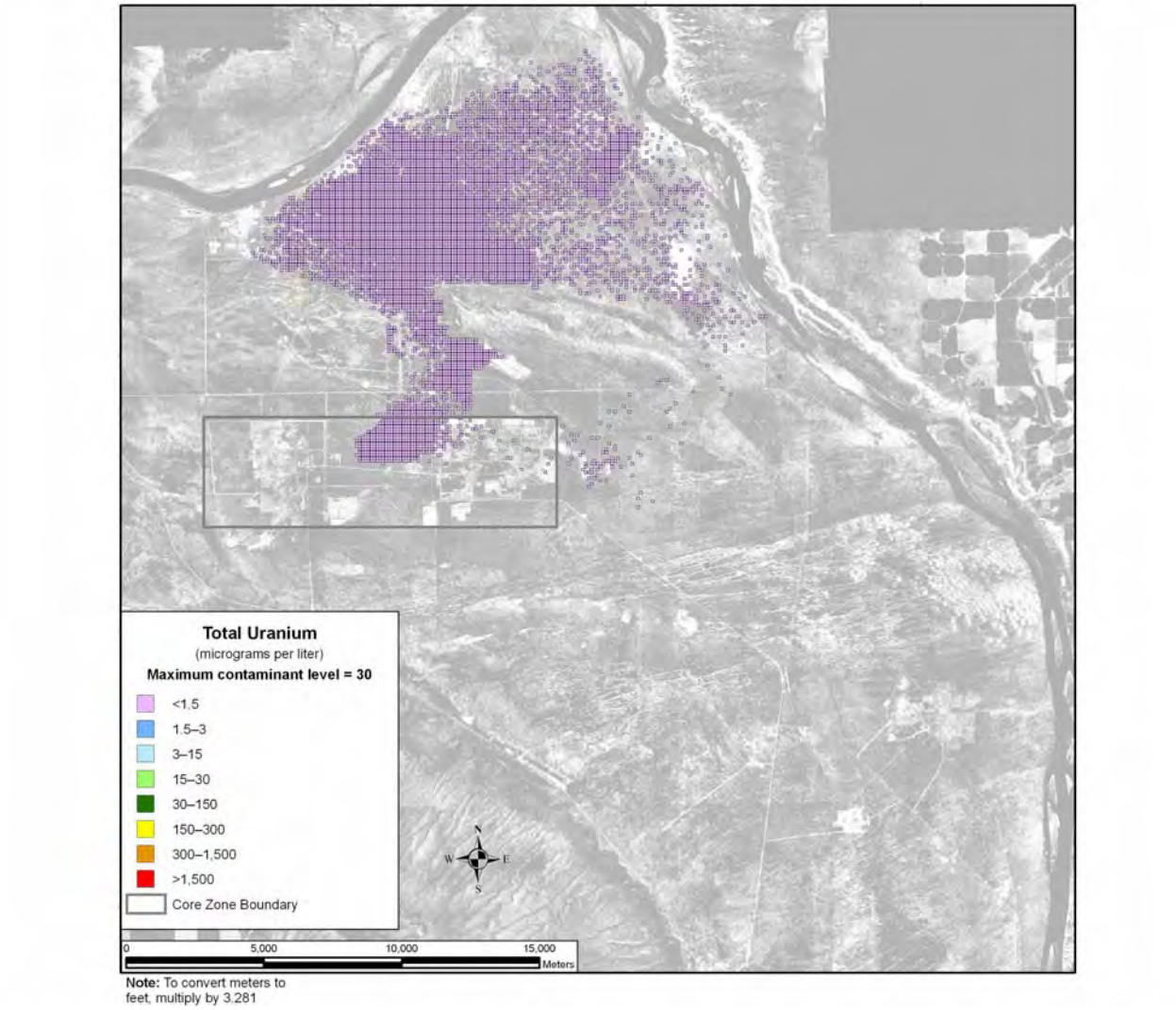


Figure 5–1064. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in general, the inventory remaining in IDF-East and IDF-West available for release to the environment at the start of the post-disposal period is the predominant contributor. The increased inventory available for release from the RPPDF during the post-disposal period is still a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary exceed or approach the benchmark standards during most of the period of analysis. Concentrations at the Columbia River are about two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3500 and CY 5500.

For total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River by CY 10,000. The peak intensity and area of the contamination plume are greatest near the end of the period of analysis.

5.3.1.3.3 Disposal Group 3

Disposal Group 3 is characterized by operational completion dates of CY 2165 for IDF-East and the RPPDF and CY 2050 for IDF-West. In Disposal Group 3, IDF-West has a large capacity (90,000 cubic meters [117,720 cubic yards]), IDF-East has a larger capacity (340,000 cubic meters [425,100 cubic yards]), and the RPPDF has an even larger capacity (8,330,000 cubic meters [10,947,960 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternative 6A, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

5.3.1.3.3.1 Disposal Group 3, Base Case

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 3, Base Case, includes Tank Closure Alternative 6A, Base Case, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 3, Base Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continues through CY 2165 when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2166 and continues through the 10,000-year period of analysis. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 3, Base Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 3, Base Case, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and acetonitrile

The COPC drivers for Waste Management Alternative 3, Disposal Group 3, Base Case, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 3, Base Case.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, chromium, nitrate, and acetonitrile) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs

that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, (IDF-East, IDF-West, and the RPPDF), in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has four subtotals plotted representing releases from ETF-generated secondary waste, PPF glass, retired melters, and tank closure secondary waste.

Figure 5–1065 shows the release to the vadose zone for the radiological risk drivers and Figure 5–1066, the chemical hazard drivers. For all four types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and chromium is tank closure and secondary waste. Iodine-129 and nitrate have ETF-generated secondary waste as the predominant source. Acetonitrile does not exist at IDF-East.

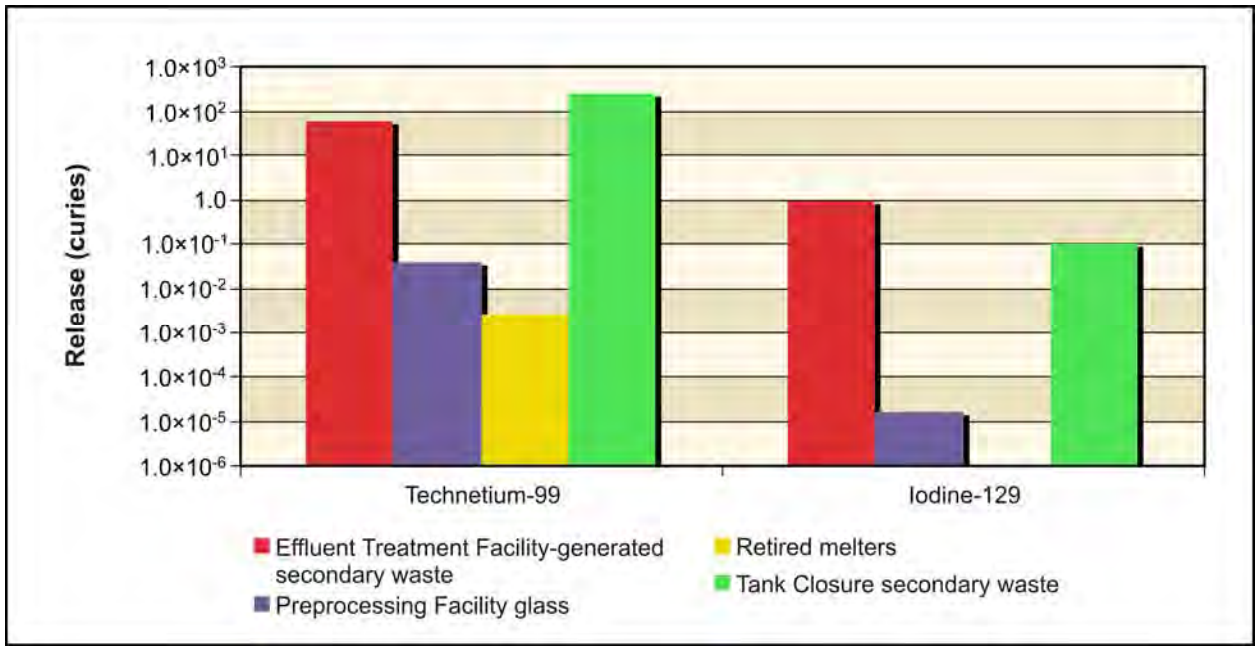


Figure 5–1065. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

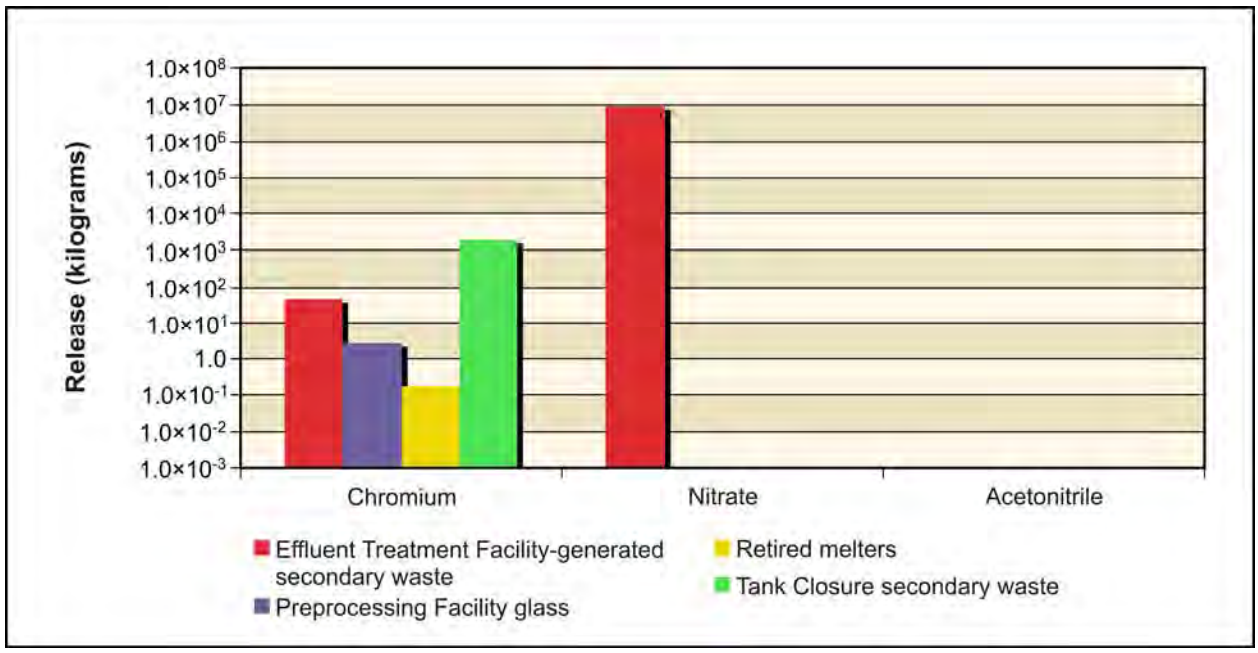


Figure 5–1066. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–1067 shows the release to groundwater for the radiological risk drivers and Figure 5–1068, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Essentially equal" means that there is a difference of less than one order of magnitude. Overall, about 58 percent of the radionuclides (curies) released to the vadose zone during the period of analysis reach groundwater; approximately 100 percent of the chemicals (kilograms) do.

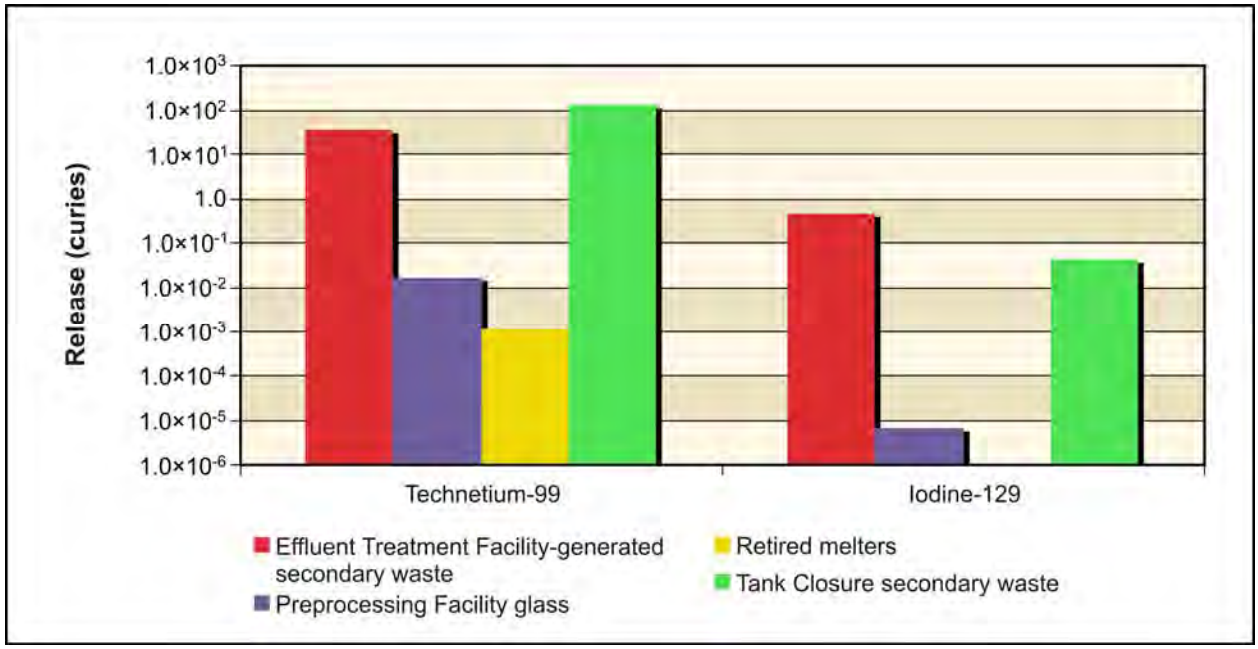


Figure 5–1067. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

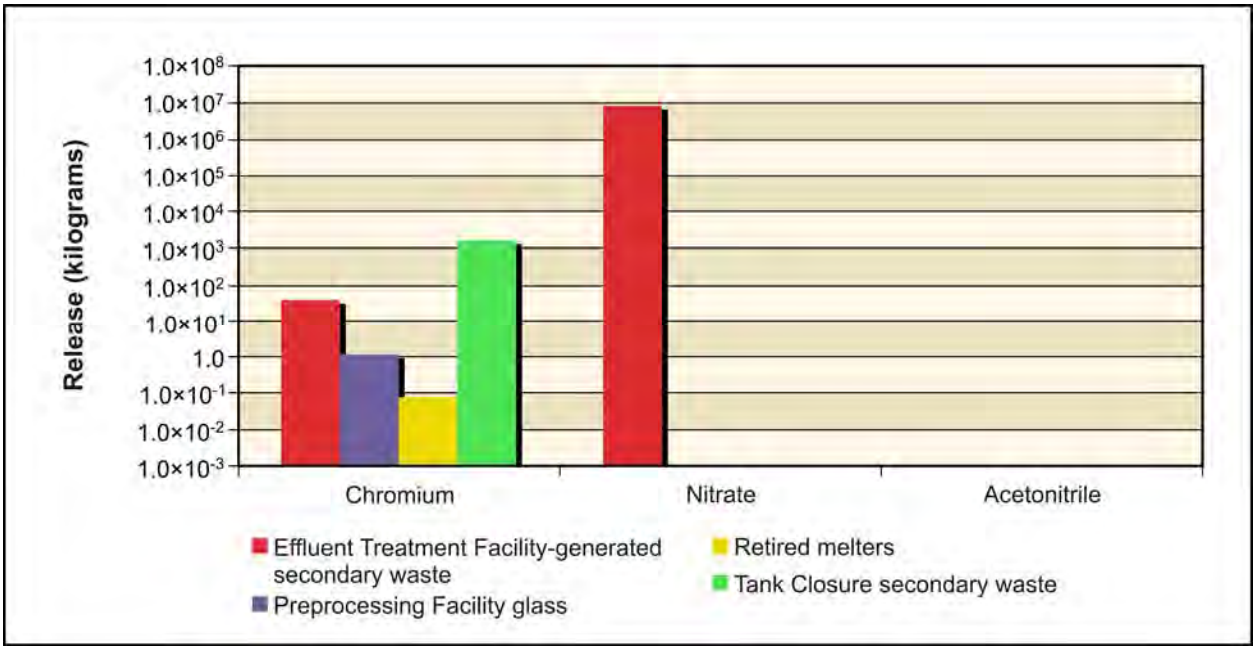


Figure 5–1068. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–1069 shows the release to the Columbia River for the radiological risk drivers and Figure 5–1070, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 70 percent of the radionuclides (curies) released to groundwater during the period of analysis reach the river; approximately 99 percent of the chemicals (kilograms) do.

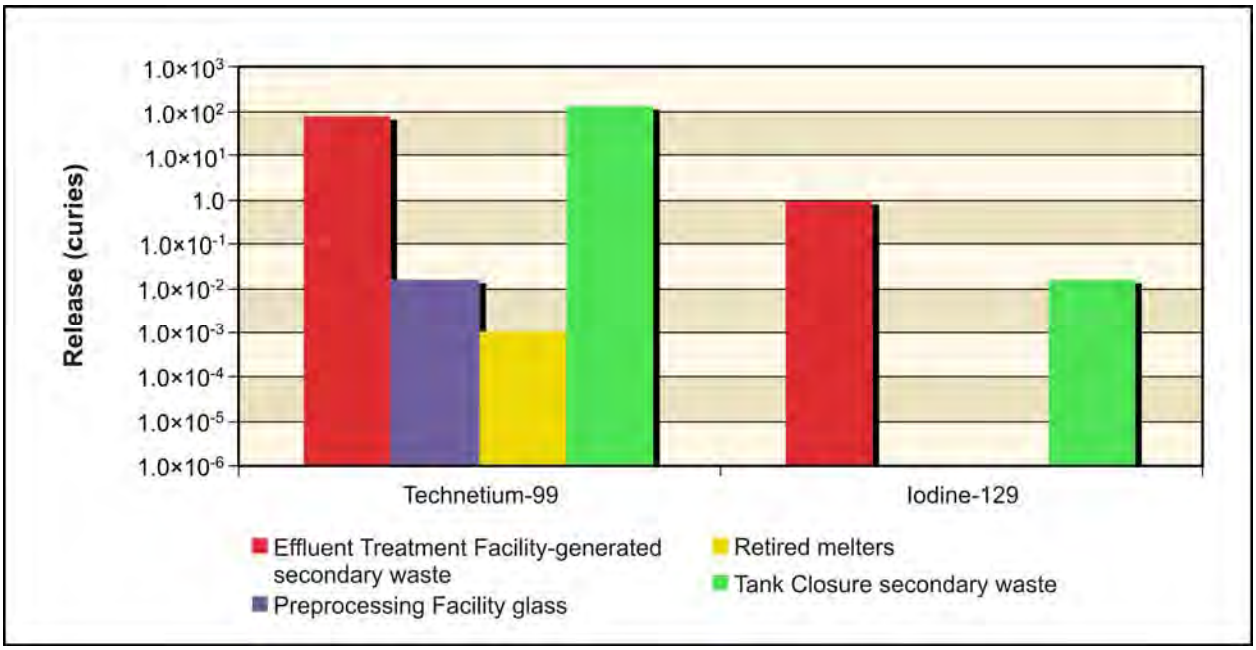


Figure 5–1069. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

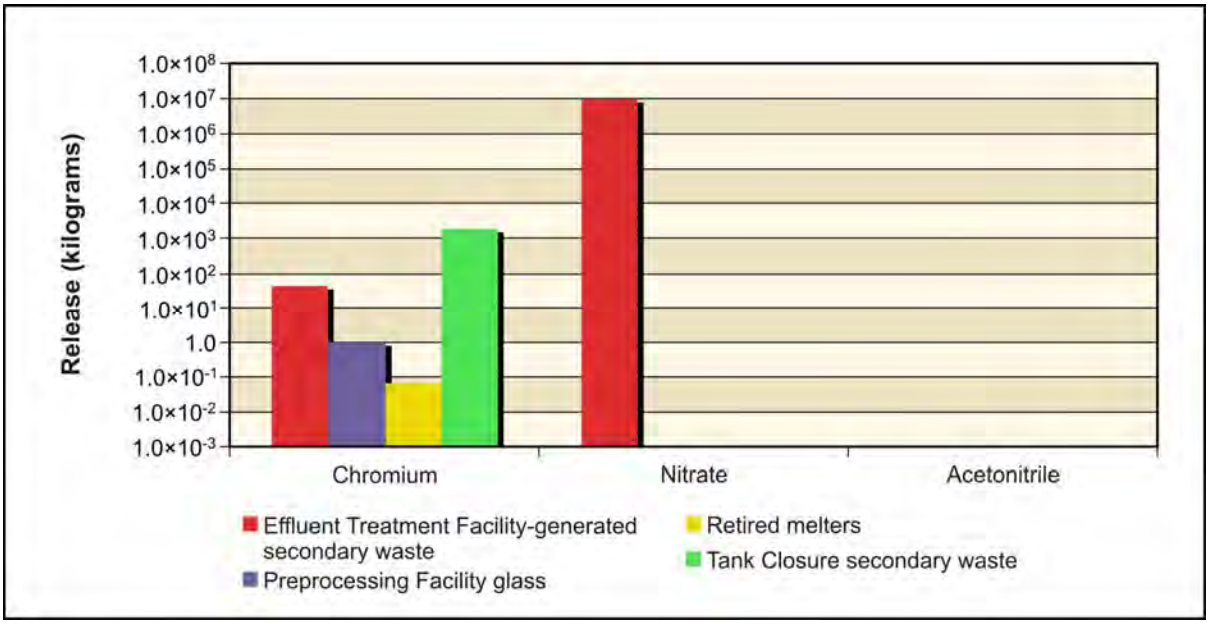


Figure 5–1070. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite-generated waste, and offsite-generated waste.

Figure 5–1071 shows the release to the vadose zone for the radiological risk drivers and Figure 5–1072, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and iodine-129 is offsite-generated waste. For chromium and nitrate, the predominant sources are waste management secondary waste and onsite-generated waste.

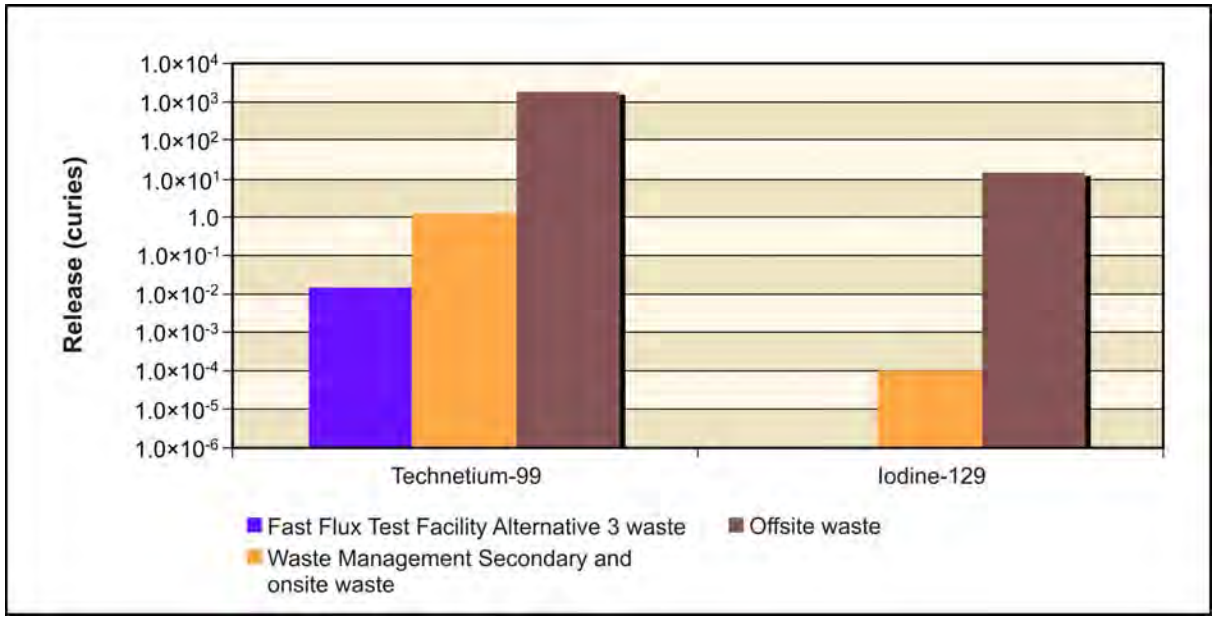


Figure 5–1071. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

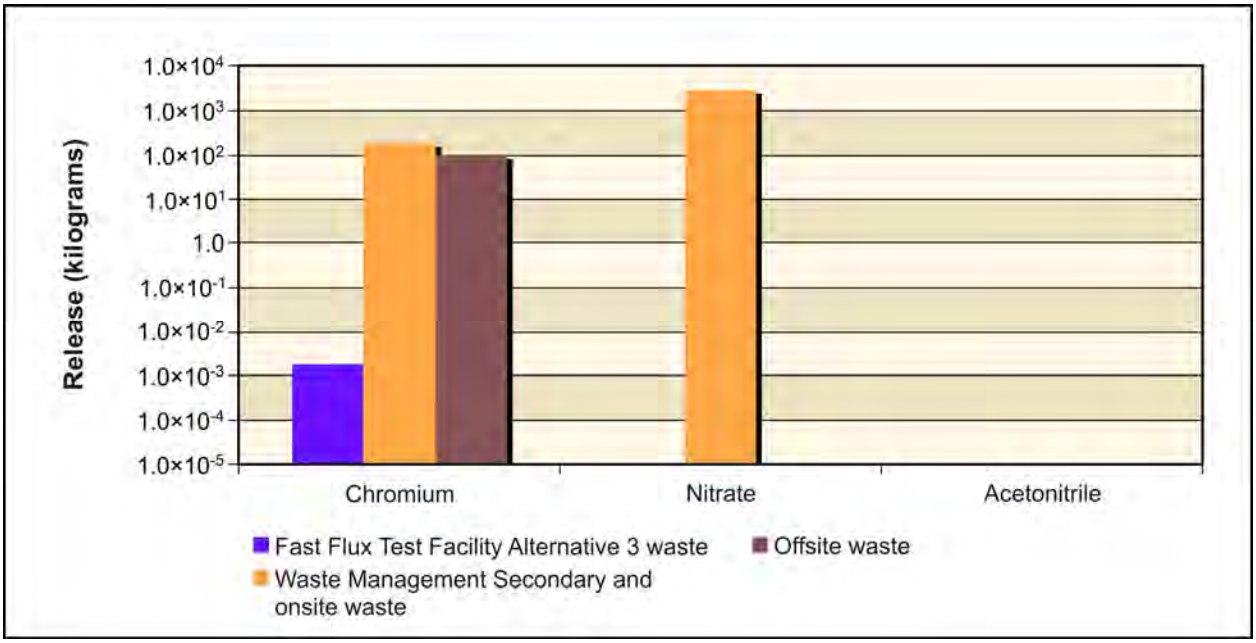


Figure 5–1072. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–1073 shows the release to groundwater for the radiological risk drivers and Figure 5–1074, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Approximately equal" means that there is a difference of less than one order of magnitude. Overall, about 98 percent of the radionuclides (curies) released to the vadose zone during the period of analysis reach the groundwater; approximately 100 percent of the chemicals (kilograms) do.

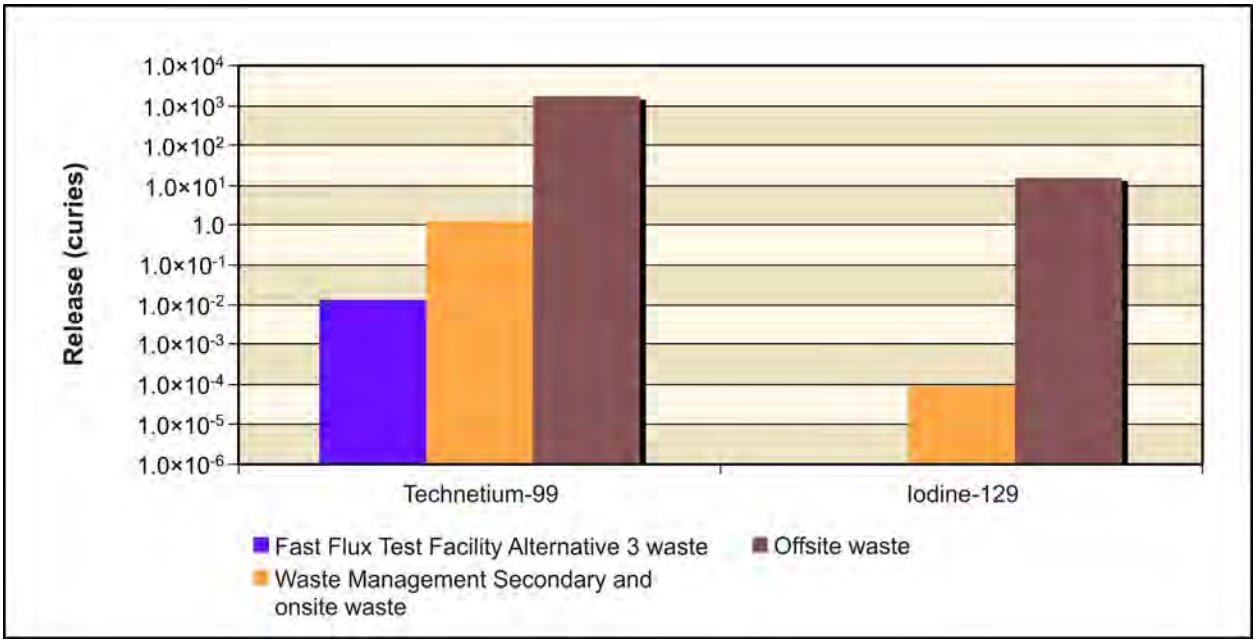


Figure 5–1073. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

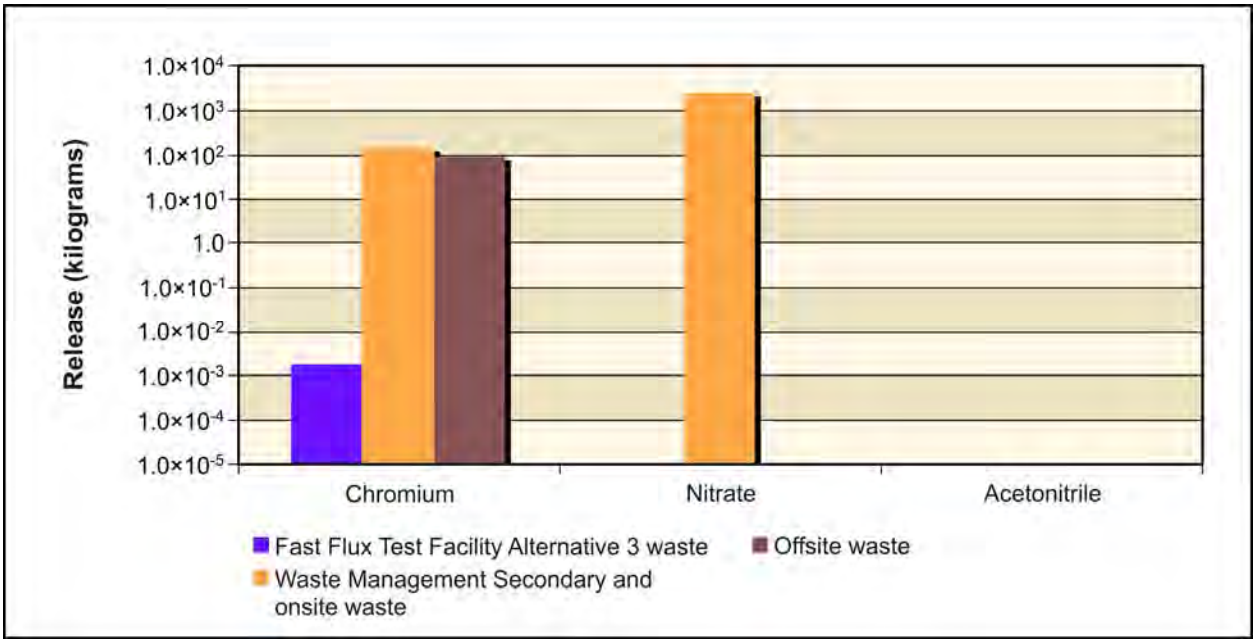


Figure 5–1074. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1075 shows the release to the Columbia River for the radiological risk drivers and Figure 5–1076, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For techetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclides (curies) released to groundwater during the period of analysis reach the river; approximately 98 percent of the chemicals (kilograms) do.

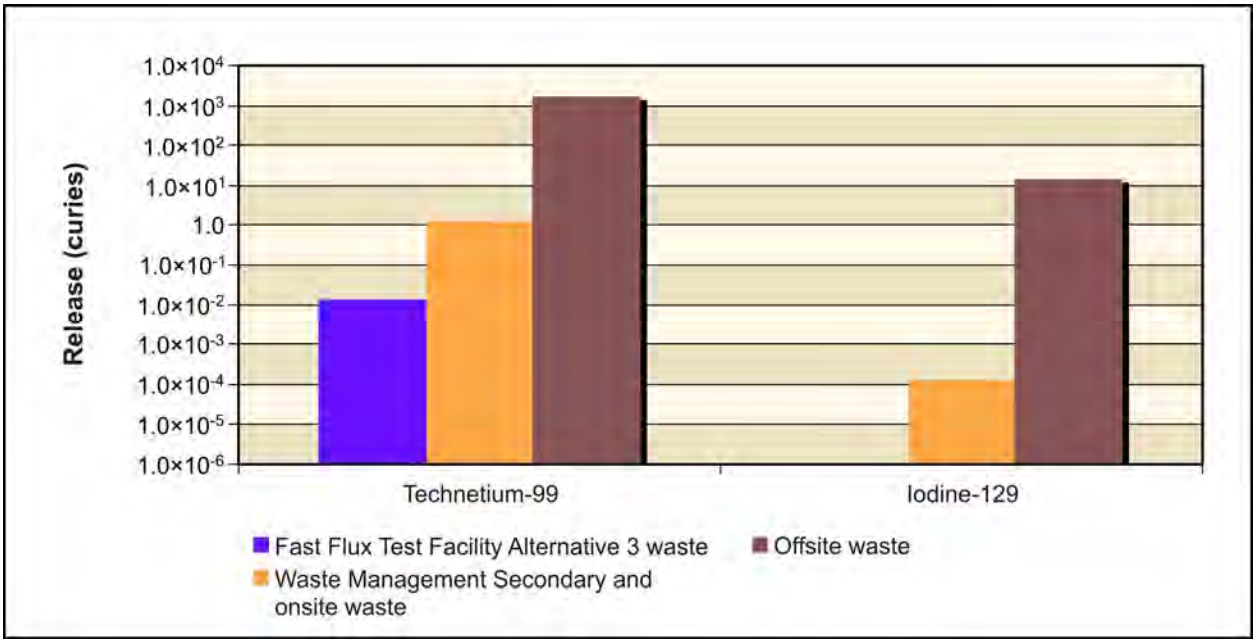


Figure 5–1075. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

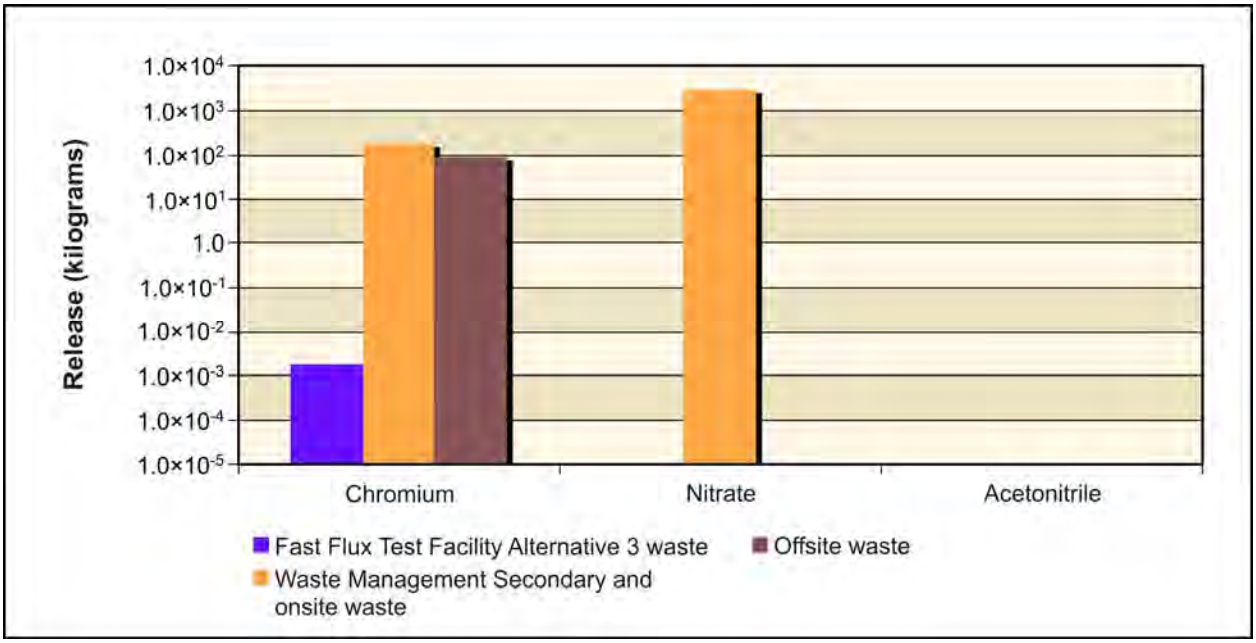


Figure 5–1076. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1077 shows the release to the vadose zone for the radiological risk drivers and Figure 5–1078, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). Radiological sources of risk to the vadose zone from the RPPDF, highest to lowest, are technetium-99 and iodine-129; chemical hazards, again highest to lowest, are nitrate, chromium, and acetonitrile.

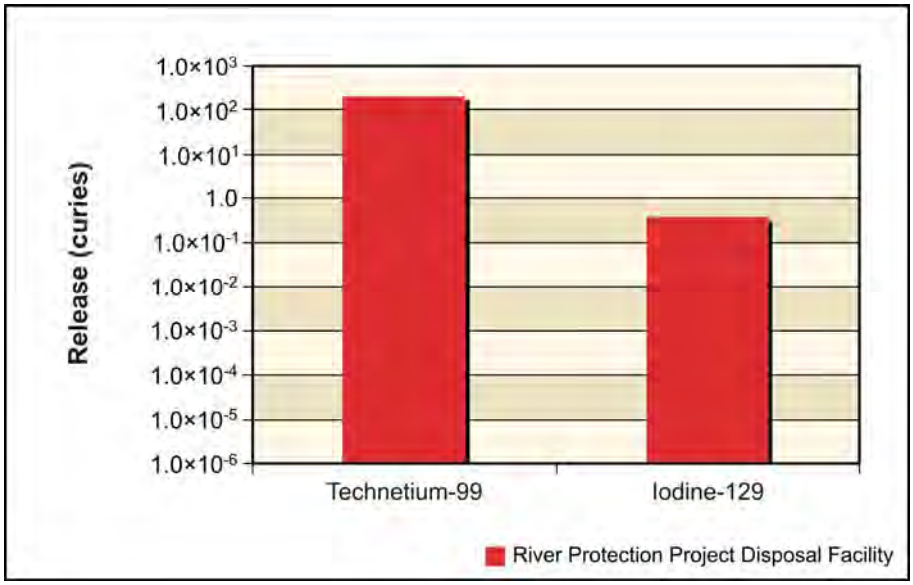


Figure 5–1077. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

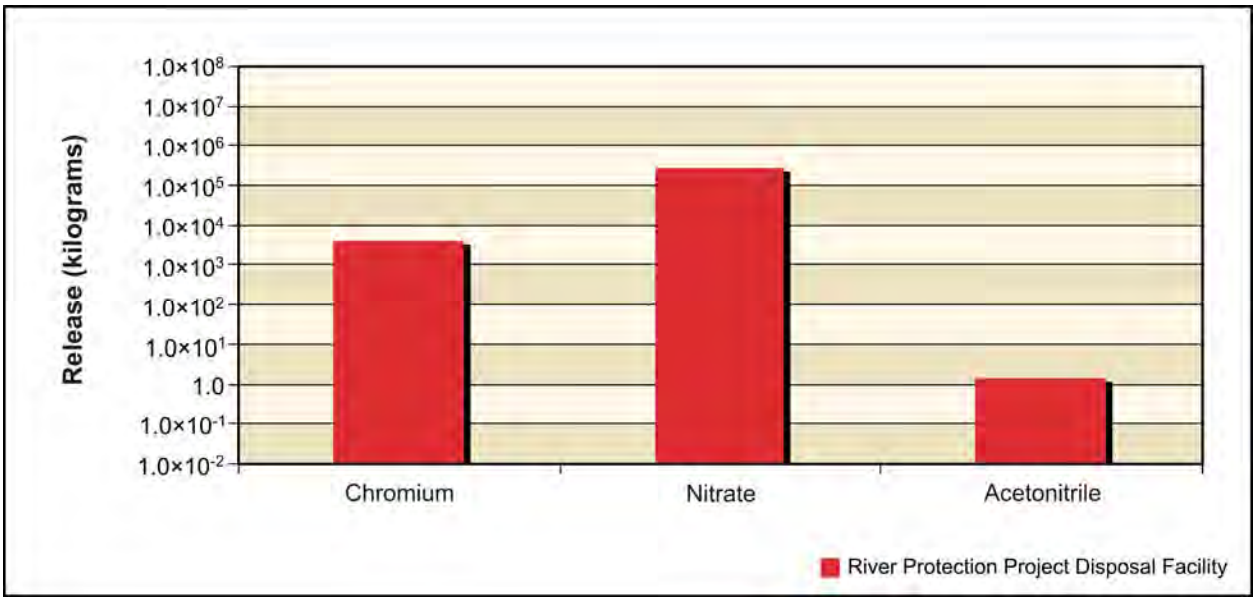


Figure 5–1078. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1079 shows the release to groundwater for the radiological risk drivers and Figure 5–1080, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclides (curies) released to the vadose zone during the period of analysis reach the groundwater; also, approximately 100 percent of the chemicals (kilograms) do.

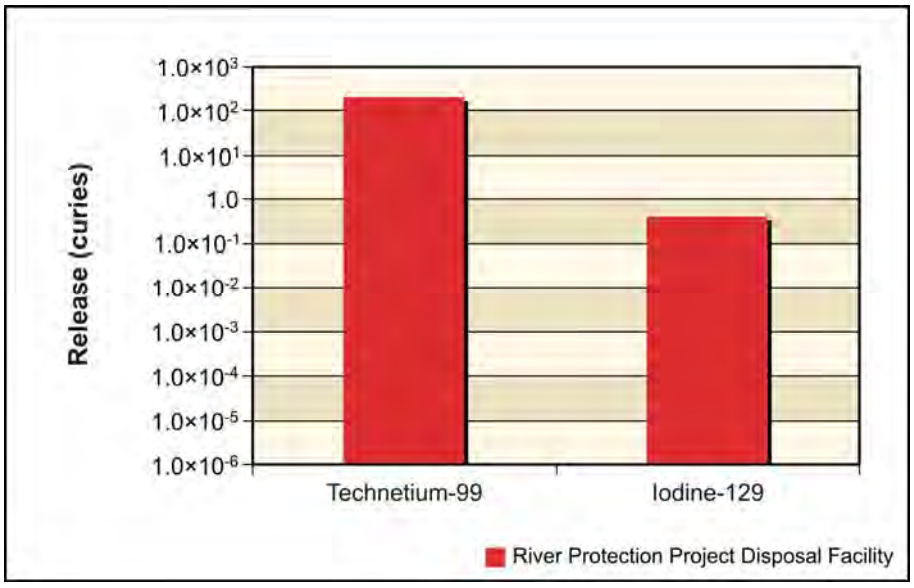


Figure 5–1079. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

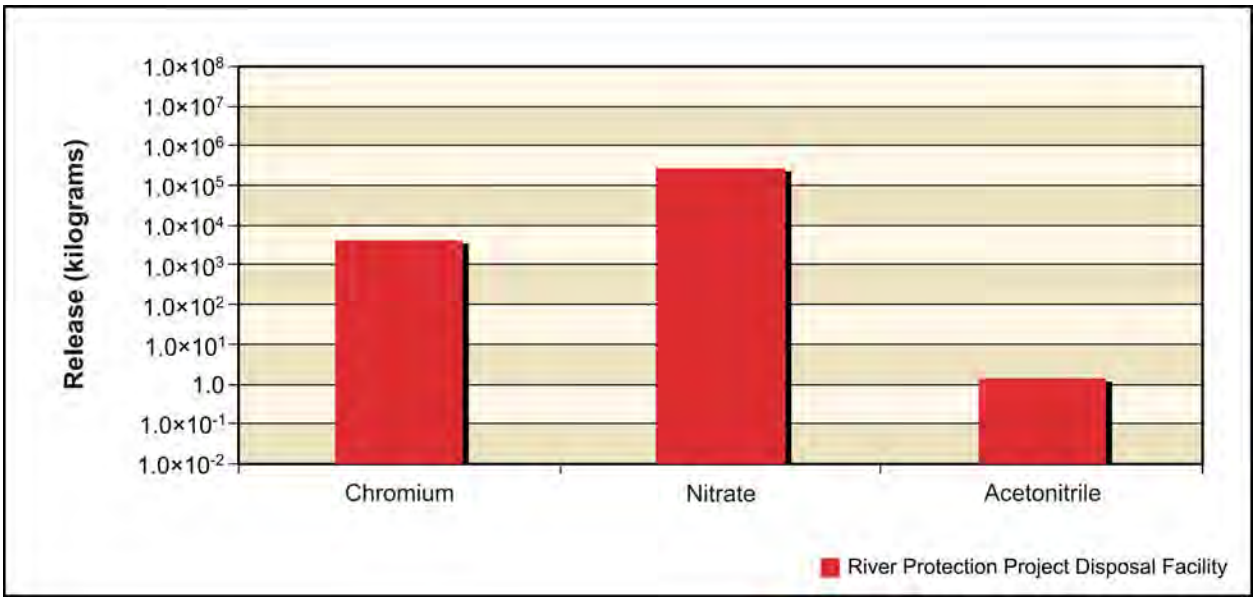


Figure 5–1080. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1081 shows the release to the Columbia River for the radiological risk drivers and Figure 5–1082, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 95 percent of the radionuclides (curies) released to the groundwater during the period of analysis reach the river; likewise, 95 percent of the chemicals (kilograms) do.

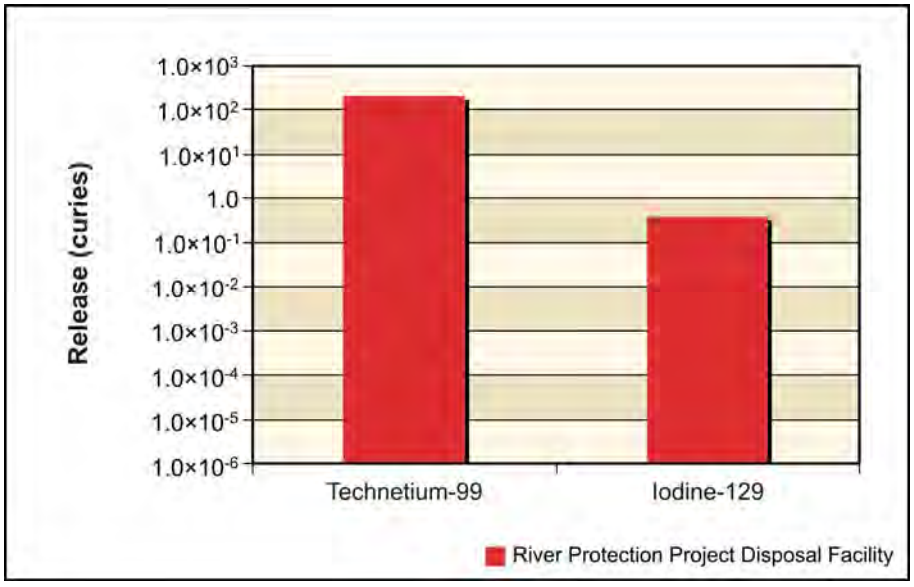


Figure 5–1081. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

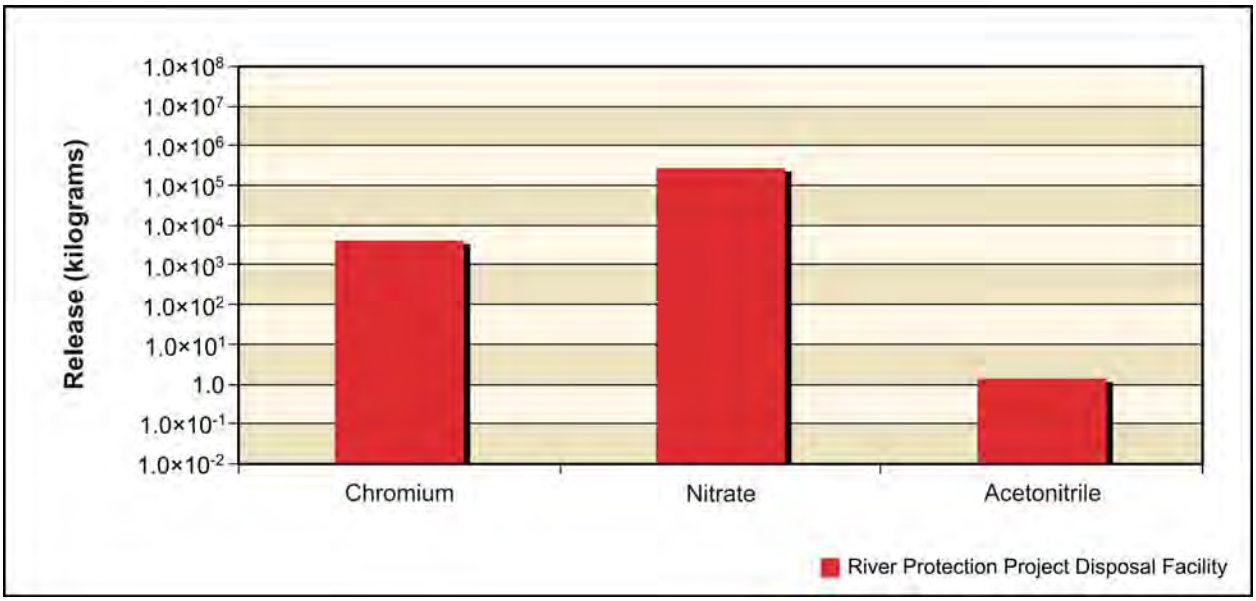


Figure 5–1082. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–1083 through 5–1086 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East, IDF-West, and the RPPDF cause groundwater concentrations of iodine-129 to exceed benchmark concentrations at the Core Zone Boundary and the Columbia River nearshore by approximately one order of magnitude. Iodine-129 exceeds the benchmark in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak lasts only for about 10 percent of the period of analysis. Technetium-99 sporadically exceeds the benchmark at the Columbia River nearshore, and the 95th percentile upper confidence limit is within an order of magnitude below the benchmark for most of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or the Columbia River nearshore. Table 5–99 shows the maximum concentrations in groundwater.

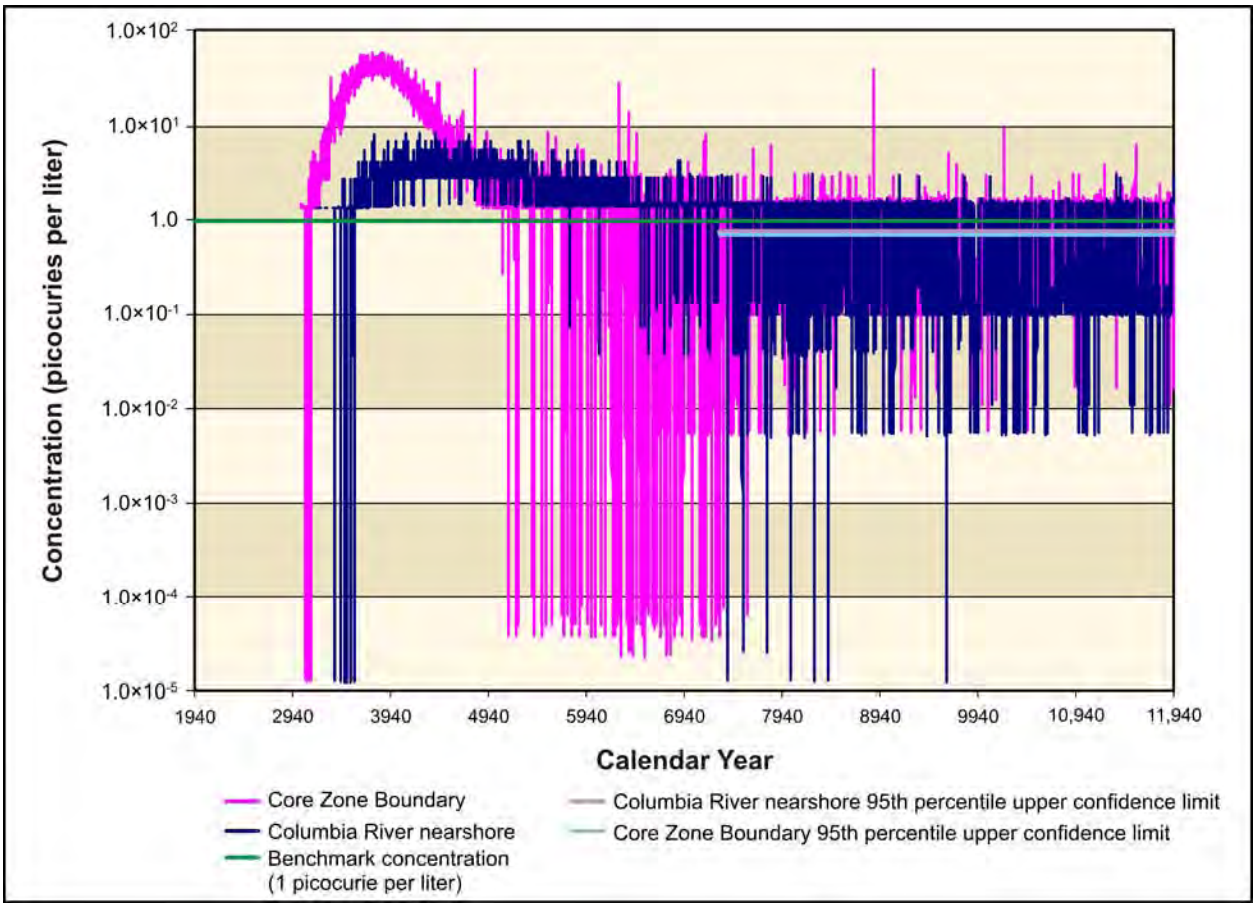


Figure 5–1083. Waste Management Alternative 3, Disposal Group 3, Base Case, Iodine-129 Concentration Versus Time

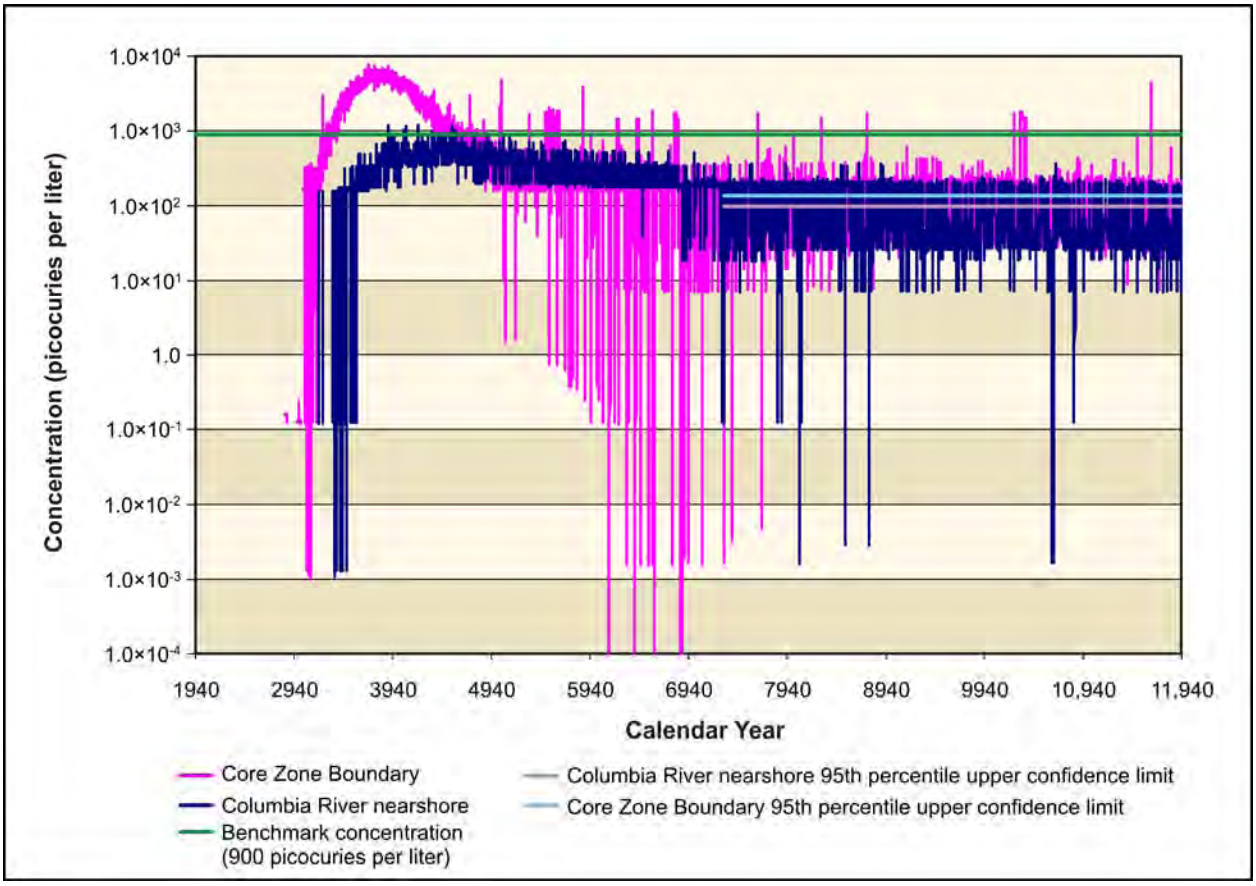


Figure 5–1084. Waste Management Alternative 3, Disposal Group 3, Base Case, Technetium-99 Concentration Versus Time

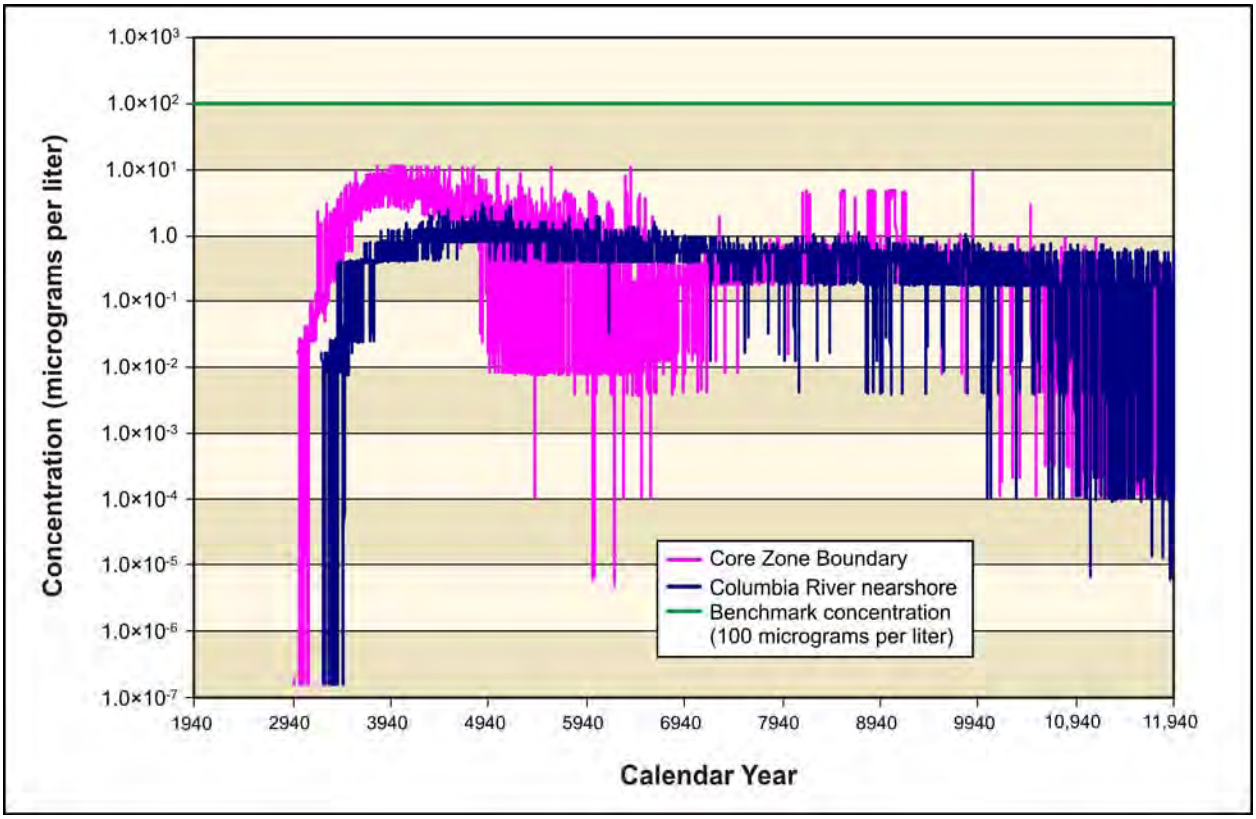


Figure 5–1085. Waste Management Alternative 3, Disposal Group 3, Base Case, Chromium Concentration Versus Time

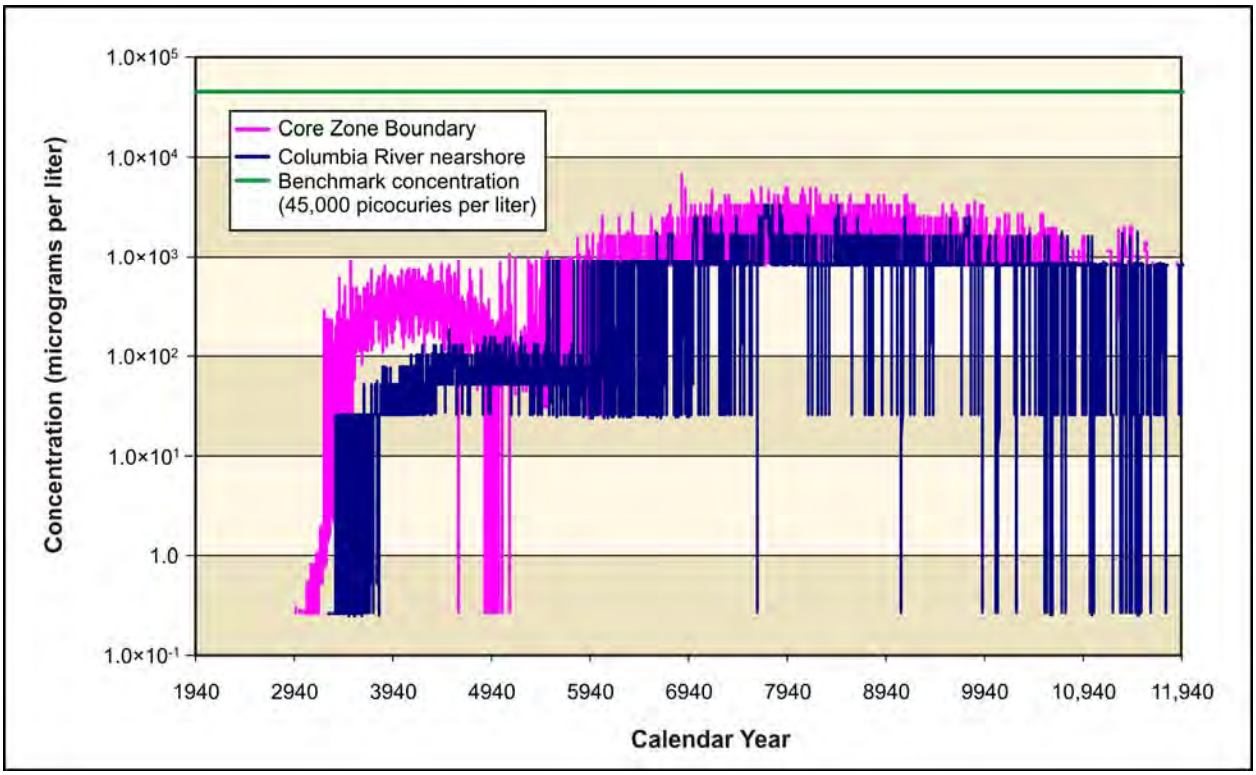


Figure 5–1086. Waste Management Alternative 3, Disposal Group 3, Base Case, Nitrate Concentration Versus Time

Table 5–99. Waste Management Alternative 3, Disposal Group 3, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	389	**20,200**	303	**7,770**	**1,180**	900
	(9324)	(3713)	(3987)	(3690)	(4186)	
Iodine-129	**2**	**173**	0.5	**61**	**8**	1
	(11,096)	(3797)	(4073)	(3853)	(4392)	
Chemical in micrograms per liter						
Chromium	3	2	6	12	3	100
	(8037)	(3696)	(4109)	(4035)	(4877)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	404	6,550	3,310	45,000
	(7367)	(3703)	(4001)	(6859)	(7717)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–1087 and 5–1088 show concentration versus time for uranium-238 and total uranium. Because uranium-238 and total uranium are slow moving through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 and total uranium concentrations, while minimal, continue to rise throughout the duration of the period of analysis, but never exceed benchmark concentrations by more than three orders of magnitude by the end of the period of analysis.

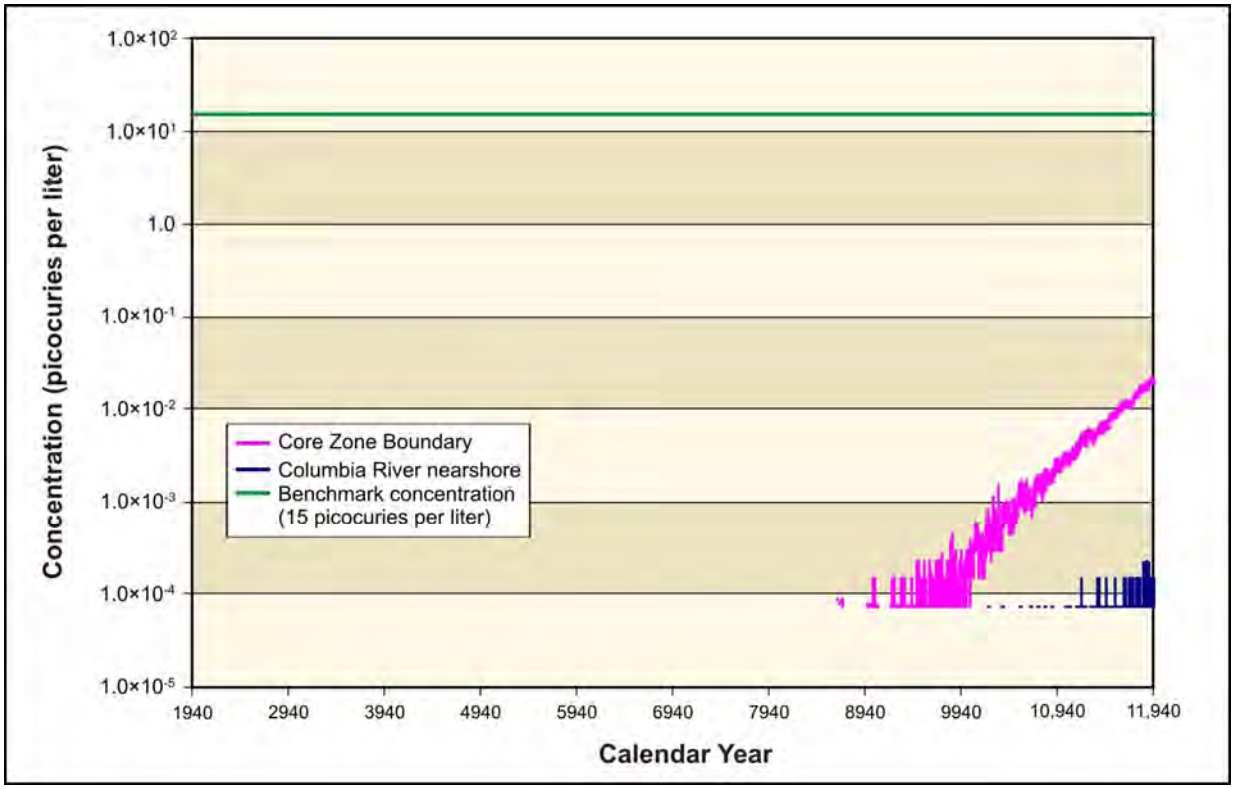


Figure 5–1087. Waste Management Alternative 3, Disposal Group 3, Base Case, Uranium-238 Concentration Versus Time

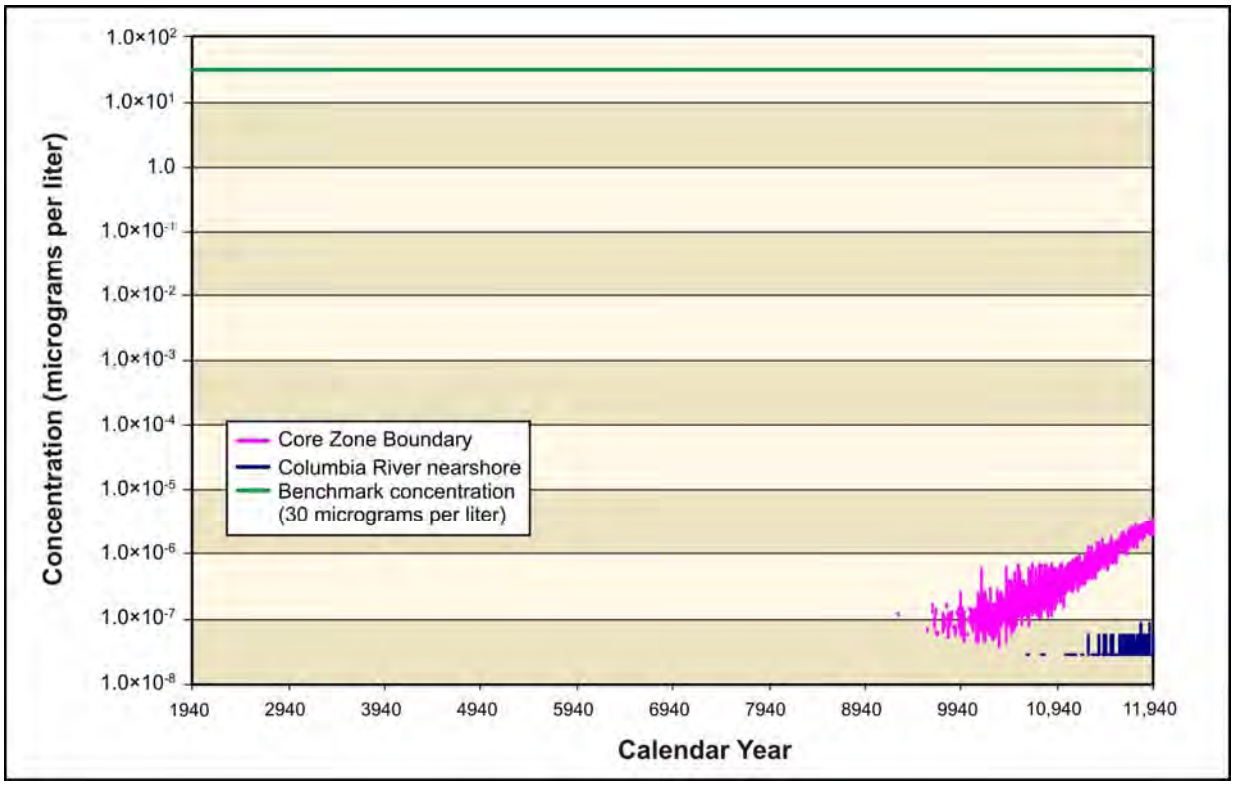


Figure 5–1088. Waste Management Alternative 3, Disposal Group 3, Base Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–1089 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from IDF-West and the RPPDF result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area eastward toward the Columbia River (see Figure 5–1090). Also by CY 7140, most of the IDF-West and RPPDF plume continues to move north and reaches the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River with only small, isolated pockets exceeding the benchmark concentration (see Figure 5–1091). Technetium-99 (see Figures 5–1092 through 5–1094) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–1095 through 5–1097), and nitrate (see Figures 5–1098 through 5–1100) show similar spatial distributions at selected times, but the peak concentrations are lower than iodine-129 and technetium-99 relative to their respective benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).

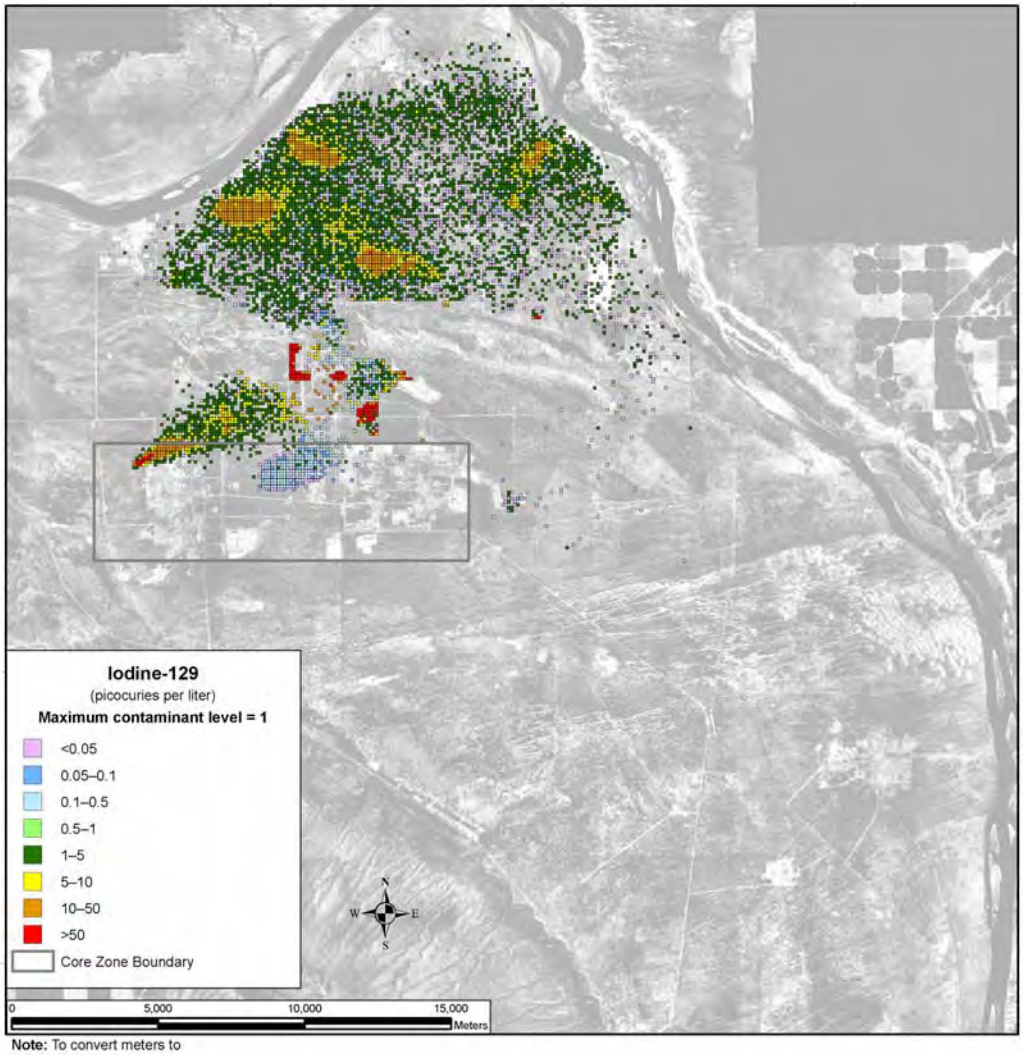


Figure 5–1089. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

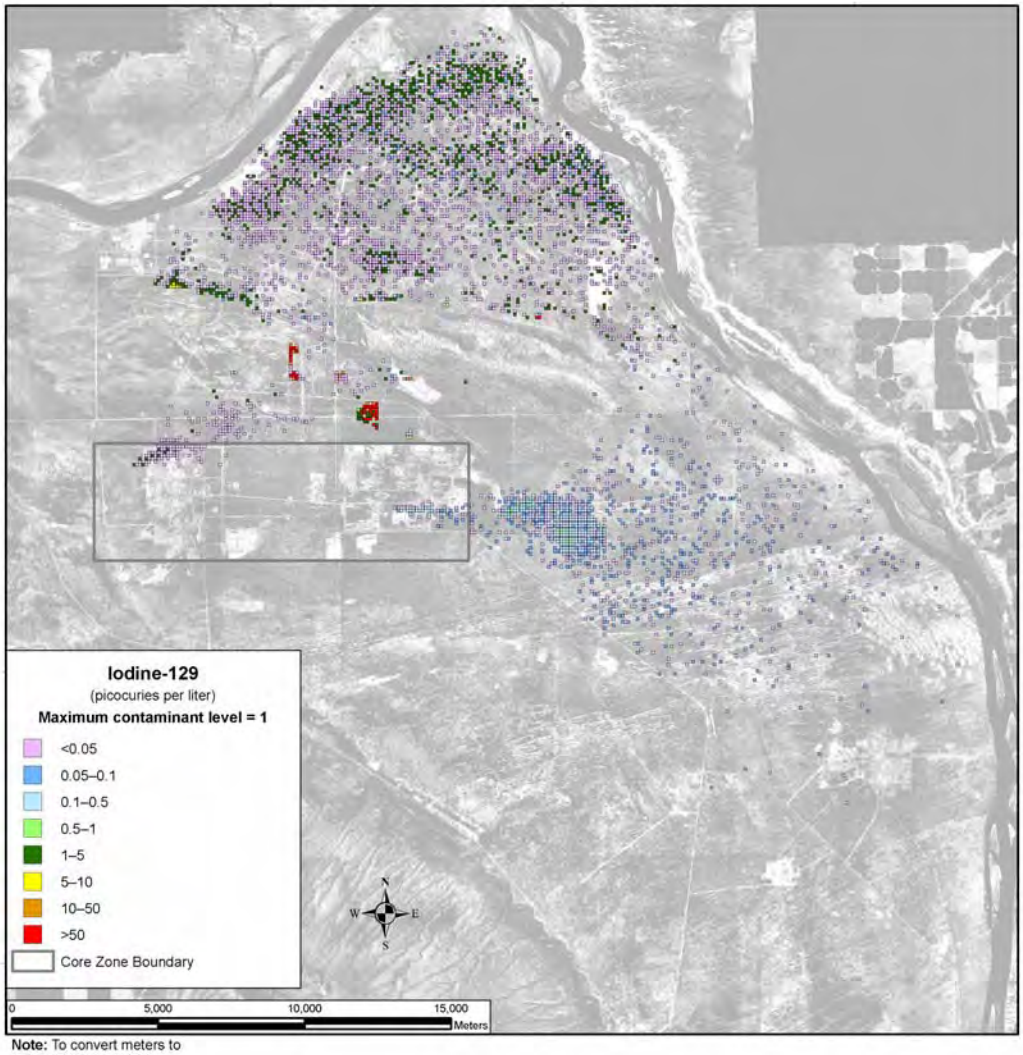


Figure 5–1090. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

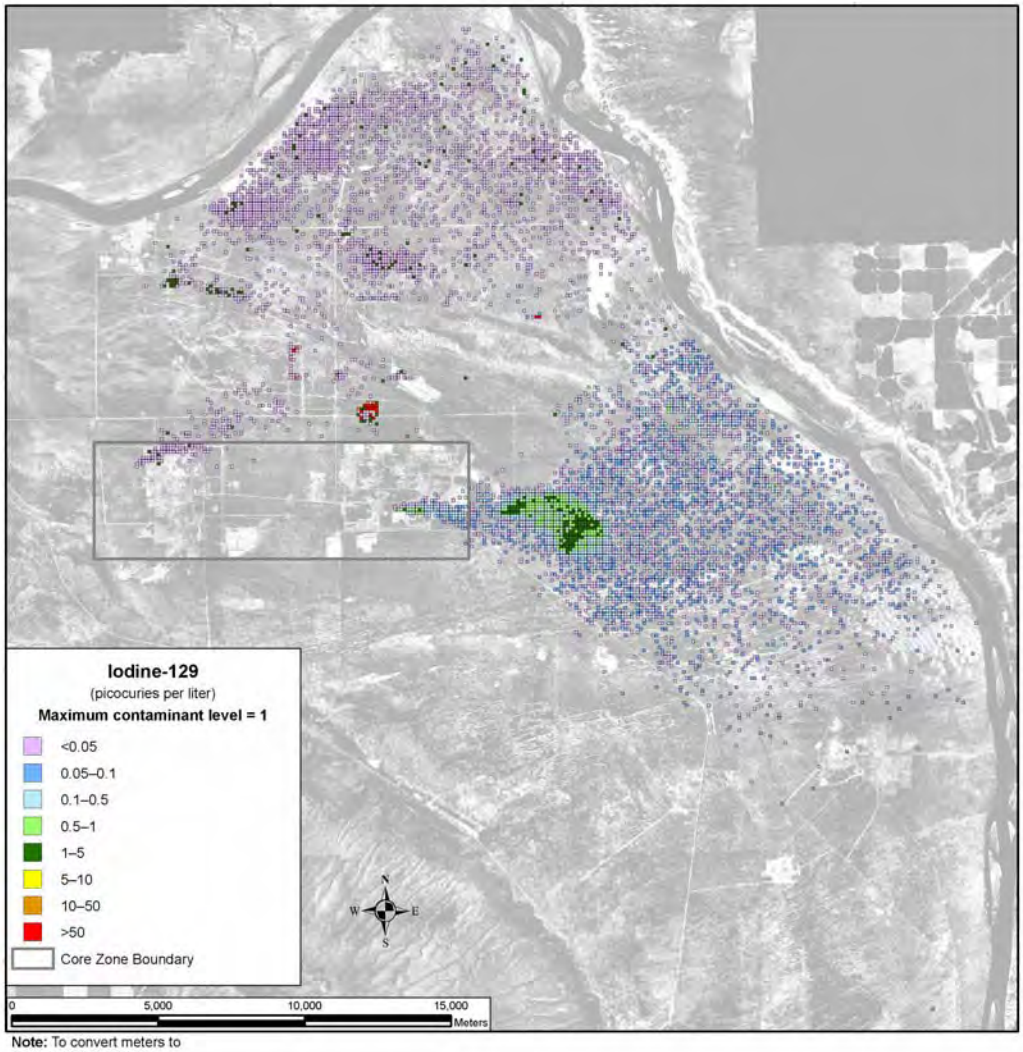


Figure 5–1091. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

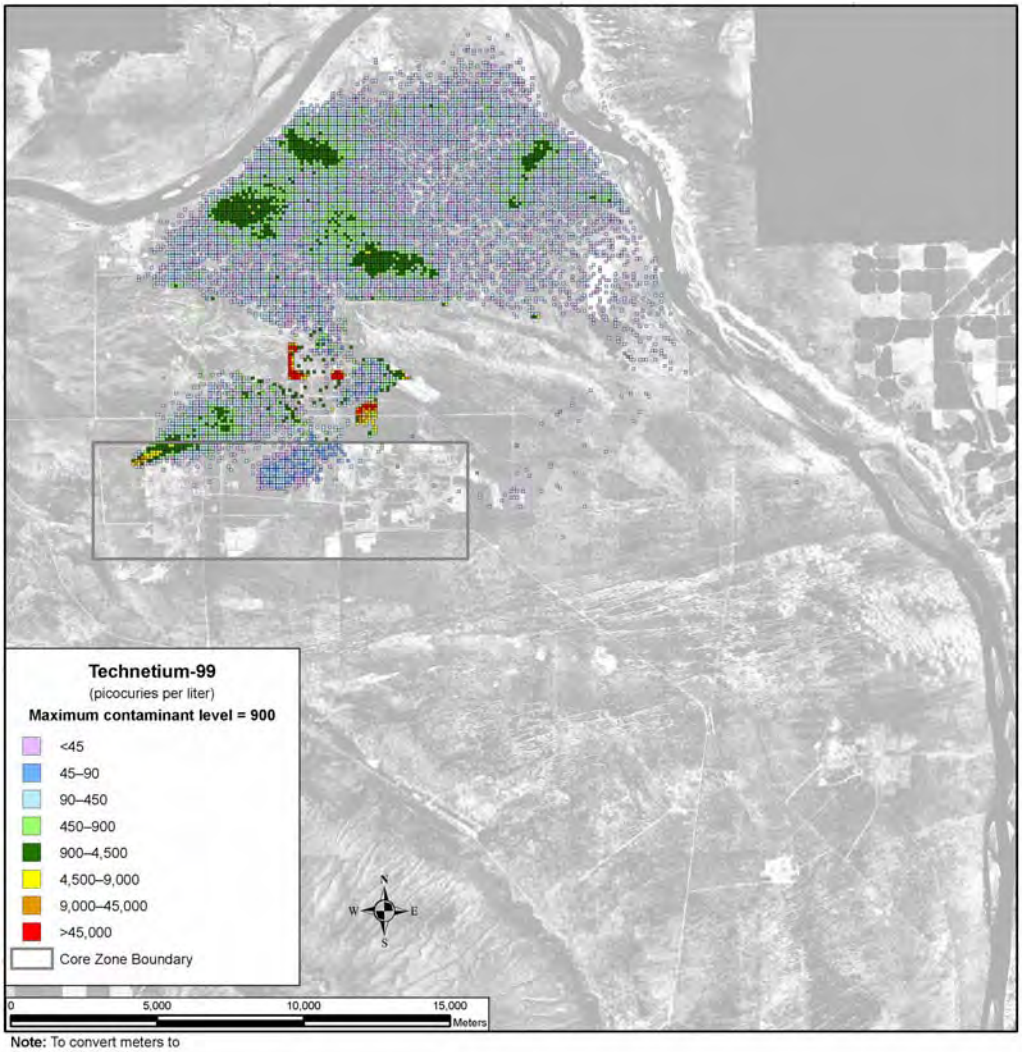


Figure 5–1092. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

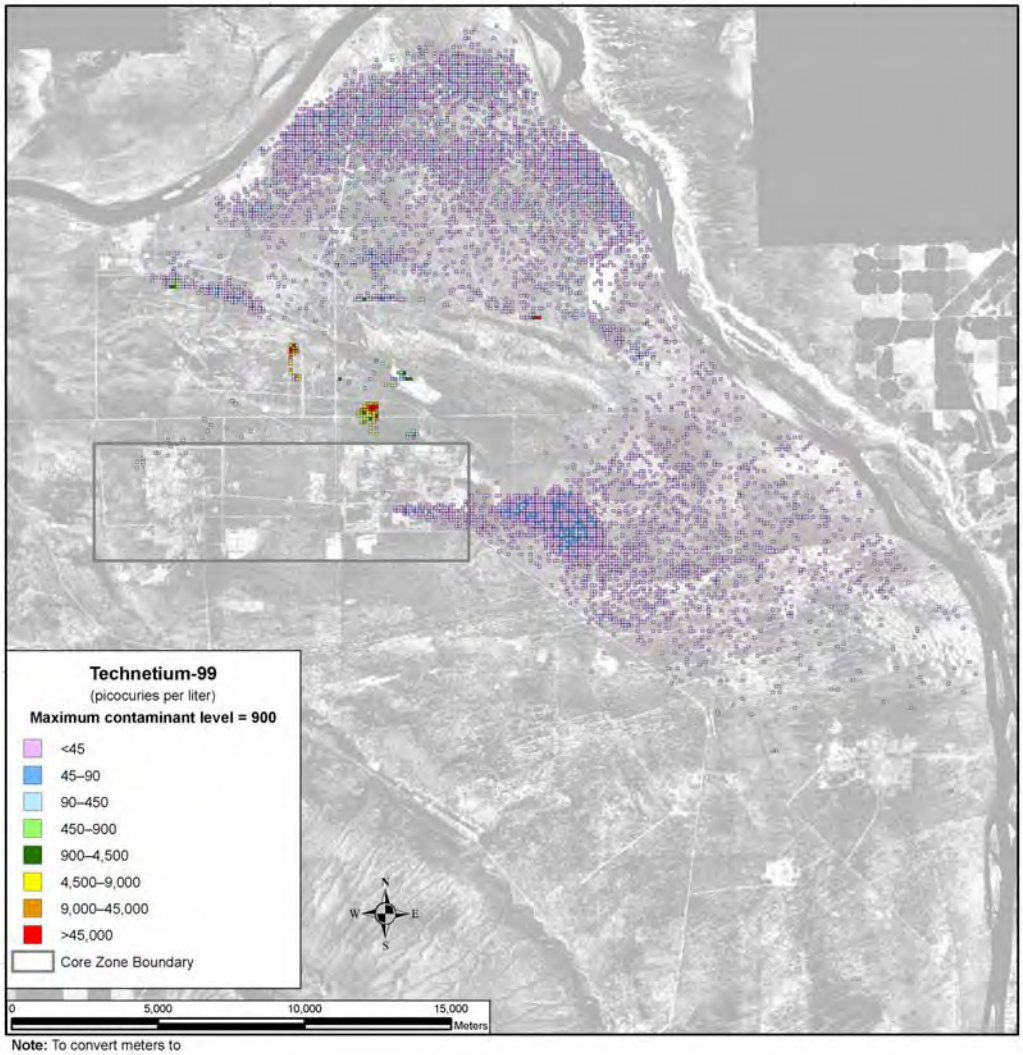


Figure 5–1093. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

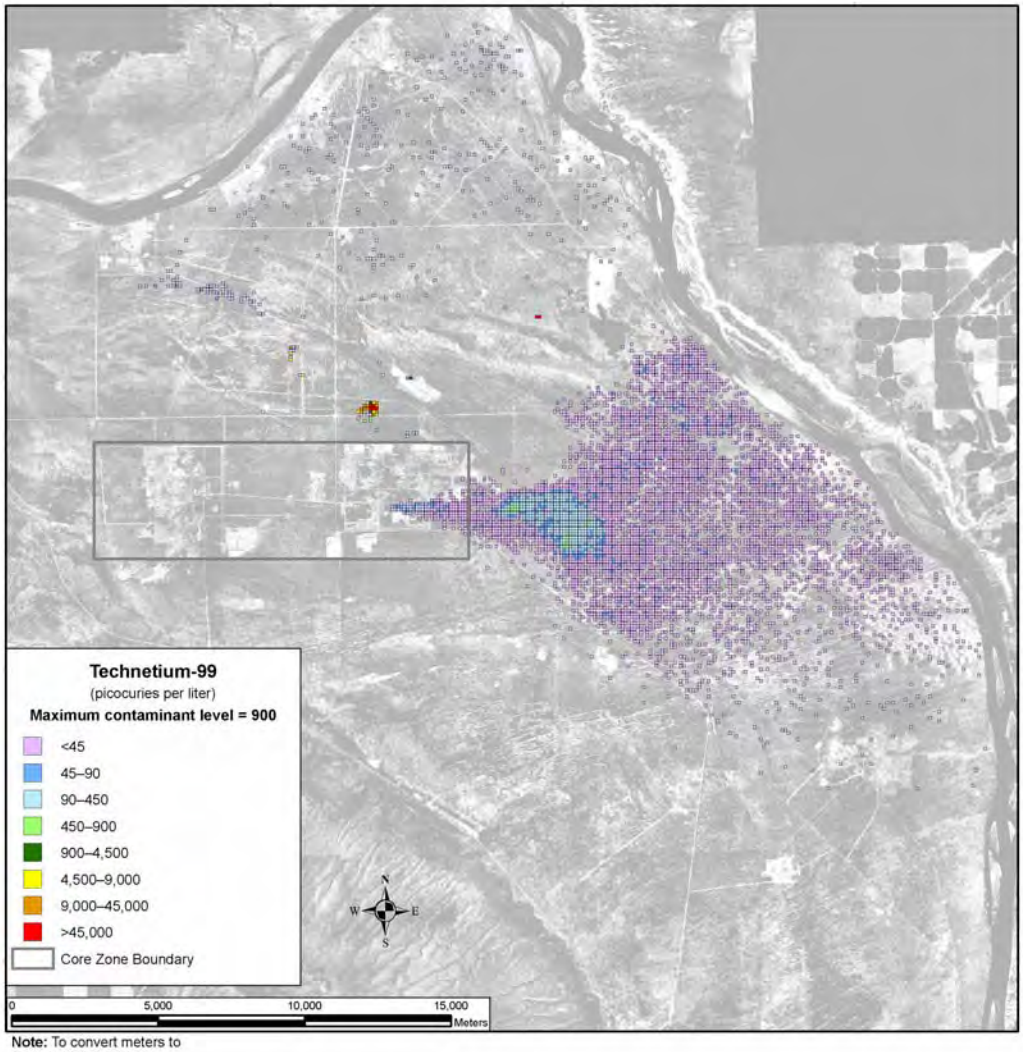


Figure 5–1094. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

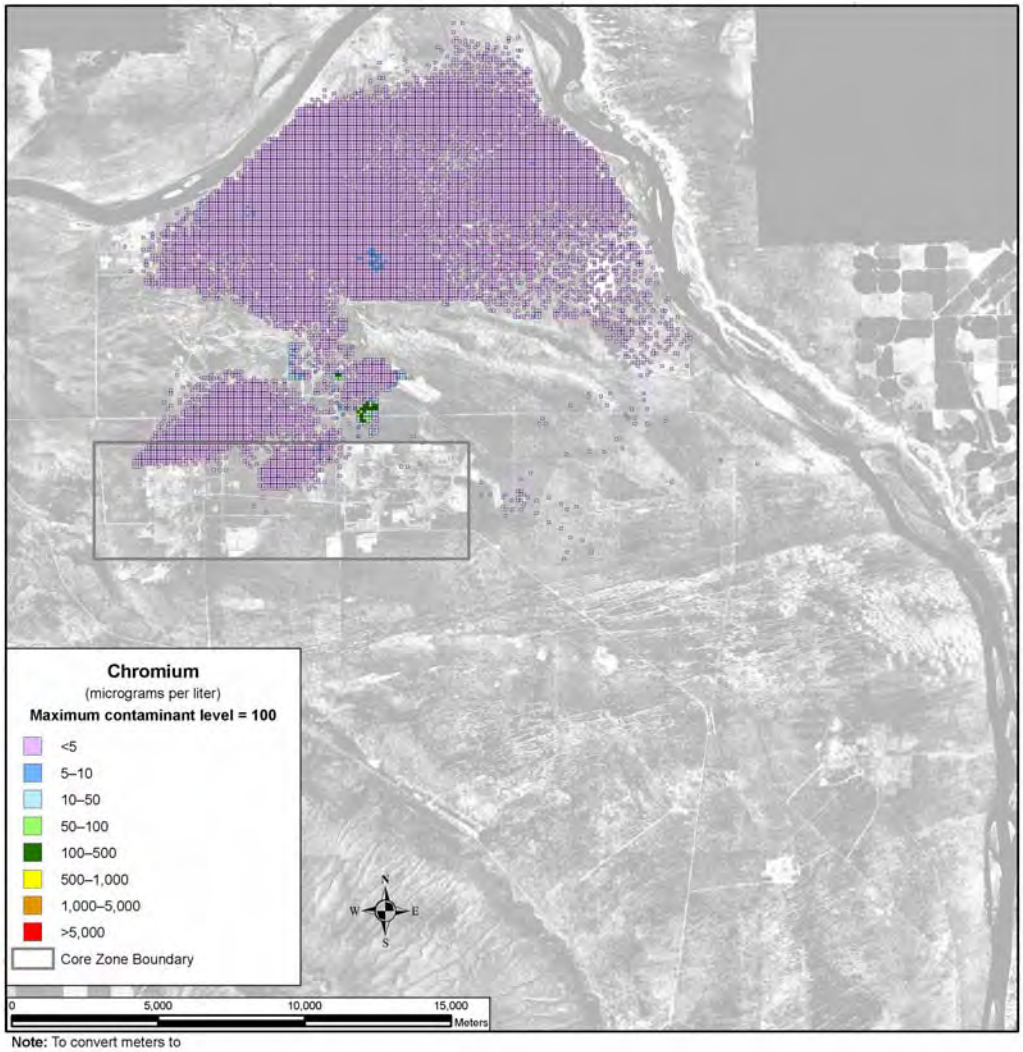


Figure 5–1095. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

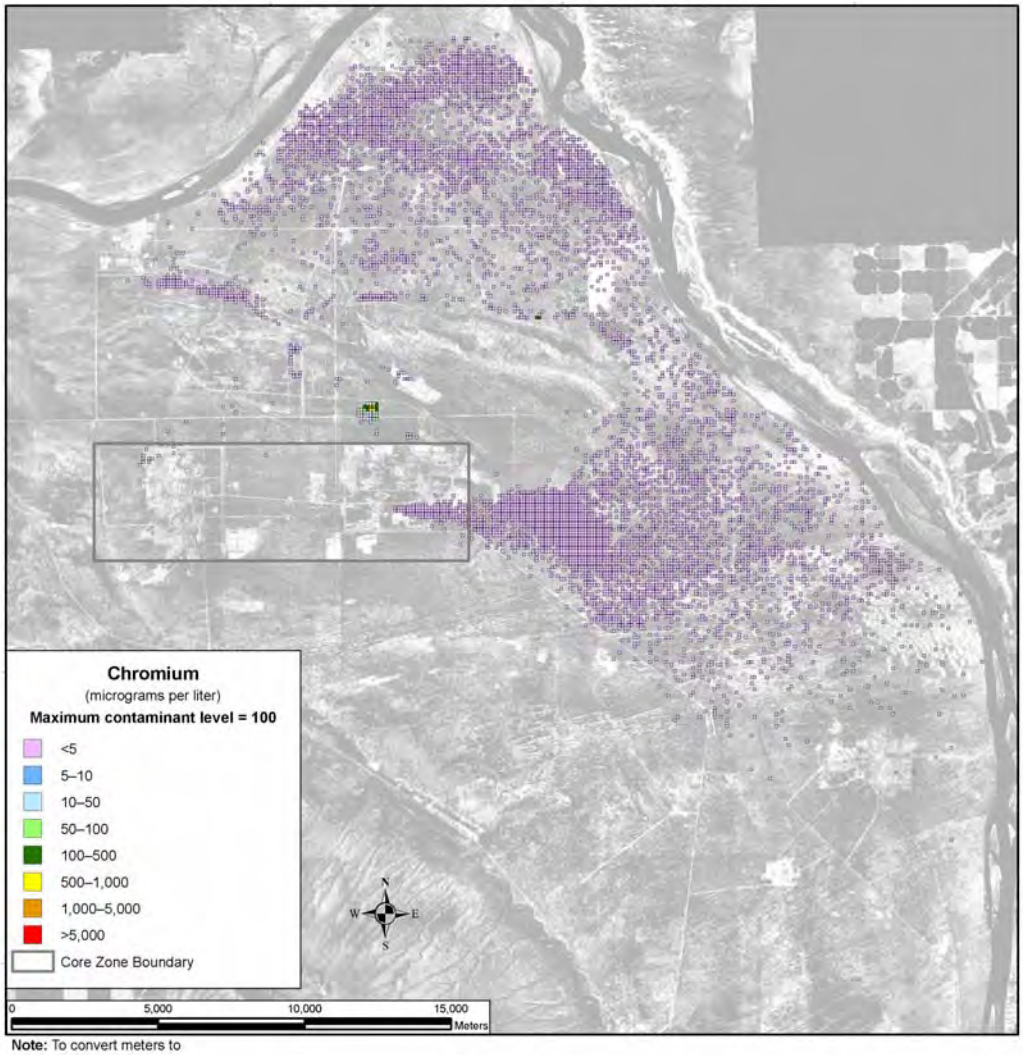


Figure 5–1096. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

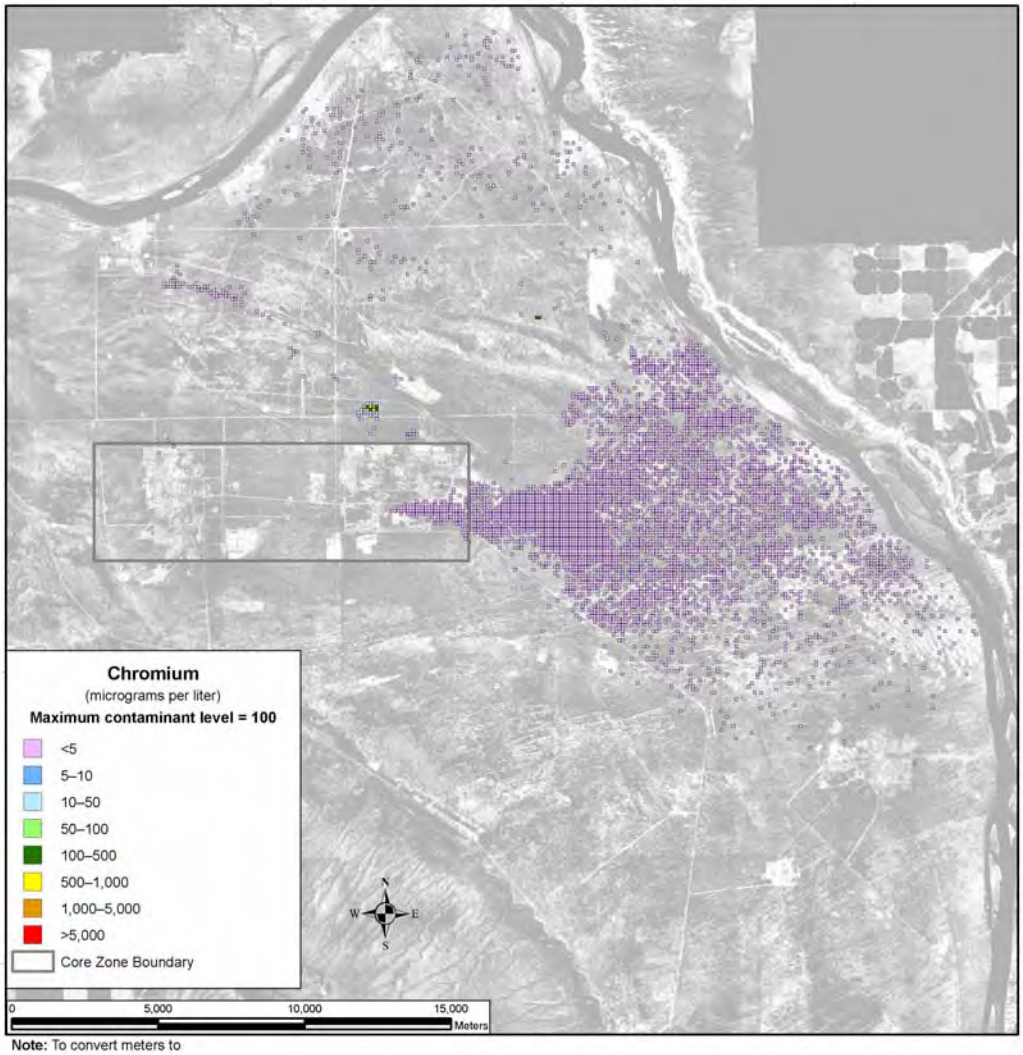


Figure 5–1097. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

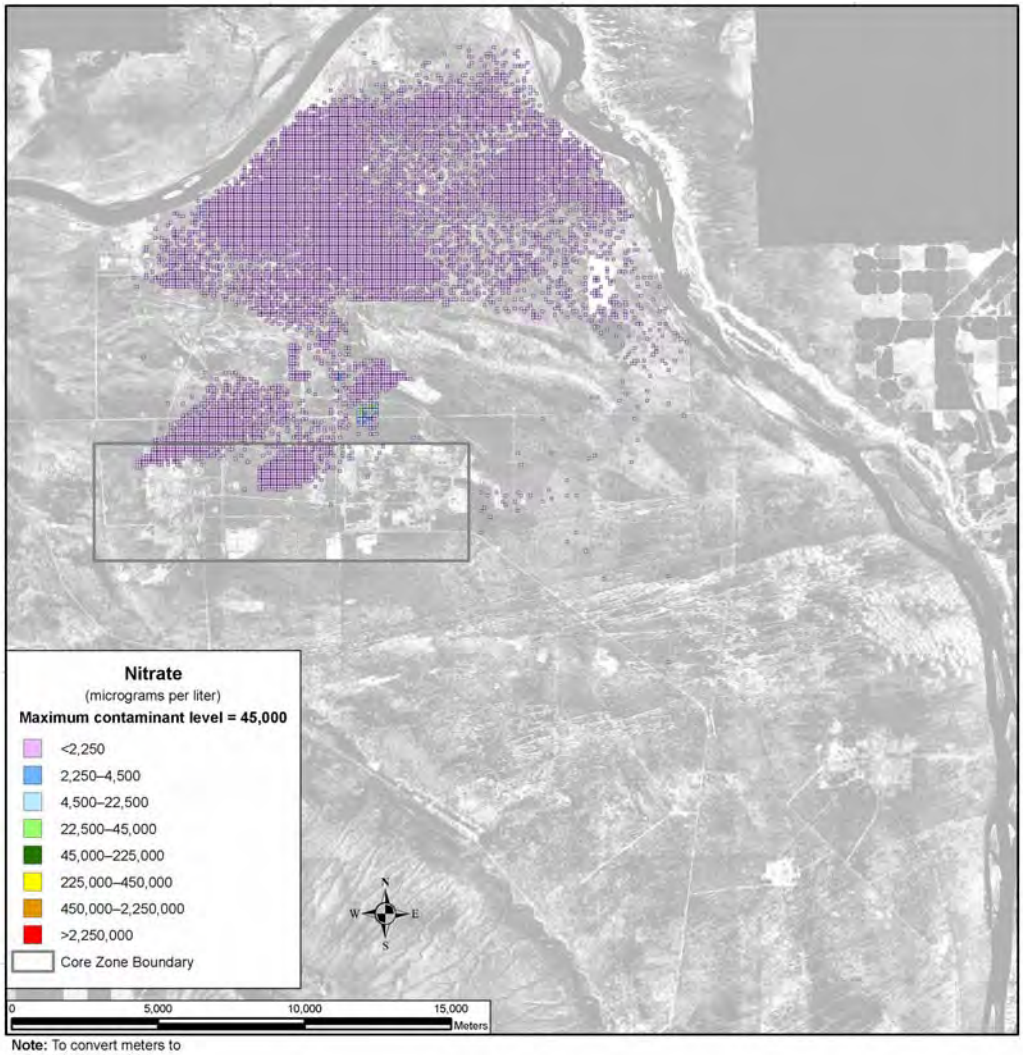


Figure 5–1098. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

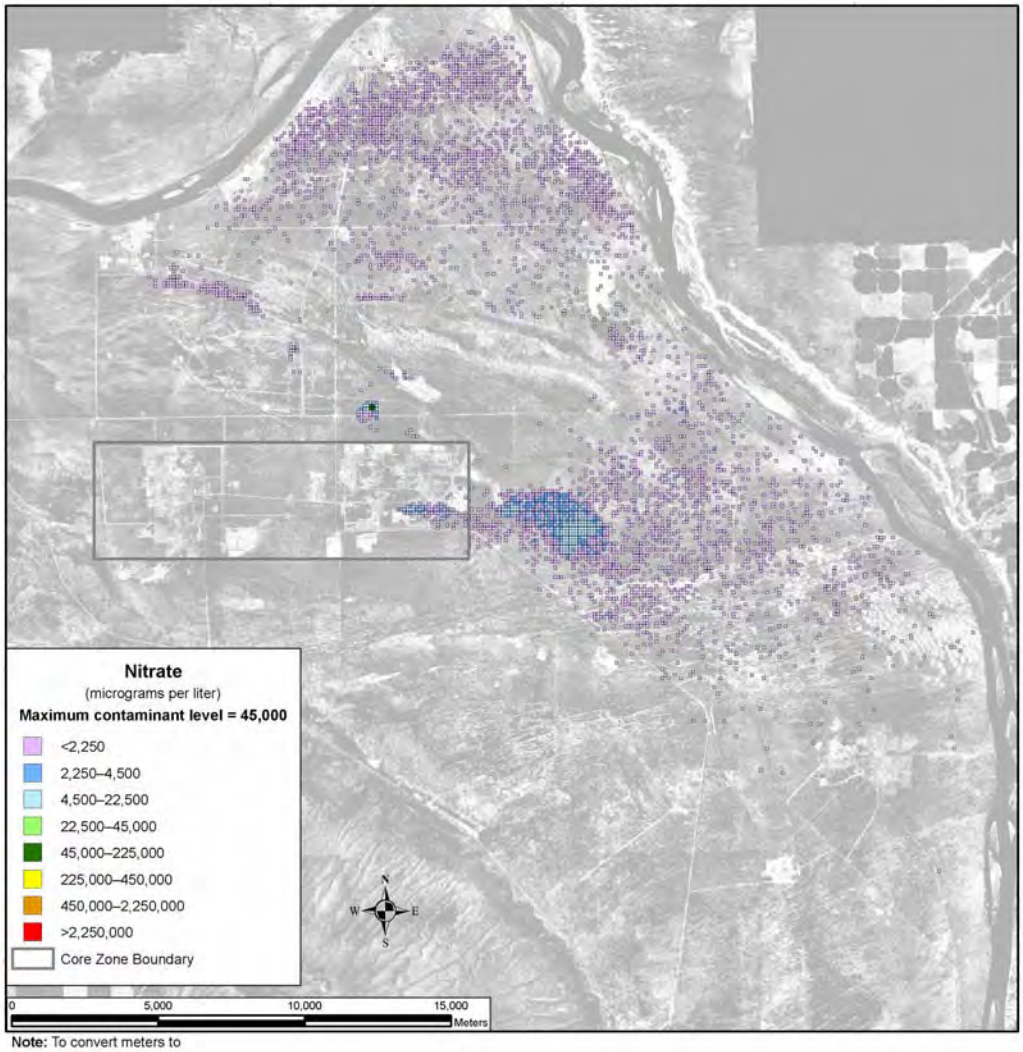


Figure 5–1099. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

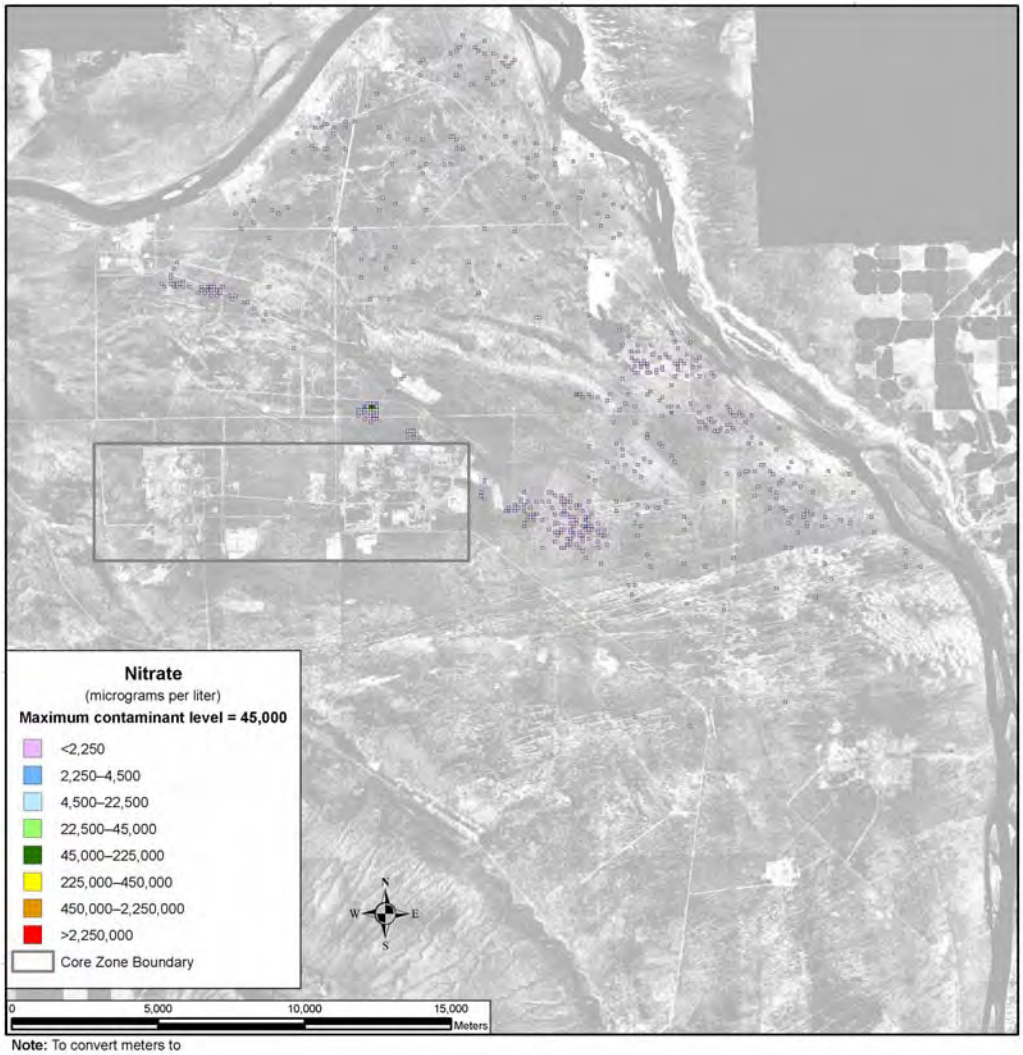


Figure 5–1100. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figures 5–1101 and 5–1102 show the distribution of uranium-238 and total uranium during CY 11,885. Releases from IDF-West and the RPPDF result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, concentrations in this plume do not exceed the benchmark concentration during the period of analysis.

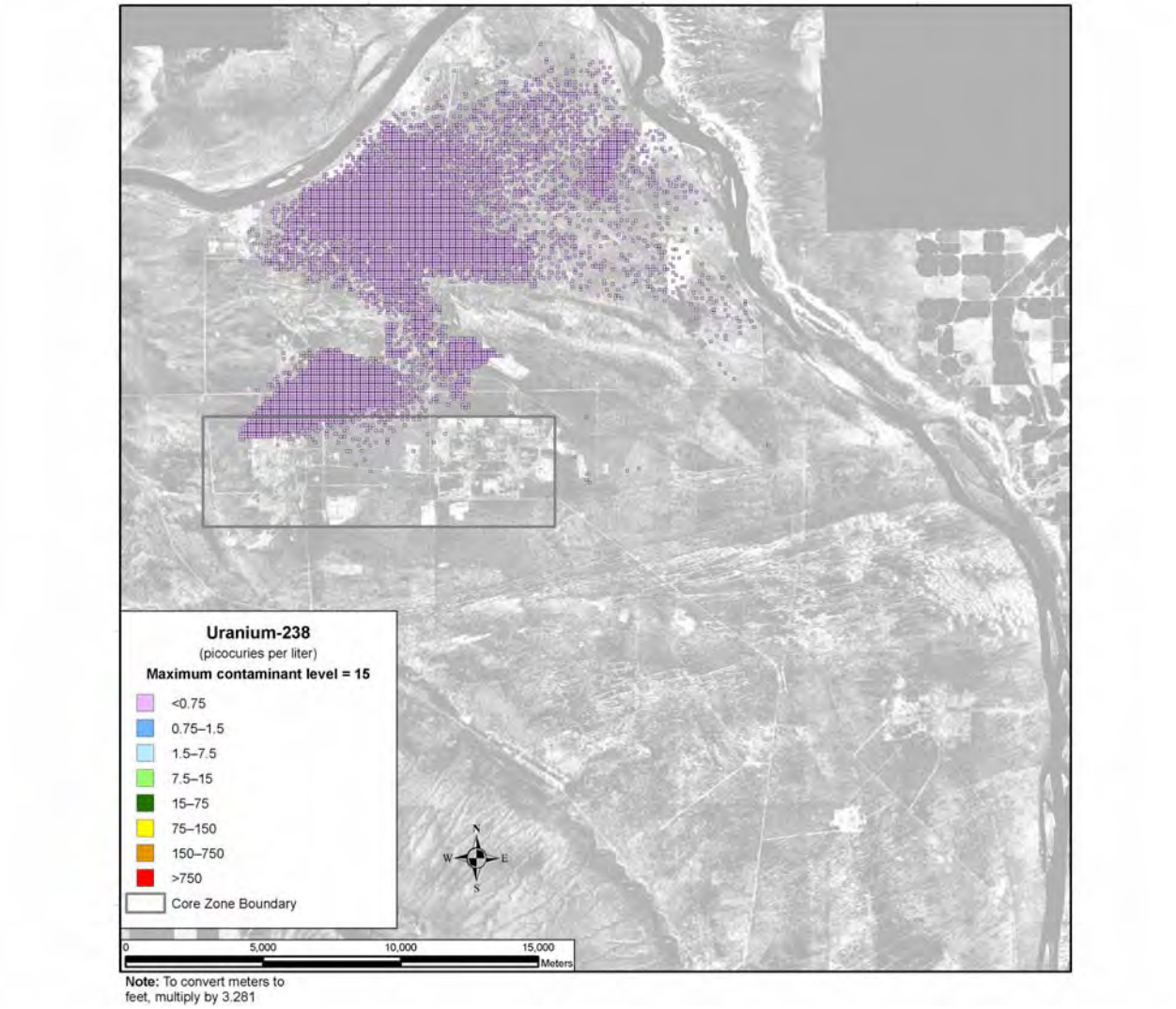


Figure 5–1101. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

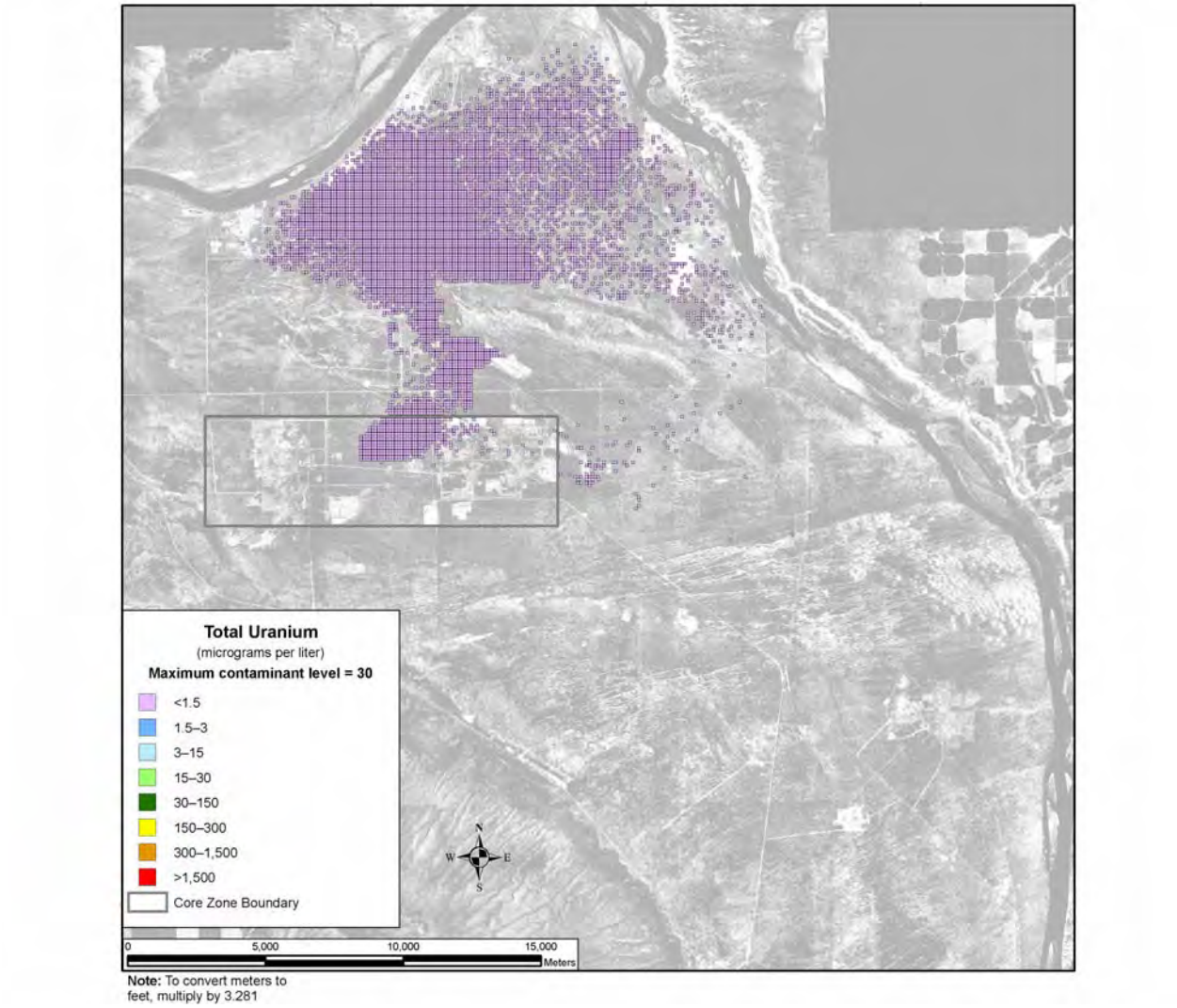


Figure 5–1102. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 3, Base Case, in general, the inventory remaining at IDF-East, IDF-West, and the RPPDF, which is available for release to the environment at the start of the post-disposal period, is the predominant contributor.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. Concentration at the Columbia River is about one to two orders of magnitude smaller. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

Uranium-238 and total uranium is limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River nearshore.

5.3.1.3.3.2 Disposal Group 3, Option Case

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 3, Option Case, includes Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 3, Option Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continues through CY 2165 when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2166 and continues through the 10,000-year period of analysis. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 3, Option Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 3, Option Case, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, boron, chromium, fluoride, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 3, Disposal Group 3, Option Case, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for 100 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 3, Option Case.

The COPC drivers that are discussed in detail in this section fall into two categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Three subtotals are plotted representing releases from ETF-generated secondary waste, PPF glass, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite-generated waste, offsite-generated waste, and the RPPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over seven orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–1103 shows the release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–1104, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant source of technetium-99 and chromium is tank closure secondary waste. ETF-generated secondary waste is the predominant source of iodine-129 and nitrate.

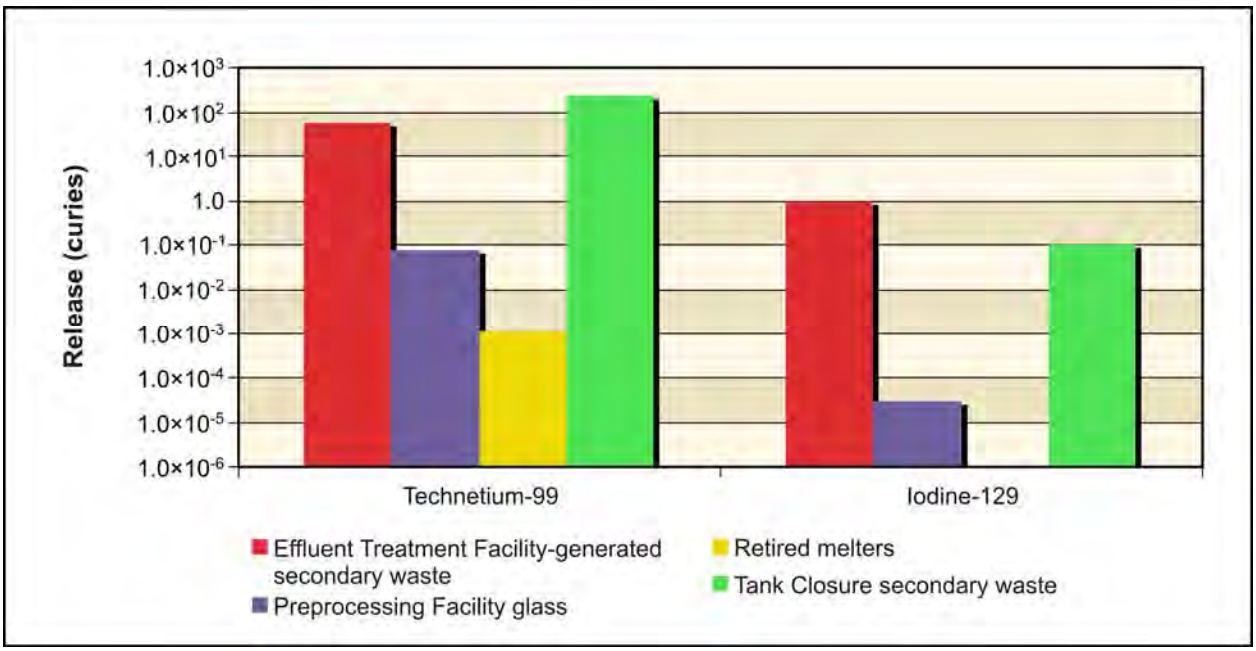


Figure 5–1103. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

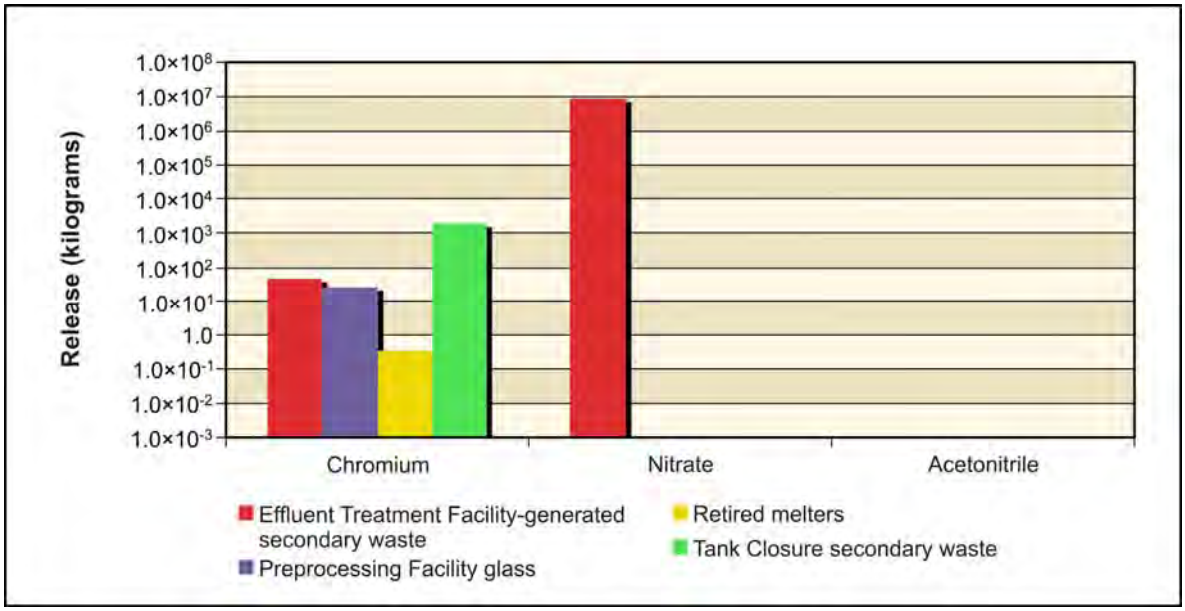


Figure 5–1104. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–1105 shows the release at IDF-East to groundwater for the radiological risk drivers and Figure 5–1106, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. With the exception of technetium-99 released from ETF-generated secondary waste, of which nearly all released to the vadose zone reaches groundwater, only 40 to 50 percent of the technetium-99 and iodine-129 released to the vadose zone reaches groundwater. Only 40 to 50 percent of the chromium originating in PPF glass and retired melters reaches groundwater. Essentially all of the chromium released from ETF-generated secondary waste and tank closure secondary waste reaches groundwater. Nearly all nitrate released to the vadose zone reaches groundwater.

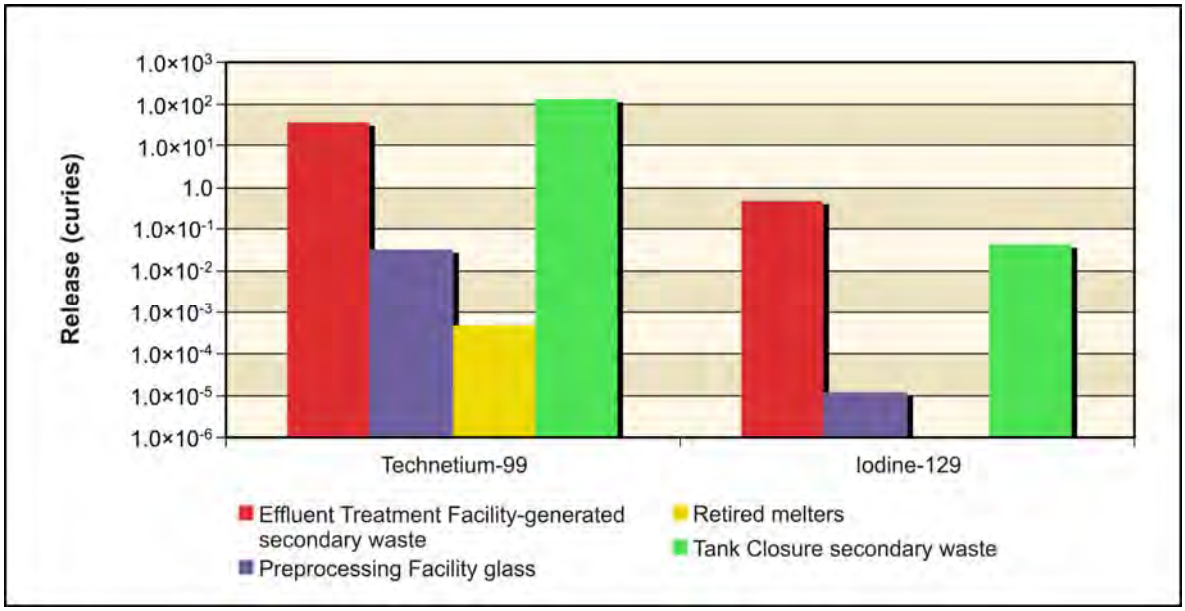


Figure 5–1105. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

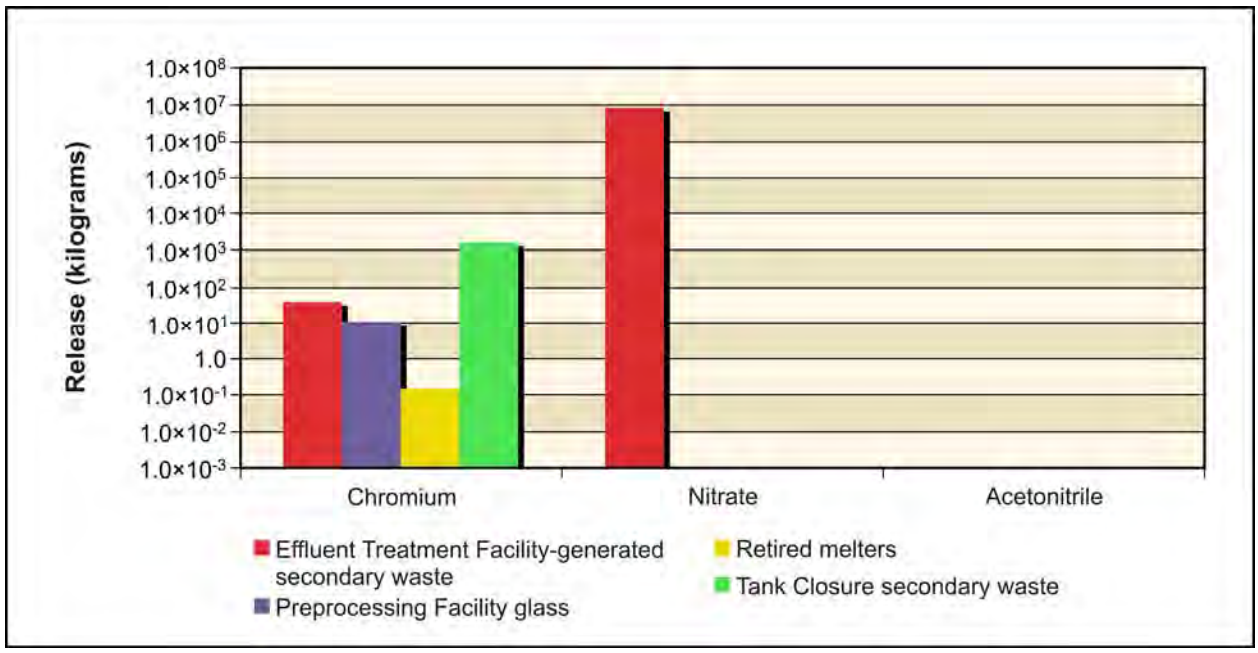


Figure 5–1106. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–1107 shows the release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–1108 the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In all cases, between 90 and 100 percent of the amount released to groundwater reaches the Columbia River.

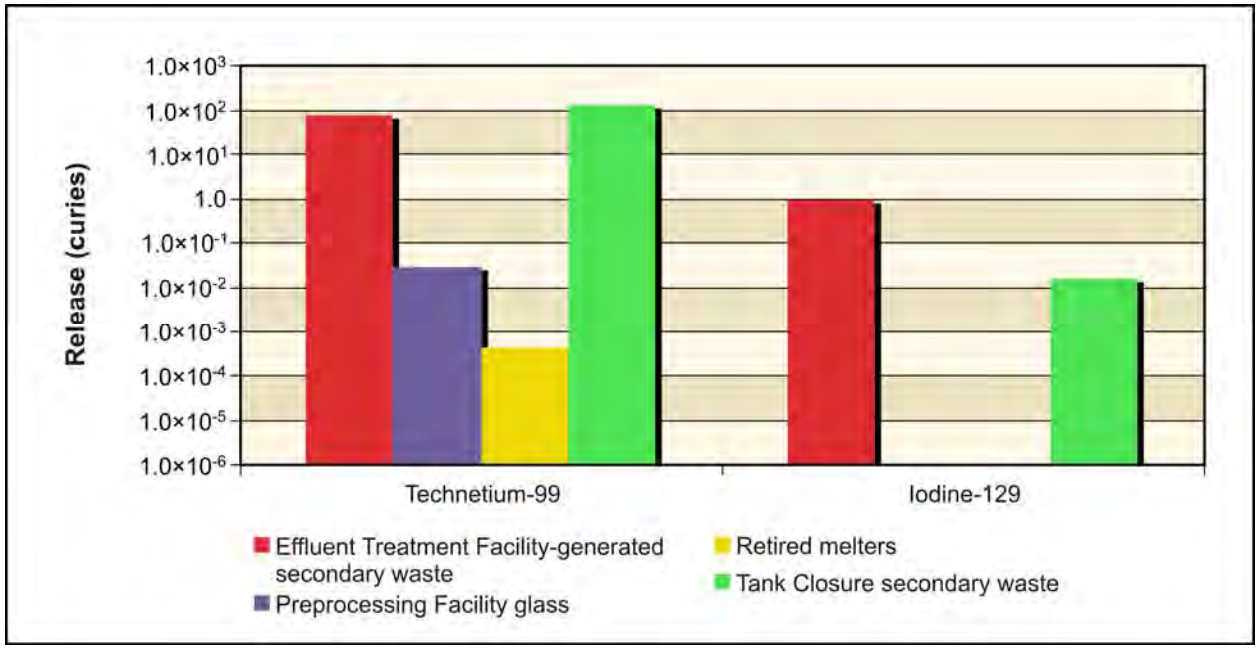


Figure 5–1107. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

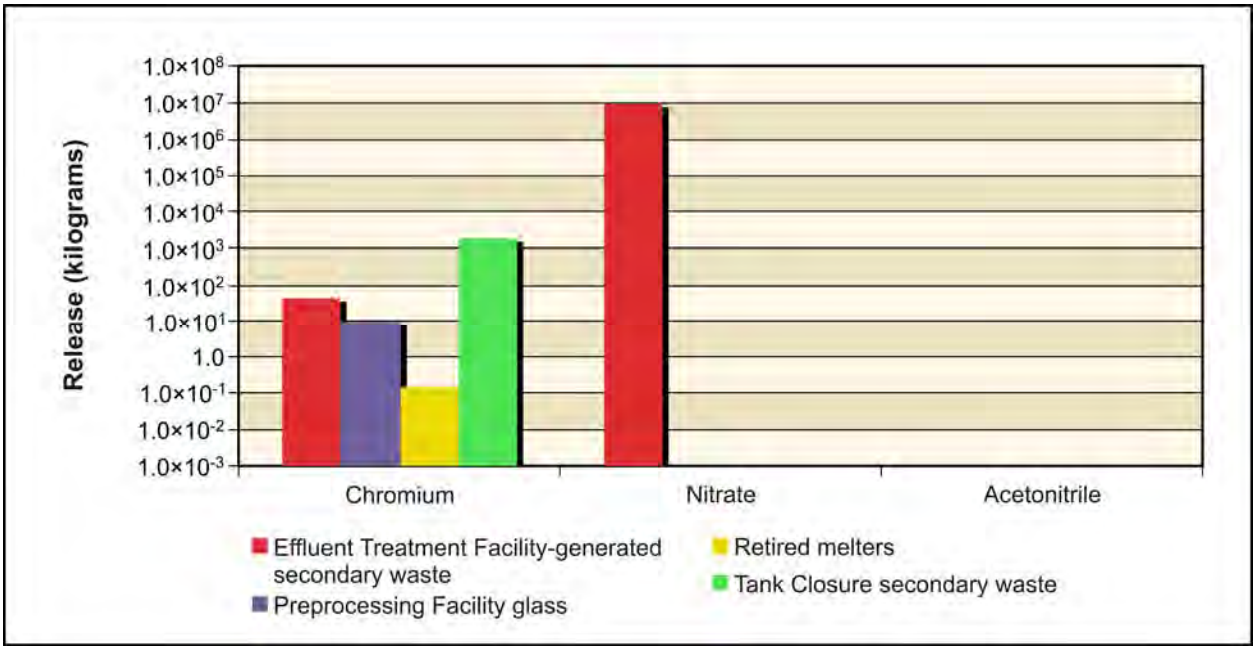


Figure 5–1108. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

Figure 5–1109 shows the release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–1110, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present in IDF-West.

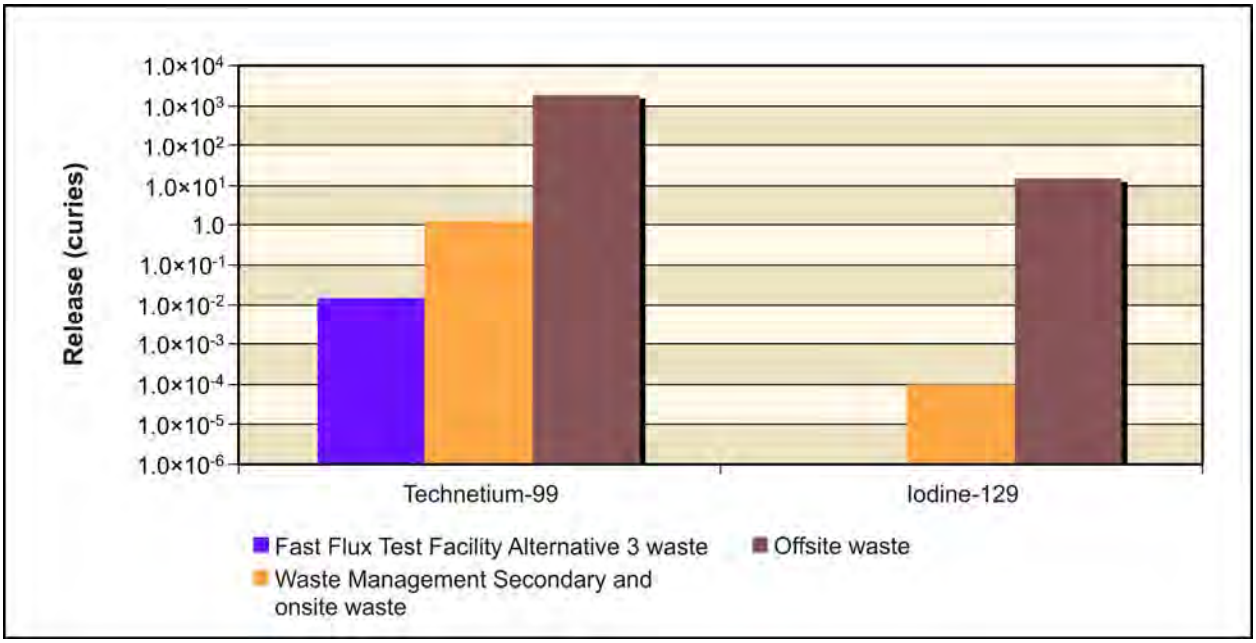


Figure 5–1109. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

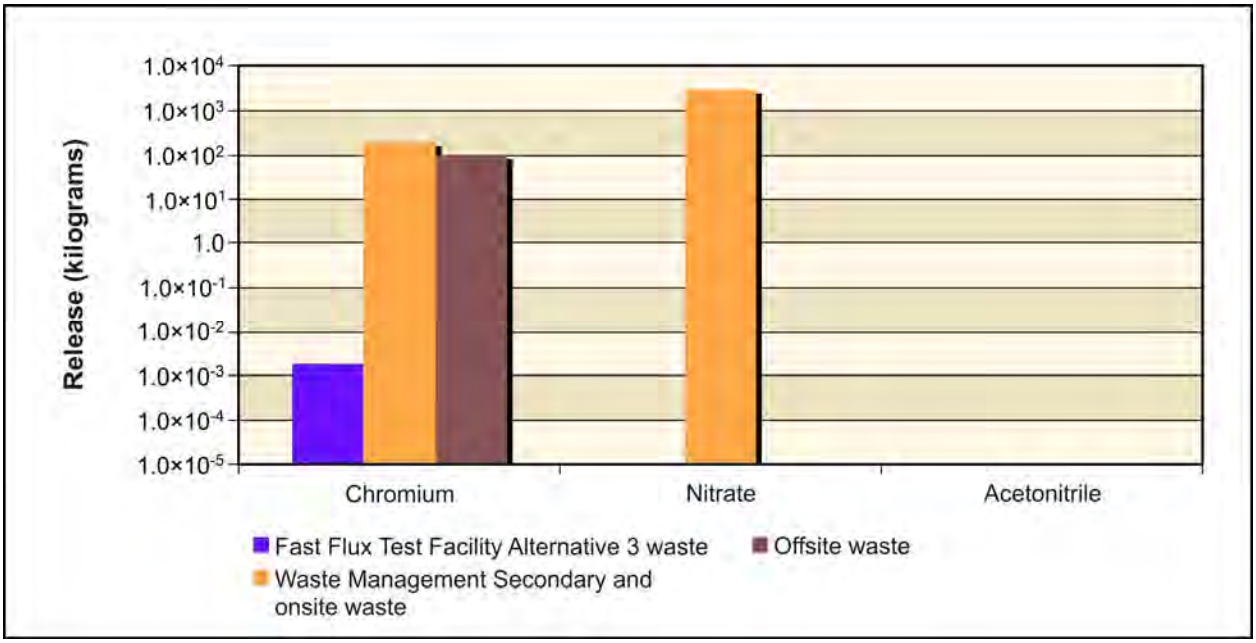


Figure 5–1110. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–1111 shows the release at IDF-West to groundwater for the radiological risk drivers and Figure 5–1112, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present in IDF-West behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

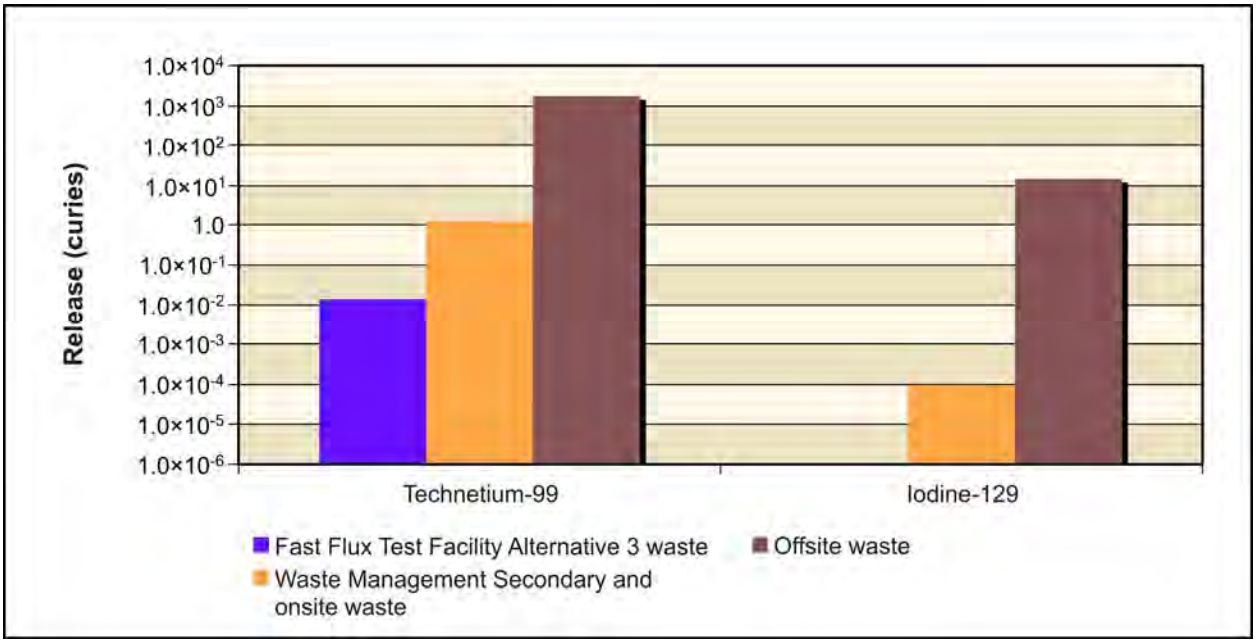


Figure 5–1111. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

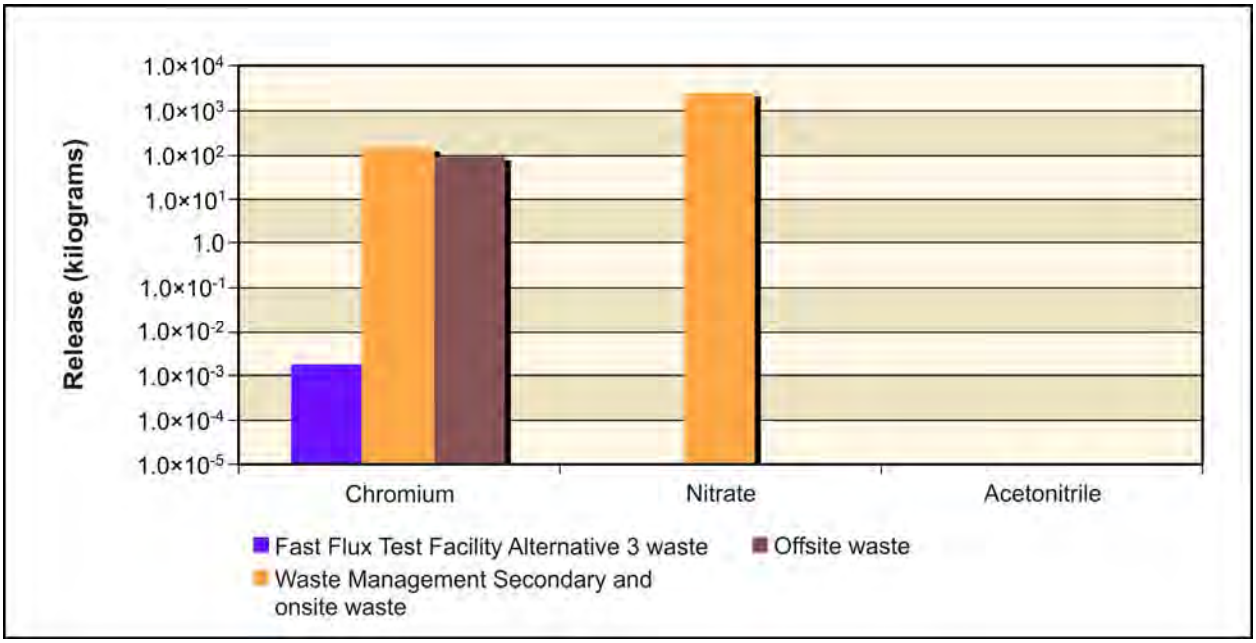


Figure 5–1112. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1113 shows the release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–1114, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially all of the COPC drivers released to groundwater reach the Columbia River.

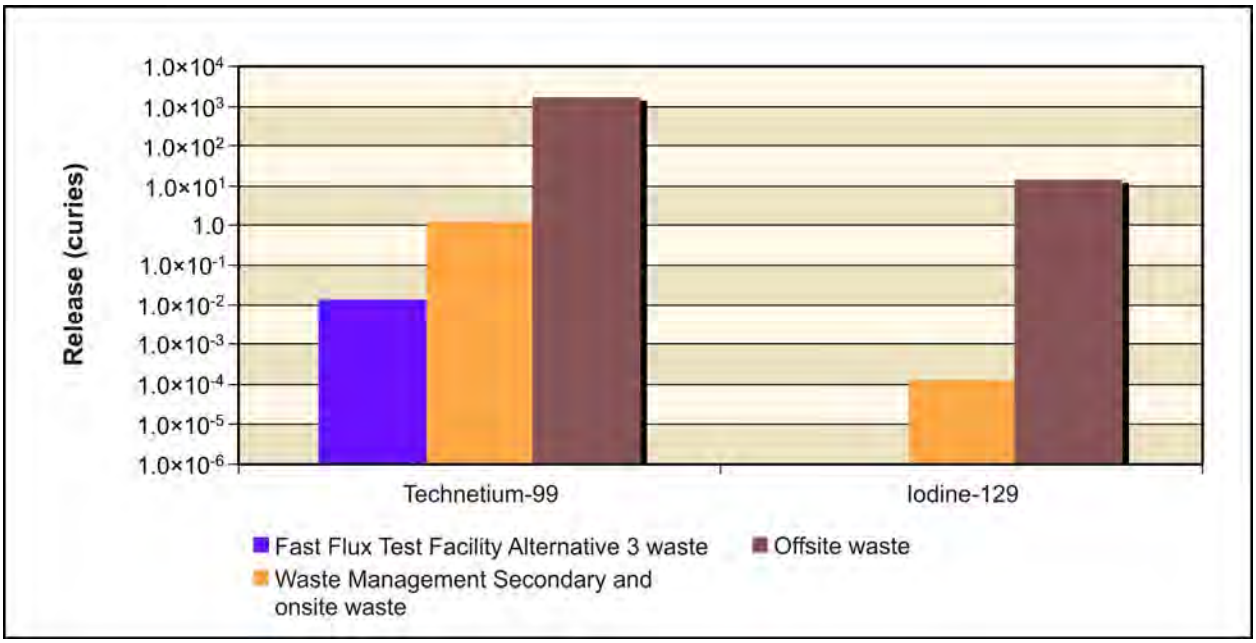


Figure 5–1113. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

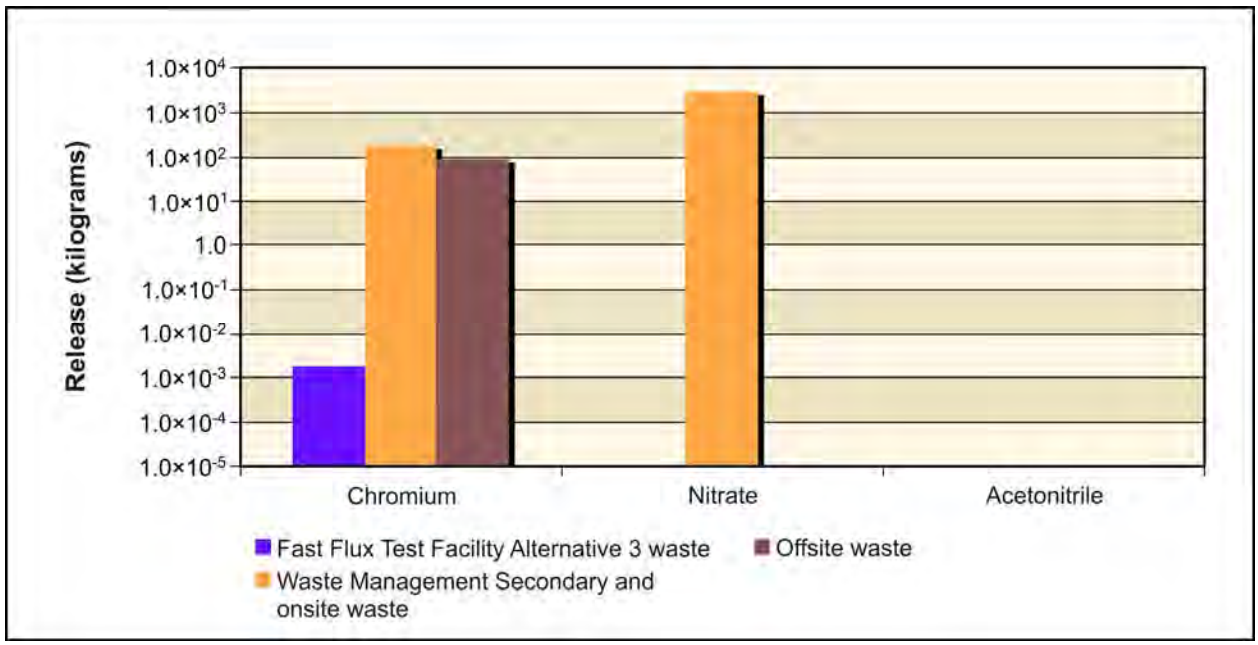


Figure 5–1114. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1115 shows the release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–1116, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF.

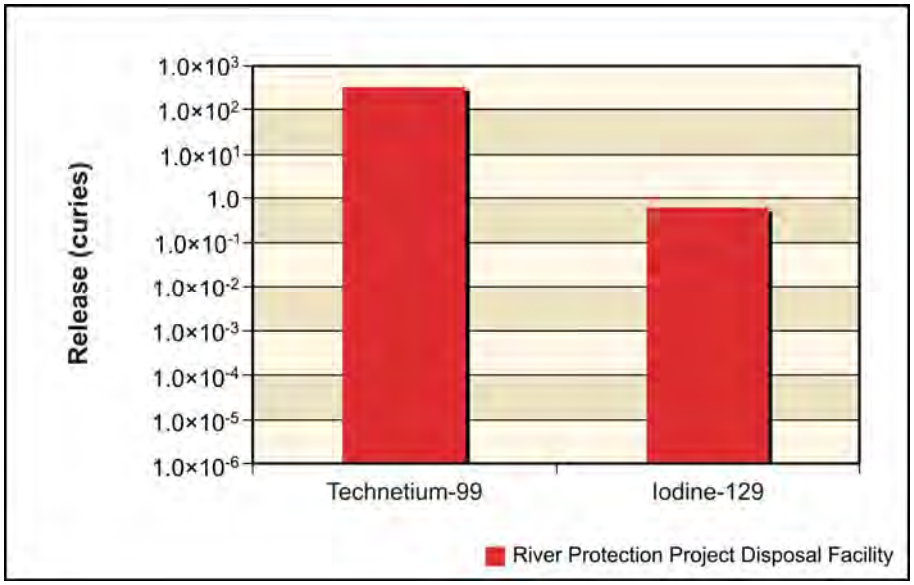


Figure 5–1115. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

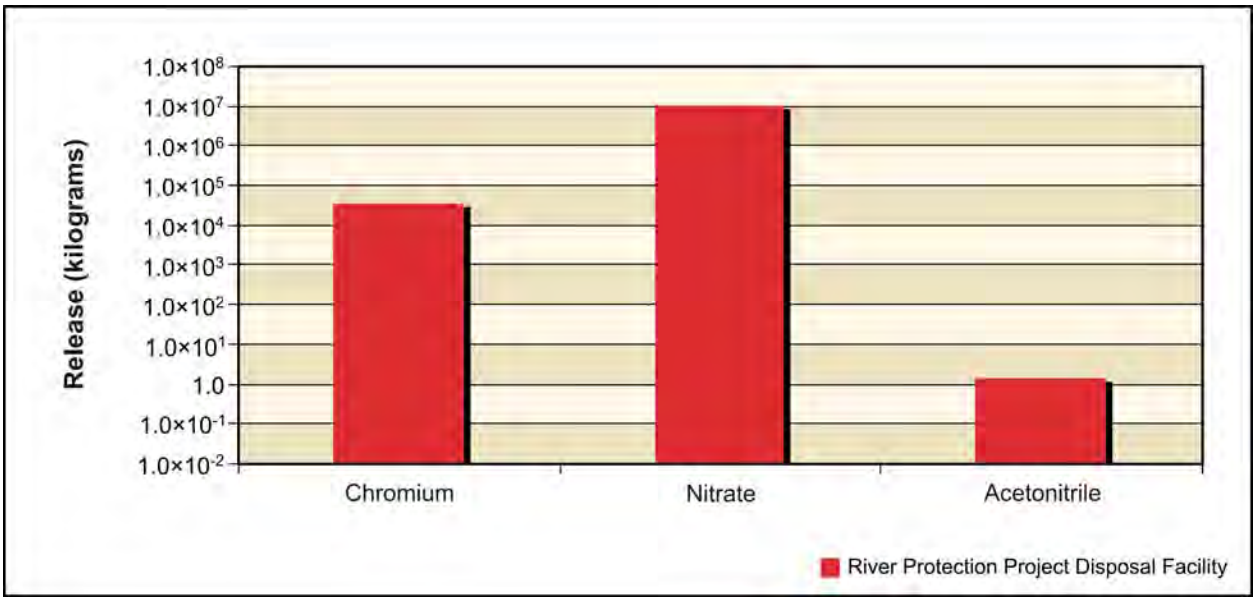


Figure 5–1116. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1117 shows the release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–1118, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

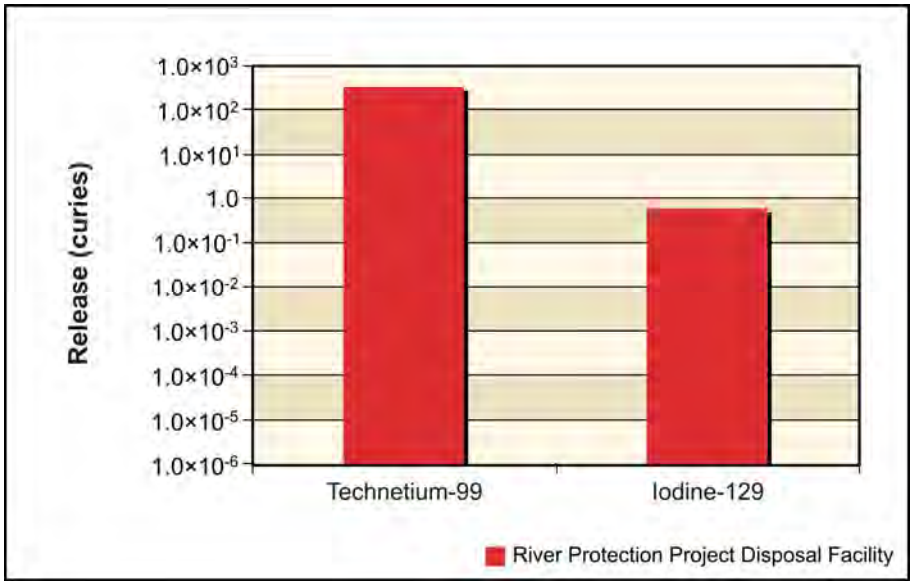


Figure 5–1117. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

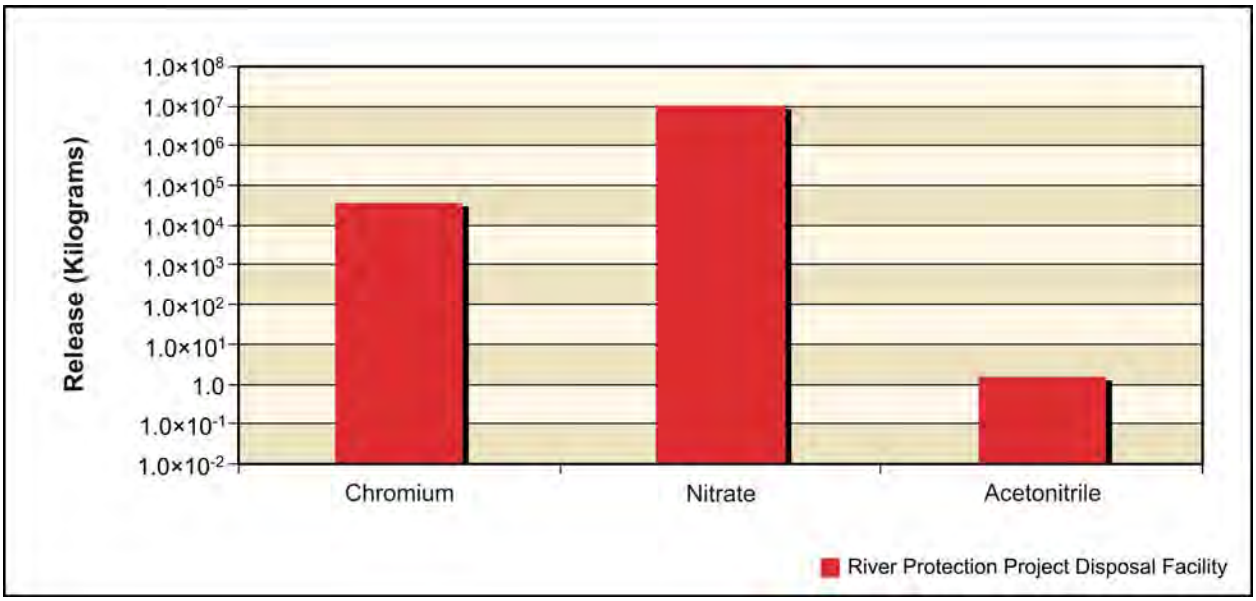


Figure 5–1118. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1119 shows the release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–1120, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially all of the COPC drivers released to groundwater reach the Columbia River.

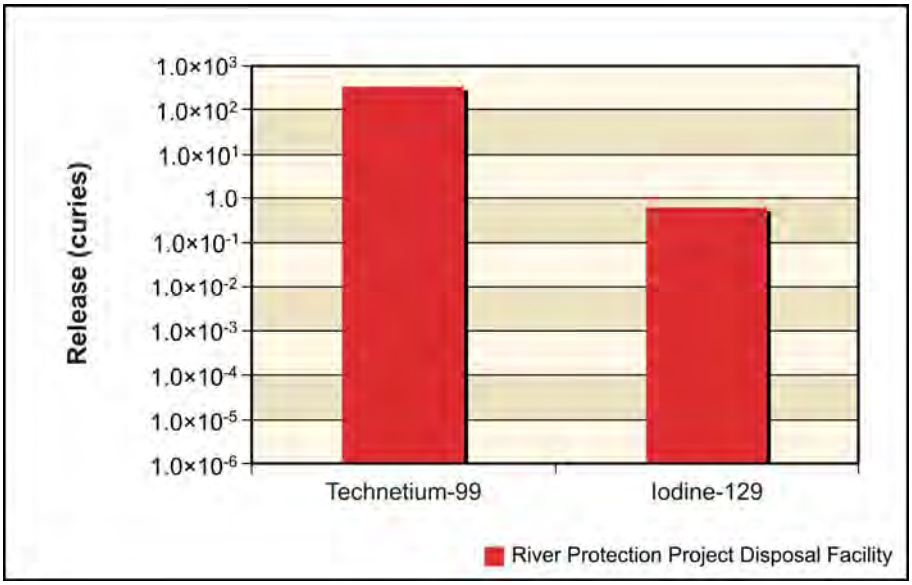


Figure 5–1119. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

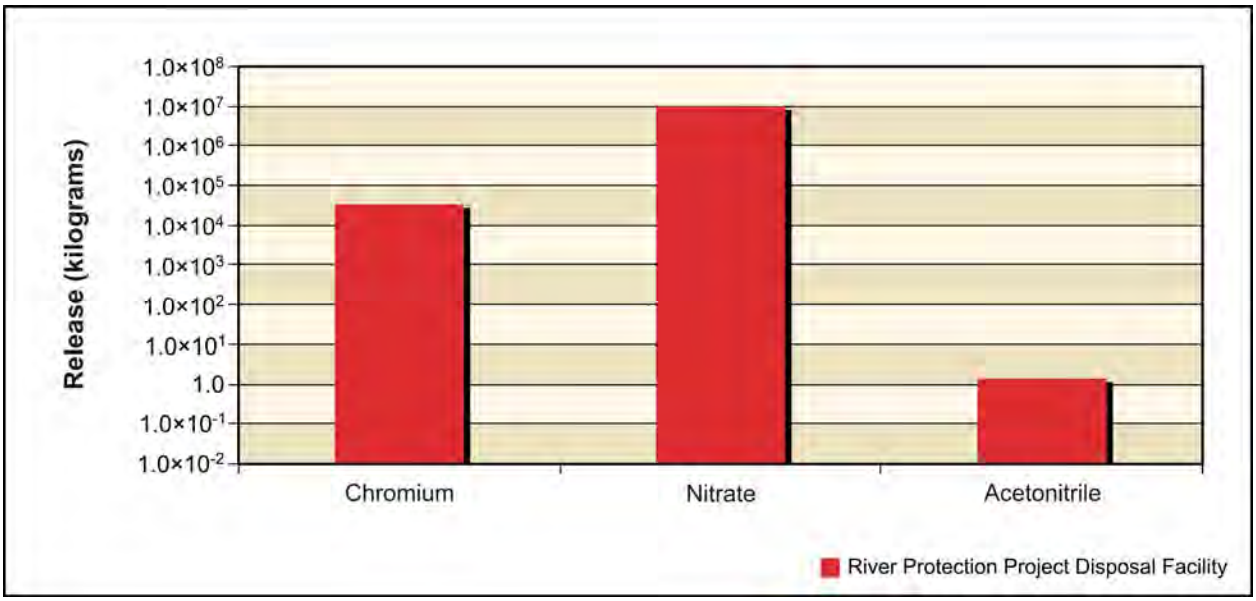


Figure 5–1120. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figures 5–1121 through 5–1124 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, concentrations at the Core Zone Boundary rise early in the simulation, reaching a peak around CY 3940 at about an order of magnitude above the benchmark concentration. Concentrations then slowly decline to nearly an order of magnitude below the benchmark. Iodine-129 follows a similar pattern, with concentrations falling slightly below the benchmark after peaking at nearly two orders of magnitude above the benchmark. Chromium and nitrate follow a similar pattern, with an early peak in concentrations at the Core Zone Boundary followed by a slow decline. Both chromium and nitrate concentrations (at the Core Zone Boundary) approach within one order of magnitude of the benchmark concentration for most of the analysis period. Note that the actual time periods of exceedance associated with the peak values (listed in Table 5–100) are extremely limited, and that the 95th percentile upper confidence limit on chromium concentrations is an order of magnitude below the benchmark concentrations. Table 5–100 shows the maximum concentrations in groundwater.

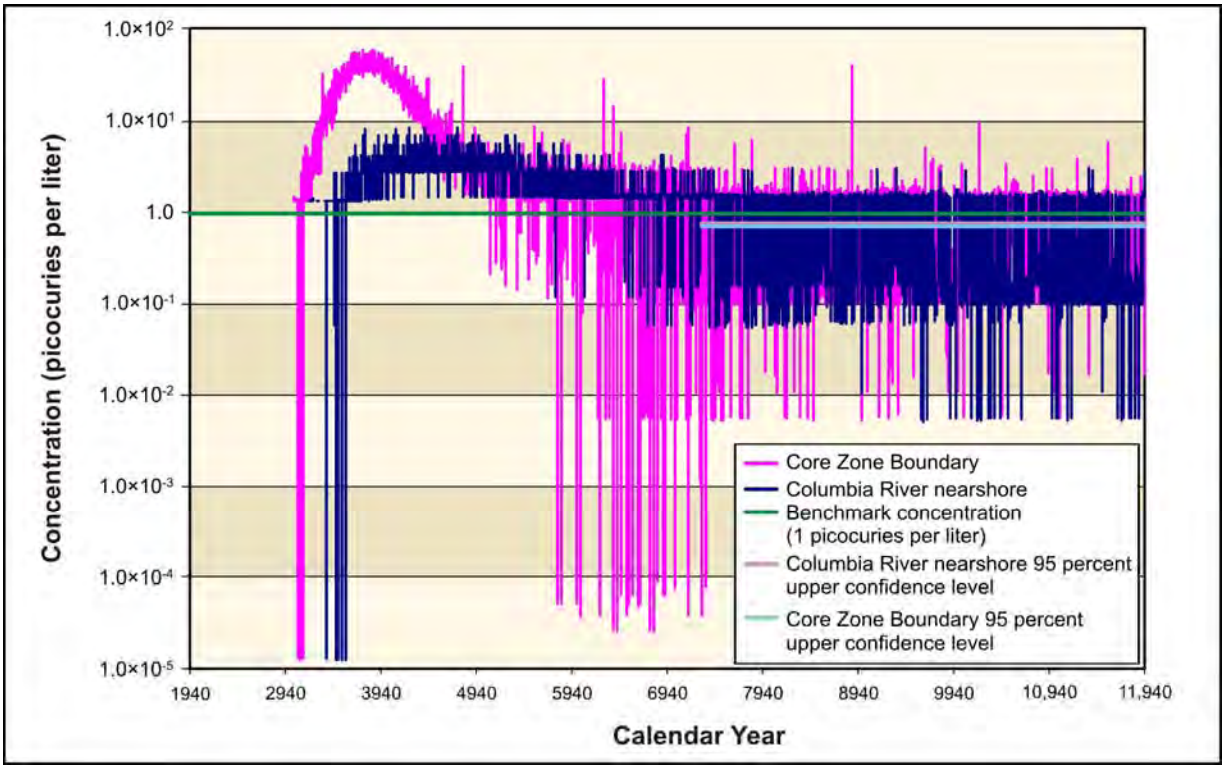


Figure 5–1121. Waste Management Alternative 3, Disposal Group 3, Option Case, Iodine-129 Concentration Versus Time

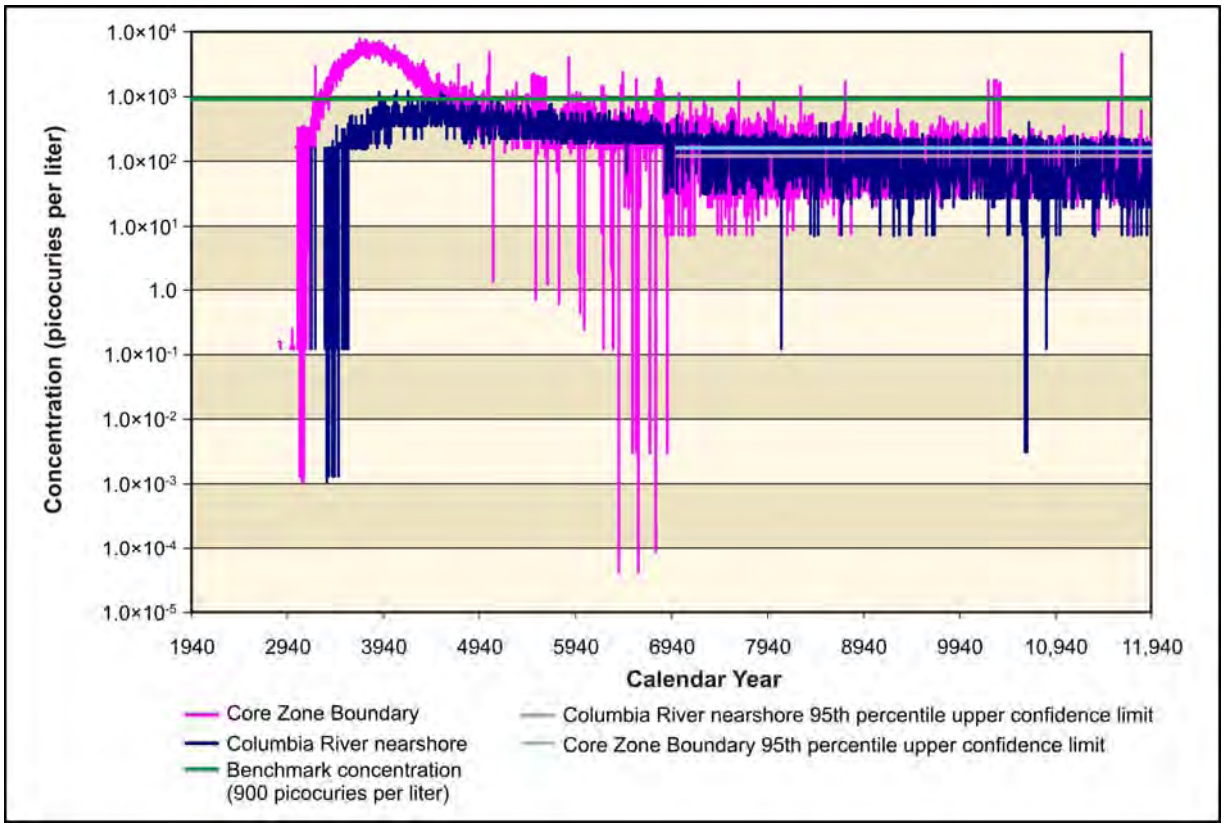


Figure 5–1122. Waste Management Alternative 3, Disposal Group 3, Option Case, Technetium-99 Concentration Versus Time

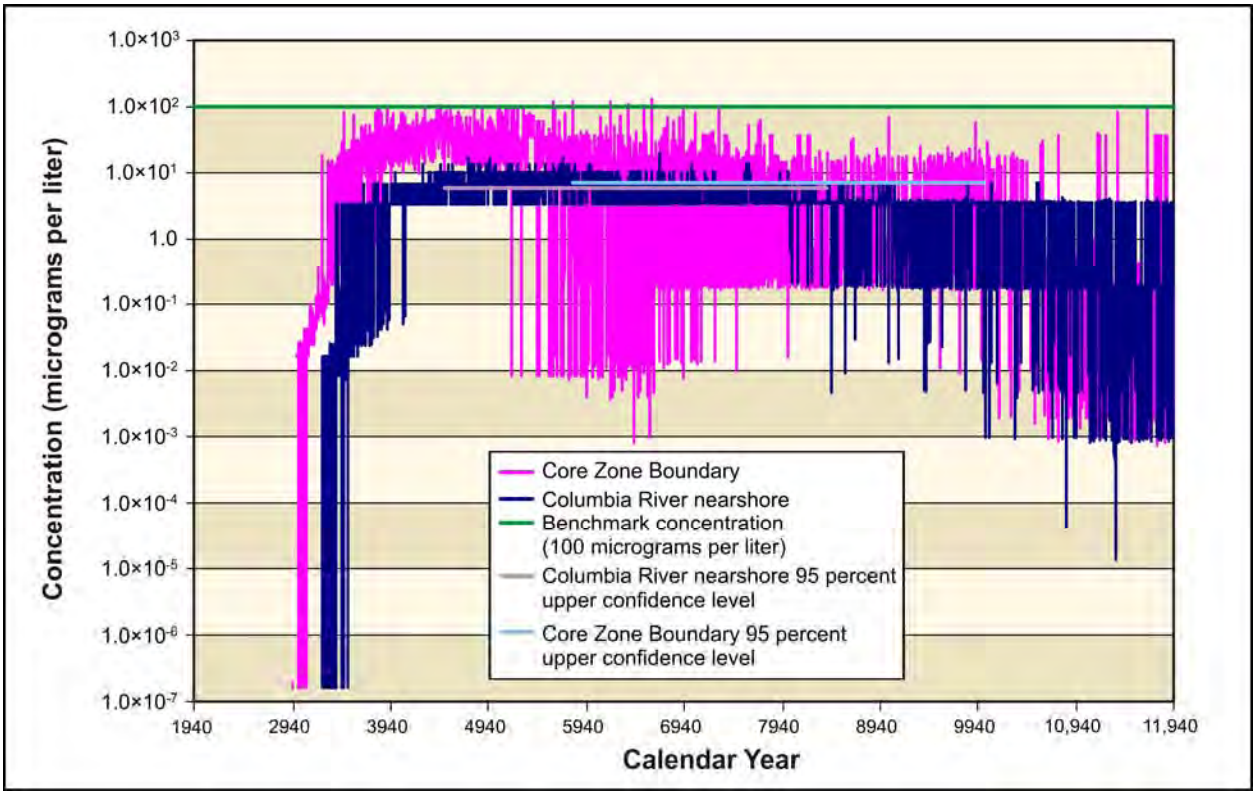


Figure 5–1123. Waste Management Alternative 3, Disposal Group 3, Option Case, Chromium Concentration Versus Time

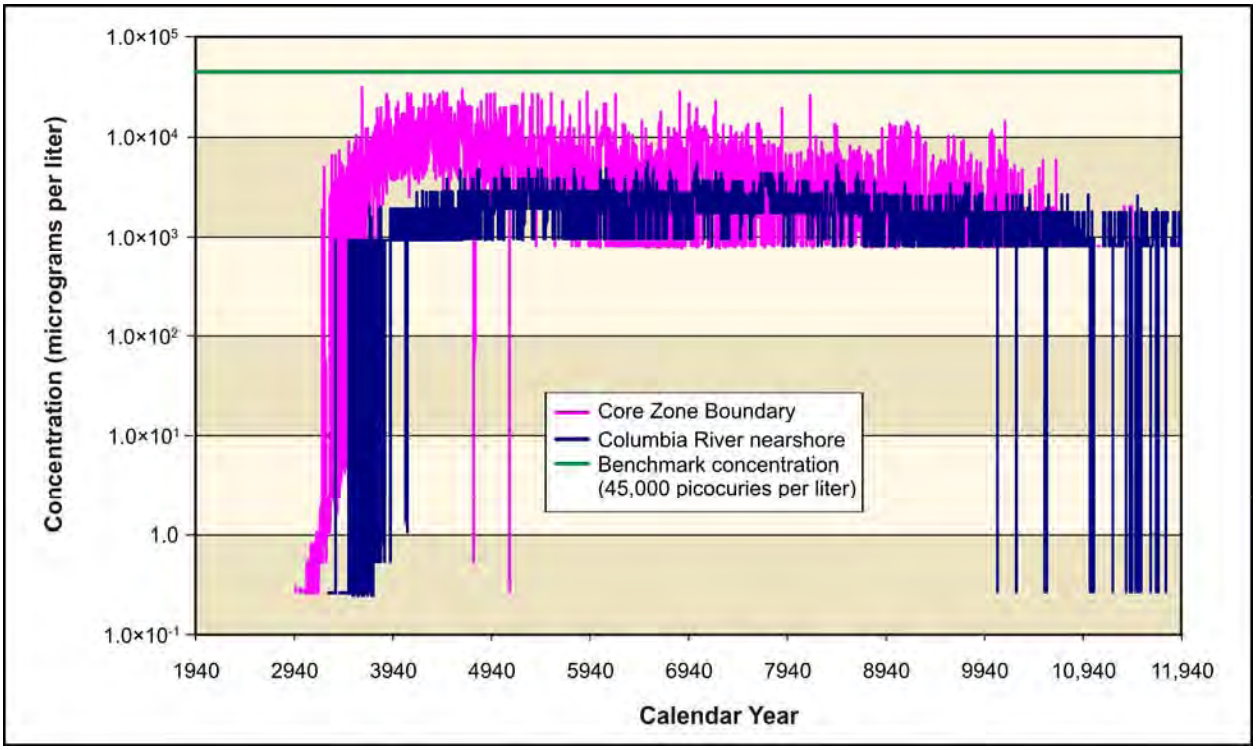


Figure 5–1124. Waste Management Alternative 3, Disposal Group 3, Option Case, Nitrate Concentration Versus Time

Table 5–100. Waste Management Alternative 3, Disposal Group 3, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	389	**20,200**	386	**7,940**	**1,220**	900
	(9324)	(3713)	(4013)	(3690)	(4066)	
Iodine-129	**2**	**173**	0.6	**61**	**8**	1
	(11,096)	(3797)	(4172)	(3853)	(4728)	
Chemical in micrograms per liter						
Chromium	3	2	36	**125**	20	100
	(8037)	(3696)	(3878)	(6610)	(6701)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	10,300	30,200	5,620	45,000
	(7367)	(3703)	(4544)	(4627)	(6522)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–1125 and 5–1126 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of uranium, no contamination appears until CY 8940, when uranium-238 concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 remains three orders of magnitude below the benchmark throughout the simulation. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation.

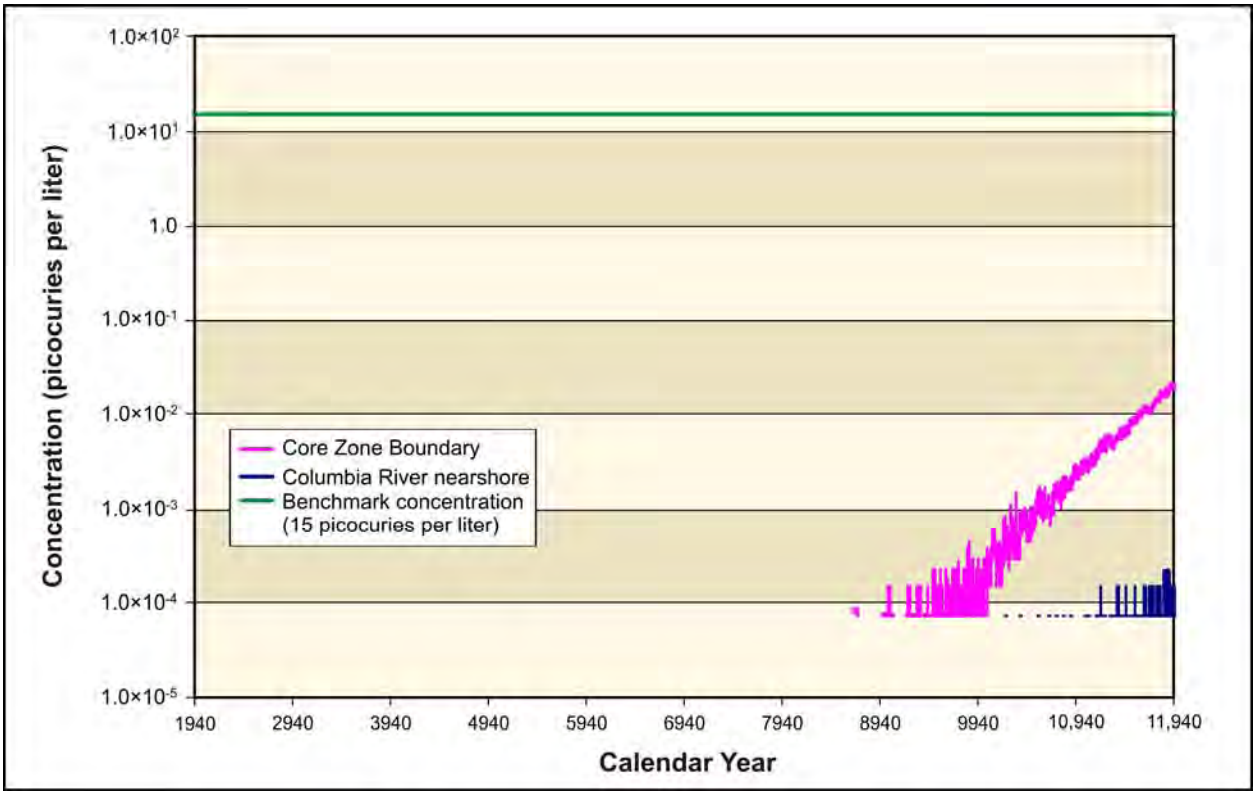


Figure 5–1125. Waste Management Alternative 3, Disposal Group 3, Option Case, Uranium-238 Concentration Versus Time

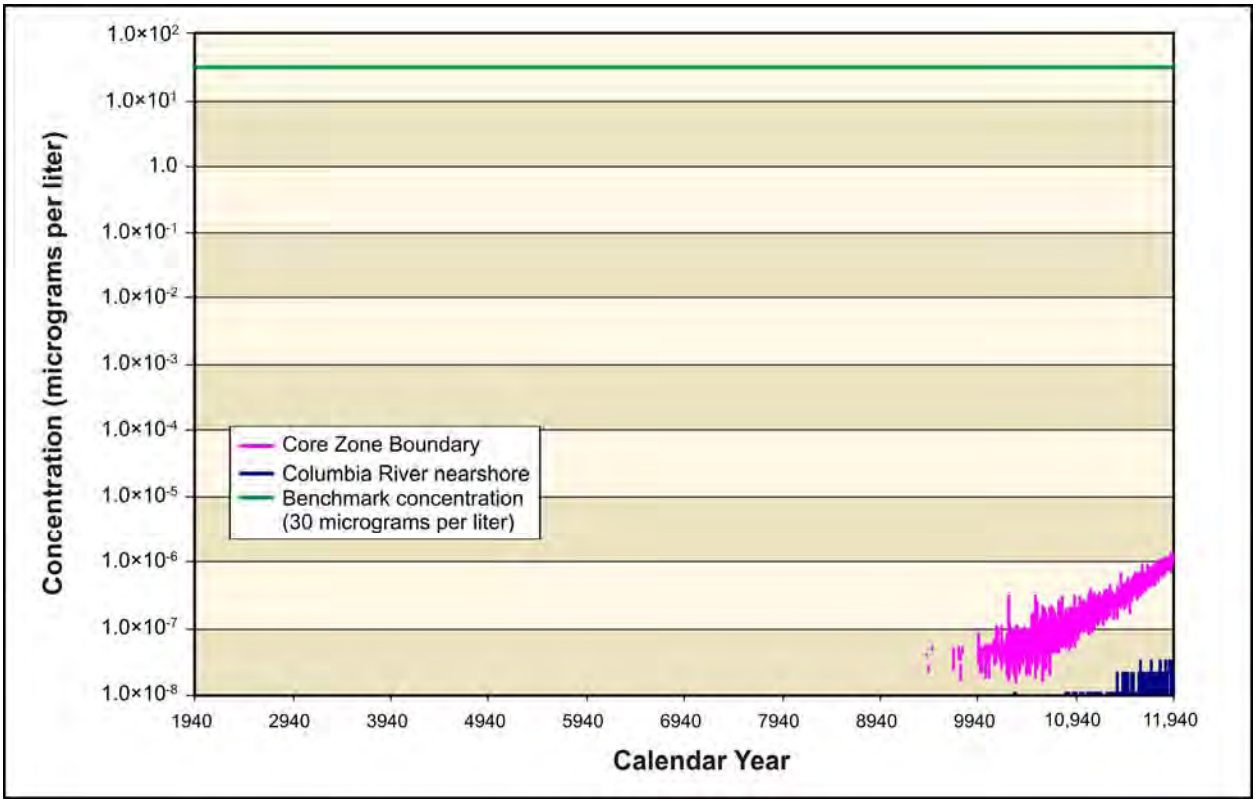


Figure 5–1126. Waste Management Alternative 3, Disposal Group 3, Option Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations below the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890 (see Figure 5–1127), there is a high-concentration plume of iodine-129 stretching northeast of IDF-West, and a low-concentration plume stretching north from the RPPDF through Gable Gap. Four separate high-concentration areas have also formed north of Gable Mountain and Gable Butte. By CY 7140 (see Figure 5–1128), the plumes from IDF-West and the RPPDF have dissipated, but a new plume has formed, traveling east from IDF-East. Figure 5–1129 shows the spatial distribution of groundwater concentration for iodine-129 during CY 11,885. Concentrations in this plume remain close to the benchmark. Technetium-99 (see Figures 5–1130 through 5–1132) shows a similar spatial distribution, but has lower concentrations. Chromium and nitrate (see Figures 5–1133 through 5–1135 and Figures 5–1136 through 5–1138) show similar spatial distributions at selected times, but have concentrations consistently well below the benchmark. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).

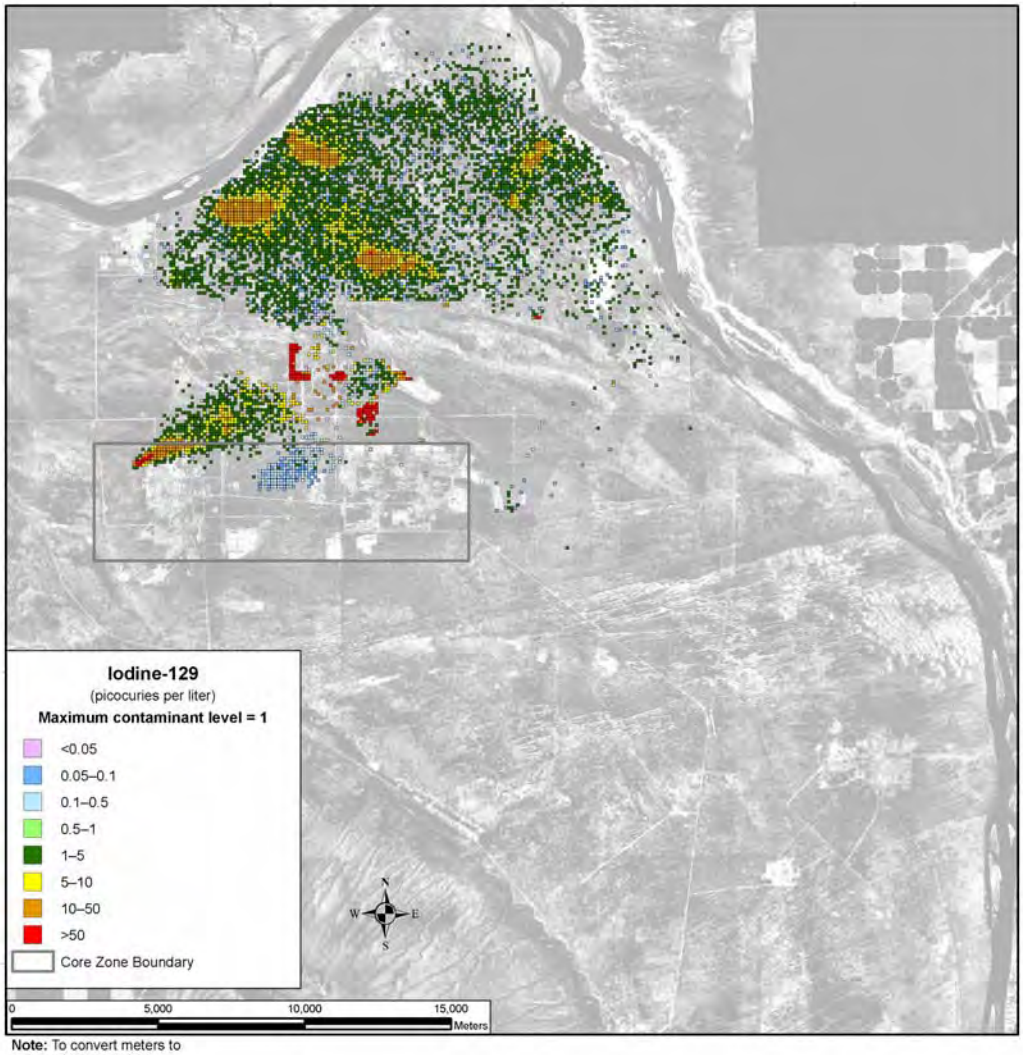
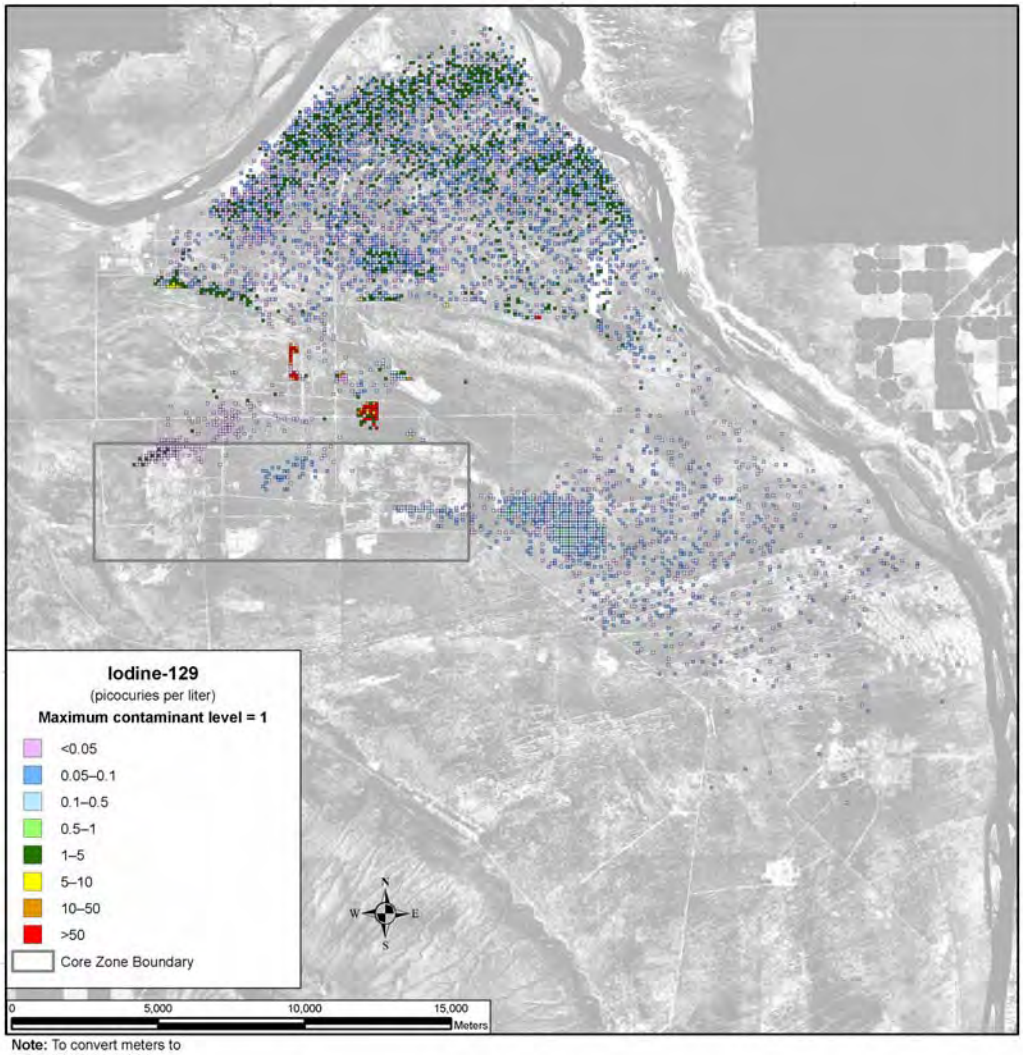


Figure 5–1127. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1128. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

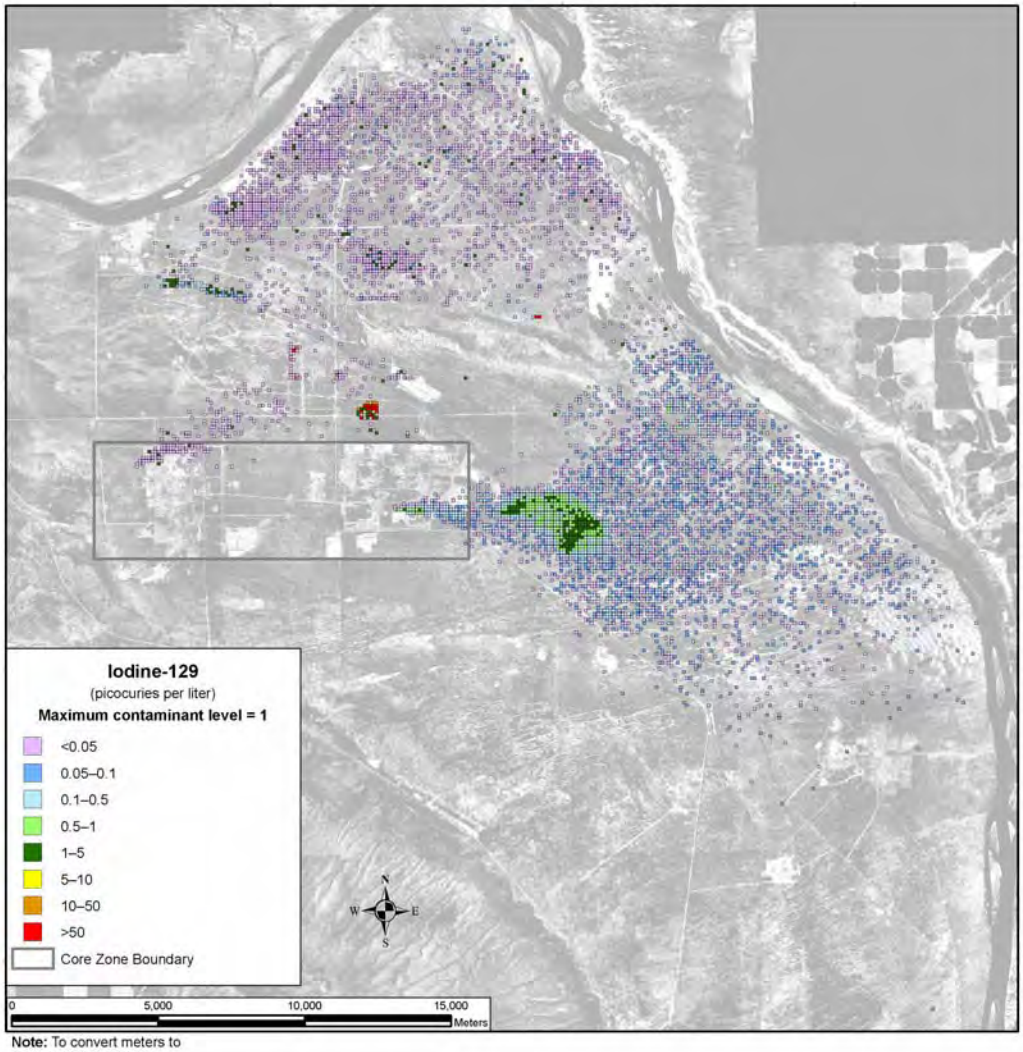


Figure 5–1129. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

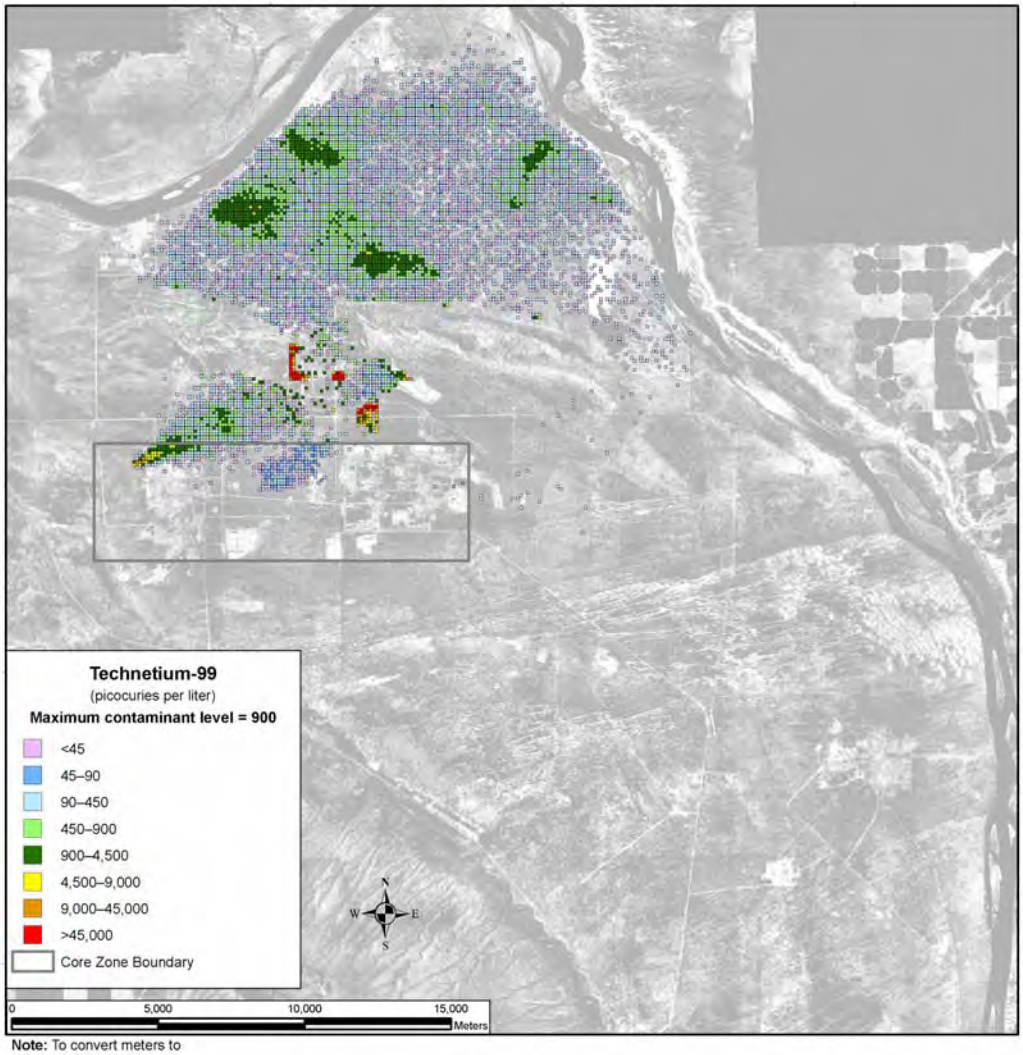


Figure 5–1130. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

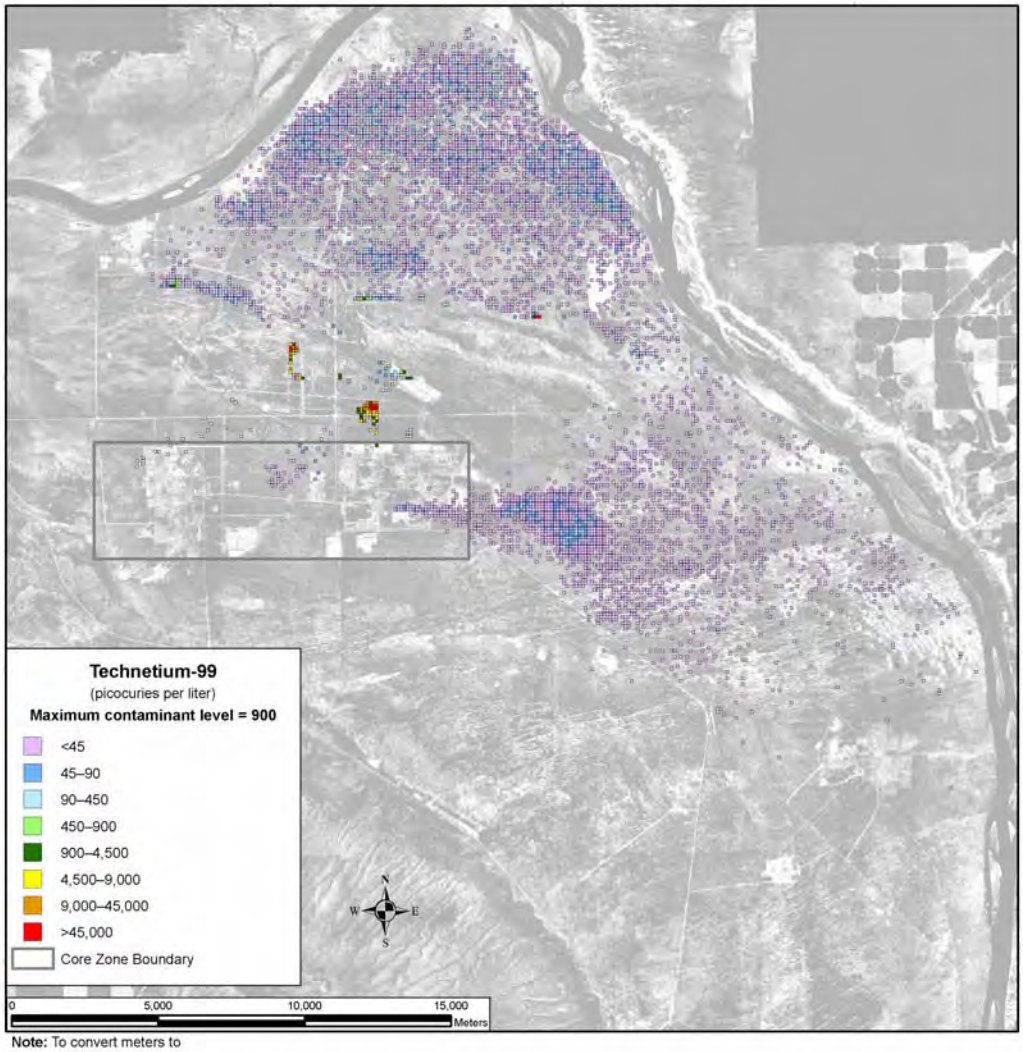


Figure 5–1131. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

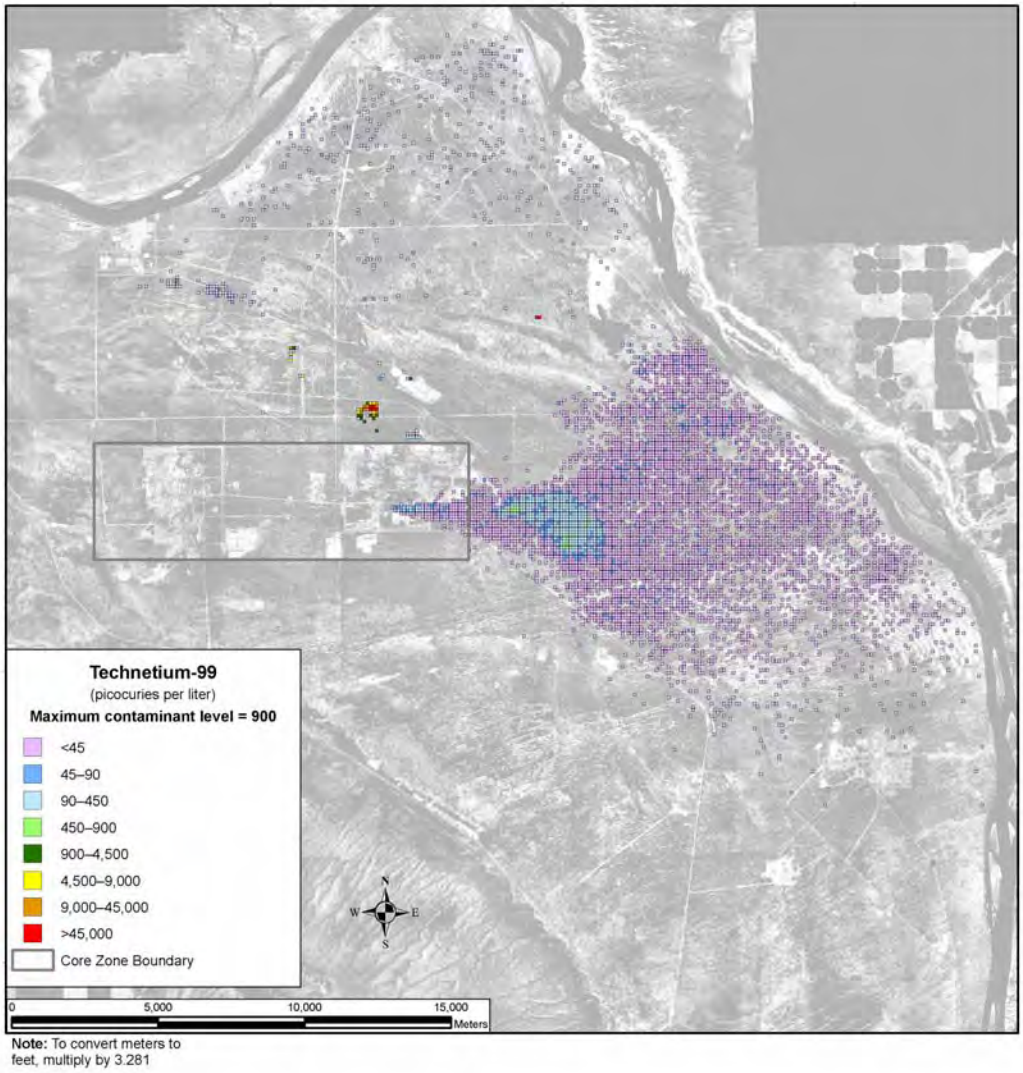


Figure 5–1132. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

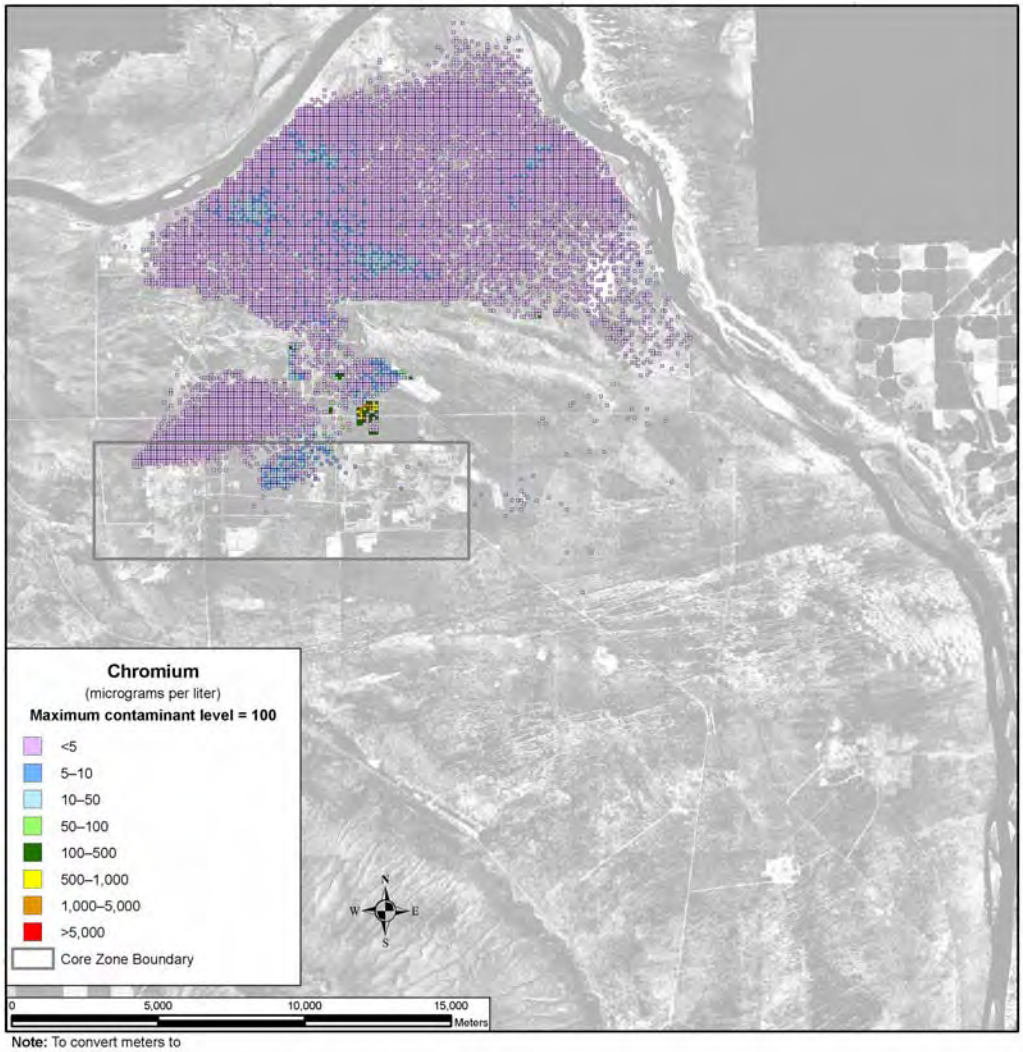


Figure 5–1133. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

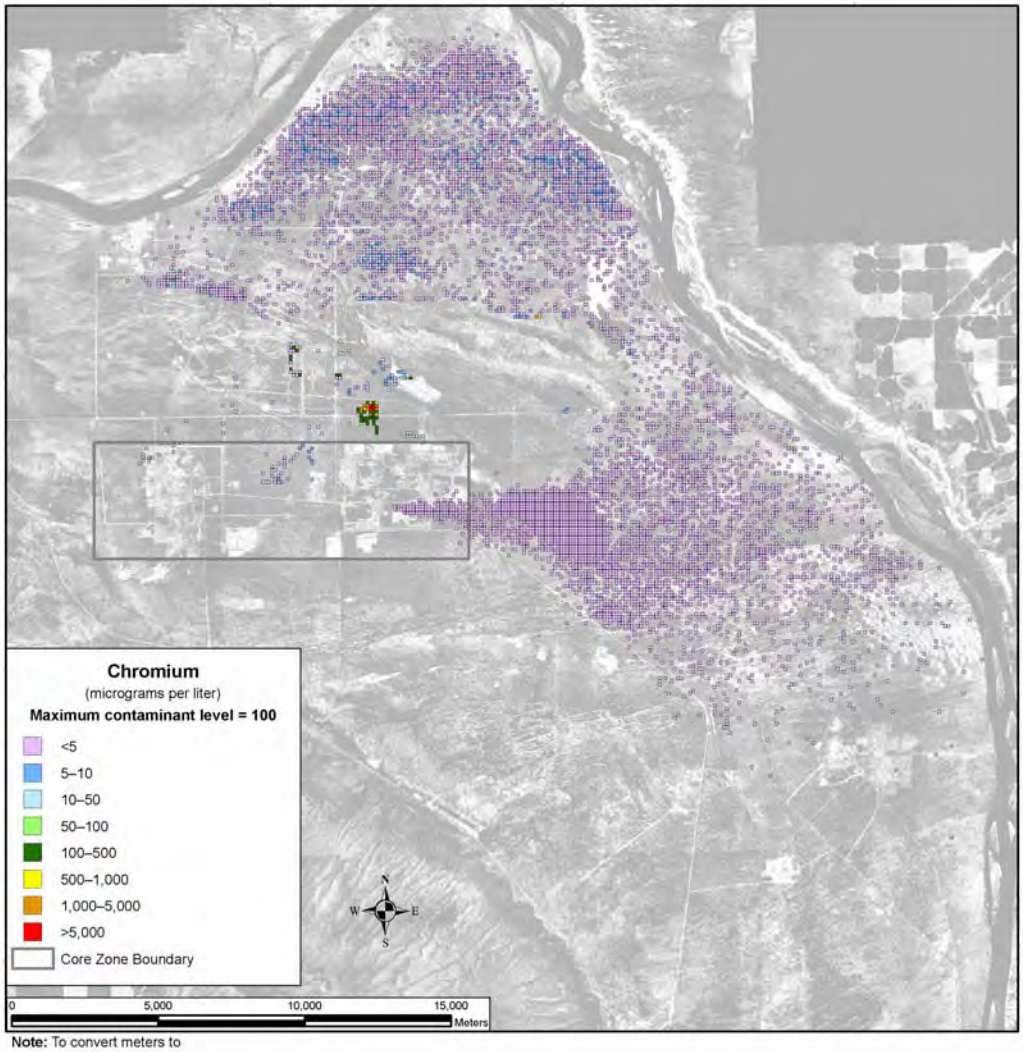


Figure 5–1134. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

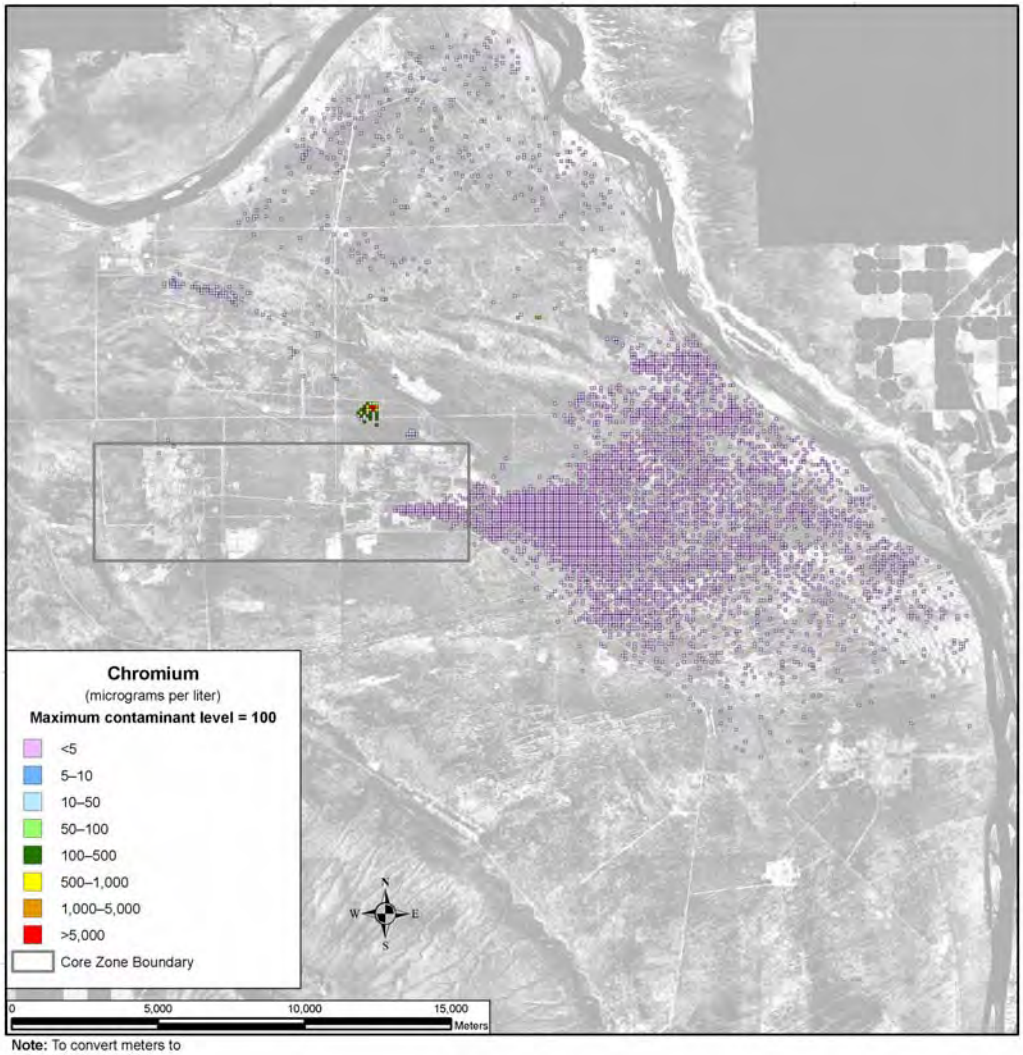


Figure 5–1135. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

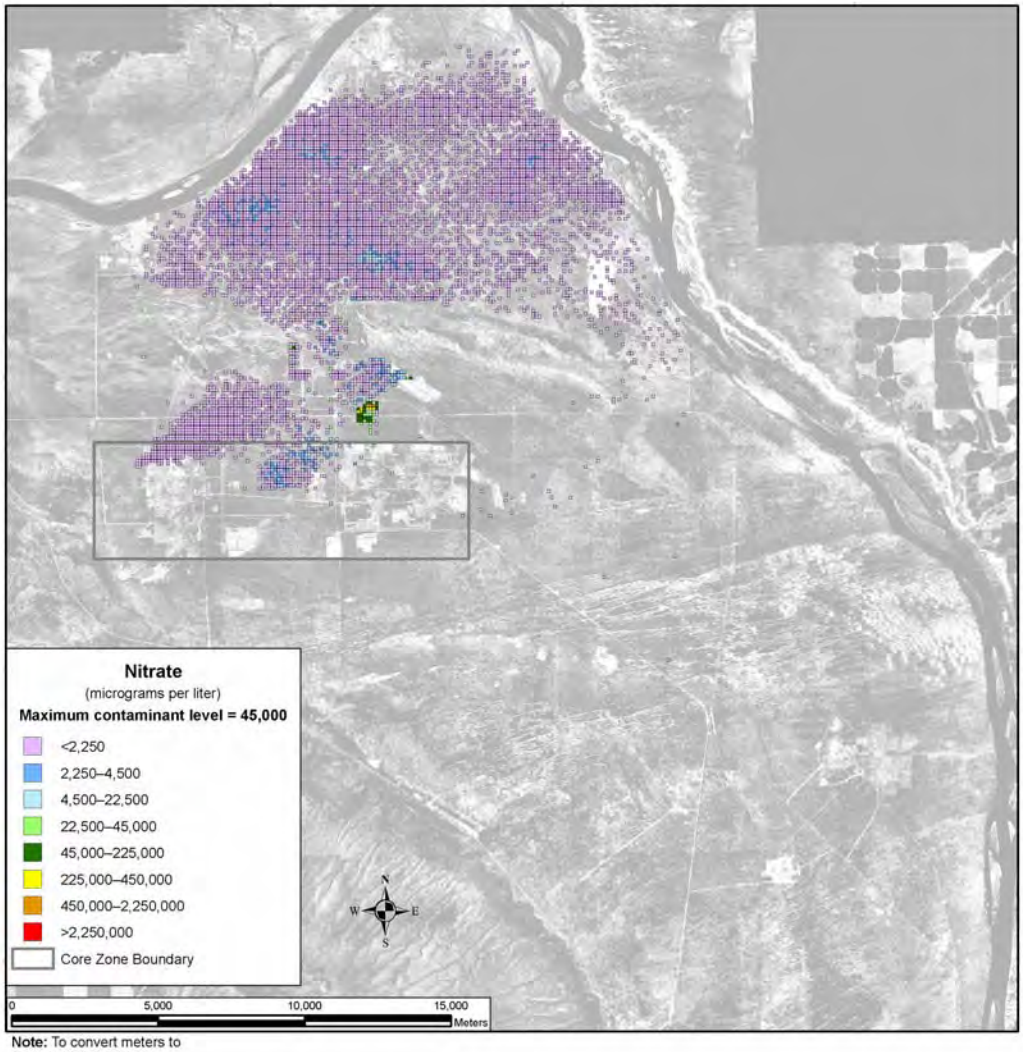


Figure 5–1136. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

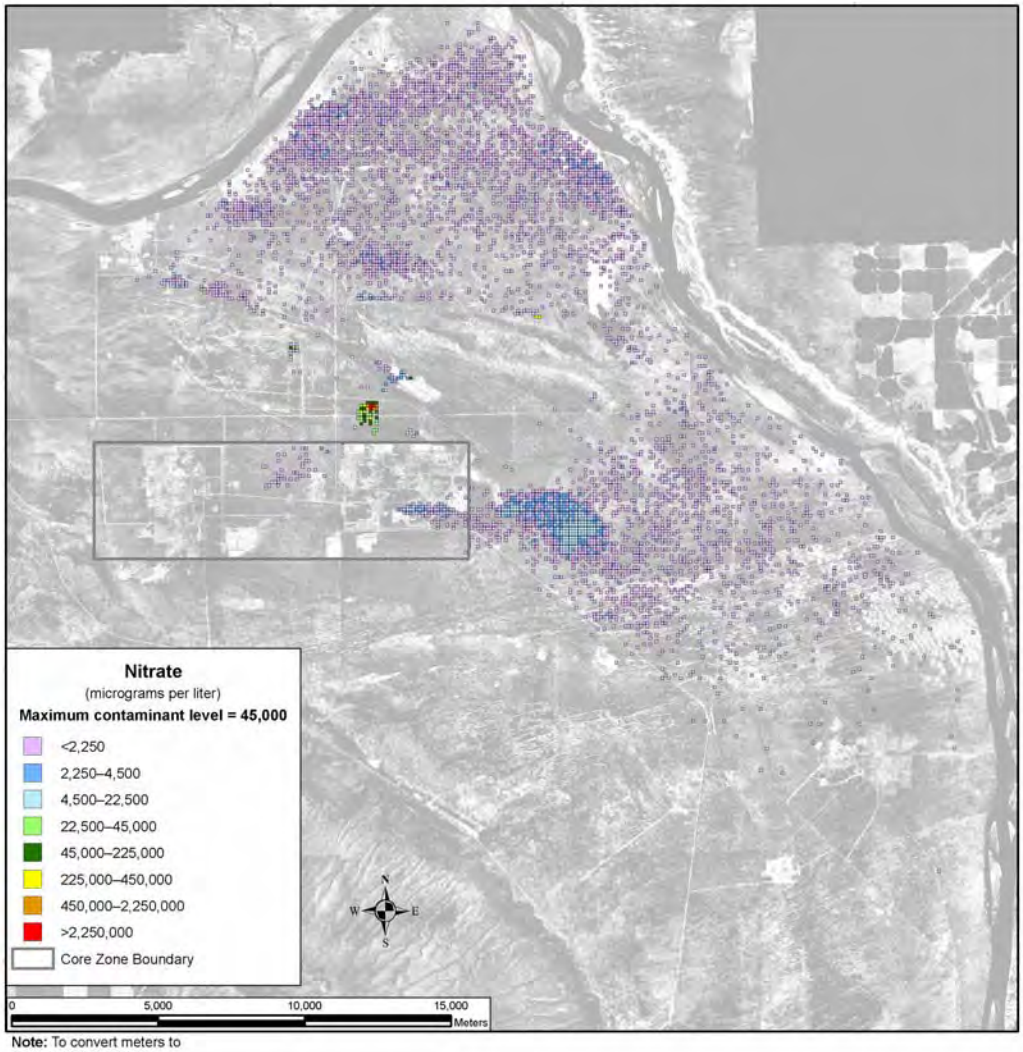


Figure 5–1137. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

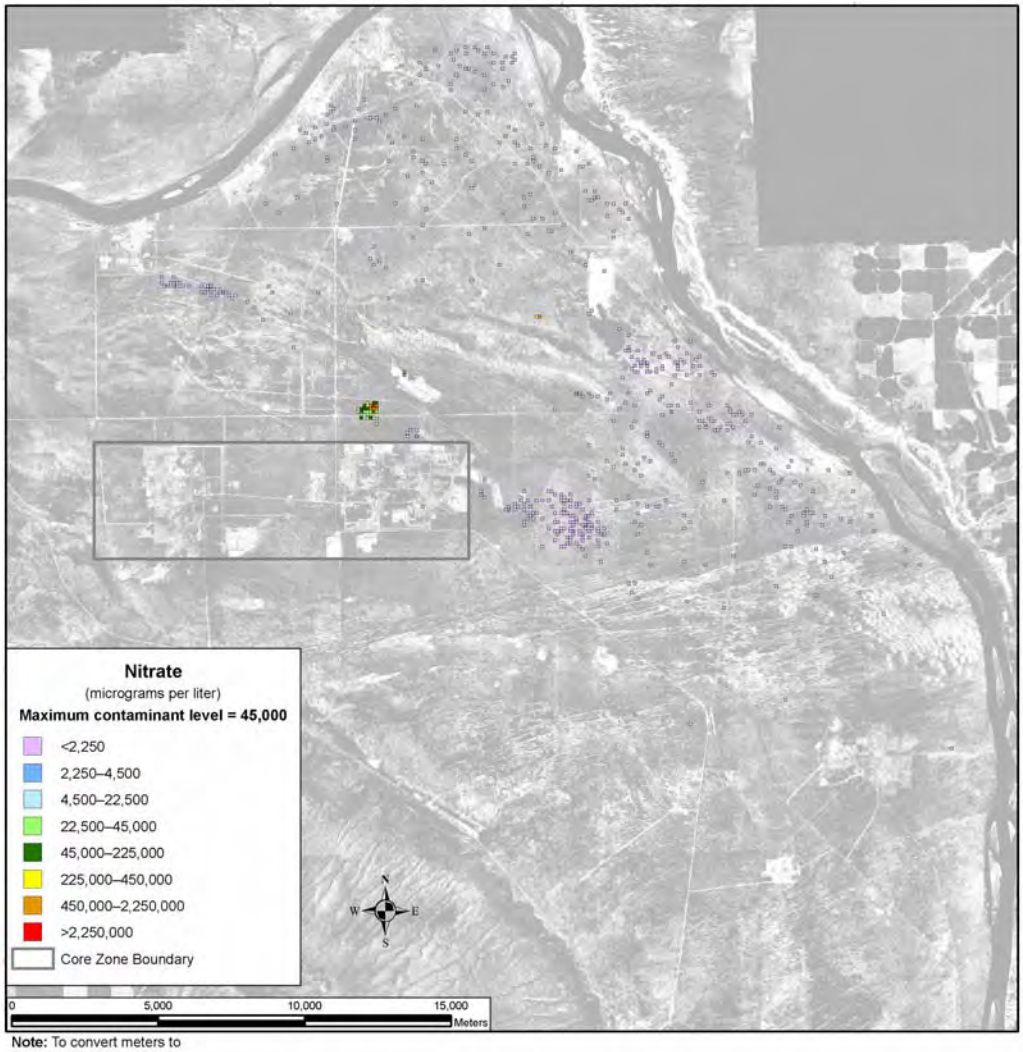


Figure 5–1138. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution Year of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium and uranium-238 show a different spatial distribution over time. They are not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, there is a uranium-238 plume extending northeast from IDF-West through Gable Gap (see Figure 5–1139). A total uranium plume extends through Gable Gap from the RPPDF (see Figure 5–1140). Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.

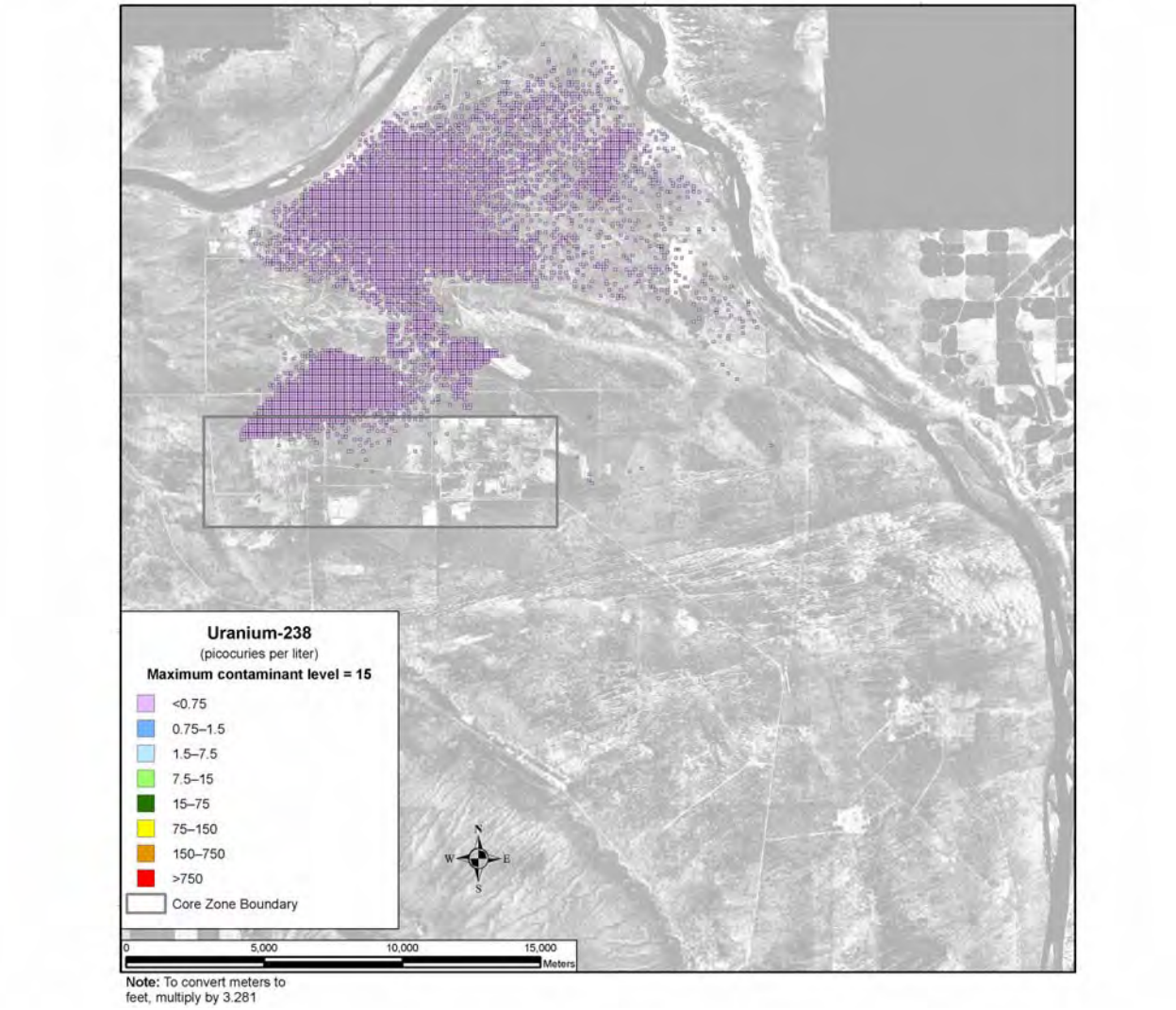


Figure 5–1139. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

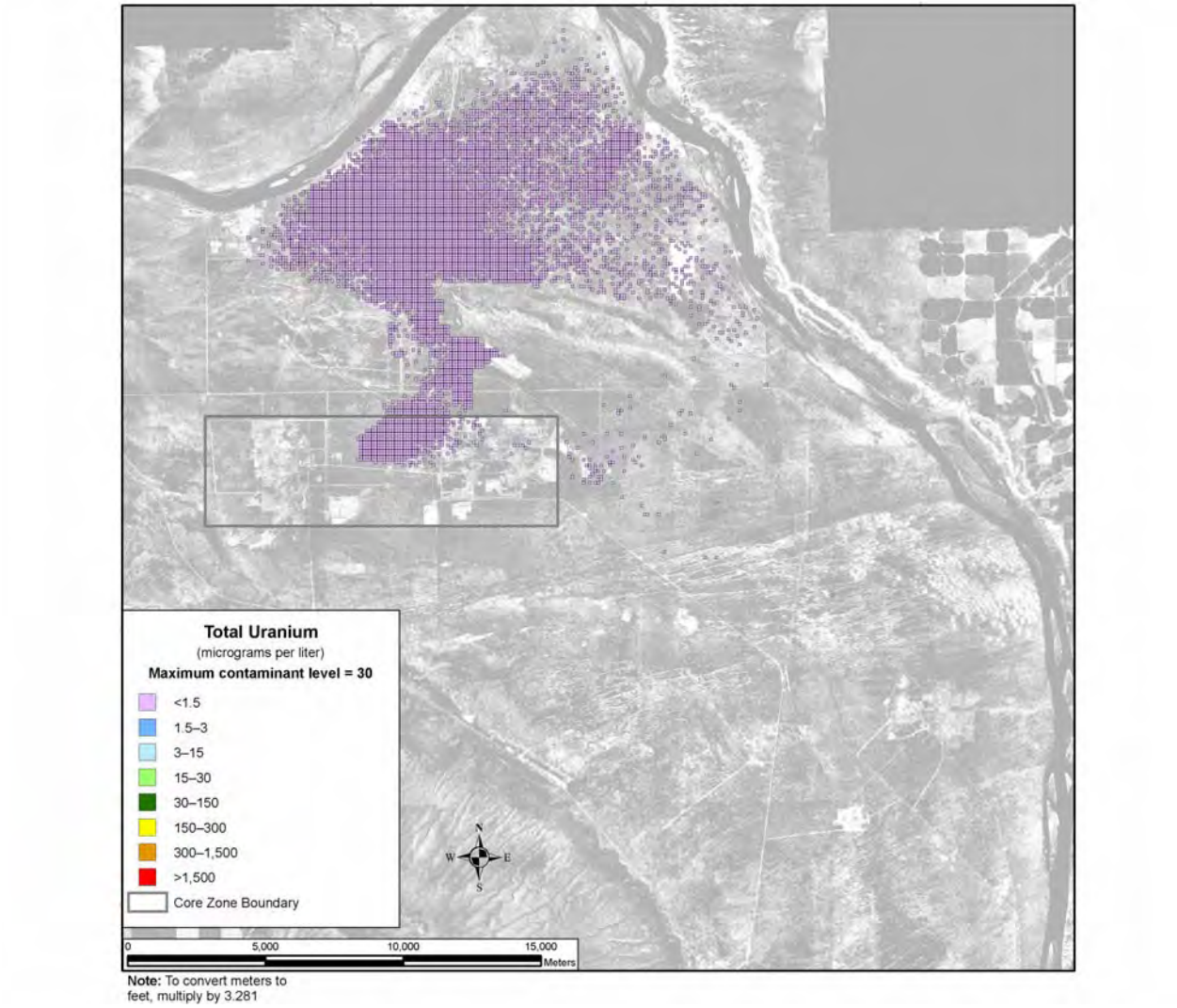


Figure 5–1140. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 3, Option Case, in general, discharges from IDF-West are the predominant contributors; those from IDF-East and the RPPDF are secondary contributors.

Concentrations of iodine-129 and technetium-99 show a sharp rise and fall between CY 2940 and CY 4940 that exceeds the benchmark by an order of magnitude or slightly more. Concentrations of these COPCs continue to decline at a slower rate after CY 4940, reaching a level around an order of magnitude below the benchmark. Chromium and nitrate show a similar rise and fall, but remain about two orders of magnitude below the benchmark.

Uranium-238 and total uranium is limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the benchmark at the Core Zone Boundary and the Columbia River throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.2 Human Health Impacts

Potential human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer. For long-term performance assessment, radiological dose and risk are estimated consistent with the recommendations of *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (Eckerman et al. 1999), including use of radionuclide-specific dose factors and risk coefficients. Potential human health effects due to the release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as Hazard Index, the sum of the Hazard Quotients of a group of chemicals. Further information on the nature of human health effects in response to exposure to radiological and chemical constituents is provided in Appendix K. Screening analysis identified 14 radionuclide and 26 chemical constituents as contributing the greatest risk of adverse impacts. Appendix Q provides more information on the screening analysis, including time of occurrence of peak impacts and constituent- and location-specific impacts under each Tank Closure, FFTF Decommissioning, and Waste Management alternatives.

Four measures of human health impacts are considered in this analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radiological constituents, and Hazard Index from chemical constituents. These measures are calculated for each year for 10,000 years for each receptor at seven locations, as appropriate (i.e., LLBG 218-W-5, trenches 31 and 34; IDF-East; IDF-West; the RPPDF; the Core Zone Boundary; the Columbia River nearshore; and the Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts as dose and the analysis results observations that risk due to exposure to chemical constituents is small relative to risk due to exposure to radiological constituents and that peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose.

Impacts on human health over the long time period following stabilization or closure of the waste management disposal facilities would be due primarily to naturally occurring release mechanisms and the degradation of waste forms over time. These releases would involve both radiological and chemical constituents.

The five onsite locations are the barriers of the LLBG 218-W-5, trenches 31 and 34; IDF-East; IDF-West; the RPPDF; the Core Zone Boundary; and the Columbia River nearshore. The two offsite locations are access points to Columbia River surface water near the site and at population centers downstream of the site. Estimates of concentrations of constituents in the Columbia River surface water are used to calculate impacts for both offsite location points of analysis. Total offsite population is 5 million people. Four types of receptor are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield are adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking-water consumption and consumes both wild plant materials, which use groundwater, and game animals, which use surface water.

The significance of dose impacts is evaluated by comparison with the 100-millirem-per-year all-exposure modes standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.* The level of protection provided for the drinking-water pathway is evaluated by comparison with applicable drinking-water standards presented in Section 5.3.1. Population doses are compared with the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The significance of noncarcinogenic chemical impacts is evaluated by comparison with a guideline value of unity for Hazard Index.

5.3.2.1 Waste Management Alternative 1: No Action

Under Waste Management Alternative 1, only the wastes currently generated on site at Hanford from non-CERCLA actions would continue to be disposed of in LLBG 218-W-5, trenches 31 and 34. Although the short-term impacts do not address the impacts associated with closure activities for this site, for purposes of analyzing long-term impacts, it is assumed that these trenches will be closed using an RCRA-compliant barrier consistent with the closure plans for these burial grounds. As a result, the non-CERLCA waste disposed of in these trenches from CY 2008 through 2035 would become available for release to the environment.

Potential human health impacts of this alternative are summarized in Tables 5–101 and 5–102. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.17×10^{-4} person-rem per year for the year of maximum impact. This corresponds to a 1.74×10^{-8} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary is presented in Figure 5–1141. The estimated lifetime risks are relatively low, with a peak of approximately 2×10^{-7}, indicating low rates of release from the disposal trenches.

Table 5–101. Waste Management Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Trenches 31 and 34	4.48×10^{-2}	3.08×10^{-2}	1.39×10^{-6}	0.00	1.39×10^{-6}	1.06×10^{-1}	3.11×10^{-2}	4.40×10^{-6}	1.16×10^{-11}	4.40×10^{-6}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	7.96×10^{-3}	5.92×10^{-3}	2.53×10^{-7}	0.00	2.53×10^{-7}	1.92×10^{-2}	5.97×10^{-3}	8.13×10^{-7}	2.27×10^{-12}	8.13×10^{-7}
Columbia River Nearshore	1.29×10^{-3}	9.93×10^{-4}	4.12×10^{-8}	0.00	4.12×10^{-8}	3.12×10^{-3}	1.00×10^{-3}	1.32×10^{-7}	3.84×10^{-13}	1.32×10^{-7}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.35×10^{-8}	2.02×10^{-8}	2.69×10^{-12}	7.48×10^{-18}	2.69×10^{-12}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–102. Waste Management Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Trenches 31 and 34	2.09×10^{-1}	4.51×10^{-2}	9.53×10^{-6}	5.33×10^{-7}	9.96×10^{-6}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.83×10^{-2}	8.69×10^{-3}	1.76×10^{-6}	1.04×10^{-7}	1.83×10^{-6}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	6.22×10^{-3}	1.45×10^{-3}	2.86×10^{-7}	1.76×10^{-8}	2.99×10^{-7}	8.02×10^{-6}	2.62×10^{-4}	4.16×10^{-10}	8.81×10^{-9}	9.09×10^{-9}
Off Site										
Columbia River	2.13×10^{-7}	2.90×10^{-6}	8.20×10^{-12}	3.43×10^{-13}	8.49×10^{-12}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

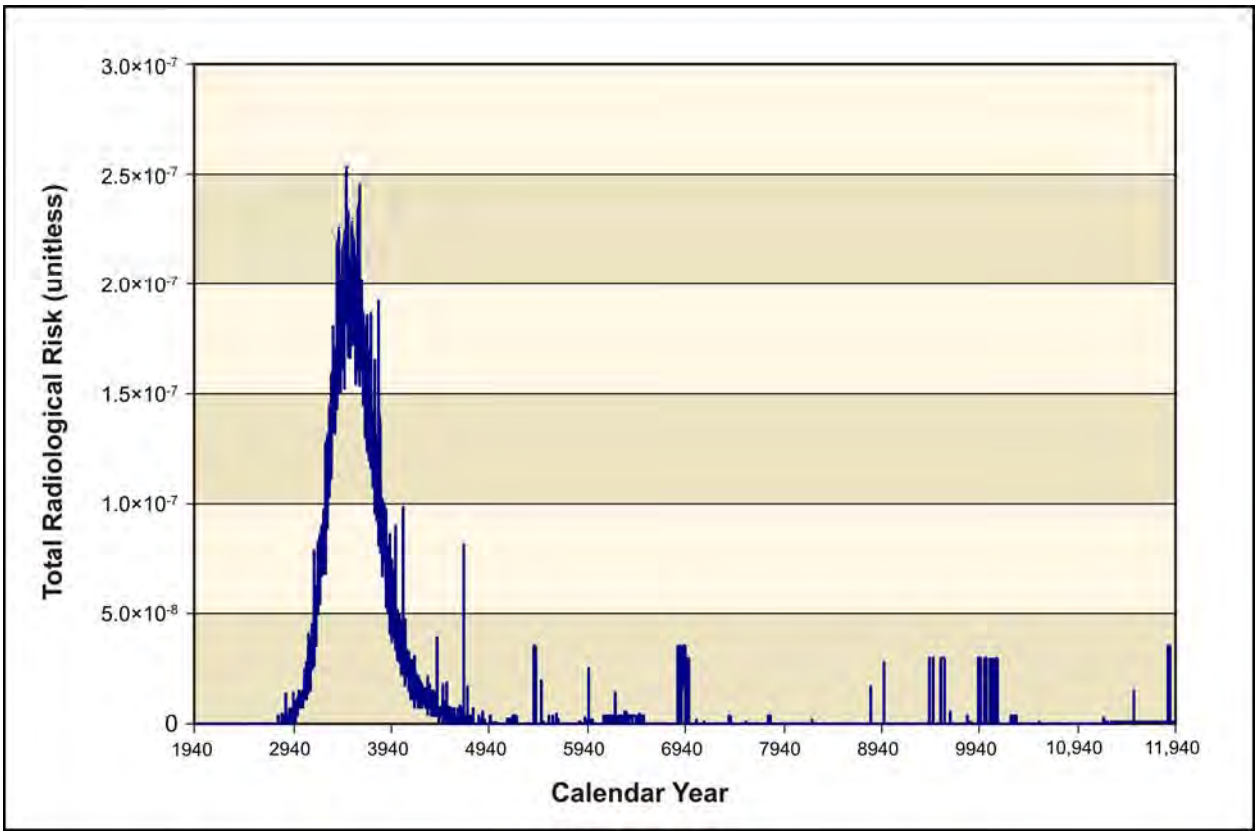


Figure 5–1141. Waste Management Alternative 1 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

Under Waste Management Alternative 2, waste from tank treatment operations, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-East. Waste from tank farm cleanup activities would be disposed of in the RPPDF. As a result, the waste disposed of in these two facilities would become available for release to the environment. Because different waste types would result from the Tank Closure action alternatives, three disposal groups were considered to account for the different sizes and operational time periods of IDF-East. In addition, within these three disposal groups, subgroups were identified to allow consideration of the different waste types resulting from the Tank Closure alternatives. Potential human health impacts of these subgroups under this alternative are discussed in the following sections.

5.3.2.2.1 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-A

Disposal Group 1, Subgroup 1-A, addresses the waste resulting from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–103 and 5–104. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.05×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 1.67×10^{-5} percent of the annual population dose due to

background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and at the Core Zone Boundary are presented in Figures 5–1142 and 5–1143, respectively. Review of the source term inventories (see Appendix D), cumulative release to the unconfined aquifer (see Appendix N), sensitivity analysis (see Appendix N), and estimates of impact presented later in this section support the interpretation that the majority of the impact is due to release of technetium-99 from offsite waste. At the IDF-East Barrier, approximately 90 percent of the risk is attributed to offsite LLW (9×10^{-5}) and approximately 10 percent is attributed to the combination of ETF-generated and tank closure secondary waste (1.3×10^{-5}). Releases from ILAW glass provide a minor contribution to estimated impacts. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1143) show a small peak at CY 3700 due to releases from the RPPDF, while the larger peak at CY 8000 is due to releases from IDF-East.

Table 5–103. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	7.49	2.73×10^{-1}	1.63×10^{-4}	0.00	1.63×10^{-4}	1.34×10^{1}	3.53×10^{-1}	4.42×10^{-4}	1.69×10^{-11}	4.42×10^{-4}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	3.13	1.04×10^{-1}	8.02×10^{-5}	0.00	8.02×10^{-5}	6.24	1.36×10^{-1}	2.45×10^{-4}	8.42×10^{-12}	2.45×10^{-4}
Columbia River Nearshore	2.58	4.78×10^{-2}	4.99×10^{-5}	0.00	4.99×10^{-5}	3.98	6.16×10^{-2}	1.46×10^{-4}	2.93×10^{-12}	1.46×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.10×10^{-5}	1.61×10^{-6}	2.09×10^{-9}	4.26×10^{-17}	2.09×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–104. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.35×10^{1}	6.84×10^{-1}	9.26×10^{-4}	7.77×10^{-7}	9.27×10^{-4}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.20×10^{1}	2.65×10^{-1}	5.25×10^{-4}	3.86×10^{-7}	5.26×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.36	1.19×10^{-1}	3.09×10^{-4}	1.34×10^{-7}	3.09×10^{-4}	1.47×10^{-2}	9.57×10^{-2}	5.22×10^{-7}	6.72×10^{-8}	5.41×10^{-7}
Off Site										
Columbia River	5.05×10^{-4}	4.21×10^{-3}	1.35×10^{-8}	1.95×10^{-12}	1.35×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not available; Rad.=radiological; yr=year.

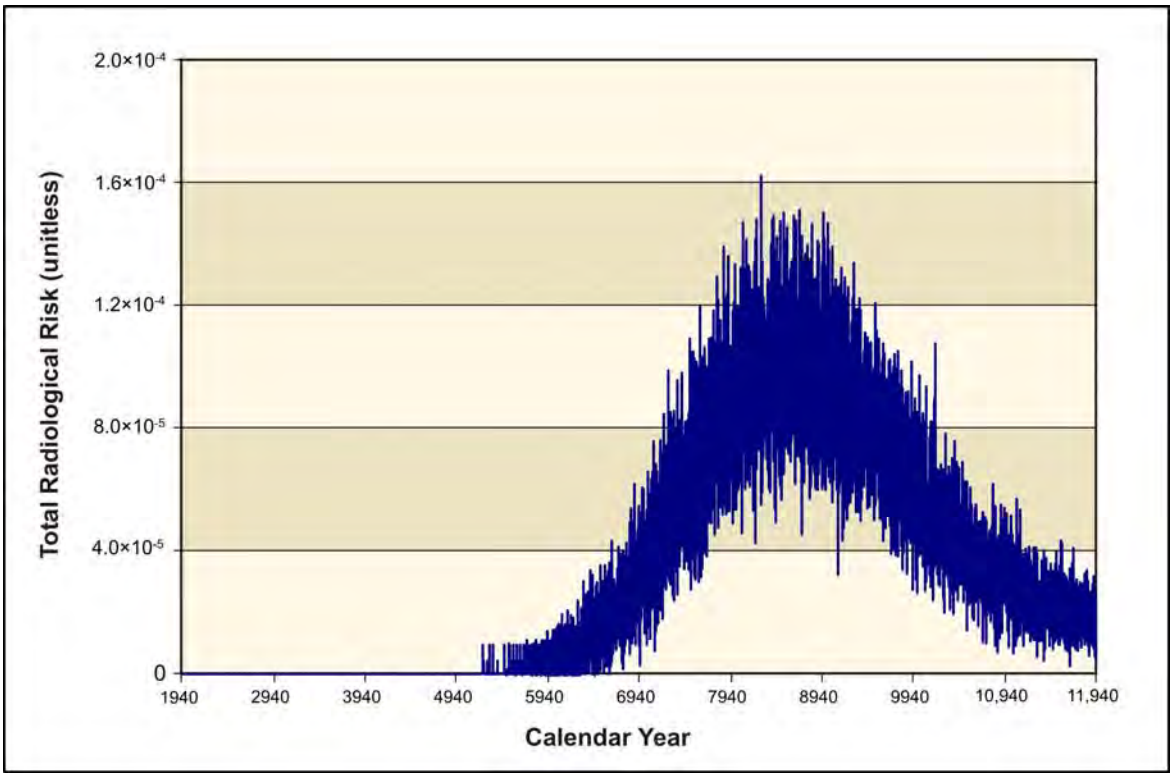


Figure 5–1142. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

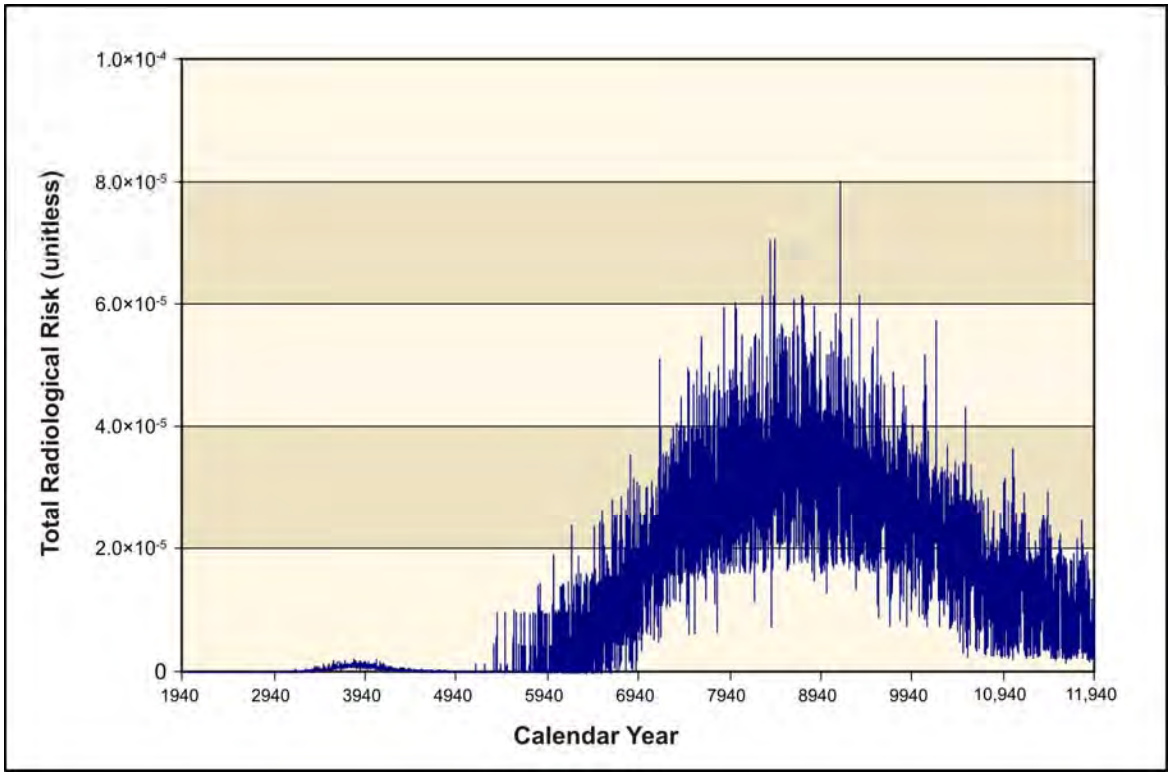


Figure 5–1143. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-B

Disposal Group 1, Subgroup 1-B, addresses the waste resulting from Tank Closure Alternative 3A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–105 and 5–106. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.87×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 2.12×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1144 and 5–1145, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.4×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the bulk vitrification glass supplemental low-activity waste (LAW) source (4×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the bulk vitrification glass waste is release of technetium-99 from the castable refractory block portion of the waste form package. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1145) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–105. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.81	2.66×10^{-1}	2.12×10^{-4}	0.00	2.12×10^{-4}	1.69×10^{1}	3.48×10^{-1}	6.19×10^{-4}	6.93×10^{-12}	6.19×10^{-4}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	3.68	1.06×10^{-1}	8.47×10^{-5}	0.00	8.47×10^{-5}	6.65	1.40×10^{-1}	2.60×10^{-4}	8.42×10^{-12}	2.60×10^{-4}
Columbia River Nearshore	2.77	6.74×10^{-2}	5.54×10^{-5}	0.00	5.54×10^{-5}	4.39	8.82×10^{-2}	1.68×10^{-4}	1.48×10^{-12}	1.68×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	7.75×10^{-5}	1.52×10^{-6}	2.76×10^{-9}	2.10×10^{-17}	2.76×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–106. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.12×10^{1}	6.77×10^{-1}	1.31×10^{-3}	3.18×10^{-7}	1.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.27×10^{1}	2.73×10^{-1}	5.58×10^{-4}	3.86×10^{-7}	5.58×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	8.19	1.72×10^{-1}	3.61×10^{-4}	6.77×10^{-8}	3.61×10^{-4}	1.60×10^{-2}	1.36×10^{-1}	5.80×10^{-7}	3.38×10^{-8}	5.97×10^{-7}
Off Site										
Columbia River	5.38×10^{-4}	4.03×10^{-3}	1.51×10^{-8}	9.65×10^{-13}	1.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

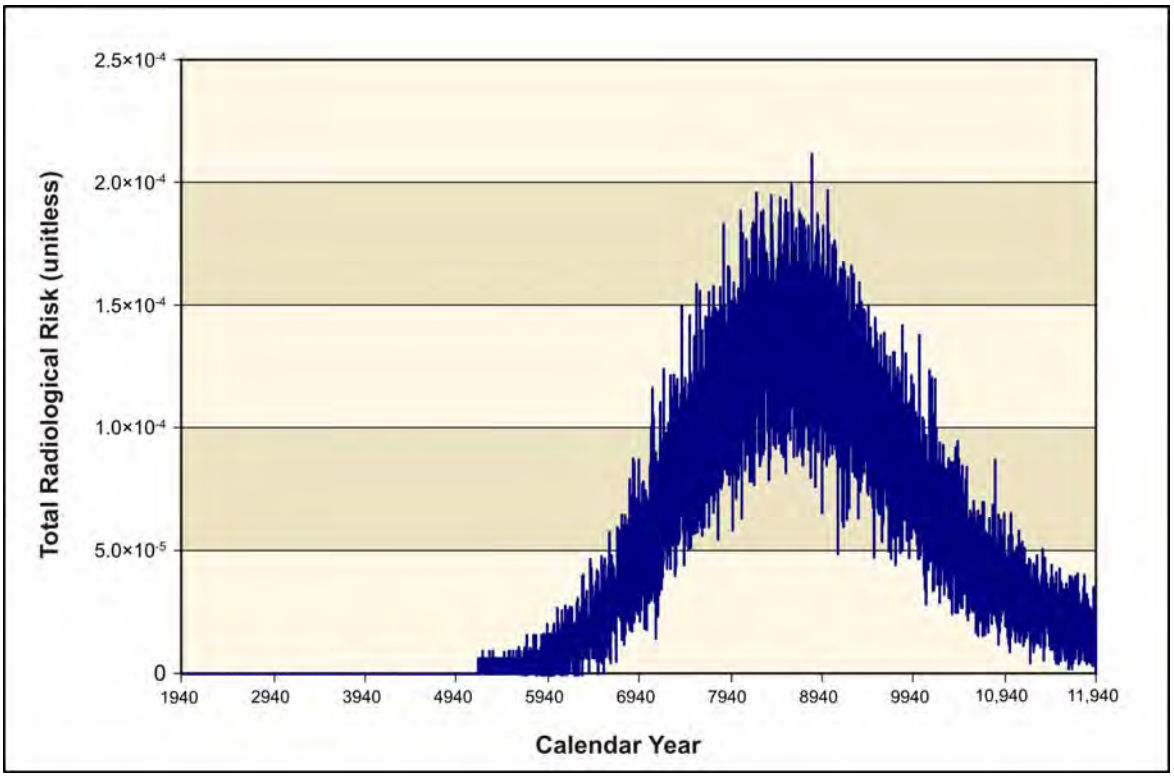


Figure 5–1144. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

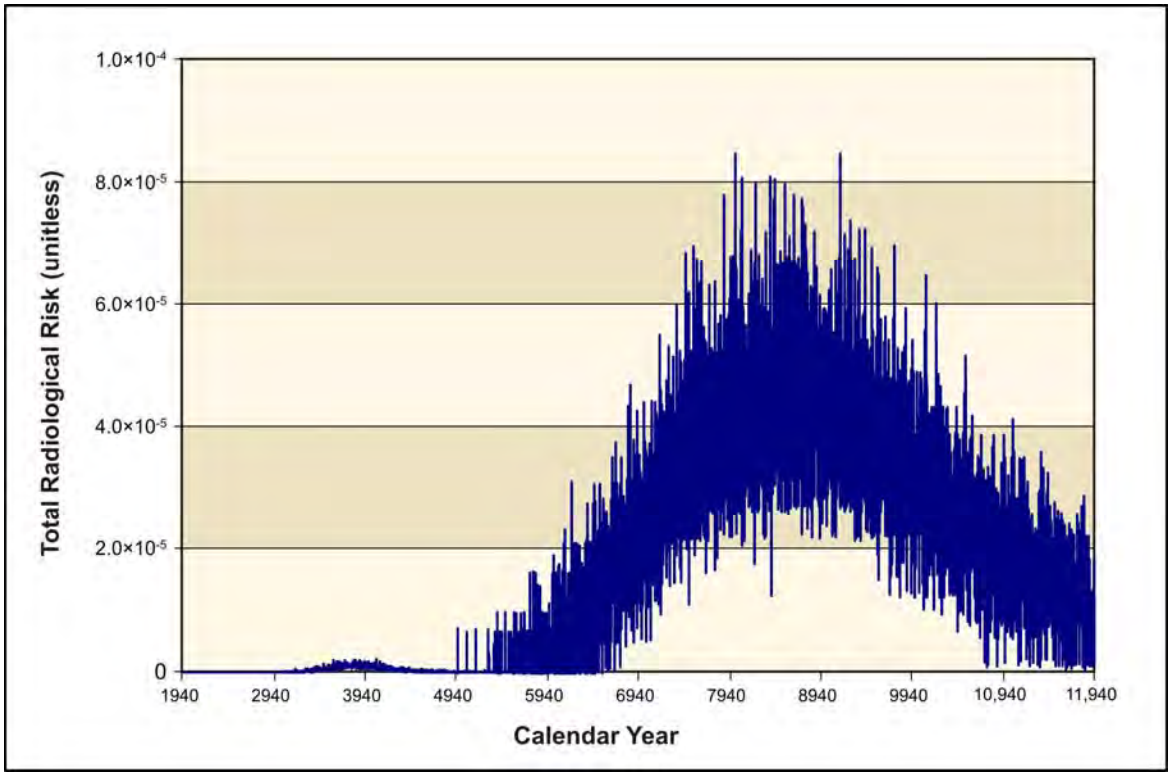


Figure 5–1145. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.3 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-C

Disposal Group 1, Subgroup 1-C, addresses the waste resulting from Tank Closure Alternative 3B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–107 and 5–108. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. However, the Hazard Index guideline would be exceeded due primarily to chromium and nitrate at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 5.55×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.04×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1146 and 5–1147, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.8×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the cast stone supplemental LAW source (8×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the cast stone waste form is release of technetium-99. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1147) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–107. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.22×10^{1}	4.86	3.64×10^{-4}	0.00	3.64×10^{-4}	2.79×10^{1}	5.08	1.15×10^{-3}	1.71×10^{-9}	1.15×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	1.59×10^{1}	2.73	5.09×10^{-4}	0.00	5.09×10^{-4}	3.85×10^{1}	2.80	1.64×10^{-3}	1.04×10^{-9}	1.64×10^{-3}
Columbia River Nearshore	4.15	1.24	1.15×10^{-4}	0.00	1.15×10^{-4}	8.97	1.29	3.51×10^{-4}	4.57×10^{-10}	3.51×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.11×10^{-4}	1.91×10^{-5}	4.28×10^{-9}	5.84×10^{-15}	4.28×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–108. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.48×10^{1}	7.87	2.48×10^{-3}	7.86×10^{-5}	2.52×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	7.70×10^{1}	4.23	3.55×10^{-3}	4.77×10^{-5}	3.56×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.72×10^{1}	1.97	7.53×10^{-4}	2.10×10^{-5}	7.58×10^{-4}	2.54×10^{-2}	6.60×10^{-1}	1.18×10^{-6}	1.05×10^{-5}	1.10×10^{-5}
Off Site										
Columbia River	5.85×10^{-4}	1.80×10^{-2}	1.80×10^{-8}	2.68×10^{-10}	1.82×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

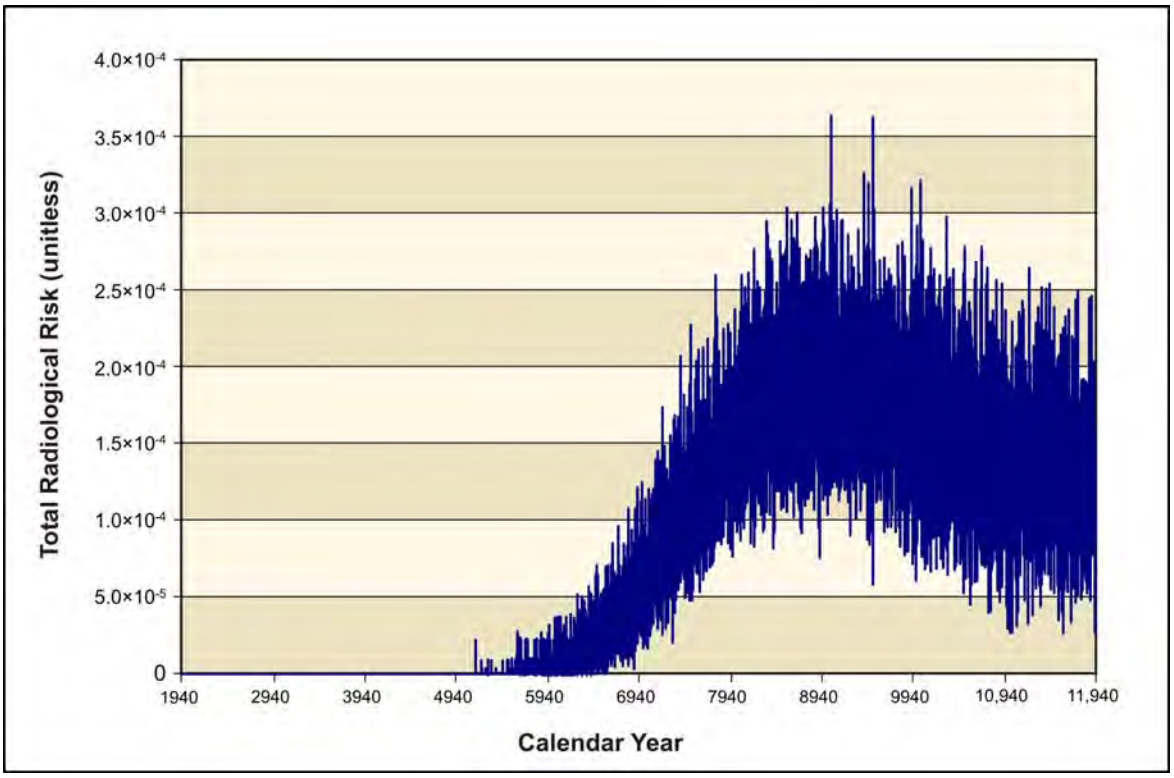


Figure 5–1146. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

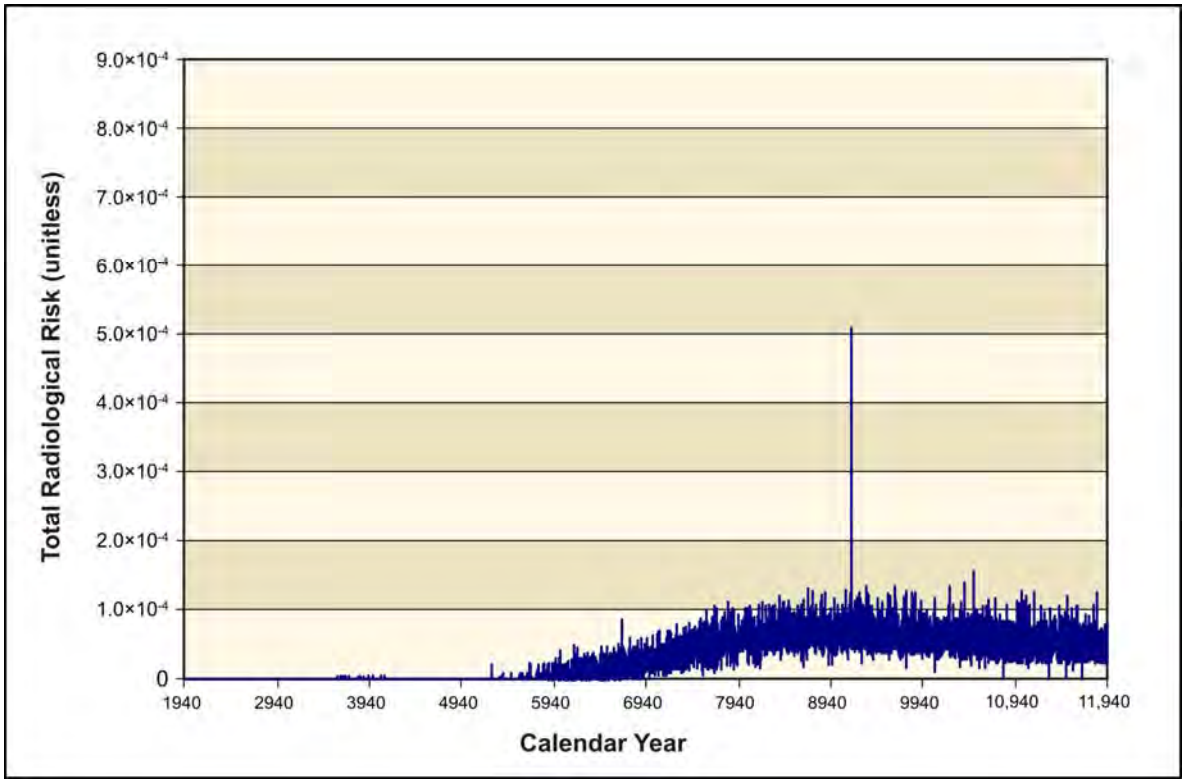


Figure 5–1147. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.4 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-D

Disposal Group 1, Subgroup 1-D, addresses the waste resulting from Tank Closure Alternative 3C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–109 and 5–110. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would be exceeded at the IDF-East Barrier and the Core Zone Boundary for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded due primarily to chromium at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 2.40 person-rem per year for the year of maximum impact. This corresponds to a 1.31×10^{-4} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East barrier and the Core Zone Boundary are presented in Figures 5–1148 and 5–1149, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (9.0×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the steam reforming solids supplemental LAW source (8×10^{-4}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the steam reforming solids is release of technetium-99. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1149) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–109. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.65×10^{1}	4.30	1.86×10^{-3}	0.00	1.86×10^{-3}	1.40×10^{2}	4.35	6.01×10^{-3}	1.71×10^{-9}	6.01×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	4.42×10^{1}	1.69	1.50×10^{-3}	0.00	1.50×10^{-3}	1.12×10^{2}	1.70	4.91×10^{-3}	6.84×10^{-10}	4.91×10^{-3}
Columbia River Nearshore	1.48×10^{1}	1.12	4.73×10^{-4}	0.00	4.73×10^{-4}	3.58×10^{1}	1.13	1.52×10^{-3}	4.56×10^{-10}	1.52×10^{-3}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.79×10^{-4}	1.69×10^{-5}	2.03×10^{-8}	6.52×10^{-15}	2.03×10^{-8}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–110. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.81×10^{2}	6.46	1.31×10^{-2}	7.85×10^{-5}	1.31×10^{-2}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.28×10^{2}	2.50	1.07×10^{-2}	3.14×10^{-5}	1.07×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.16×10^{1}	1.66	3.31×10^{-3}	2.09×10^{-5}	3.31×10^{-3}	9.11×10^{-2}	2.88×10^{-1}	4.75×10^{-6}	1.05×10^{-5}	1.18×10^{-5}
Off Site										
Columbia River	1.46×10^{-3}	4.74×10^{-3}	5.94×10^{-8}	2.99×10^{-10}	5.95×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not available; Rad.=radiological; yr=year.

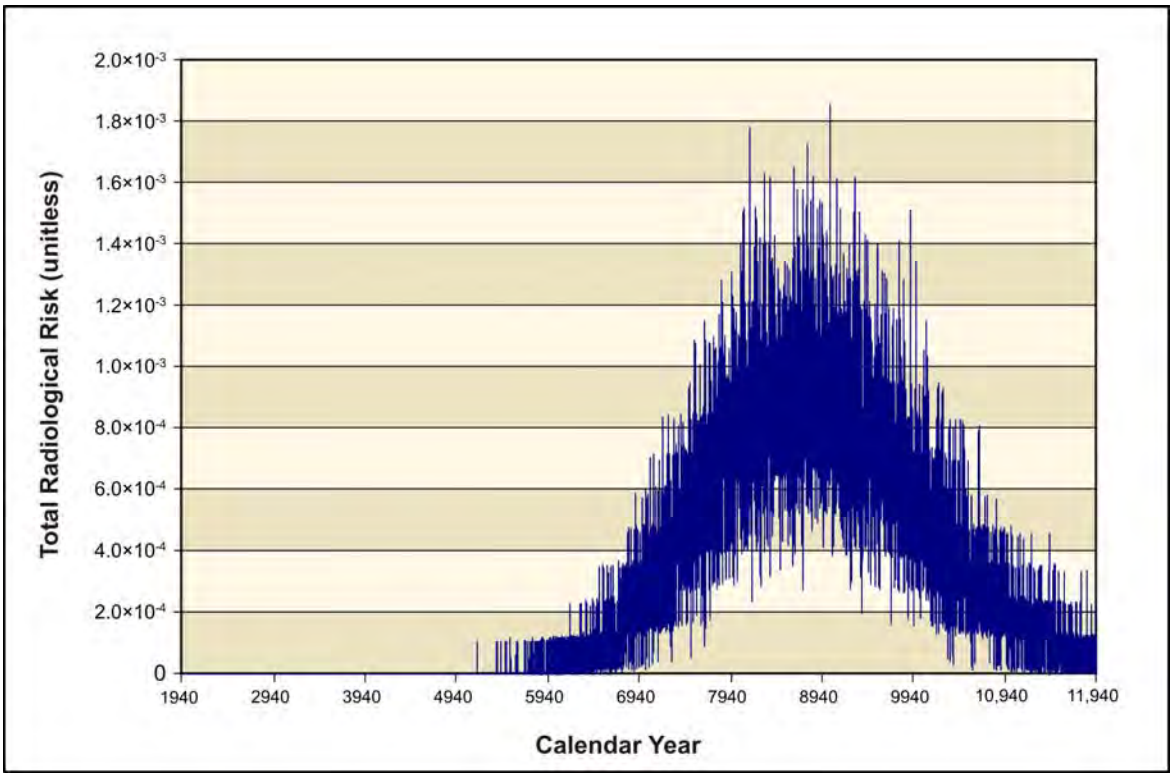


Figure 5–1148. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

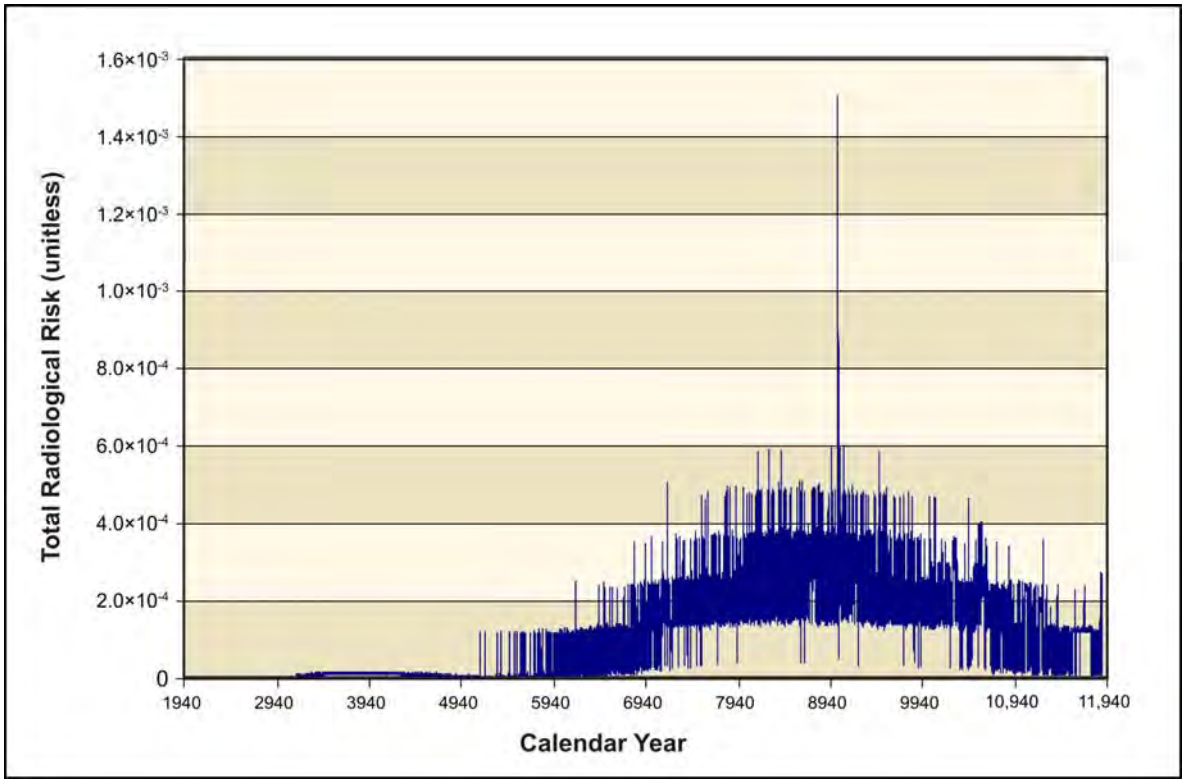


Figure 5–1149. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.5 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-E

Disposal Group 1, Subgroup 1-E, addresses the waste resulting from Tank Closure Alternative 4, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–111 and 5–112. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. The Hazard Index guideline would be exceeded primarily due to chromium at the IDF-East Barrier and the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would also be exceeded primarily due to chromium and nitrate at the Columbia River nearshore location for the American Indian resident farmer. Population dose was estimated as 6.25×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.42×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1150 and 5–1151, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier ($2.2\times \times 10^{-4}$) is distributed among the offsite LLW (9×10^{-5}), the combination of ILAW glass and bulk vitrification and cast stone LAW sources (1.2×10^{-4}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the LAW sources is release of technetium-99 from cast stone and the castable refractory block portion of the bulk vitrification glass waste form package. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1151) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–111. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.38×10^{1}	2.48	4.10×10^{-4}	0.00	4.10×10^{-4}	3.11×10^{1}	2.59	1.31×10^{-3}	8.78×10^{-10}	1.31×10^{-3}
River Protection Project Disposal Facility	2.15×10^{-1}	5.86×10^{-2}	6.59×10^{-6}	0.00	6.59×10^{-6}	5.03×10^{-1}	5.95×10^{-2}	2.08×10^{-5}	2.30×10^{-11}	2.08×10^{-5}
Core Zone Boundary	5.91	1.02	1.92×10^{-4}	0.00	1.92×10^{-4}	1.45×10^{1}	1.06	6.18×10^{-4}	3.76×10^{-10}	6.18×10^{-4}
Columbia River Nearshore	4.36	6.59×10^{-1}	1.31×10^{-4}	0.00	1.31×10^{-4}	1.01×10^{1}	6.75×10^{-1}	4.13×10^{-4}	2.50×10^{-10}	4.13×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.25×10^{-4}	1.15×10^{-5}	5.05×10^{-9}	3.65×10^{-15}	5.05×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–112. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	6.19×10^{1}	4.01	2.84×10^{-3}	4.03×10^{-5}	2.86×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	9.92×10^{-1}	8.87×10^{-2}	4.51×10^{-5}	1.06×10^{-6}	4.59×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.90×10^{1}	1.62	1.34×10^{-3}	1.72×10^{-5}	1.35×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.98×10^{1}	1.02	8.93×10^{-4}	1.15×10^{-5}	8.96×10^{-4}	2.69×10^{-2}	3.40×10^{-1}	1.33×10^{-6}	5.74×10^{-6}	6.22×10^{-6}
Off Site										
Columbia River	6.20×10^{-4}	1.05×10^{-2}	1.94×10^{-8}	1.67×10^{-10}	1.95×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not available; Rad.=radiological; yr=year.

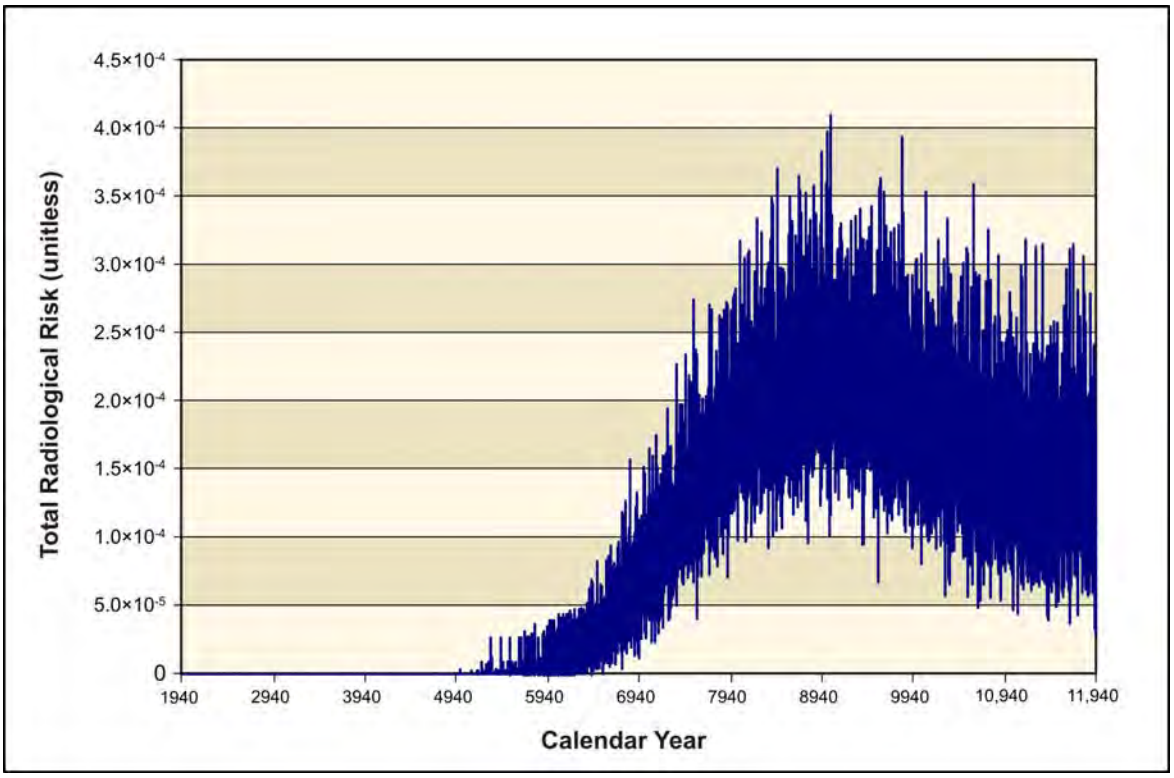


Figure 5–1150. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

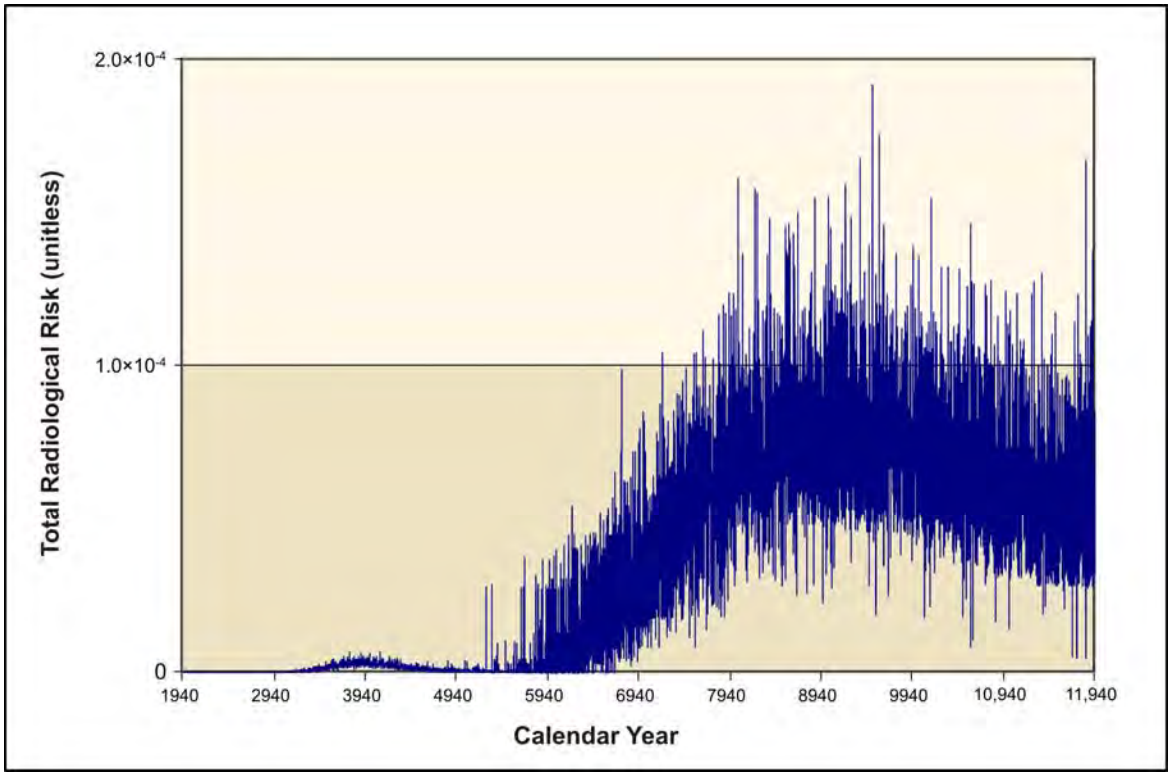


Figure 5–1151. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.6 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-F

Disposal Group 1, Subgroup 1-F, addresses the waste resulting from Tank Closure Alternative 5, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–113 and 5–114. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier, Core Zone Boundary and the Columbia River nearshore locations for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 4.18×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 2.29×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1152 and 5–1153, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.5×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the combination of ILAW glass and bulk vitrification and cast stone sources (5.0×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the sources is release of technetium-99 from cast stone and the castable refractory block portion of the bulk vitrification glass waste form package. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1153) does not include an early peak, as the RPPDF is not constructed for this alternative, but does include a late peak due to sources at IDF-East.

Table 5–113. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.02×10^{1}	3.51	2.57×10^{-4}	0.00	2.57×10^{-4}	2.05×10^{1}	3.62	7.56×10^{-4}	1.32×10^{-9}	7.56×10^{-4}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.89	1.47	9.97×10^{-5}	0.00	9.97×10^{-5}	7.70	1.50	3.09×10^{-4}	5.81×10^{-10}	3.09×10^{-4}
Columbia River Nearshore	2.97	1.09	6.15×10^{-5}	0.00	6.15×10^{-5}	4.89	1.10	1.83×10^{-4}	4.32×10^{-10}	1.83×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	8.36×10^{-5}	1.32×10^{-5}	3.10×10^{-9}	4.79×10^{-15}	3.10×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–114. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.80×10^{1}	5.50	1.60×10^{-3}	6.04×10^{-5}	1.63×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.49×10^{1}	2.23	6.64×10^{-4}	2.67×10^{-5}	6.72×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	9.11	1.63	3.93×10^{-4}	1.98×10^{-5}	3.98×10^{-4}	1.73×10^{-2}	3.31×10^{-1}	6.40×10^{-7}	9.90×10^{-6}	1.03×10^{-5}
Off Site										
Columbia River	5.56×10^{4}	6.96×10^{-3}	1.59×10^{-8}	2.20×10^{-10}	1.61×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

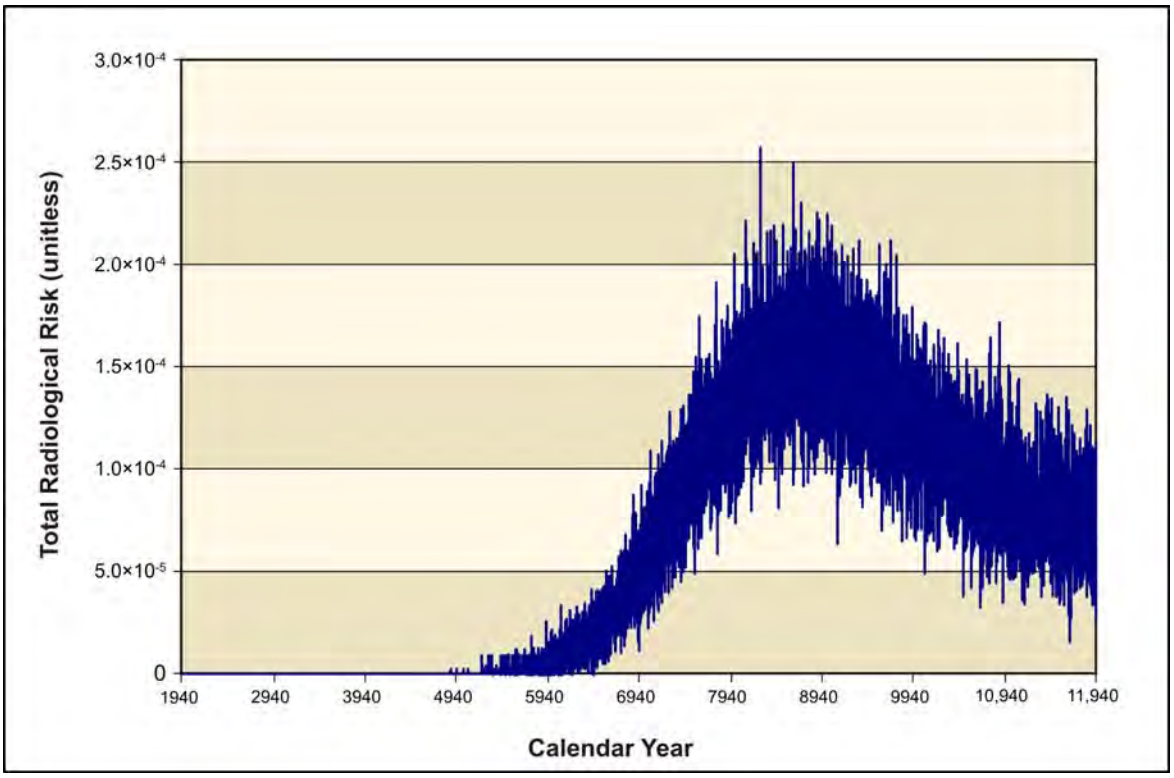


Figure 5–1152. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

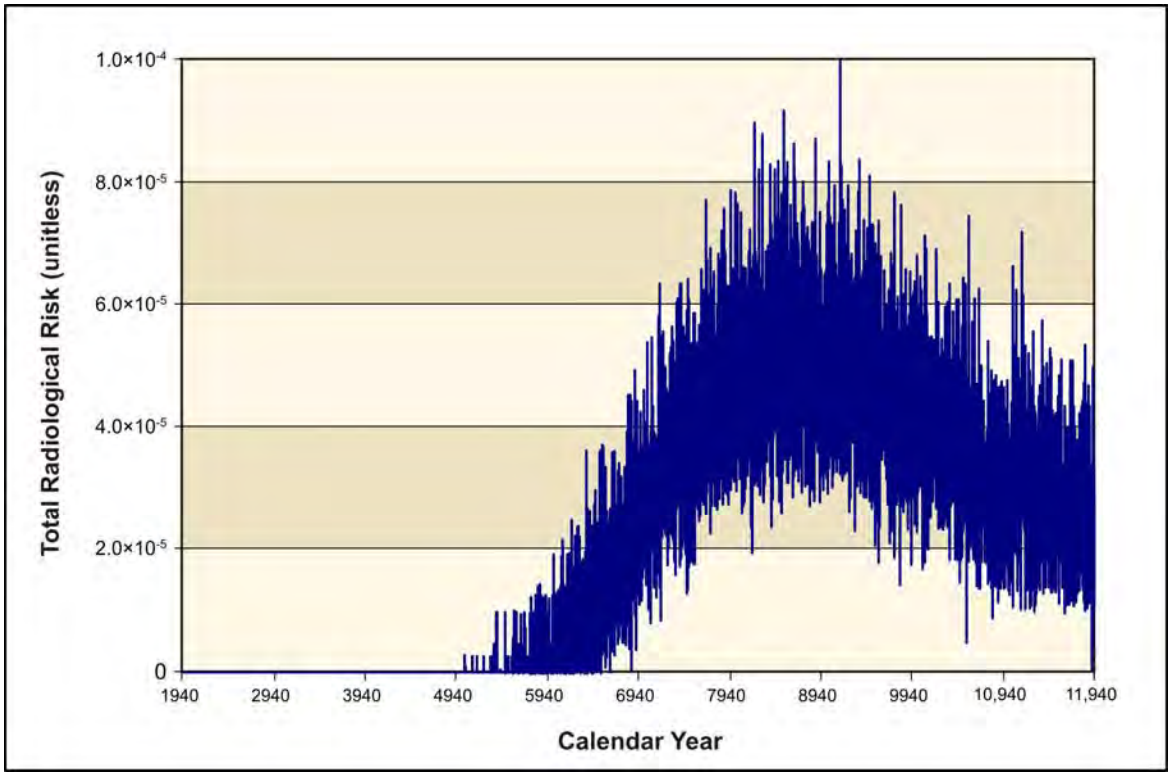


Figure 5–1153. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.7 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-G

Disposal Group 1, Subgroup 1-G, addresses the waste resulting from Tank Closure Alternative 6C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–115 and 5–116. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.06×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 1.68×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1154 and 5–1155, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.0×10^{-4}) is distributed among the offsite LLW (9×10^{-5}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for secondary waste sources is release of technetium-99 from tank closure secondary waste and iodine-129 from the combined ETF-generated and tank closure secondary waste sources. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1155) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–115. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	7.59	2.68×10^{-1}	1.60×10^{-4}	0.00	1.60×10^{-4}	1.33×10^{1}	3.45×10^{-1}	4.64×10^{-4}	1.52×10^{-11}	4.64×10^{-4}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	3.07	1.04×10^{-1}	7.86×10^{-5}	0.00	7.86×10^{-5}	6.13	1.36×10^{-1}	2.40×10^{-4}	8.42×10^{-12}	2.40×10^{-4}
Columbia River Nearshore	2.61	4.79×10^{-2}	4.98×10^{-5}	0.00	4.98×10^{-5}	3.98	6.17×10^{-2}	1.46×10^{-4}	3.16×10^{-12}	1.46×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.12×10^{-5}	1.61×10^{-6}	2.10×10^{-9}	4.03×10^{-17}	2.10×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–116. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.32×10^{1}	6.71×10^{-1}	9.88×10^{-4}	6.96×10^{-7}	9.88×10^{-4}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.17×10^{1}	2.65×10^{-1}	5.14×10^{-4}	3.86×10^{-7}	5.14×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.34	1.19×10^{-1}	3.08×10^{-4}	1.45×10^{-7}	3.08×10^{-4}	1.49×10^{-2}	9.61×10^{-2}	5.21×10^{-7}	7.25×10^{-8}	5.40×10^{-7}
Off Site										
Columbia River	5.05×10^{-4}	4.21×10^{-3}	1.34×10^{-8}	1.85×10^{-12}	1.34×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

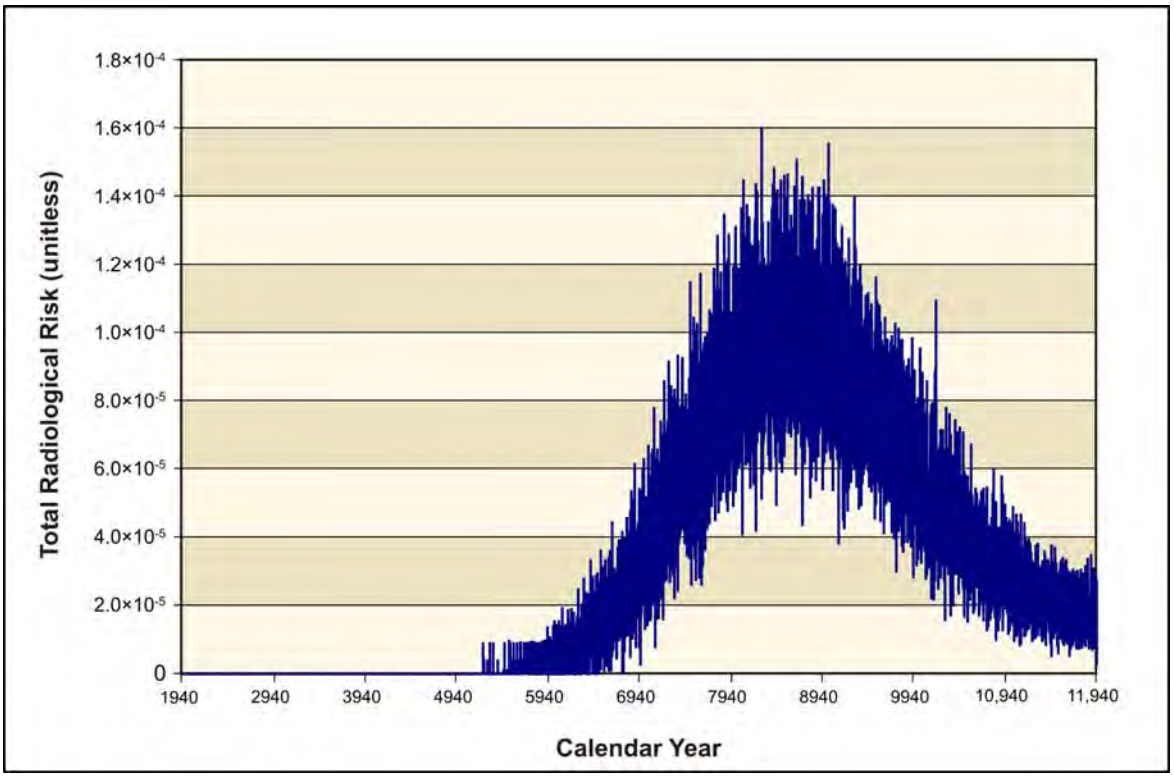


Figure 5–1154. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

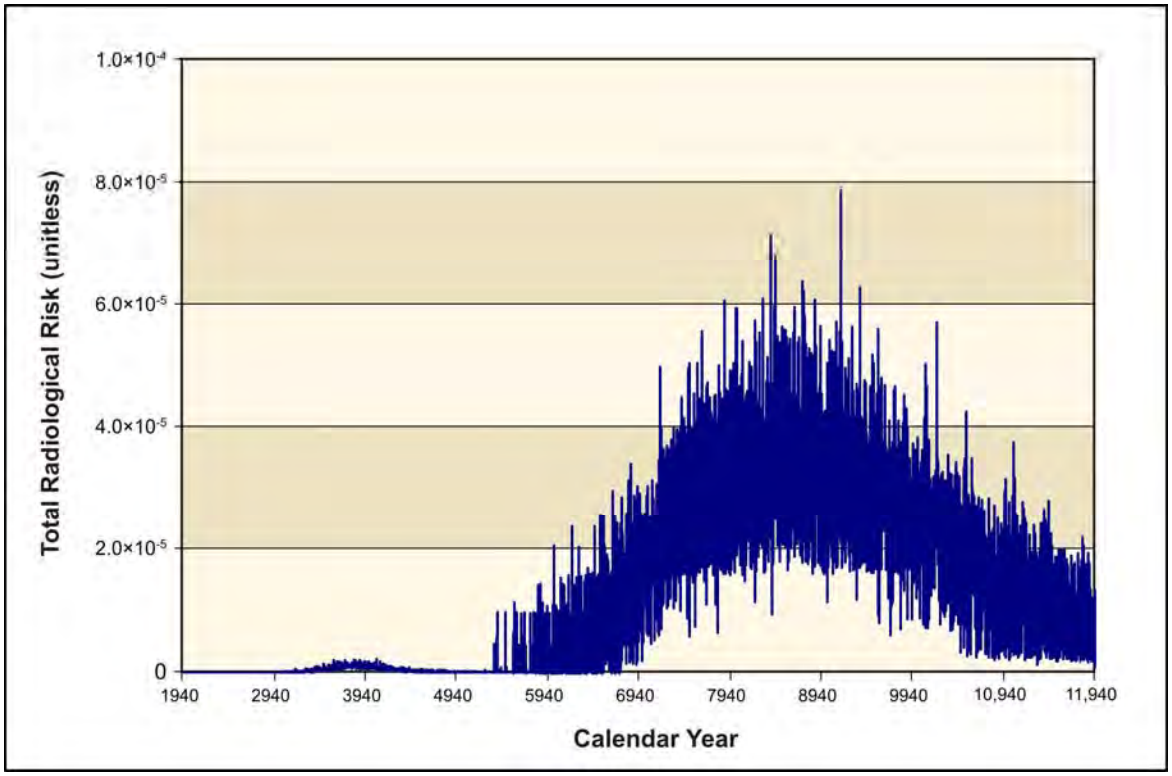


Figure 5–1155. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.8 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 2, Subgroup 2-A

Disposal Group 2, Subgroup 2-A, addresses the waste resulting from Tank Closure Alternative 2A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–117 and 5–118. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.18×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 1.74×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and at the Core Zone Boundary are presented in Figures 5–1156 and 5–1157, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.2×10^{-4}) includes contributions from offsite LLW (9×10^{-5}), the combination of ETF-generated and tank closure secondary waste (1.3×10^{-5}), and ILAW glass (2.0×10^{-5}); ILAW glass provides a minor contribution to estimated impacts. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1157) does not include an early peak, as the RPPDF is not constructed for this alternative, but does include a late peak due to sources at IDF-East.

Table 5–117. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.12×10^{1}	2.98×10^{-1}	2.32×10^{-4}	0.00	2.32×10^{-4}	1.94×10^{1}	3.86×10^{-1}	6.24×10^{-4}	1.25×10^{-11}	6.24×10^{-4}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.98	1.05×10^{-1}	8.27×10^{-5}	0.00	8.27×10^{-5}	6.55	1.38×10^{-1}	2.45×10^{-4}	6.51×10^{-12}	2.45×10^{-4}
Columbia River Nearshore	1.92	7.46×10^{-2}	4.52×10^{-5}	0.00	4.52×10^{-5}	3.51	9.76×10^{-2}	1.39×10^{-4}	2.96×10^{-12}	1.39×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.36×10^{-5}	1.64×10^{-6}	2.12×10^{-9}	4.07×10^{-17}	2.12×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–118. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.33×10^{1}	7.47×10^{-1}	1.31×10^{-3}	5.75×10^{-7}	1.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.22×10^{1}	2.68×10^{-1}	5.20×10^{-4}	2.99×10^{-7}	5.20×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	6.75	1.91×10^{-1}	2.98×10^{-4}	1.36×10^{-7}	2.99×10^{-4}	1.09×10^{-2}	1.52×10^{-1}	4.71×10^{-7}	6.79×10^{-8}	5.00×10^{-7}
Off Site										
Columbia River	4.89×10^{-4}	4.31×10^{-3}	1.37×10^{-8}	1.87×10^{-12}	1.37×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

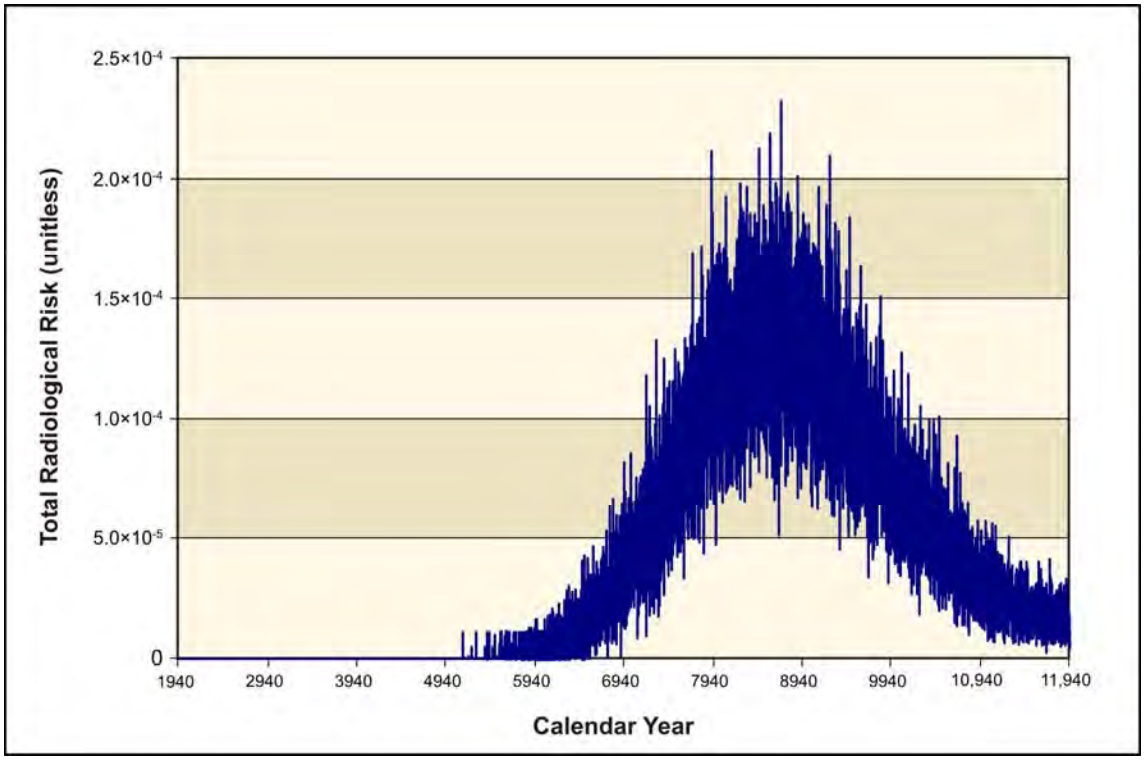


Figure 5–1156. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

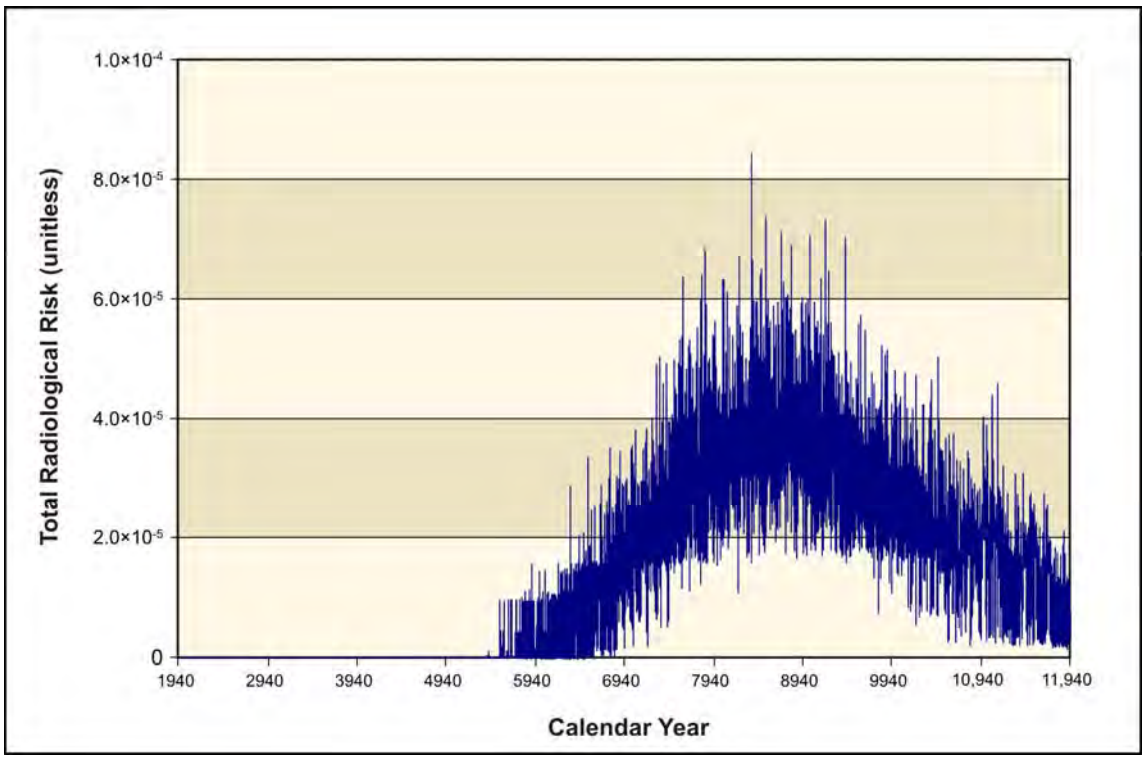


Figure 5–1157. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.9 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 2, Subgroup 2-B

Disposal Group 2, Subgroup 2-B, addresses the waste resulting from Tank Closure Alternative 6B (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–119 through 5–122. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium for chemicals. For radionuclides, the dose standard would not be exceeded at any location. For Base Case, the Hazard Index guideline would not be exceeded at any location. For the Option Case, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer due primarily to presence of chromium and nitrate. Population dose was estimated for Subgroup 2-B, Base Case, as 3.23×10^{-1} person-rem per year for the year of maximum impact and for Subgroup 2-B, Option Case, as 3.12×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.77×10^{-5} percent and 1.71×10^{-5} percent of the annual population dose due to background exposure for Subgroup 2-B, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1158 and 5–1159 for the Base Case and in Figures 5–1160 and 5–1161 for the Option Case. The Base and Option Cases differ in the amounts of constituents disposed of at the RPPDF because the Option Case includes removal of the Tank Closure alternative cribs and trenches (ditches). Estimates of impacts for IDF-East are the same for the two cases. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.2×10^{-4}) is distributed primarily among the offsite LLW (9×10^{-5}) and the combined ETF-generated, tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for secondary waste sources is release of technetium-99 from tank closure secondary waste and iodine-129 from the combined ETF-generated and tank closure secondary waste sources. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary for the Base Case (see Figure 5–1159) and the Option Case (see Figure 5–1161) each comprise a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East. The early peak is greater for the Option Case relative to the Base Case due to the inclusion of additional waste from cribs and trenches (ditches).

Table 5–119. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.14×10^{1}	3.21×10^{-1}	2.34×10^{-4}	0.00	2.34×10^{-4}	1.96×10^{1}	4.15×10^{-1}	6.38×10^{-4}	1.27×10^{-11}	6.38×10^{-4}
River Protection Project Disposal Facility	5.92×10^{-1}	5.96×10^{-2}	1.82×10^{-5}	0.00	1.82×10^{-5}	1.39	6.11×10^{-2}	5.75×10^{-5}	2.27×10^{-11}	5.75×10^{-5}
Core Zone Boundary	3.96	1.16×10^{-1}	8.23×10^{-5}	0.00	8.23×10^{-5}	6.52	1.40×10^{-1}	2.43×10^{-4}	4.41×10^{-11}	2.43×10^{-4}
Columbia River Nearshore	1.92	6.48×10^{-2}	4.73×10^{-5}	0.00	4.73×10^{-5}	3.66	8.36×10^{-2}	1.46×10^{-4}	9.08×10^{-12}	1.46×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.43×10^{-5}	1.73×10^{-6}	2.14×10^{-9}	1.23×10^{-16}	2.14×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–120. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.36×10^{1}	8.02×10^{-1}	1.34×10^{-3}	5.81×10^{-7}	1.34×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.73	9.24×10^{-2}	1.24×10^{-4}	1.04×10^{-6}	1.25×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.22×10^{1}	2.72×10^{-1}	5.17×10^{-4}	2.02×10^{-6}	5.17×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.06	1.61×10^{-1}	3.13×10^{-4}	4.17×10^{-7}	3.13×10^{-4}	1.09×10^{-2}	1.26×10^{-1}	4.93×10^{-7}	2.08×10^{-7}	5.49×10^{-7}
Off Site										
Columbia River	4.90×10^{-4}	4.50×10^{-3}	1.38×10^{-8}	5.63×10^{-12}	1.38×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–121. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.14×10^{1}	3.21×10^{-1}	2.34×10^{-4}	0.00	2.34×10^{-4}	1.96×10^{1}	4.15×10^{-1}	6.38×10^{-4}	1.27×10^{-11}	6.38×10^{-4}
River Protection Project Disposal Facility	6.96×10^{-1}	3.91×10^{-1}	2.16×10^{-5}	0.00	2.16×10^{-5}	1.65	4.38×10^{-1}	6.87×10^{-5}	1.28×10^{-10}	6.87×10^{-5}
Core Zone Boundary	3.96	1.38	8.33×10^{-5}	0.00	8.33×10^{-5}	6.52	1.54	2.70×10^{-4}	3.82×10^{-10}	2.70×10^{-4}
Columbia River Nearshore	1.94	2.29×10^{-1}	4.81×10^{-5}	0.00	4.81×10^{-5}	3.73	2.51×10^{-1}	1.48×10^{-4}	6.67×10^{-11}	1.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.46×10^{-5}	3.44×10^{-6}	2.16×10^{-9}	8.31×10^{-16}	2.16×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–122. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.36×10^{1}	8.02×10^{-1}	1.34×10^{-3}	5.82×10^{-7}	1.34×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.26	7.37×10^{-1}	1.49×10^{-4}	5.87×10^{-6}	1.51×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.26×10^{1}	2.56	5.86×10^{-4}	1.75×10^{-5}	5.91×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.19	4.12×10^{-1}	3.18×10^{-4}	3.06×10^{-6}	3.20×10^{-4}	1.10×10^{-2}	2.21×10^{-1}	5.01×10^{-7}	1.53×10^{-6}	1.61×10^{-6}
Off Site										
Columbia River	4.93×10^{-4}	5.08×10^{-3}	1.39×10^{-8}	3.81×10^{-11}	1.39×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

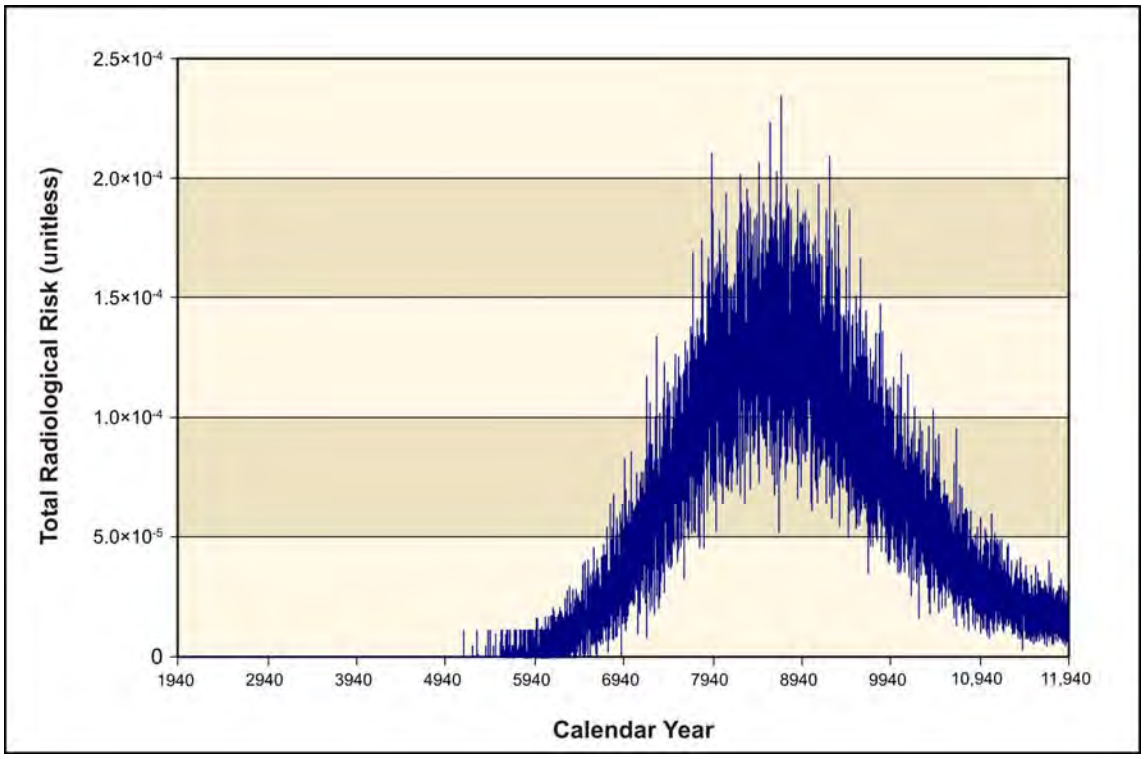


Figure 5–1158. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

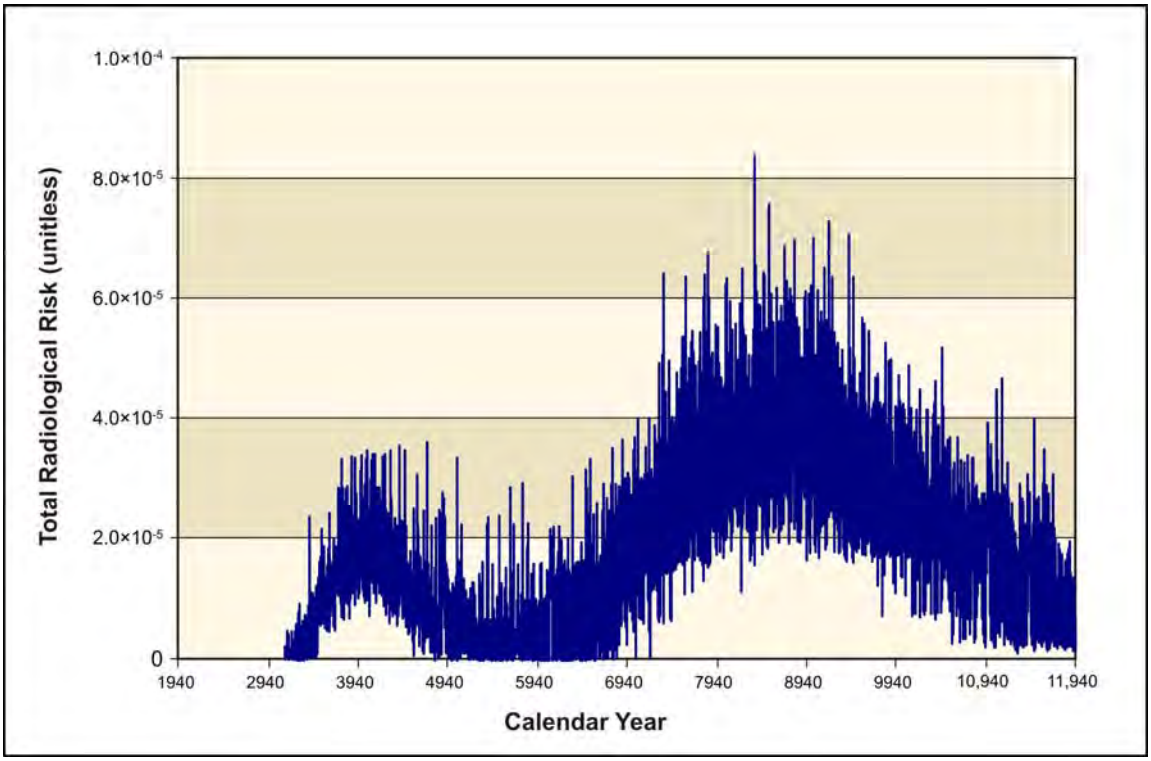


Figure 5–1159. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

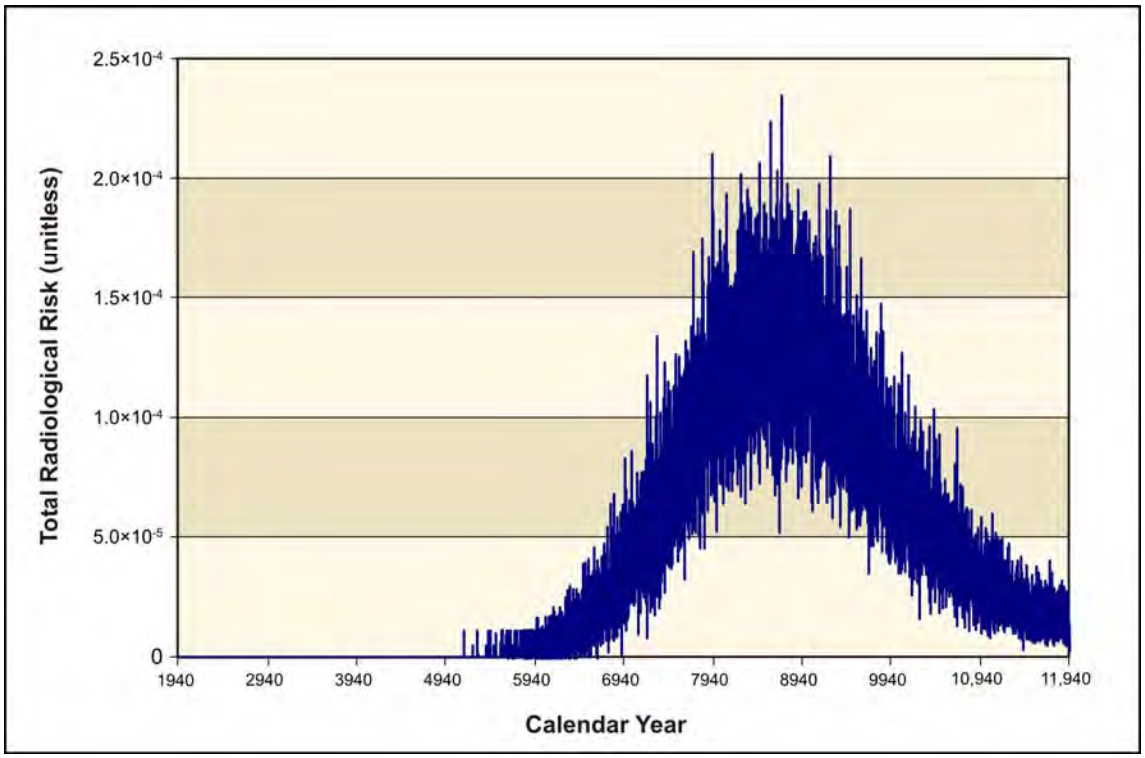


Figure 5–1160. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

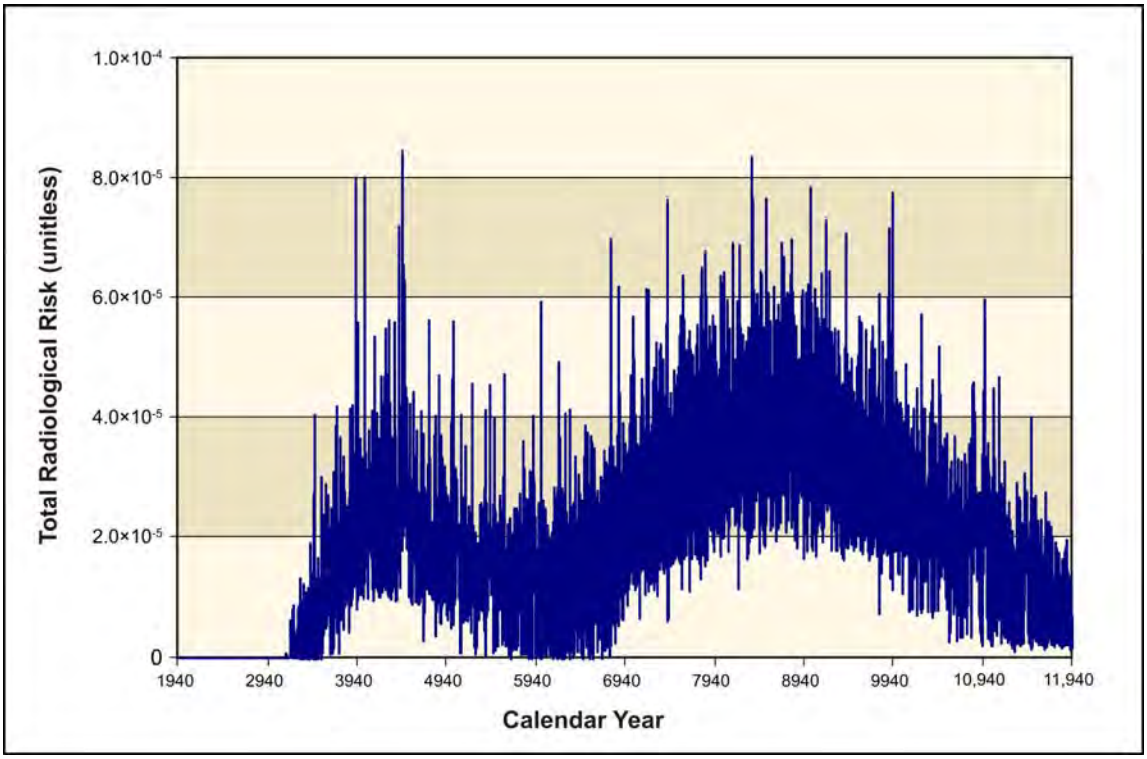


Figure 5–1161. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.10 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 3

Disposal Group 3 addresses the waste resulting from Tank Closure Alternative 6A (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this disposal group.

Potential human health impacts of this alternative are summarized in Tables 5–123 through 5–126. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium for chemicals. For radionuclides, the dose standard would not be exceeded at any location under both Base and Option Cases. For Base Case, the Hazard Index guidelines would not be exceeded at any location. For the Option Case, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer due primarily to presence of chromium and nitrate. The Hazard Index would be exceeded for chromium at the Core Zone Boundary under the Option Case. Population dose was estimated for Disposal Group 3, Base Case, as 3.12×10^{-1} person-rem per year for the year of maximum impact and for Disposal Group 3, Option Case, as 3.13×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.71×10^{-5} percent and 1.71×10^{-5} percent of the annual population dose due to background exposure for Disposal Group 3, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1162 and 5–1163 for the Base Case and in Figures 5–1164 and 5–1165 for the Option Case. The Base and Option Cases differ in the amounts of constituents disposed of at the RPPDF because the Option Case includes removal of the Tank Closure alternative cribs and trenches (ditches). Estimates of impacts for IDF-East are the same for the two cases. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.2×10^{-4}) is distributed primarily among the offsite LLW (9×10^{-5}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for secondary waste sources is release of technetium-99 from tank closure secondary waste and iodine-129 from the combined ETF-generated and tank closure secondary waste sources. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary for the Base Case (see Figure 5–1163) and the Option Case (see Figure 5–1165) each comprise a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East. The early peak is greater for the Option Case relative to the Base Case due to the inclusion of additional waste from cribs and trenches (ditches).

Table 5–123. Waste Management Alternative 2, Disposal Group 3, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.08×10^{1}	3.07×10^{-1}	2.29×10^{-4}	0.00	2.29×10^{-4}	1.90×10^{1}	4.01×10^{-1}	6.48×10^{-4}	1.20×10^{-11}	6.48×10^{-4}
River Protection Project Disposal Facility	6.35×10^{-1}	5.89×10^{-2}	1.94×10^{-5}	0.00	1.94×10^{-5}	1.48	6.01×10^{-2}	6.15×10^{-5}	2.27×10^{-11}	6.15×10^{-5}
Core Zone Boundary	3.59	1.21×10^{-1}	7.77×10^{-5}	0.00	7.77×10^{-5}	5.99	1.56×10^{-1}	2.42×10^{-4}	4.31×10^{-11}	2.42×10^{-4}
Columbia River Nearshore	2.31	6.81×10^{-2}	6.03×10^{-5}	0.00	6.03×10^{-5}	4.76	8.67×10^{-2}	1.80×10^{-4}	1.21×10^{-11}	1.80×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.24×10^{-5}	1.79×10^{-6}	2.12×10^{-9}	1.23×10^{-16}	2.12×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–124. Waste Management Alternative 2, Disposal Group 3, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.30×10^{1}	7.82×10^{-1}	1.38×10^{-3}	5.52×10^{-7}	1.38×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.93	9.04×10^{-2}	1.33×10^{-4}	1.04×10^{-6}	1.33×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.17×10^{1}	3.05×10^{-1}	5.21×10^{-4}	1.98×10^{-6}	5.21×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	8.94	1.65×10^{-1}	3.83×10^{-4}	5.54×10^{-7}	3.84×10^{-4}	1.41×10^{-2}	1.26×10^{-1}	6.28×10^{-7}	2.77×10^{-7}	6.82×10^{-7}
Off Site										
Columbia River	5.26×10^{-4}	4.71×10^{-3}	1.41×10^{-8}	5.64×10^{-12}	1.41×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–125. Waste Management Alternative 2, Disposal Group 3, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.08×10^{1}	3.07×10^{-1}	2.29×10^{-4}	0.00	2.29×10^{-4}	1.90×10^{1}	4.01×10^{-1}	6.48×10^{-4}	1.21×10^{-11}	6.48×10^{-4}
River Protection Project Disposal Facility	7.87×10^{-1}	4.29×10^{-1}	2.45×10^{-5}	0.00	2.45×10^{-5}	1.86	4.69×10^{-1}	7.79×10^{-5}	1.43×10^{-10}	7.79×10^{-5}
Core Zone Boundary	4.10	1.35	8.54×10^{-5}	0.00	8.54×10^{-5}	7.13	1.53	2.42×10^{-4}	4.89×10^{-10}	2.42×10^{-4}
Columbia River Nearshore	2.34	2.29×10^{-1}	6.13×10^{-5}	0.00	6.13×10^{-5}	4.84	2.51×10^{-1}	1.83×10^{-4}	8.04×10^{-11}	1.83×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.25×10^{-5}	3.19×10^{-6}	2.13×10^{-9}	7.90×10^{-16}	2.13×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–126. Waste Management Alternative 2, Disposal Group 3, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.30×10^{1}	7.82×10^{-1}	1.38×10^{-3}	5.53×10^{-7}	1.38×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.70	7.80×10^{-1}	1.69×10^{-4}	6.54×10^{-6}	1.72×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.23×10^{1}	2.59	5.21×10^{-4}	2.24×10^{-5}	5.23×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	9.08	4.11×10^{-1}	3.89×10^{-4}	3.69×10^{-6}	3.89×10^{-4}	1.43×10^{-2}	2.17×10^{-1}	6.38×10^{-7}	1.84×10^{-6}	2.00×10^{-6}
Off Site										
Columbia River	5.28×10^{-4}	5.31×10^{-3}	1.42×10^{-8}	3.62×10^{-11}	1.42×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

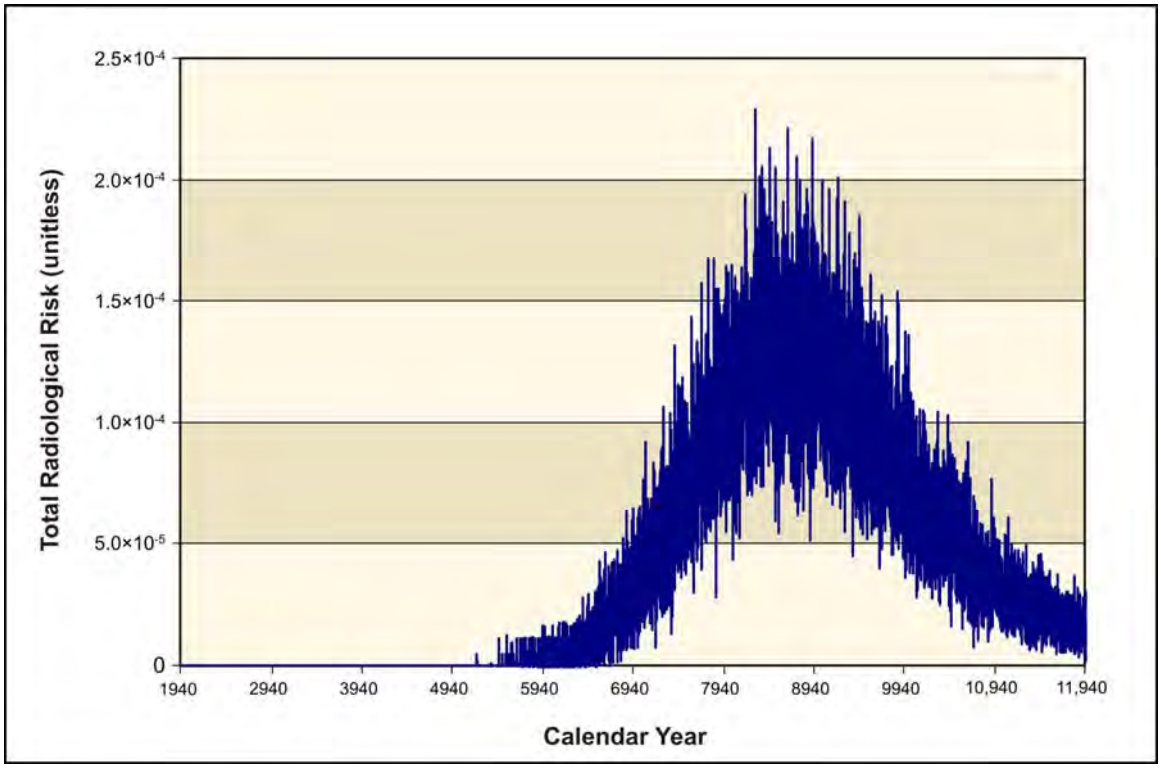


Figure 5–1162. Waste Management Alternative 2, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

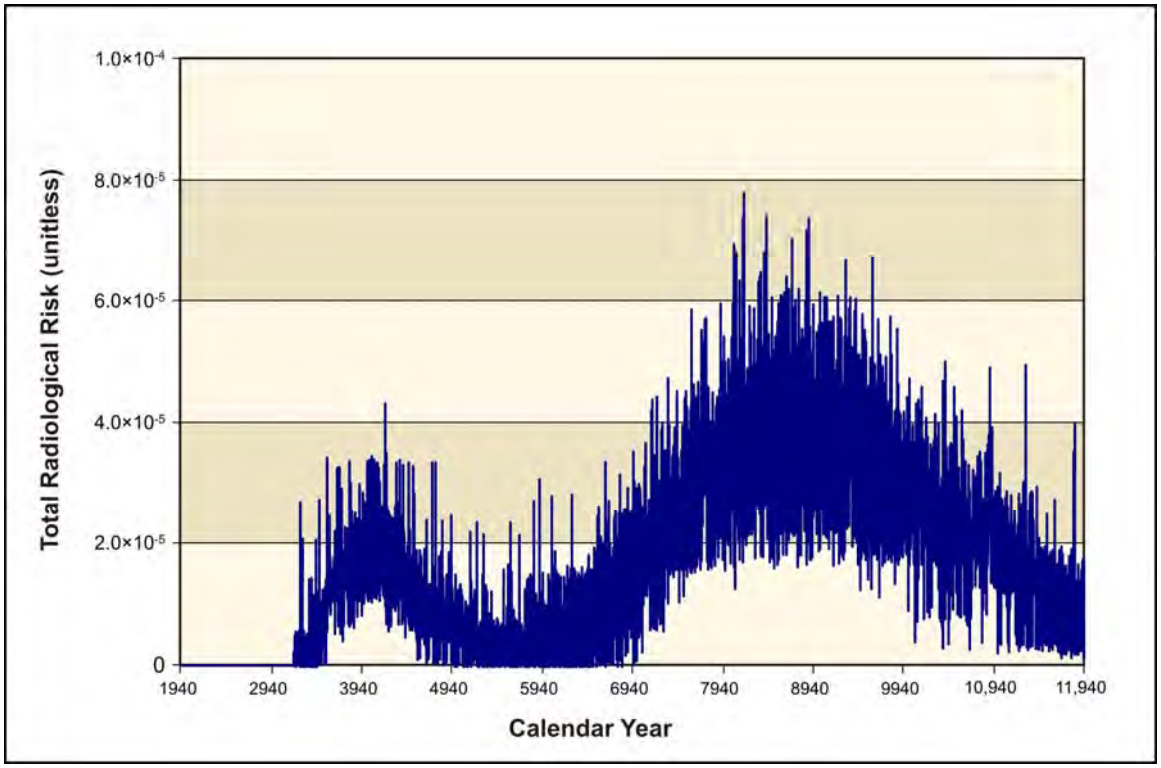


Figure 5–1163. Waste Management Alternative 2, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

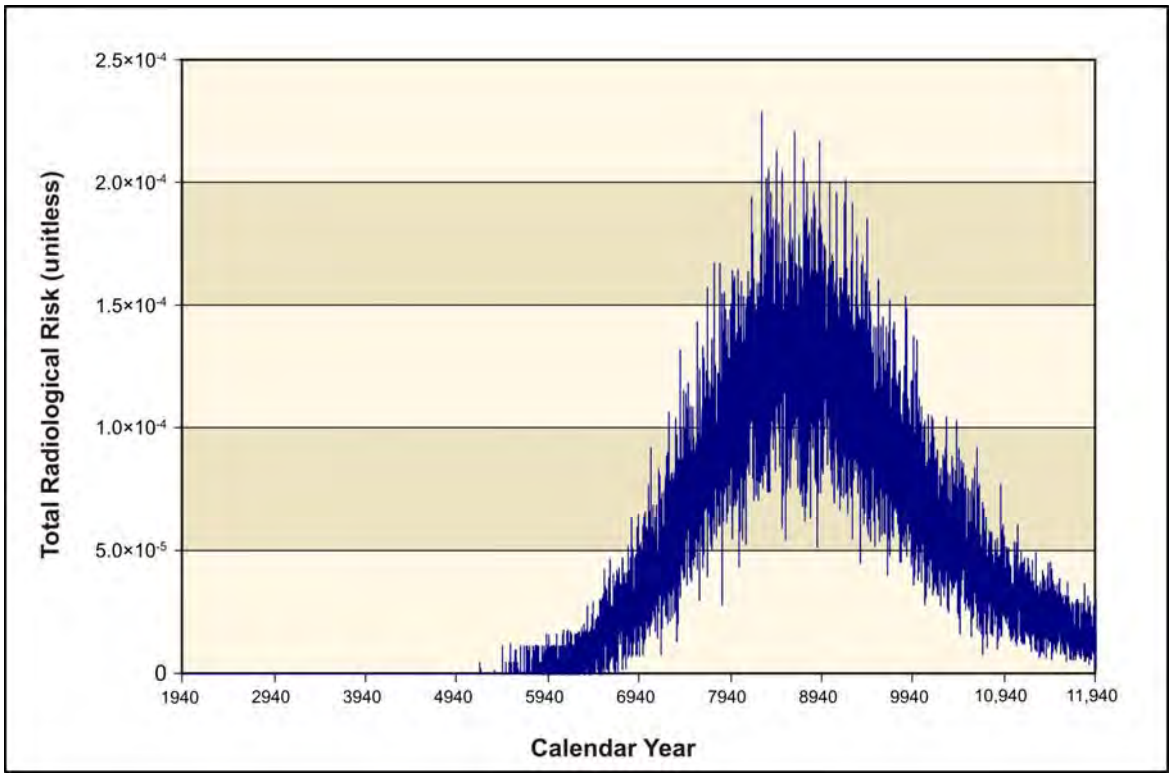


Figure 5–1164. Waste Management Alternative 2, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

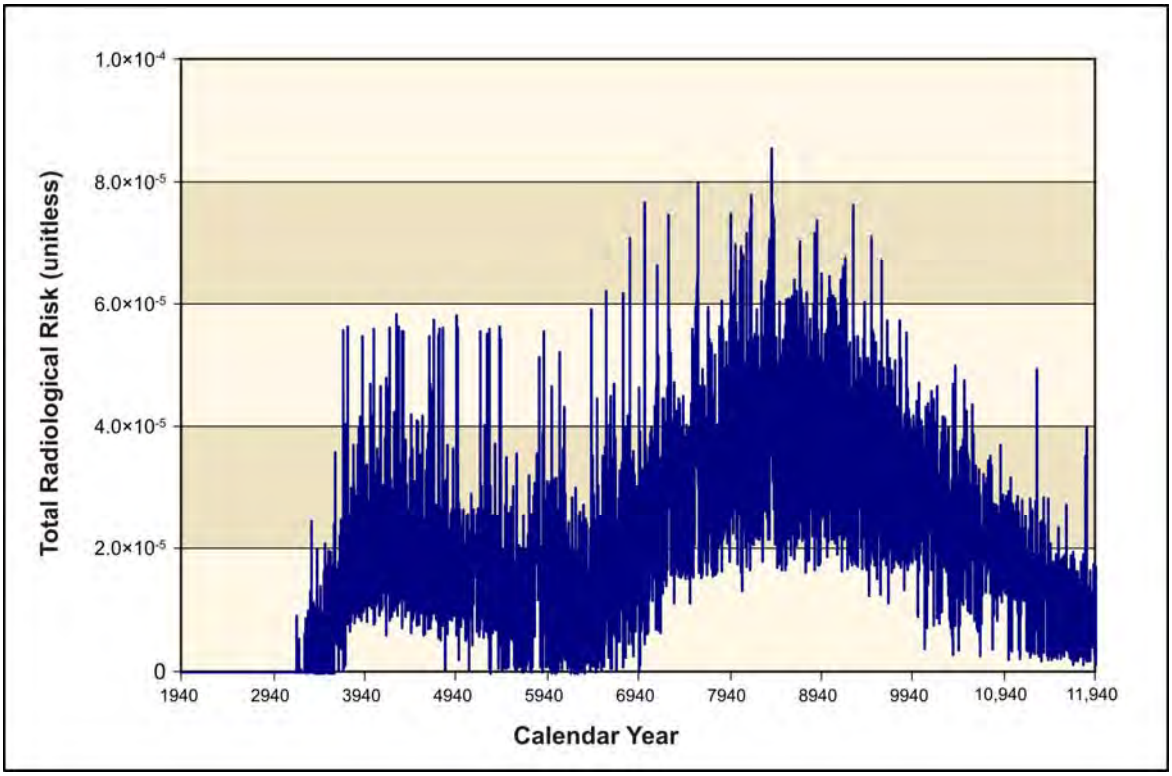


Figure 5–1165. Waste Management Alternative 2, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Under Waste Management Alternative 3, the waste from tank treatment operations would be disposed of in IDF-East, and the waste from onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-West. Waste from tank farm cleanup operations would be disposed of in the RPPDF. As a result, the waste disposed of in these three facilities would become available for release to the environment. Because of the different waste types that result from the Tank Closure action alternatives, three disposal groups were considered to account for the different sizes and operational time periods of IDF-East. In addition, within these three disposal groups, subgroups were identified to allow consideration of the different waste types resulting from the Tank Closure alternatives. Potential human health impacts of these subgroups under this alternative are discussed in the following sections.

5.3.2.3.1 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-A

Disposal Group 1, Subgroup 1-A, addresses the waste resulting from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–127 and 5–128. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate; however, the peak chemical hazard is negligible. For radionuclides, the dose standard would be exceeded at the IDF-West boundary for the resident farmer and the American Indian resident farmer. The Hazard Index would not be exceeded at any location. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier, the IDF-West Barrier, and the Core Zone Boundary are presented in Figures 5–1166 through 5–1168, respectively. At the IDF-East Barrier, the peak of the time-averaged lifetime radiological risk (1.3×10^{-5}) is attributed primarily to the combination of ETF-generated and tank closure secondary waste. Releases from ILAW glass contribute a minor portion of the risk. At IDF-West, the peak of the time-averaged lifetime radiological risk (1.5×10^{-3}) is due primarily to release of technetium-99 from offsite LLW. For the time series of risk at the Core Zone Boundary (see Figure 5–1168), the large, early peak at CY 3700, is due to releases from IDF-West, while the lower peak at CY 9900 is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–127. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.04	2.71×10^{-1}	3.05×10^{-5}	0.00	3.05×10^{-5}	2.35	3.52×10^{-1}	9.59×10^{-5}	1.62×10^{-11}	9.59×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	1.04×10^{-1}	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	1.36×10^{-1}	1.66×10^{-3}	1.22×10^{-11}	1.66×10^{-3}
Columbia River nearshore	3.37	4.76×10^{-2}	8.13×10^{-5}	0.00	8.13×10^{-5}	6.44	6.14×10^{-2}	2.41×10^{-4}	2.88×10^{-12}	2.41×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.61×10^{-6}	3.77×10^{-9}	3.91×10^{-17}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–128. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.58	6.82×10^{-1}	2.07×10^{-4}	7.41×10^{-7}	2.07×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	2.65×10^{-1}	3.50×10^{-3}	5.58×10^{-7}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.18×10^{-1}	5.12×10^{-4}	1.32×10^{-7}	5.12×10^{-4}	2.00×10^{-2}	9.57×10^{-2}	8.58×10^{-7}	6.61×10^{-8}	8.79×10^{-7}
Off Site										
Columbia River	9.15×10^{-4}	4.21×10^{-3}	2.51×10^{-8}	1.79×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

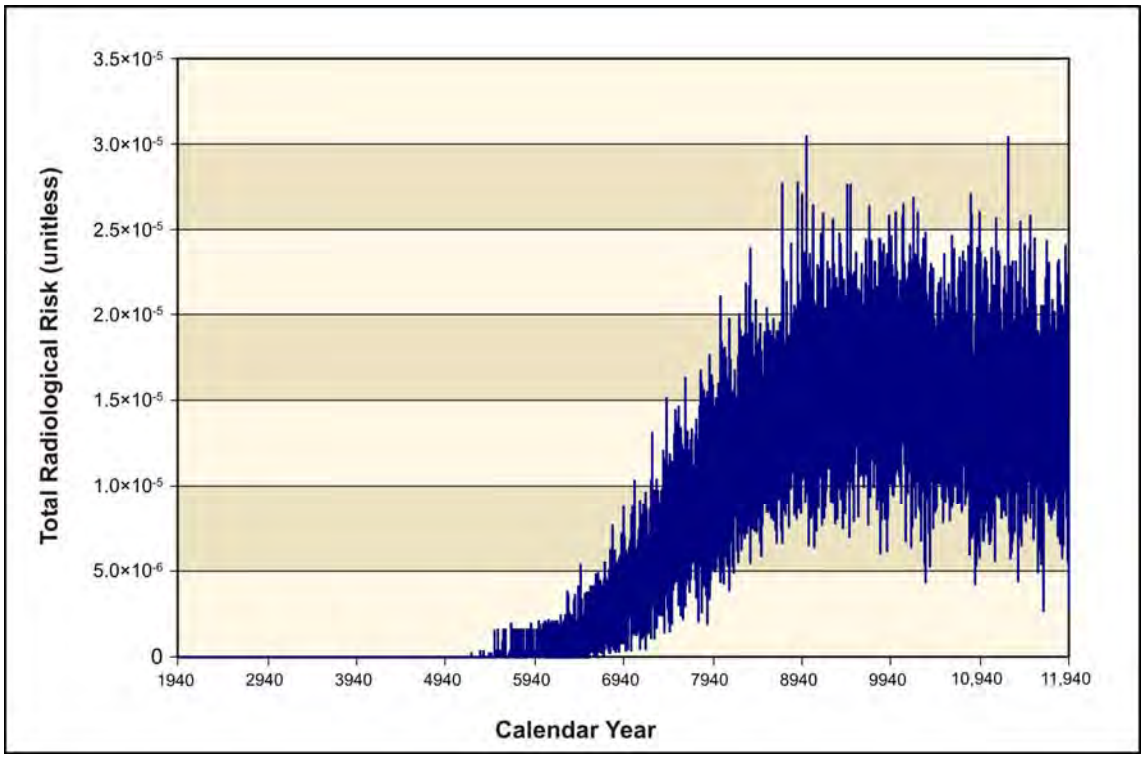


Figure 5–1166. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

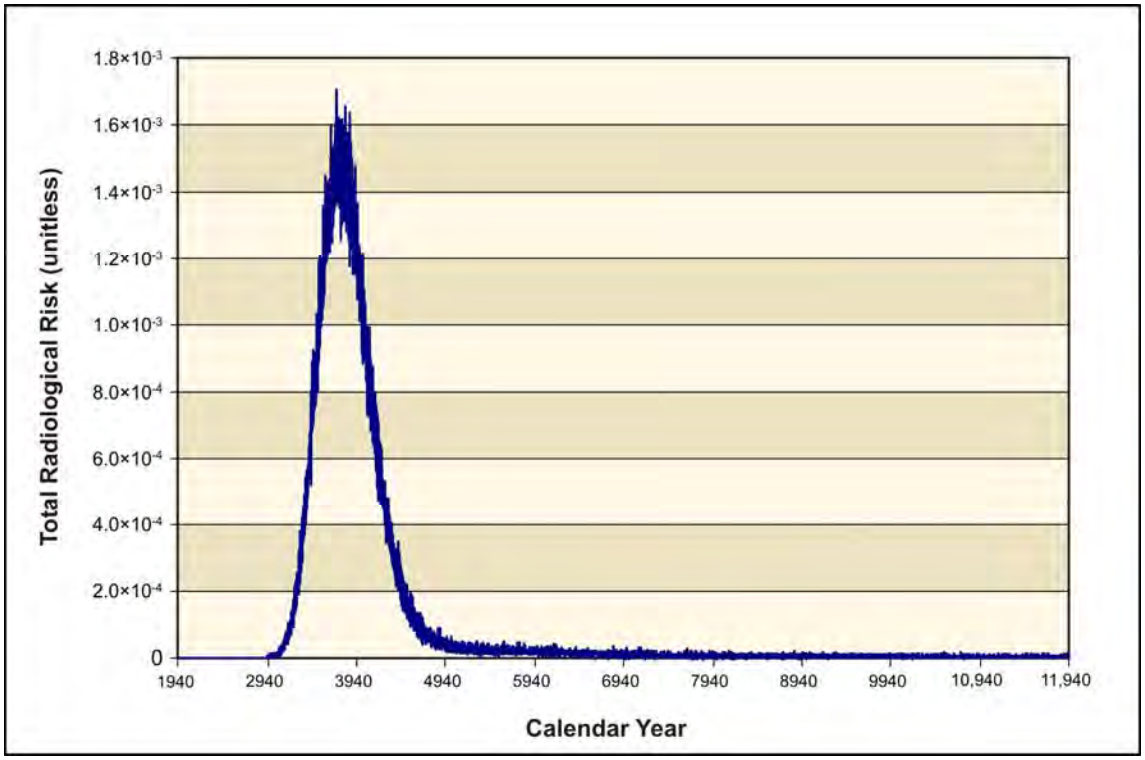


Figure 5–1167. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-West Area Integrated Disposal Facility Barrier

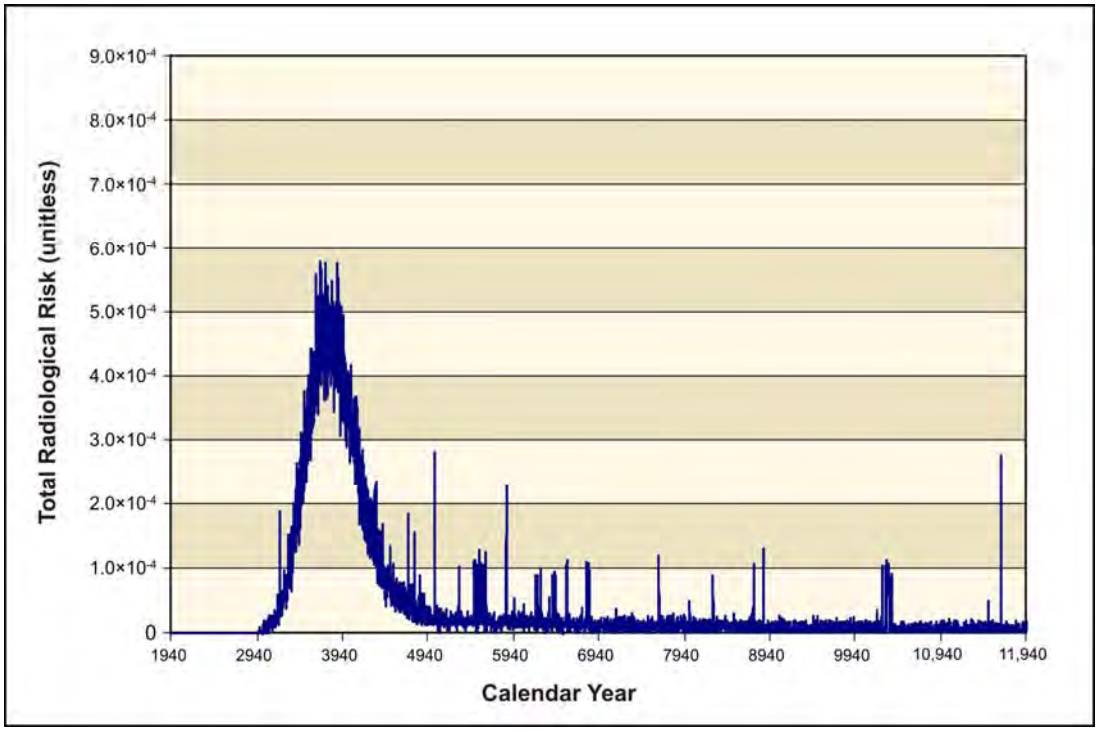


Figure 5–1168. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.2 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-B

Disposal Group 1, Subgroup 1-B, addresses the waste resulting from Tank Closure Alternative 3A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–129 and 5–130. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate; however, the peak chemical hazard is negligible. For radionuclides, the dose standard would be exceeded at the IDF-West boundary for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1169 and 5–1170, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167, and peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (5.0×10^{-5}) is distributed primarily between the bulk vitrification glass (4×10^{-5}) and the combined ETF-generated and tank closure secondary waste sources (1×10^{-5}). The major contributor to risk for the bulk vitrification glass is release of technetium-99 from the castable refractory block portion of the waste form package. For the time series of risk at the Core Zone Boundary (see Figure 5–1170), the large, early peak at CY 3700, is due to releases from IDF-West, while the low plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–129. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.00	2.64×10^{-1}	9.88×10^{-5}	0.00	9.88×10^{-5}	7.44	3.45×10^{-1}	3.20×10^{-4}	6.22×10^{-12}	3.20×10^{-4}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	1.06×10^{-1}	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	1.39×10^{-1}	1.66×10^{-3}	1.22×10^{-11}	1.66×10^{-3}
Columbia River nearshore	3.37	6.71×10^{-2}	8.13×10^{-5}	0.00	8.13×10^{-5}	6.44	8.79×10^{-2}	2.41×10^{-4}	1.80×10^{-12}	2.41×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.51×10^{-6}	3.77×10^{-9}	3.00×10^{-17}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–130. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.50×10^{1}	6.74×10^{-1}	6.96×10^{-4}	2.85×10^{-7}	6.96×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	2.72×10^{-1}	3.50×10^{-3}	5.58×10^{-7}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.72×10^{-1}	5.12×10^{-4}	8.28×10^{-8}	5.12×10^{-4}	2.00×10^{-2}	1.36×10^{-1}	8.58×10^{-7}	4.14×10^{-8}	8.79×10^{-7}
Off Site										
Columbia River	9.15×10^{-4}	4.03×10^{-3}	2.51×10^{-8}	1.37×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

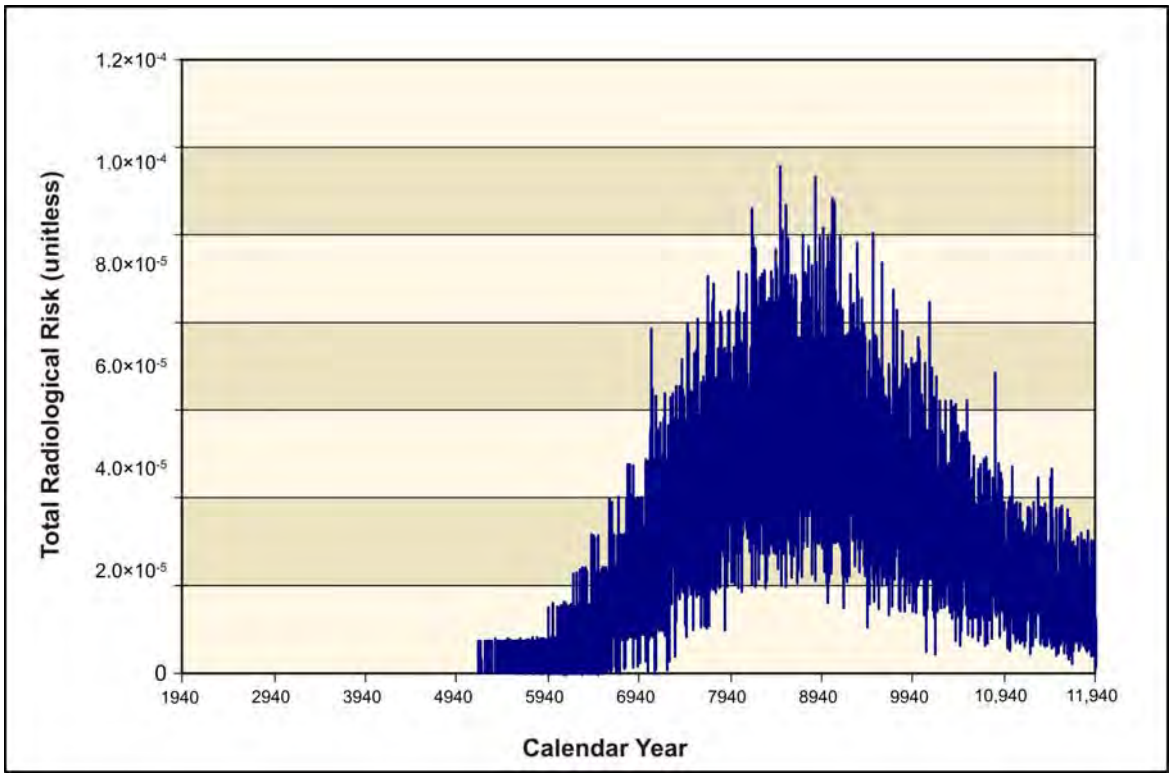


Figure 5–1169. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

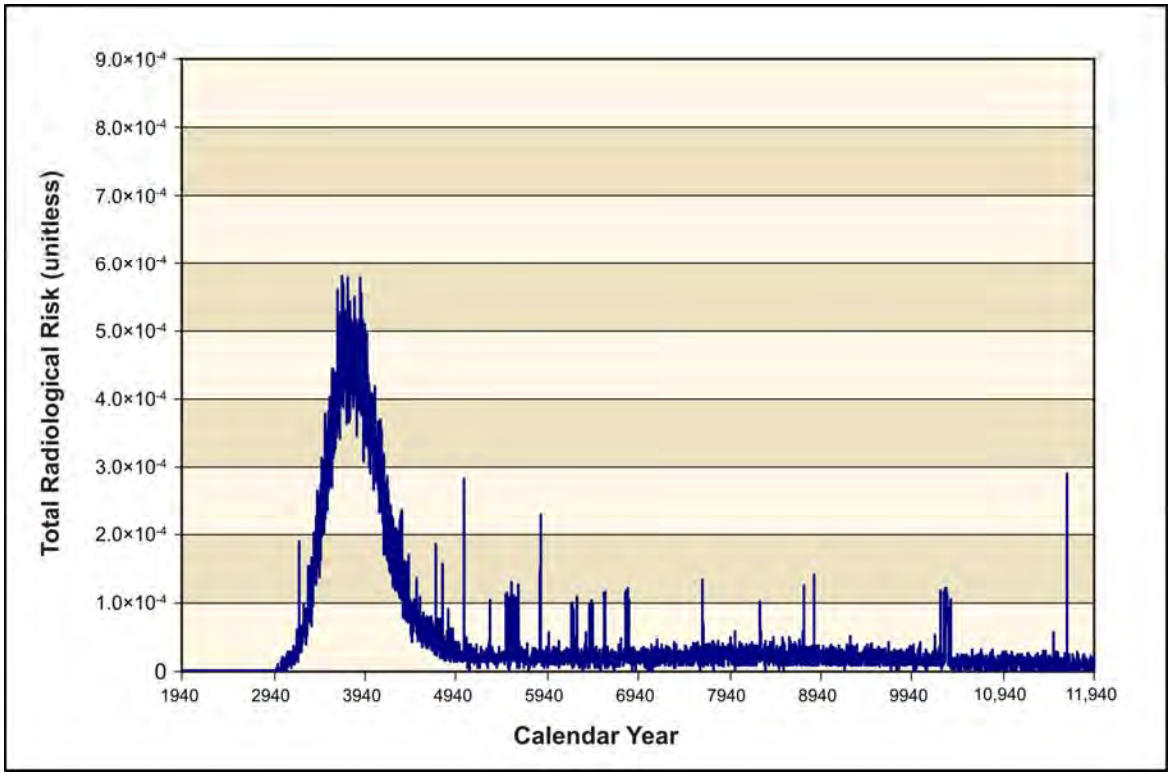


Figure 5–1170. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-C

Disposal Group 1, Subgroup 1-C, addresses the waste resulting from Tank Closure Alternative 3B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–131 and 5–132. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier, Core Zone boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1171 and 5–1172, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-4}) is distributed primarily between the cast stone waste (1.2×10^{-4}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the cast stone LAW is release of technetium-99. For the time series of risk at the Core Zone Boundary (see Figure 5–1172), the large, early peak at CY 3700 is due to releases from IDF-West, while the low plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–131. Waste Management Alternative 3, Disposal Group 2, Subgroup 1-C, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.88	4.86	3.03×10^{-4}	0.00	3.03×10^{-4}	2.27×10^{1}	5.08	9.93×10^{-4}	1.71×10^{-9}	9.93×10^{-4}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	2.73	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	2.80	1.66×10^{-3}	1.04×10^{-9}	1.66×10^{-3}
Columbia River Nearshore	3.37	1.24	1.06×10^{-4}	0.00	1.06×10^{-4}	8.08	1.29	3.40×10^{-4}	4.57×10^{-10}	3.40×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.91×10^{-5}	3.77×10^{-9}	5.84×10^{-15}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–132. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.61×10^{1}	7.87	2.17×10^{-3}	7.86×10^{-5}	2.20×10^{-3}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	4.23	3.50×10^{-3}	4.77×10^{-5}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.61×10^{1}	1.97	7.37×10^{-4}	2.10×10^{-5}	7.42×10^{-4}	2.06×10^{-2}	6.59×10^{-1}	1.07×10^{-6}	1.05×10^{-5}	1.08×10^{-5}
Off Site										
Columbia River	9.15×10^{-4}	1.80×10^{-2}	2.51×10^{-8}	2.68×10^{-10}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

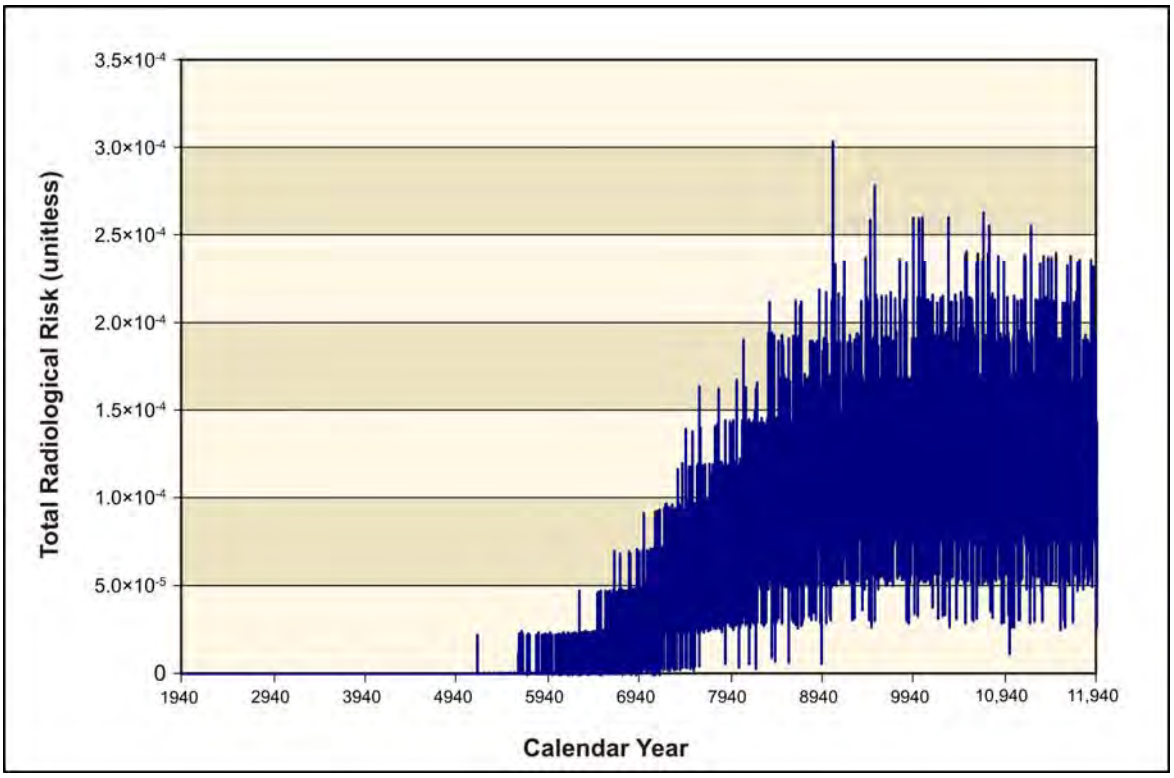


Figure 5–1171. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

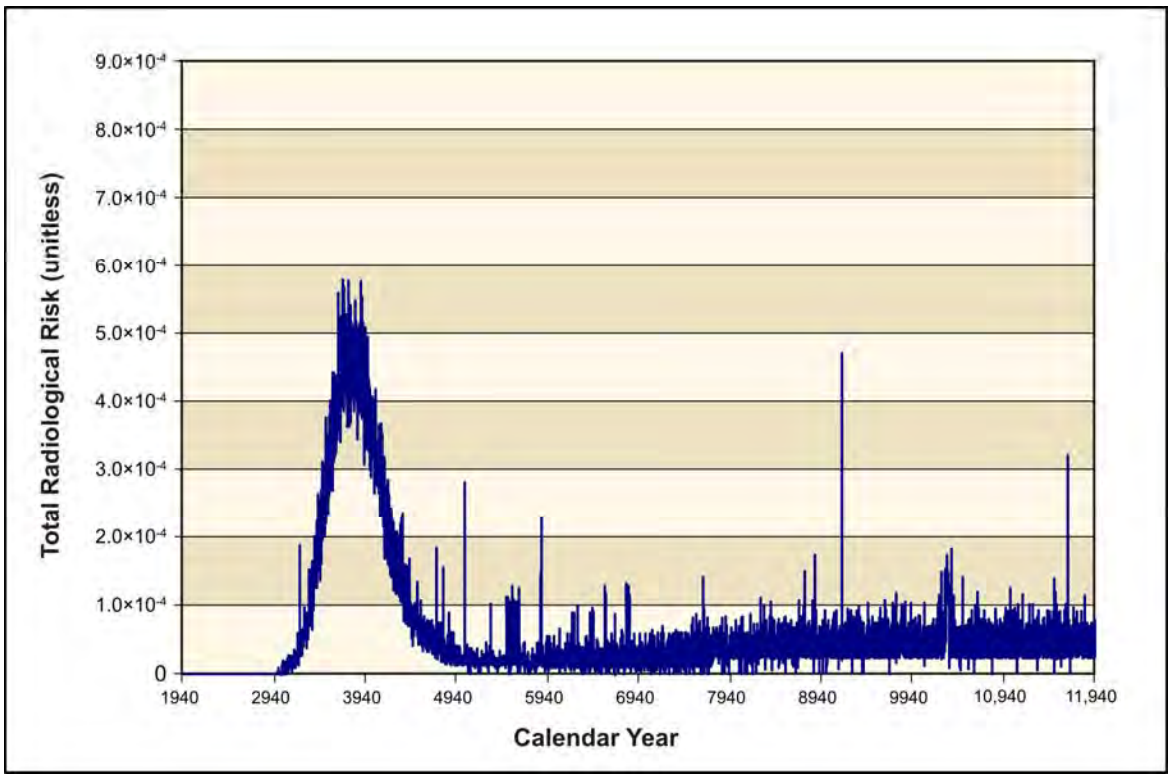


Figure 5–1172. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.4 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-D

Disposal Group 1, Subgroup 1-D addresses the waste resulting from Tank Closure Alternative 3C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–133 and 5–134. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-East Barrier, the IDF-West Barrier, and the Core Zone Boundary for the resident farmer and the American Indian resident farmer. The Hazard Index would be exceeded primarily due to chromium at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore location for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 2.24 person-rem per year for the year of maximum impact. This corresponds to a 1.23×10^{-4} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1173 and 5–1174, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (8.0×10^{-4}) is distributed primarily between the steam reforming waste (8.0×10^{-4}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the steam reforming waste LAW is release of technetium-99. For the time series of risk at the Core Zone Boundary (see Figure 5–1174), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent peak at CY 8000 is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak. While the peak of the series of time-averaged lifetime radiological risk appears on the curve of Figure 5–1174, the peak of the series of instantaneous lifetime radiological risk does not appear in the figure because the upper limit of the risk scale was reduced to facilitate comparison of the peaks attributed to RPPDF and IDF-East.

Table 5–133. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.28×10^{1}	4.30	1.78×10^{-3}	0.00	1.78×10^{-3}	1.33×10^{2}	4.35	5.79×10^{-3}	1.71×10^{-9}	5.79×10^{-3}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	4.39×10^{1}	1.69	1.49×10^{-3}	0.00	1.49×10^{-3}	1.12×10^{2}	1.70	4.88×10^{-3}	6.84×10^{-10}	4.88×10^{-3}
Columbia River nearshore	1.40×10^{1}	1.12	4.60×10^{-4}	0.00	4.60×10^{-4}	3.46×10^{1}	1.13	1.49×10^{-3}	4.56×10^{-10}	1.49×10^{-3}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.47×10^{-4}	1.69×10^{-5}	1.94×10^{-8}	6.52×10^{-15}	1.94×10^{-8}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–134. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.70×10^{2}	6.46	1.26×10^{-2}	7.85×10^{-5}	1.27×10^{-2}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.27×10^{2}	2.50	1.06×10^{-2}	3.14×10^{-5}	1.06×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	6.96×10^{1}	1.65	3.23×10^{-3}	2.09×10^{-5}	3.24×10^{-3}	8.66×10^{-2}	2.88×10^{-1}	4.59×10^{-6}	1.05×10^{-5}	1.16×10^{-5}
Off Site										
Columbia River	1.14×10^{-3}	4.74×10^{-3}	5.11×10^{-8}	2.99×10^{-10}	5.12×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

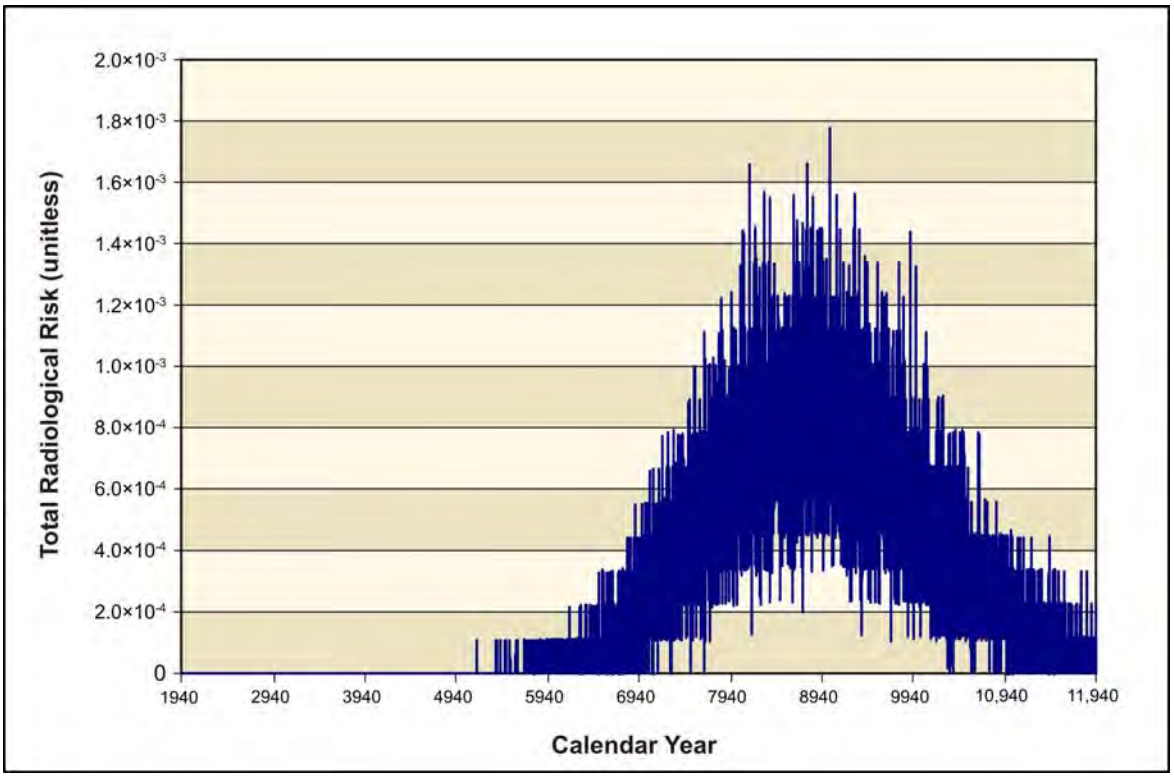


Figure 5–1173. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

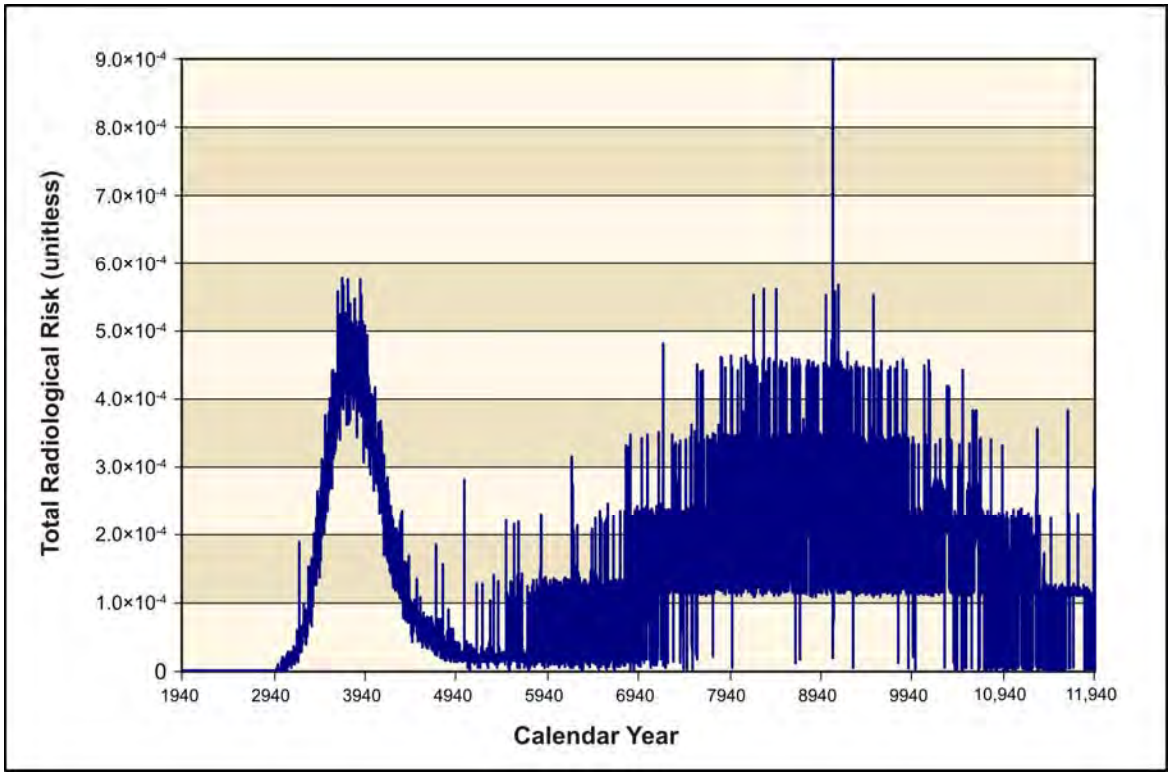


Figure 5–1174. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.5 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-E

Disposal Group 1, Subgroup 1-E, addresses the waste resulting from Tank Closure Alternative 4, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–135 and 5–136. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier and Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer and at the Columbia River nearshore location for the American Indian resident farmer. Population dose was estimated as 5.79×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.17×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1175 and 5–1176, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167 and peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.5×10^{-4}) is distributed among the combination of ILAW glass, bulk vitrification glass, and cast stone waste (1.2×10^{-4}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the supplemental waste forms is release of technetium-99 from cast stone waste and the castable refractory block portion of the bulk vitrification glass. For the time series of risk at the Core Zone Boundary (see Figure 5–1176), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–135. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.01×10^{1}	2.48	3.42×10^{-4}	0.00	3.42×10^{-4}	2.56×10^{1}	2.59	1.12×10^{-3}	8.78×10^{-10}	1.12×10^{-3}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	2.15×10^{-1}	5.86×10^{-2}	6.59×10^{-6}	0.00	6.59×10^{-6}	5.03×10^{-1}	5.95×10^{-2}	2.08×10^{-5}	2.30×10^{-11}	2.08×10^{-5}
Core Zone Boundary	2.73×10^{1}	1.02	5.82×10^{-4}	0.00	5.82×10^{-4}	4.75×10^{1}	1.06	1.67×10^{-3}	3.76×10^{-10}	1.67×10^{-3}
Columbia River nearshore	3.98	6.59×10^{-1}	1.27×10^{-4}	0.00	1.27×10^{-4}	9.62	6.75×10^{-1}	4.08×10^{-4}	2.50×10^{-10}	4.08×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.16×10^{-4}	1.15×10^{-5}	4.44×10^{-9}	3.65×10^{-15}	4.44×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–136. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.20×10^{1}	4.00	2.43×10^{-3}	4.03×10^{-5}	2.44×10^{-3}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	9.92×10^{-1}	8.87×10^{-2}	4.51×10^{-5}	1.06×10^{-6}	4.59×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.53×10^{1}	1.62	3.52×10^{-3}	1.72×10^{-5}	3.52×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.92×10^{1}	1.02	8.85×10^{-4}	1.15×10^{-5}	8.87×10^{-4}	2.44×10^{-2}	3.40×10^{-1}	1.27×10^{-6}	5.74×10^{-6}	6.20×10^{-6}
Off Site										
Columbia River	9.18×10^{-4}	1.05×10^{-2}	2.52×10^{-8}	1.67×10^{-10}	2.52×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

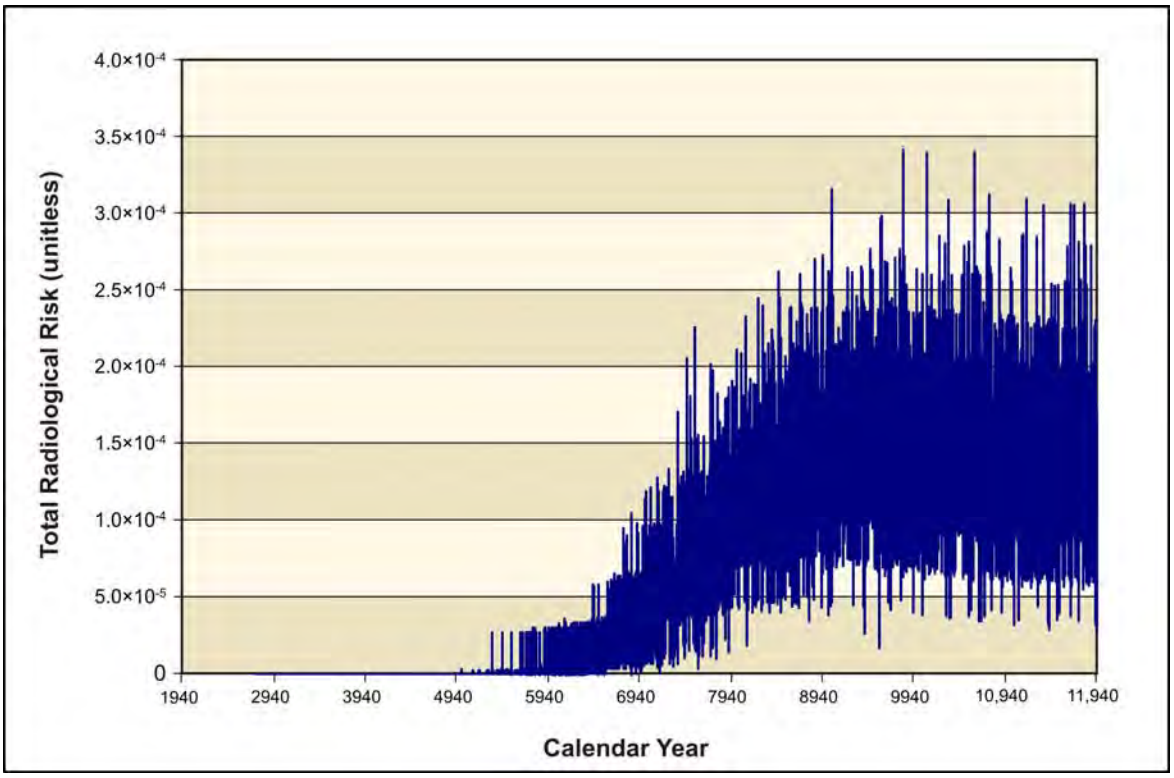


Figure 5–1175. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

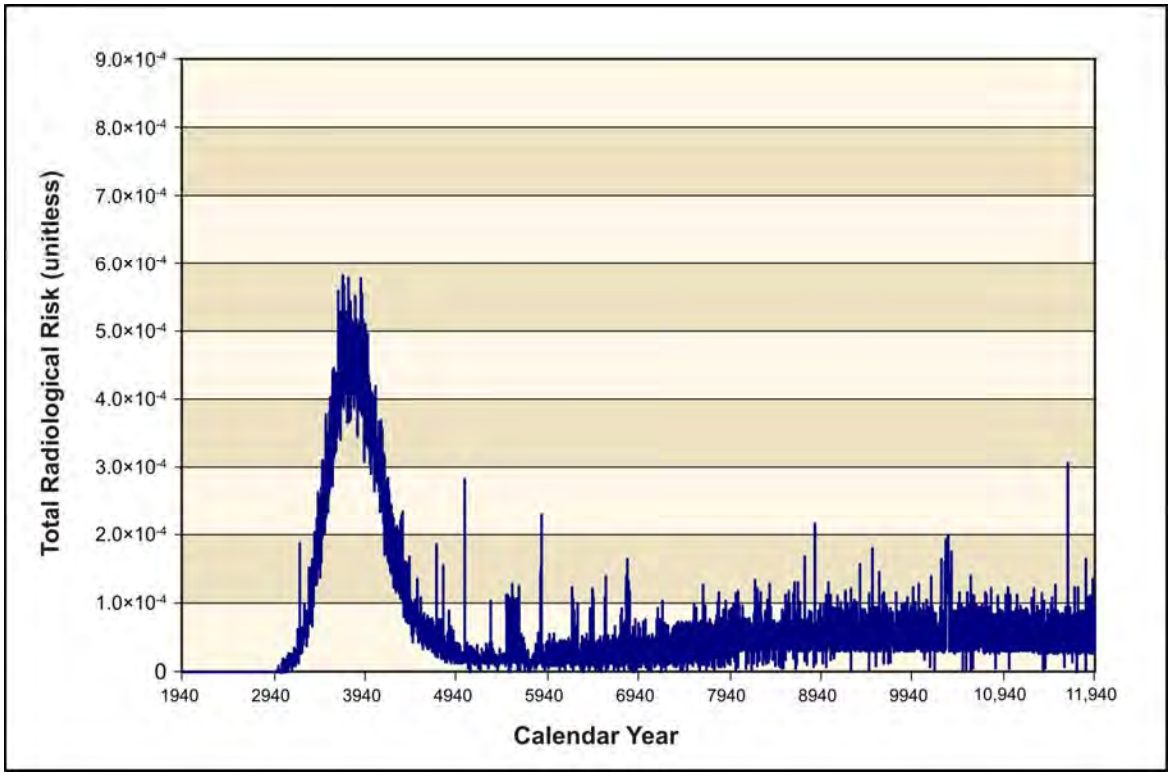


Figure 5–1176. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.6 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-F

Disposal Group 1, Subgroup 1-F, addresses the waste resulting from Tank Closure Alternative 5, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–137 and 5–138. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 5.74×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1177 and 5–1178, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (8.0×10^{-5}) is distributed among the combination of ILAW glass, bulk vitrification glass, and cast stone waste (7.0×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the supplemental waste forms is release of technetium-99 from cast stone waste and the castable refractory block portion of the bulk vitrification glass waste form package. For the time series of risk at the Core Zone Boundary (see Figure 5–1178), the large early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. The RPPDF would not be constructed for this alternative.

Table 5–137. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.34	3.51	1.46×10^{-4}	0.00	1.46×10^{-4}	1.09×10^{1}	3.62	4.74×10^{-4}	1.32×10^{-9}	4.74×10^{-4}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.72×10^{1}	1.47	5.78×10^{-4}	0.00	5.78×10^{-4}	4.74×10^{1}	1.50	1.66×10^{-3}	5.81×10^{-10}	1.66×10^{-3}
Columbia River nearshore	3.36	1.09	8.11×10^{-5}	0.00	8.11×10^{-5}	6.42	1.10	2.40×10^{-4}	4.32×10^{-10}	2.40×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.32×10^{-5}	3.75×10^{-9}	4.79×10^{-15}	3.75×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–138. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.21×10^{1}	5.49	1.03×10^{-3}	6.04×10^{-5}	1.05×10^{-3}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.47×10^{1}	2.23	3.49×10^{-3}	2.67×10^{-5}	3.49×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.63	5.11×10^{-4}	1.98×10^{-5}	5.11×10^{-4}	2.00×10^{-2}	3.31×10^{-1}	8.57×10^{-7}	9.90×10^{-6}	1.02×10^{-5}
Off Site										
Columbia River	9.13×10^{-4}	6.96×10^{-3}	2.51×10^{-8}	2.20×10^{-10}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

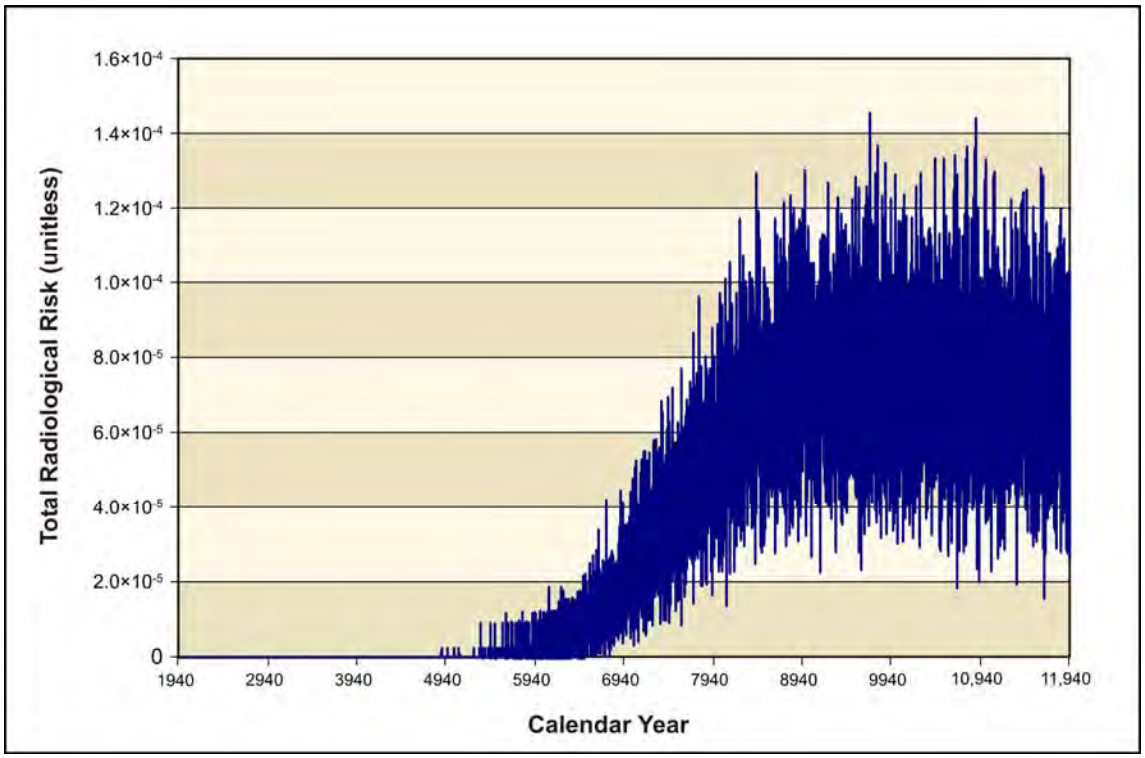


Figure 5–1177. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

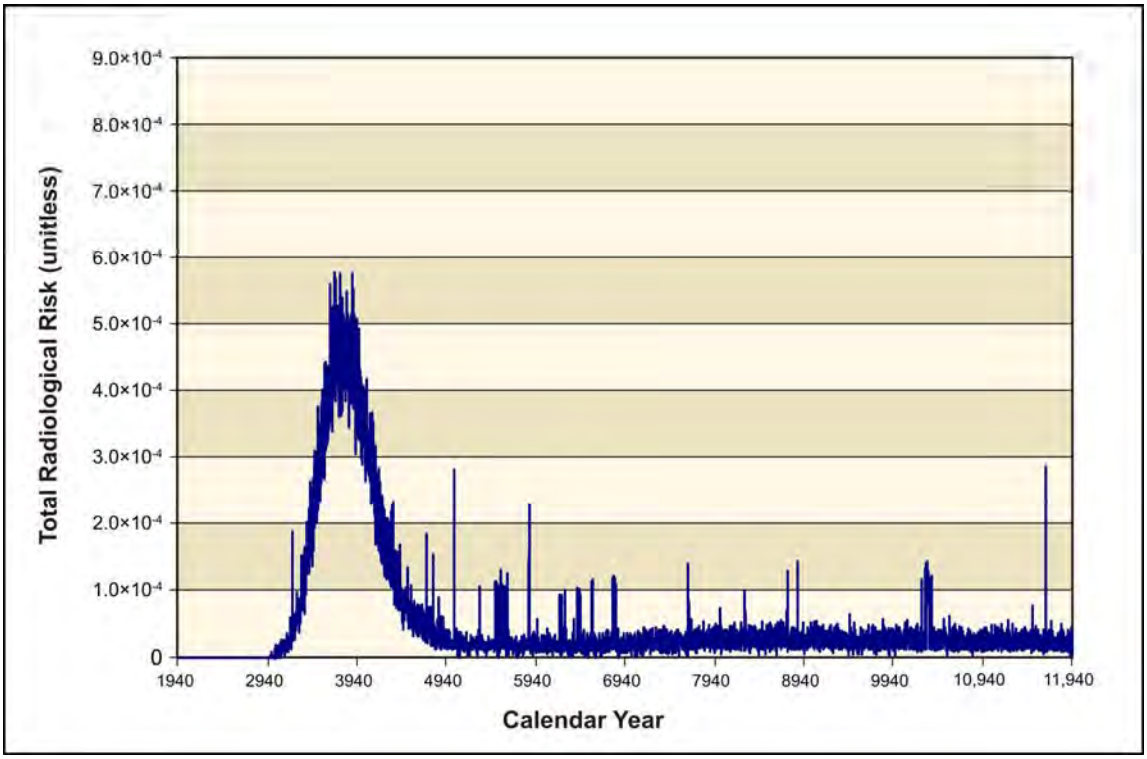


Figure 5–1178. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.7 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-G

Disposal Group 1, Subgroup 1-G, addresses the waste resulting from Tank Closure Alternative 6C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–139 and 5–140. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1179 and 5–1180, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary (see Figure 5–1180), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–139. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	9.07×10^{-1}	2.66×10^{-1}	2.70×10^{-5}	0.00	2.70×10^{-5}	2.07	3.43×10^{-1}	8.45×10^{-5}	1.44×10^{-11}	8.45×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	1.04×10^{-1}	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	1.36×10^{-1}	1.66×10^{-3}	1.22×10^{-11}	1.66×10^{-3}
Columbia River nearshore	3.37	4.78×10^{-2}	8.13×10^{-5}	0.00	8.13×10^{-5}	6.44	6.16×10^{-2}	2.41×10^{-4}	3.08×10^{-12}	2.41×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.61×10^{-6}	3.77×10^{-9}	3.70×10^{-17}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–140. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.05	6.69×10^{-1}	1.82×10^{-4}	6.61×10^{-7}	1.82×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	2.65×10^{-1}	3.50×10^{-3}	5.58×10^{-7}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.19×10^{-1}	5.12×10^{-4}	1.41×10^{-7}	5.12×10^{-4}	2.00×10^{-2}	9.61×10^{-2}	8.58×10^{-7}	7.06×10^{-8}	8.79×10^{-7}
Off Site										
Columbia River	9.15×10^{-4}	4.21×10^{-3}	2.51×10^{-8}	1.70×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

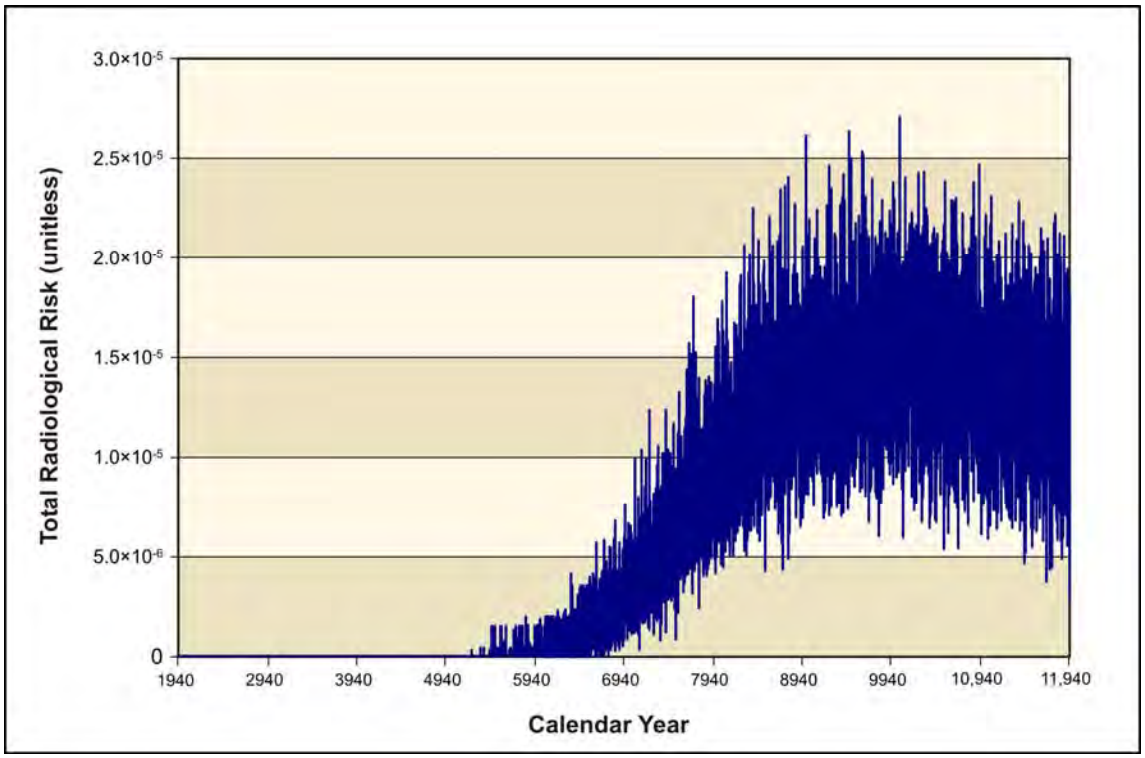


Figure 5–1179. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

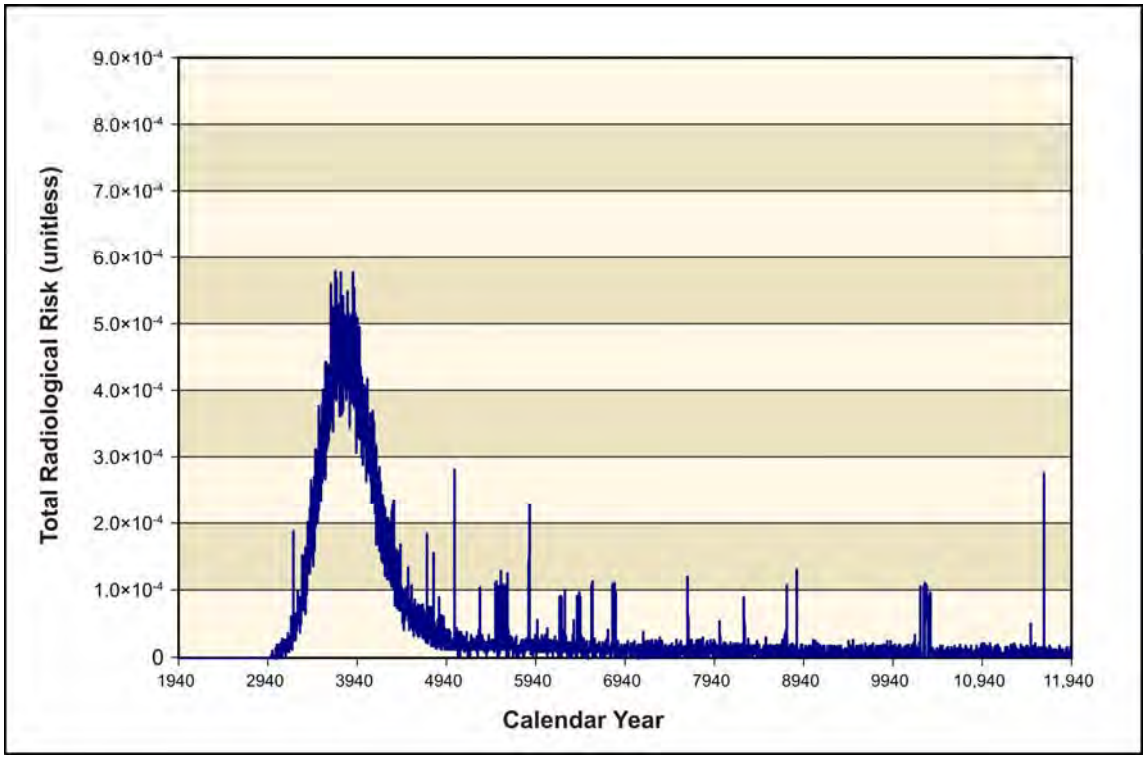


Figure 5–1180. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.8 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 2, Subgroup 2-A

Disposal Group 2, Subgroup 2-A, addresses the waste resulting from Tank Closure Alternative 2A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–141 and 5–142. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 5.74×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1181 and 5–1182, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary (see Figure 5–1182), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–141. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.64×10^{-1}	2.96×10^{-1}	2.25×10^{-5}	0.00	2.25×10^{-5}	1.74	3.84×10^{-1}	6.91×10^{-5}	1.20×10^{-11}	6.91×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.72×10^{1}	1.05×10^{-1}	5.78×10^{-4}	0.00	5.78×10^{-4}	4.74×10^{1}	1.37×10^{-1}	1.66×10^{-3}	6.29×10^{-12}	1.66×10^{-3}
Columbia River nearshore	3.36	7.45×10^{-2}	8.11×10^{-5}	0.00	8.11×10^{-5}	6.42	9.75×10^{-2}	2.40×10^{-4}	2.81×10^{-12}	2.40×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.63×10^{-6}	3.75×10^{-9}	3.77×10^{-17}	3.75×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–142. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.36	7.43×10^{-1}	1.48×10^{-4}	5.49×10^{-7}	1.49×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.47×10^{1}	2.68×10^{-1}	3.49×10^{-3}	2.88×10^{-7}	3.49×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.90×10^{-1}	5.11×10^{-4}	1.29×10^{-7}	5.11×10^{-4}	2.00×10^{-2}	1.52×10^{-1}	8.57×10^{-7}	6.46×10^{-8}	8.63×10^{-7}
Off Site										
Columbia River	9.13×10^{-4}	4.31×10^{-3}	2.51×10^{-8}	1.73×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

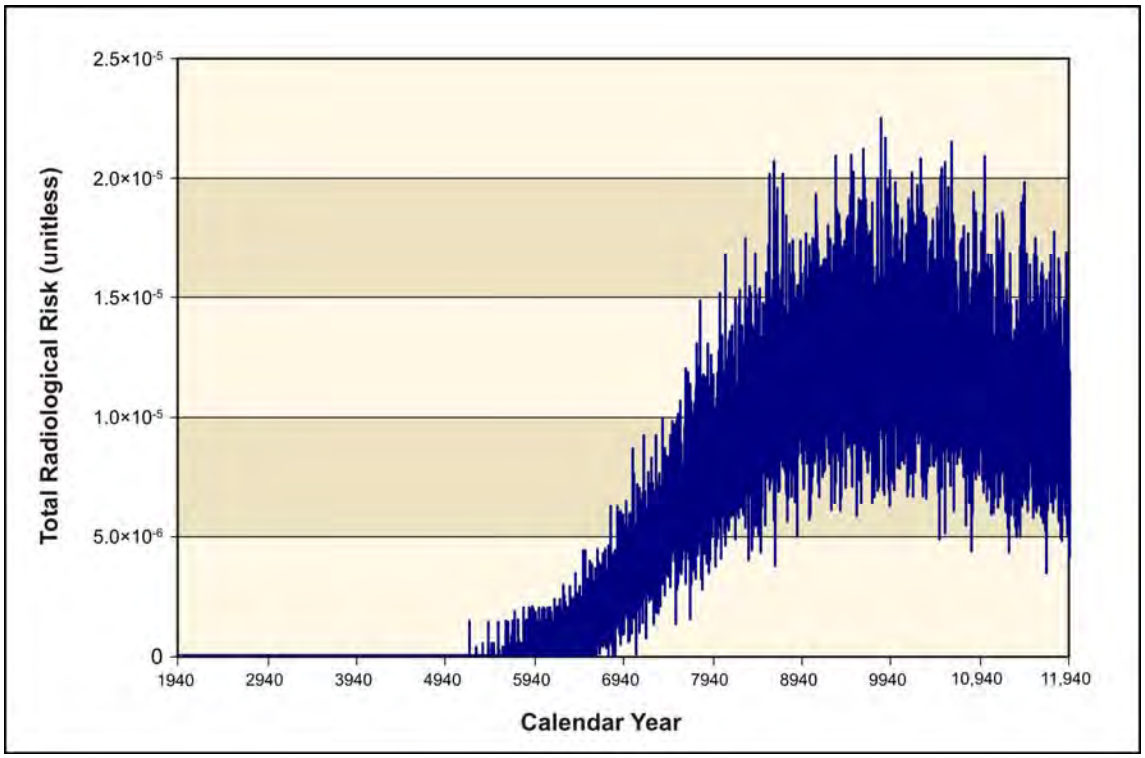


Figure 5–1181. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

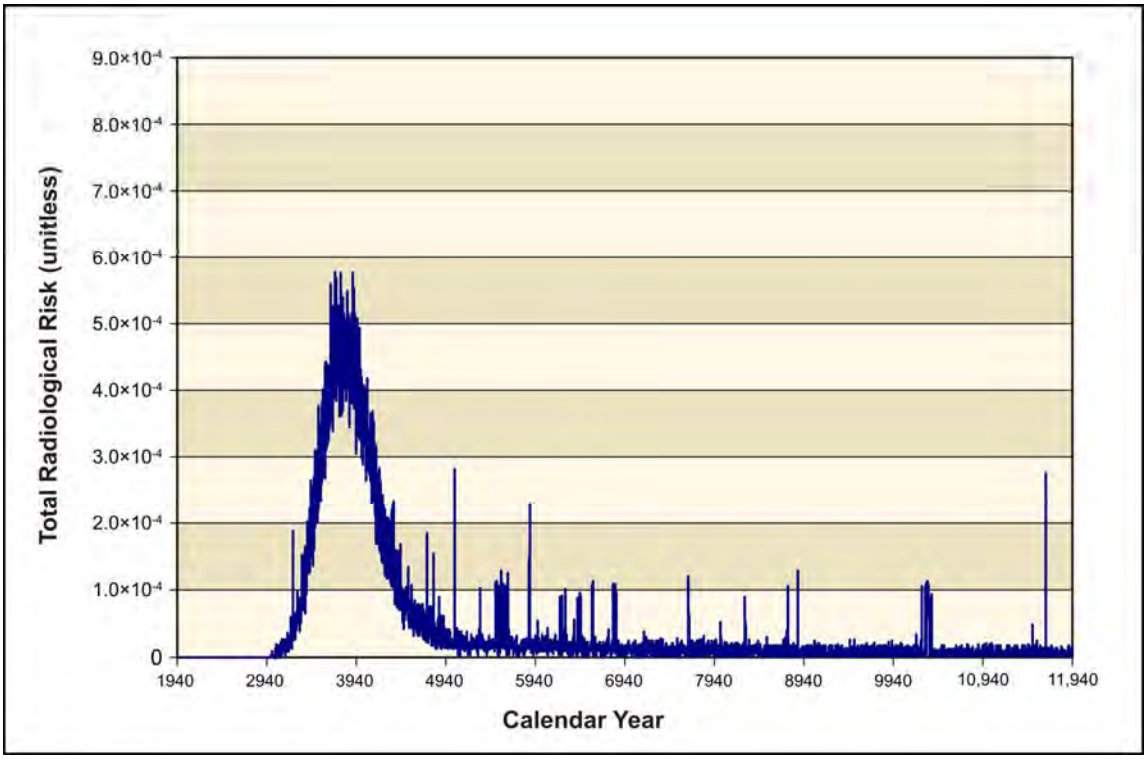


Figure 5–1182. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.9 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 2, Subgroup 2-B

Disposal Group 2, Subgroup 2-B, addresses the waste resulting from Tank Closure Alternative 6B (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–143 through 5–146. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would be exceeded at IDF-West for the resident farmer and the American Indian resident farmer under both Base and Option Cases. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated for Subgroup 2-B, Base Case, as 6.02×10^{-1} person-rem per year for the year of maximum impact and for Subgroup 2-B, Option Case, as 5.91×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 3.30×10^{-5} percent and 3.24×10^{-5} percent of the annual population dose due to background exposure for Subgroup 2-B, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1183 and 5–1184 for the Base Case and in Figures 5–1185 and 5–1186 for the Option Case. The Base and Option Cases differ in the amount of constituents disposed of at the RPPDF because the Option Case includes removal of tank closure cribs and trenches (ditches). At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. Under both the Base and Option Cases, the peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary under the Base Case (see Figure 5–1184) and the Option Case (see Figure 5–1186), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide minor contributions to the early peak.

Table 5–143. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.97×10^{-1}	3.18×10^{-1}	2.38×10^{-5}	0.00	2.38×10^{-5}	1.87	4.12×10^{-1}	7.22×10^{-5}	1.20×10^{-11}	7.22×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	5.92×10^{-1}	5.96×10^{-2}	1.82×10^{-5}	0.00	1.82×10^{-5}	1.39	6.11×10^{-2}	5.75×10^{-5}	2.27×10^{-11}	5.75×10^{-5}
Core Zone Boundary	2.76×10^{1}	1.25×10^{-1}	5.92×10^{-4}	0.00	5.92×10^{-4}	4.84×10^{1}	1.39×10^{-1}	1.70×10^{-3}	4.72×10^{-11}	1.70×10^{-3}
Columbia River nearshore	3.53	6.48×10^{-2}	8.35×10^{-5}	0.00	8.35×10^{-5}	6.60	8.35×10^{-2}	2.48×10^{-4}	9.42×10^{-12}	2.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.20×10^{-4}	1.72×10^{-6}	3.97×10^{-9}	1.30×10^{-16}	3.97×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–144. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.53	7.98×10^{-1}	1.55×10^{-4}	5.49×10^{-7}	1.55×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.73	9.24×10^{-2}	1.24×10^{-4}	1.04×10^{-6}	1.25×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.68×10^{1}	2.71×10^{-1}	3.58×10^{-3}	2.17×10^{-6}	3.58×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.23×10^{1}	1.61×10^{-1}	5.27×10^{-4}	4.32×10^{-7}	5.27×10^{-4}	2.10×10^{-2}	1.26×10^{-1}	8.82×10^{-7}	2.16×10^{-7}	9.86×10^{-7}
Off Site										
Columbia River	9.42×10^{-4}	4.50×10^{-3}	2.59×10^{-8}	5.94×10^{-12}	2.59×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–145. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.97×10^{-1}	3.18×10^{-1}	2.38×10^{-5}	0.00	2.38×10^{-5}	1.87	4.12×10^{-1}	7.22×10^{-5}	1.20×10^{-11}	7.22×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.96×10^{-1}	3.91×10^{-1}	2.16×10^{-5}	0.00	2.16×10^{-5}	1.65	4.38×10^{-1}	6.87×10^{-5}	1.28×10^{-10}	6.87×10^{-5}
Core Zone Boundary	2.77×10^{1}	1.38	5.88×10^{-4}	0.00	5.88×10^{-4}	4.85×10^{1}	1.54	1.67×10^{-3}	3.81×10^{-10}	1.67×10^{-3}
Columbia River nearshore	3.49	2.30×10^{-1}	8.53×10^{-5}	0.00	8.53×10^{-5}	6.74	2.52×10^{-1}	2.53×10^{-4}	6.69×10^{-11}	2.53×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.18×10^{-4}	3.45×10^{-6}	3.96×10^{-9}	8.34×10^{-16}	3.96×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–146. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.53	7.98×10^{-1}	1.55×10^{-4}	5.50×10^{-7}	1.55×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.26	7.37×10^{-1}	1.49×10^{-4}	5.87×10^{-6}	1.51×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.57×10^{1}	2.56	3.51×10^{-3}	1.75×10^{-5}	3.52×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.26×10^{1}	4.13×10^{-1}	5.39×10^{-4}	3.07×10^{-6}	5.40×10^{-4}	2.08×10^{-2}	2.22×10^{-1}	8.93×10^{-7}	1.53×10^{-6}	2.13×10^{-6}
Off Site										
Columbia River	9.32×10^{-4}	5.08×10^{-3}	2.57×10^{-8}	3.82×10^{-11}	2.57×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

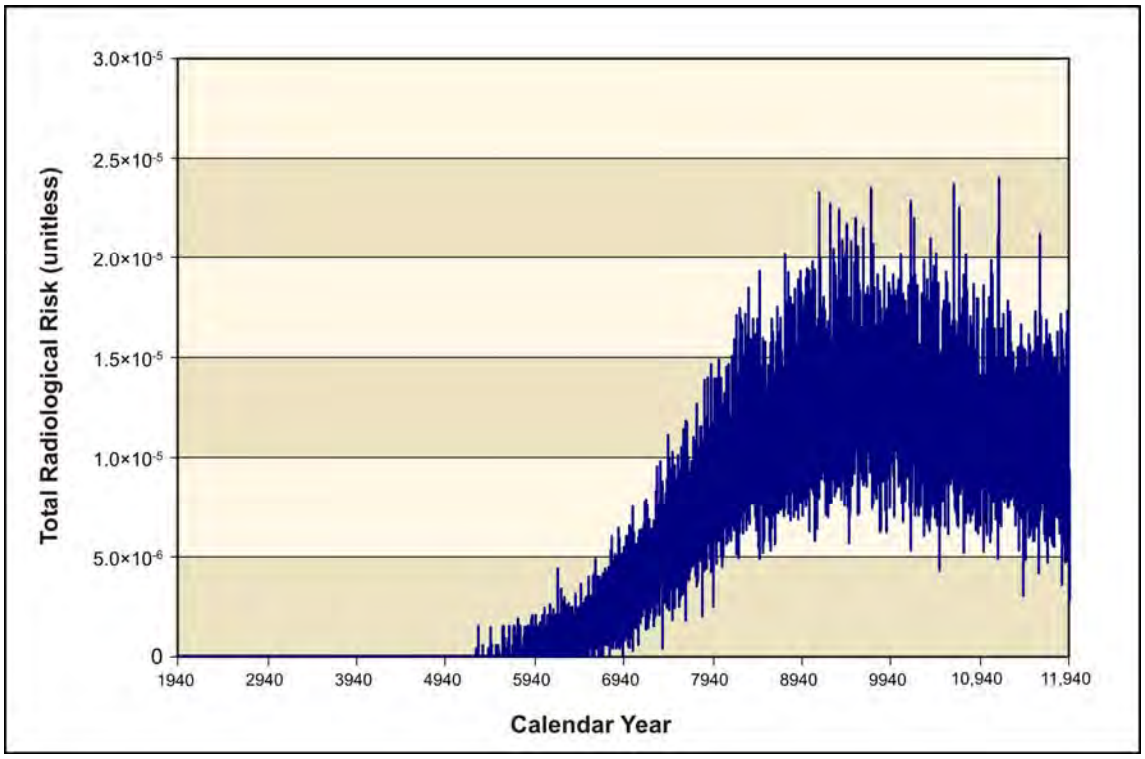


Figure 5–1183. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

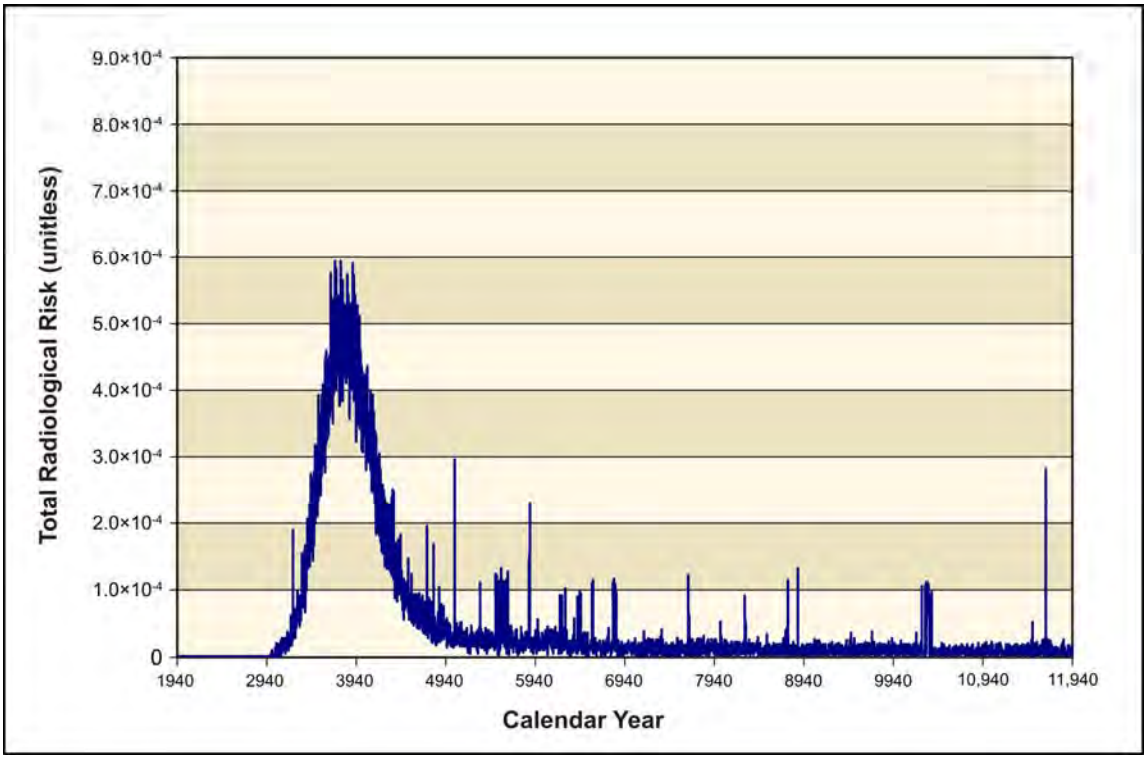


Figure 5–1184. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

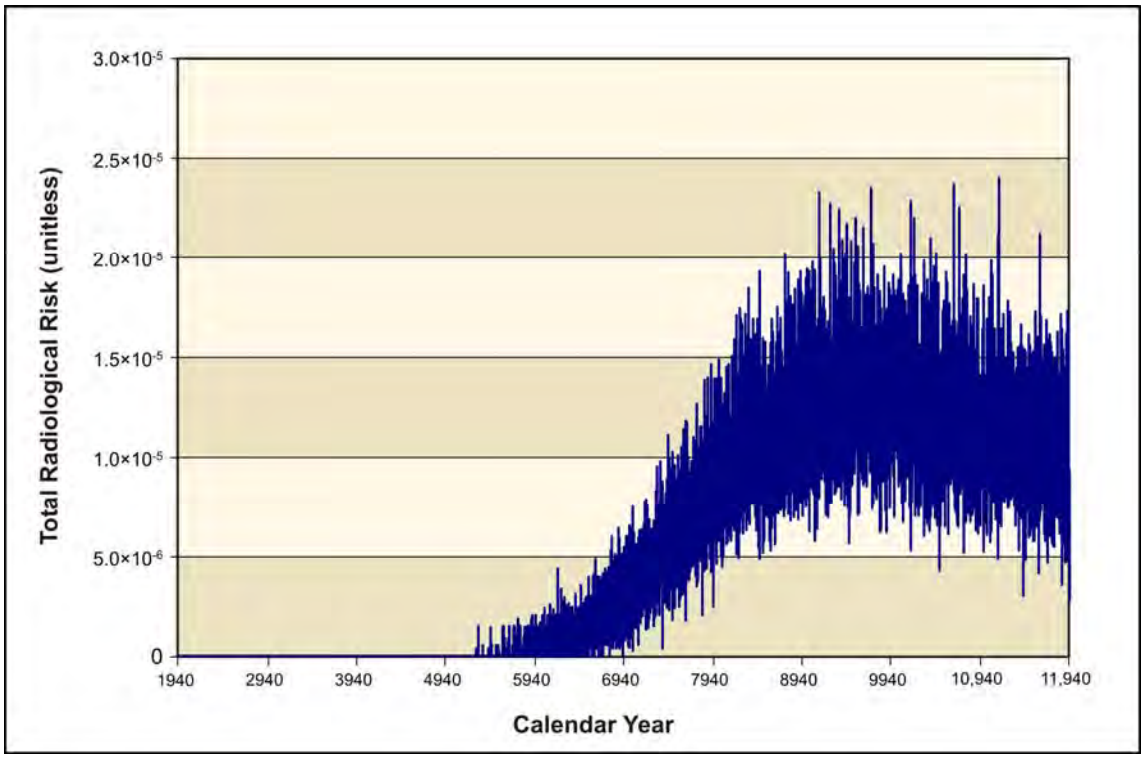


Figure 5–1185. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

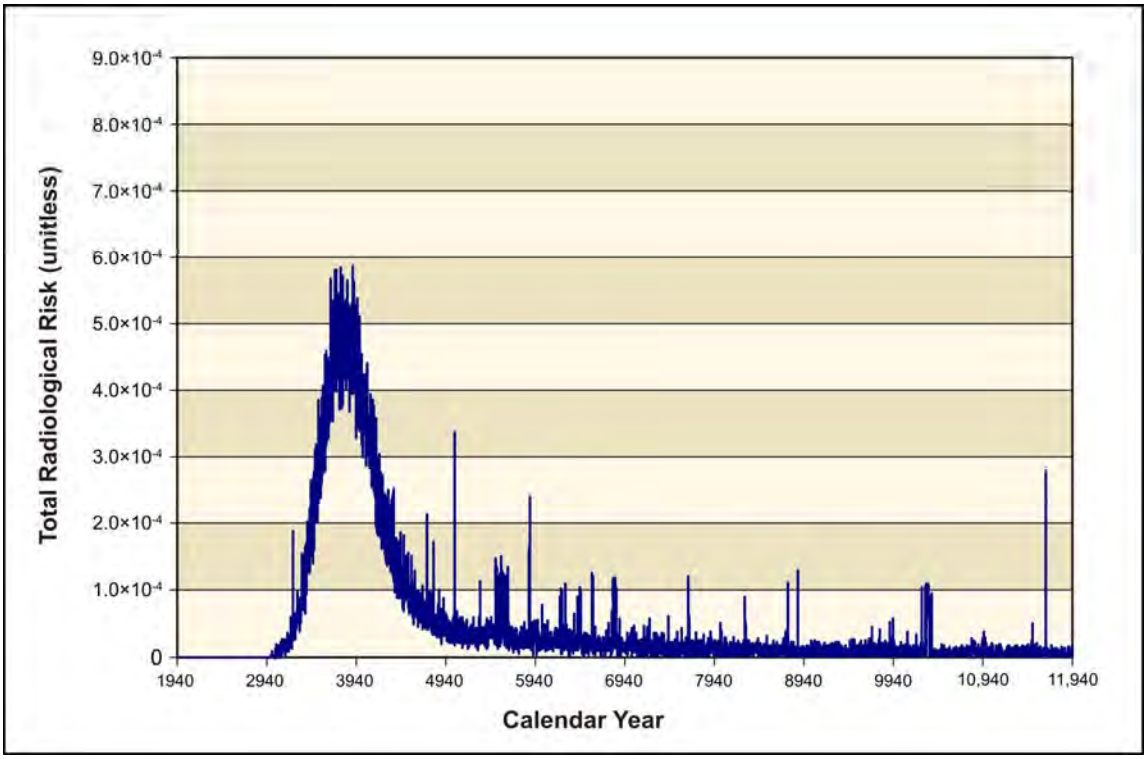


Figure 5–1186. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.10 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 3

Disposal Group 3 addresses the waste resulting from Tank Closure Alternative 6A (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this disposal group.

Potential human health impacts of this alternative are summarized in Tables 5–147 through 5–150. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would be exceeded at IDF-West for the resident farmer and the American Indian resident farmer under both the Base and Option Cases. The Hazard Index guideline would not be exceeded at any location for both the Base and Option Cases. Population dose was estimated for Disposal Group 3, Base Case, as 5.97×10^{-1} person-rem per year for the year of maximum impact and for Disposal Group 3, Option Case, as 5.95×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 3.27×10^{-5} percent and 3.26×10^{-5} percent of the annual population dose due to background exposure for Disposal Group 2, Subgroups 2-B, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1187 and 5–1188 for the Base Case and in Figures 5–1189 and 5–1190 for the Option Case. The Base and Option Cases differ in the amount of constituents disposed of at the RPPDF because the Option Case includes removal of tank closure cribs and trenches (ditches). At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. For both the Base and Option Cases, the peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary for the Base Case (see Figure 5–1188) and the Option Case (see Figure 5–1190), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide minor contributions to the early peak.

Table 5–147. Waste Management Alternative 3, Disposal Group 3, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.62×10^{-1}	3.06×10^{-1}	2.50×10^{-5}	0.00	2.50×10^{-5}	1.91	4.00×10^{-1}	7.89×10^{-5}	1.13×10^{-11}	7.89×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.35×10^{-1}	5.89×10^{-2}	1.94×10^{-5}	0.00	1.94×10^{-5}	1.48	6.01×10^{-2}	6.15×10^{-5}	2.27×10^{-11}	6.15×10^{-5}
Core Zone Boundary	2.75×10^{1}	1.20×10^{-1}	6.01×10^{-4}	0.00	6.01×10^{-4}	4.88×10^{1}	1.56×10^{-1}	1.70×10^{-3}	4.57×10^{-11}	1.70×10^{-3}
Columbia River nearshore	3.45	6.80×10^{-2}	8.36×10^{-5}	0.00	8.36×10^{-5}	6.61	8.66×10^{-2}	2.48×10^{-4}	1.25×10^{-11}	2.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.19×10^{-4}	1.79×10^{-6}	3.98×10^{-9}	1.27×10^{-16}	3.98×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–148. Waste Management Alternative 3, Disposal Group 3, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.76	7.80×10^{-1}	1.71×10^{-4}	5.16×10^{-7}	1.71×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.93	9.04×10^{-2}	1.33×10^{-4}	1.04×10^{-6}	1.33×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.77×10^{1}	3.05×10^{-1}	3.59×10^{-3}	2.10×10^{-6}	3.59×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.24×10^{1}	1.65×10^{-1}	5.27×10^{-4}	5.72×10^{-7}	5.27×10^{-4}	2.05×10^{-2}	1.26×10^{-1}	8.81×10^{-7}	2.86×10^{-7}	9.84×10^{-7}
Off Site										
Columbia River	9.37×10^{-4}	4.71×10^{-3}	2.56×10^{-8}	5.84×10^{-12}	2.56×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–149. Waste Management Alternative 3, Disposal Group 3, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.62×10^{-1}	3.06×10^{-1}	2.50×10^{-5}	0.00	2.50×10^{-5}	1.91	4.00×10^{-1}	7.90×10^{-5}	1.13×10^{-11}	7.90×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	7.87×10^{-1}	4.29×10^{-1}	2.45×10^{-5}	0.00	2.45×10^{-5}	1.86	4.69×10^{-1}	7.79×10^{-5}	1.43×10^{-10}	7.79×10^{-5}
Core Zone Boundary	2.76×10^{1}	1.36	6.03×10^{-4}	0.00	6.03×10^{-4}	4.85×10^{1}	1.53	1.74×10^{-3}	4.89×10^{-10}	1.74×10^{-3}
Columbia River nearshore	3.58	2.30×10^{-1}	8.69×10^{-5}	0.00	8.69×10^{-5}	6.86	2.51×10^{-1}	2.59×10^{-4}	8.05×10^{-11}	2.59×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.19×10^{-4}	3.20×10^{-6}	3.90×10^{-9}	7.92×10^{-16}	3.90×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–150. Waste Management Alternative 3, Disposal Group 3, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.76	7.80×10^{-1}	1.71×10^{-4}	5.17×10^{-7}	1.71×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.70	7.80×10^{-1}	1.69×10^{-4}	6.54×10^{-6}	1.72×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.85×10^{1}	2.59	3.66×10^{-3}	2.24×10^{-5}	3.67×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.29×10^{1}	4.12×10^{-1}	5.52×10^{-4}	3.69×10^{-6}	5.52×10^{-4}	2.10×10^{-2}	2.17×10^{-1}	9.16×10^{-7}	1.85×10^{-6}	2.06×10^{-6}
Off Site										
Columbia River	9.30×10^{-4}	5.31×10^{-3}	2.57×10^{-8}	3.63×10^{-11}	2.57×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

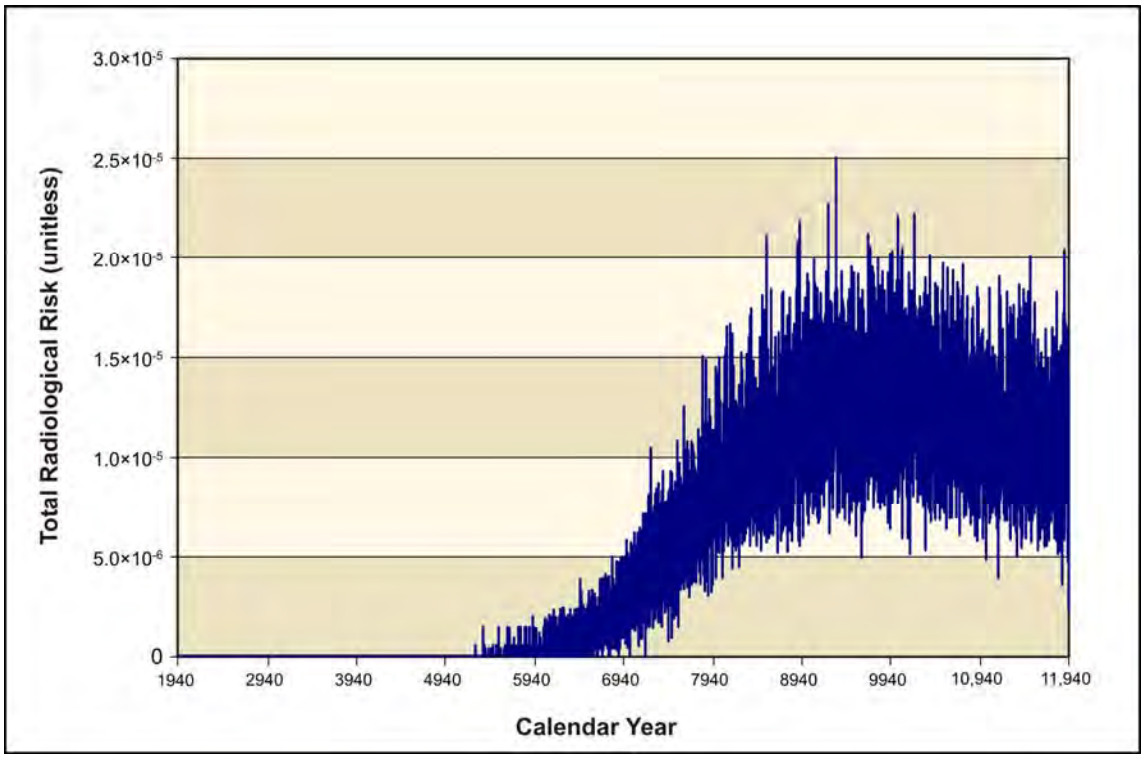


Figure 5–1187. Waste Management Alternative 3, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

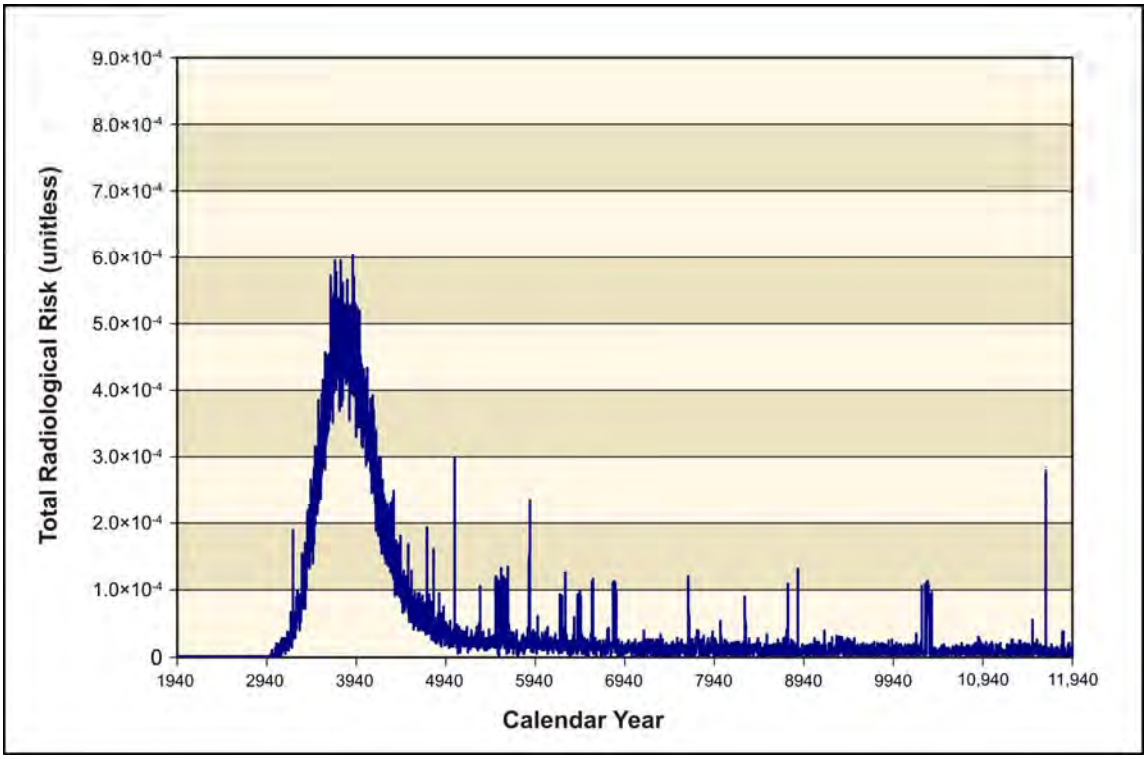


Figure 5–1188. Waste Management Alternative 3, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

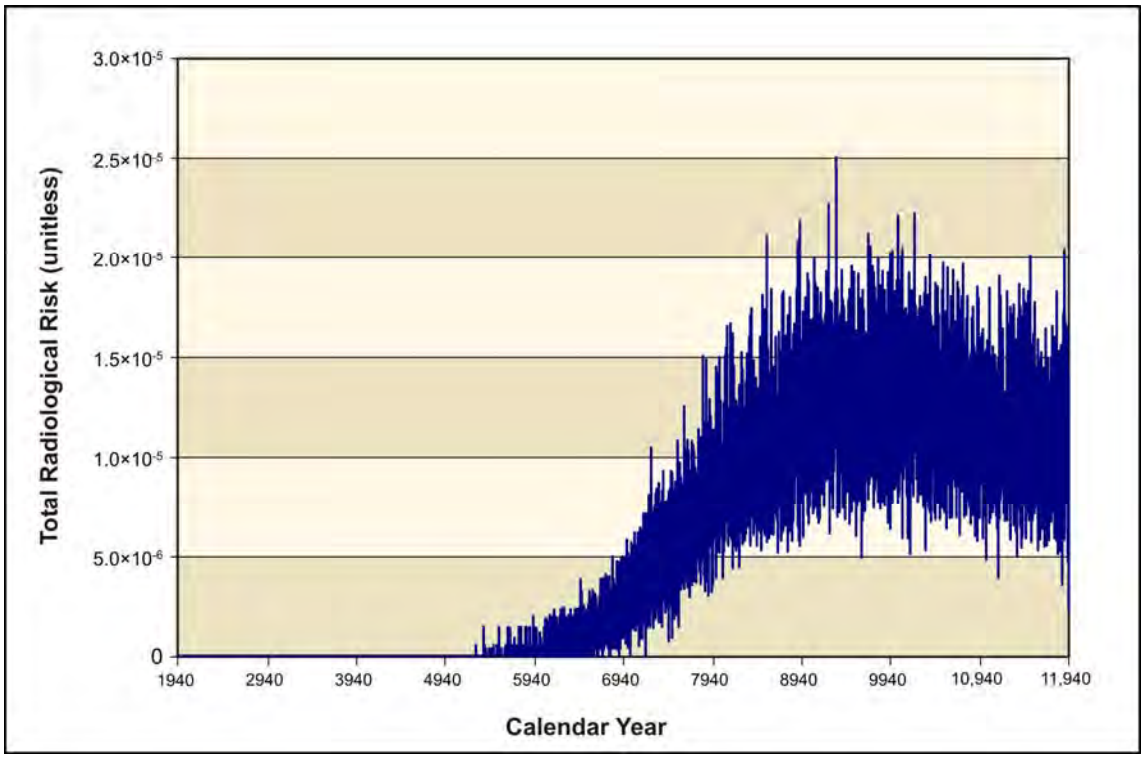


Figure 5–1189. Waste Management Alternative 3, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

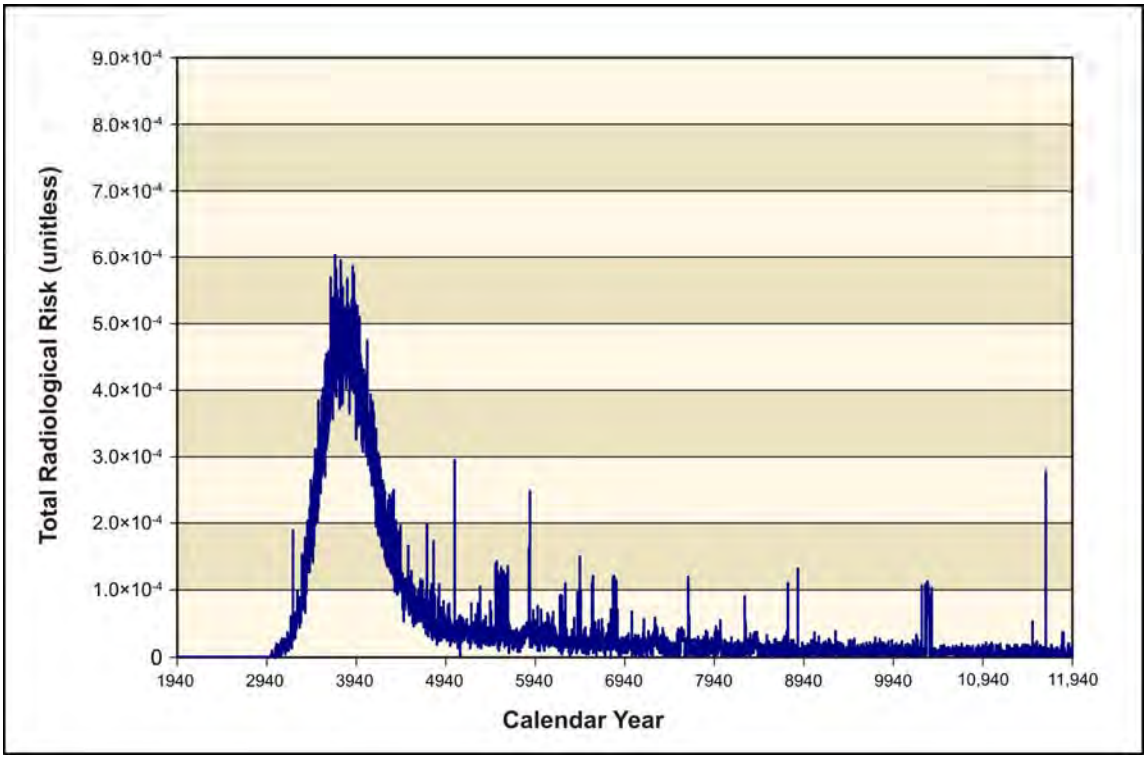


Figure 5–1190. Waste Management Alternative 3, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.3 Ecological Risk

This section presents the results of the evaluation of long-term impacts on ecological resources of releases to air and groundwater under the Waste Management alternatives. Risk indices—Hazard Quotient or Hazard Index—were calculated by comparing predicted dose to benchmark dose (see Appendix P). Risk indices could not be calculated for soil-dwelling invertebrates, lizards, toads, or birds for COPCs (organic compounds only) released under the Waste Management alternatives because there are no toxicity reference values for such receptors for these COPCs. Calculated risk indices are for the COPCs with the highest Hazard Quotient or Hazard Index presented for each receptor.

Releases to air and groundwater are expected under all Waste Management alternatives and all disposal group variants under Waste Management Alternatives 2 and 3. The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources of releases to groundwater were evaluated at the Columbia River.

5.3.3.1 Waste Management Alternative 1: No Action

Predicted emissions of COPCs in air from disposal in LLBG 218-W-5, trenches 31 and 34, under Waste Management Alternative 1, No Action, do not pose a risk to ecological receptors. This No Action Alternative is not expected to result in releases of radionuclides to air. Releases of chemicals to air are expected from ongoing waste management activities (see Section 5.3 and Chapter 2, Section 2.4). The chemical COPC with the largest calculated Hazard Quotient (3.3) is for the mouse exposed to air releases of xylene at the onsite maximum-exposure location (see Table 5–151). There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Waste Management Alternative 1 at the offsite maximum-exposure location (Columbia River). The uncertainty about the risk to terrestrial receptors from chemical COPCs in air releases under *TC & WM EIS* alternatives is discussed in Appendix P (see Section P.2.2)

Predicted emissions of chemical and radiological COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (Hazard Quotient is 0.005) for groundwater releases under Waste Management Alternative 1 (see Table 5–152) is that calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 1.

Table 5–151. Waste Management Alternatives – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

Waste Management Alternative	Maximum Hazard Quotient of Chemical COPC by Receptor			
	Plants	Great Basin Pocket Mouse	Coyote	Mule Deer
	Toluene	Xylene	Xylene	Formaldehyde
1	6.87×10^{-2}	**3.29**	4.18×10^{-1}	4.75×10^{-1}
2, Disposal Group 1	4.74×10^{-1}	**2.59×10^{1}**	3.29	1.04×10^{1}
2, Disposal Group 2	3.20	**1.66×10^{2}**	2.11×10^{1}	4.81×10^{1}
2, Disposal Group 3	5.65	**2.89×10^{2}**	3.67×10^{1}	8.07×10^{1}
3, Disposal Group 1	4.74×10^{-1}	**2.63×10^{1}**	3.34	1.12×10^{1}
3, Disposal Group 2	3.20	**1.67×10^{2}**	2.12×10^{1}	4.96×10^{1}
3, Disposal Group 3	5.58	**2.89×10^{2}**	3.67×10^{1}	8.14×10^{1}

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text. Results are not available for other terrestrial receptors: side-blotched lizard, mourning dove, western meadowlark, and burrowing owl.
Key: COPC=constituent of potential concern.

5.3.3.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

Predicted emissions of COPCs in air under Waste Management Alternative 2 pose little risk to plants and a moderate risk to mammals at the onsite maximum-exposure location (see Table 5–151). The largest calculated risk indices are for mammals exposed to organic chemicals released in air: formaldehyde for the deer and xylene, toluene, formaldehyde, and benzene for the mouse and coyote, all at the onsite maximum-exposure location. These are summarized below. There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Waste Management Alternative 2 at the offsite maximum-exposure location (Columbia River).

Releases to air and resulting long-term impacts on ecological resources would be similar under Waste Management Alternative 2, Disposal Groups 2 and 3. There would be a slight difference in peak air emissions between Disposal Groups 2 and 3 for operation of IDF-East and the RPPDF. IDF-East and the RPPDF, while the same size, would operate for a longer period of time under Disposal Group 3. This would result in higher cumulative emissions of all COPCs under Disposal Group 3 as compared to Disposal Group 2, with a somewhat greater long-term impact on ecological resources of air releases under Disposal Group 3.

5.3.3.2.1 Waste Management Alternative 2, Disposal Group 1

Predicted emissions of COPCs in air under Waste Management Alternative 2, Disposal Group 1 (Subgroups 1-A through 1-G), pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location only. The calculated Hazard Quotient for deer is 10 for formaldehyde under Waste Management Alternative 2, Disposal Group 1 (see Table 5–151). The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (26) and formaldehyde (17) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different subgroups of Waste Management Alternative 2, Disposal Group 1 (i.e., Subgroups 1-A through 1-G).

Table 5–152. Waste Management Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Resources at the Columbia River

Waste Management Alternative	Maximum Hazard Quotient or Hazard Index of Chemical or Radiological COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Chromium	Chromium	Chromium	Chromium	Nitrate	Chromium	Chromium
1	7.15×10^{-5}	2.80×10^{-6}	4.85×10^{-4}	5.87×10^{-5}	9.10×10^{-6}	7.47×10^{-6}	**4.72×10^{-3}**
2, DG 1-A	5.45×10^{-4}	2.13×10^{-5}	3.70×10^{-3}	4.48×10^{-4}	1.32×10^{-2}	5.15×10^{-5}	**2.69×10^{-2}**
2, DG 1-B	2.75×10^{-4}	1.07×10^{-5}	1.86×10^{-3}	2.25×10^{-4}	1.30×10^{-2}	2.58×10^{-5}	**1.33×10^{-2}**
2,,DG 1-C	8.51×10^{-2}	3.33×10^{-3}	5.77×10^{-1}	6.99×10^{-2}	5.72×10^{-2}	7.72×10^{-3}	**3.69**
2, DG 1-D	8.48×10^{-2}	3.32×10^{-3}	5.75×10^{-1}	6.97×10^{-2}	1.50×10^{-2}	7.97×10^{-3}	**4.12**
2, DG 1-E	4.66×10^{-2}	1.82×10^{-3}	3.16×10^{-1}	3.83×10^{-2}	3.28×10^{-2}	4.40×10^{-3}	**2.30**
2, DG 1-F	8.03×10^{-2}	3.14×10^{-3}	5.45×10^{-1}	6.60×10^{-2}	2.19×10^{-2}	7.01×10^{-3}	**3.02**
2, DG 1-G	5.88×10^{-4}	2.30×10^{-5}	3.99×10^{-3}	4.83×10^{-4}	1.32×10^{-2}	5.34×10^{-5}	**2.54×10^{-2}**
2, DG 2-A	5.51×10^{-4}	2.15×10^{-5}	3.74×10^{-3}	4.52×10^{-4}	1.39×10^{-2}	5.11×10^{-5}	**2.57×10^{-2}**
2, DG 2-B, Base	1.69×10^{-3}	6.61×10^{-5}	1.15×10^{-2}	1.39×10^{-3}	1.43×10^{-2}	1.56×10^{-4}	**7.74×10^{-2}**
2, DG 2-B, Option	1.24×10^{-2}	4.85×10^{-4}	8.41×10^{-2}	1.02×10^{-2}	1.66×10^{-2}	1.12×10^{-3}	**5.25×10^{-1}**
2, DG 3, Base	2.25×10^{-3}	8.79×10^{-5}	1.52×10^{-2}	1.85×10^{-3}	1.49×10^{-2}	1.92×10^{-4}	**7.77×10^{-2}**
2, DG 3, Option	1.50×10^{-2}	5.85×10^{-4}	1.02×10^{-1}	1.23×10^{-2}	1.73×10^{-2}	1.27×10^{-3}	**4.99×10^{-1}**
3, DG 1-A	5.37×10^{-4}	2.10×10^{-5}	3.64×10^{-3}	4.41×10^{-4}	1.32×10^{-2}	4.96×10^{-5}	**2.47×10^{-2}**
3, DG 1-B	3.36×10^{-4}	1.31×10^{-5}	2.28×10^{-3}	2.76×10^{-4}	1.30×10^{-2}	3.31×10^{-5}	**1.89×10^{-2}**
3, DG 1-C	8.51×10^{-2}	3.33×10^{-3}	5.77×10^{-1}	6.99×10^{-2}	5.72×10^{-2}	7.72×10^{-3}	**3.69**
3, DG 1-D	8.48×10^{-2}	3.32×10^{-3}	5.75×10^{-1}	6.96×10^{-2}	1.50×10^{-2}	7.96×10^{-3}	**4.12**
3, DG 1-E	4.66×10^{-2}	1.82×10^{-3}	3.16×10^{-1}	3.83×10^{-2}	3.28×10^{-2}	4.40×10^{-3}	**2.30**
3, DG 1-F	8.03×10^{-2}	3.14×10^{-3}	5.45×10^{-1}	6.59×10^{-2}	2.19×10^{-2}	7.01×10^{-3}	**3.02**
3, DG 1-G	5.73×10^{-4}	2.24×10^{-5}	3.89×10^{-3}	4.71×10^{-4}	1.32×10^{-2}	5.11×10^{-5}	**2.34×10^{-2}**
3, DG 2-A	5.24×10^{-4}	2.05×10^{-5}	3.55×10^{-3}	4.30×10^{-4}	1.39×10^{-2}	4.82×10^{-5}	**2.38×10^{-2}**
3, DG 2-B, Base	1.75×10^{-3}	6.85×10^{-5}	1.19×10^{-2}	1.44×10^{-3}	1.43×10^{-2}	1.63×10^{-4}	**8.18×10^{-2}**
3, DG 2-B, Option	1.25×10^{-2}	4.87×10^{-4}	8.45×10^{-2}	1.02×10^{-2}	1.66×10^{-2}	1.12×10^{-3}	**5.26×10^{-1}**
3, DG 3, Base	2.32×10^{-3}	9.07×10^{-5}	1.57×10^{-2}	1.91×10^{-3}	1.49×10^{-2}	1.98×10^{-4}	**8.03×10^{-2}**
3, DG 3, Option	1.50×10^{-2}	5.86×10^{-4}	1.02×10^{-1}	1.23×10^{-2}	1.73×10^{-2}	1.27×10^{-3}	**5.00×10^{-1}**

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.

Key: Base=Base Case; COPC=constituent of potential concern; DG=Disposal Group; Option=Option Case.

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 2, Disposal Group 1, Subgroups 1-A through 1-G. The largest risk index (Hazard Quotient is 4.1) is for groundwater releases under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This Hazard Quotient is 3 orders of magnitude greater than under Waste Management Alternative 1. The Hazard Quotient for chromium is within the margin of error resulting from the uncertainties in the estimated exposure and toxicity. No other risk indices exceeded 1. This indicates no risk to ecological receptors from chromium or other chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 2, Disposal Group 1.

5.3.3.2.2 Waste Management Alternative 2, Disposal Group 2

Predicted emissions of COPCs in air under Waste Management Alternative 2, Disposal Group 2, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 2, Disposal Group 1 (see Table 5–151). The calculated Hazard Quotient for deer is nearly 50 for formaldehyde under Waste Management Alternative 2, Disposal Group 2, as compared to 10 under Waste Management Alternative 2, Disposal Group 1. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (166) and formaldehyde (79.6) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different subgroups of Waste Management Alternative 2, Disposal Group 2 (i.e., Subgroups 2-A and 2-B).

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A or 2-B. The largest risk index (Hazard Quotient is 0.53) is for groundwater releases under Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 2, Disposal Group 2.

5.3.3.2.3 Waste Management Alternative 2, Disposal Group 3

Predicted emissions of COPCs in air under Waste Management Alternative 2, Disposal Group 3, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 2, Disposal Group 2. The calculated Hazard Quotient for deer is 81 for formaldehyde under Waste Management Alternative 2, Disposal Group 3 (see Table 5–151). The largest Hazard Quotients for the release of chemical COPCs to air were predicted for the mouse exposed to xylene (289) and formaldehyde (134) at the onsite maximum-exposure location.

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 2, Disposal Group 3. The largest risk index (Hazard Quotient is 0.5) is for groundwater releases under Waste Management Alternative 2, Disposal Group 3 (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 2, Disposal Group 3.

5.3.3.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Predicted emissions of COPCs in air under Waste Management Alternative 3 pose little risk to plants and a moderate risk to mammals at the onsite maximum-exposure location (see Table 5–151). These results are discussed below. There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Waste Management Alternative 3 at the offsite maximum-exposure location (Columbia River).

Releases to air and resulting long-term impacts on ecological resources at the onsite maximum-exposure location would be similar under Waste Management Alternative 3, Disposal Groups 2 and 3. There would be a slight difference in peak air emissions between Disposal Groups 2 and 3 for operation of an IDF and the RPPDF. An IDF and the RPPDF, while the same size, operate for a longer period of time under Waste Management Alternative 3, Disposal Group 3. This would result in higher cumulative emissions of COPCs and slightly lower peak emissions of others (e.g., formaldehyde and ammonia under Disposal Group 3 as compared to Disposal Group 2), with only minor differences in long-term impacts on ecological resources of air releases.

5.3.3.3.1 Waste Management Alternative 3, Disposal Group 1

Predicted emissions of COPCs in air under Waste Management Alternative 3, Disposal Group 1, pose a slightly greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 2, Disposal Group 1 (see Table 5–151). The calculated Hazard Quotient for deer is 11 for formaldehyde under Waste Management Alternative 3, Disposal Group 1, as compared to 10 under Waste Management Alternative 2, Disposal Group 1. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (26) and formaldehyde (18.5) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different subgroups of Waste Management Alternative 3, Disposal Group 1 (i.e., Subgroups 1-A through 1-G).

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 3, Disposal Group 1, Subgroups 1-A through 1-G. The largest risk index (Hazard Quotient is 4.1) is for groundwater releases under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This Hazard Quotient is 3 orders of magnitude greater than under Waste Management Alternative 1. The Hazard Quotient for chromium is within the margin of error resulting from the uncertainties in the estimated exposure and toxicity. No other risk indices exceeded 1. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 3, Disposal Group 1.

5.3.3.3.2 Waste Management Alternative 3, Disposal Group 2

Predicted emissions of COPCs in air under Waste Management Alternative 3, Disposal Group 2, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 3, Disposal Group 1, and a slightly greater probability of impact than under Waste Management Alternative 2, Disposal Group 2 (see Table 5–151). The calculated Hazard Quotient for deer is 50 for formaldehyde under Waste Management Alternative 3, Disposal Group 2, as compared to 11 under Waste Management Alternative 3, Disposal Group 1, and 48 under Waste Management Alternative 2, Disposal Group 2. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (167) and formaldehyde (82) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different variants of Waste Management Alternative 3, Disposal Group 2 (i.e., Subgroups 2-A and 2-B).

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 3, Disposal Group 2, Subgroups 2-A or 2-B. The largest risk index (Hazard Quotient is 0.53) is for groundwater releases under Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 3, Disposal Group 2.

5.3.3.3.3 Waste Management Alternative 3, Disposal Group 3

Predicted emissions of COPCs in air under Waste Management Alternative 3, Disposal Group 3, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 3, Disposal Group 2. The calculated Hazard Quotient for deer is 81 for formaldehyde under Waste Management Alternative 3, Disposal Group 3, as compared to 50 under Waste Management Alternative 3, Disposal Group 2 (see Table 5–151). The calculated formaldehyde Hazard Quotient under Waste Management Alternative 3, Disposal Group 3, is the maximum risk index for the mule deer under all alternatives (see Appendix P, Table P–5). The chemical COPCs with the largest calculated Hazard Quotients for air release are xylene (289) and formaldehyde (135) for the mouse at the onsite maximum-exposure location.

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 3, Disposal Group 3. The largest risk index (Hazard Quotient is 0.5) is for groundwater releases under Waste Management Alternative 3, Disposal Group 3 (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 3, Disposal Group 3.

5.3.4 Environmental Justice

Sections 5.3.1 and 5.3.2 evaluate groundwater impacts and associated potential long-term human health effects under the Waste Management alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs from the American Indian resident farmer. The American Indian hunter-gatherer does not cultivate crops but gathers food from indigenous plants, harvests fish from the Columbia River, and is exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Appendix Q, Section Q.3.3.1. Long-term human health impacts of waste management actions would be greatest under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D. Radiological releases under this alternative would result in the doses at the IDF-East Barrier and the Core Zone Boundary exceeding regulatory limits for the resident farmer and the American Indian resident farmer. None of the hypothetical receptors at the RPPDF Barrier, the Columbia River nearshore, or the Columbia River surface-water location would be exposed to a dose in excess of regulatory limits. Nonradiological releases under this alternative would result in exceedance of the Hazard Index for chromium at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the resident farmer and the American Indian resident farmer. The analysis determined that the greatest impact of any alternative on long-term human health could result in radiological doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the IDF-East Barrier, Core Zone Boundary, or Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptors scenarios to develop in the future, none are expected for the foreseeable future because the Core Zone is designated as Industrial-Exclusive, the Columbia River nearshore is designated as Preservation (Hanford Reach National Monument), and the area between them is designated as

Preservation (DOE 1999). It is unlikely, therefore, that any of the Waste Management alternatives would pose a disproportionately high and adverse long-term human health risk to the American Indian population at offsite locations. The greatest risk would be to the American Indian resident farmer at the IDF-East Barrier. During the year of peak dose, this receptor would receive a radiological dose of 281 millirem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The greatest risk in such a situation would be to the American Indian resident farmer. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent.

5.4 COMBINATION OF ALTERNATIVES

The potential long-term environmental and human health impacts associated with implementation of alternatives and options for (1) Hanford SST system waste retrieval, treatment, and closure (i.e., tank closure), (2) decommissioning of FFTF and auxiliary facilities (i.e., FFTF decommissioning), and (3) management of waste from other Hanford activities and limited volumes from other DOE sites (i.e., waste management) are presented separately in Sections 5.1, 5.2, and 5.3, respectively. The individual Tank Closure, FFTF Decommissioning, and Waste Management alternatives and options, as applicable, are described in detail in Chapter 2. This section presents the potential long-term, combined impacts to air and groundwater on key resource indicators of implementing selected alternatives and options associated with the three sets of proposed actions.

Key resource indicators have been selected from the total range of impact measures presented for each resource area or discipline (analyzed elsewhere in this chapter) to focus on those measures providing the most meaningful and useful assessment of potential impact. As presented in this section, the combined impact analyses provide a basis for determining the potential peak and/or total impact on an environmental resource area or human health indicator associated with implementation of alternatives and options from each set of proposed actions analyzed in this EIS.

Several hundred impact scenarios could result from the potential combinations of the 11 Tank Closure, 3 FFTF Decommissioning, and 3 Waste Management alternatives when factored with their associated option cases and waste disposal groups. For purposes of analysis, the following combinations of alternatives were chosen to represent key points along the range of actions and associated overall impacts that could result from full implementation of the three sets of proposed actions.

- Alternative Combination 1: all No Action Alternatives

- Alternative Combination 2: Tank Closure Alternative 2B (Expanded WTP Vitrification; Landfill Closure); FFTF Decommissioning Alternative 2 (Entombment) with the Idaho Option for Disposition of RH-SCs and the Hanford Reuse Option for Disposition of Bulk Sodium; and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 1, Subgroup 1-A.

- Alternative Combination 3: Tank Closure Alternative 6B (All Vitrification with Separations; Clean Closure), Base Case; FFTF Decommissioning Alternative 3 (Removal) with the Idaho Option for Disposition of RH-SCs and the Hanford Reuse Option for Disposition of Bulk Sodium; and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 2. Subgroup 2-B.

Alternative Combination 1 represents the potential short-term impacts of minimal DOE action and the greatest long-term impacts with respect to groundwater. Alternative Combination 2 is a midrange case representative of DOE's Preferred Alternative(s), as addressed in Chapter 2, Section 2.12. Alternative Combination 3 would result in maximum reasonably foreseeable short-term impacts (in terms of the

intensity of the potential impact) on most resource areas and therefore represents, on the whole, a combination that would result in maximum potential short-term impacts, but would likely have the lowest long-term impacts on groundwater. For some resource areas, a combination that included Tank Closure Alternative 6A, Option Case, would result in maximum impacts. Selection of these three alternative combinations for detailed analysis in this EIS is done only to establish overall impact-level reference cases for stakeholders and decisionmakers to consider and does not preclude the selection and implementation of different combinations of the various alternatives in support of final agency decisions.

5.4.1 Groundwater

5.4.1.1 Alternative Combination 1

This section describes the results of the long-term groundwater impacts analysis for Alternative Combination 1, which comprises Tank Closure Alternative 1, FFTF Decommissioning Alternative 1, and Waste Management Alternative 1. The focus is the combined long-term groundwater impacts of these alternatives. More-detailed discussion of the individual impacts is provided in Sections 5.1.1, 5.2.1, and 5.3.1.

This discussion of long-term impacts is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose the alternative combination. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Alternative Combination 1 in terms of total amount of COPCs released to the vadose zone, to groundwater, and to the Columbia River. Releases of radionuclides are totaled in curies; chemicals in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 5–153 lists the releases to the vadose zone for the COPC drivers. For Alternative Combination 1, the releases to the vadose zone are controlled by inventory; the entire inventory from all sources was released to the vadose zone during the period of analysis. The releases to the vadose zone for Alternative Combination 1 are dominated by sources associated with Tank Closure Alternative 1; releases from FFTF decommissioning and waste management sources account for less than 1 percent of the total. This result suggests that the long-term impacts of Alternative Combination 1 would closely match the long-term impacts of Tank Closure Alternative 1.

Table 5–153. Alternative Combination 1 Release to Vadose Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 1	5.75×10^{4}	4.78×10^{1}	2.58×10^{4}	9.38×10^{2}	6.94×10^{5}	9.74×10^{7}	6.32×10^{5}
FFTF Decommissioning Alternative 1	2.29	0.00	2.72×10^{1}	0.00	5.72×10^{-3}	0.00	2.79×10^{-2}
Waste Management Alternative 1	3.52×10^{3}	1.32×10^{-3}	1.21	7.35×10^{-1}	1.80×10^{2}	2.98×10^{3}	9.47×10^{-1}
Total	6.10×10^{4}	4.78×10^{1}	2.59×10^{4}	9.39×10^{2}	6.94×10^{5}	9.74×10^{7}	6.32×10^{5}

Key: COPC=constituent of potential concern.

Table 5–154 lists the releases to groundwater for the COPC drivers. In addition to the inventory consideration discussed in the previous paragraph, releases to groundwater are controlled by the transport properties of the COPC drivers and the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, that amount is attenuated by radioactive decay during transit through the vadose zone. About 55 percent of the tritium released to the vadose zone reaches the unconfined aquifer. For uranium-238 and total uranium, the amount released to groundwater is lower than that released to the vadose zone because of retardation. Less than 5 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 5–154. Alternative Combination 1 Release to Groundwater for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 1	3.23×10^{4}	4.65×10^{1}	2.51×10^{4}	2.57×10^{1}	6.34×10^{5}	9.40×10^{7}	2.86×10^{4}
FFTF Decommissioning Alternative 1	5.30×10^{-3}	0.00	2.67×10^{1}	0.00	5.61×10^{-3}	0.00	2.35×10^{-2}
Waste Management Alternative 1	1.76×10^{3}	1.31×10^{-3}	1.21	3.09×10^{-5}	1.77×10^{2}	2.94×10^{3}	4.39×10^{-5}
Total	3.41×10^{4}	4.65×10^{1}	2.51×10^{4}	2.57×10^{1}	6.34×10^{5}	9.40×10^{7}	2.86×10^{4}

Key: COPC=constituent of potential concern.

Table 5–155 lists the releases to the Columbia River for the COPC drivers. Releases to the Columbia River are controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to Columbia River is essentially equal to that released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reaches the Columbia River. For uranium-238 and total uranium, the amount released to the Columbia River is lower than the release to groundwater because of retardation in the aquifer. Overall, about 25 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

Table 5–155. Alternative Combination 1 Release to the Columbia River for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 1	8.68×10^{2}	4.54×10^{1}	2.46×10^{4}	6.26	6.52×10^{5}	9.42×10^{7}	6.87×10^{3}
FFTF Decommissioning Alternative 1	3.15×10^{-4}	0.00	2.72×10^{1}	0.00	5.73×10^{-3}	0.00	2.20×10^{-2}
Waste Management Alternative 1	0.00	1.28×10^{-3}	1.18	2.67×10^{-6}	1.75×10^{2}	2.90×10^{3}	3.50×10^{-6}
Total	8.68×10^{2}	4.54×10^{1}	2.46×10^{4}	6.26	6.52×10^{5}	9.42×10^{7}	6.87×10^{3}

Key: COPC= constituent of potential concern.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section describes the impacts of Alternative Combination 1 in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–156 lists the maximum concentrations for the COPCs at the peak year at the Core Zone Boundary and the Columbia River nearshore.

Figure 5–1191 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from CY 1940 through CY 5940 rather than the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore peak at about an order of magnitude lower than the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates the groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

Table 5–156. Alternative Combination 1 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary and Columbia River Nearshore

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter			
Hydrogen-3 (tritium)	**2,860,000**	1,720	20,000
	(1956)	(1998)	
Technetium-99	**350,000**	**5,230**	900
	(3837)	(4032)	
Iodine-129	**682**	**13**	1
	(3801)	(4411)	
Uranium isotopes	**1,070**	6	15
(includes uranium-233, -234, -235, -238)	(11,683)	(11,918)	
Chemical in micrograms per liter			
Acetonitrile	**121**	9	100
	(3338)	(3285)	
Chromium	**28,700**	**165**	100
	(1956)	(4019)	
Dichloromethane	0.0	0.0	5
	(1940)	(1940)	
Fluoride	1	0	4,000
	(3661)	(4592)	
Nitrate	**13,400,000**	23,500	45,000
	(1956)	(3911)	
Total uranium	**1,220**	8	30
	(11,648)	(11,591)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern

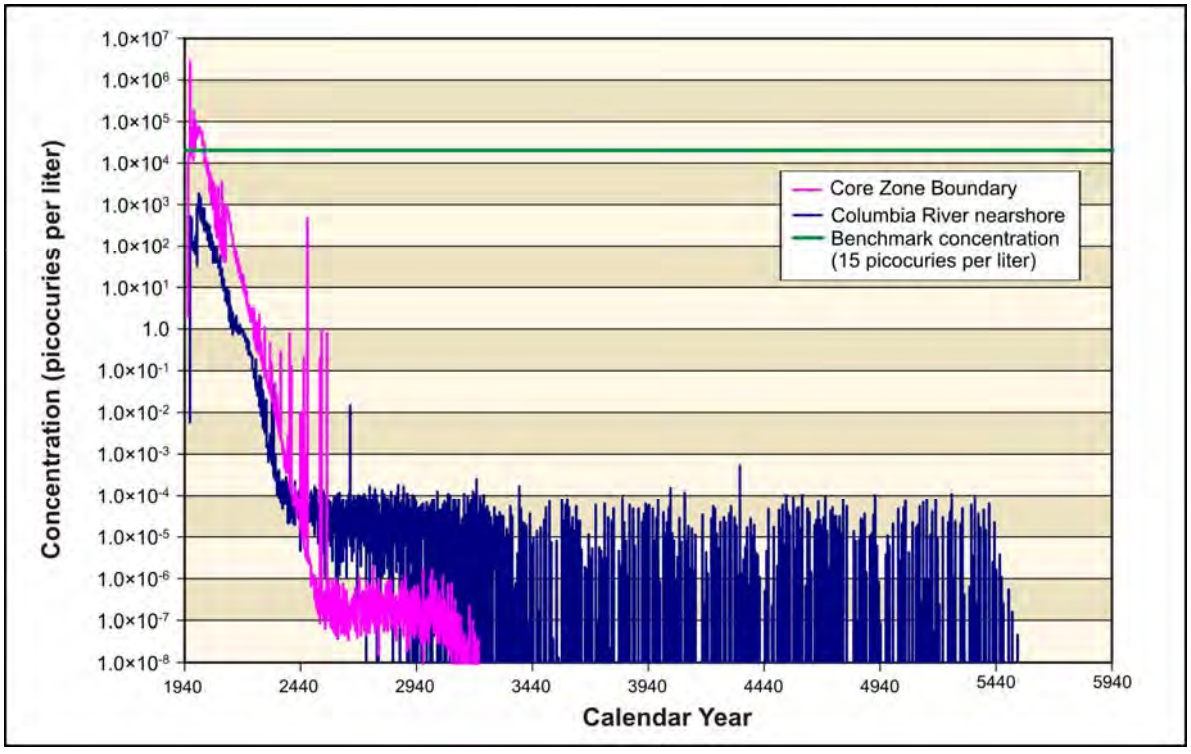


Figure 5–1191. Alternative Combination 1 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–1192 through 5–1195 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Groundwater concentrations of iodine-129 exceed benchmark concentrations by more than two orders of magnitude during the first several thousand years of the analysis period. During this time, groundwater concentrations at the Columbia River nearshore exceed the benchmark concentration by about an order of magnitude. Later in the analysis period, the concentrations at the Core Zone Boundary exceed the benchmark by about an order of magnitude, and are of the same order of magnitude as the benchmark at the Columbia River nearshore. Technetium-99, chromium, and nitrate concentrations show a similar curve, with chromium and nitrate concentrations at the Columbia River nearshore dropping below the benchmark concentrations.

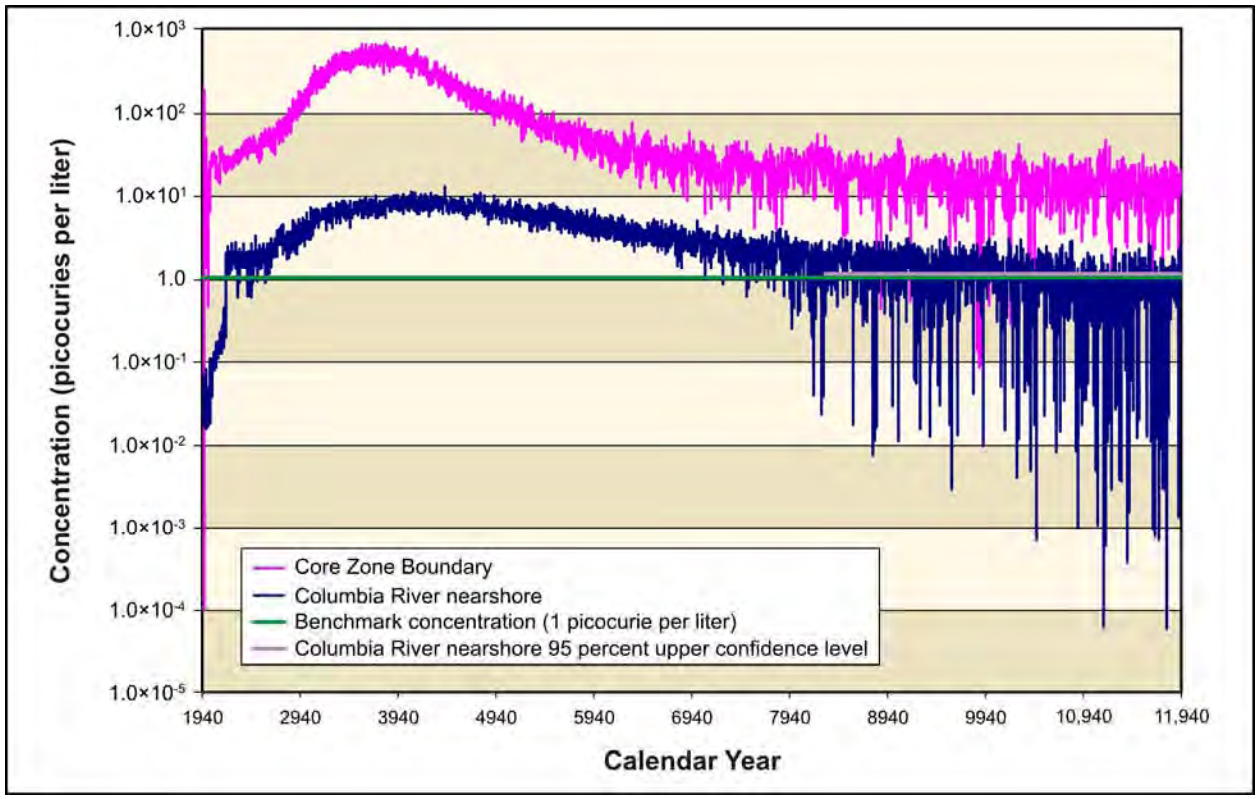


Figure 5–1192. Alternative Combination 1 Iodine-129 Concentration Versus Time

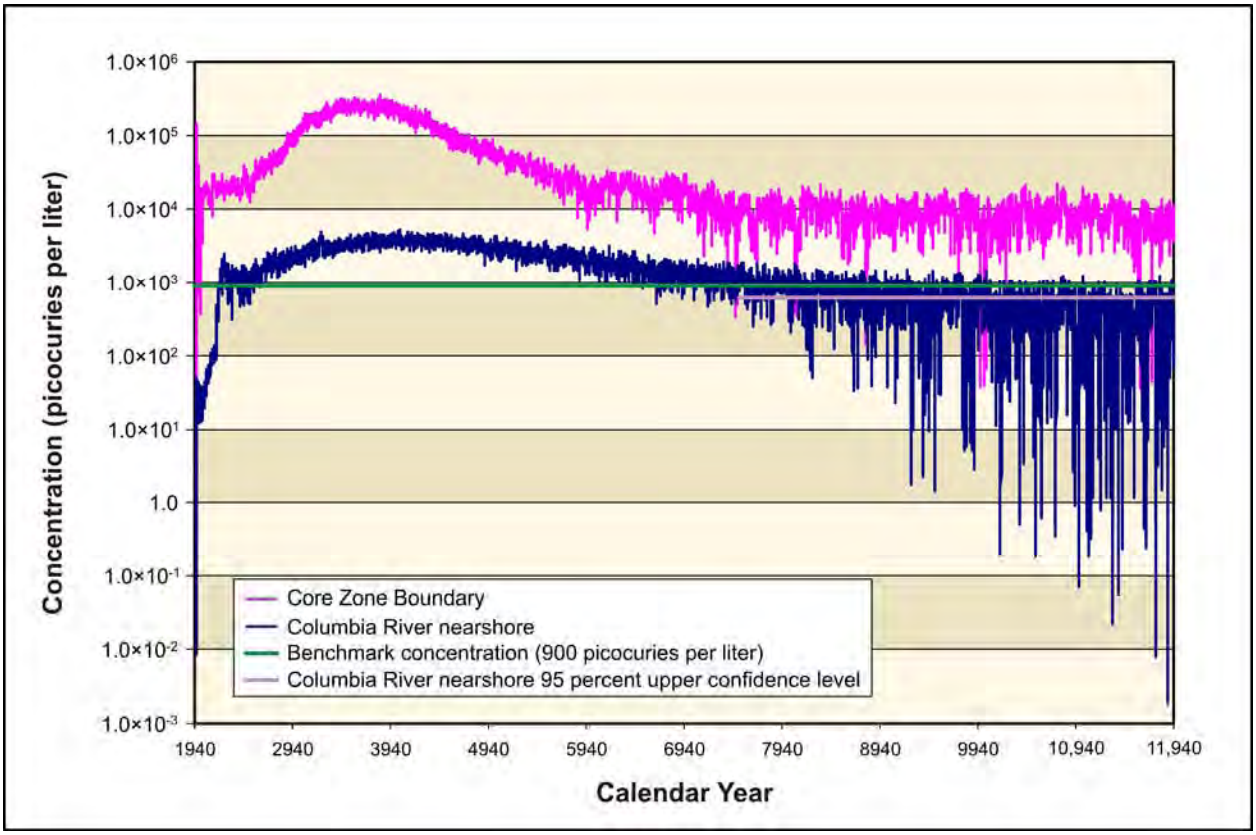


Figure 5–1193. Alternative Combination 1 Technetium-99 Concentration Versus Time

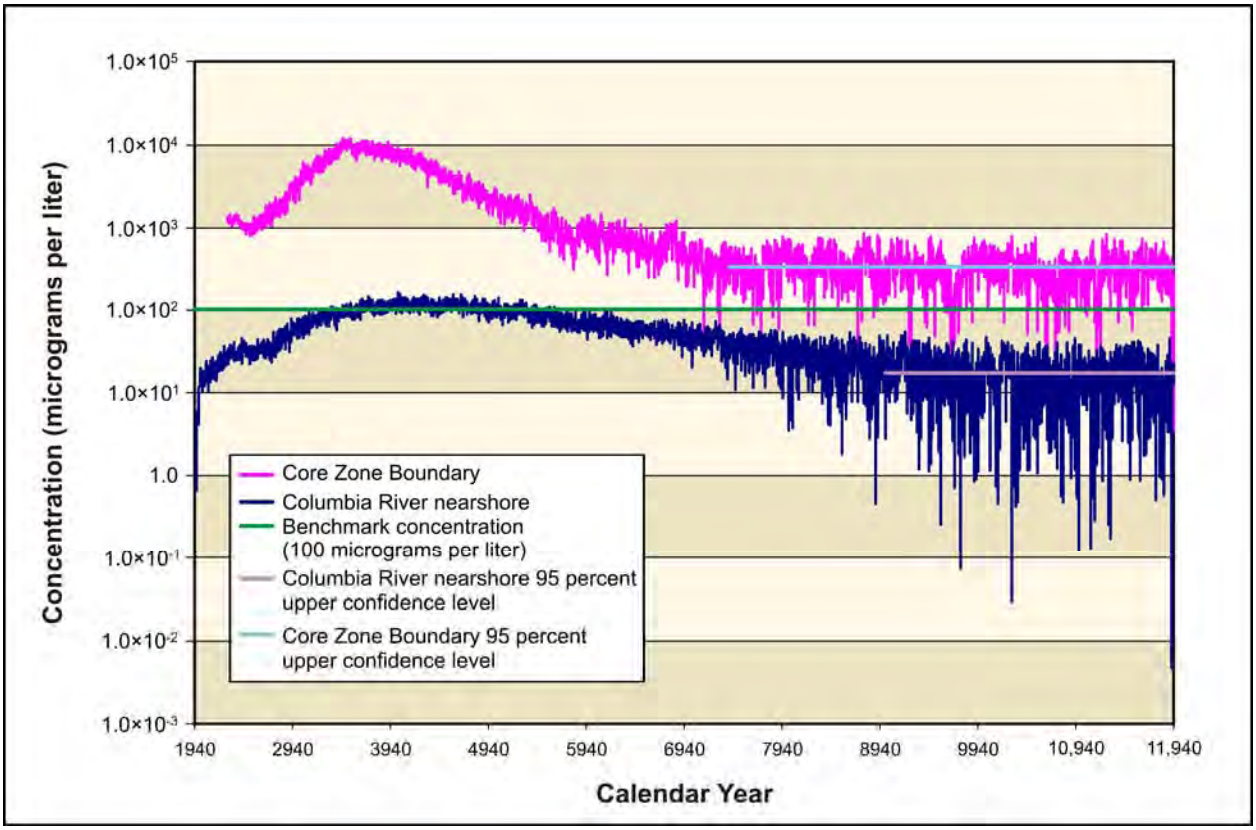


Figure 5–1194. Alternative Combination 1 Chromium Concentration Versus Time

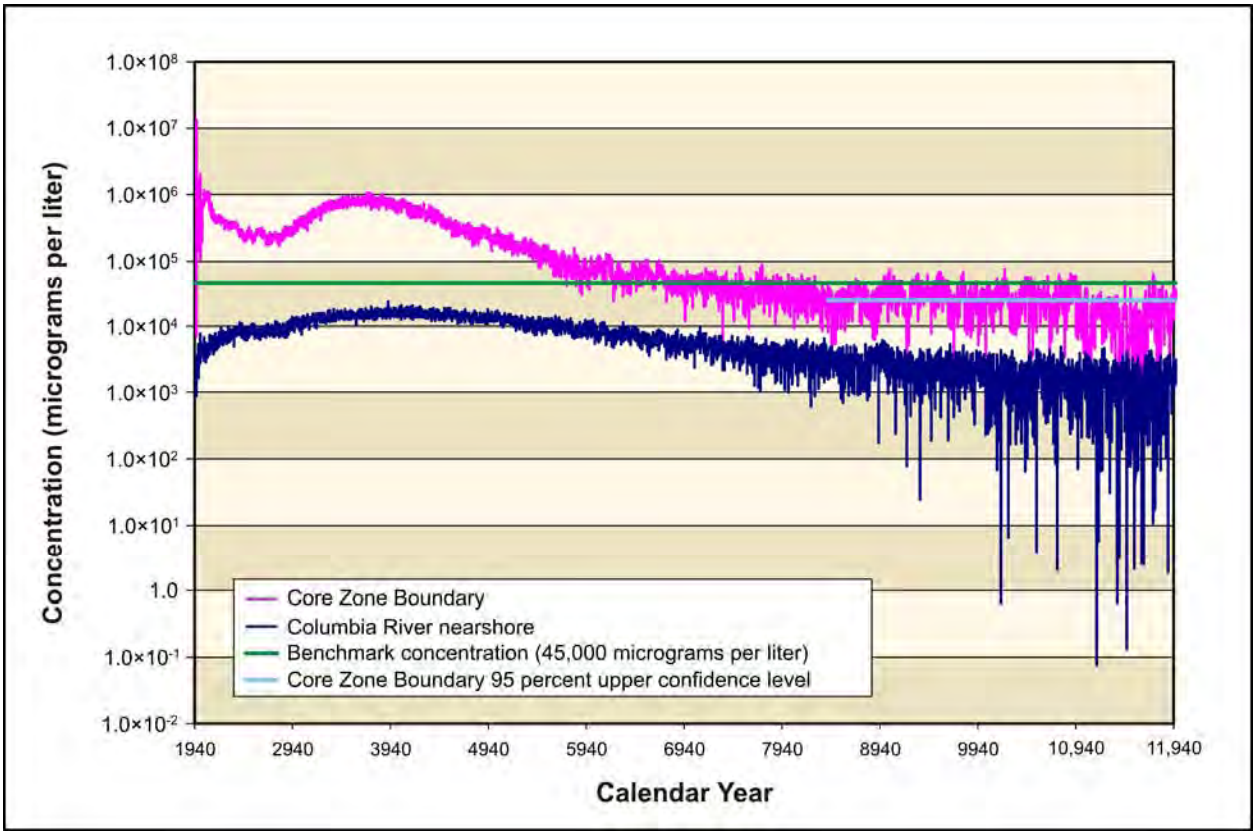


Figure 5–1195. Alternative Combination 1 Nitrate Concentration Versus Time

Figures 5–1196 and 5–1197 show concentration versus time for uranium-238 and total uranium. Concentrations of uranium-238 and total uranium rise throughout the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and the Columbia River are retarded relative to the conservative tracers by about a factor of seven. After about 5,000 years, concentrations of both uranium-238 and total uranium approach the benchmark concentration at the Core Zone Boundary, and continue to rise until the end of the period of analysis, when they exceed the benchmark concentration by about a factor of 30. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, nearing the benchmark concentration by CY 11,940.

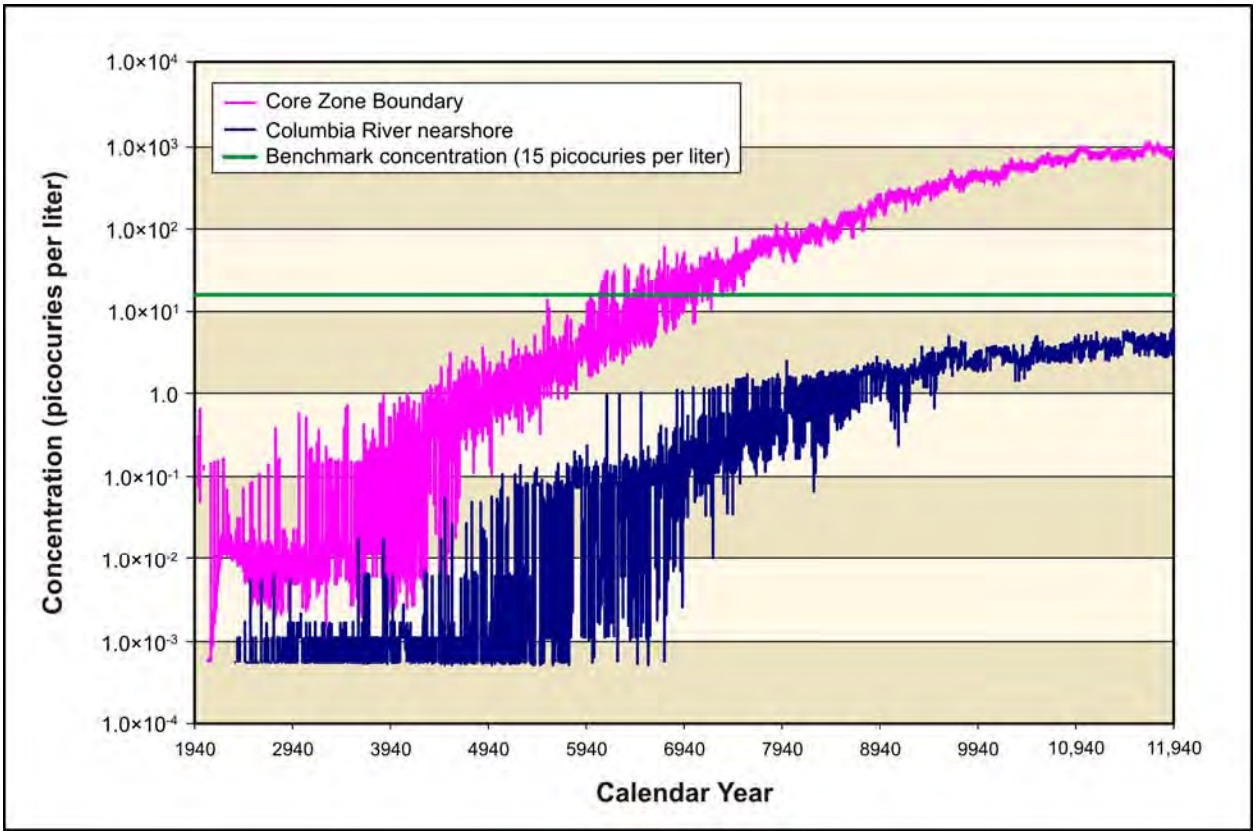


Figure 5–1196. Alternative Combination 1 Uranium-238 Concentration Versus Time

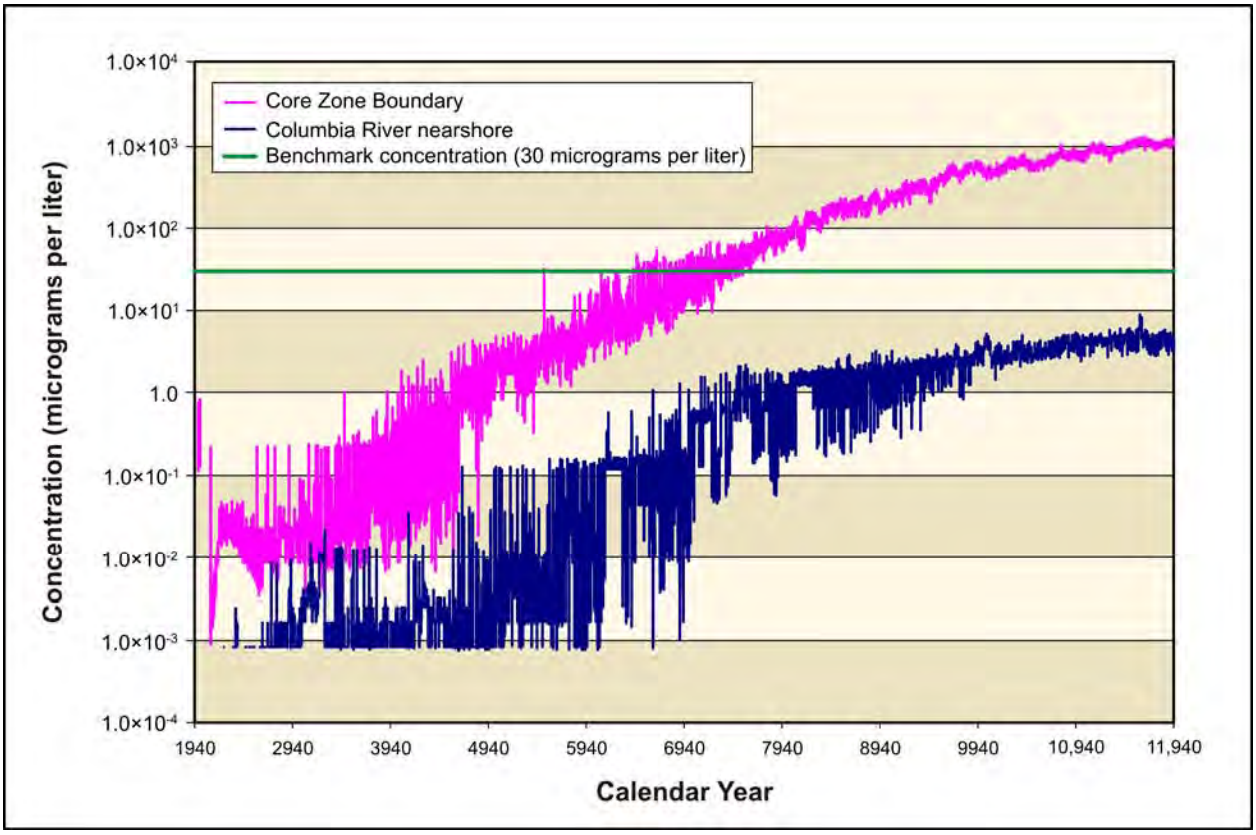


Figure 5–1197. Alternative Combination 1 Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section describes the impacts of Alternative Combination 1 in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1198 shows the spatial distribution of groundwater concentrations of tritium during CY 2005. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135.

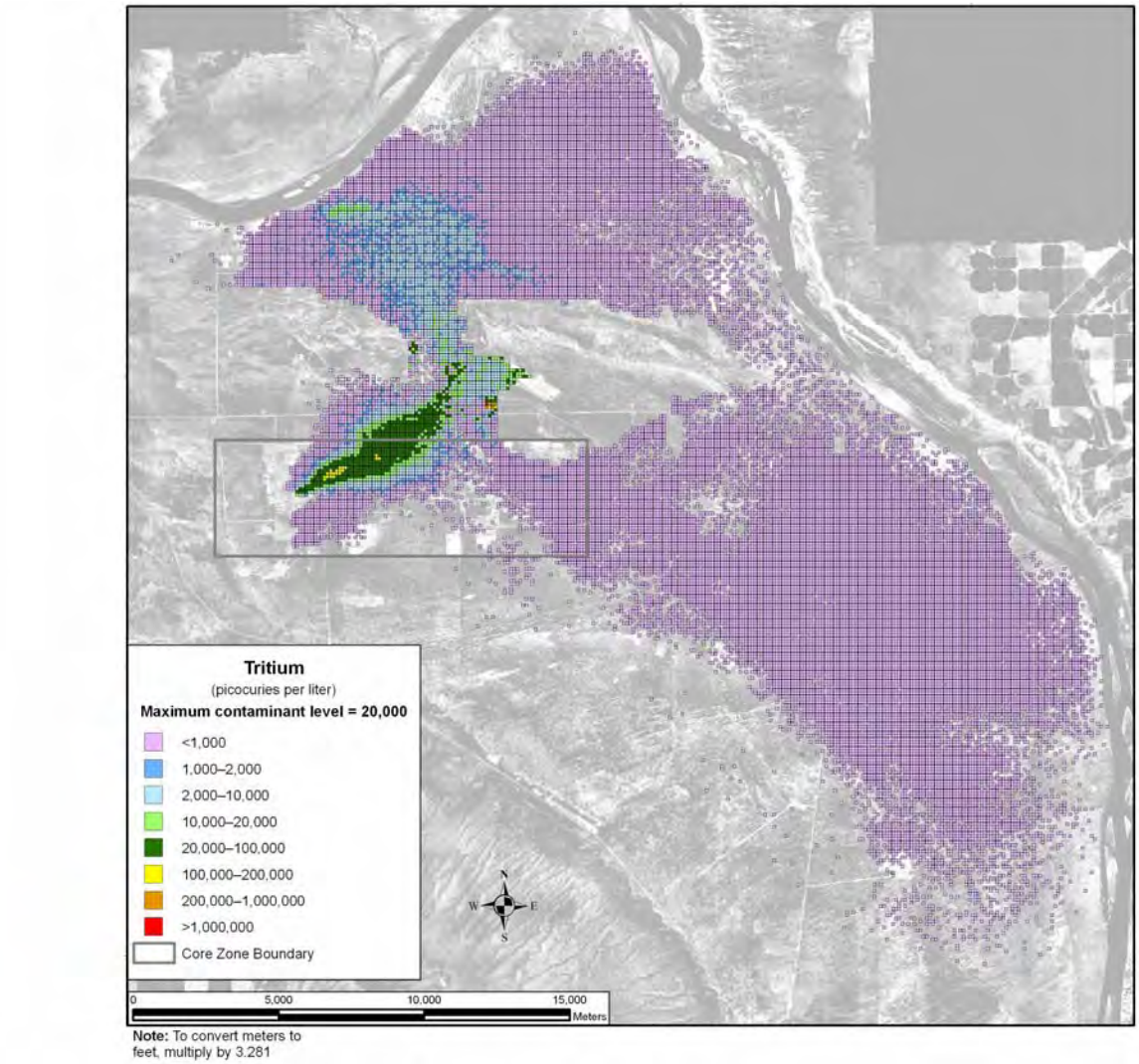


Figure 5–1198. Alternative Combination 1 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

Figure 5–1199 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Around CY 3890, releases from other tank farm sources create a large plume exceeding the benchmark, extending from the tank farm barriers to the Columbia River (see Figure 5–1200). A secondary plume from trenches 31 and 34 (Waste Management Alternative 1 sources) can also be seen in the 200-West Area. By CY 7140, most of the mass in the plume reaches the Columbia River, with only isolated pockets of high-concentration areas where the groundwater flow velocities are extremely low (see Figure 5–1201). Figure 5–1202 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. The area of exceedance peaks between CY 3240 and CY 4540, driven primarily by releases from other tank farm sources. Figures 5–1203 through 5–1206 show the spatial distribution at the same three times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 is similar to that of iodine-129. The other conservative tracers, chromium (see Figures 5–1207 through 5–1209) and nitrate (see Figures 5–1210 through 5–1212) show similar spatial distributions.

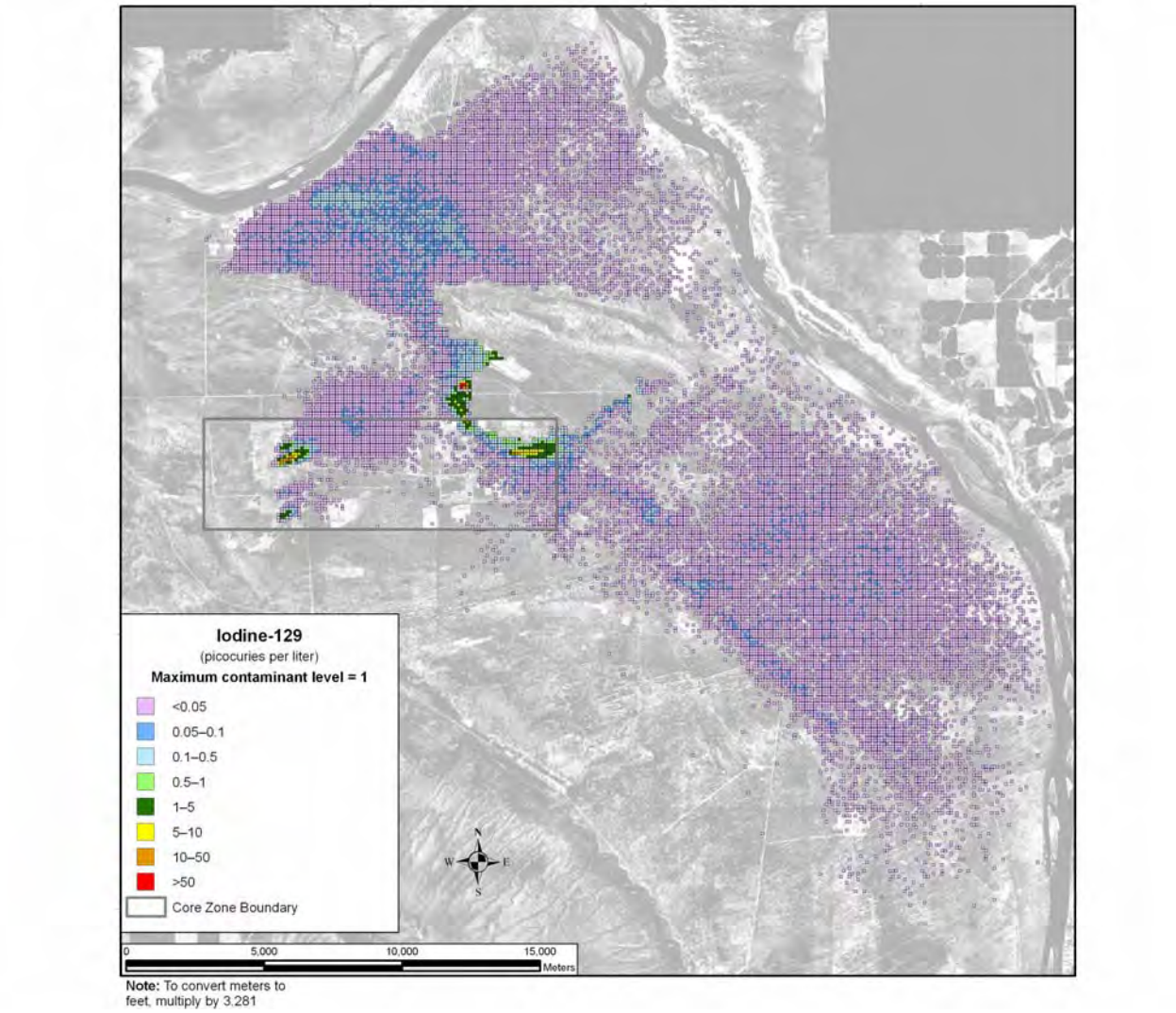


Figure 5–1199. Alternative Combination 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

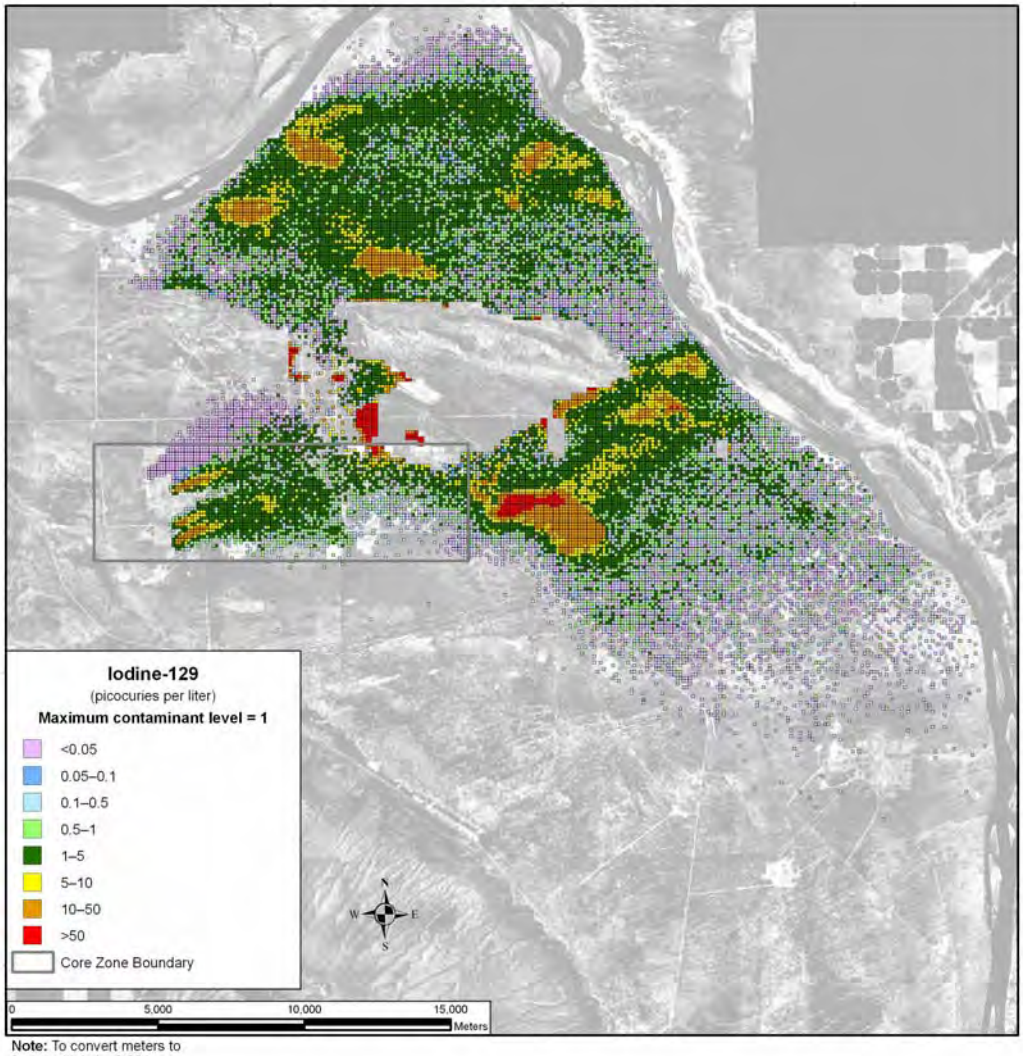


Figure 5–1200. Alternative Combination 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

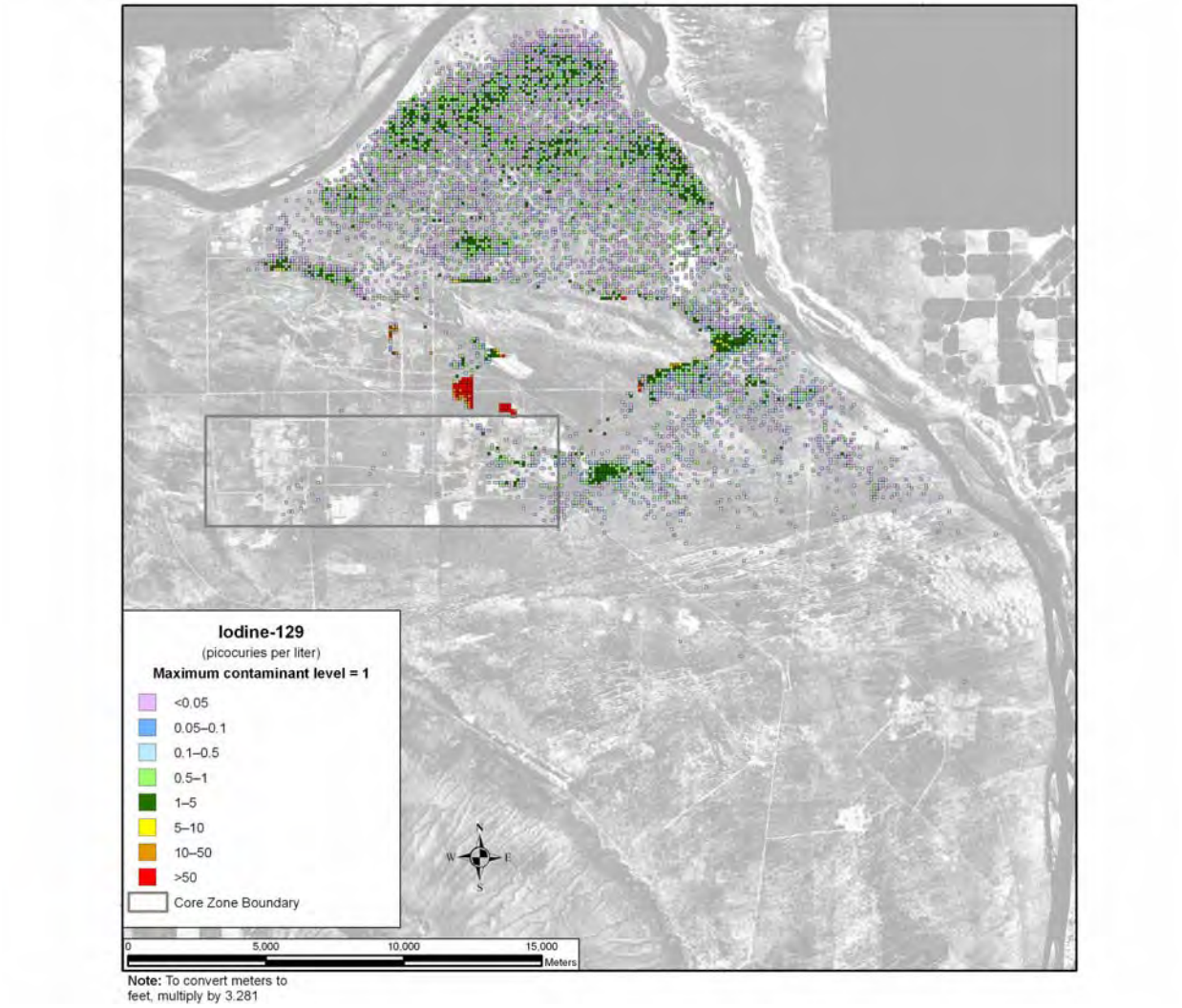


Figure 5–1201. Alternative Combination 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

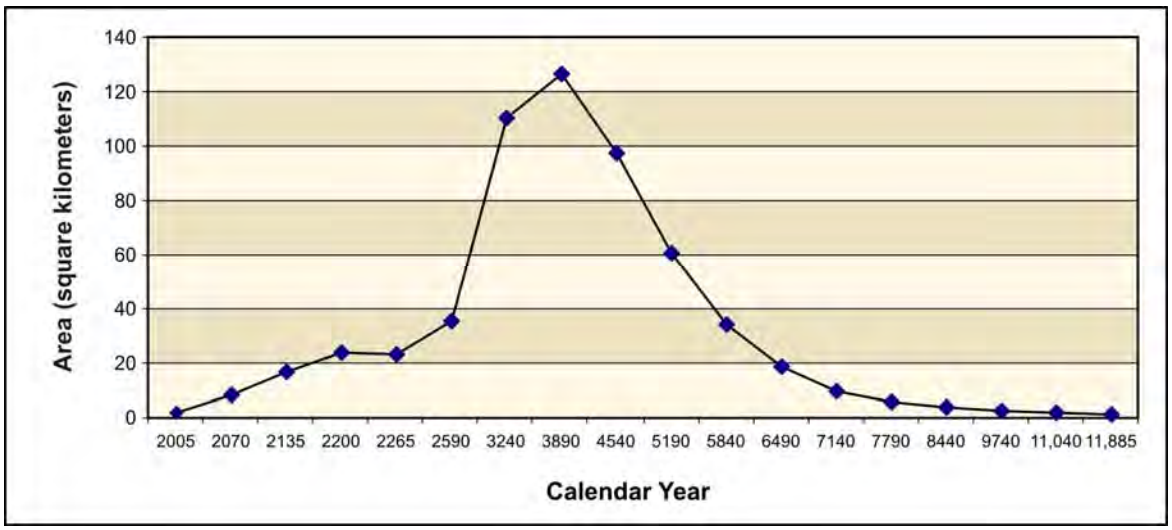


Figure 5–1202. Alternative Combination 1 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

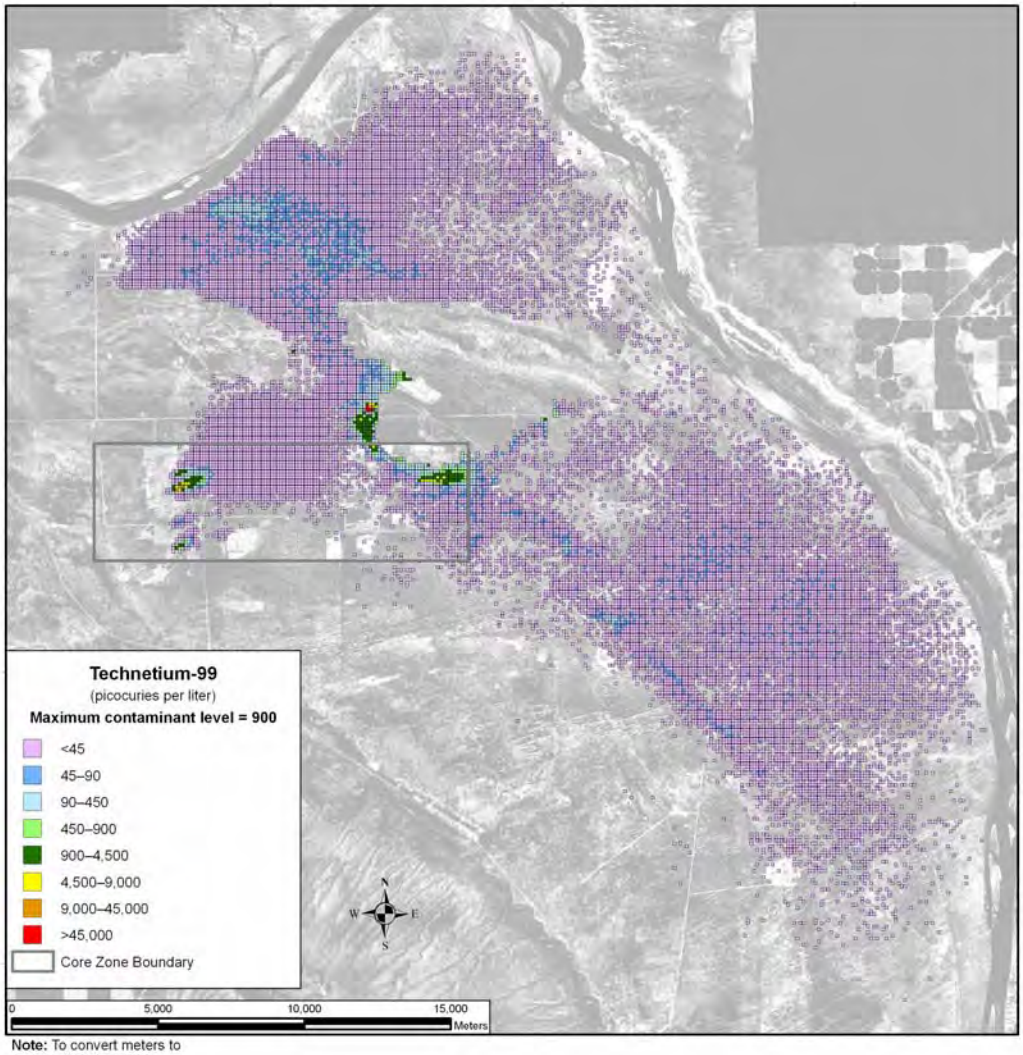


Figure 5–1203. Alternative Combination 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

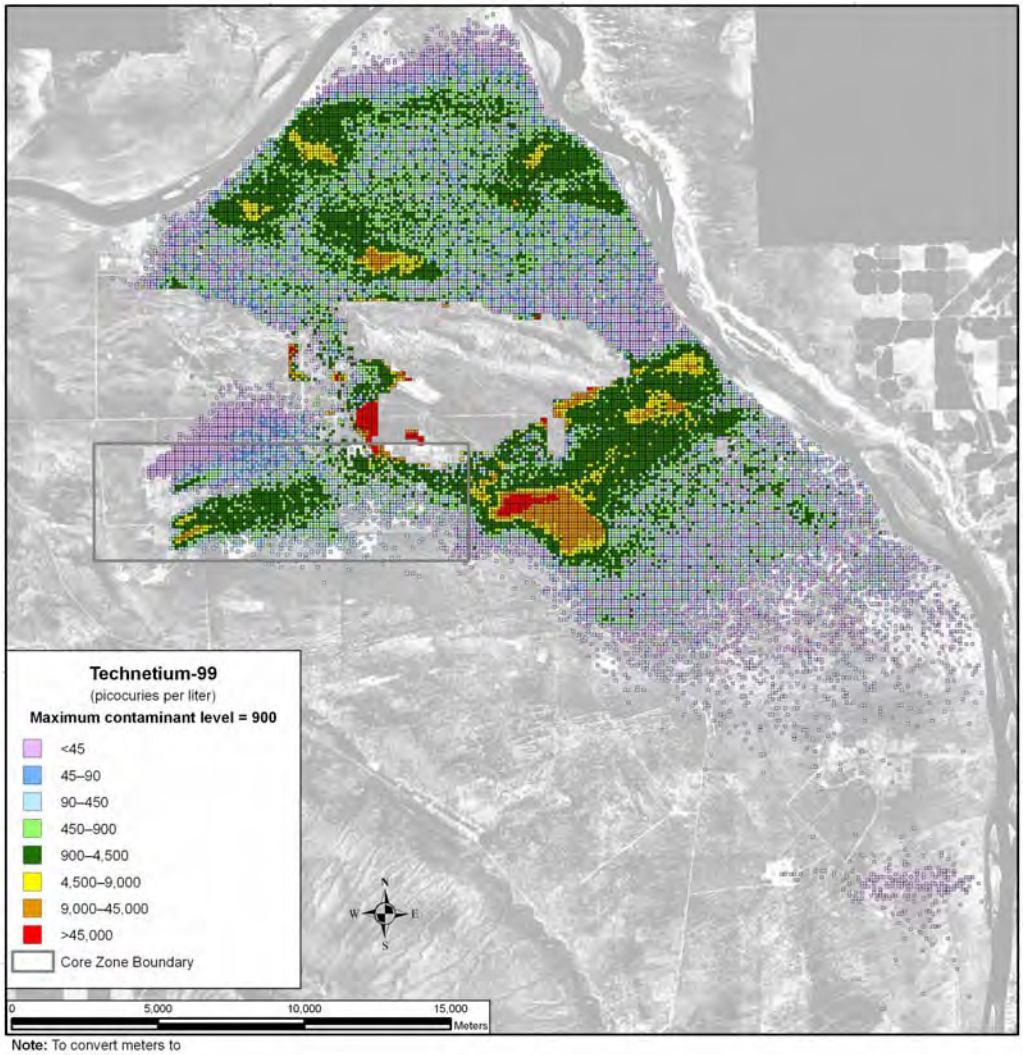


Figure 5–1204. Alternative Combination 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

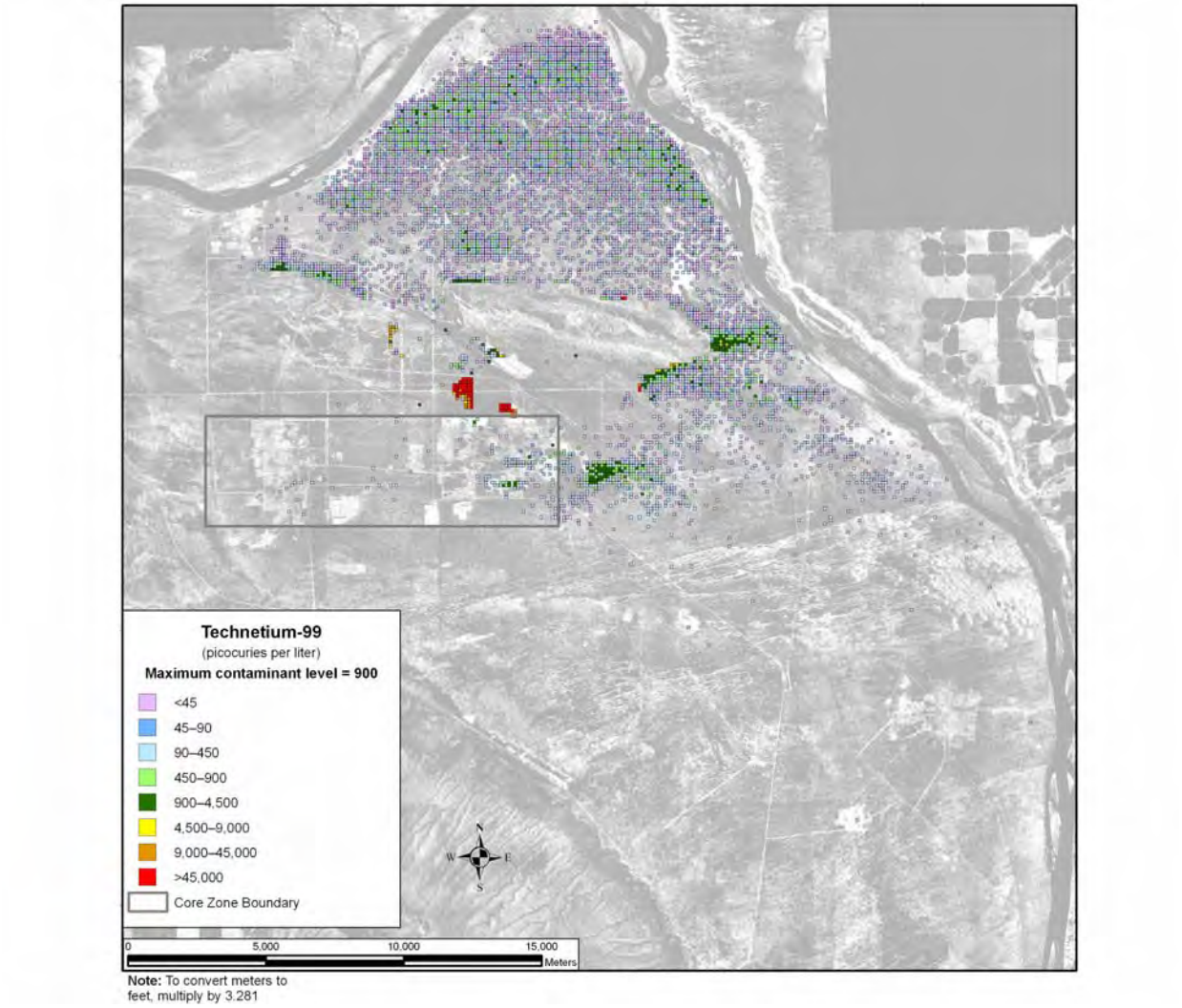


Figure 5–1205. Alternative Combination 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

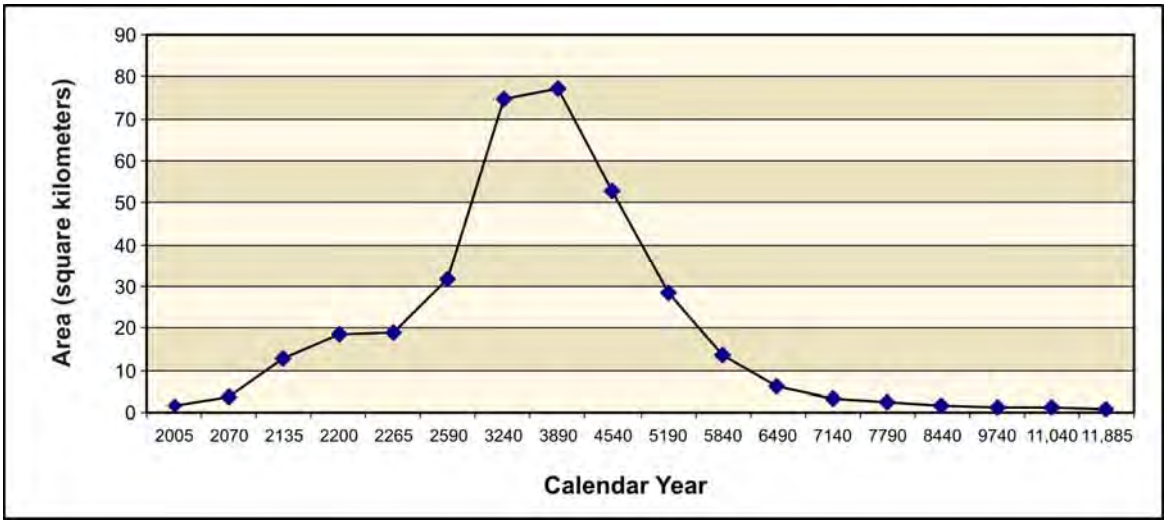


Figure 5–1206. Alternative Combination 1 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

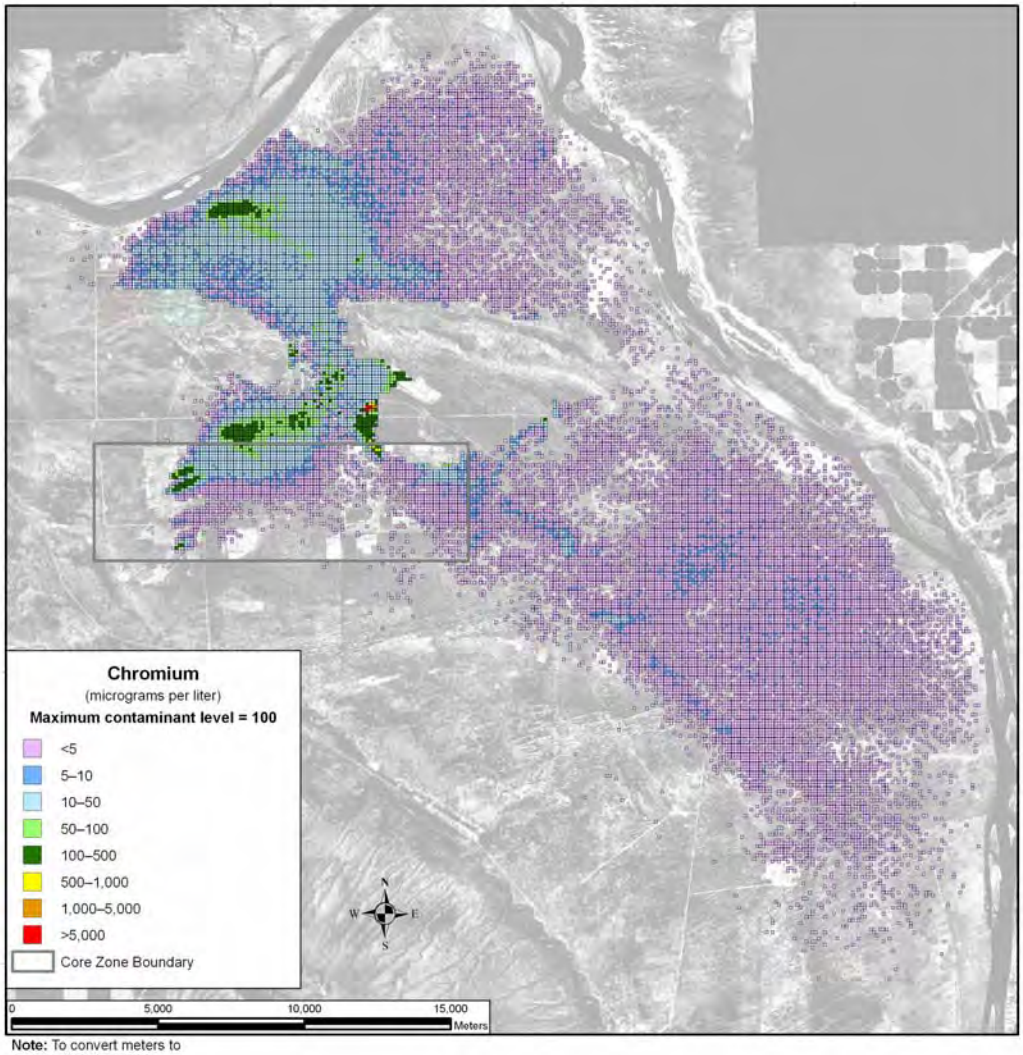


Figure 5–1207. Alternative Combination 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

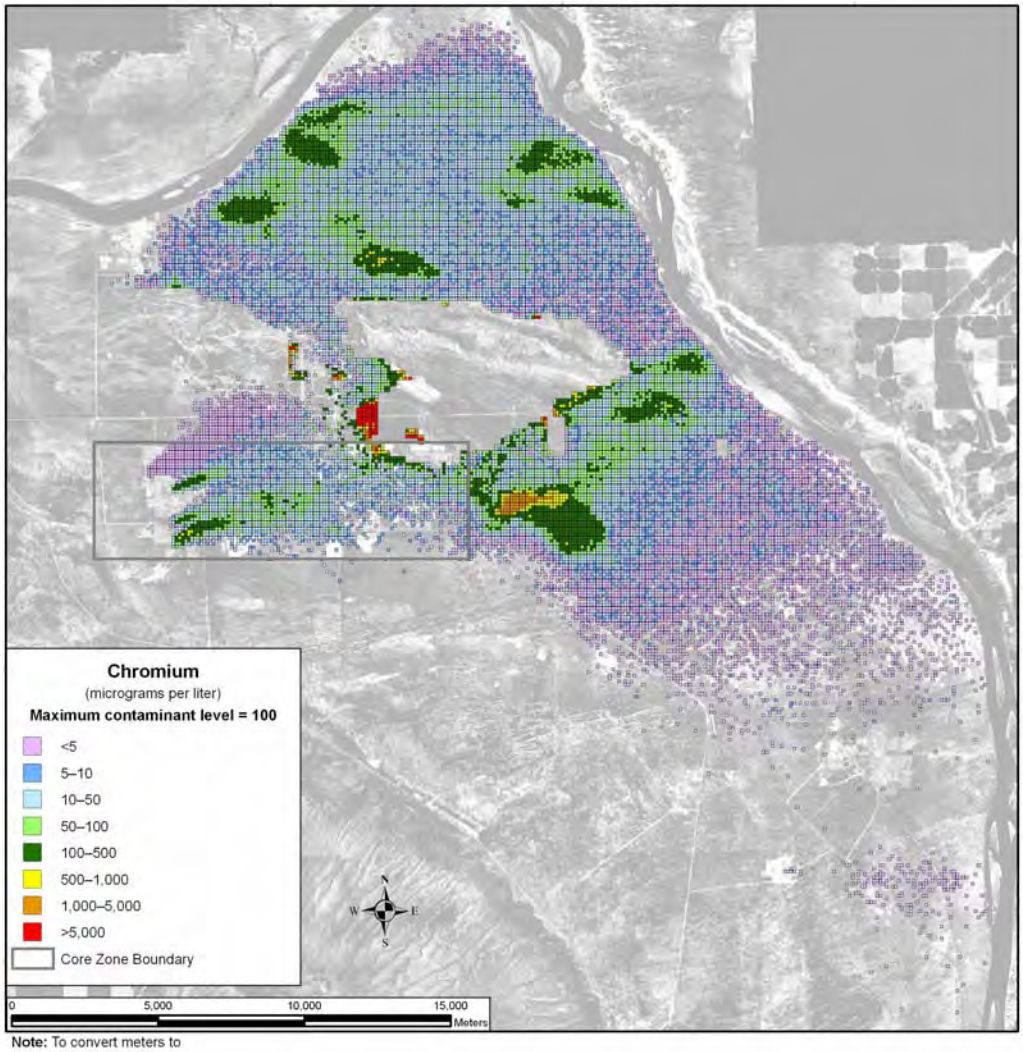


Figure 5–1208. Alternative Combination 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

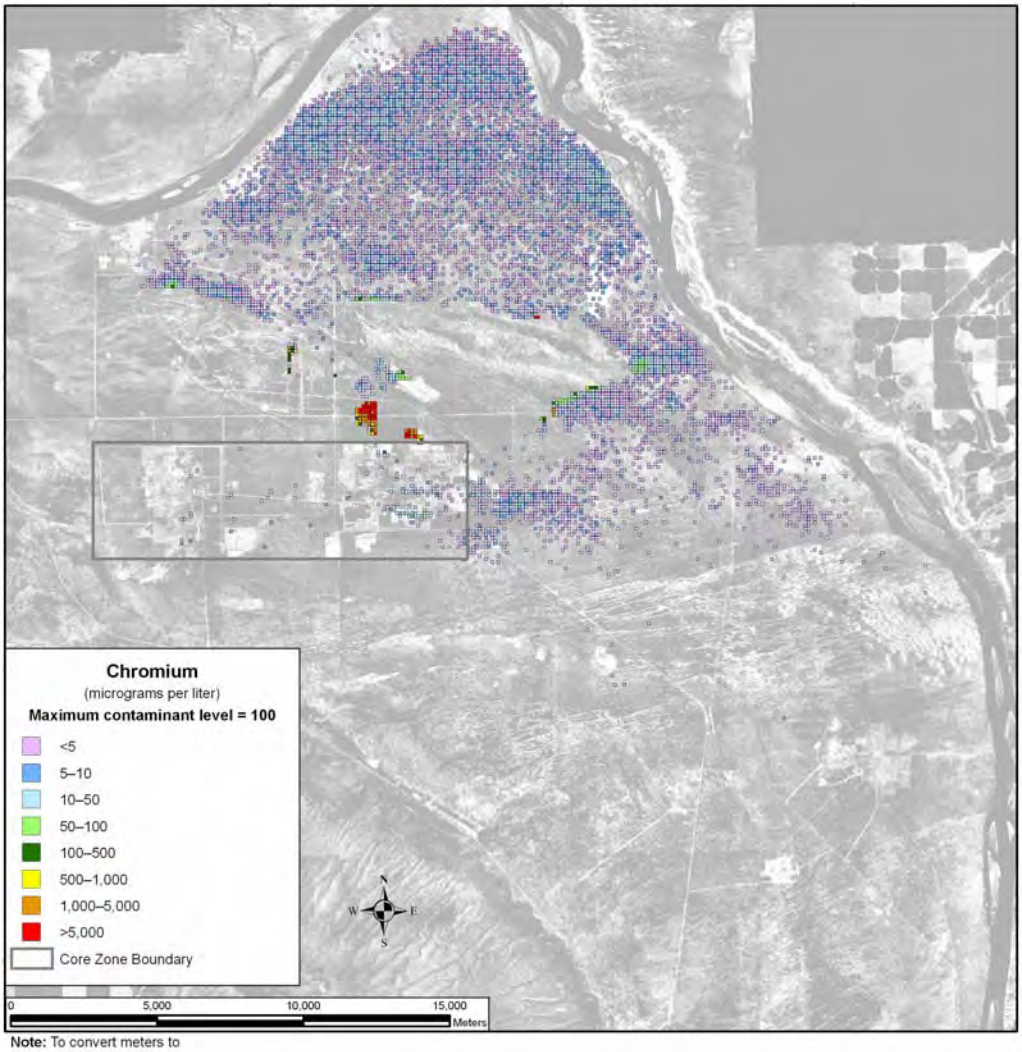


Figure 5–1209. Alternative Combination 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

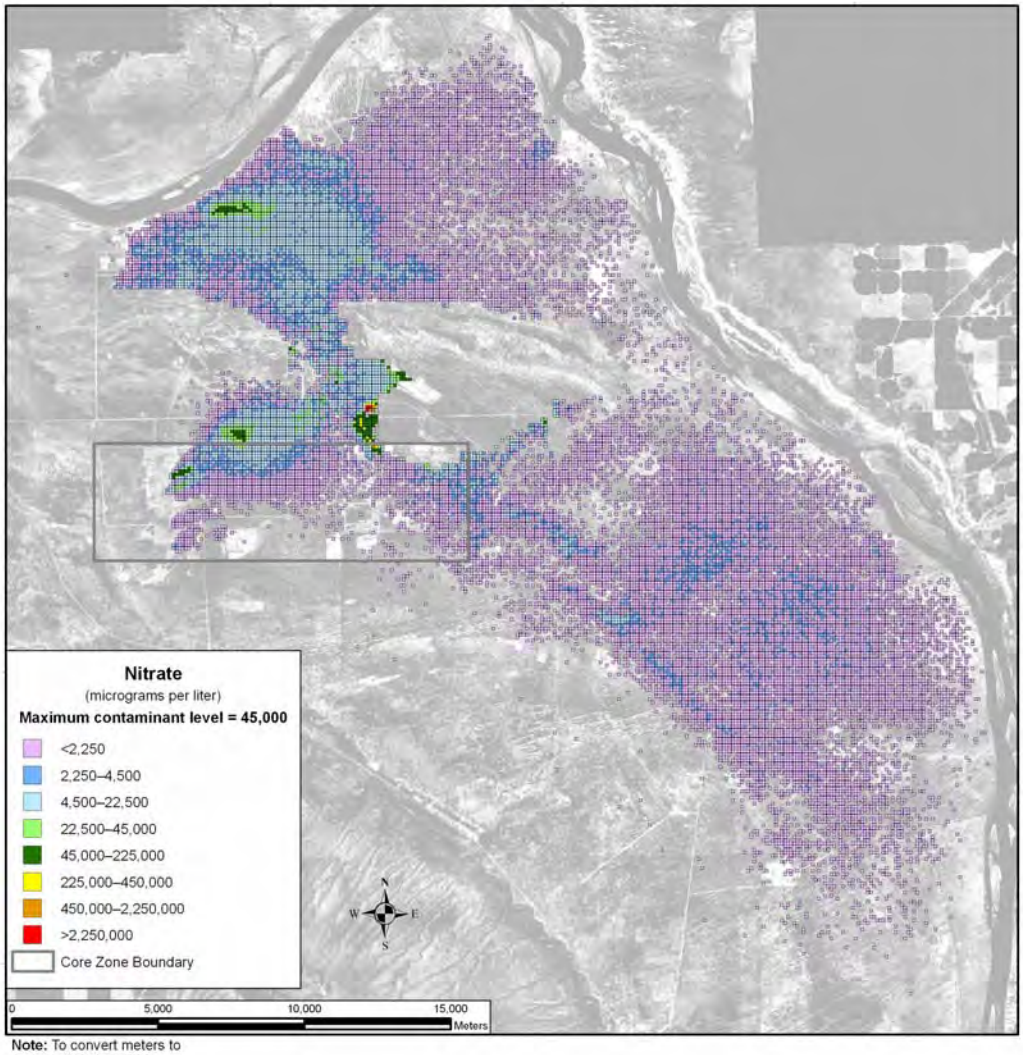


Figure 5–1210. Alternative Combination 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

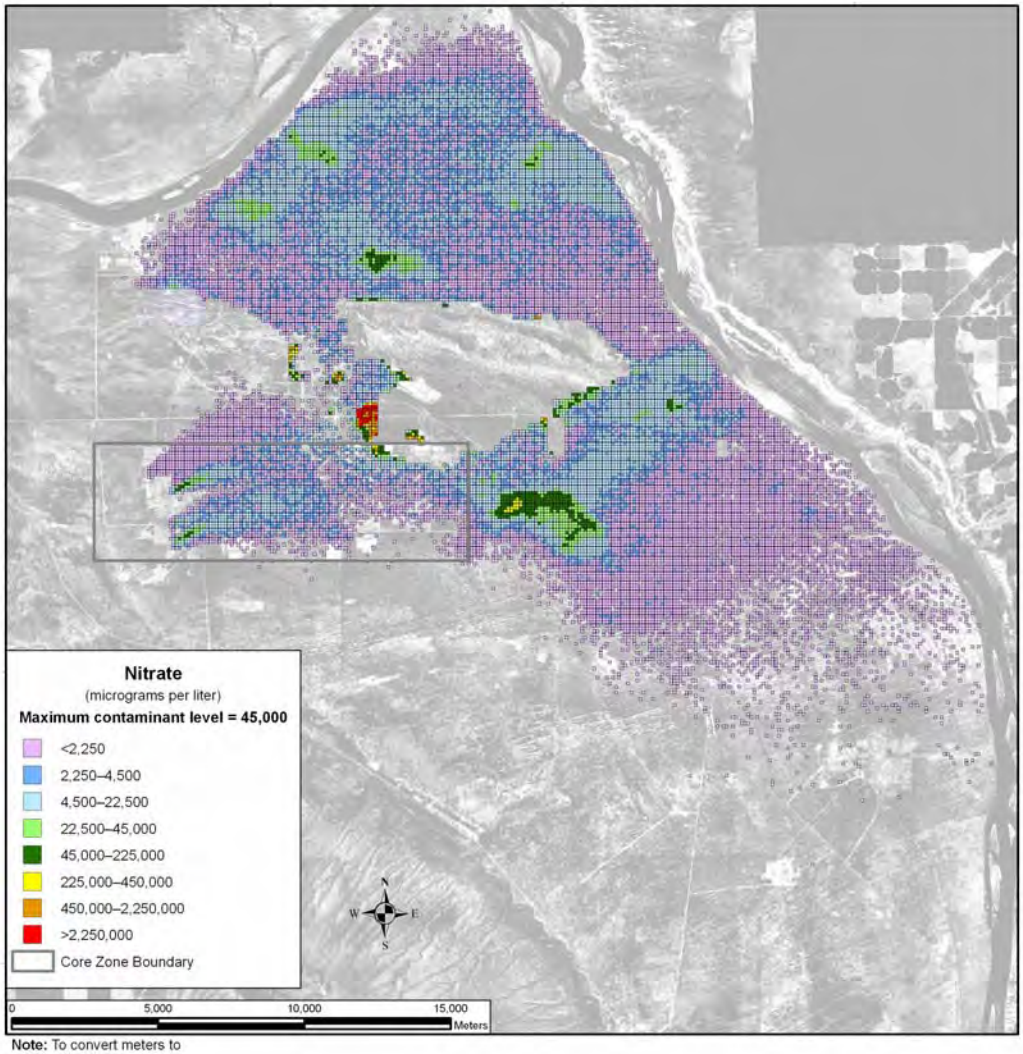


Figure 5–1211. Alternative Combination 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

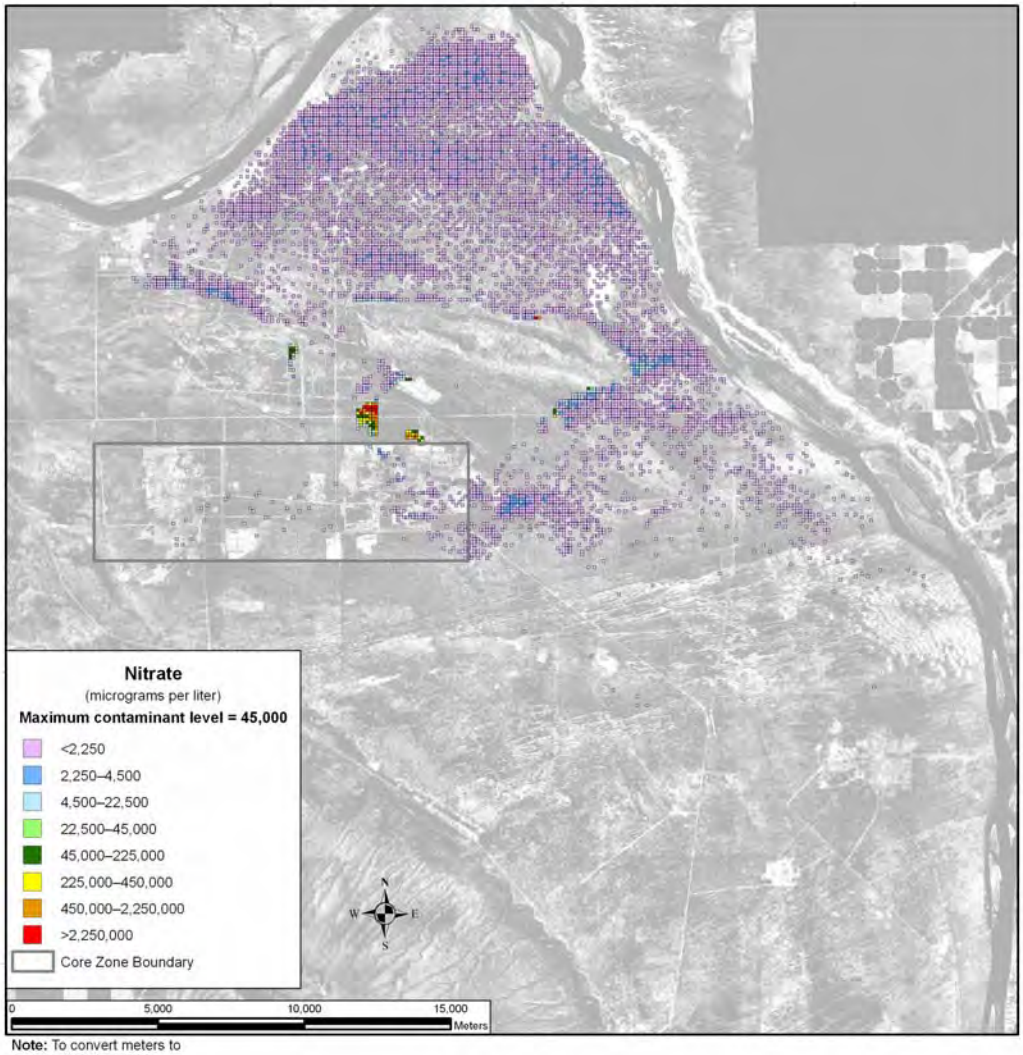


Figure 5–1212. Alternative Combination 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1213 shows the distribution of uranium-238 during CY 2135. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark and contained within the Core Zone Boundary. By CY 3890 (see Figure 5–1214), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–1215), the greatest development of the plume during the analysis period is seen, resulting primarily from releases from other tank farm sources. Figure 5–1216 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest near the end of the period of analysis. Figures 5–1217 through 5–1219 show the corresponding spatial distribution for total uranium.

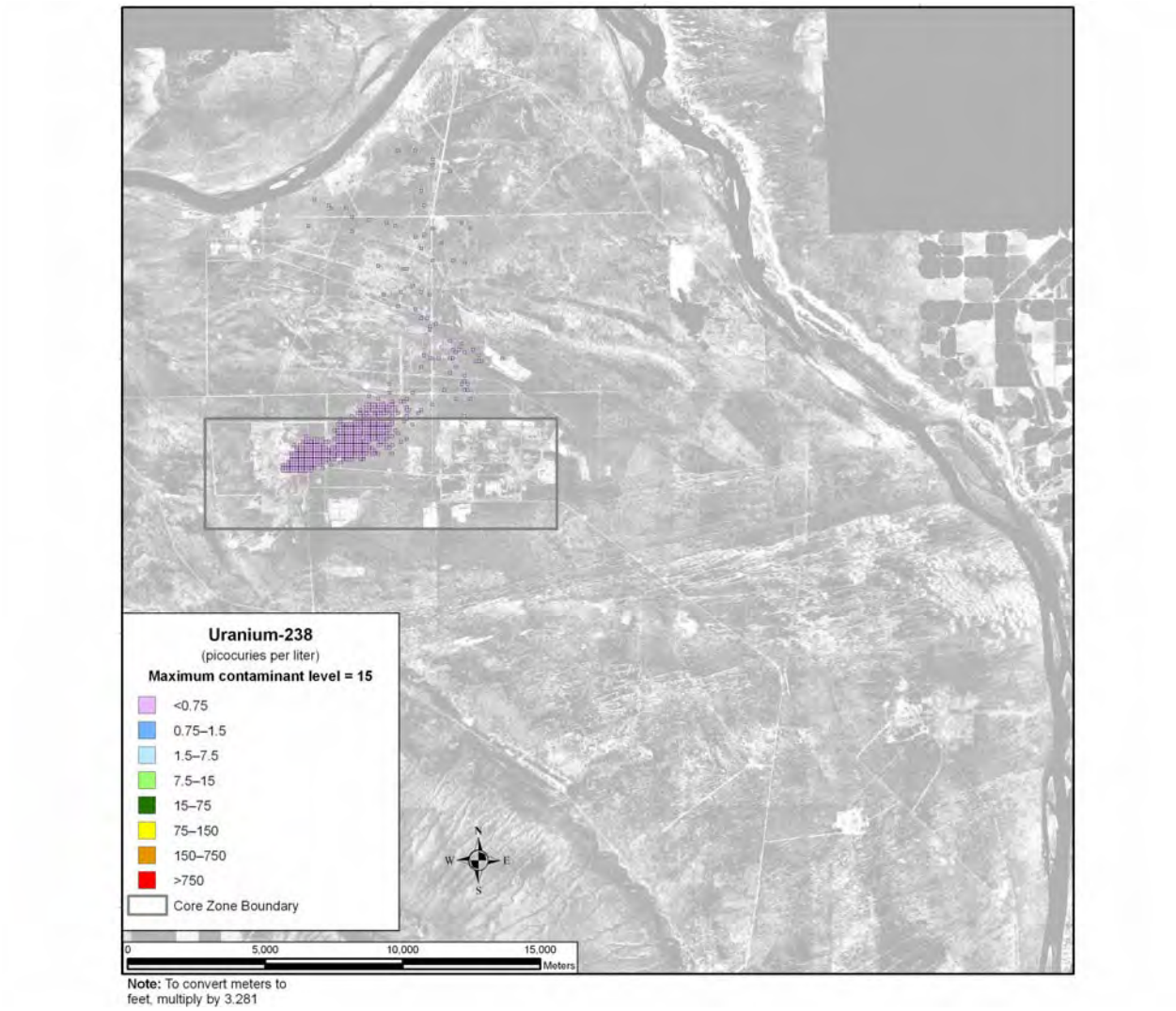


Figure 5–1213. Alternative Combination 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135

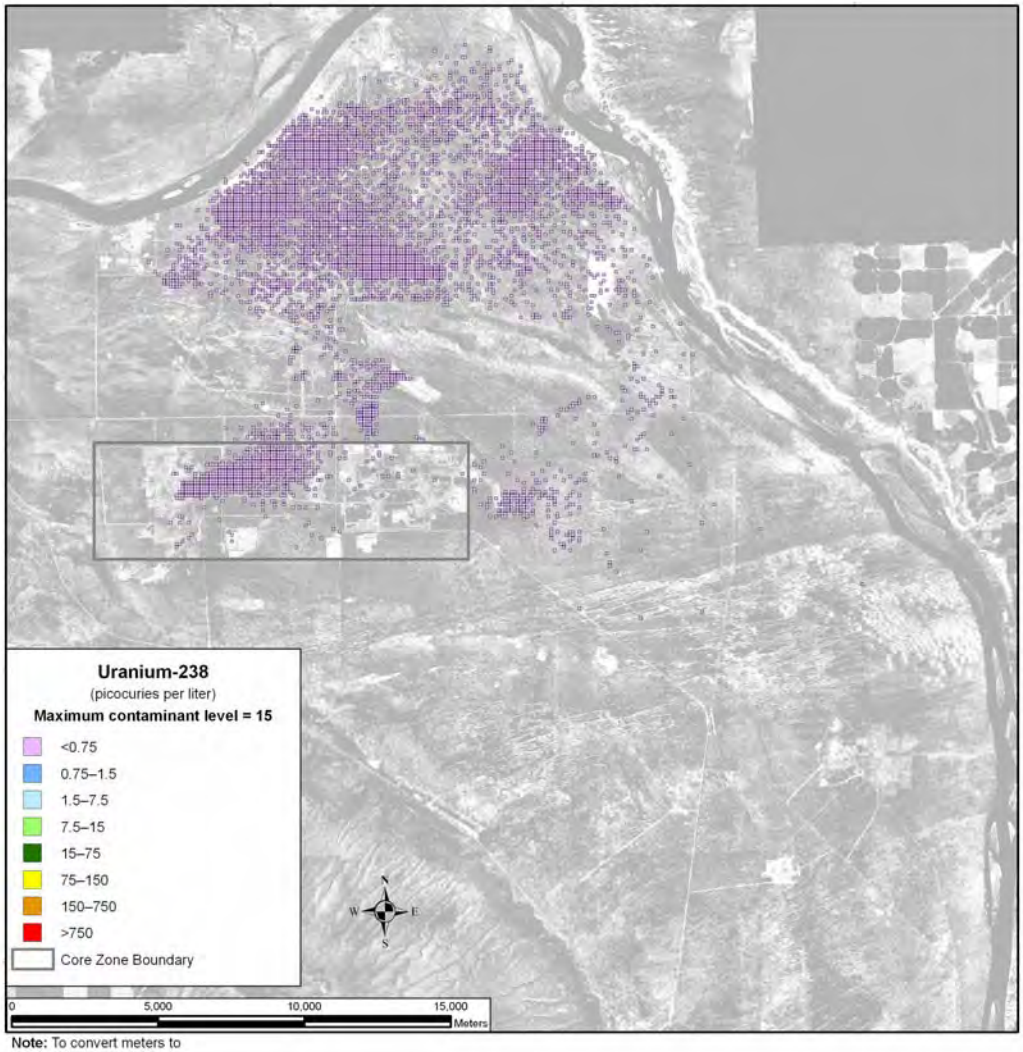


Figure 5–1214. Alternative Combination 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890

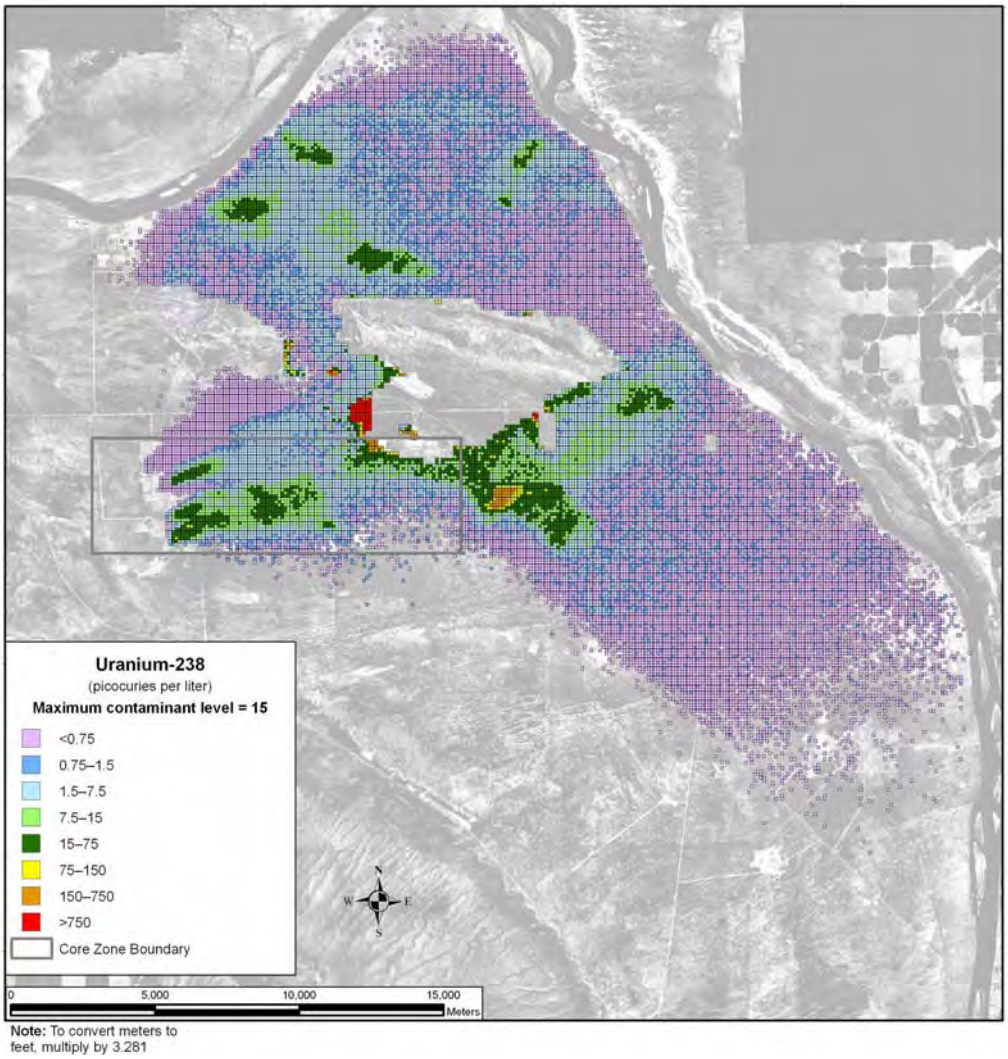


Figure 5–1215. Alternative Combination 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

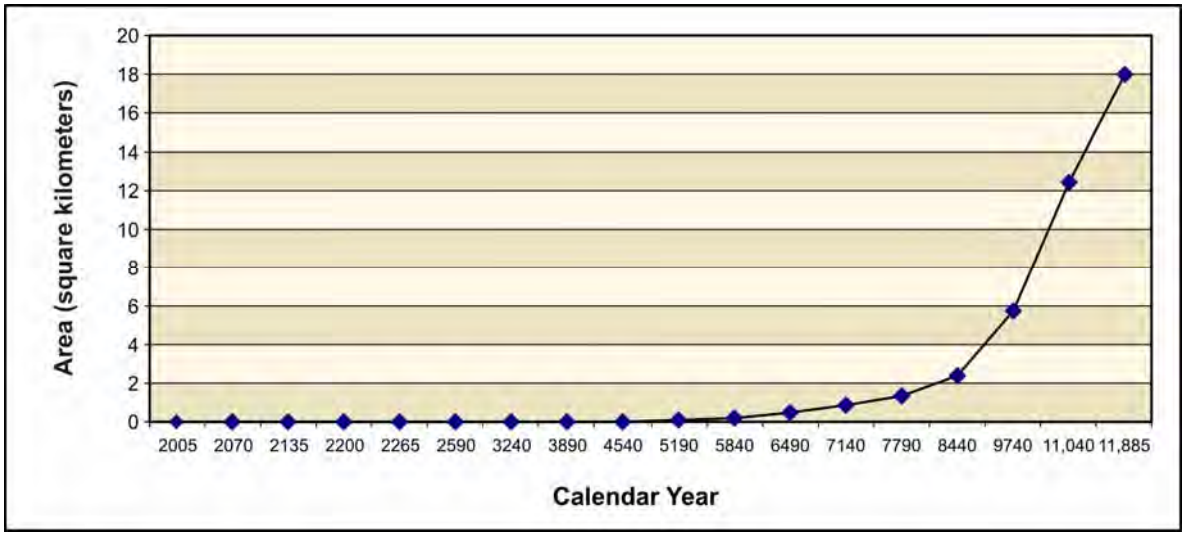


Figure 5–1216. Alternative Combination 1 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

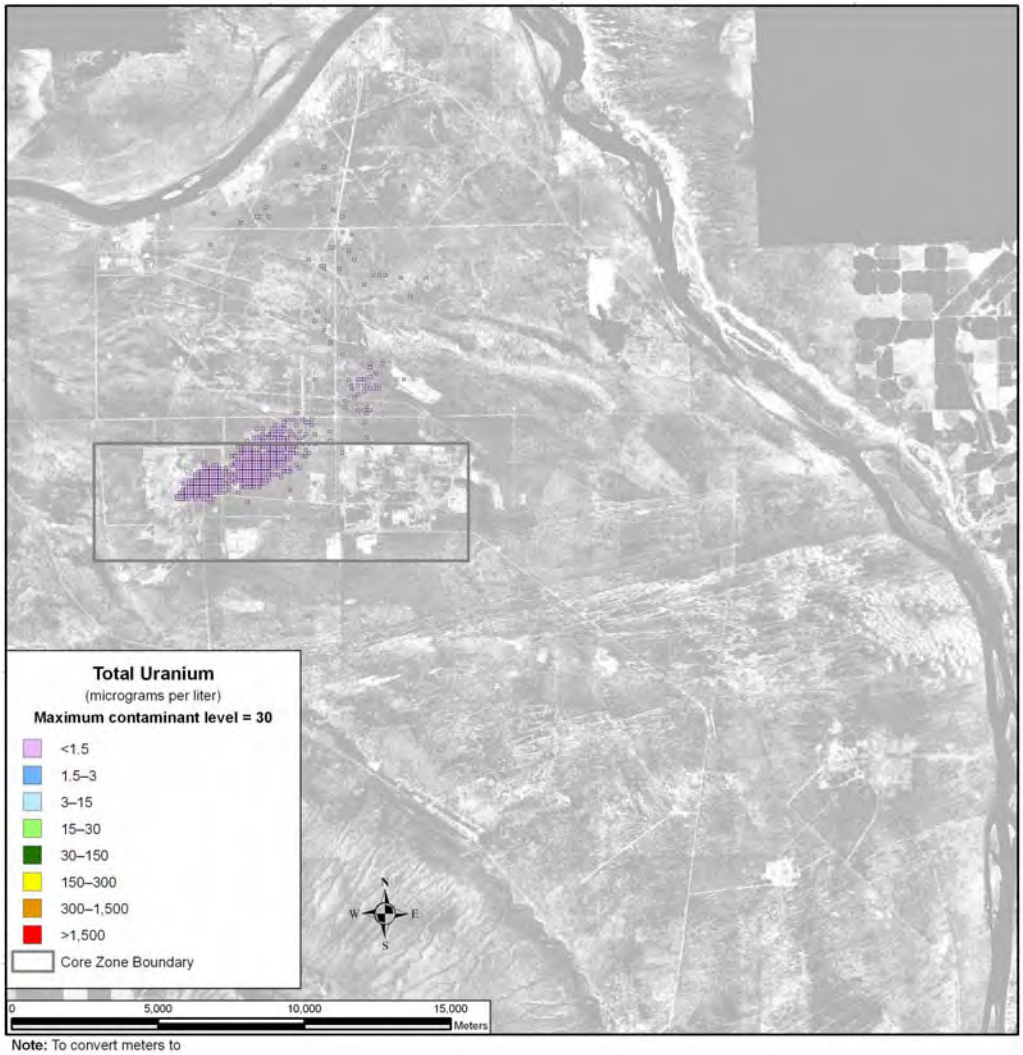
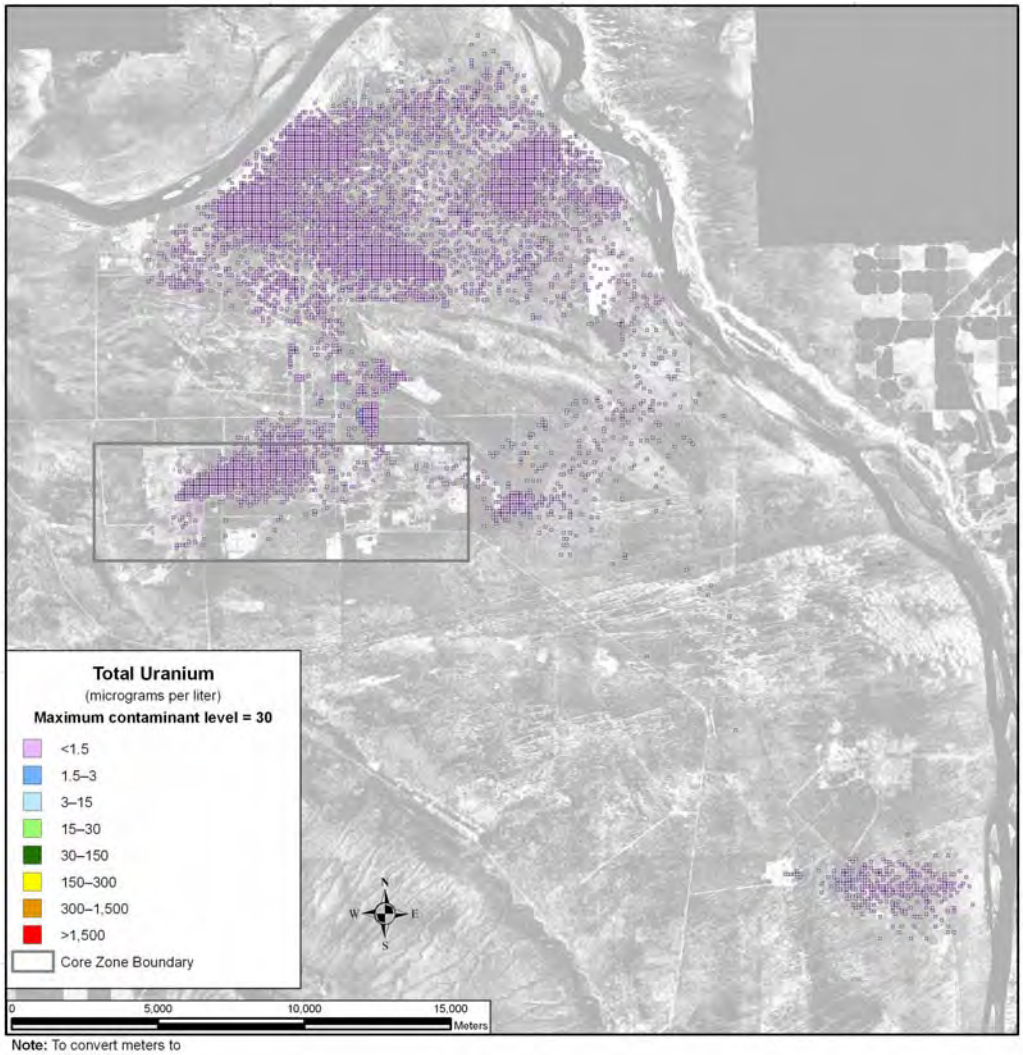


Figure 5–1217. Alternative Combination 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–1218. Alternative Combination 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890

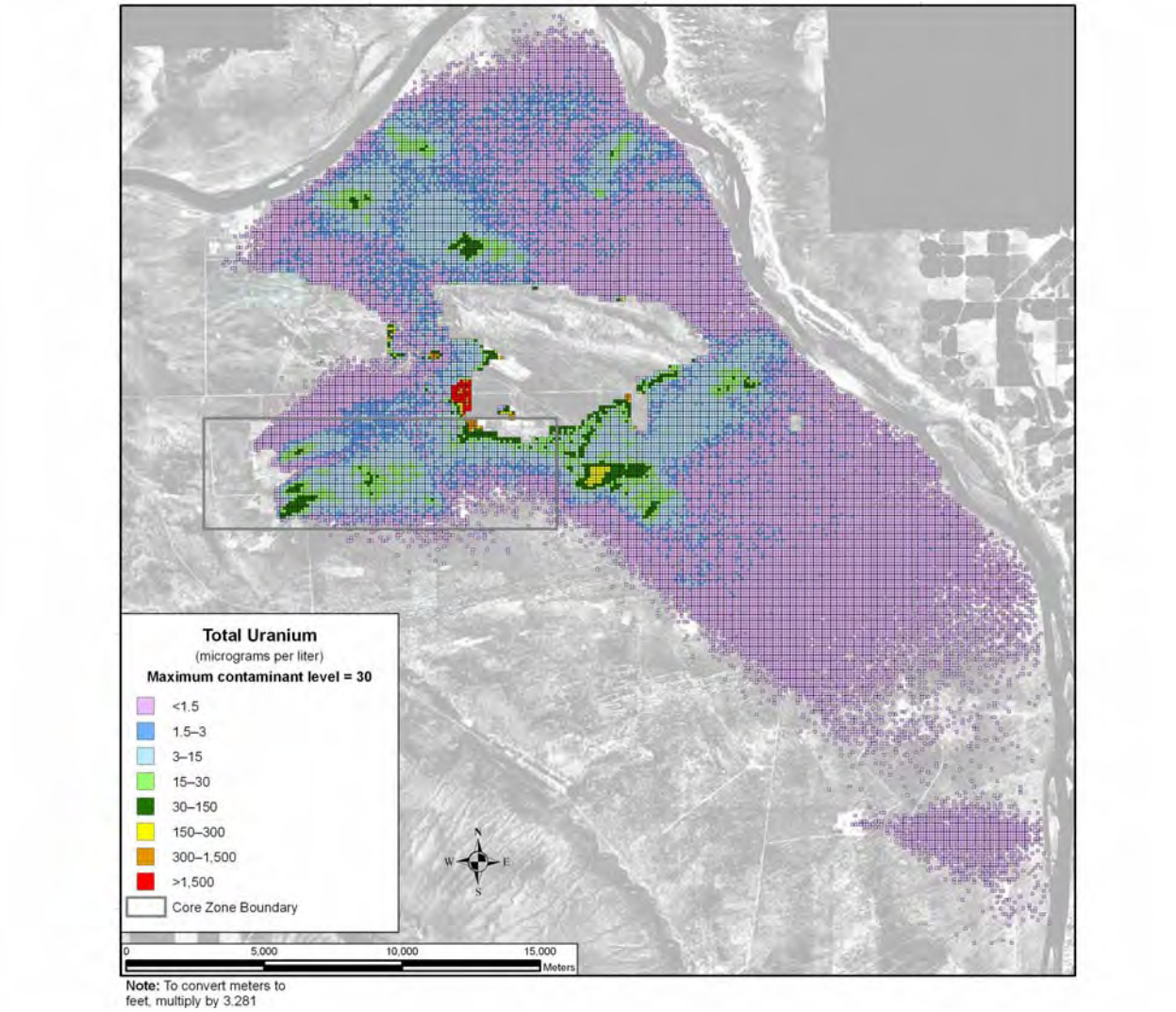


Figure 5–1219. Alternative Combination 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

The long-term impacts of Alternative Combination 1 are dominated by sources under Tank Closure Alternative 1. In particular, the inventory remaining in the tank farms is the predominant contributor. Discharges to cribs and trenches (ditches) and leaks during the past-practice period are a secondary contributor. Contributions from Waste Management Alternative 1 and FFTF Decommissioning Alternative 1 sources account for well below 1 percent of the total amount released to the environment.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by two to three orders of magnitude during most of the period of analysis. Concentrations at the Columbia River nearshore are about two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3200 and CY 4000.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism

that limits the intensity and duration of groundwater impacts by tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark at the Core Zone Boundary beyond CY 6000, and approach the benchmark at the Columbia River after CY 10,000. The intensity is highest and the area of the contamination plume largest near the end of the period of analysis.

5.4.1.2 Alternative Combination 2

This section describes the results of the long-term groundwater impacts analysis for Alternative Combination 2, which comprises Tank Closure Alternative 2B, FFTF Decommissioning Alternative 2, and Waste Management Alternative 2. The focus is the combined long-term groundwater impacts of these alternatives. More-detailed discussion of the individual impacts is provided in Sections 5.1.1, 5.2.1, and 5.3.1.

This discussion of long-term impacts is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose the alternative combination. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short lived. The half-life of tritium is 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, limited rates of release (i.e., retention in waste form), high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Alternative Combination 2 in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 5–157 lists the release to the vadose zone for the COPC drivers. For Alternative Combination 2, the release to the vadose zone is controlled by a combination of inventory and waste form. For tank closure and FFTF decommissioning sources, the entire inventory is released to the vadose zone during the period of analysis. For some waste management sources (e.g., ILAW glass), some of the inventory is not released to the vadose zone during the 10,000-year period of analysis because of retention in the waste form. The release to the vadose zone for Alternative Combination 2 is dominated by sources associated with Tank Closure Alternative 2B for tritium, uranium-238, chromium, nitrate, and total uranium. For these COPC drivers, releases from FFTF decommissioning and waste management sources account for less than 25 percent of the total. For iodine-129 and technetium-99, release to the vadose zone is dominated by waste management sources, in particular by offsite waste disposed of in IDF-East. Offsite waste accounts for over 93 percent of the total release to the vadose zone for iodine-129 and over 83 percent of the total release to the vadose zone for technetium-99.

Table 5–157. Alternative Combination 2 Release to Vadose Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 2B Base	4.60×10^{4}	1.51	8.67×10^{2}	4.54×10^{1}	1.00×10^{5}	2.70×10^{7}	4.13×10^{4}
FFTF Decommissioning Alternative 2	1.73×10^{-5}	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 1, Subgroup 1-A	6.27×10^{4}	1.80×10^{1}	2.39×10^{3}	3.17×10^{2}	2.97×10^{3}	9.05×10^{6}	2.65×10^{3}
Total	1.09×10^{5}	1.95×10^{1}	3.28×10^{3}	3.63×10^{2}	1.03×10^{5}	3.61×10^{7}	4.40×10^{4}

Key: COPC=constituent of potential concern.

Table 5–158 lists the release to groundwater for the COPC drivers. In addition to the inventory and waste form considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Note that delayed release to the vadose zone (i.e., retention in the waste form) can enhance retention in the vadose zone because contaminant mass released into the vadose zone near the end of the 10,000-year period of analysis may not reach the water table. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater ranges from 100 percent down to 80 percent of the amount released to the vadose zone. For tritium, the amount released to groundwater is attenuated by radioactive decay during transit through the vadose zone. About 70 percent of the tritium released to the vadose zone reaches the unconfined aquifer. For uranium-238 and total uranium, the amount released to groundwater is lower than that of the release to the vadose zone because of retardation. Less than 7 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 5–158. Alternative Combination 2 Release to Groundwater Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 2B Base	3.23×10^{4}	1.51	8.61×10^{2}	2.91	1.04×10^{5}	2.80×10^{7}	2.96×10^{3}
FFTF Decommissioning Alternative 2	2.58×10^{-8}	0.00	2.62×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 1 Subgroup 1-A	0.00	1.64×10^{1}	2.10×10^{3}	3.02×10^{-10}	2.89×10^{3}	9.03×10^{6}	5.14×10^{-5}
Total	3.23×10^{4}	1.79×10^{1}	2.99×10^{3}	2.91	1.06×10^{5}	3.70×10^{7}	2.96×10^{3}

Key: COPC=constituent of potential concern.

Table 5–159 lists the release to the Columbia River for the radiological risk drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reaches the Columbia River. For uranium-238 and total uranium, the amount released to the Columbia River is less than that released to groundwater because of retardation in the aquifer. Overall, about 30 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

Table 5–159. Alternative Combination 2 Release to Columbia River for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 2B Base	8.70×10^{2}	1.45	8.37×10^{2}	8.46×10^{-1}	1.03×10^{5}	2.78×10^{7}	8.54×10^{2}
FFTF Decommissioning Alternative 2	0.00	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 1 Subgroup 1-A	0.00	1.59×10^{1}	2.04×10^{3}	0.00	2.80×10^{3}	8.89×10^{6}	3.77×10^{-6}
Total	8.70×10^{2}	1.74×10^{1}	2.90×10^{3}	8.46×10^{-1}	1.06×10^{5}	3.67×10^{7}	8.54×10^{2}

Key: COPC=constituent of potential concern.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Alternative Combination 2 in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid to interpreting data with a significant amount random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–160 lists the maximum concentrations for the COPCs at the peak year at the Core Zone Boundary and the Columbia River nearshore.

Table 5–160. Alternative Combination 2 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary and Columbia River Nearshore

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter			
Hydrogen-3 (Tritium)	**2,820,000**	1,280	20,000
	(1956)	(1994)	
Technetium-99	**144,000**	699	900
	(1956)	(9454)	
Iodine-129	**187**	**7**	1
	(1956)	(8700)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	**73**	1	15
	(11,691)	(11,871)	
Chemical in micrograms per liter			
Acetonitrile	1	0	100
	(3829)	(4021)	
Chromium	**28,000**	34	100
	(1956)	(2695)	
Fluoride	1	0	4,000
	(7258)	(8913)	
Nitrate	**12,900,000**	8,580	45,000
	(1956)	(2450)	
Total uranium	**103**	1	30
	(11,683)	(11,146)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern.

Figure 5–1220 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from CY 1940 through CY 2540 rather than for the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River peak at about an order of magnitude lower than the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

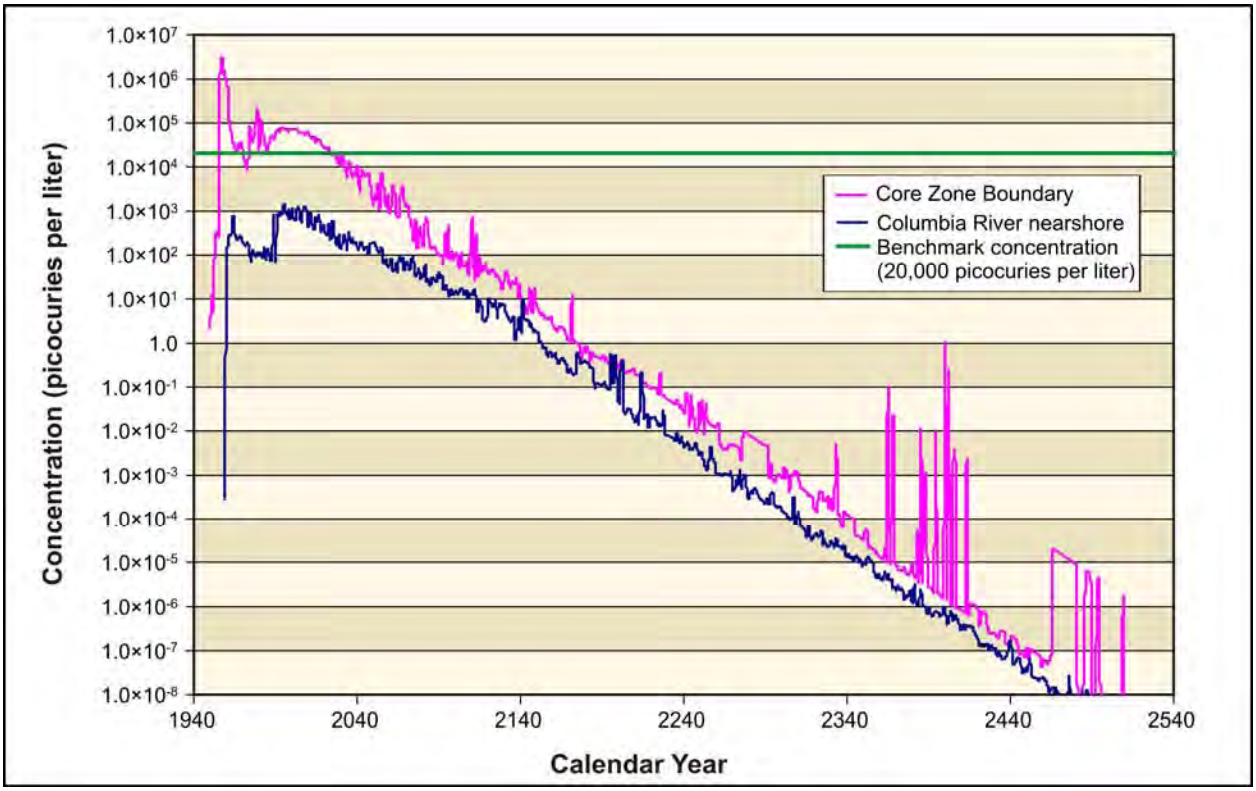


Figure 5–1220. Alternative Combination 2 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–1221 and 5–1222 show concentration versus time for chromium and nitrate, the conservative tracers that are not affected by retention in the waste forms. Groundwater concentrations of chromium exceed benchmark concentrations by an order of magnitude during the first several thousand years of the analysis. During this time, groundwater concentrations at the Columbia River nearshore are below, but within an order of magnitude of, the benchmark concentration. During later times in the analysis, the concentrations at the Core Zone Boundary and the Columbia River nearshore are below the benchmark by about one and two orders of magnitude, respectively. Nitrate shows a similar concentration pattern with respect to time. For iodine-129 and technetium-99, the behavior during the first 4,000 years is similar to that of chromium and nitrate (see Figures 5–1223 and 5–1224). After CY 6000, the effects of delayed release from waste management sources are seen. For iodine-129, the post–CY 6000 concentrations at the Core Zone Boundary and the Columbia River nearshore are above, but within an order of magnitude of, the benchmark concentration. For technetium-99 the corresponding concentrations are below, but within an order of magnitude of, the benchmark concentration.

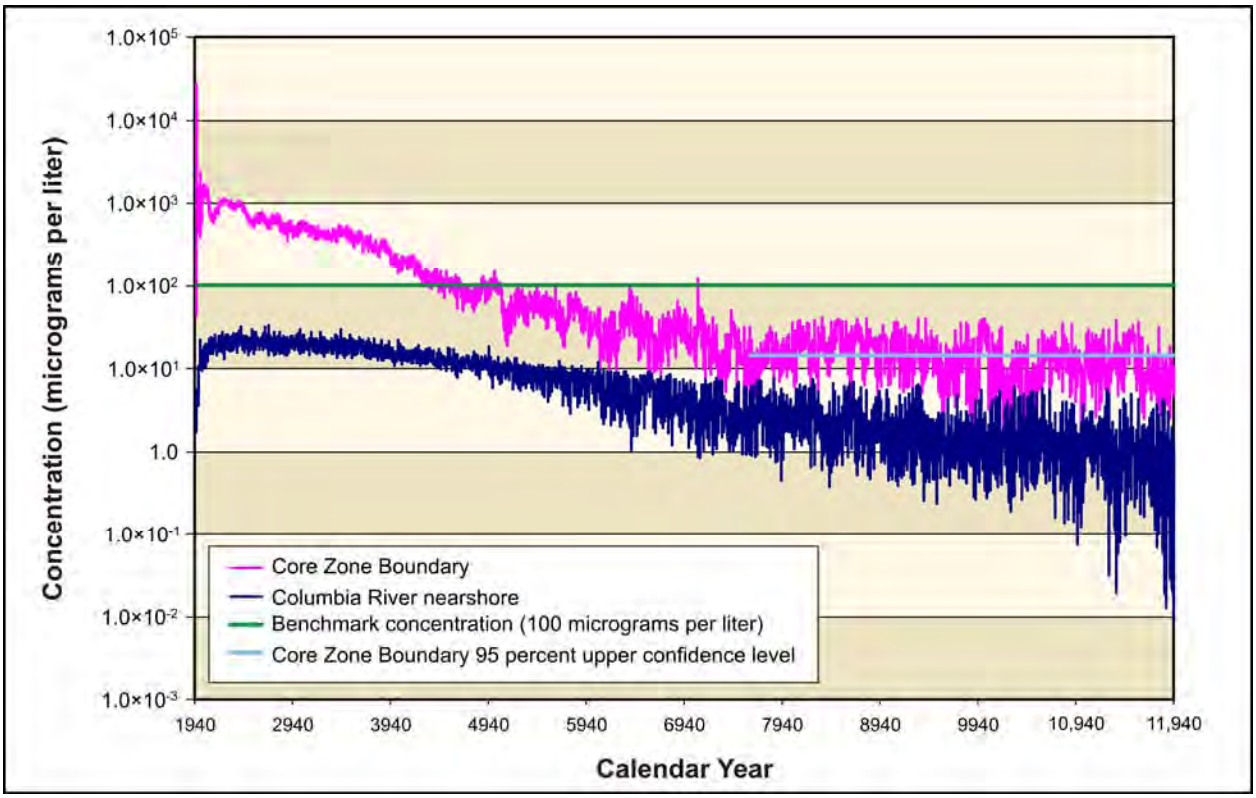


Figure 5–1221. Alternative Combination 2 Chromium Concentration Versus Time

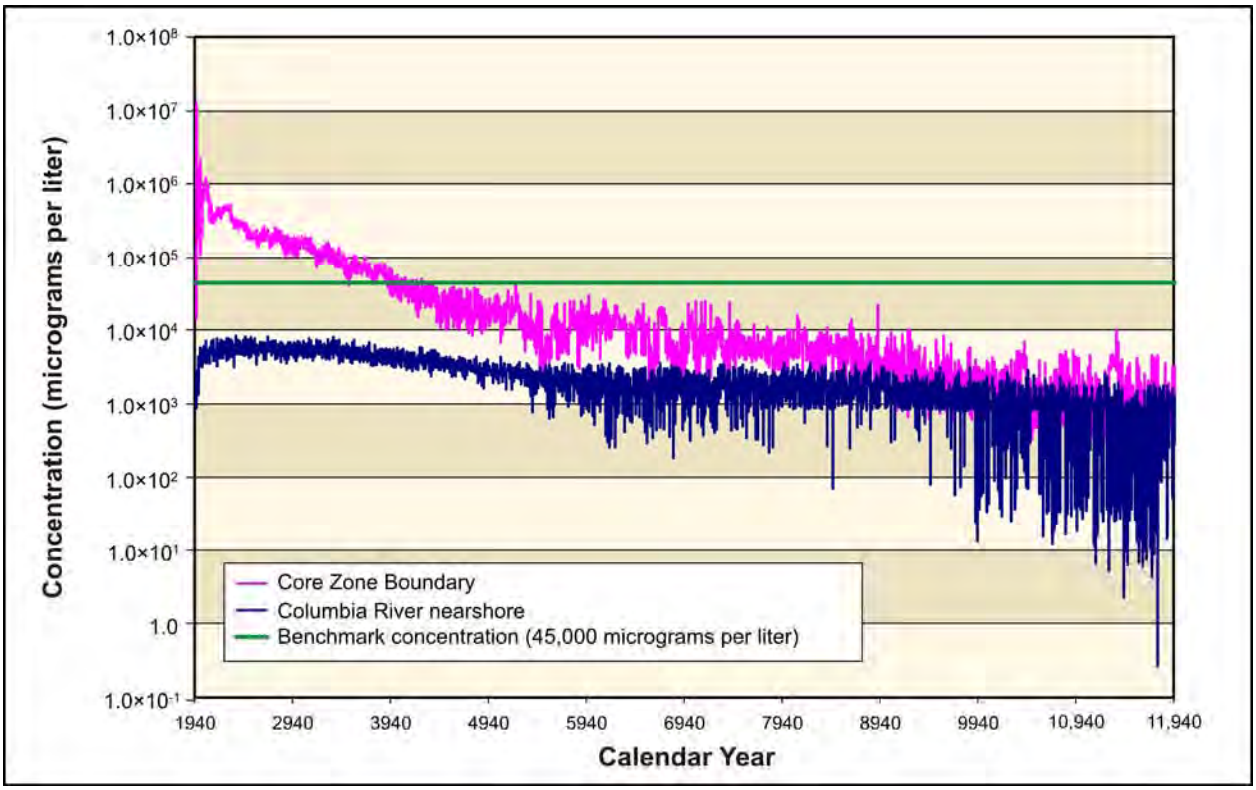


Figure 5–1222. Alternative Combination 2 Nitrate Concentration Versus Time

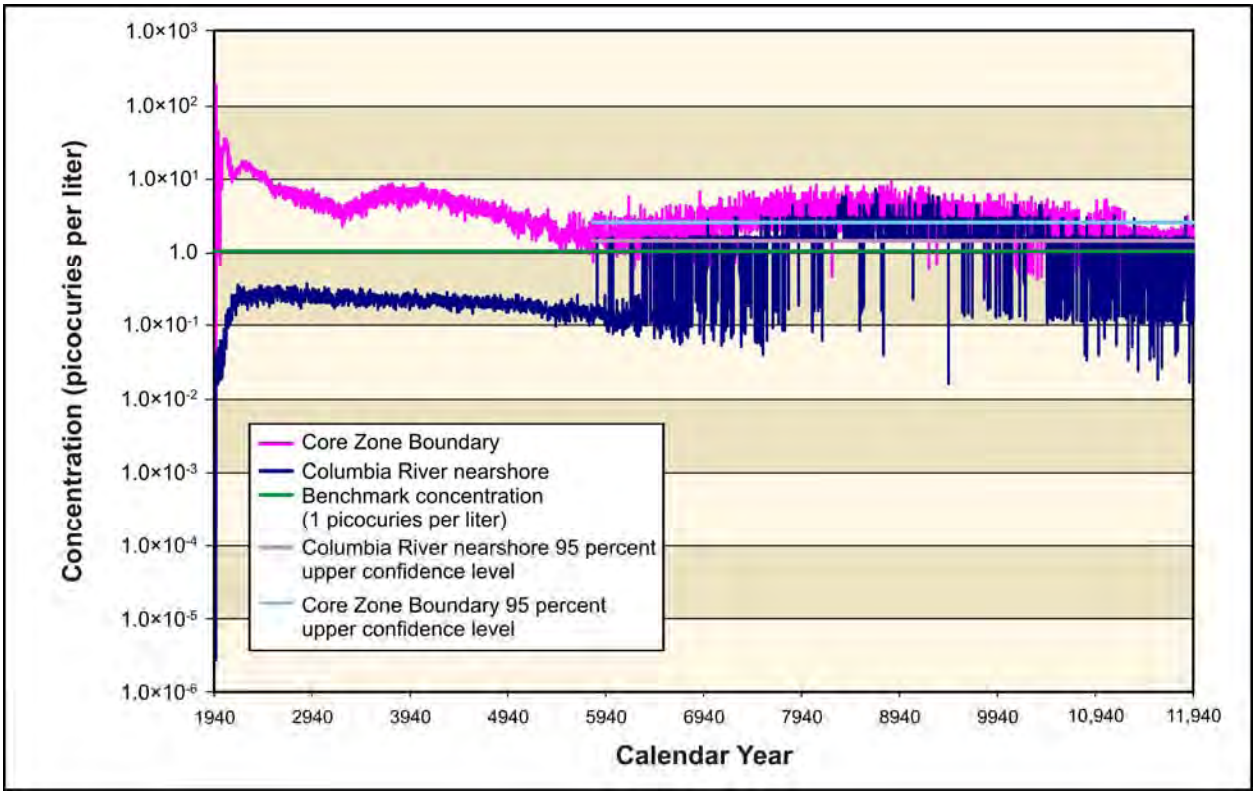


Figure 5–1223. Alternative Combination 2 Iodine-129 Concentration Versus Time

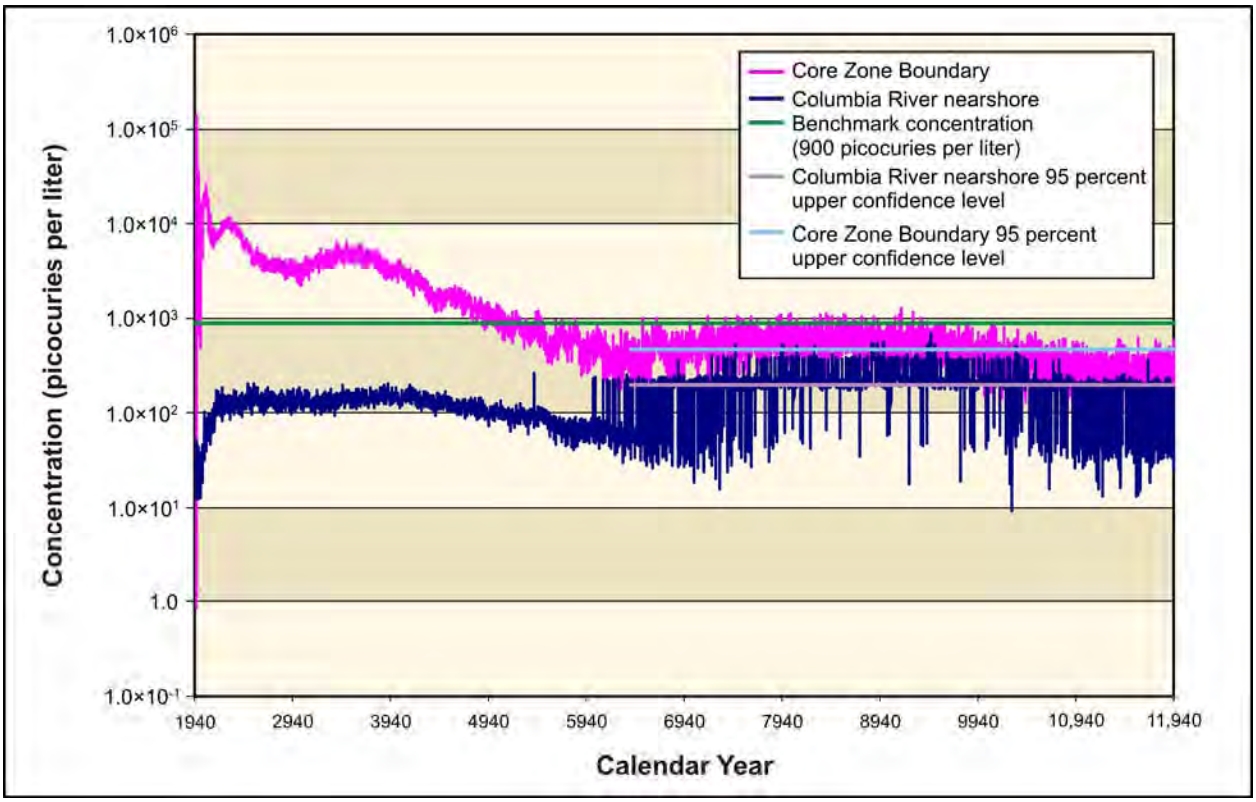


Figure 5–1224. Alternative Combination 2 Technetium-99 Concentration Versus Time

Figures 5–1225 and 5–1226 show concentration versus time for uranium-238 and total uranium. These concentrations rise throughout the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and the Columbia River are retarded relative to the conservative tracers by a factor of about seven. After about 8,000 years, concentrations of both uranium-238 and total uranium are near the benchmark concentration at the Core Zone Boundary, and continue to rise until the end of the period of analysis, when they exceed the benchmark concentration by a factor of about three to five. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, but remain more than an order of magnitude below the benchmark concentration by CY 11,940.

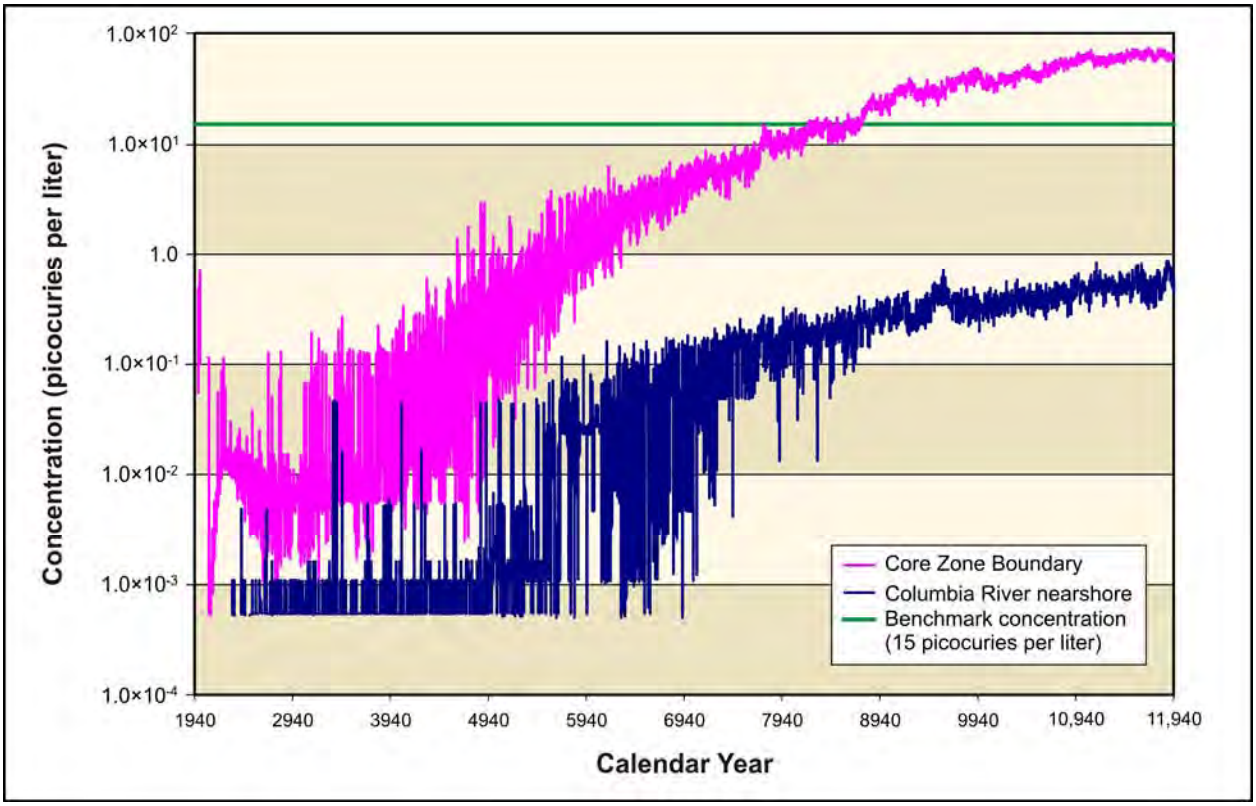


Figure 5–1225. Alternative Combination 2 Uranium-238 Concentration Versus Time

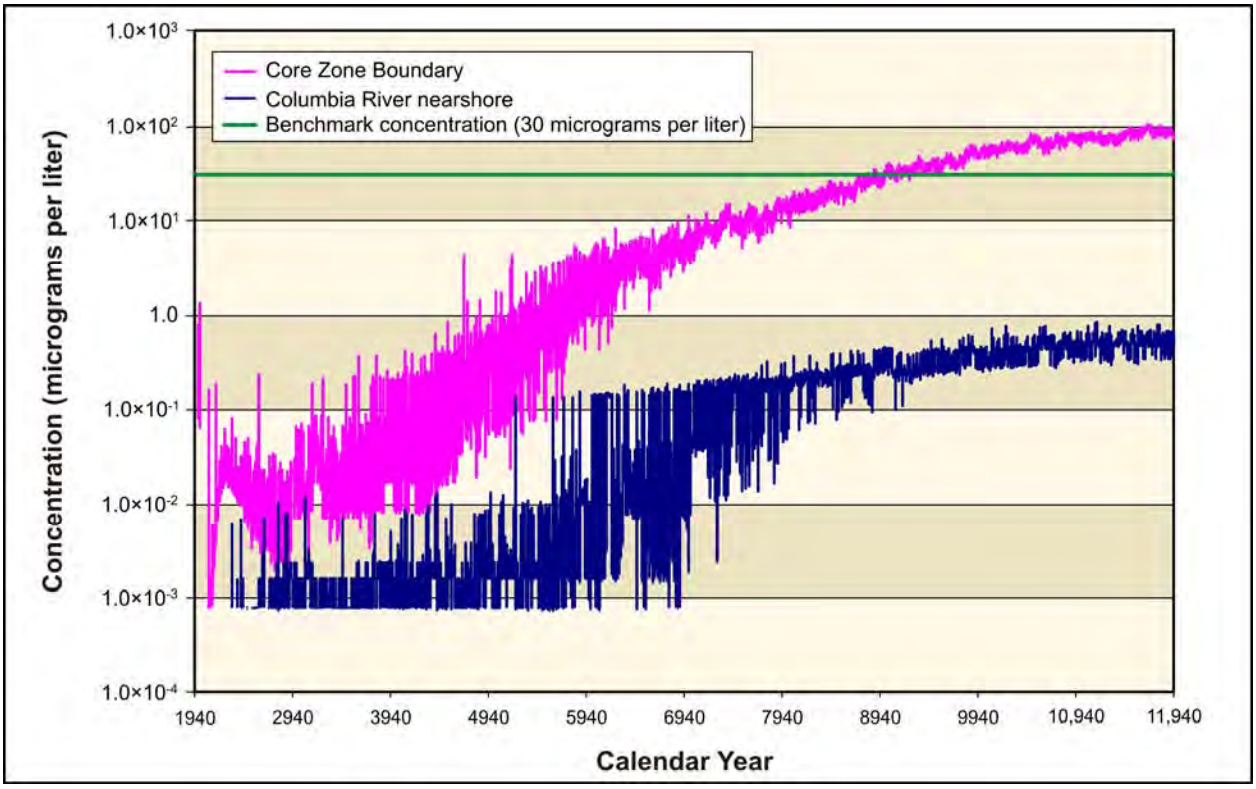


Figure 5–1226. Alternative Combination 2 Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Alternative Combination 2, in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1227 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135.

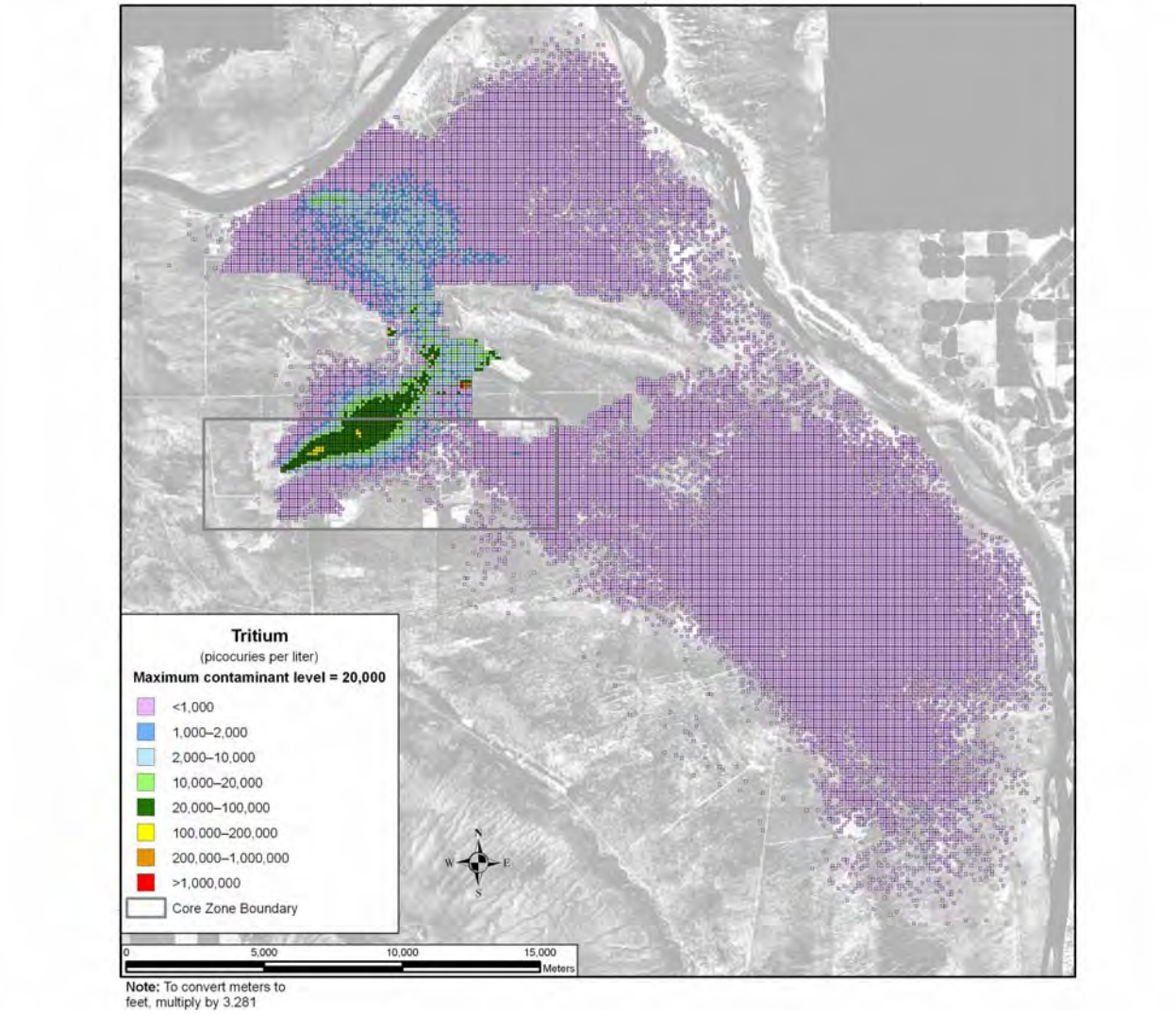


Figure 5–1227. Alternative Combination 2 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

Figure 5–1228 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Around CY 3890, releases from other tank farm sources create a rather small plume that exceeds, but is within an order of magnitude of, the benchmark concentration just east of the Core Zone Boundary (see Figure 5–1229). A comparison of this result against the corresponding distribution for Alternative Combination 1 (see Figure 5–1200) illustrates the reduction in impacts resulting from the retrieval of other tank farm sources and, secondarily, from landfill closure. By CY 7140, the groundwater concentration distribution is driven primarily by waste management sources at IDF-East (see Figure 5–1230). The impact is characterized by a plume east of the Core Zone Boundary that exceeds the benchmark concentration by more than an order of magnitude. Because of retention in the waste forms, this impact lasts until the end of the 10,000-year period of analysis (see Figure 5–1231). Figure 5–1232 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. Again, a comparison of this result with the corresponding distribution for Alternative Combination 1 (see Figure 5–1202) illustrates the reduction of impacts resulting from retrieval of other tank farm sources (around CY 4000), but also

the increase in impacts associated with waste management sources, primarily offsite waste (around CY 9000). Figures 5–1233 through 5–1237 show the spatial distribution at the same four times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 is similar to that of iodine-129. The other conservative tracers, chromium (see Figures 5–1238 through 5–1241) and nitrate (see Figures 5–1242 through 5–1244) show similar spatial distributions.

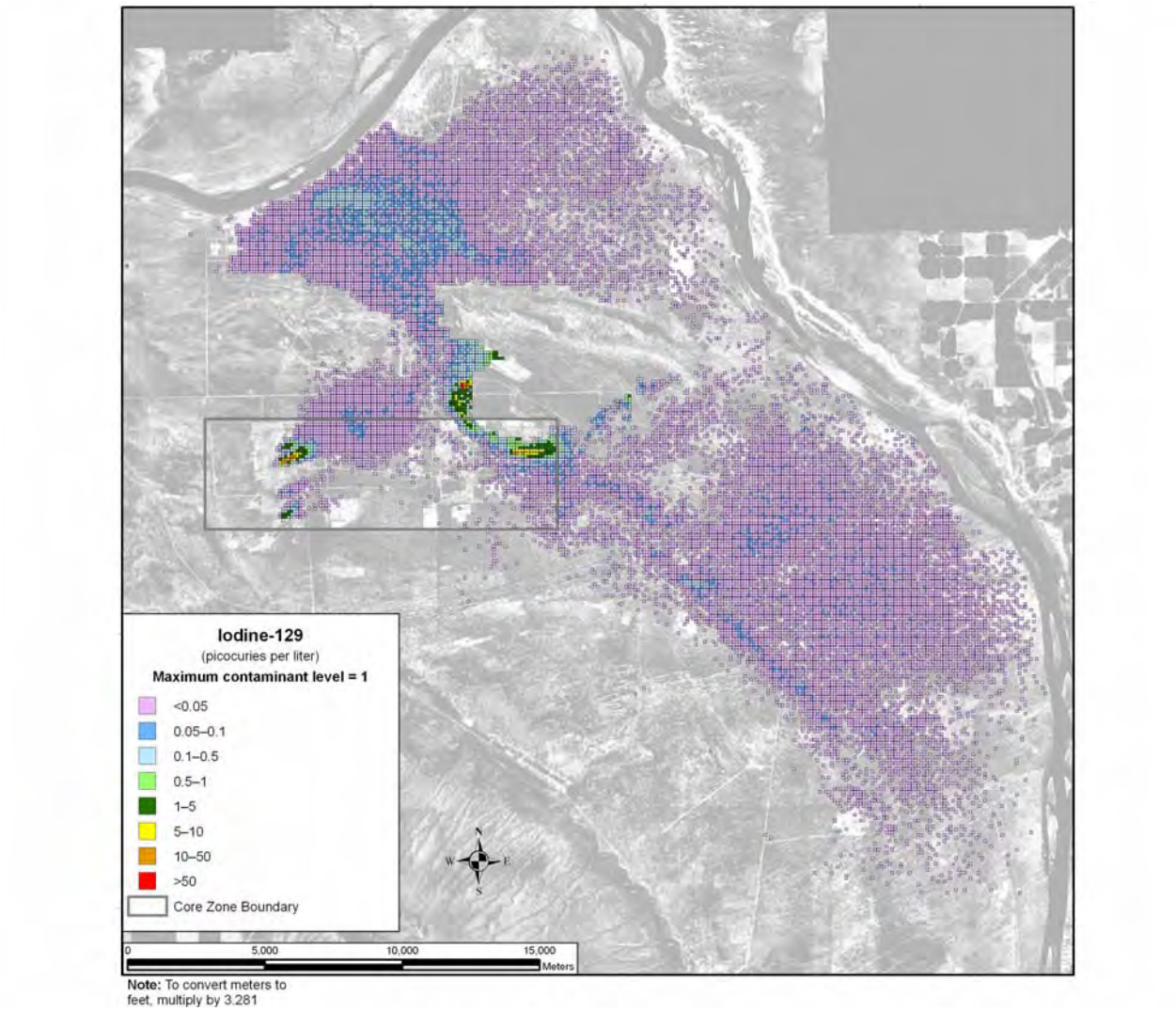


Figure 5–1228. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005

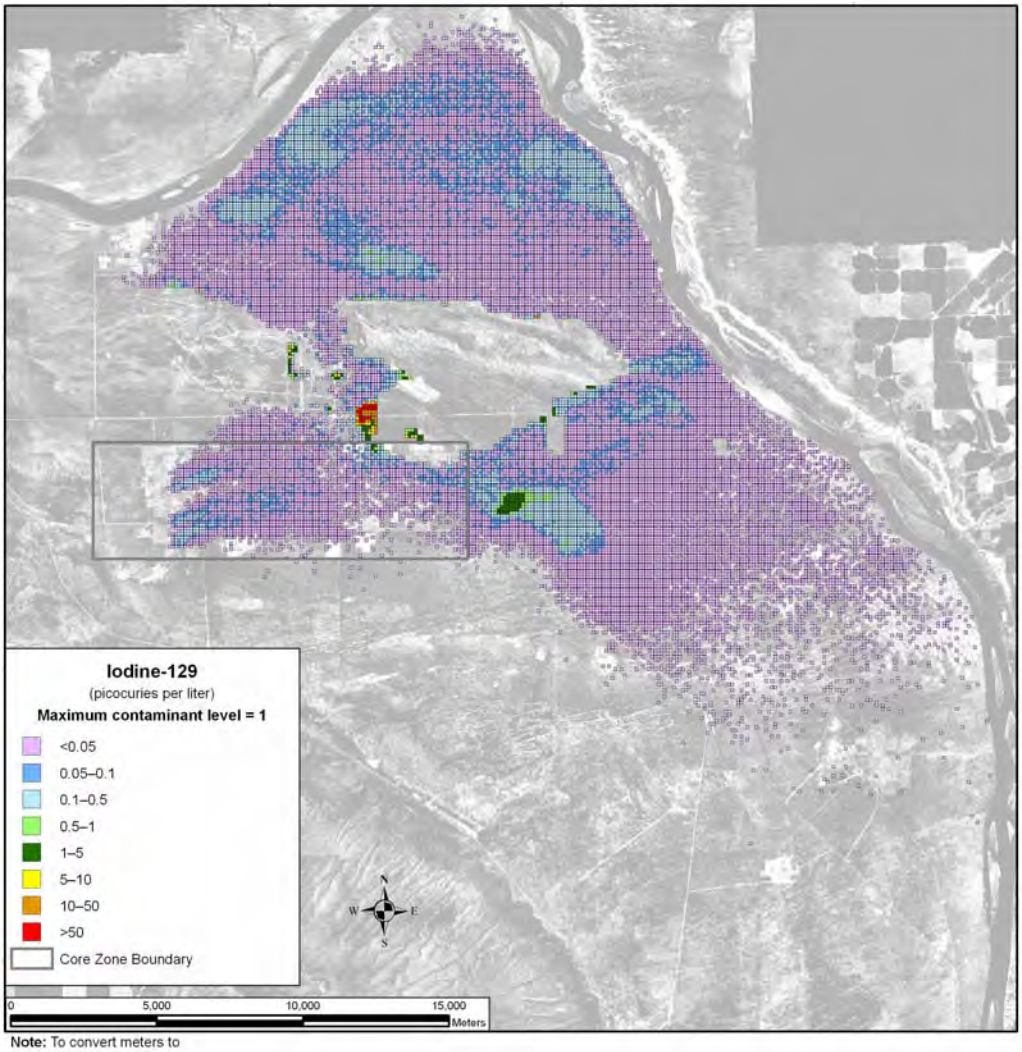


Figure 5–1229. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

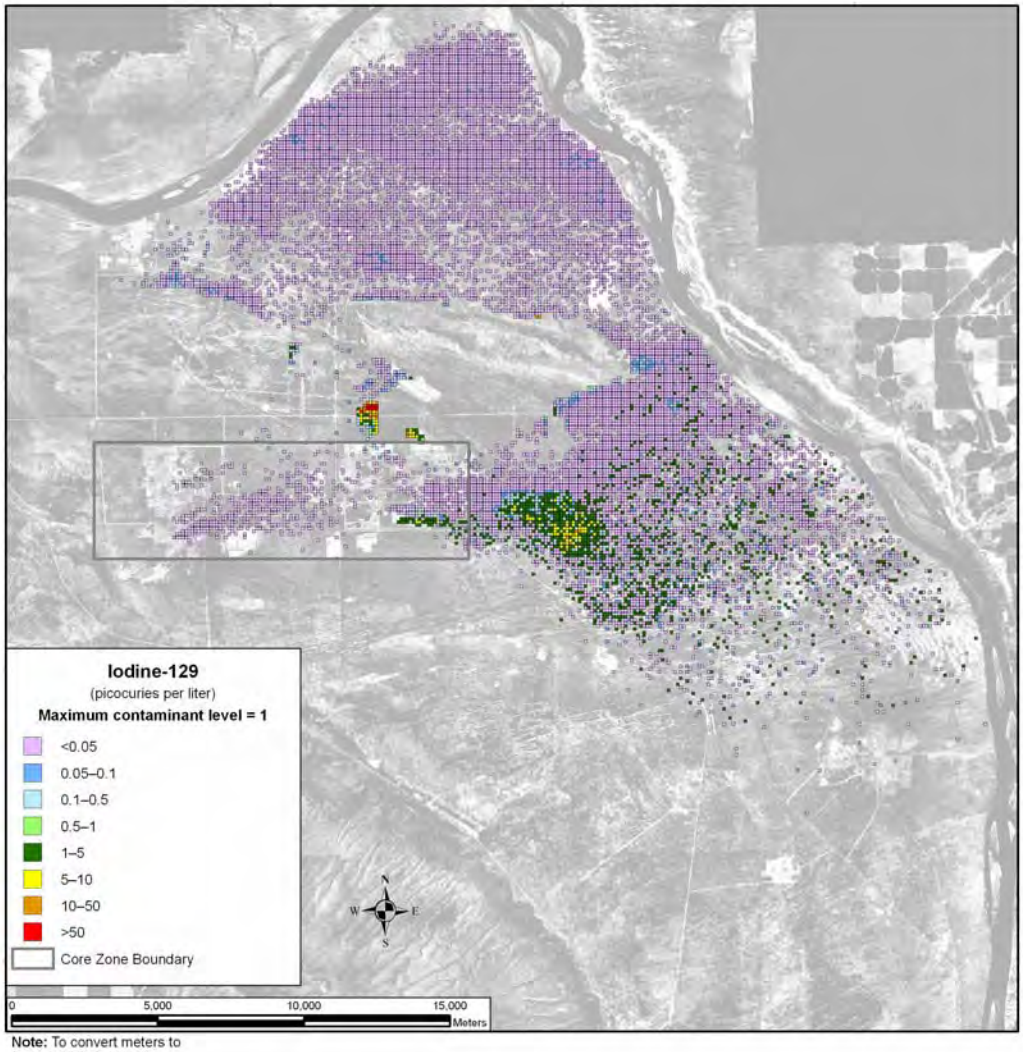


Figure 5–1230. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

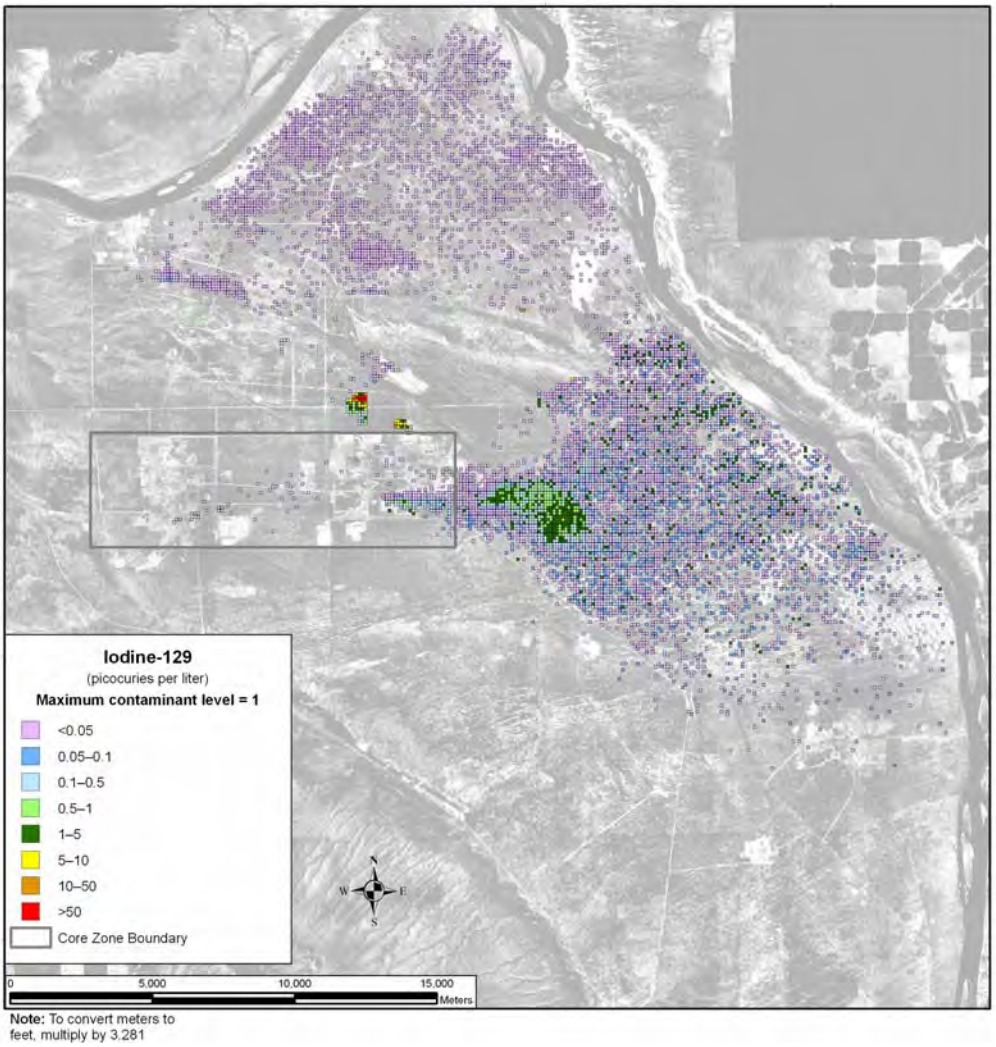


Figure 5–1231. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

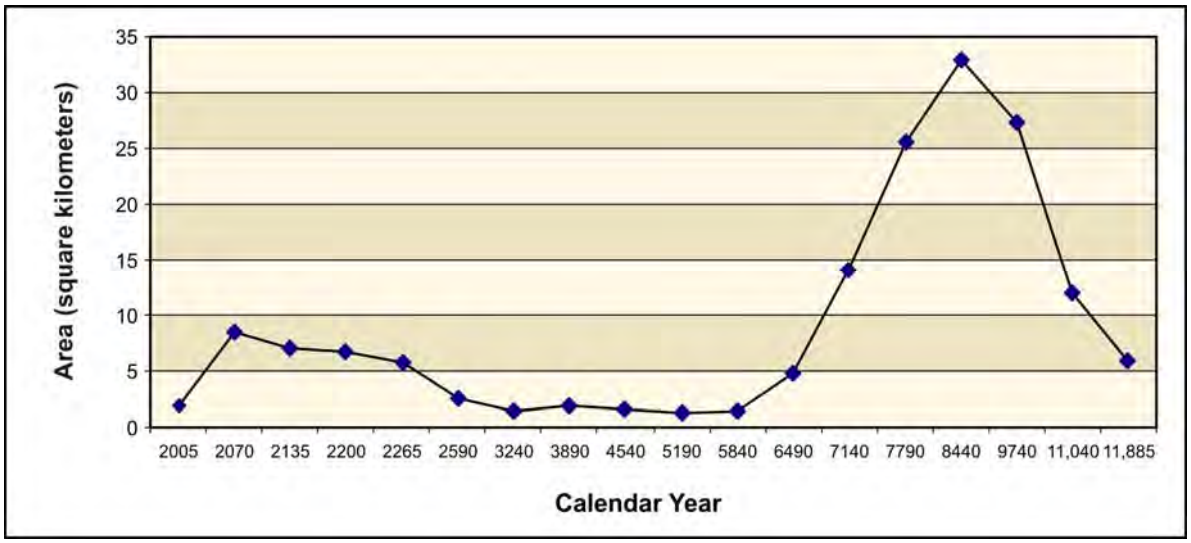


Figure 5–1232. Alternative Combination 2 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

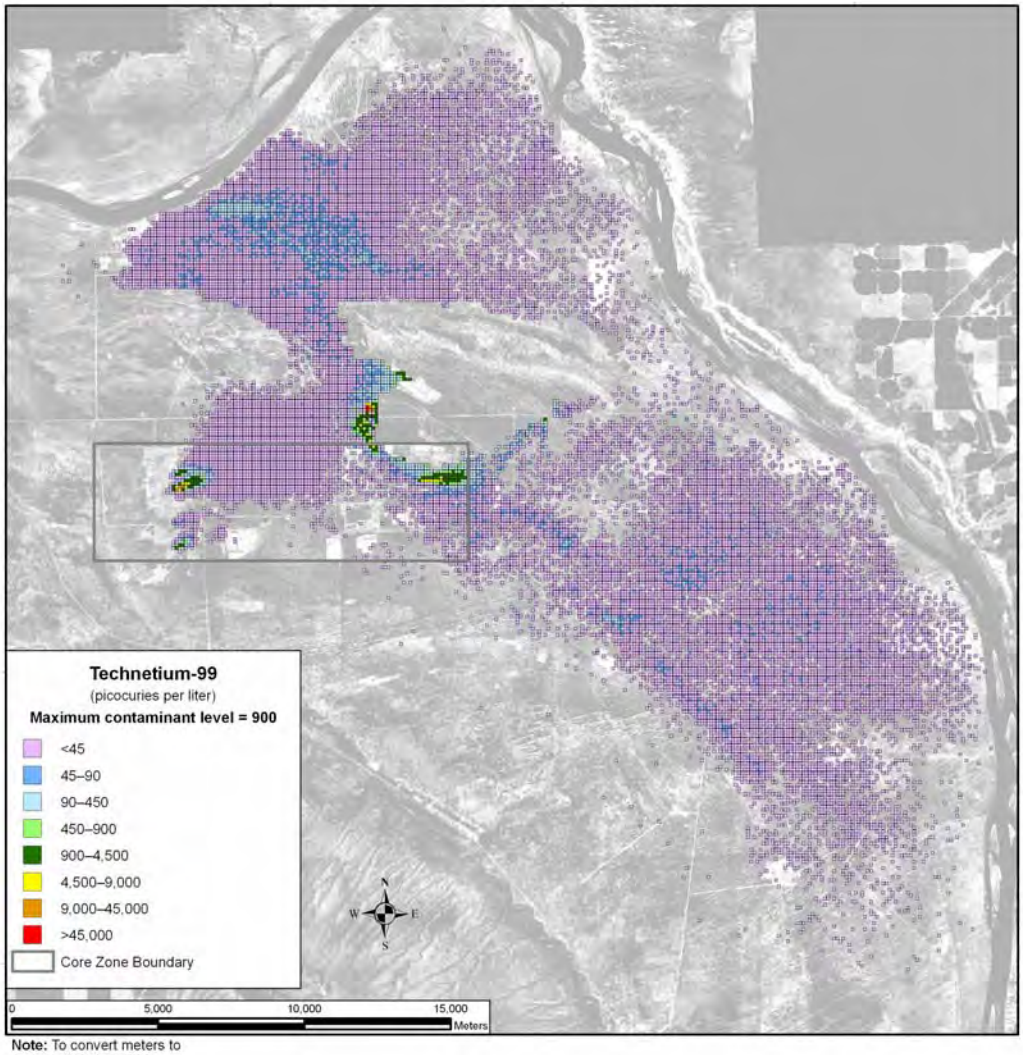


Figure 5–1233. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

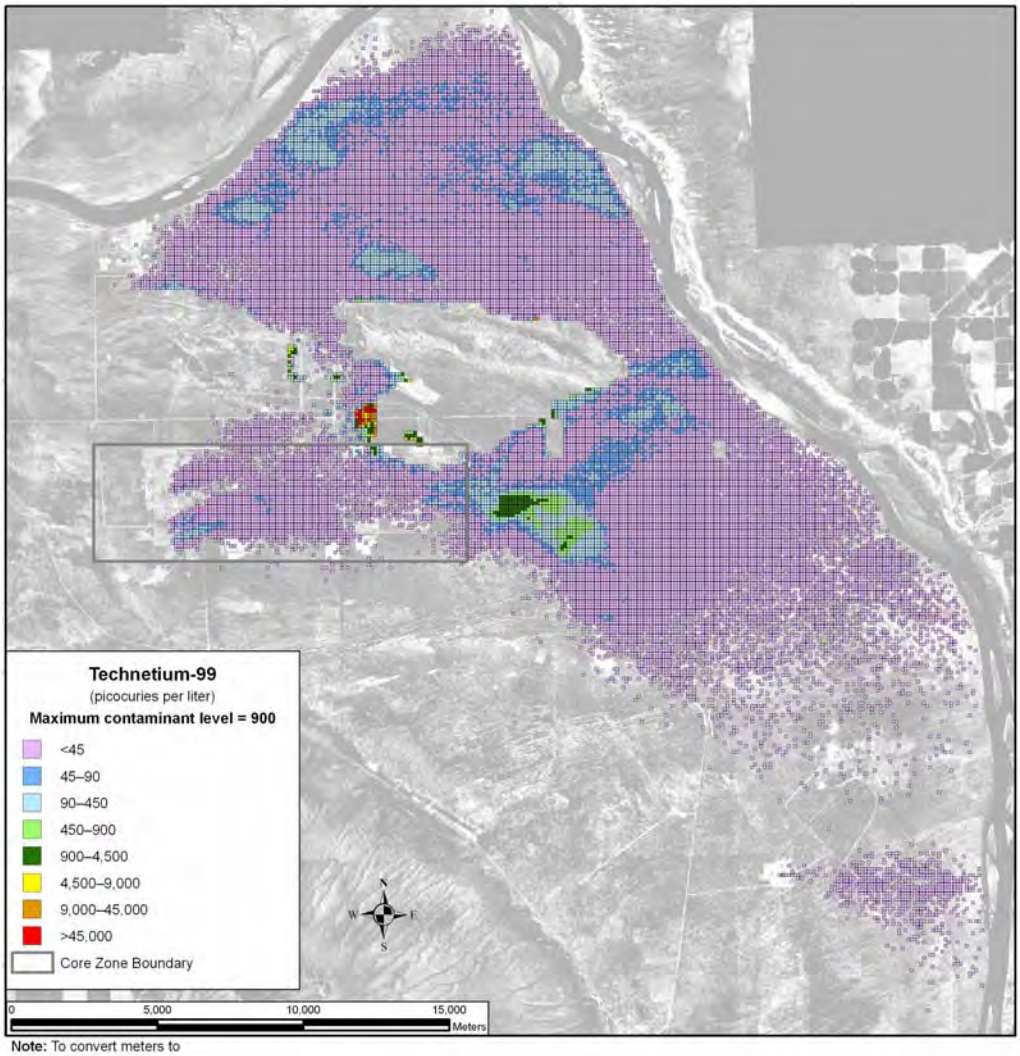


Figure 5–1234. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

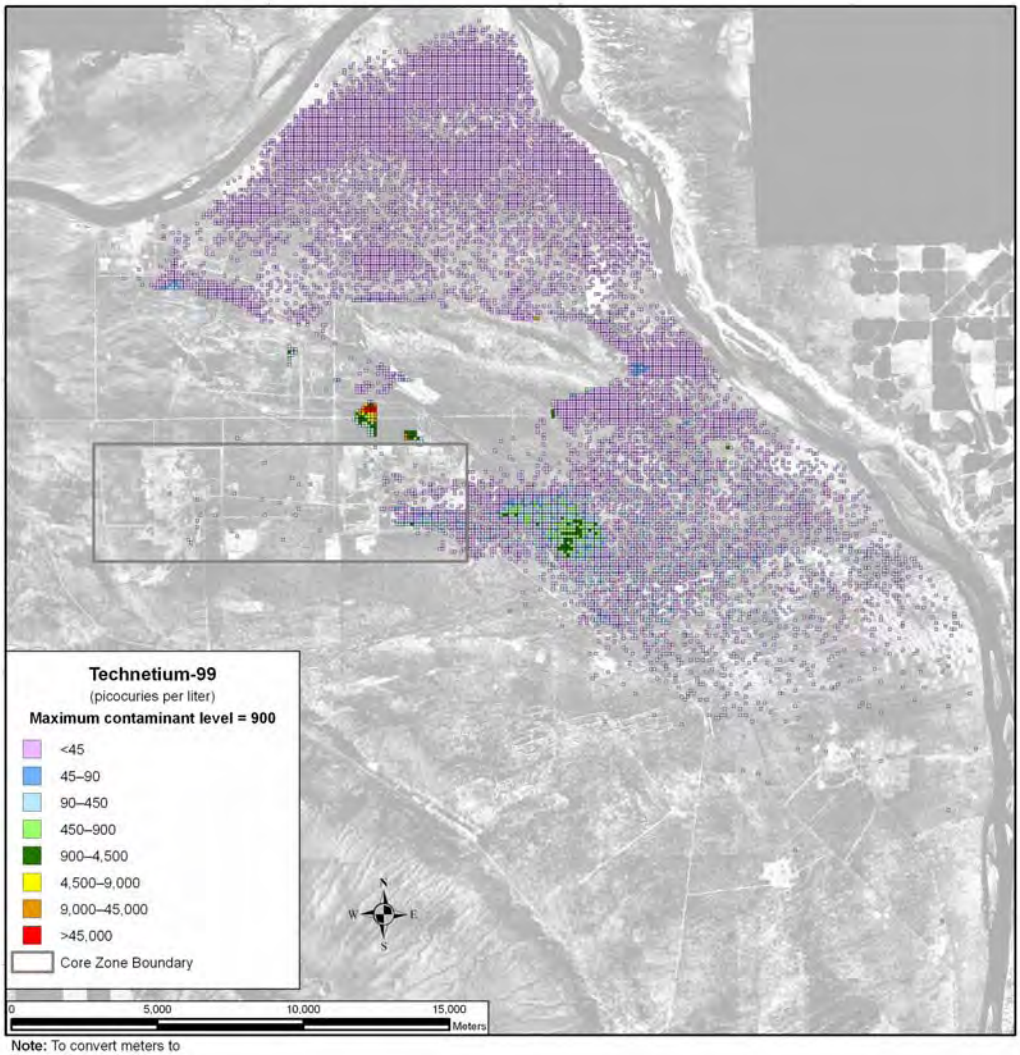


Figure 5–1235. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

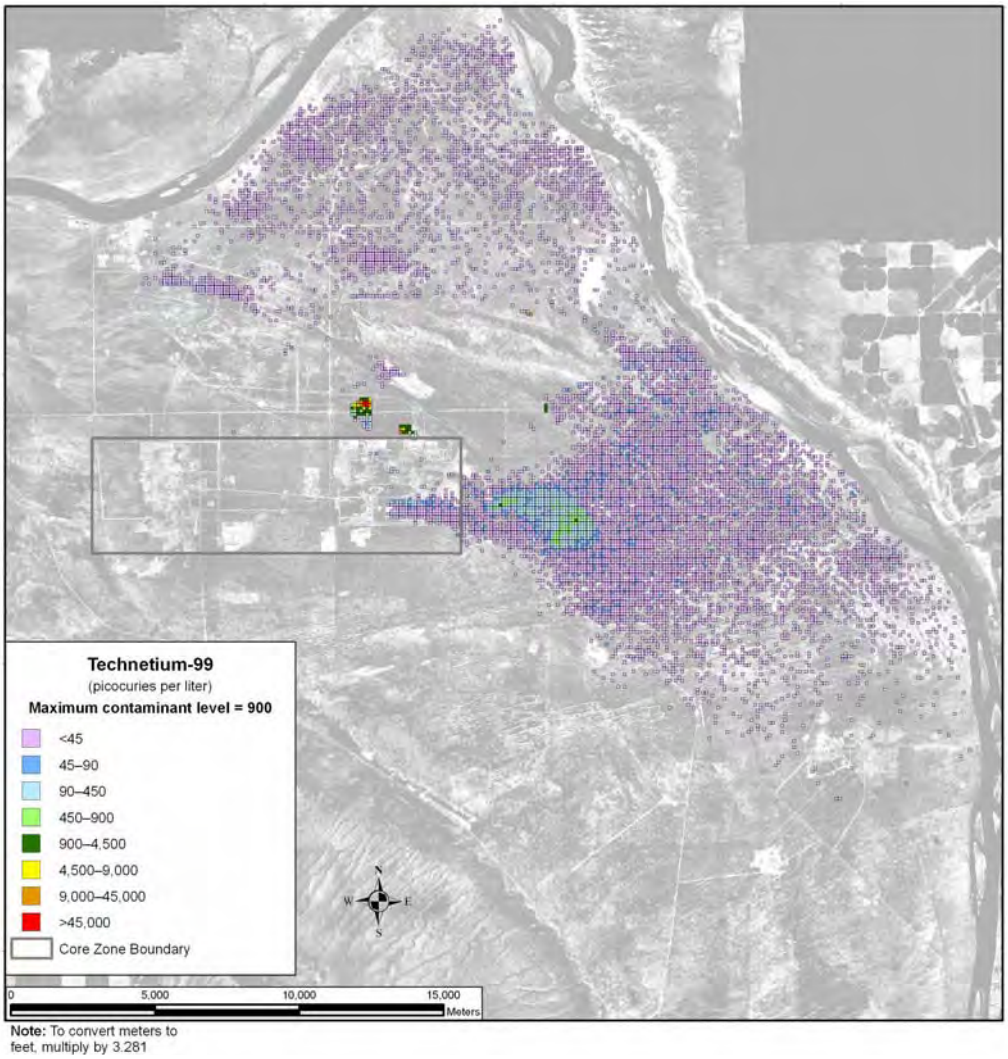


Figure 5–1236. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

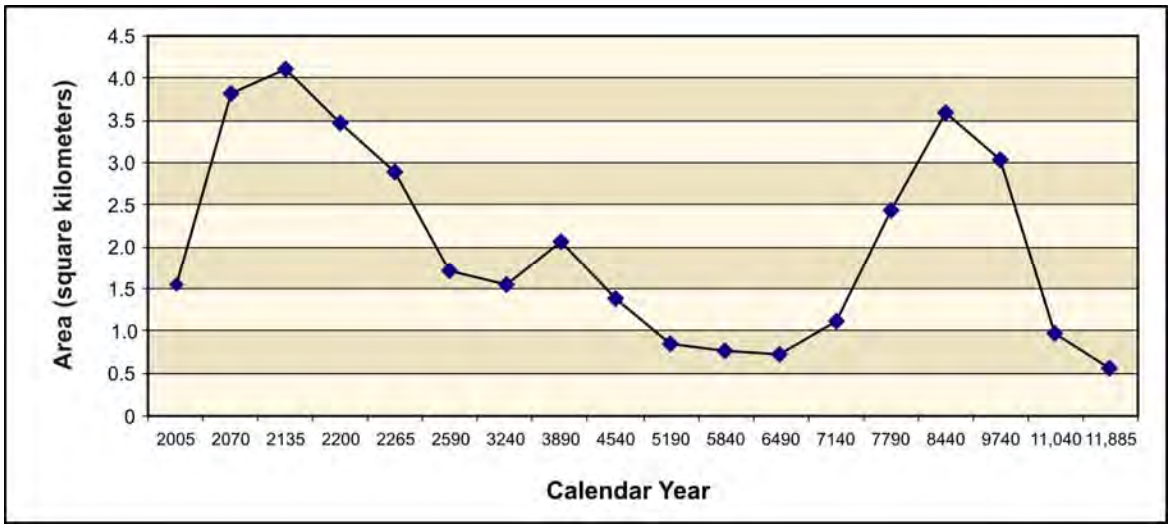


Figure 5–1237. Alternative Combination 2 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

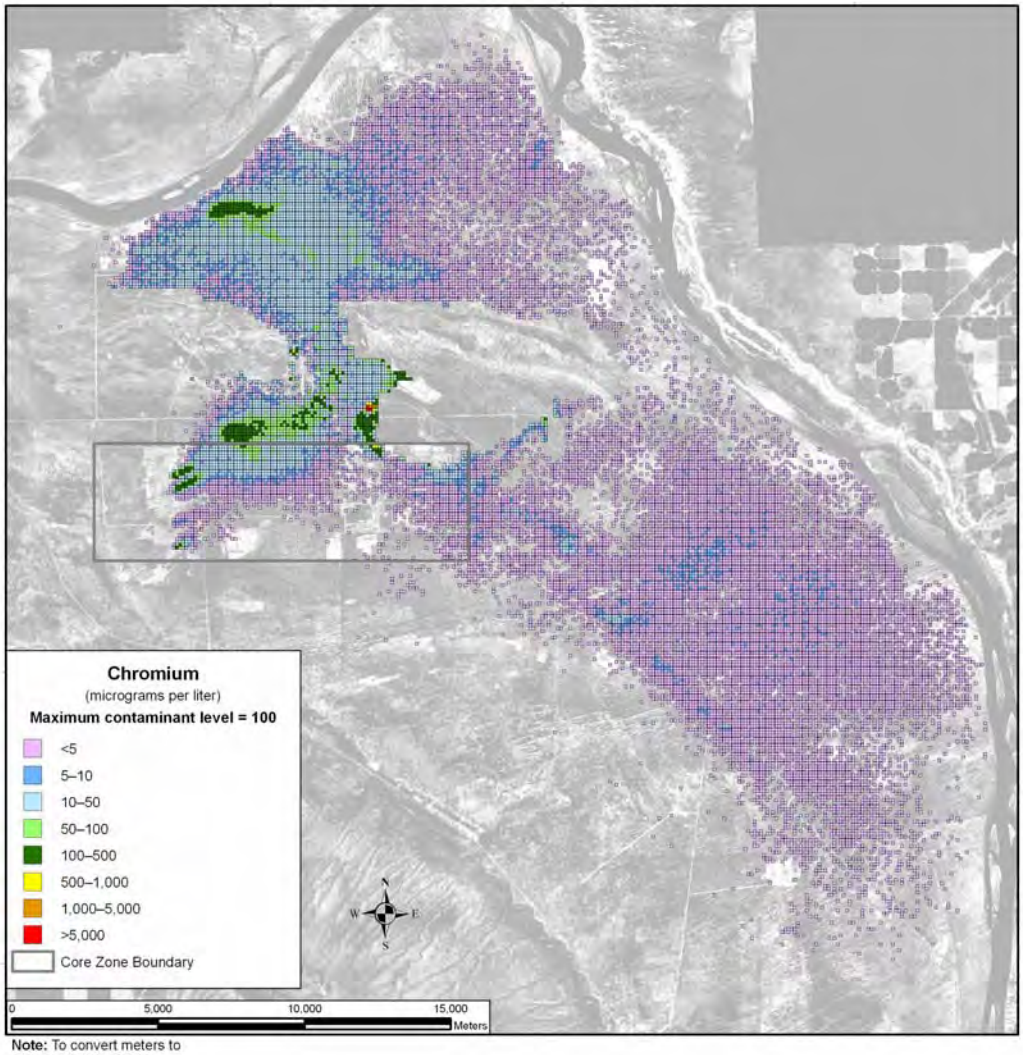


Figure 5–1238. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005

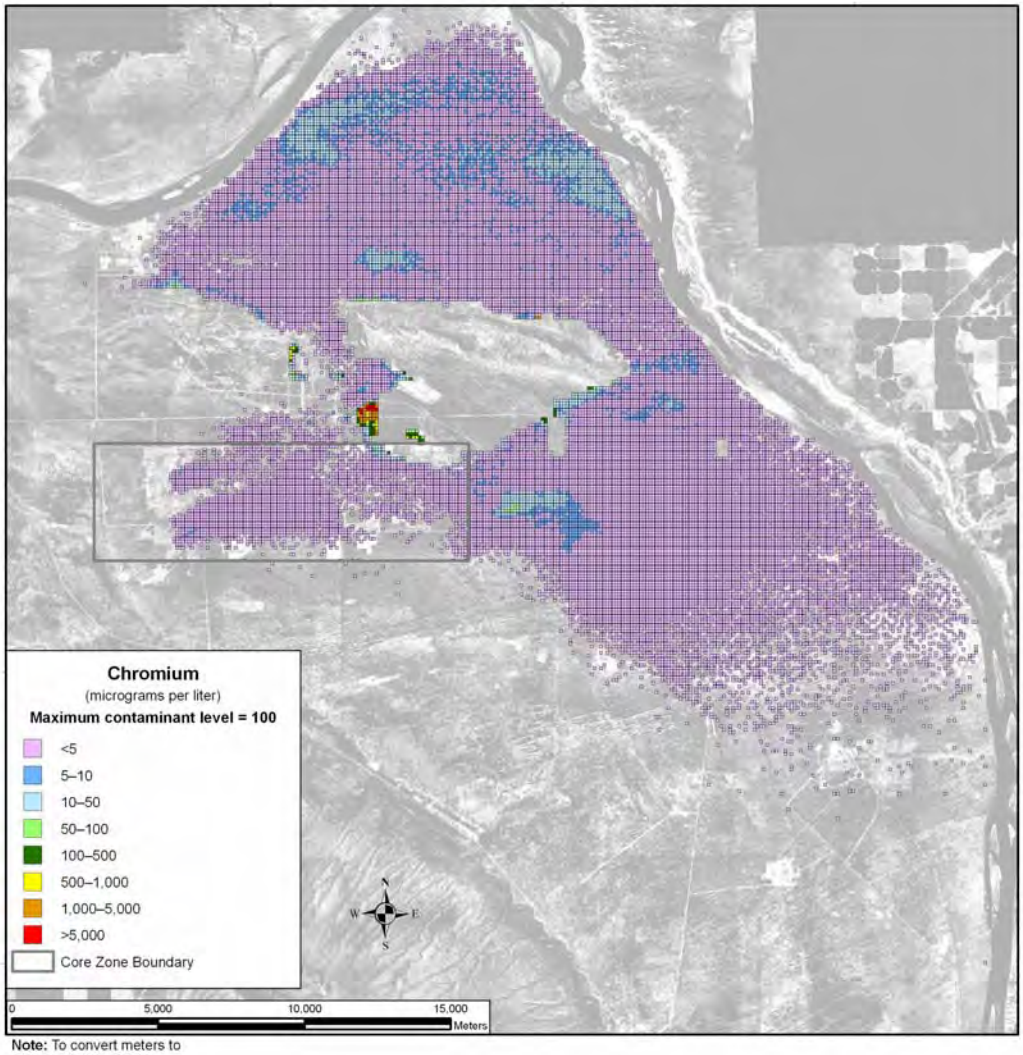


Figure 5–1239. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

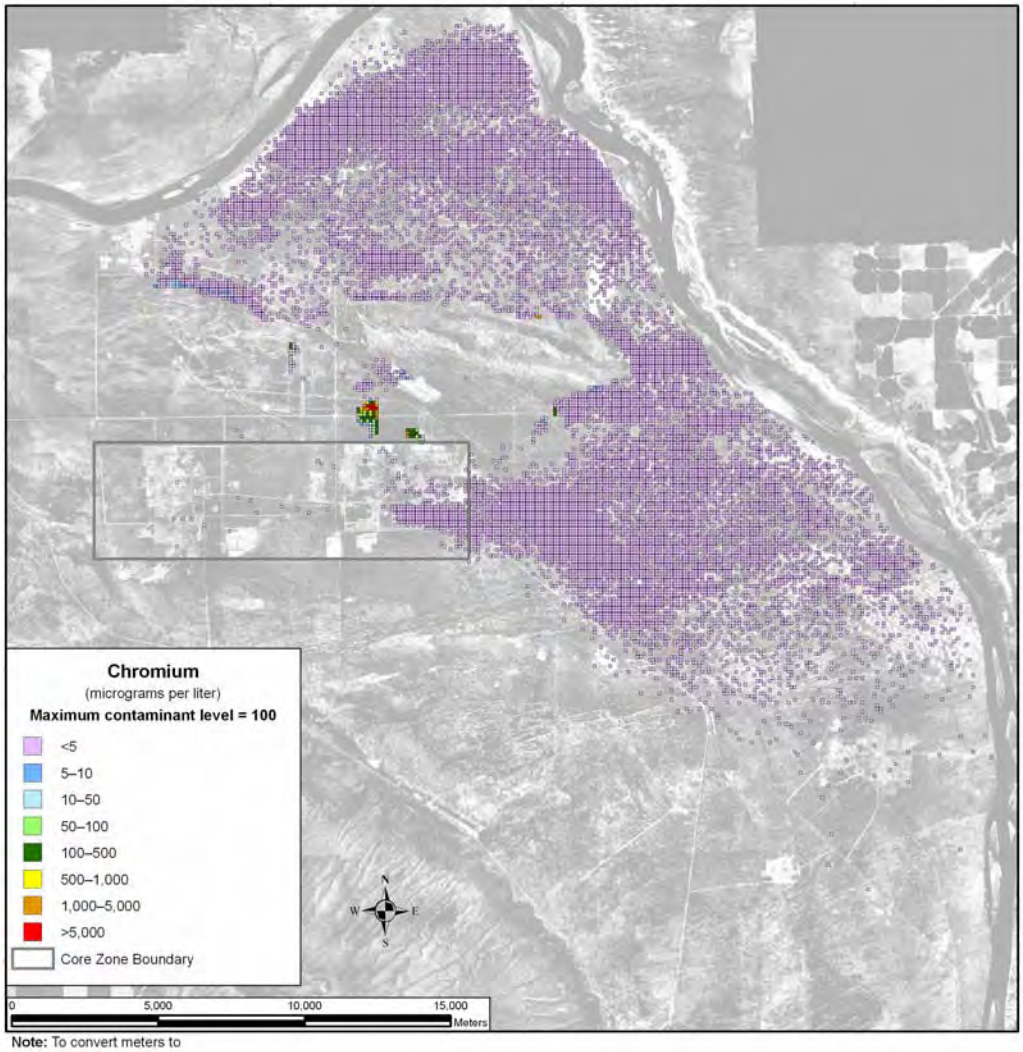


Figure 5–1240. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

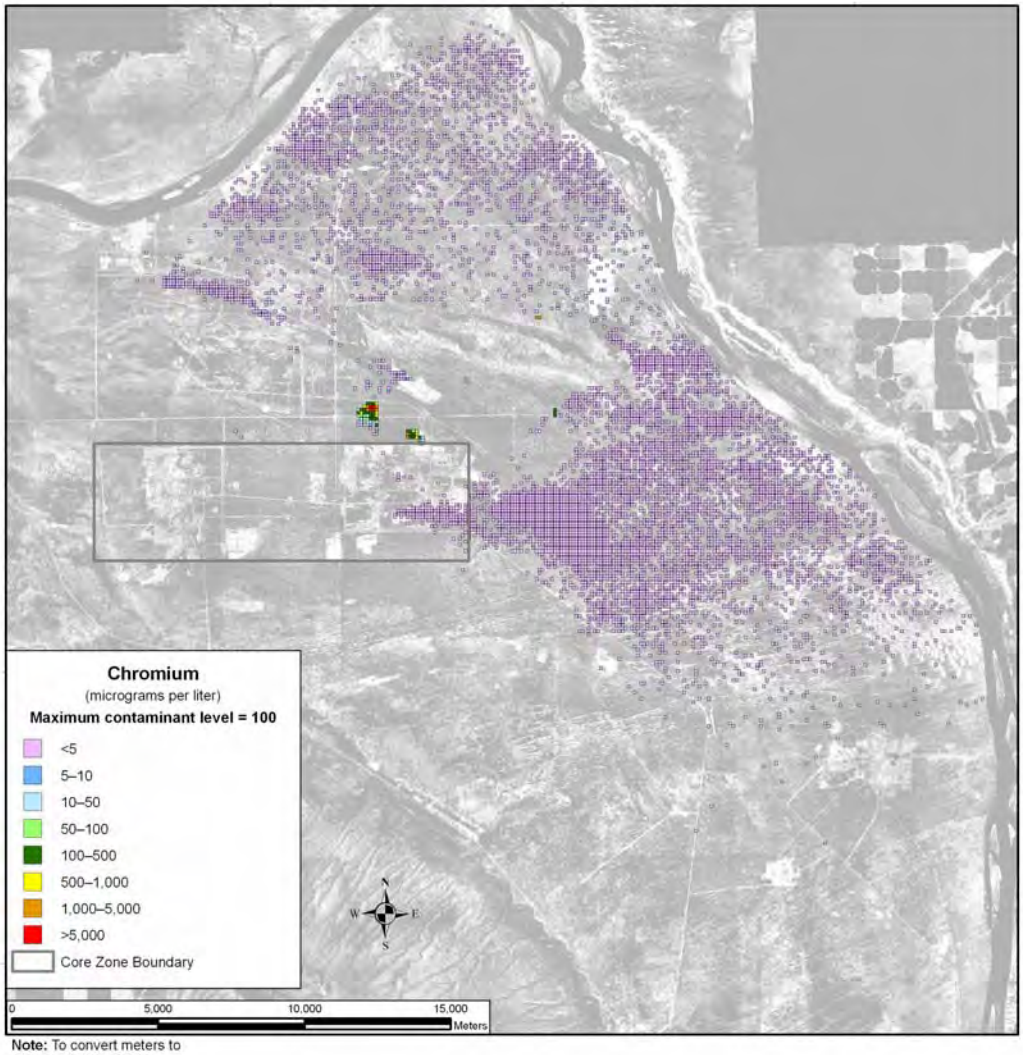


Figure 5–1241. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

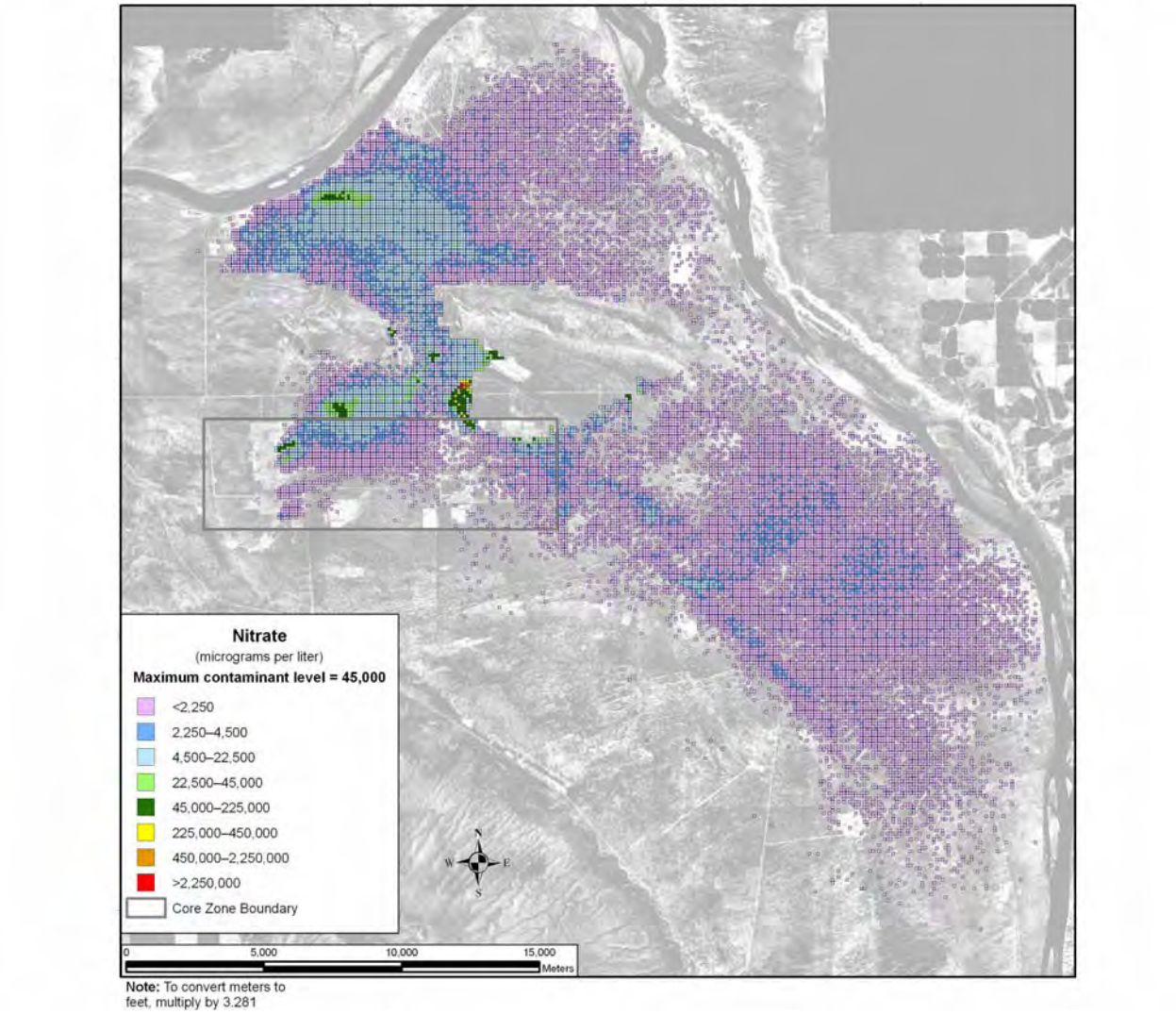


Figure 5–1242. Alternative Combination 2 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

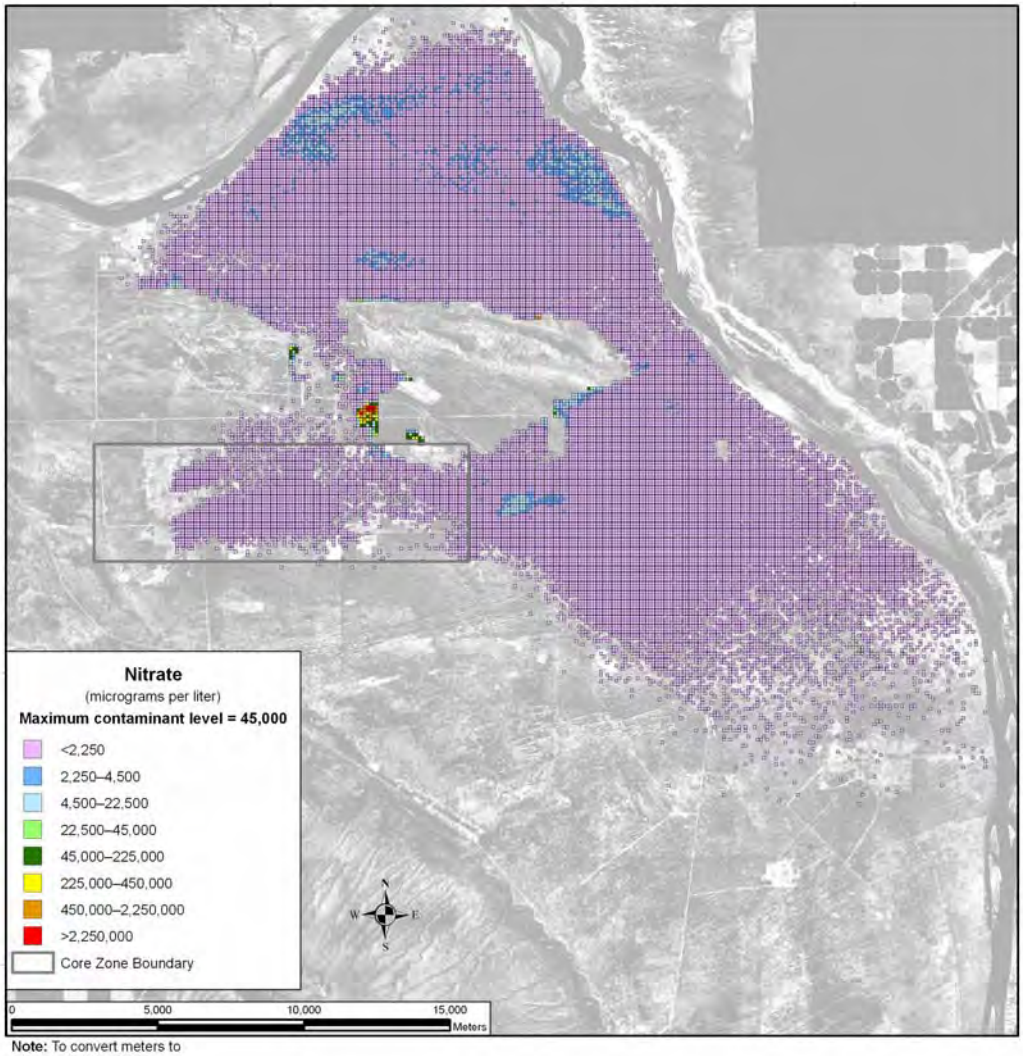


Figure 5–1243. Alternative Combination 2 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

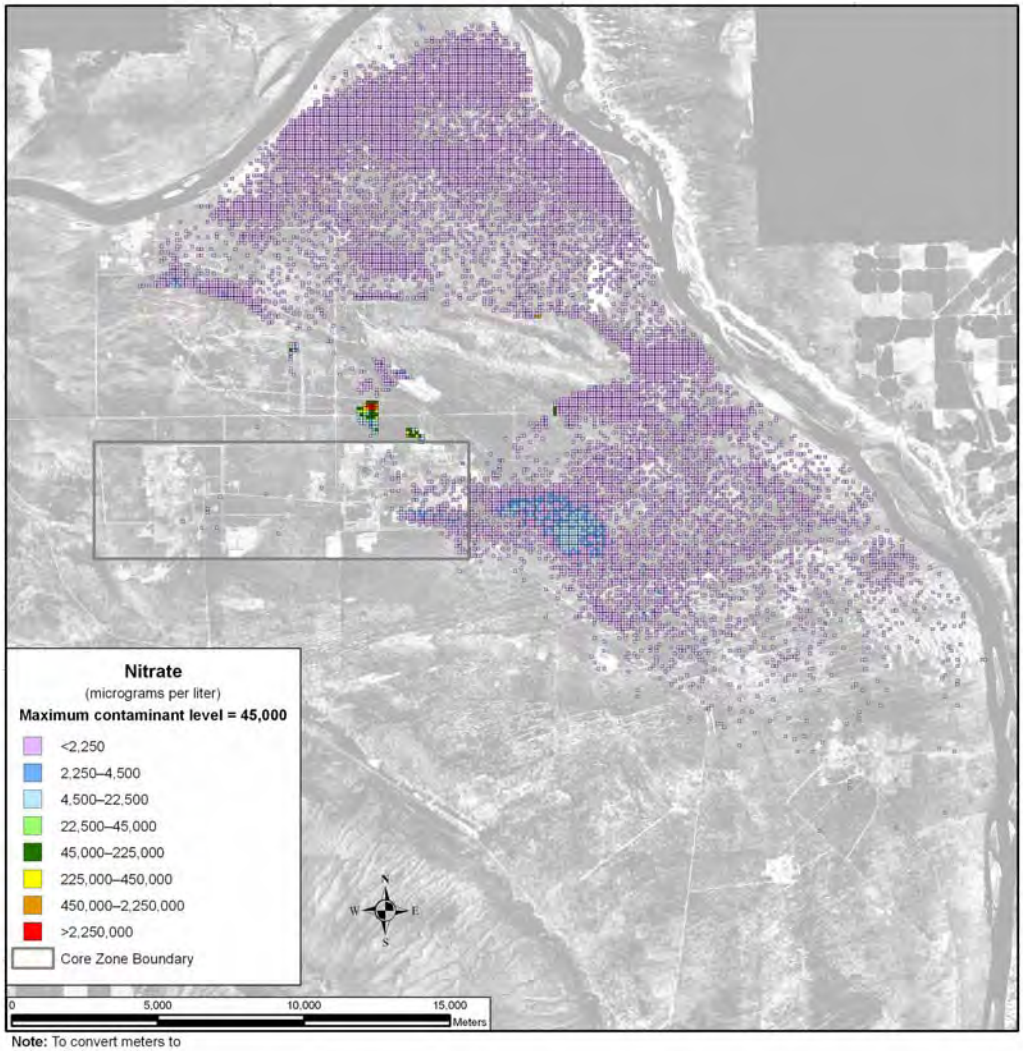


Figure 5–1244. Alternative Combination 2 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium show different spatial distributions over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1245 shows the distribution of uranium-238 during CY 2135. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark and contained within the Core Zone Boundary. By CY 3890 (see Figure 5–1246), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–1247), the greatest development of the plume during the analysis period is seen. Figure 5–1248 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest near the end of the period of analysis. Figures 5–1249 through 5–1251 show the corresponding spatial distribution for total uranium.

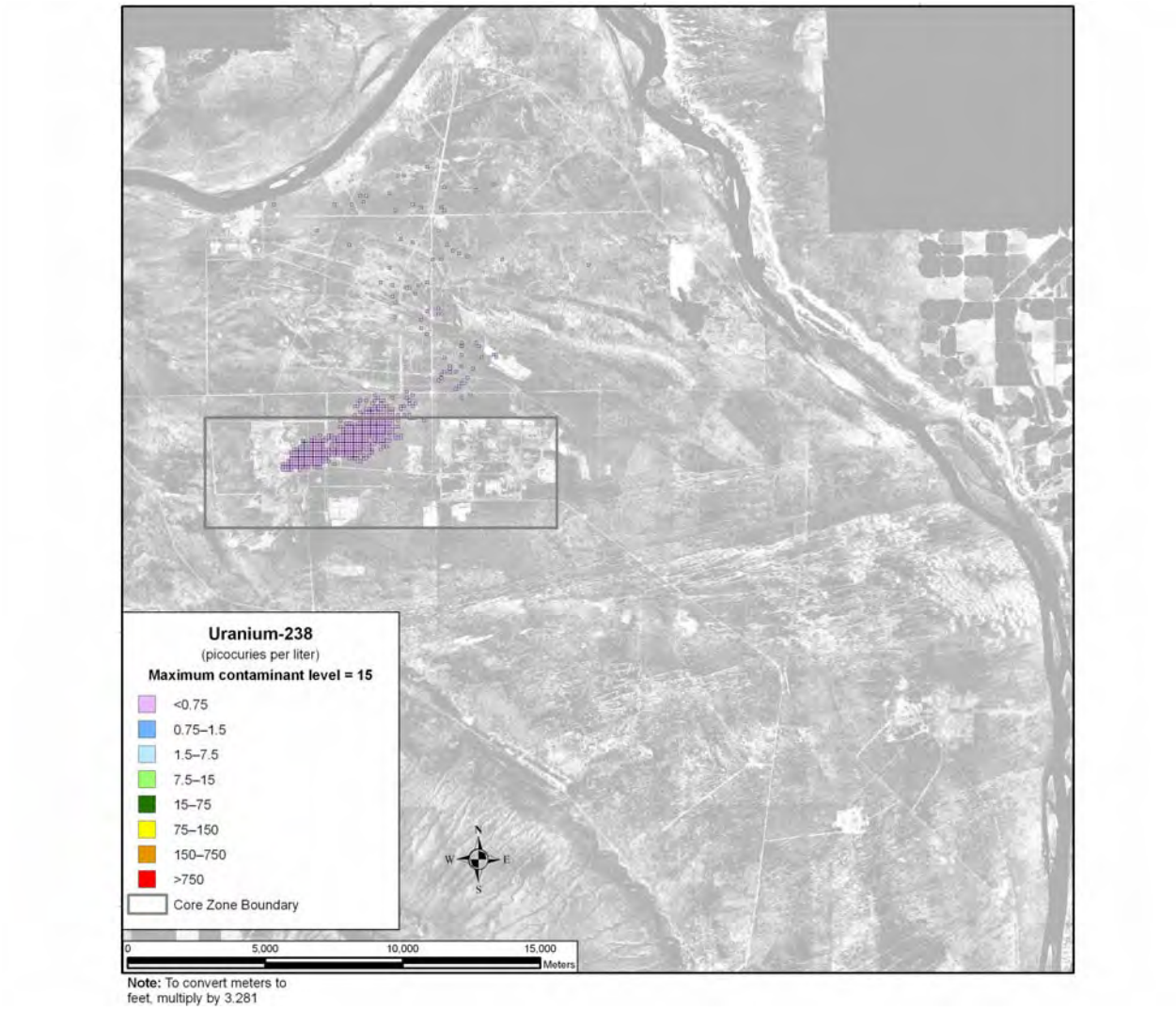


Figure 5–1245. Alternative Combination 2 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135

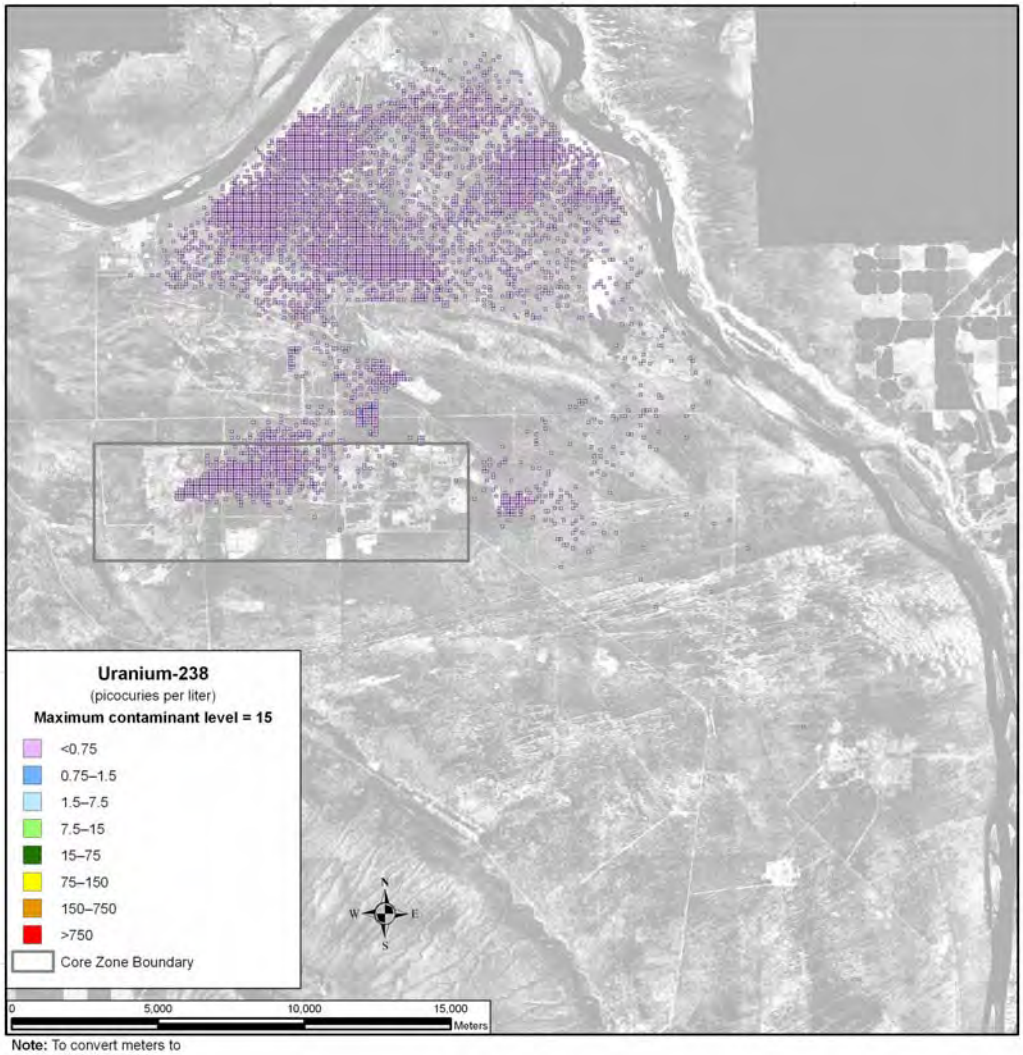


Figure 5–1246. Alternative Combination 2 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890

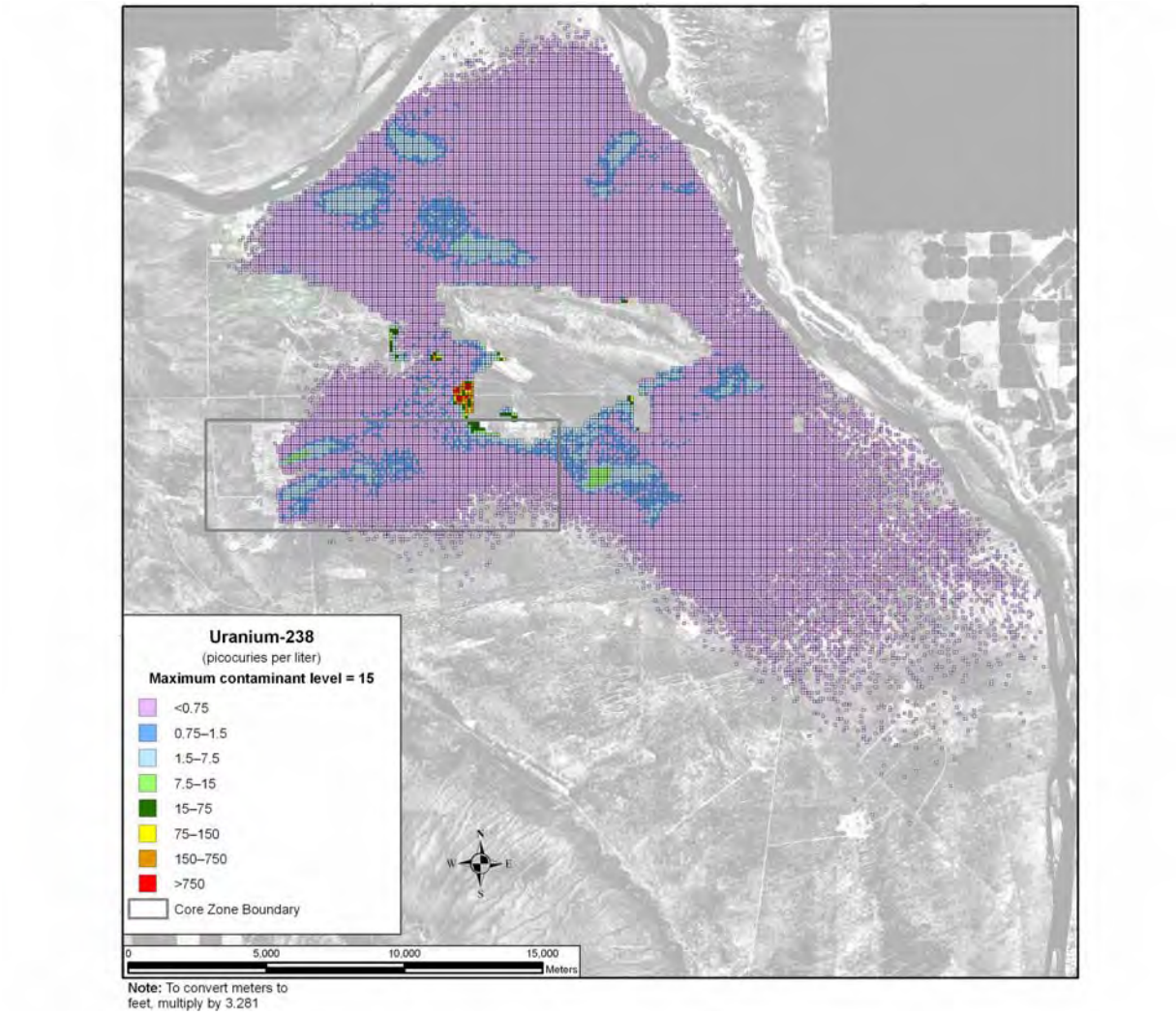


Figure 5–1247. Alternative Combination 2 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

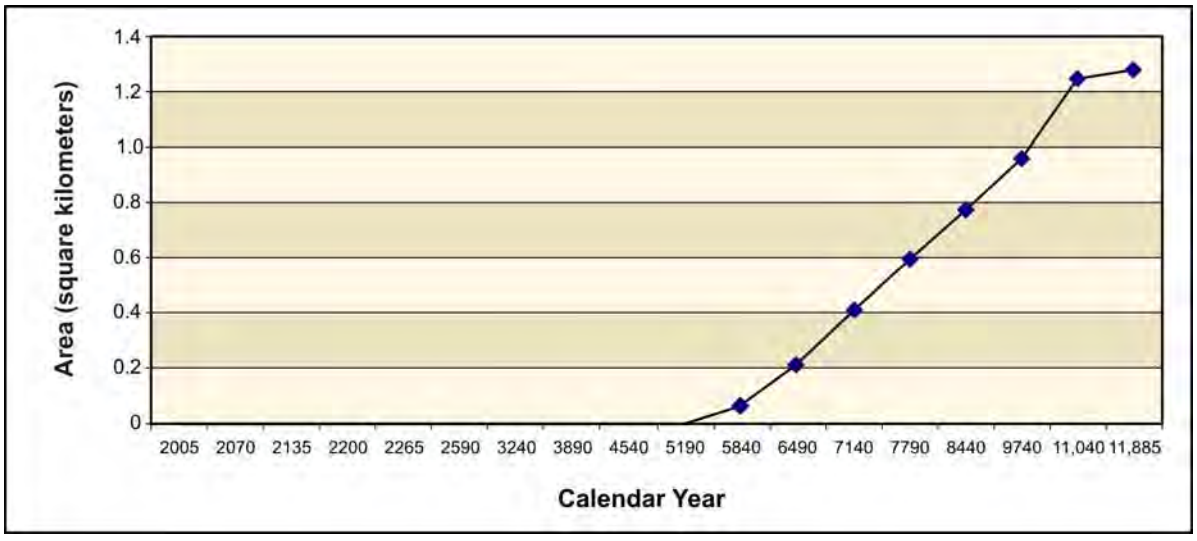


Figure 5–1248. Alternative Combination 2 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

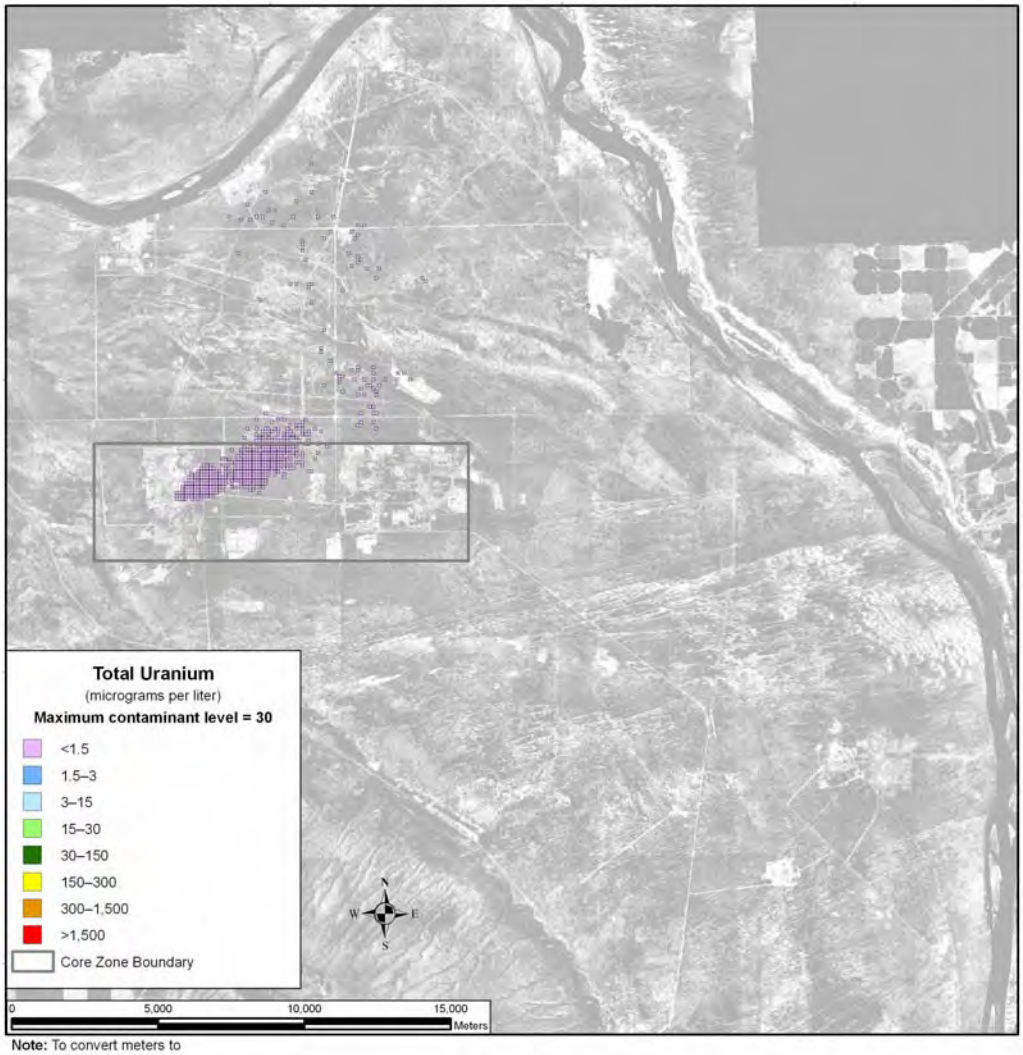


Figure 5–1249. Alternative Combination 2 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135

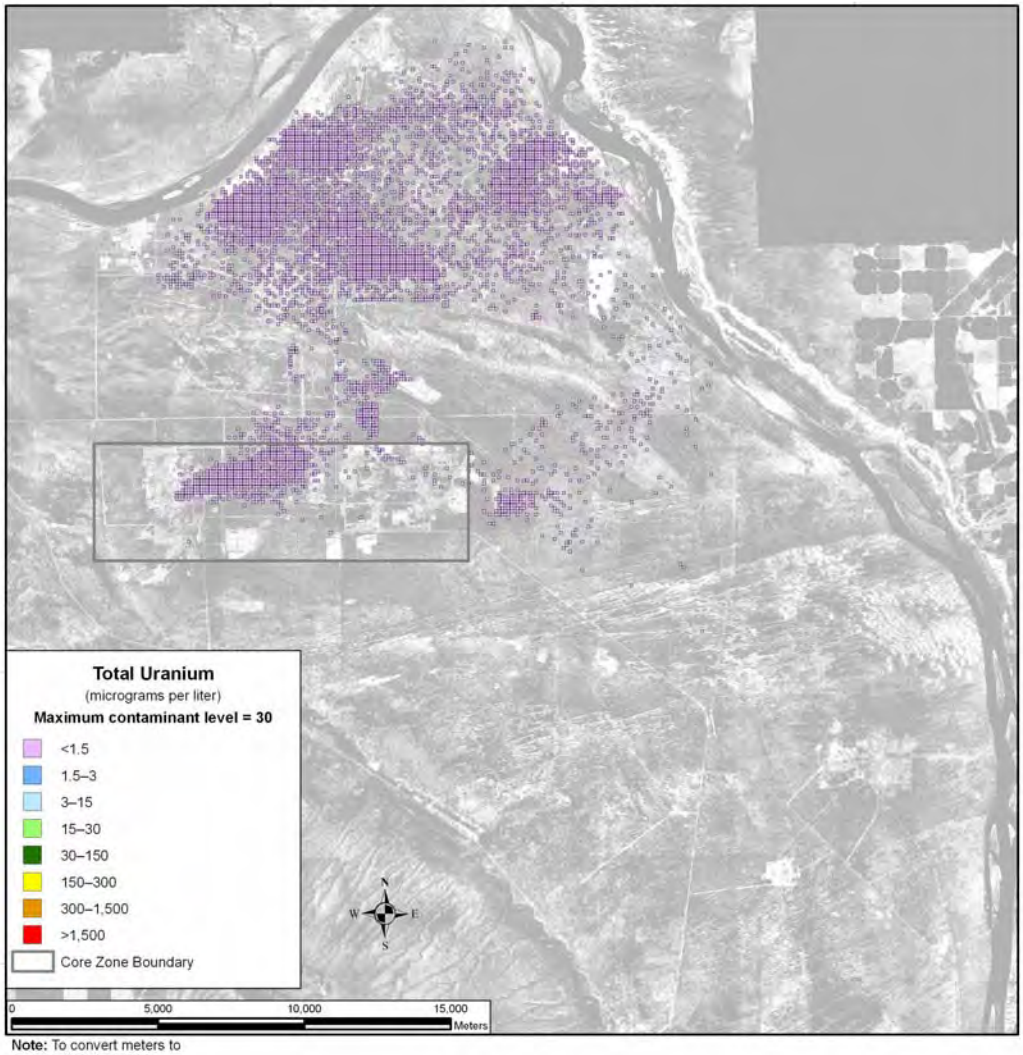


Figure 5–1250. Alternative Combination 2 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890

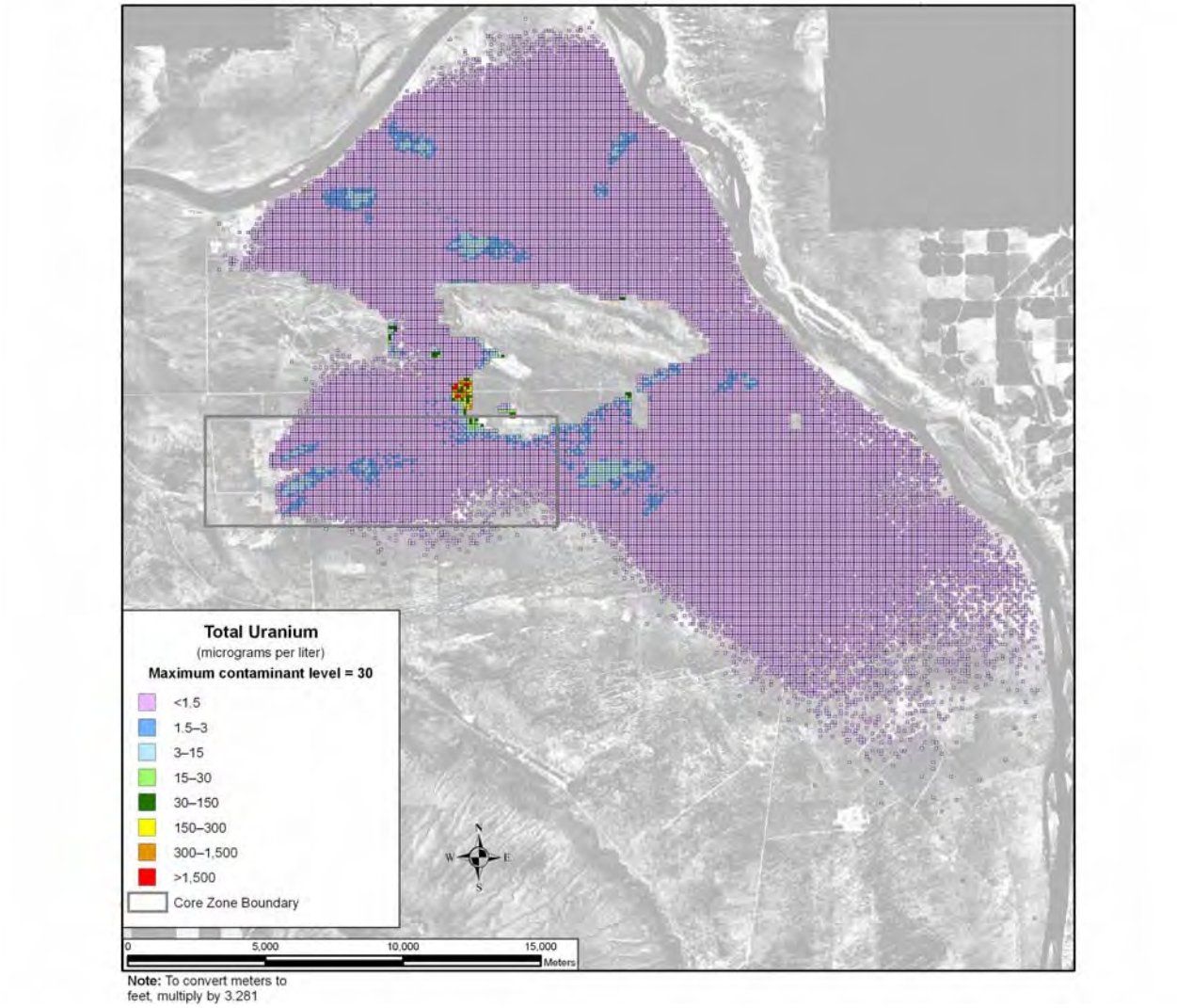


Figure 5–1251. Alternative Combination 2 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

The long-term impacts of Alternative Combination 2 are dominated by tank farm sources for tritium, uranium-238, chromium, nitrate, and total uranium. The dominant contributors for iodine-129 and technetium-99 are waste management sources, particularly offsite waste disposed of at IDF-East. Contributions from FFTF Decommissioning Alternative 2 sources account for well below 1 percent of the total amount released to the environment.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by an order of magnitude during the first several thousand years of the period of analysis, and concentrations at the Columbia River nearshore are about an order of magnitude lower. For chromium and nitrate, the concentration trend decreases with time past CY 6000. For iodine-129 and technetium-99, the concentration trend is level with respect to time, and concentrations are within an order of magnitude of the benchmark concentration at both the Core Zone Boundary and the Columbia River nearshore. The intensities and areas of these groundwater plumes are highest during the early and later parts of the period of analysis.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is the predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark at the Core Zone Boundary beyond CY 9000, but remain about an order of magnitude lower than the benchmark at the Columbia River after CY 10,000. The intensity is highest and the area of the contamination plume largest near the end of the period of analysis.

5.4.1.3 Alternative Combination 3

This section describes the results of the long-term groundwater impacts analysis for Alternative Combination 3, which comprises Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternative 2; and Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case. The focus is the combined long-term groundwater impacts of these alternatives. More-detailed discussion of the individual impacts is provided in Sections 5.1.1, 5.2.1, and 5.3.1.

This discussion of long-term impacts is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose the alternative combination. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, limited rates of release (i.e., retention in waste form), high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Alternative Combination 3 in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies, chemicals in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 5–161 lists the release to the vadose zone for the COPC drivers. For Alternative Combination 3, the release to the vadose zone is controlled by a combination of inventory and waste form. For tank closure and FFTF decommissioning sources, the entire inventory is released to the vadose zone during the period of analysis. For some waste management sources (e.g., PPF glass), some of the inventory is not released to the vadose zone during the 10,000-year period of analysis because of retention in the waste form. The release to the vadose zone for Alternative Combination 3 is dominated by sources associated with Tank Closure Alternative 6B, Base Case, for tritium, uranium-238, chromium, nitrate, and total uranium. For these COPC drivers, releases from FFTF decommissioning and waste management sources account for less than 25 percent of the total. For iodine-129 and technetium-99, releases to the vadose

zone are dominated by waste management sources, in particular offsite waste disposed of in IDF-East. Offsite waste accounts for over 93 percent of the total release to the vadose zone for iodine-129 and over 83 percent of the total release to the vadose zone for technetium-99.

Table 5–161. Alternative Combination 3 Release to Vadose Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 6B Base	4.59×10^{4}	8.35×10^{-1}	4.53×10^{2}	2.59×10^{1}	9.07×10^{4}	2.56×10^{7}	2.93×10^{4}
FFTF Decommissioning Alternative 3	1.73×10^{-5}	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 2, Subgroup 2-B, Base	6.29×10^{4}	1.84×10^{1}	2.53×10^{3}	3.30×10^{2}	6.48×10^{3}	9.38×10^{6}	1.27×10^{4}
Total	1.09×10^{5}	1.92×10^{1}	3.01×10^{3}	3.56×10^{2}	9.71×10^{4}	3.49×10^{7}	4.20×10^{4}

Key: Base=Base Case; COPC=constituent of potential concern.

Table 5–162 lists the release to groundwater for the COPC drivers. In addition to the inventory and waste form considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Note that delayed release to the vadose zone (i.e., retention in the waste form) can enhance retention in the vadose zone because contaminant mass released into the vadose zone near the end of the 10,000-year period of analysis may not reach the water table. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater ranges from 100 percent down to 80 percent of the amount released to the vadose zone. For tritium, the amount released to groundwater is attenuated by radioactive decay during transit through the vadose zone. About 70 percent of the tritium released to the vadose zone reaches the unconfined aquifer. For uranium-238 and total uranium, the amount released to groundwater is lower than that of the release to the vadose zone because of retardation. Less than 3 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 5–162. Alternative Combination 3 Release to Groundwater for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 6B Base	3.23×10^{4}	7.49×10^{-1}	4.08×10^{2}	7.31×10^{-1}	9.27×10^{4}	2.64×10^{7}	2.42×10^{2}
FFTF Decommissioning Alternative 3	2.58×10^{-8}	0.00	2.62×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 2, Subgroup 2-B, Base	0.00	1.68×10^{1}	2.27×10^{3}	2.68×10^{-7}	6.46×10^{3}	9.36×10^{6}	4.64×10^{-4}
Total	3.23×10^{4}	1.75×10^{1}	2.71×10^{3}	7.31×10^{-1}	9.92×10^{4}	3.58×10^{7}	2.42×10^{2}

Key: Base=Base Case; COPC=constituent of potential concern.

Table 5–163 lists the release to the Columbia River for the COPC drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reaches the Columbia River. For uranium-238 and total uranium, the amount released to the Columbia River is lower than that released to groundwater because of retardation in the aquifer. Overall, about 30 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

Table 5–163. Alternative Combination 3 Release to Columbia River for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium**	**Nitrate**	**Total Uranium**
Tank Closure Alternative 6B Base	8.70×10^{2}	7.23×10^{-1}	3.94×10^{2}	2.44×10^{-1}	9.23×10^{4}	2.63×10^{7}	7.87×10^{1}
FFTF Decommissioning Alternative 3	0.00	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 2, Subgroup 2-B, Base	0.00	1.63×10^{1}	2.20×10^{3}	0.00	6.22×10^{3}	9.21×10^{6}	3.05×10^{-5}
Total	8.70×10^{2}	1.70×10^{1}	2.62×10^{3}	2.44×10^{-1}	9.85×10^{4}	3.55×10^{7}	7.87×10^{1}

Key: Base=Base Case; COPC=constituent of potential concern.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Alternative Combination 3 in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid to interpreting data with a significant amount random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–164 lists the maximum concentrations of the COPCs at the peak year for the Core Zone Boundary and the Columbia River nearshore.

Table 5–164. Alternative Combination 3 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary and Columbia River Nearshore

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide picocuries per liter			
Hydrogen-3 (Tritium)	**2,820,000**	1,280	20,000
	(1956)	(1994)	
Technetium-99	**144,000**	716	900
	(1956)	(8477)	
Iodine-129	**187**	**6**	1
	(1956)	(9652)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	10	0	15
	(11,758)	(11,844)	
Chemical in micrograms per liter			
Chromium	**28,000**	33	100
	(1956)	(2695)	
Nitrate	**12,900,000**	8,420	45,000
	(1956)	(2450)	
Total uranium	7	0	30
	(11,678)	(11,508)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern.

Figure 5–1252 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from CY 1940 through CY 2640 rather than for the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore peak at about an order of magnitude lower than the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

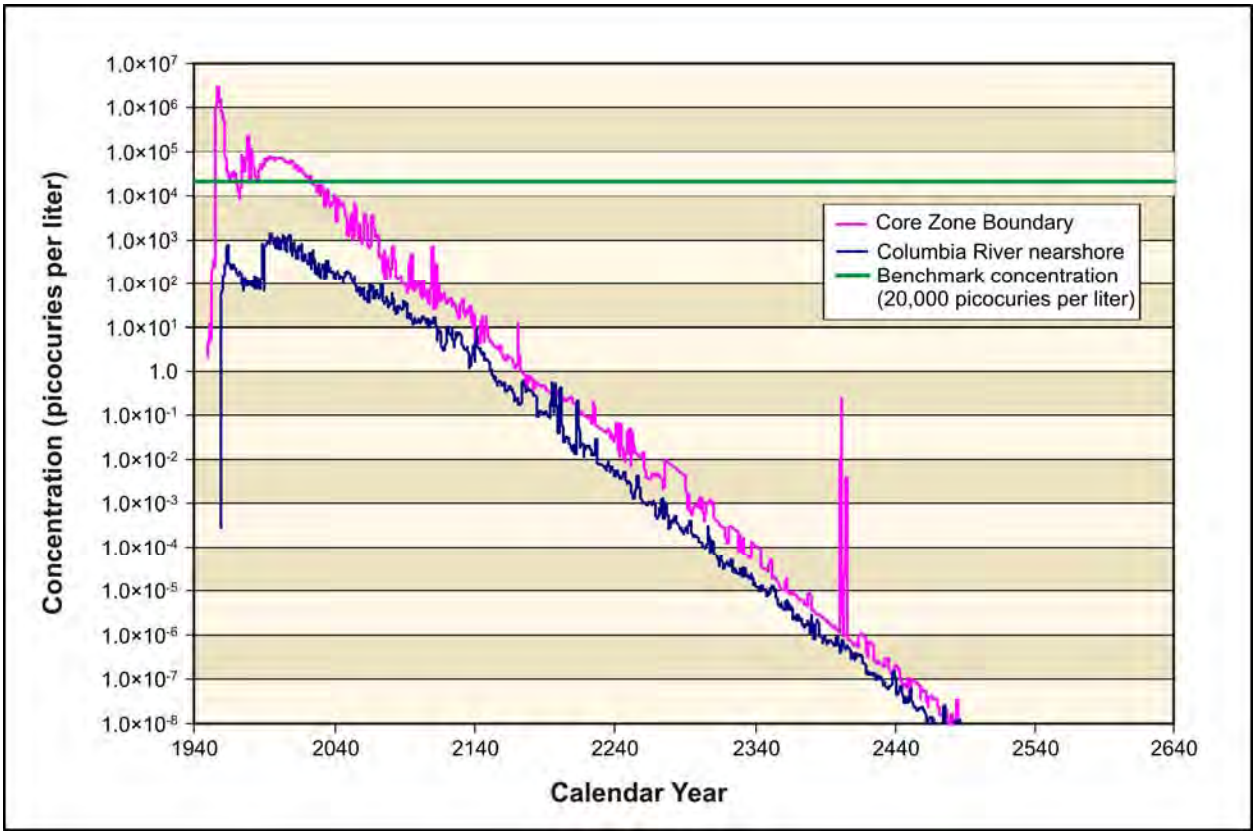


Figure 5–1252. Alternative Combination 3 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–1253 and 5–1254 show concentration versus time for chromium and nitrate (the conservative tracers that are not affected by retention in the waste forms). Groundwater concentrations of chromium exceed benchmark concentrations by an order of magnitude during the first several thousand years of the analysis. During this time, groundwater concentrations at the Columbia River nearshore are below, but within an order of magnitude of, the benchmark concentration. During later times in the analysis, the concentrations at the Core Zone Boundary and the Columbia River nearshore are below the benchmark by about one and two orders of magnitude, respectively. Nitrate shows a similar concentration pattern with respect to time. For iodine-129 and technetium-99, the behavior during the first four thousand years is similar to that of chromium and nitrate (see Figures 5–1255 and 5–1256). After CY 6000, the effects of delayed release from waste management sources are seen. For iodine-129, the post–CY 6000 concentrations at the Core Zone Boundary and the Columbia River nearshore are above, but within an order of magnitude of, the benchmark concentration. For technetium-99, the corresponding concentrations are below, but within an order of magnitude of, the benchmark concentration.

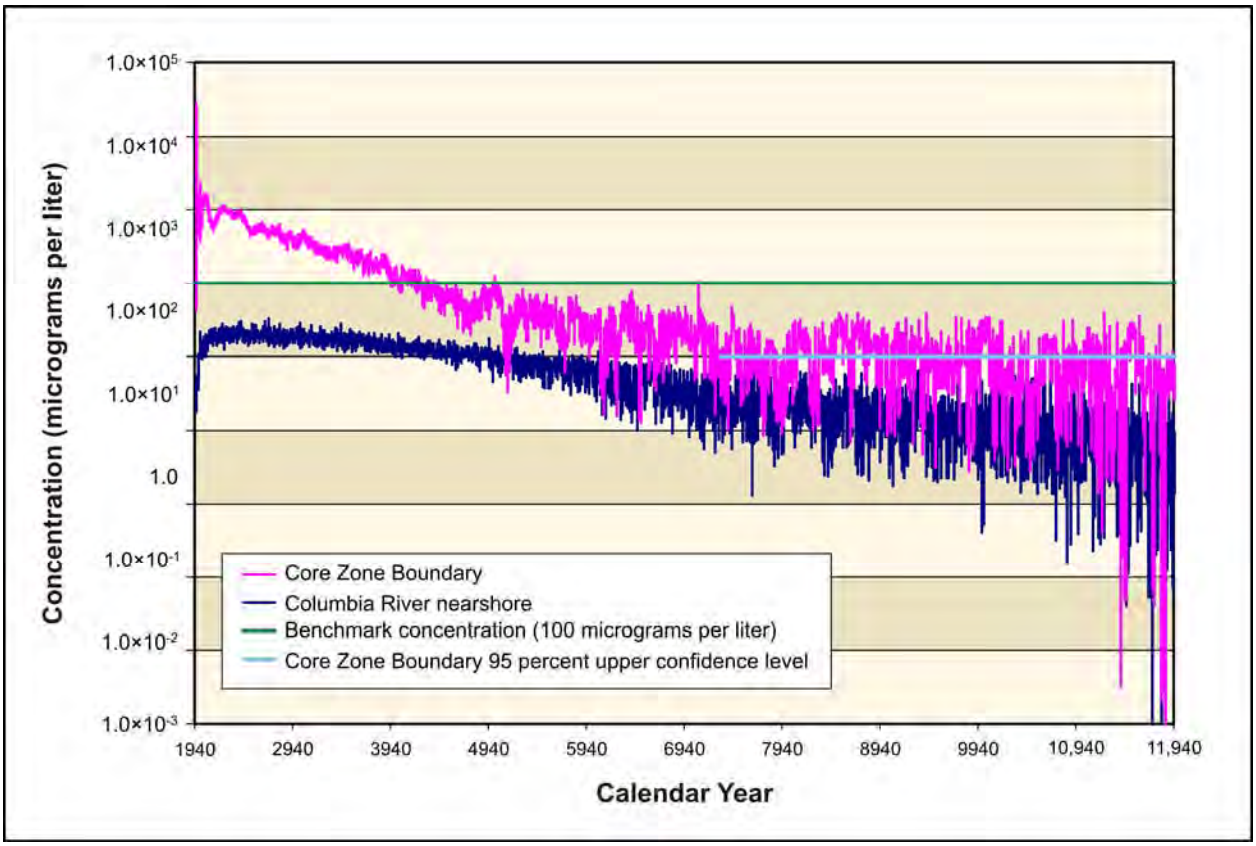


Figure 5–1253. Alternative Combination 3 Chromium Concentration Versus Time

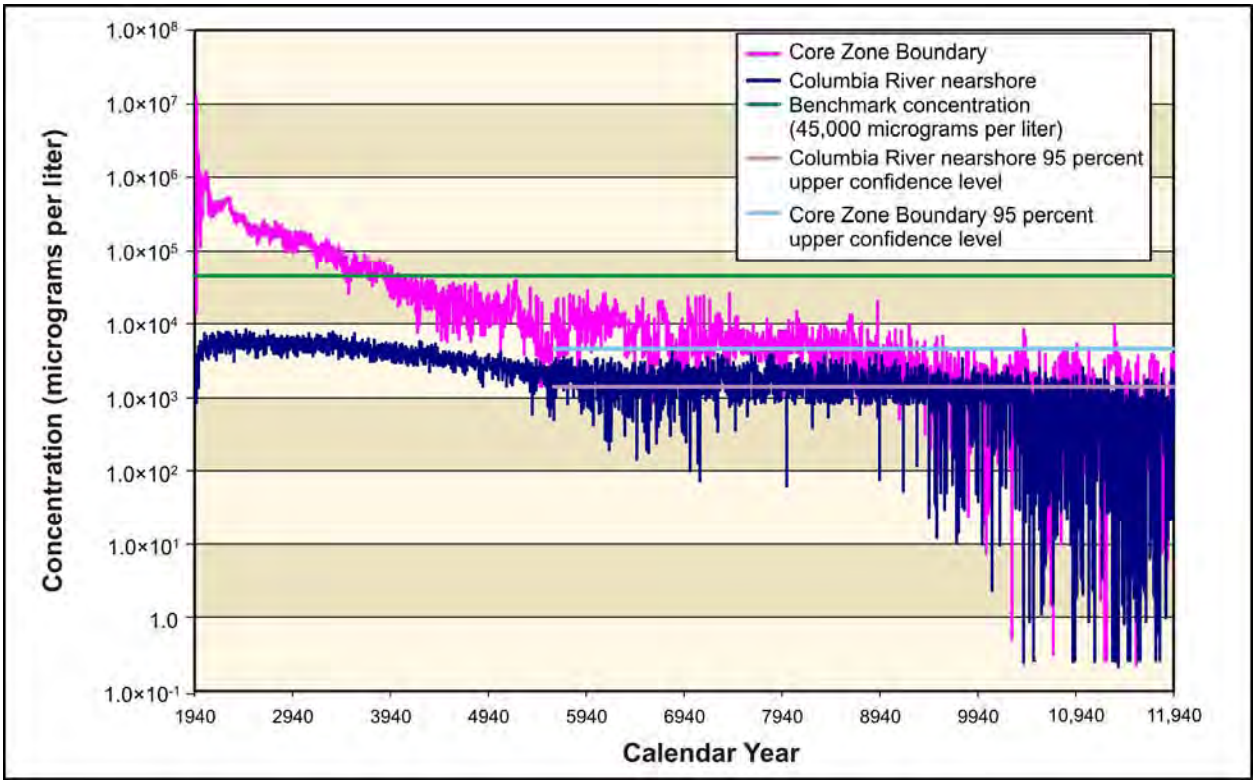


Figure 5–1254. Alternative Combination 3 Nitrate Concentration Versus Time

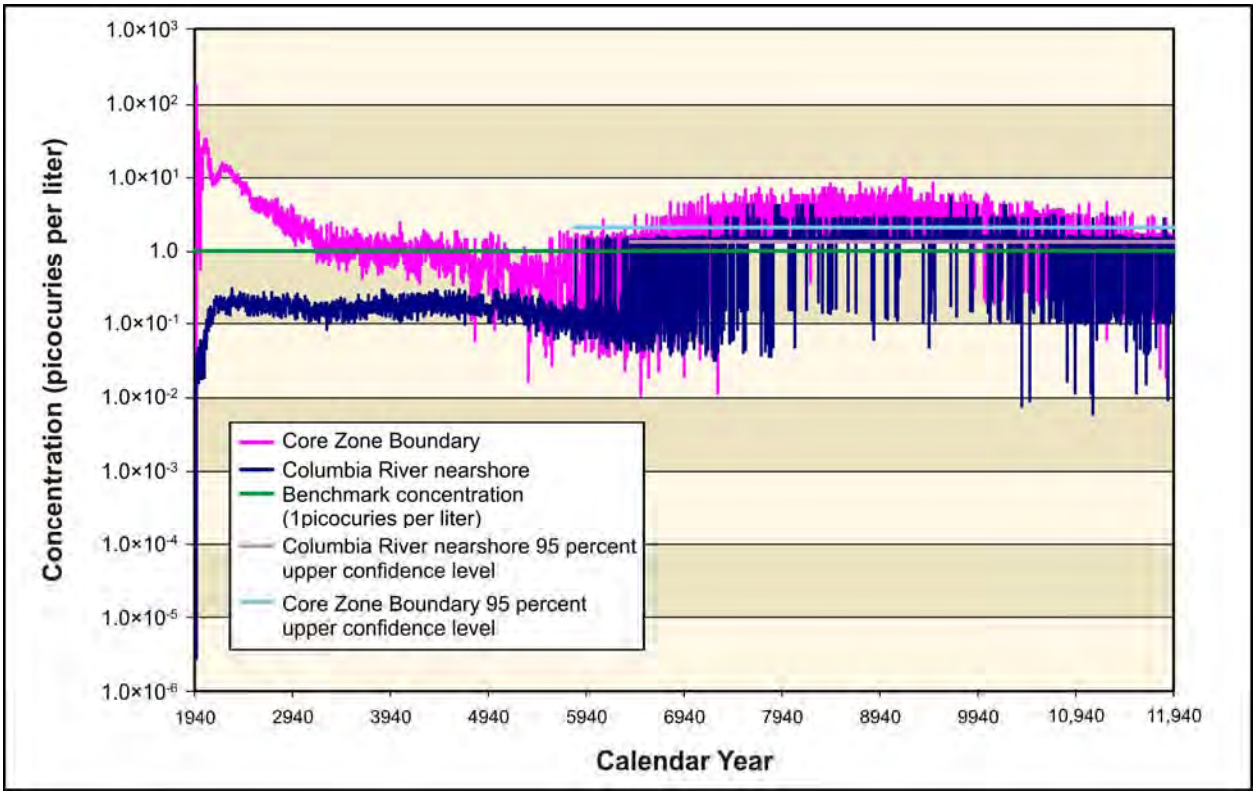


Figure 5–1255. Alternative Combination 3 Iodine-129 Concentration Versus Time

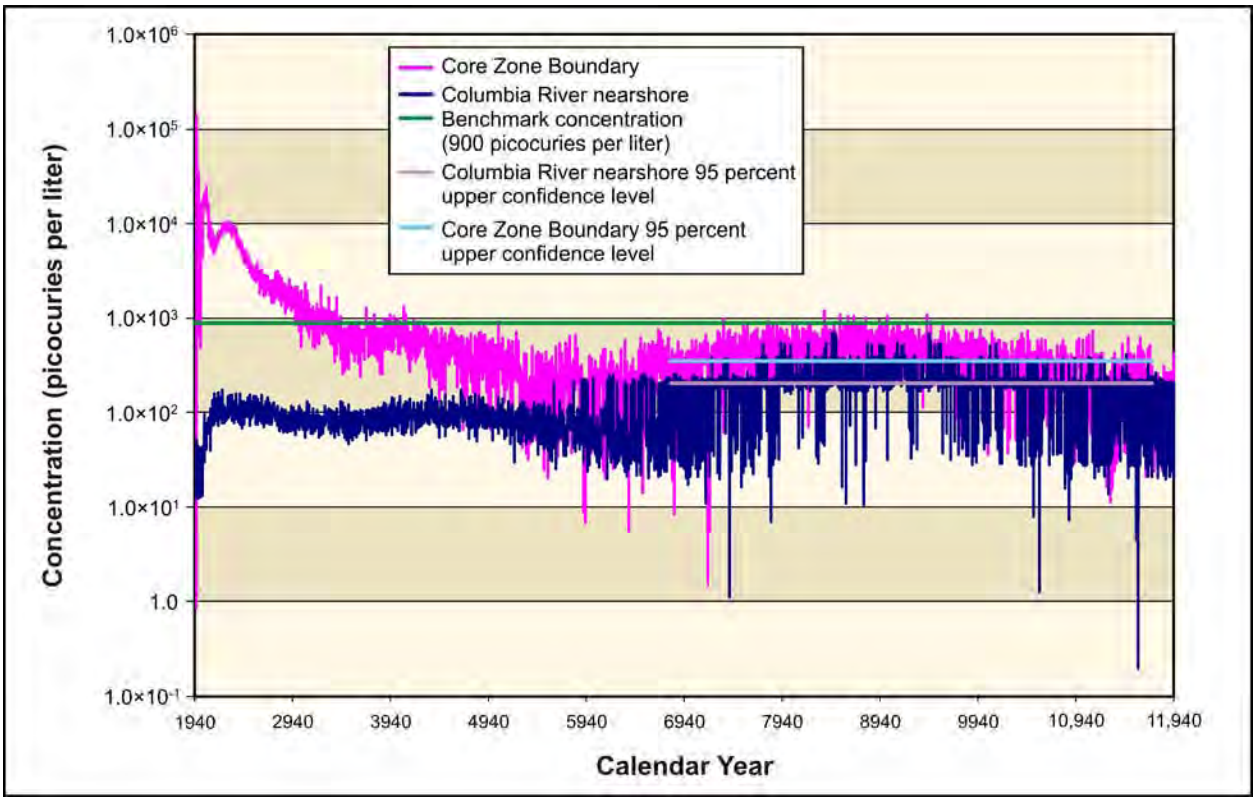


Figure 5–1256. Alternative Combination 3 Technetium-99 Concentration Versus Time

Figures 5–1257 and 5–1258 show concentration versus time for uranium-238 and total uranium. Concentrations of uranium-238 and total uranium rise throughout the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and Columbia River nearshore are retarded relative to the conservative tracers by a factor of about seven. Concentrations of uranium-238 and total uranium approach, but do not exceed, the benchmark concentration at the Core Zone Boundary at the end of the period of analysis. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, but remain more than an order of magnitude below the benchmark concentration by CY 11,940.

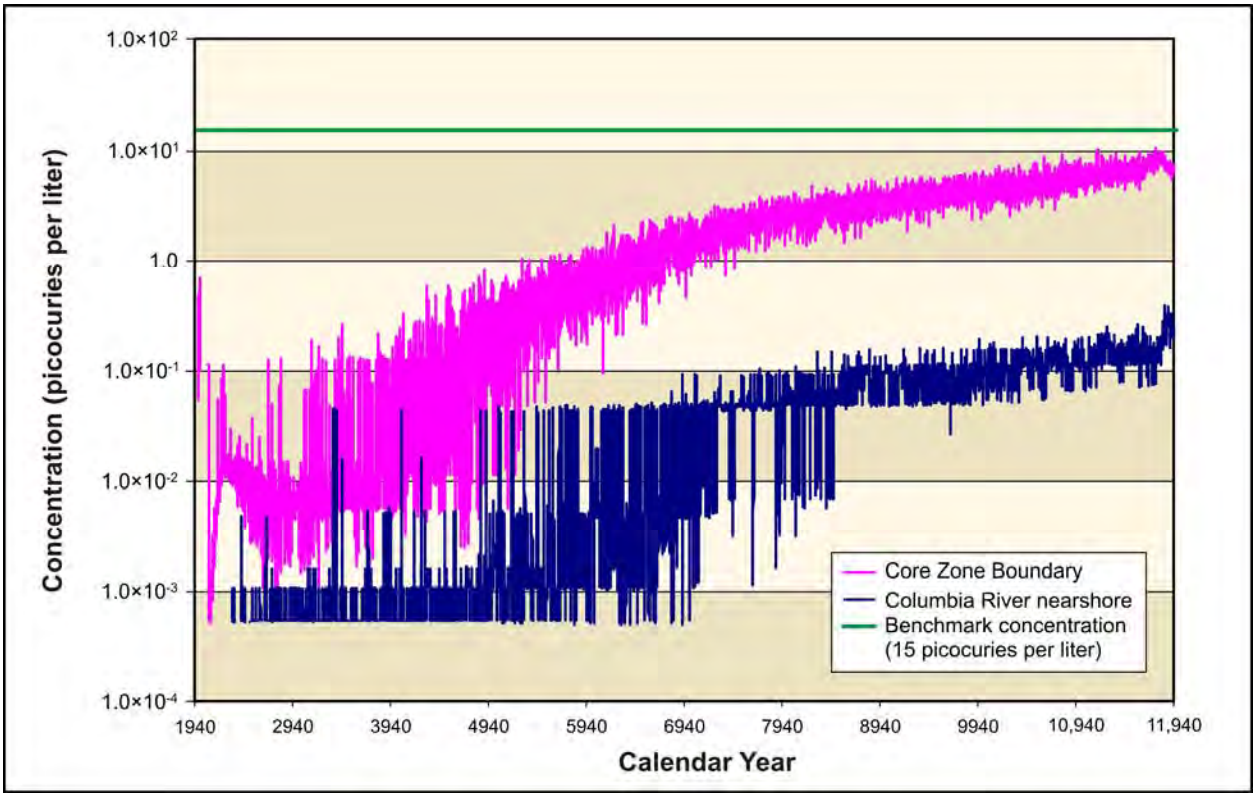


Figure 5–1257. Alternative Combination 3 Uranium-238 Concentration Versus Time

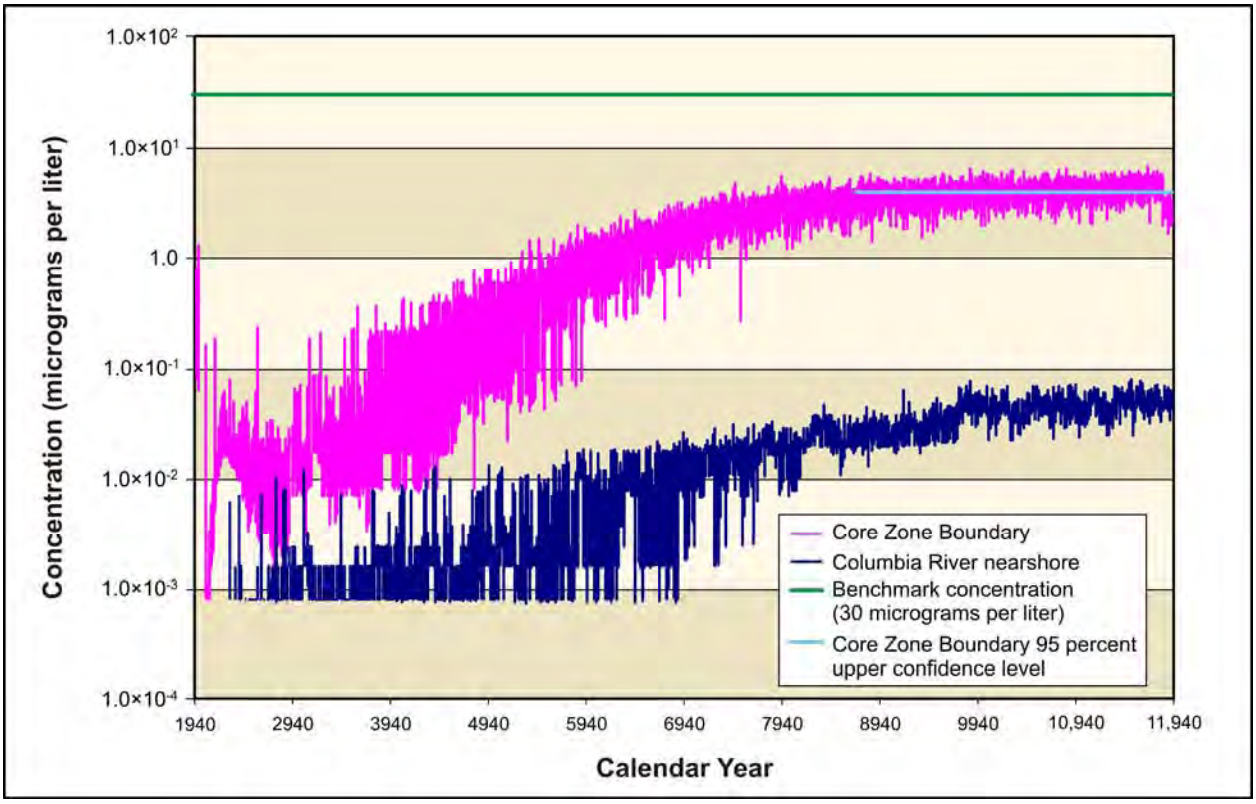


Figure 5–1258. Alternative Combination 3 Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Alternative Combination 3 in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1259 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135.

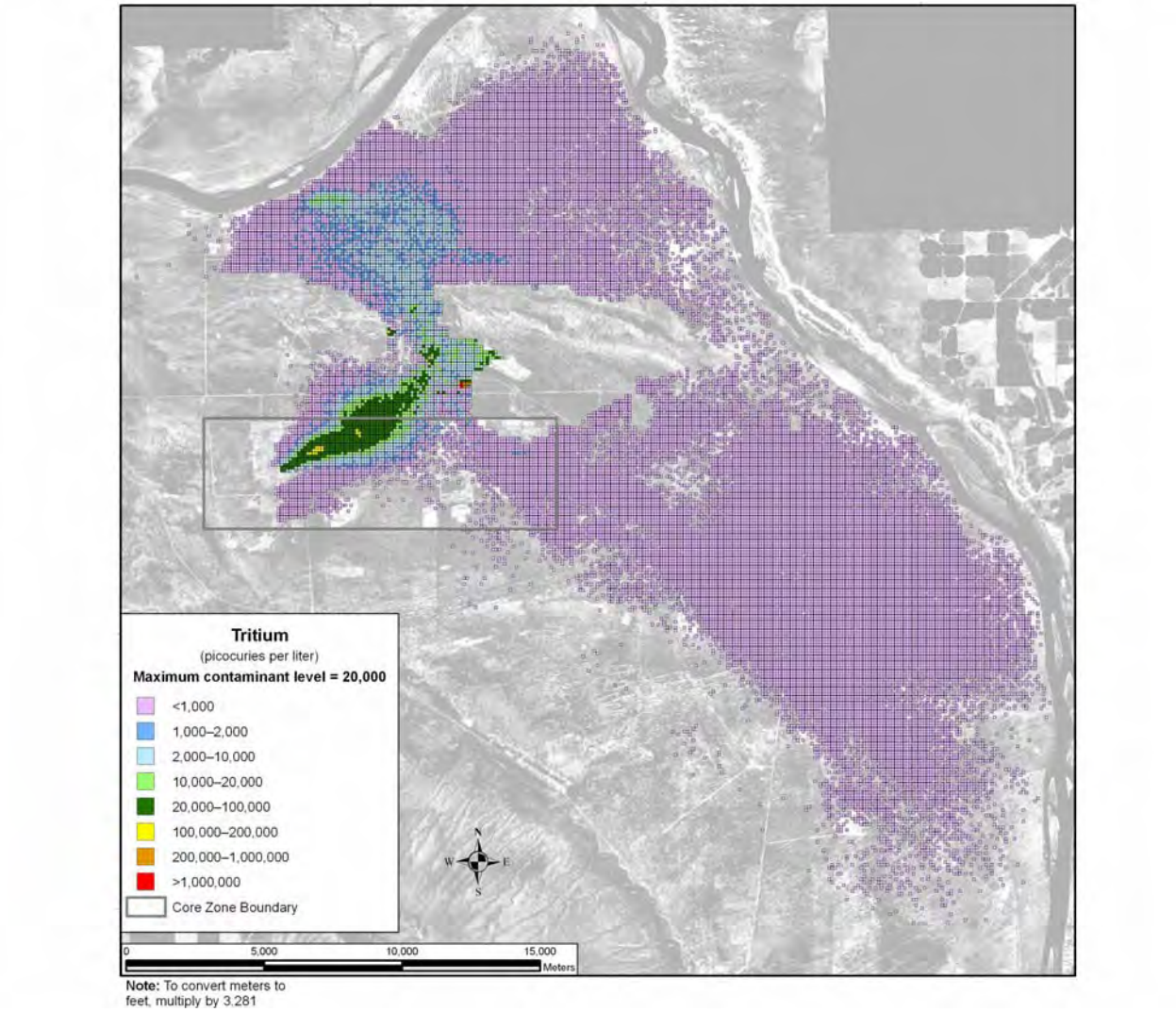


Figure 5–1259. Alternative Combination 3 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

Figure 5–1260 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Around CY 3890, releases from the RPPDF create a rather small plume near the center of the Core Zone, with concentrations less than an order of magnitude below the benchmark (see Figure 5–1261). A comparison of this result against the corresponding distribution for Alternative Combination 1 (see Figure 5–1200) illustrates the reduction in impacts resulting from retrieval of other tank farm sources and from clean closure. By CY 7140, the spatial distribution of the groundwater concentration is driven primarily by waste management sources IDF-East (see Figure 5–1262). The impact is characterized by a plume east of the Core Zone Boundary that exceeds the benchmark concentration by more than an order of magnitude. Because of retention in the waste forms, this impact lasts until the end of the 10,000-year period of analysis (see Figure 5–1263). Figure 5–1264 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. Again, a comparison of this result with the corresponding distribution for Alternative Combination 1 (see Figure 5–1202) illustrates the reduction of impacts resulting from retrieval of other tank farm sources (around CY 4000), but also the increase in impacts

associated with waste management sources, primarily offsite waste (around CY 9000). Figures 5–1265 through 5–1269 show the spatial distribution at the same four times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 is similar to that of iodine-129. The other conservative tracers, chromium (see Figures 5–1270 through 5–1273) and nitrate (see Figures 5–1274 through 5–1277) show similar spatial distributions.

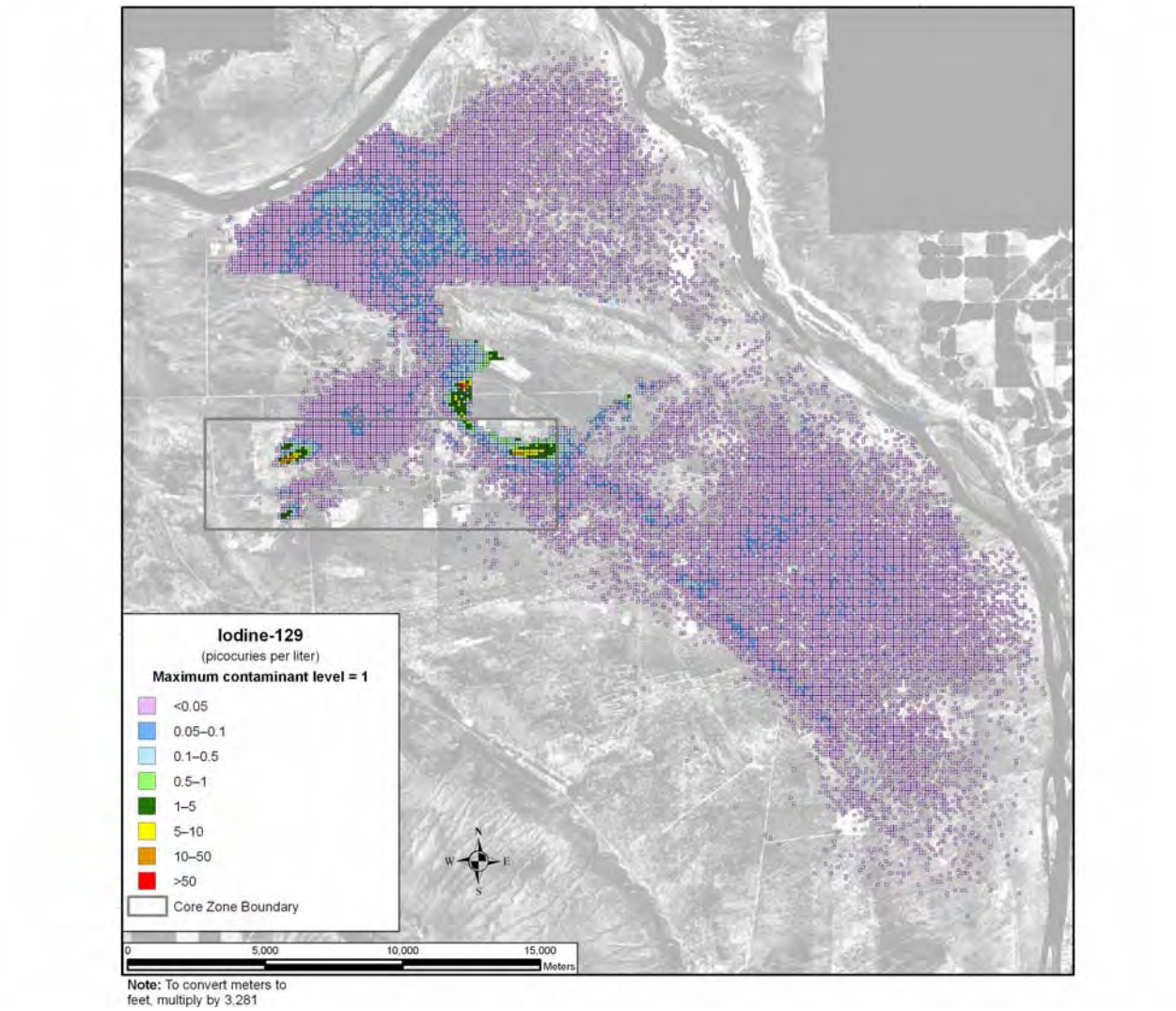
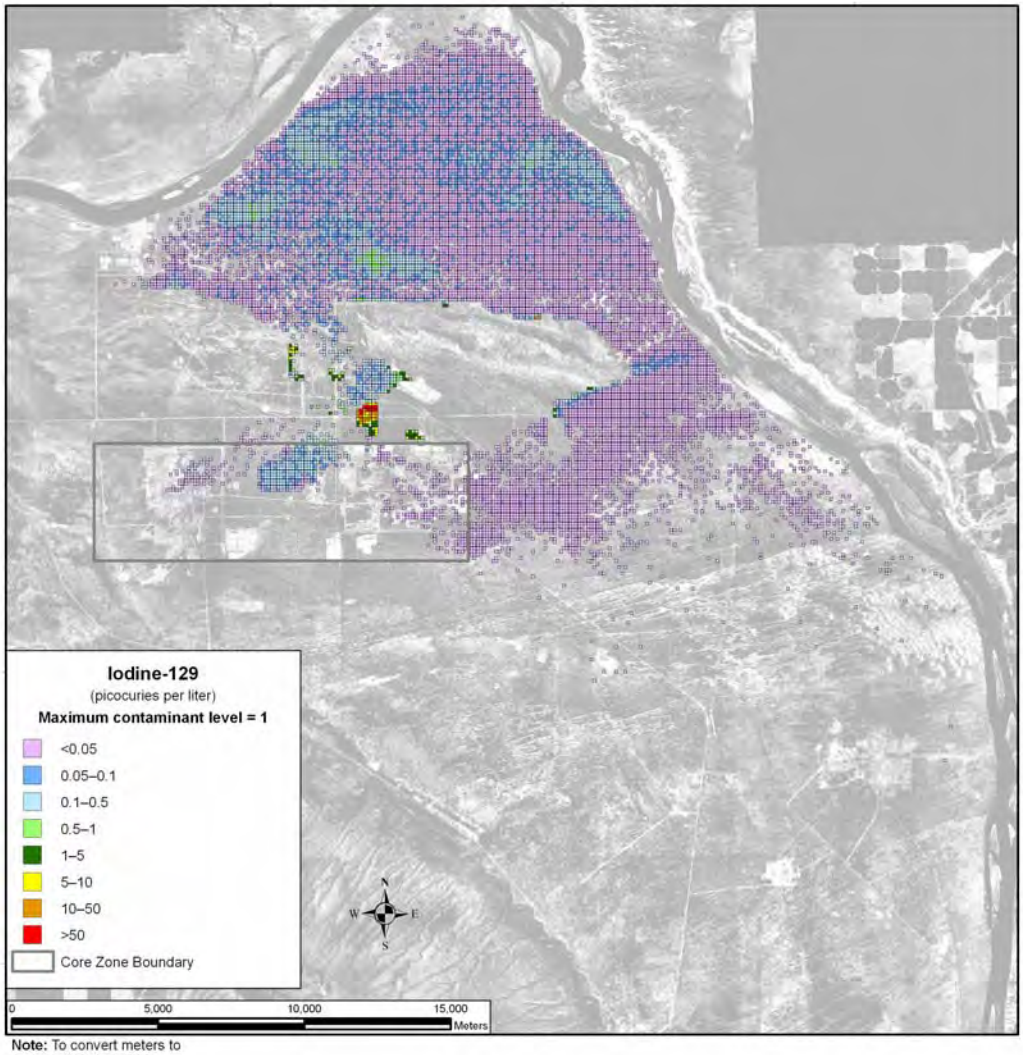


Figure 5–1260. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005



Note: To convert meters to feet, multiply by 3.281

Figure 5–1261. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890

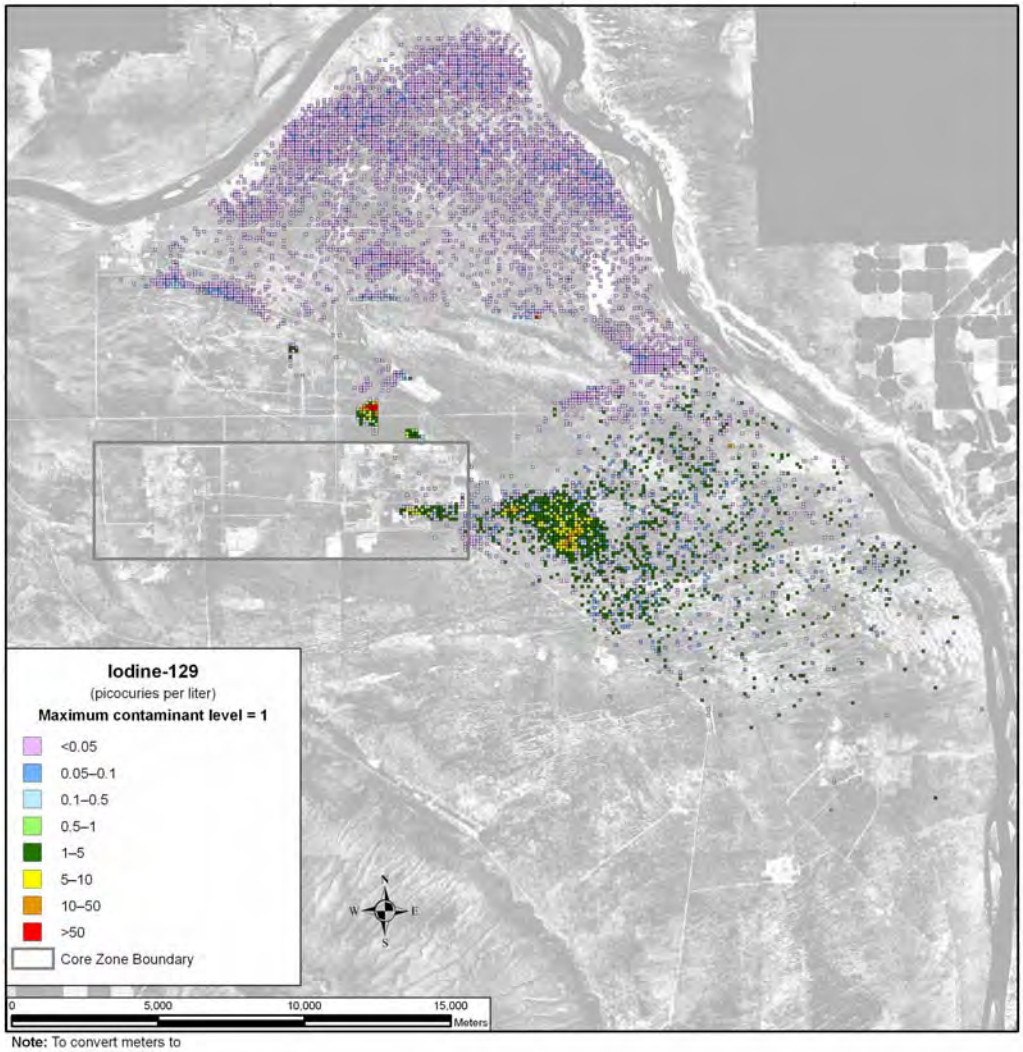


Figure 5–1262. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

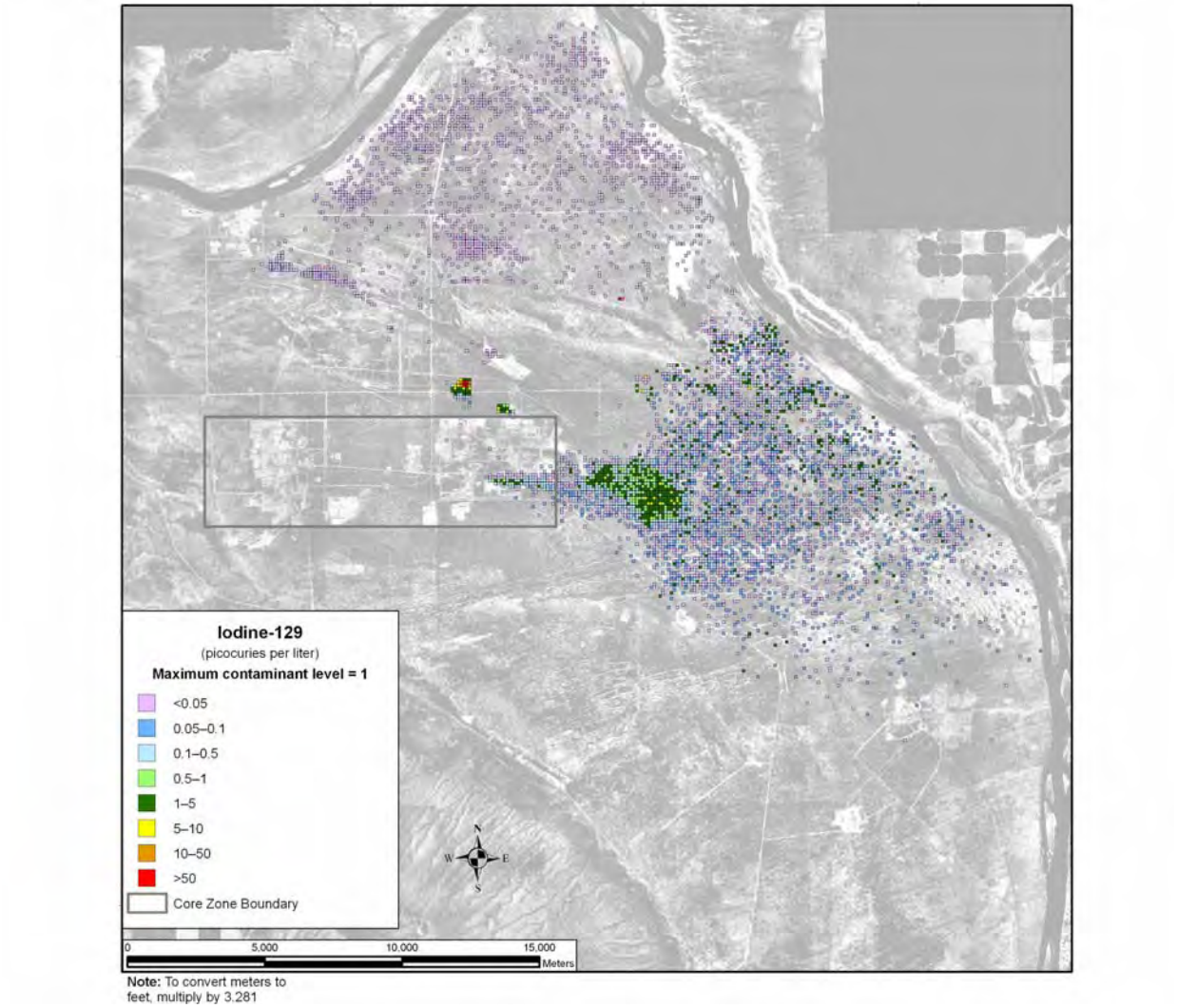


Figure 5–1263. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

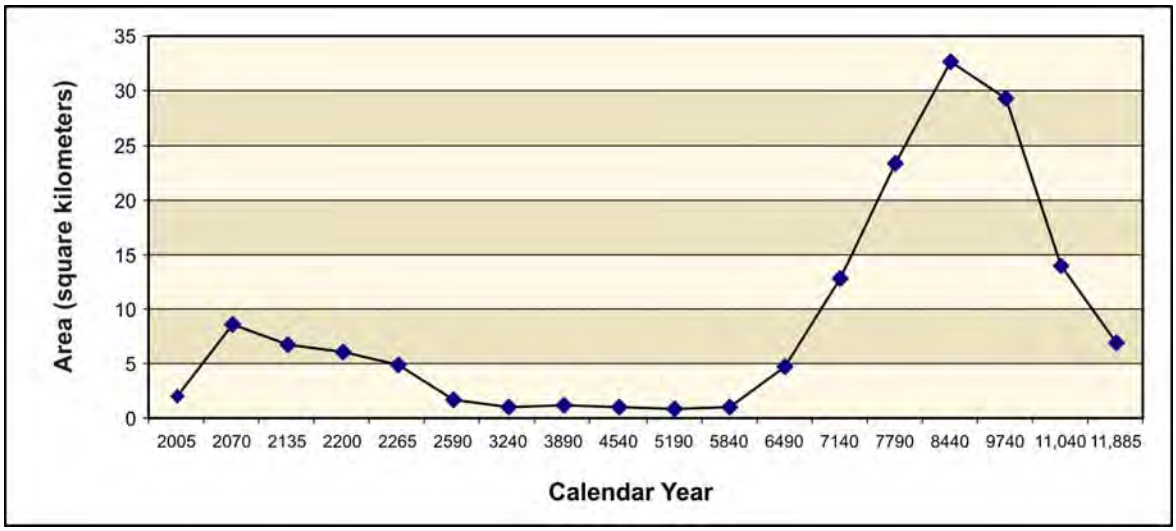


Figure 5–1264. Alternative Combination 3 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

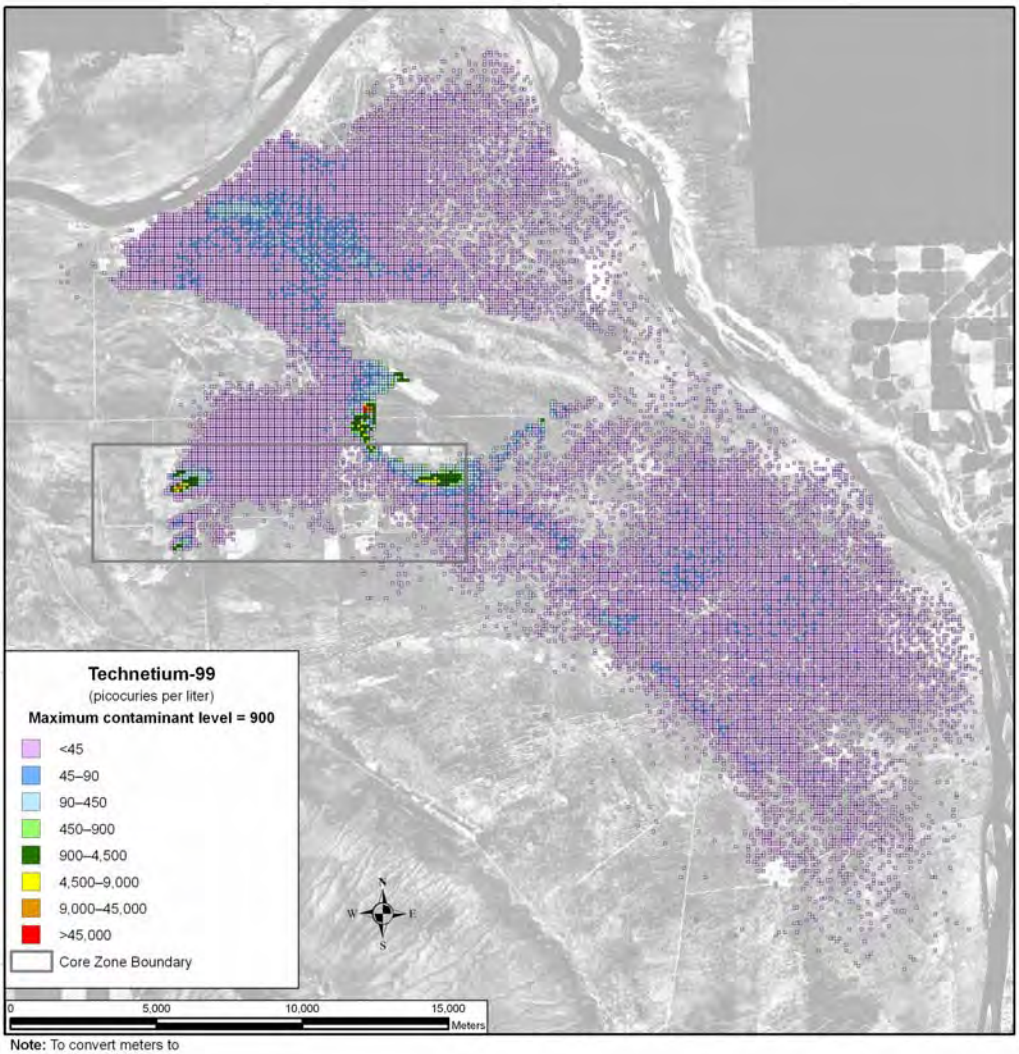


Figure 5–1265. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005

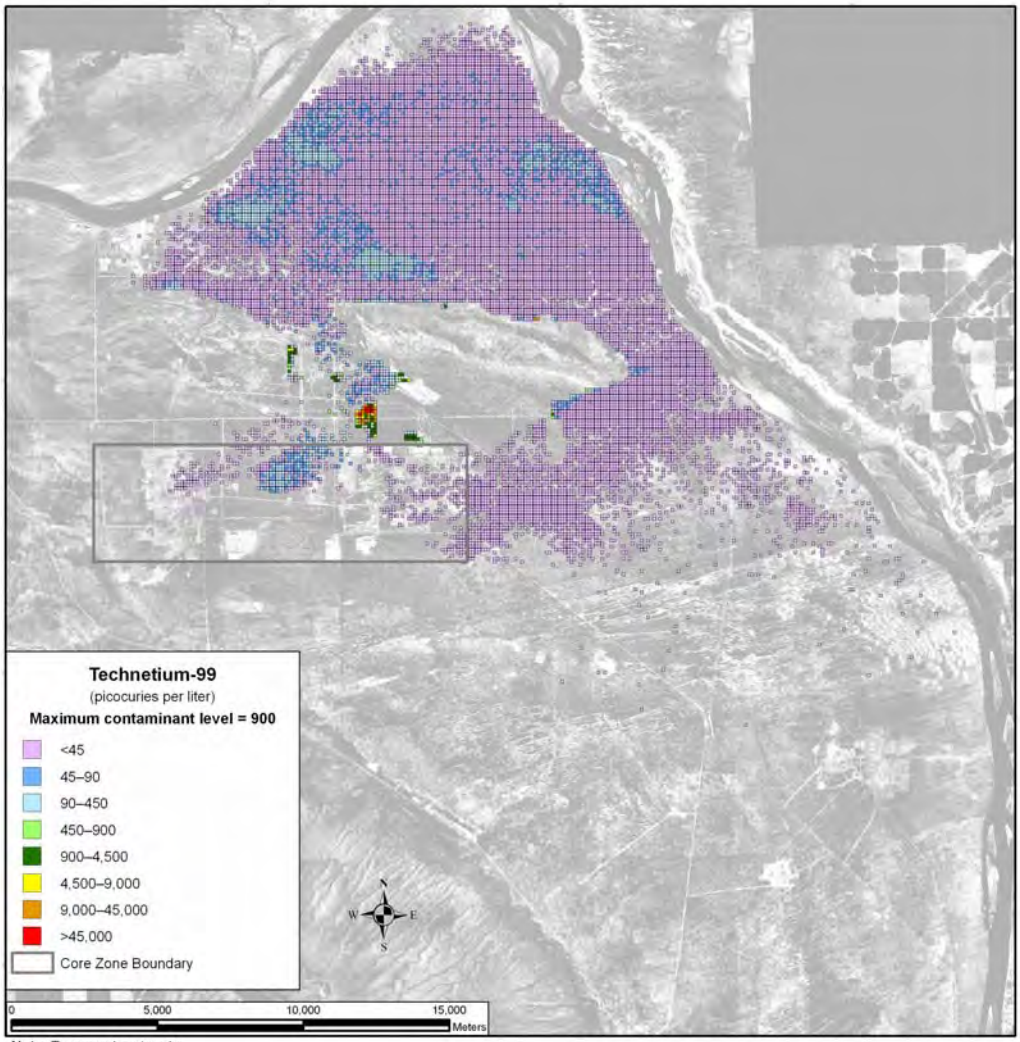


Figure 5–1266. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890

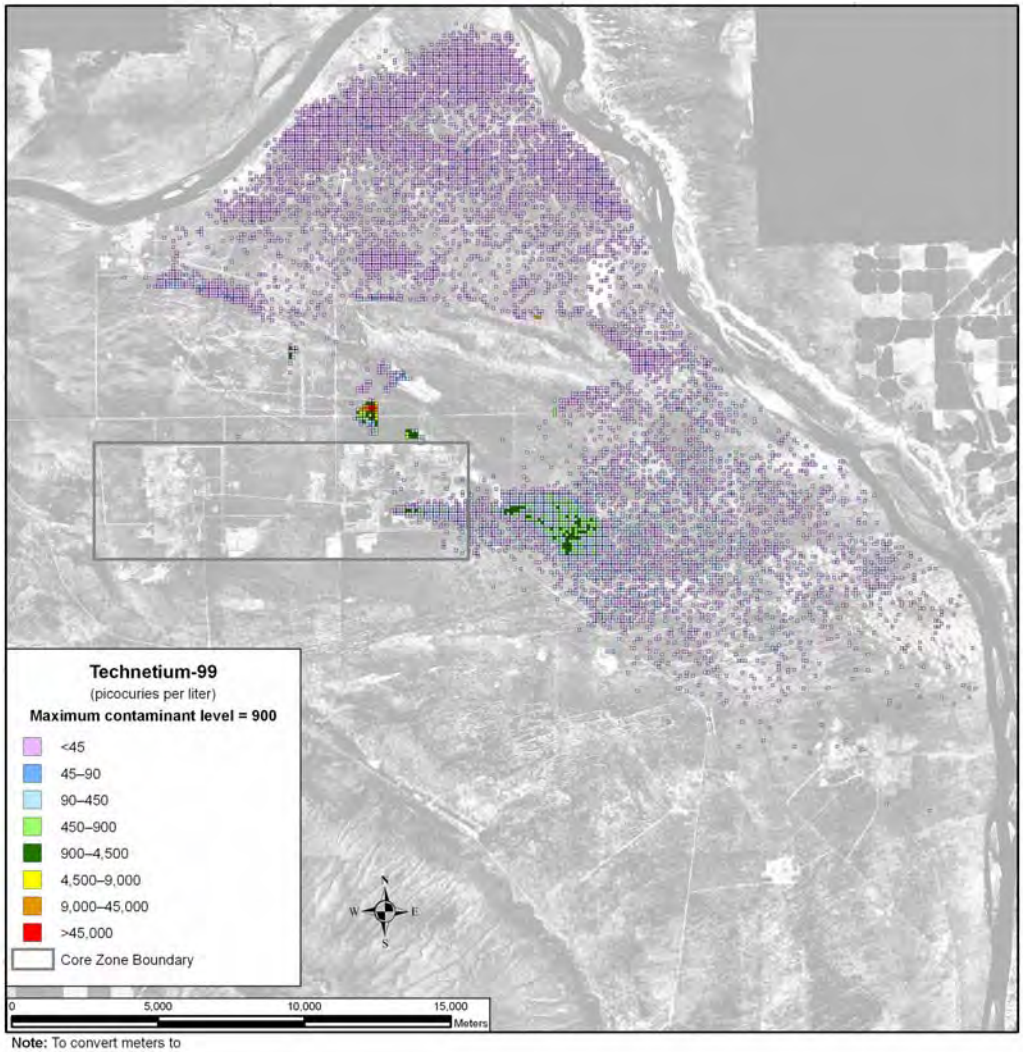


Figure 5–1267. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

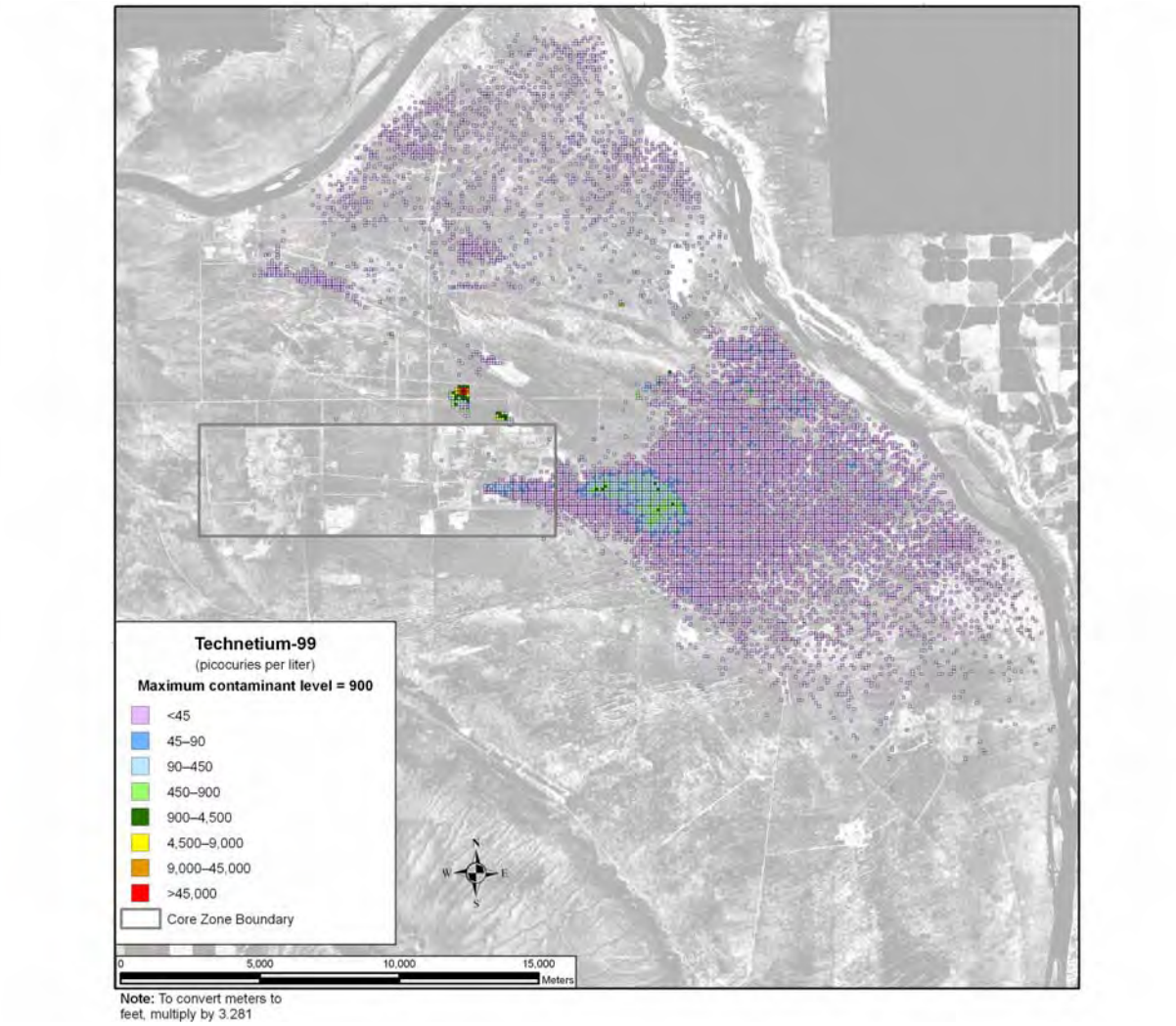


Figure 5–1268. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

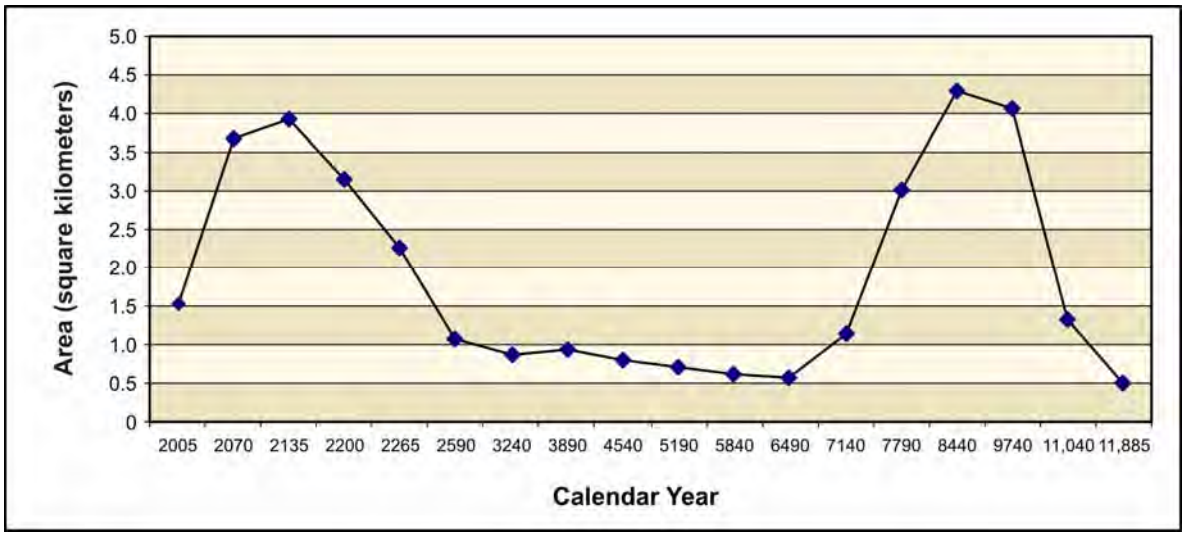


Figure 5–1269. Alternative Combination 3 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

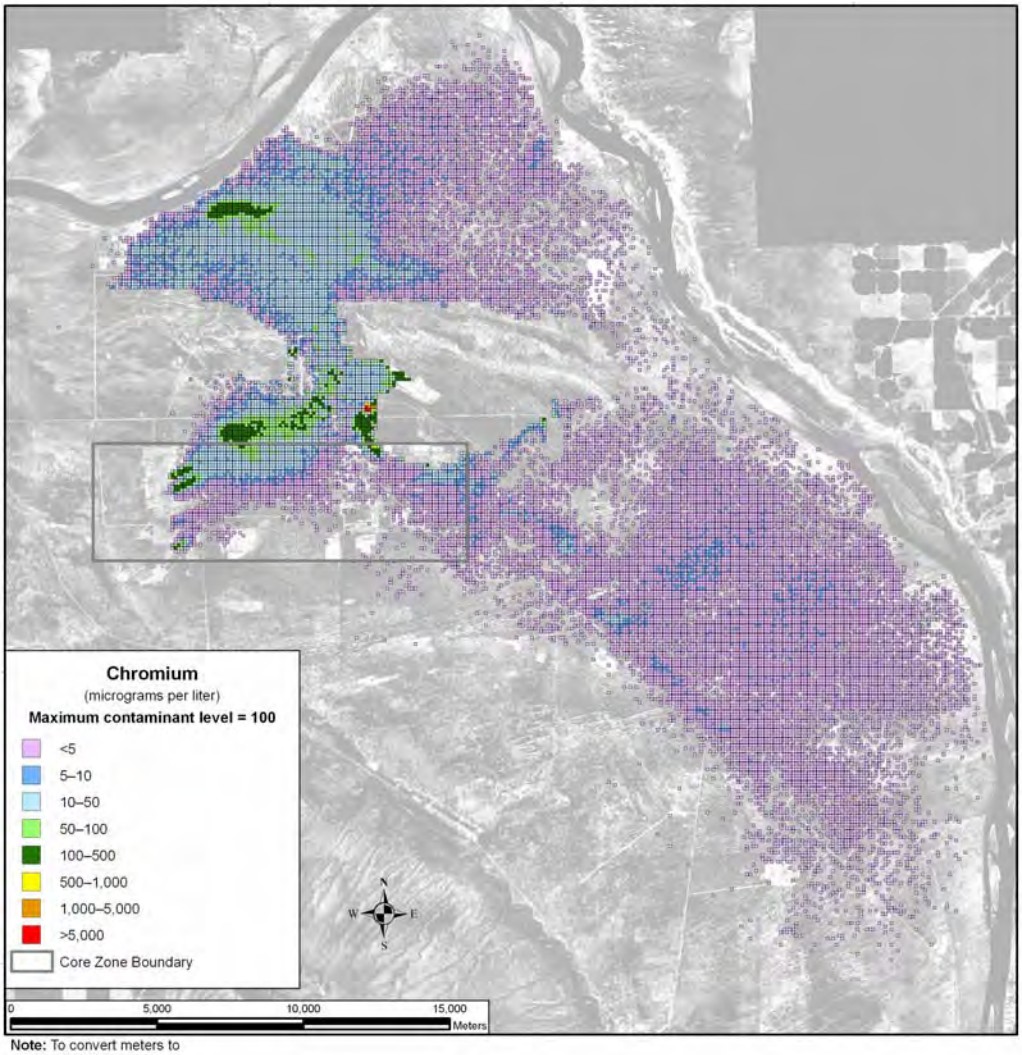
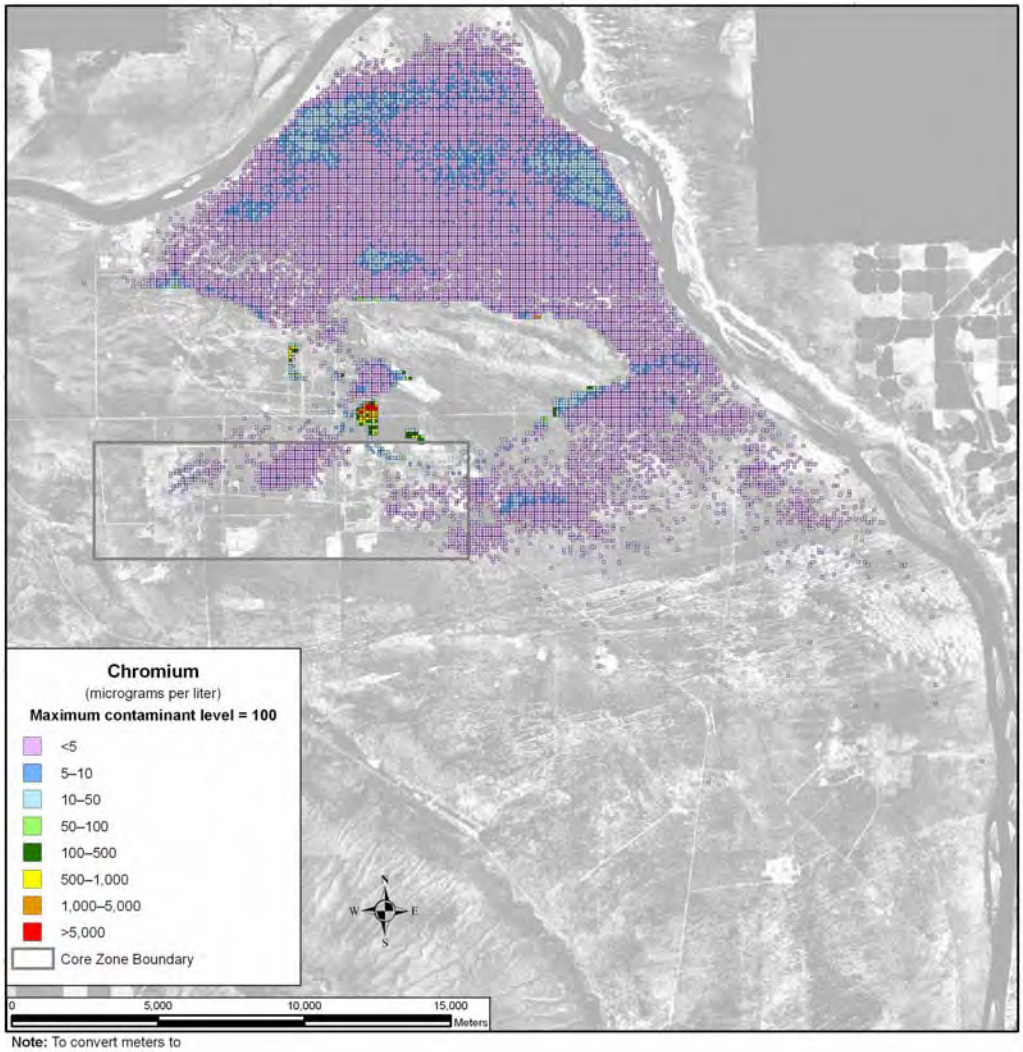


Figure 5–1270. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005



Note: To convert meters to feet, multiply by 3.281

Figure 5–1271. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890

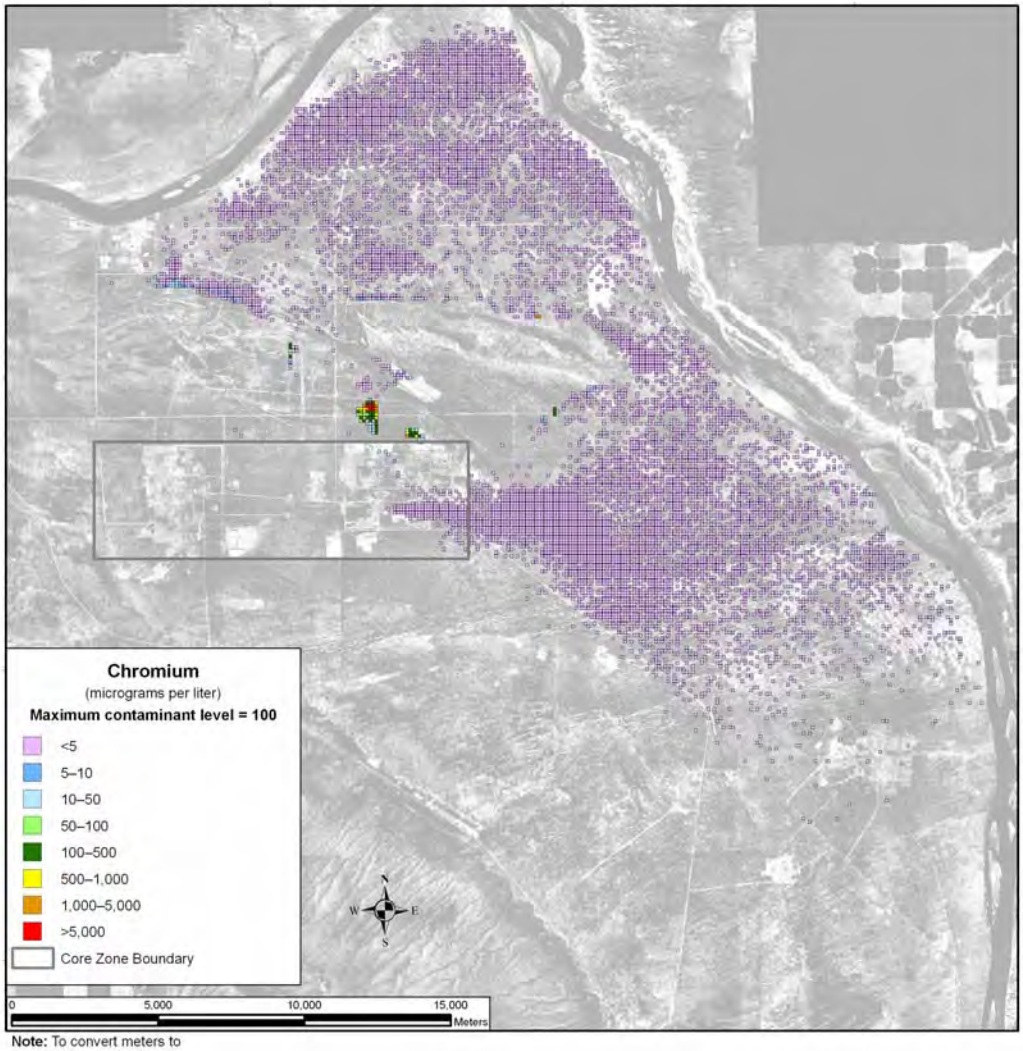


Figure 5–1272. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

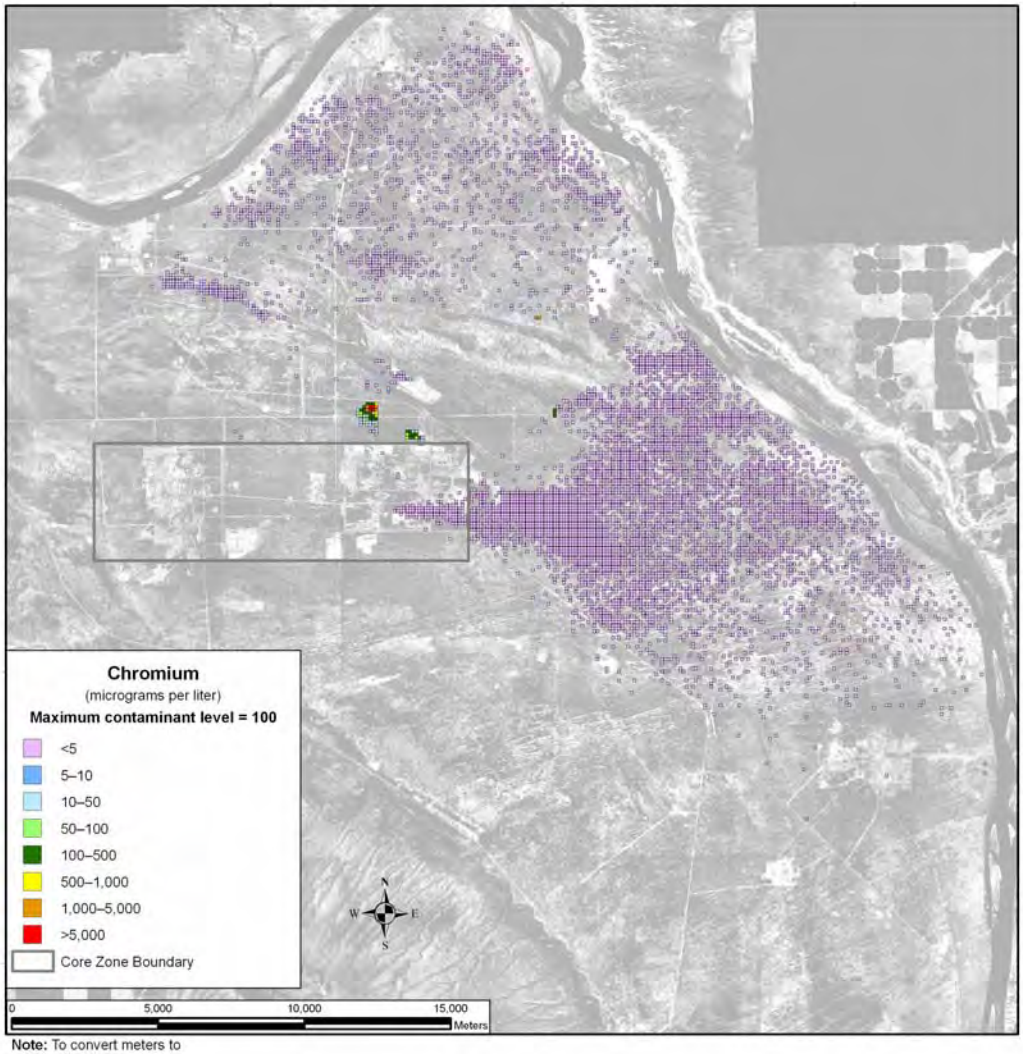


Figure 5–1273. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

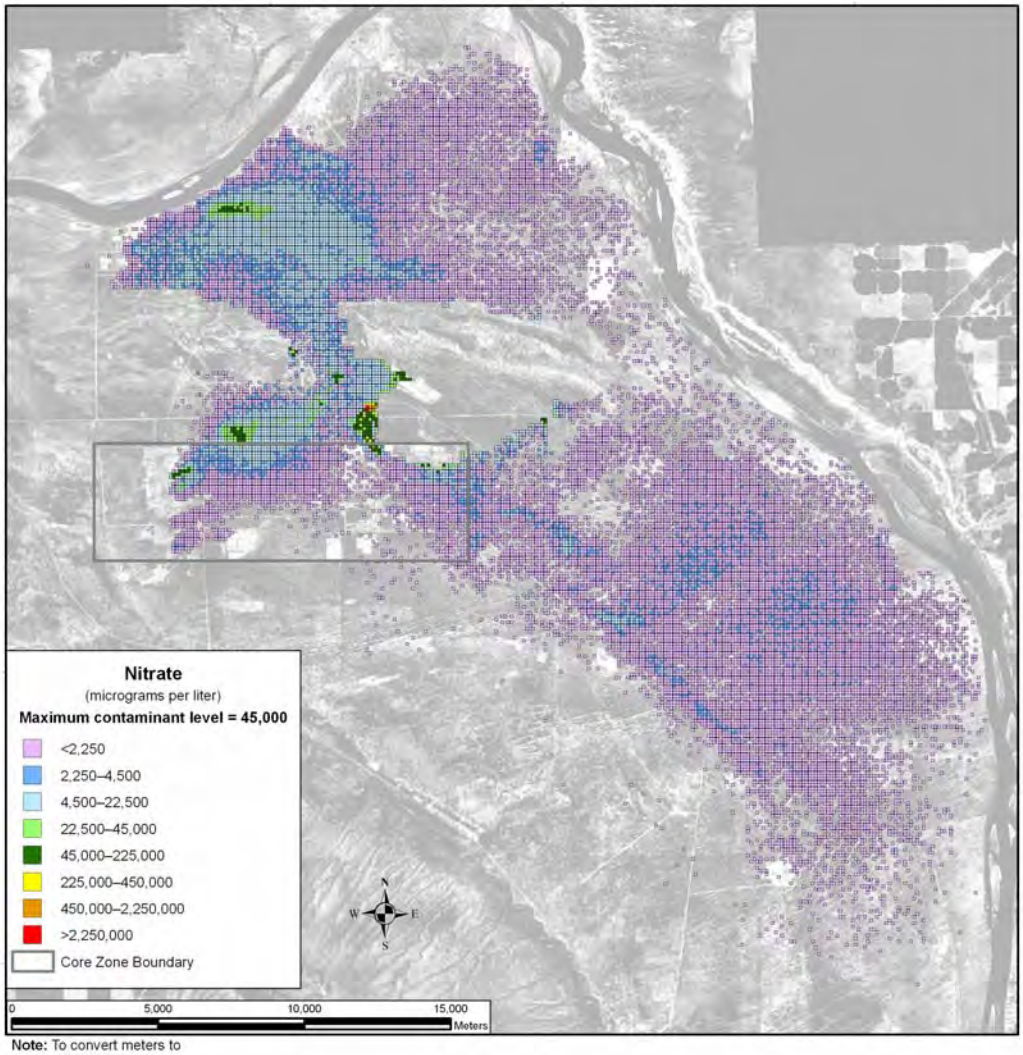


Figure 5–1274. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005

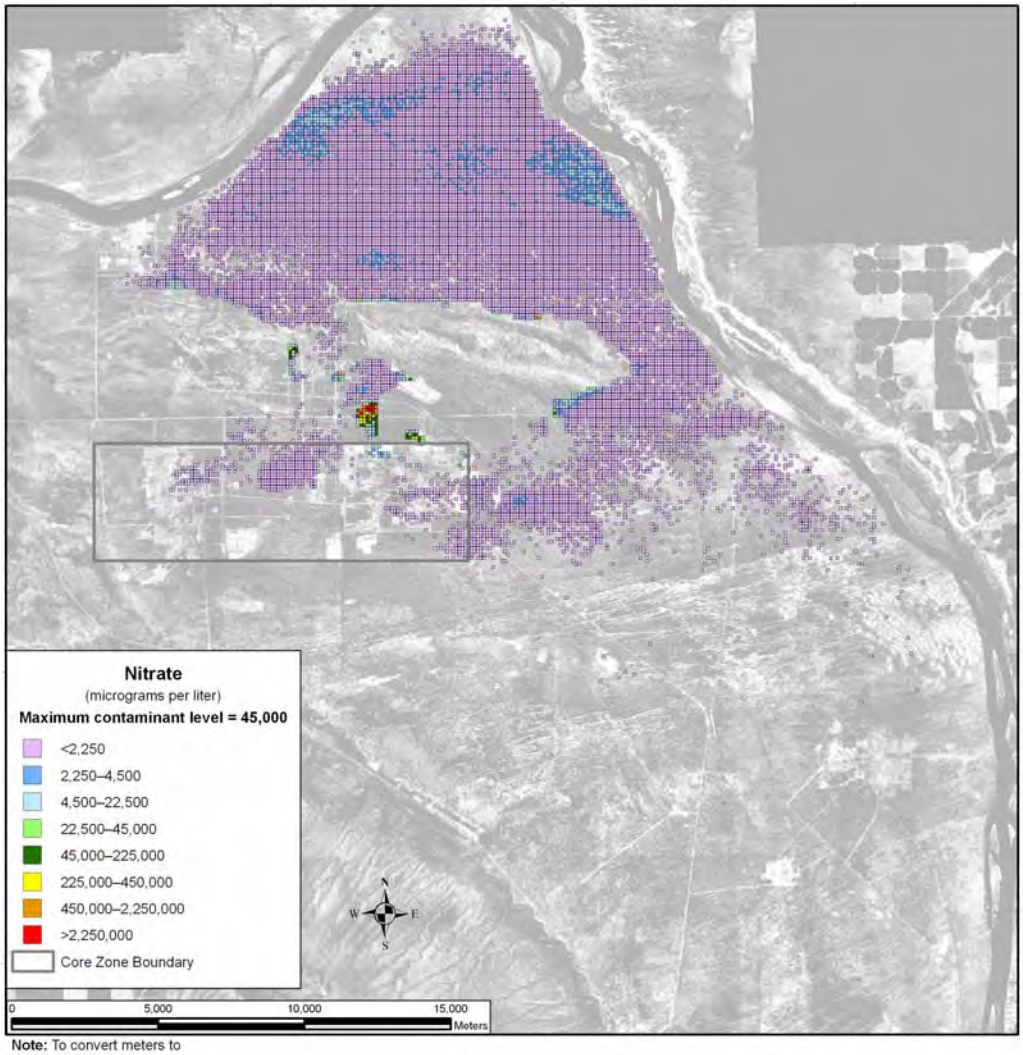


Figure 5–1275. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890

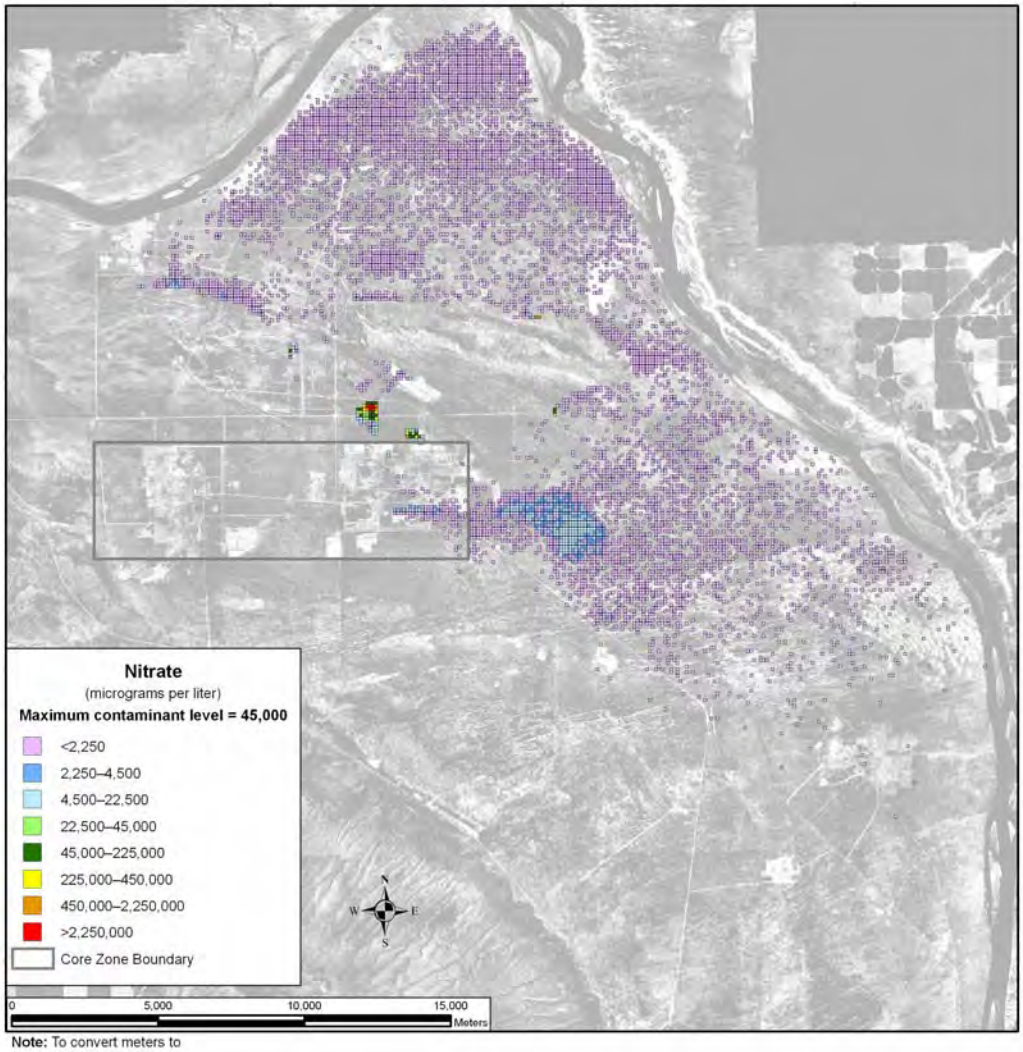


Figure 5–1276. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

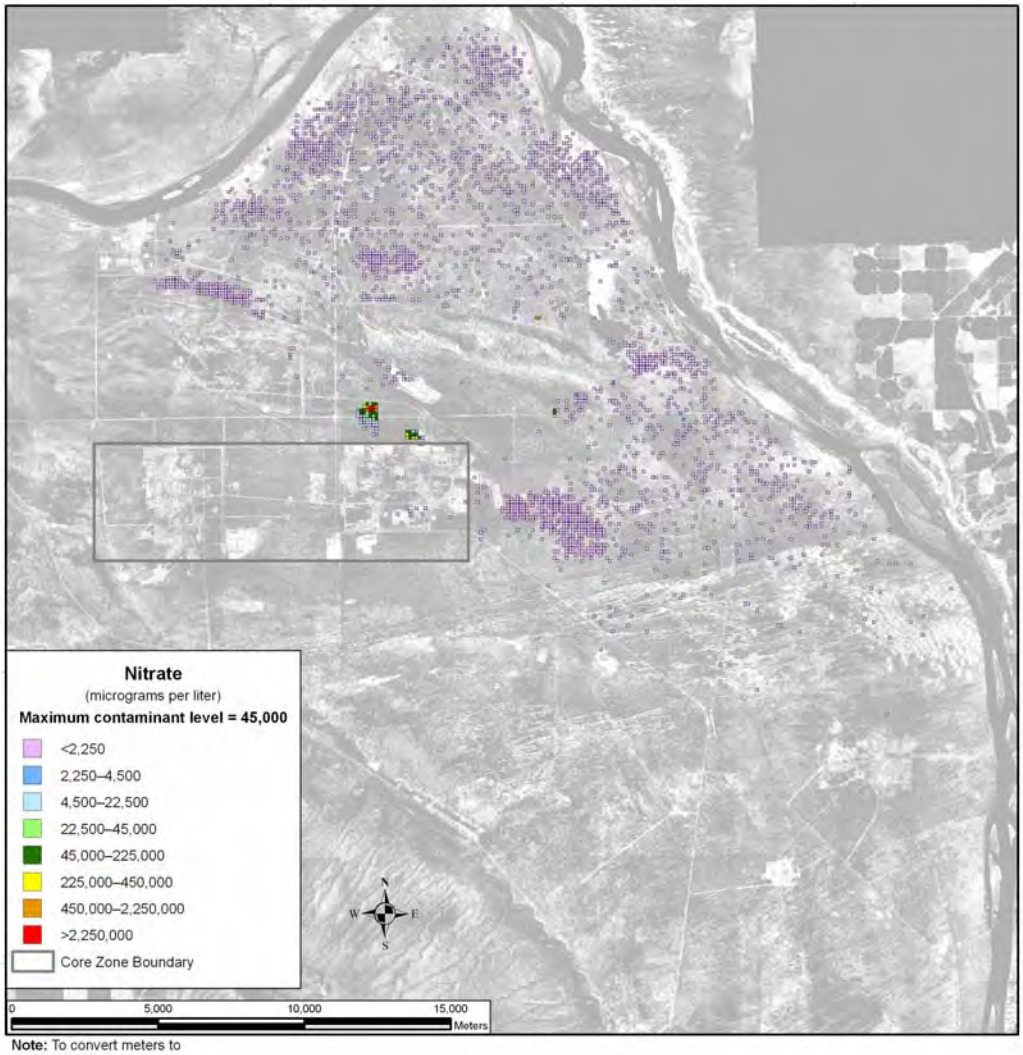


Figure 5–1277. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show different spatial distributions over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1278 shows the distribution of uranium-238 during CY 2135. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark and contained within the Core Zone Boundary. By CY 3890 (see Figure 5–1279), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–1280), the greatest development of the plume during the analysis period is seen. Figure 5–1281 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest near the end of the period of analysis. Figures 5–1282 through 5–1284 show the corresponding spatial distribution for total uranium.

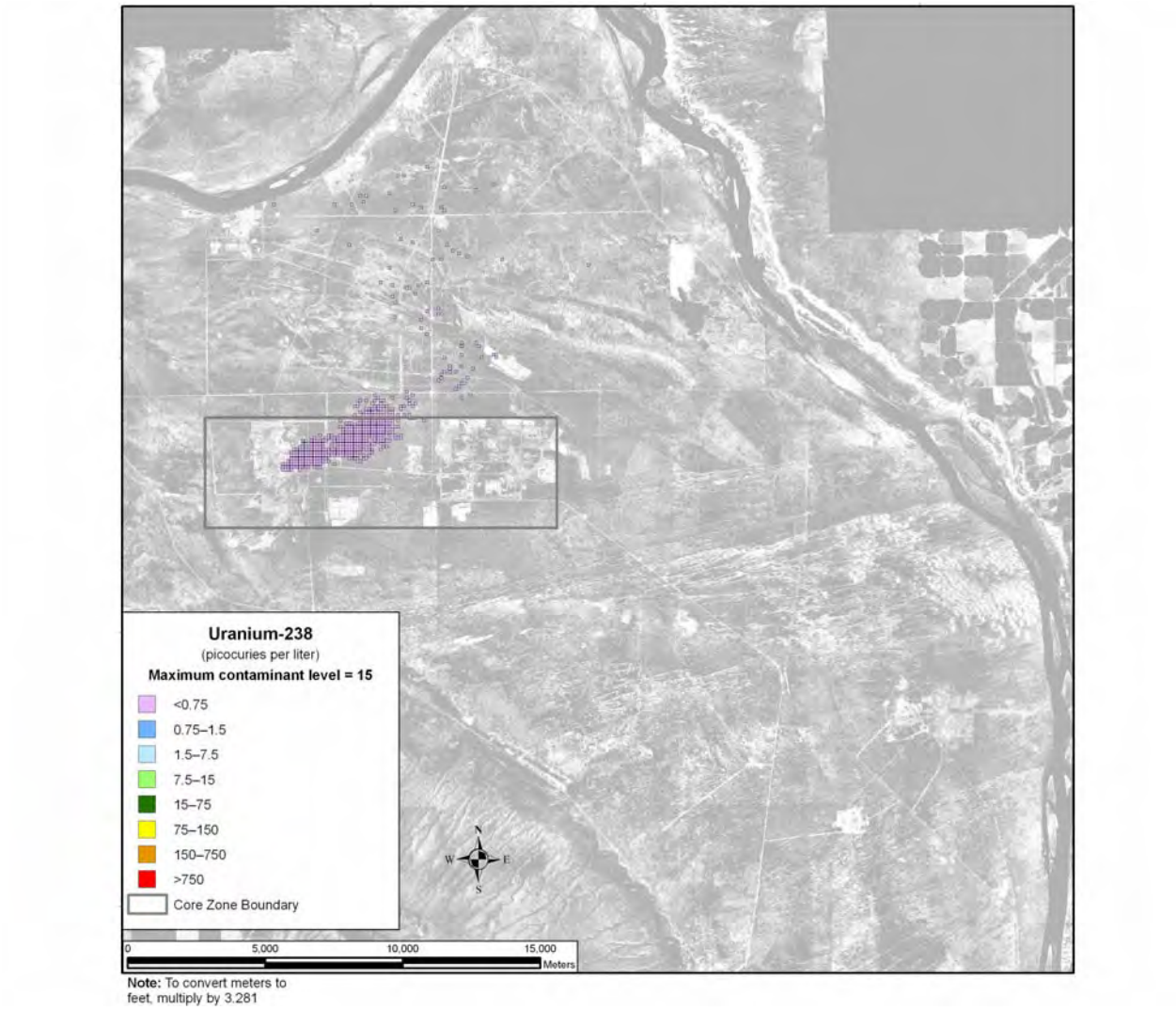


Figure 5–1278. Alternative Combination 3 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135

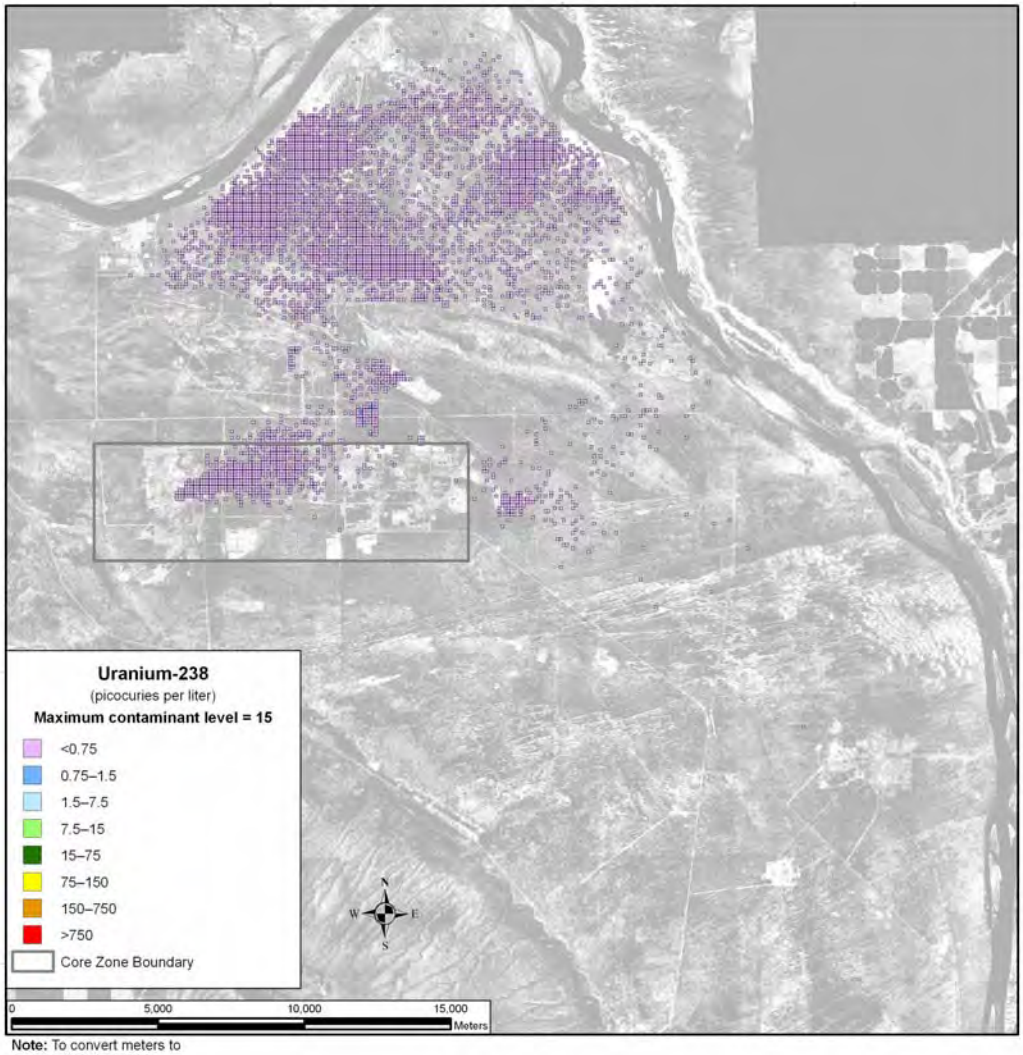


Figure 5–1279. Alternative Combination 3 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890

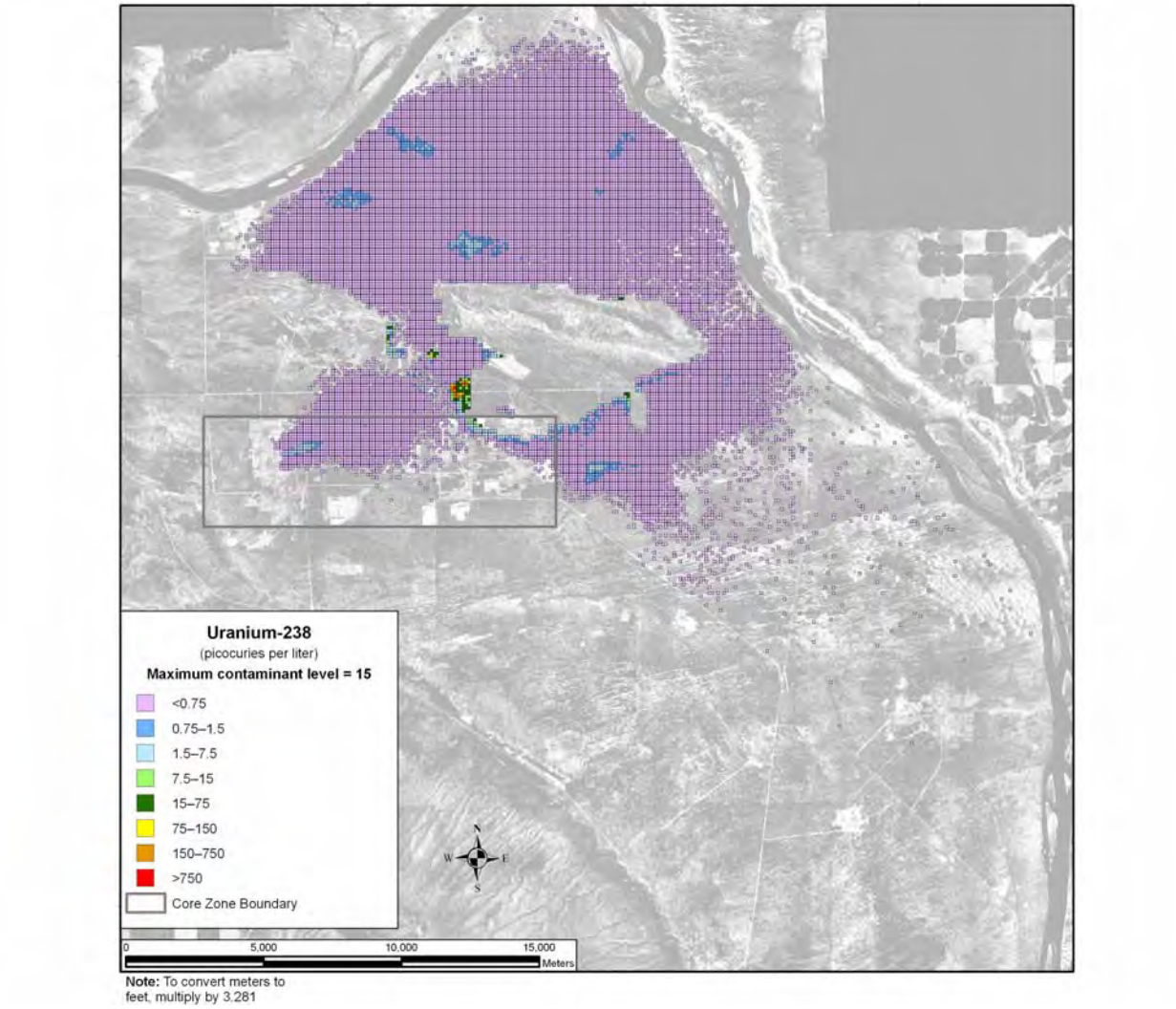


Figure 5–1280. Alternative Combination 3 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

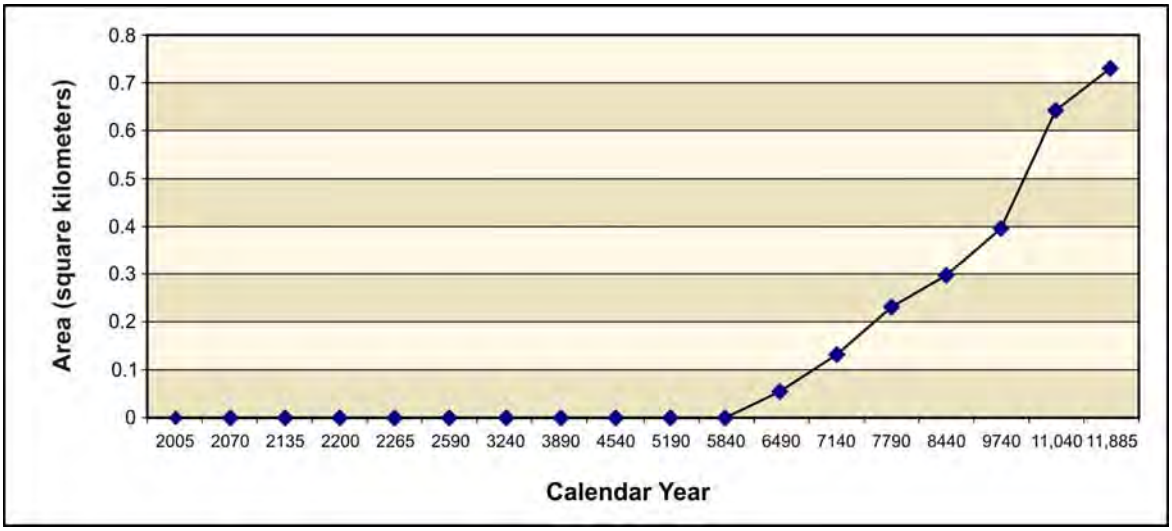


Figure 5–1281. Alternative Combination 3 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

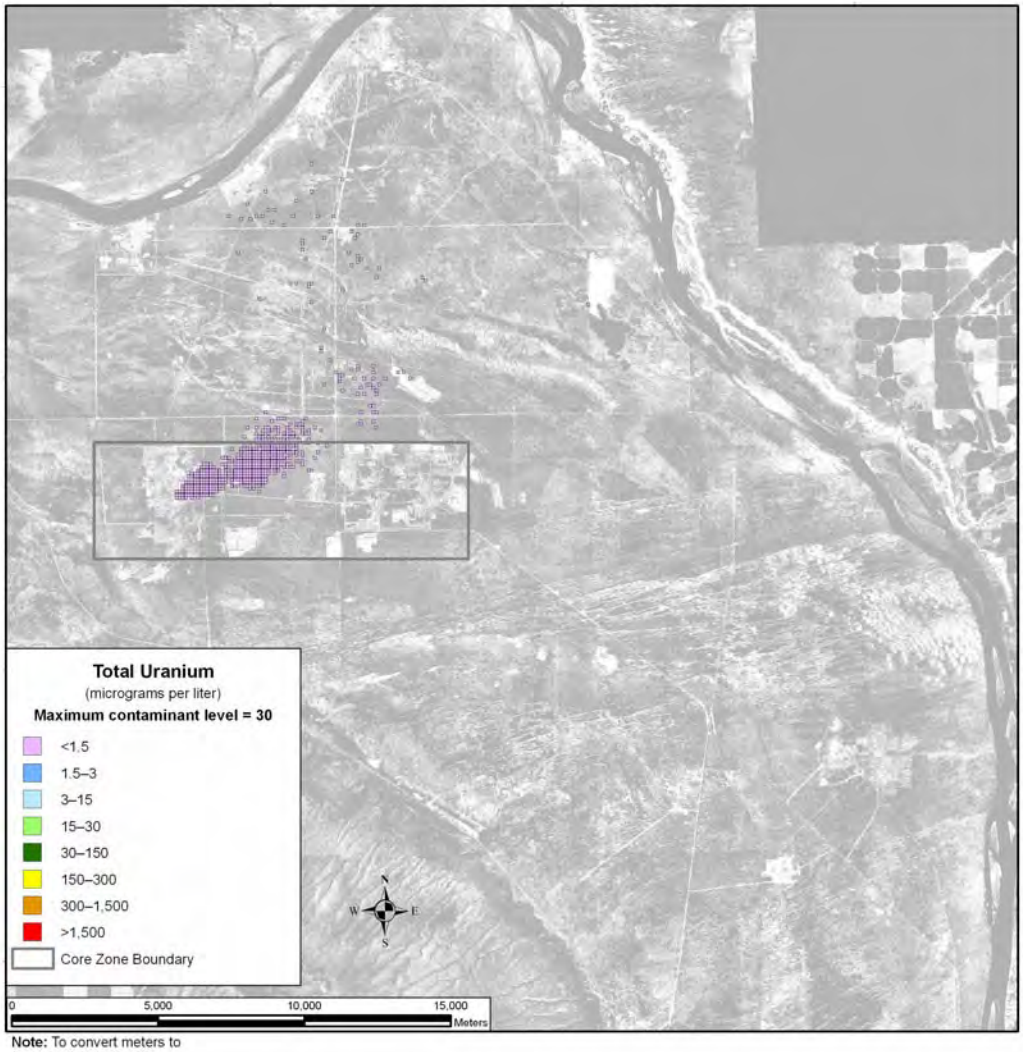


Figure 5–1282. Alternative Combination 3 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135

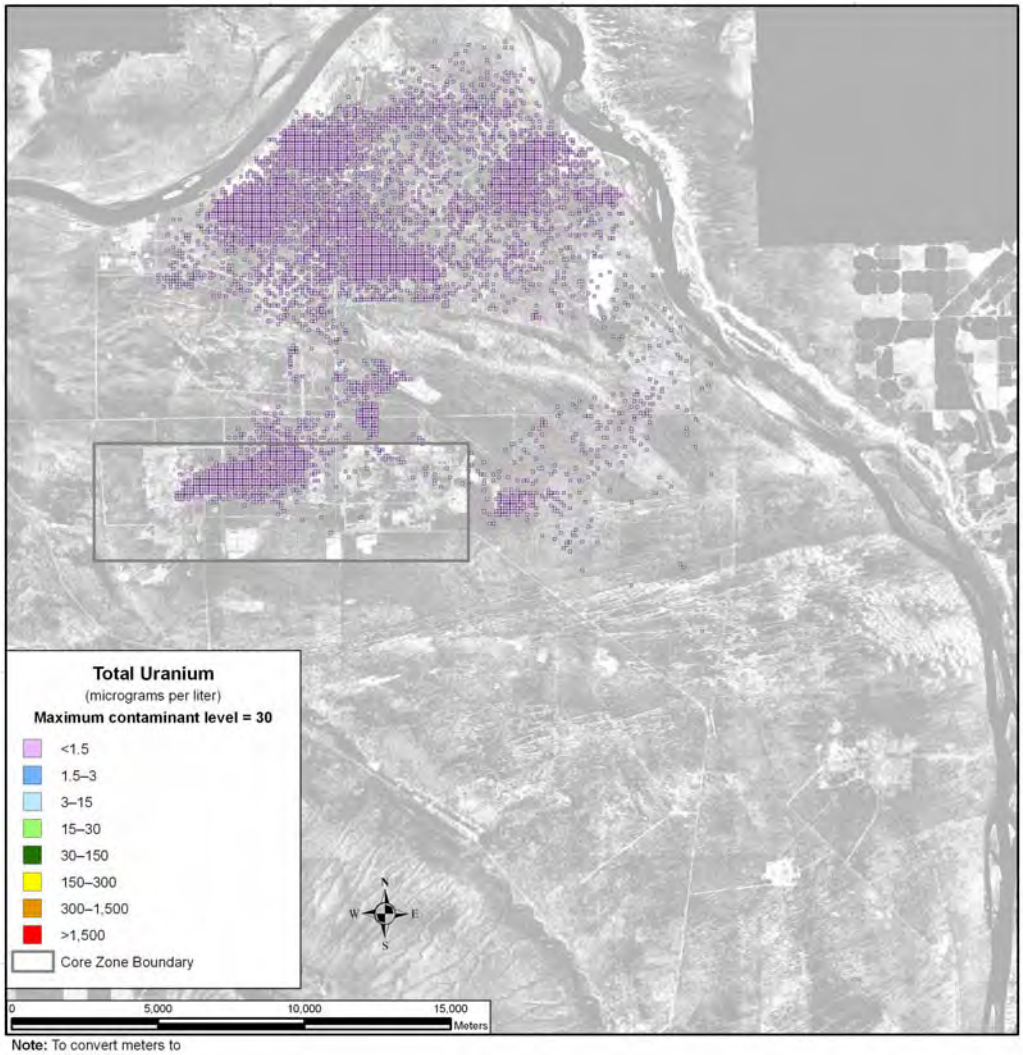


Figure 5–1283. Alternative Combination 3 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890

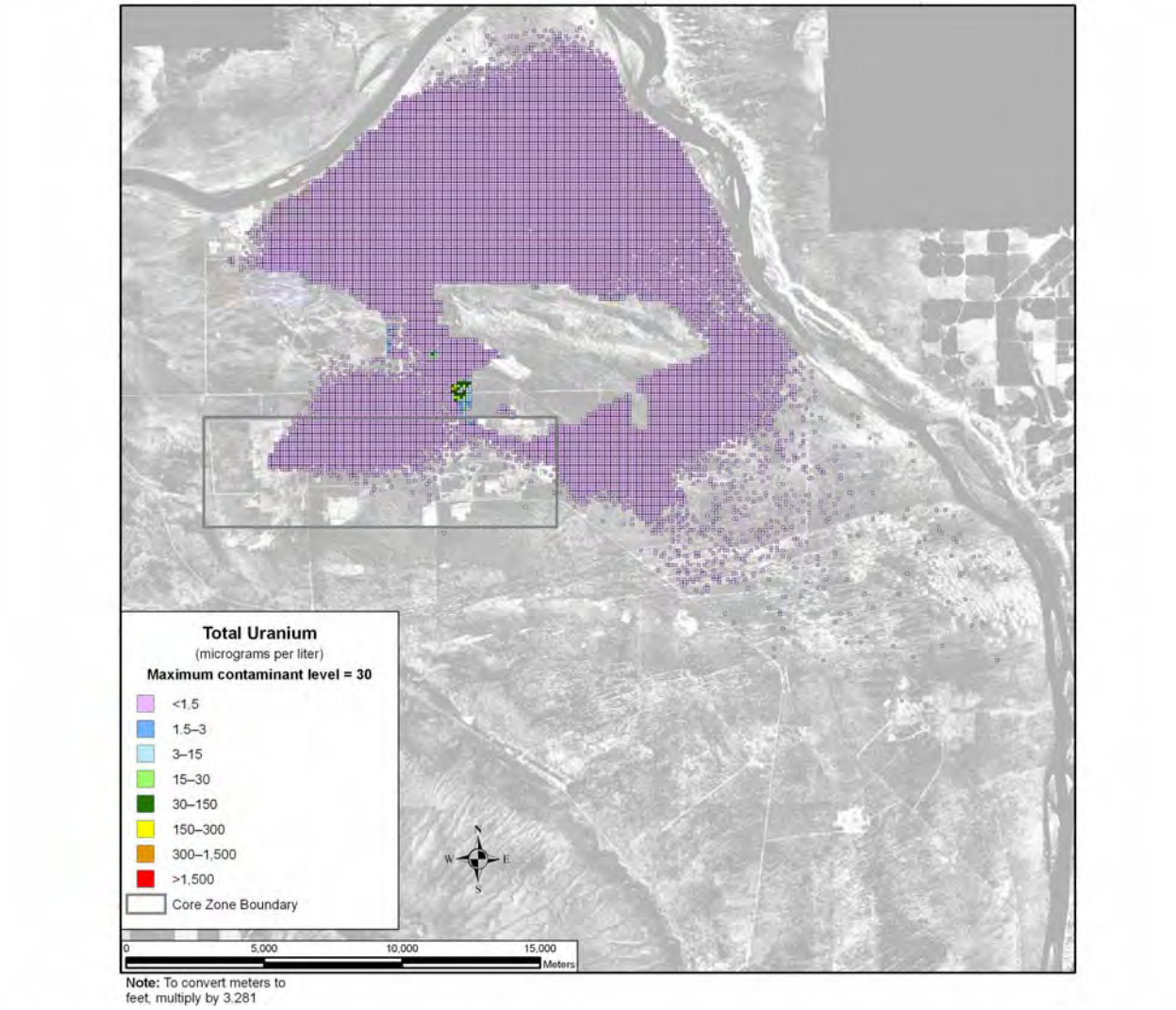


Figure 5–1284. Alternative Combination 3 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

The long-term impacts for Alternative Combination 3 are dominated by tank farm sources (cribs and trenches [ditches] and past leaks) for tritium, uranium-238, chromium, nitrate, and total uranium. The dominant contributors for iodine-129 and technetium-99 are waste management sources, particularly offsite waste disposed of at IDF-East. Contributions from FFTF Decommissioning Alternative 3 sources are essentially negligible.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by an order of magnitude during the first several thousand years of the period of analysis, and concentrations at the Columbia River nearshore are about an order of magnitude lower. For chromium and nitrate, the concentration trend decreases with time past CY 6000. For iodine-129 and technetium-99, the concentration trend is level with respect to time, and concentrations are within an order of magnitude of the benchmark concentration at both the Core Zone Boundary and the Columbia River nearshore. The intensities and areas of these groundwater plumes are highest during the early and later parts of the period of analysis.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River nearshore approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts by tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species approach, but do not exceed, the benchmark at the Core Zone Boundary beyond CY 9000, and remain at least an order of magnitude lower than the benchmark at the Columbia River nearshore after CY 10,000. The intensity is highest and the area of the contamination plume largest near the end of the period of analysis.

5.4.2 Human Health Impacts

This section evaluates long-term impacts on human health as a result of the three combinations of Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Alternative Combination 1 comprises the No Action Alternatives for tank closure (Tank Closure Alternative 1), FFTF decommissioning (FFTF Decommissioning Alternative 1), and waste management (Waste Management Alternative 1). Alternative Combination 2 comprises Tank Closure Alternative 2B; FFTF Decommissioning Alternative 2 (Entombment); and Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A. Alternative Combination 3 comprises Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternative 3 (Removal); and Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

The long-term human health impacts due to release of radionuclides are estimated as dose and lifetime risk of incidence of cancer. Potential human health impacts due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as Hazard Index, the sum of the Hazard Quotients of a group of chemicals.

As with the individual alternatives, four measures of human health impacts are considered in this analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radiological constituents, and Hazard Index from chemical constituents. These measures are calculated for each year for 10,000 years for each receptor at four locations (i.e., facility barriers, Core Zone Boundary, Columbia River nearshore, and Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts as dose and the analysis results that peak risk and peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose.

Onsite locations are the facility barriers, Core Zone Boundary, and Columbia River nearshore. Offsite locations are access points to Columbia River surface water near the site and at population centers downstream of the site. Estimates of concentration of constituents in the Columbia River surface water are used to calculate impacts for both offsite location points of analysis. Total offsite population is 5 million people. Four types of receptor are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses groundwater for drinking water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce the entirety of average

requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking water consumption and consumes both wild plant materials, which use groundwater, and game animals, which use surface water.

The significance of dose impacts is evaluated by comparison with the 100-millirem-per-year all-exposure modes standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.* The level of protection provided for the drinking water pathway is evaluated by comparison with applicable drinking water standards presented in Section 5.1.1. Population doses are compared with the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The significance of noncarcinogenic chemical impacts is evaluated by comparison with a Hazard Index guideline value of unity.

5.4.2.1 Alternative Combination 1

Potential human health impacts of Alternative Combination 1 for the years of peak impact for the time period beginning in CY 1940 are summarized in Tables 5–165 and 5–166. The key radiological constituent contributors to human health risk are tritium, technetium-99, iodine-129, and uranium isotopes. The chemical risk and hazard drivers are acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium. For radionuclides, the dose standard would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the Core Zone Boundary and the Columbia River nearshore location for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 3.39 person-rem per year for the year of maximum impact.

The time series of lifetime radiological risk for the drinking-water well user at the Core Zone Boundary are presented in Figures 5–1285 and 5–1286 for Tank Closure Alternative 1 and Waste Management Alternative 1, respectively. The time series of lifetime radiological risk for the drinking-water well user at the FFTF Barrier is presented in Figure 5–1287 for FFTF Decommissioning Alternative 1. Impacts estimated for FFTF Decommissioning Alternative 1 and Waste Management Alternative 1 are lower than those estimated for Tank Closure Alternative 1 because FFTF has a lower inventory of radiological constituents and Waste Management Alternative 1 considers disposal only of onsite-generated LLW that is not related to tank closure activities. Tank Closure Alternative 1 assumes catastrophic failure of HLW tanks after loss of institutional control, leading to lifetime risk on the order of 0.02 at CY 3800 and long-term risk on the order of 0.002. In addition, planned discharges to cribs and trenches (ditches) and past leaks from tanks produce estimates of a high level of risk for the near-term period and elevated risk extending through the entire long-term period.

Table 5–165. Alternative Combination 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	7.44×10^{2}	5.12×10^{2}	2.26×10^{-2}	2.99×10^{-11}	2.26×10^{-2}	1.73×10^{3}	5.88×10^{2}	7.12×10^{-2}	1.13×10^{-7}	7.12×10^{-2}
Columbia River near shore	1.19×10^{1}	1.88	3.40×10^{-4}	6.19×10^{-13}	3.40×10^{-4}	2.62×10^{1}	1.98	1.07×10^{-3}	6.47×10^{-10}	1.07×10^{-3}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.77×10^{-4}	1.60×10^{-4}	2.76×10^{-8}	3.39×10^{-14}	2.76×10^{-8}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–166. Alternative Combination 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	3.40×10^{3}	1.02×10^{3}	1.54×10^{-1}	5.17×10^{-3}	1.55×10^{-1}	N/A	N/A	N/A	N/A	N/A
Columbia River near shore	5.11×10^{1}	3.10	2.30×10^{-3}	2.97×10^{-5}	2.32×10^{-3}	5.44×10^{-1}	1.14	6.69×10^{-6}	1.48×10^{-5}	1.77×10^{-5}
Off site										
Columbia River	2.61×10^{-3}	2.10×10^{-1}	9.42×10^{-8}	1.56×10^{-9}	9.47×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

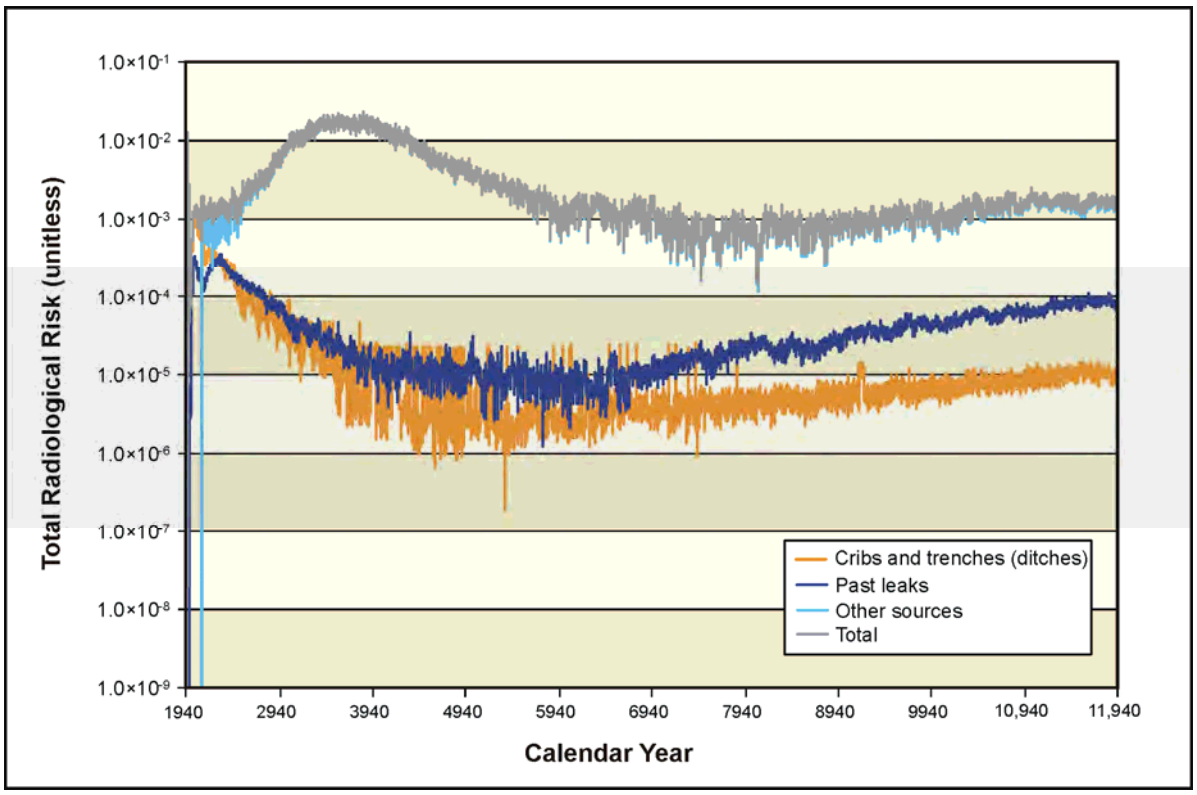


Figure 5–1285. Tank Closure Alternative 1 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

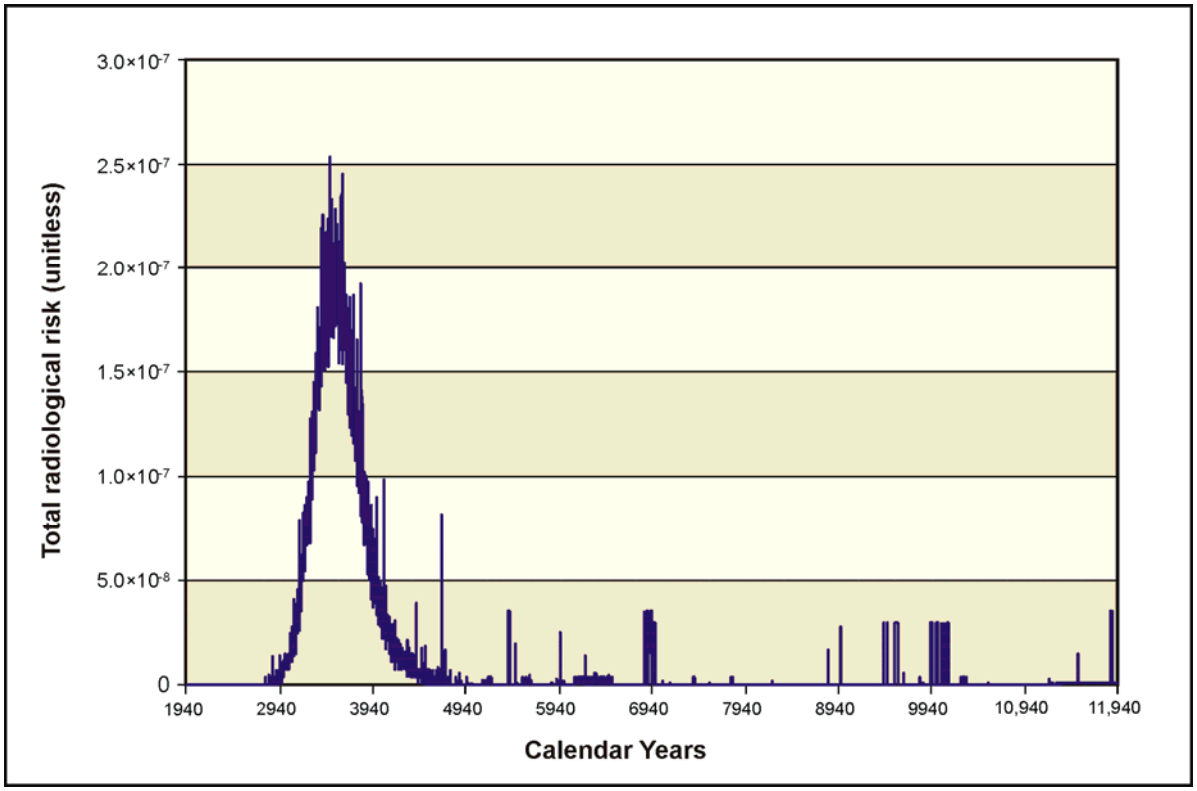


Figure 5–1286. Waste Management Alternative 1 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

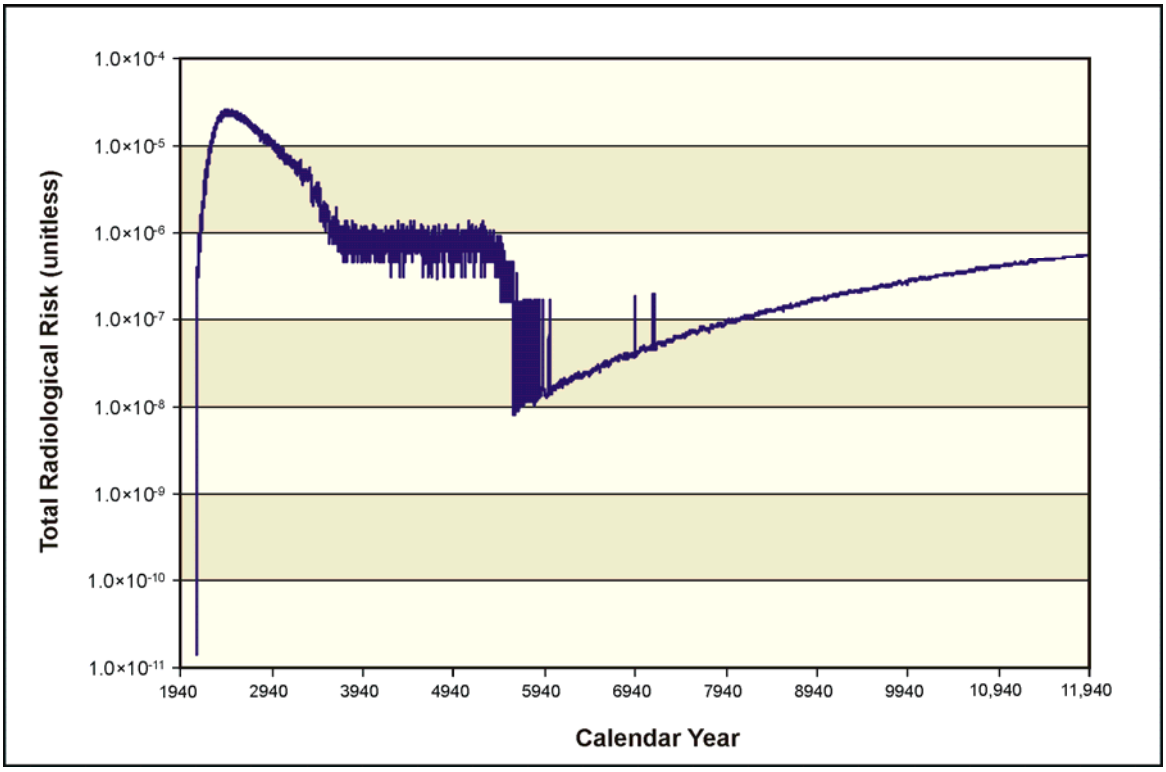


Figure 5–1287. FFTF Decommissioning Alternative 1 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the FFTF Barrier

5.4.2.2 Alternative Combination 2

Potential human health impacts of Alternative Combination 2 for the year of peak impact for the time period beginning in CY 1940 are summarized in Tables 5–167 and 5–168. The key radiological constituent contributors to human health risk are tritium, carbon-14, technetium-99, iodine-129, and uranium isotopes. The chemical risk and hazard drivers are chromium and nitrate. For radionuclides, the dose standard would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 9.53×10^{-1} person-rem per year for the year of maximum impact.

The time series of lifetime radiological risk for the drinking-water well user at the Core Zone Boundary are presented in Figures 5–1288 and 5–1289 for Tank Closure Alternative 2B and Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, respectively. The time series of lifetime radiological risk for the drinking-water well user at the FFTF Barrier is presented in Figure 5–1290 for FFTF Decommissioning Alternative 2. Tank Closure Alternative 2B assumes retrieval of 99 percent of tank waste, producing significant reduction in impacts relative to Tank Closure Alternative 1. Peak lifetime risk due to future releases from the tank farms is reduced by a factor of approximately 100 to 3×10^{-4}. Estimates of impacts for planned discharges to cribs and trenches (ditches) and past leaks from tanks are similar to those for Tank Closure Alternative 1, with estimates of high level of risk, approximately 0.02, for the near-term period and elevated risk extending through the entire long-term period. The estimate of peak lifetime risk at the Core Zone Boundary under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, is approximately 3×10^{-5}. Disposal of offsite waste at IDF-East is the major contributor to this risk, while disposal of ETF-generated, tank closure, and secondary waste account for the remainder of the total risk. The estimate of peak lifetime risk for release from the entombed FFTF is approximately 2×10^{-5}.

Table 5–167. Alternative Combination 2 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	3.26×10^{-14}	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.64	4.35×10^{-1}	5.12×10^{-5}	1.07×10^{-15}	5.12×10^{-5}	4.09	4.70×10^{-1}	1.49×10^{-4}	1.35×10^{-10}	1.49×10^{-4}
Off site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–168. Alternative Combination 2 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.93×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	7.52	7.58×10^{-1}	3.15×10^{-4}	6.17×10^{-6}	3.15×10^{-4}	4.04×10^{-1}	7.14×10^{-1}	4.98×10^{-6}	3.09×10^{-6}	6.40×10^{-6}
Off site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

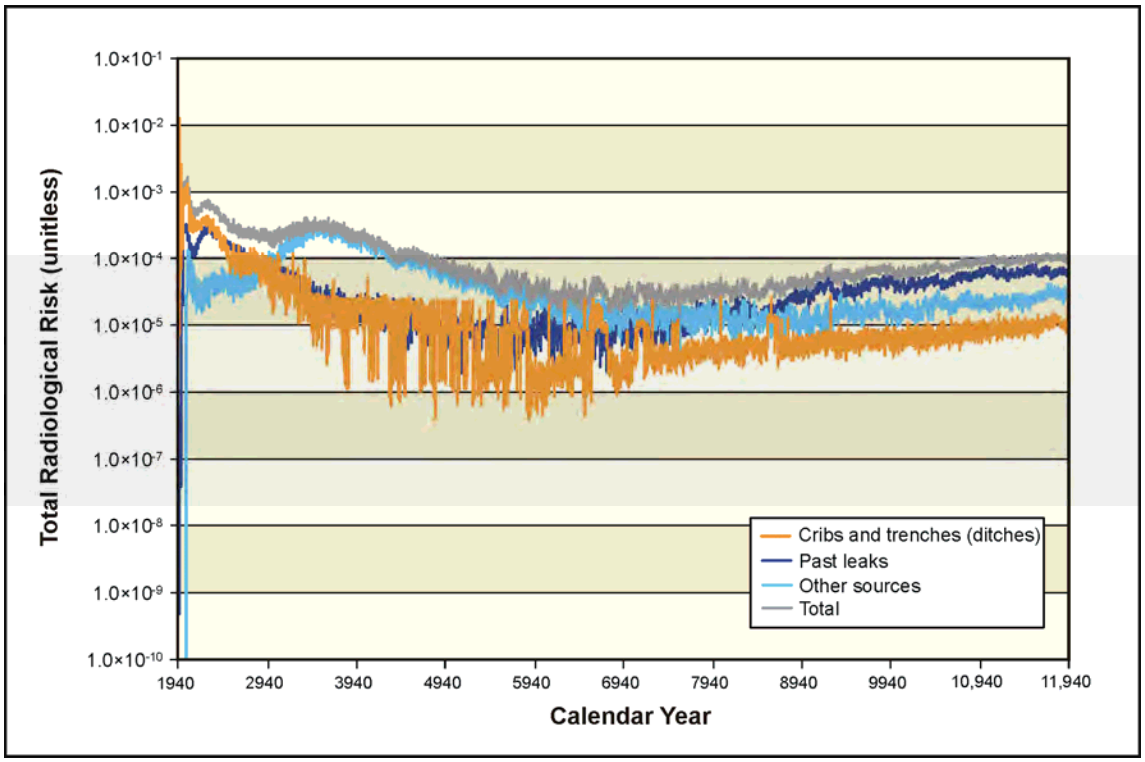


Figure 5–1288. Tank Closure Alternative 2B Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

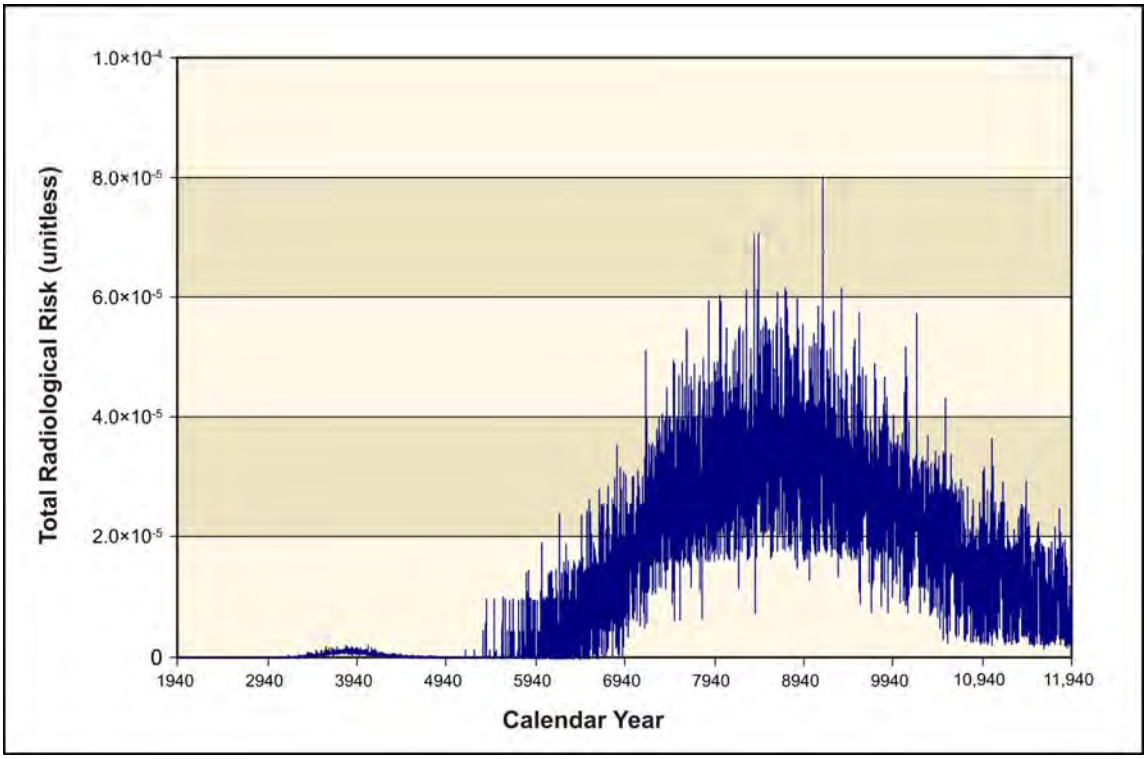


Figure 5–1289. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

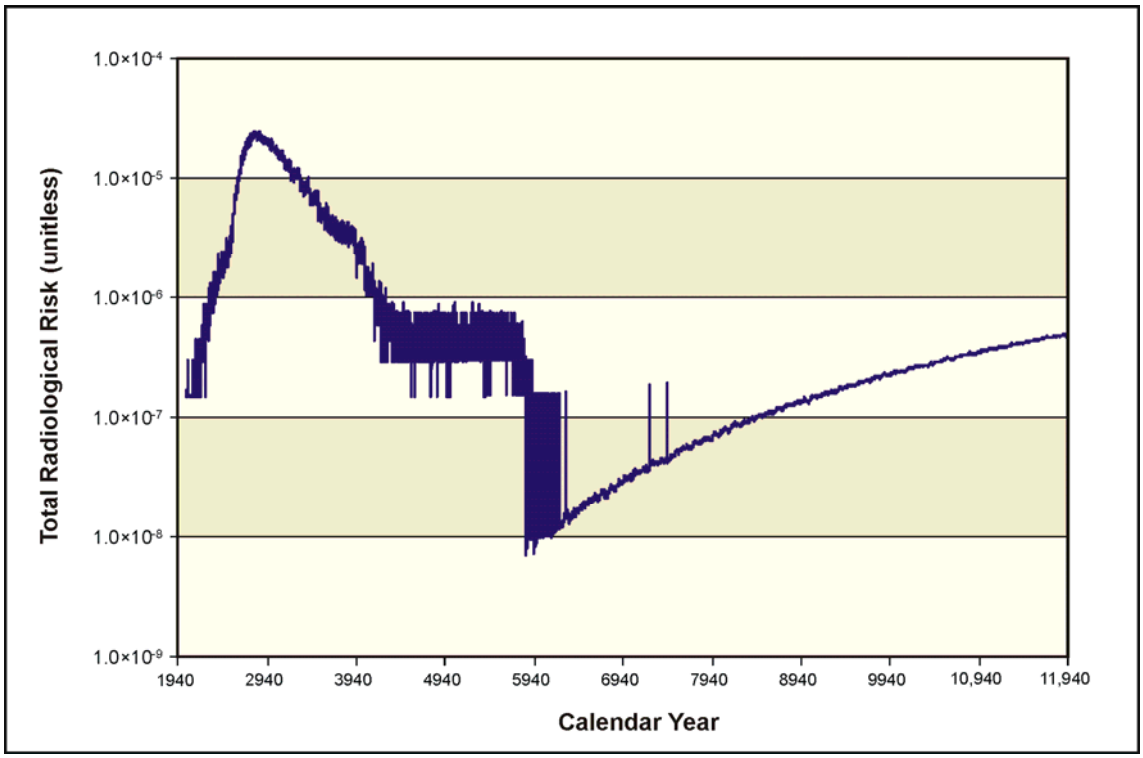


Figure 5–1290. FFTF Decommissioning Alternative 2 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the FFTF Barrier

5.4.2.3 Alternative Combination 3

Potential human health impacts of Alternative Combination 3 are summarized in Tables 5–169 and 5–170. The key radiological constituent contributors to human health risk are tritium, technetium-99, iodine-129, and uranium isotopes. The chemical risk and hazard drivers are chromium and nitrate. For radionuclides, the dose standard would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 9.53×10^{-1} person-rem per year for the year of maximum impact.

The time series of lifetime radiological risk for the drinking-water well user at the Core Zone Boundary are presented in Figures 5–1291 and 5–1292 for Tank Closure Alternative 6B, Base Case, and Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, respectively. Tank Closure Alternative 6B, Base Case, assumes removal of the HLW waste tanks and recovery of tank farm contaminated soil, producing significant reduction in impacts relative to both Tank Closure Alternatives 1 and 2B. Risk due to future releases from the tank farms is eliminated. Estimates of impacts for planned discharges to cribs and trenches (ditches) are similar to those for Tank Closure Alternatives 1 and 2B, but long-term risk from past tank leaks are reduced by a factor of approximately 100 to approximately 1×10^{-6}. The estimate of peak lifetime risk at the Core Zone Boundary for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, approximately 4×10^{-5}, is slightly higher than that for Alternative 2, Disposal Group 1, Subgroup 1-A, reflecting disposal of greater quantities of waste. Disposal of offsite waste at IDF-East is the major contributor to the peak lifetime risk, while disposal of ETF-generated and tank closure secondary waste are secondary contributors. Increase of the disposal inventory for the RPPDF accentuates the pulse in the risk curve (see Figure 5–1292) centered at CY 4000. Risk due to releases from FFTF is eliminated by removal under FFTF Decommissioning Alternative 3.

Table 5–169. Alternative Combination 3 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	1.94	4.22×10^{-1}	4.28×10^{-5}	0.00	4.28×10^{-5}	3.74	4.56×10^{-1}	1.48×10^{-4}	1.31×10^{-10}	1.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–170. Alternative Combination 3 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.93×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	7.20	7.35×10^{-1}	3.18×10^{-4}	6.00×10^{-6}	3.19×10^{-4}	4.04×10^{-1}	7.14×10^{-1}	4.98×10^{-6}	3.00×10^{-6}	6.40×10^{-6}
Off site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

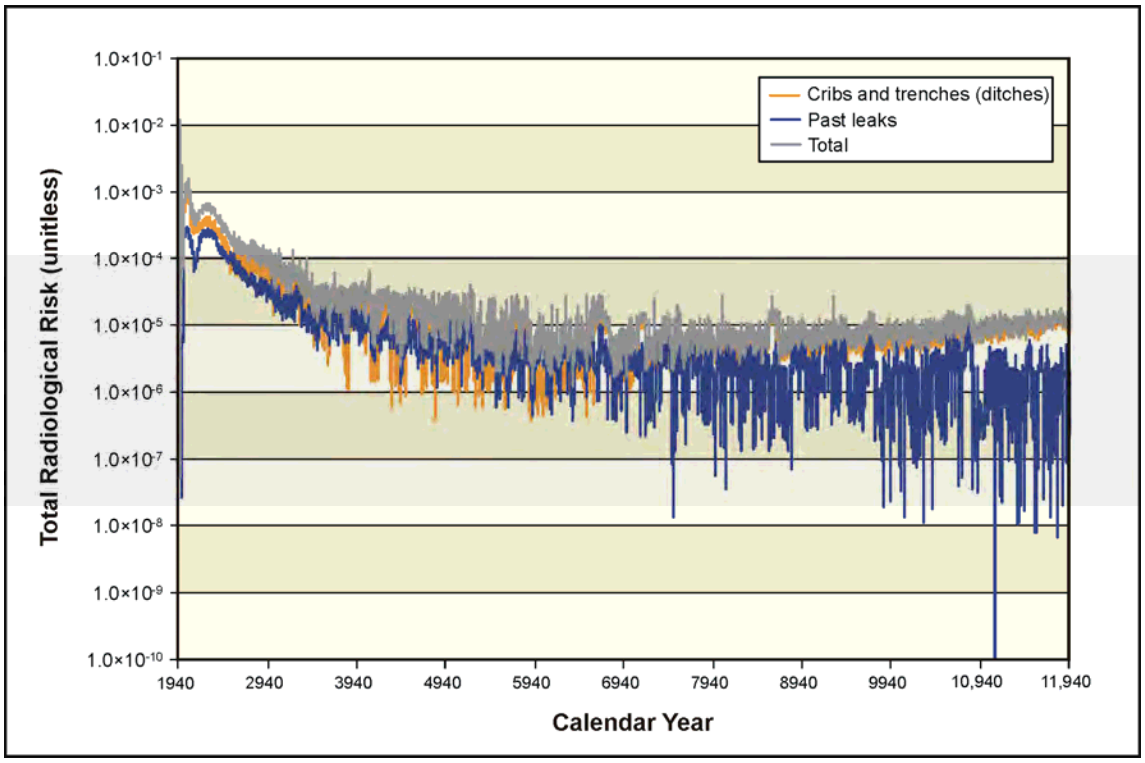


Figure 5–1291. Tank Closure Alternative 6B, Base Case, Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

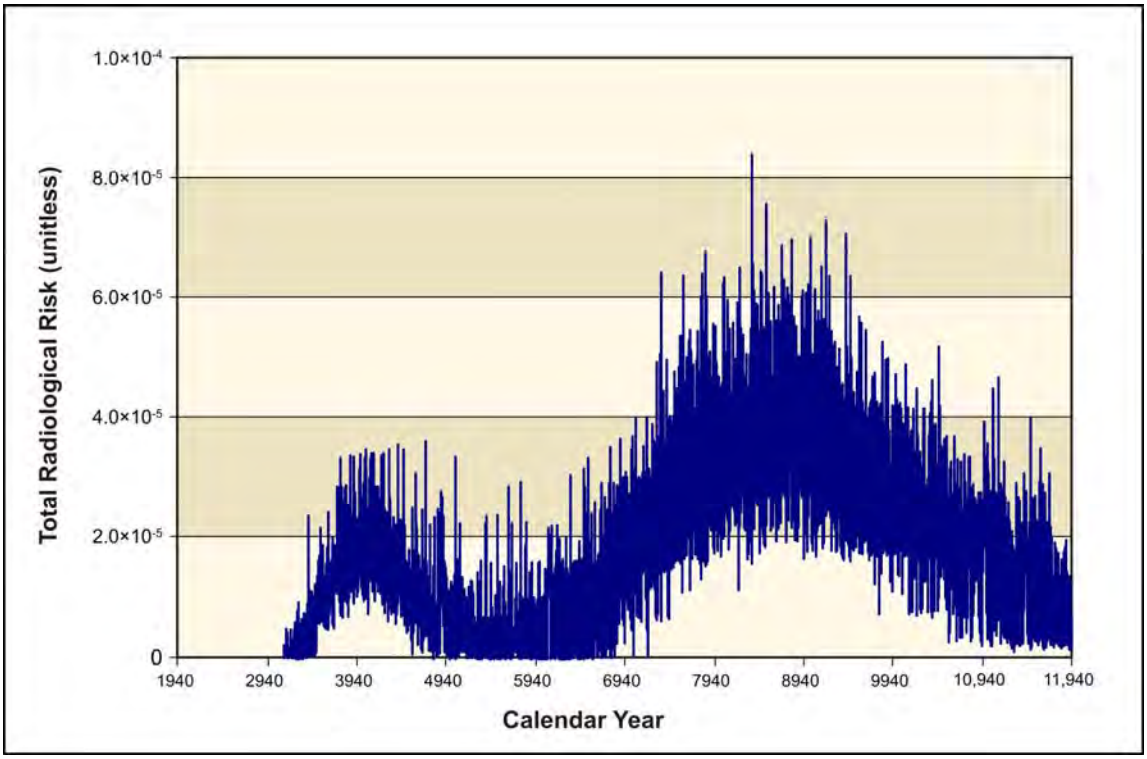


Figure 5–1292. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.4.3 Ecological Resources

This section evaluates long-term impacts on ecological resources of releases to air and groundwater under three combinations of Tank Closure, FFTF Decommissioning, and Waste Management alternatives.

The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources of releases to groundwater were evaluated at the Columbia River. Risk indices could not be calculated for soil-dwelling invertebrates, lizards, toads, or birds for chemical COPCs (organic compounds only) because this *TC & WM EIS* does not include toxicity reference values for these receptors for these COPCs. The uncertainty about the risk to ecological resources from releases to air and groundwater under the *TC & WM EIS* alternatives is discussed in Appendix P (see Sections P.2.2 and P.3.2). Calculated risk indices are presented below for the COPCs with the highest Hazard Quotients or Hazard Indices for each receptor.

The highest risk indices for ecological receptors are calculated for Alternative Combinations 1 and 3. For air releases, the risk indices calculated for plants, omnivorous mammals (Great Basin pocket mouse), and mammalian top carnivores (coyote) from air releases are highest under Alternative Combination 1. Risk indices calculated for the soil-dwelling invertebrates, side-blotched lizard, herbivorous mammals (mule deer), herbivorous birds (mourning dove), omnivorous birds (western meadowlark), and avian top carnivores (burrowing owl) are highest under Alternative Combination 3 (see Table 5–171). Predicted emissions of chemical COPCs in air under Alternative Combination 1 pose a small risk to plants (toluene Hazard Quotient is 47) and a moderate risk to mice and the coyote at the onsite maximum-exposure location. The largest calculated Hazard Quotients are xylene (2120), toluene (339), formaldehyde (80), and benzene (17) for the mouse at the onsite maximum-exposure location. Predicted emissions of chemical COPCs in air under Alternative Combination 3 pose a small probability of adverse impacts on the mourning dove and burrowing owl (mercury Hazard Quotient is less than 10) and a moderate probability for the side-blotched lizard (mercury Hazard Quotient is 172), meadowlark (mercury Hazard Quotient is 103), and mule deer (formaldehyde Hazard Quotient is 72) at the onsite maximum-exposure location. There would be no risk to soil-dwelling invertebrates at the onsite maximum-exposure location (calculated mercury Hazard Quotient is 1.02). This value is well within the margin of error of the uncertainties in the estimated exposure and toxicity.

There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under any of the alternative combinations at the offsite maximum-exposure location (Columbia River). The calculated Hazard Quotient of 2.4 for the mouse exposed to xylene at the Columbia River under Combination Alternative 1 exceeds 1 slightly.

The risk indices for each of the alternative combinations is the sum of the risk indices for the individual Tank Closure, FFTF Decommissioning, and Waste Management alternatives included in the combination. Alternative Combination 3 has the highest calculated risk indices for the side-blotched lizard, mule deer, mourning dove, western meadowlark, and burrowing owl (see Table 5–171). Alternative Combination 3 includes Tank Closure Alternative 6B, and the calculated indices for Tank Closure Alternative 6B are larger than the indices for Tank Closure Alternatives 1 and 2B, which are included, respectively, in Alternative Combinations 1 and 2. The calculated risk indices for these receptors under Tank Closure Alternative 6B are not the largest for such receptors—the largest are for Tank Closure Alternatives 3A and 3C (see Table 5–64). Alternative Combination 1 has the highest calculated risk indices for plants, the Great Basin pocket mouse, and the coyote (see Table 5–171). Alternative Combination 1 includes FFTF Decommissioning Alternative 1, and the calculated indices for FFTF Decommissioning Alternative 1 are much larger than the indices for FFTF Decommissioning Alternatives 2 and 3, which are included, respectively, in Alternative Combinations 2 and 3.

For groundwater releases, the highest risk indices for ecological receptors were calculated under Alternative Combinations 1 and 3 (see Table 5–172). Risk indices exceed 1 for aquatic biota, including salmonids, for chromium under all alternative combinations, corresponding to the Hazard Quotients exceeding 1 under the Tank Closure alternatives included in those alternative combinations. Waste Management Alternatives 2 and 3 (Disposal Group 1, Subgroups 1-C, 1-D, 1-E, and 1-F), which have Hazard Quotients that exceed 1 for aquatic biota and the spotted sandpiper, do not contribute to the risk indices for alternative combinations. There are no other receptors with risk indices exceeding 1 under the alternative combinations, including for all radiological COPCs (see Appendix P, Table P–12).

Table 5–171. Alternative Combinations – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

Alternative Combination	Maximum Hazard Quotient of Chemical COPC by Receptor								
	Plants	Soil-Dwelling Invertebrate	Side-Blotched Lizard	Great Basin Pocket Mouse	Coyote	Mule Deer	Meadow Lark	Mourning Dove	Burrowing Owl
	Toluene	Mercury	Mercury	Xylene	Xylene	Formaldehyde	Mercury	Mercury	Mercury
1	4.69×10^{1}	0.00	0.00	**2.12×10^{3}**	2.69×10^{2}	4.85×10^{1}	0.00	0.00	0.00
2	2.69	9.85×10^{-1}	**1.66×10^{2}**	1.31×10^{2}	1.67×10^{1}	2.33×10^{1}	9.95×10^{1}	8.22	6.92
3	6.50	1.02	1.72×10^{2}	**3.25×10^{2}**	4.13×10^{1}	7.19×10^{1}	1.03×10^{2}	8.54	7.20

Note: The maximum Hazard Quotient under each alternative combination is indicated by **bold** text.
Key: COPC=constituent of potential concern.

Table 5–172. Alternative Combinations – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Resources at the Columbia River

Alternative Combination	Maximum Hazard Quotient or Hazard Index of Chemical or Radiological COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Chromium	Chromium	Chromium	Uranium	Nitrate	Chromium	Chromium
1	1.20×10^{-1}	4.71×10^{-3}	8.17×10^{-1}	2.95×10^{-1}	6.31×10^{-1}	2.08×10^{-2}	**2.14×10^{1}**
2	2.56×10^{-2}	1.00×10^{-3}	1.74×10^{-1}	2.88×10^{-2}	6.43×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
3	2.60×10^{-2}	1.02×10^{-3}	1.77×10^{-1}	2.72×10^{-3}	6.44×10^{-1}	1.52×10^{-2}	**2.23×10^{1}**

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.
Key: COPC=constituent of potential concern; Rad.=radiological.

5.4.4 Environmental Justice

Sections 5.4.1 and 5.4.2 evaluate groundwater impacts and associated potential long-term human health effects under the combinations of alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs from the American Indian resident farmer. The American Indian hunter-gatherer does not cultivate crops but gathers food from indigenous plants, harvests fish from the Columbia River, and is exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Section 5.4.2. Long-term human health impacts of actions associated with the combinations of alternatives analyzed would be greatest under Alternative Combination 1. Under this combination of alternatives, radiological releases would result in the dose at the Core Zone Boundary exceeding regulatory limits for the resident farmer and the American Indian resident farmer. None of the hypothetical receptors at the Columbia River nearshore would be exposed to a dose in excess of regulatory limits. Nonradiological releases under Alternative Combination 1 would result in exceedance of the Hazard Index guidelines for chromium and nitrate at the Core Zone Boundary and the Columbia River nearshore for the resident farmer and American Indian resident farmer. The analysis determined that the greatest impact of any alternative combination on long-term human health could result in radiological doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the Core Zone Boundary and the Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected for the foreseeable future because the Core Zone is designated as Industrial-Exclusive, the Columbia River nearshore is designated as Preservation (Hanford Reach National Monument), and the area between them is designated as Preservation (DOE 1999). It is unlikely, therefore, that any of the combinations of alternatives would pose a disproportionately high and adverse long-term human health risk to American Indian populations at offsite locations. The greatest risk would be to the American Indian resident farmer at the Core Zone Boundary. During the year of peak dose, this receptor would receive a radiological dose of 3.4 rem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent.

5.5 REFERENCES

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CHAPTER 6
CUMULATIVE IMPACTS

This chapter presents the cumulative impacts analyses for the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. The cumulative impacts analyses build on the impacts of the three alternative combinations presented in Chapters 4 and 5. Generally, short-term cumulative impacts are the highest when Alternative Combination 3 is included and are the lowest when Alternative Combination 1 is included. This is because Alternative Combination 3 generally uses the most resources and produces the most effluents and wastes, and Alternative 1 the least. By contrast, long-term cumulative groundwater-related impacts are generally highest with Alternative Combination 1 and lowest with Alternative Combination 3. This is largely because Alternative Combination 1 would leave the most waste and contaminants in the ground and Alternative Combination 3 the least. Although the long-term cumulative groundwater related impacts are highest with Alternative Combination 1 and lowest with Alternative Combination 3, cumulative groundwater-related impacts are dominated by the impacts of past releases.

6.1 METHODOLOGY

Cumulative Impact

Impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions (40 CFR 1508.7).

The methodology used in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* to estimate cumulative impacts was divided into four phases: (1) identification of resource areas and appropriate regions of influence (ROIs); (2) identification of reasonably foreseeable future actions; (3) estimation of cumulative impacts; and (4) identification of monitoring and mitigation requirements. The detailed cumulative impacts methodology and a flow chart showing the four phases are presented in Appendix R of this environmental impact statement (EIS).

Region of Influence

A site-specific geographic area in which the principal direct and indirect effects of the proposed actions are likely to occur.

Phase 1 - Identification of Resource Areas and Appropriate ROIs. This phase involved selecting the resource areas for the cumulative impacts analyses. The resource areas selected were those considered most likely to have a potential for meaningful cumulative impacts. Steps in this process included the following:

1(a) Examining the resource areas evaluated in recent Hanford Site (Hanford) National Environmental Policy Act (NEPA) documents, resource areas evaluated in this *TC & WM EIS* (see Chapters 4 and 5), and resource areas where historically significant impacts have occurred to develop a list of those resource areas that are likely to exhibit cumulative effects.

1(b) Identifying the ROI for each resource area to be evaluated. The ROIs determined the spatial limits of the cumulative impacts analyses conducted for each resource area. These ROIs are described in the introduction to Appendix R, Table R–3, of this *TC & WM EIS*.

Phase 2 - Identification of Reasonably Foreseeable Future Actions. In this phase, reasonably foreseeable future actions were examined and screened to determine those that needed to be included in the cumulative impacts analyses. Steps in this process included the following:

Reasonably foreseeable actions are ongoing and will continue into the future, are funded for future implementation, or are included in firm near-term plans.

2(a) Identifying future Federal, non-Federal, or private actions planned in the ROIs. Information sources used for identification included Records of Decision (RODs); documents related to the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental

Response, Compensation, and Liability Act (CERCLA), NEPA, and the Washington State Environmental Policy Act; the Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (TPA); permits and permit applications; land use and development plans; and other data sources.

2(b) Examining each future action to determine whether the action is reasonably foreseeable, would occur within the ROI, would occur within the same timeframe as the *TC & WM EIS* proposed actions, and was not already accounted for in the analyses of the baseline environmental conditions.

2(c) Retaining those future actions that met the criteria listed in item 2(b) for analysis purposes. Future actions that did not meet all of the criteria were eliminated from further consideration.

Phase 3 - Estimation of Cumulative Impacts. During this phase, impact indicators for the alternative combinations (see Chapter 4, Section 4.4) were added to the baseline values and the values for the reasonably foreseeable future actions for the purpose of estimating the cumulative impacts. Steps in this process included the following:

3(a) Identifying and to the extent possible, quantifying the baseline conditions. Baseline conditions reflect the effects of past and present actions (i.e., level of direct/indirect, beneficial/adverse, short-term/long-term effects that a resource is currently experiencing). These conditions are described in Chapter 3, "Affected Environment," of this *TC & WM EIS*. Current actions include both cleanup activities that could reduce the impacts of past actions and activities that could further degrade a resource. The importance of past actions to cumulative impacts is resource-specific. For example, past air pollutant releases would not affect baseline (current) site air quality, whereas liquid releases to the ground could have a lasting effect and need to be considered as part of the baseline conditions. Therefore, only past actions that will continue to have impacts on a resource were considered in the cumulative analyses.

3(b) Identifying the impacts of the *TC & WM EIS* Preferred Alternative(s) and the *TC & WM EIS* alternative combinations (described in Chapters 4 and 5).

3(c) Identifying the impacts of reasonably foreseeable future actions from Phase 2 of the cumulative impacts analysis methodology. If quantitative data were available, these values were incorporated into quantitative or semiquantitative cumulative impacts analyses. If quantitative data were not available, qualitative data were used.

3(d) Aggregating the effects on each resource from past, present, and reasonably foreseeable future actions, including the proposed actions. The aggregate effects were used to estimate cumulative impacts for each resource area. The degree of the impacts was largely determined using the same impact measures described in Chapters 4 and 5 of this *TC & WM EIS*.

Phase 4 - Identification of Monitoring and Mitigation Requirements. In the fourth phase, the cumulative impacts estimates developed in Phase 3 were examined to determine whether monitoring and/or mitigation activities would be needed. Steps in this process included the following:

4(a) Determining those resource areas where appreciable cumulative impacts are estimated.

4(b) Describing the measures that could be used to monitor and/or mitigate these potentially appreciable cumulative impacts.

In the NEPA *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*, Second Edition (known as The Green Book) (DOE 2004a:1, 2, 19, 20), the U.S.

Department of Energy (DOE) expands on Council on Environmental Quality instructions (40 CFR 1502.2) by stating that impacts should be discussed in proportion to their significance, and that this sliding-scale approach applies to all of the recommendations in The Green Book. The Green Book specifically recommends the use of the sliding scale for impact identification and quantification (Chapter 6, Section 6.1, of The Green Book).

As described in Chapter 4, Section 4.4, several hundred impacts scenarios could result from the potential combinations of the 11 Tank Closure, 3 Fast Flux Test Facility (FFTF) Decommissioning, and 3 Waste Management alternatives when factored with their associated option cases and waste disposal groups. For purposes of cumulative impact analysis, three combinations of alternatives were chosen to represent key points along the range of actions and associated overall impacts that could result from full implementation of the three sets of proposed actions. Alternative Combination 1 represents the potential short-term impacts resulting from minimal DOE action and the greatest long-term impacts with respect to groundwater. Alternative Combination 2 is a midrange case that represents DOE's Preferred Alternative(s). Alternative Combination 3 represents a combination that generally results in maximum potential short-term impacts, but would likely have the lowest long-term impacts on groundwater. (Note: For some resource areas, a combination that includes Alternative 6A, Option Case, would result in maximum impacts). Selection of these three alternative combinations for cumulative impacts analysis in this EIS was done only to establish overall cumulative impact reference cases for stakeholders and decisionmakers to consider, and does not preclude the selection and implementation of different combinations of the various alternatives in support of final agency decisions.

Analyses of cumulative impacts in this *TC & WM EIS* relied on a range of analytical methods based on the significance of the short-term and long-term cumulative impacts on a given resource area, the available data, and the need to adequately address the impacts to provide information to decisionmakers and the public. Short-term cumulative impacts are discussed in Section 6.3**.** Long-term cumulative impacts are discussed in Section 6.4.

The short-term cumulative impacts were assumed to occur during the active project phase for each of the three *TC & WM EIS* alternative combinations and were assessed for a period up to 188 years (2006 to 2193 under Tank Closure Alternative 2A). The following resource areas were selected for short-term cumulative impacts analysis: land resources (land use and visual resources); infrastructure; noise and vibration; air quality; geology and soils; water resources; ecological resources; cultural and paleontological resources; socioeconomics; public and occupational health and safety-normal operations; public and occupational health and safety-transportation; waste management; and industrial safety. The short-term cumulative impacts on these resource areas were analyzed based on semiquantitative data (i.e., simple addition of impact indicators) or qualitative information (i.e., non-numerical data). However, where data were not uniformly available or comparable across an ROI, some resource areas were addressed using a combination of semiquantitative and qualitative data.

The long-term cumulative impacts were assumed to occur following the active project phase for each *TC & WM EIS* alternative and were assessed out to approximately 10,000 years in the future. Resource areas selected for long-term cumulative impacts analysis included groundwater quality, public health, ecological risk, and environmental justice. In general, the long-term cumulative impacts on these resource areas were evaluated quantitatively (i.e., they were modeled).

As described in Appendix R, there would be few short-term or long-term impacts that could substantially contribute to cumulative impacts at Idaho National Laboratory (INL) because: (1) there would be no marked increase in the daily effluent emissions from, or waste generation by, the facilities; (2) sodium hydroxide, produced at INL's Sodium Processing Facility, would be returned to Hanford for use in processing tank waste; (3) hazardous and radioactive wastes would not be disposed of at INL; and (4) impacts of the activities would be small. Therefore, cumulative impacts at INL were considered and

found to be insignificant. Transportation of materials and waste to and from INL, however, is included in the cumulative impact analyses.

6.2 POTENTIAL CUMULATIVE ACTIONS

As stated under "Principles of Cumulative Effects Analysis" in the Council on Environmental Quality's 1997 publication, *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ 1997), "cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions," and "cumulative effects are the total effect…of all actions taken, no matter who (Federal, non-Federal, or private) has taken the action." Therefore, it is important to identify past, present, and future actions that may appreciably degrade resources or add to the impacts on them.

For most resource areas, baseline conditions were culled from the information on the affected environment provided in Chapter 3 of this EIS. For example, as described in Chapter 3, current air quality in the ROI reflects both past and present activities. In contrast, current resource use alone may not adequately account for past resource loss, and therefore is not a good indicator of baseline conditions.

Past, present, and reasonably foreseeable future actions that may contribute to cumulative impacts include those located within the ROIs considered. Examples of past Hanford activities include operation of the fuel fabrication plants, production reactors, Plutonium-Uranium Extraction (PUREX) Plant and other fuel reprocessing facilities, Plutonium Finishing Plant, and research facilities, as well as waste treatment and disposal activities Current Hanford activities include site cleanup, waste disposal, and tank waste stabilization.

Non-DOE activities at Hanford include the following:

- Continued transport of U.S. Navy reactor compartments from the Columbia River and their disposal in trench 218-E-12B in the 200-East Area
- Continued operation of the Columbia Generating Station
- Continued operation of the US Ecology Commercial Low-Level Radioactive Waste Disposal Facility
- Management of the Hanford Reach of the Columbia River as a national monument and a national wildlife refuge

Examples of past, present, and reasonably foreseeable future offsite activities that may contribute to cumulative impacts include clearing land for agriculture and urban development, water diversion and irrigation projects, waste management, industrial and commercial development, mining, power generation, and development of transportation and utility networks. Activities in the region surrounding Hanford include the following:

- Future regional land use as described in local city and county comprehensive land use plans (see Chapter 3 for descriptions and locations of the cities and counties surrounding Hanford)
- U.S. Department of Defense Base Realignment and Closure
- Cleanup of toxic, hazardous, and dangerous waste disposal sites
- Columbia River and Yakima River water management, including the proposed Black Rock Reservoir

- Power generation and transmission line projects
- Wind energy projects
- Pipeline projects
- Transportation projects

Appendix R, Table R–4, shows the activities considered in the cumulative impacts analyses.

In addition, under the American Recovery and Reinvestment Act (P.L. 111-5), DOE will conduct projects to accelerate its existing cleanup program at Hanford, including projects to demolish nuclear facilities and support facilities, remediate contaminated groundwater, and retrieve solid waste from burial grounds. These projects are focused waste sites and other locations along the Columbia River to support shrinking the active area of cleanup at the site from 1,518 to 194 square kilometers (586 to 75 square miles) or less by 2015. The projects will be conducted predominantly under CERCLA, with incorporation of NEPA values. However, additional NEPA reviews may be conducted as appropriate.

6.3 SHORT-TERM CUMULATIVE IMPACTS

Short-term cumulative impacts are associated with the active project phase during which the decommissioning and closure activities described under the *TC & WM EIS* alternatives would take place. For this EIS, short-term cumulative impacts were assumed to occur for up to 188 years (2006 to 2193 under Tank Closure Alternative 2A).

This section presents short-term cumulative impacts for the following resource areas: land resources (land use and visual resources); infrastructure; noise and vibration; air quality; geology and soils; water resources; ecological resources; cultural and paleontological resources; socioeconomics; public and occupational health and safety–normal operations; public and occupational health and safety-transportation; waste management; and industrial safety. Detailed tables supporting the short-term cumulative impacts analyses are presented in Appendix T.

6.3.1 Land Resources

Cumulative impacts related to land use were evaluated in an ROI that includes the proposed *TC & WM EIS* action areas, the site, and areas up to 80 kilometers (50 miles) from the site. The land use analysis focuses on the area of land impacted by recent and future growth within the ROI. A general description of land resources at Hanford and within the region is presented in Chapter 3, Section 3.2.1.1. Additional detailed information is presented in Appendix T, Table T–1.

Because project descriptions did not always identify existing land use, it was not always possible to determine specific future changes; however, in most cases, land use would change from agricultural or vacant land to a new use. In some cases, aerial photography obtained from Google Earth was used to determine current land use. It was assumed that, prior to the actual implementation of any offsite project within the ROI, issues such as conformance with existing land use plans and zoning would be resolved at the county or local level; thus, this issue was not addressed further.

For visual resources, the ROI includes the proposed *TC & WM EIS* action areas, the site, and nearby offsite areas. A qualitative analysis was performed to examine whether recently completed and reasonably foreseeable future actions would change the character of the viewshed. Factors considered included the overall area of land disturbed by the activities, the location of the activities relative to each other and public points of observation, and the proximity of the activities to the proposed *TC & WM EIS* action areas.

6.3.1.1 Land Use

To estimate the cumulative land area that would be disturbed within the ROI, the total area disturbed by the *TC & WM EIS* alternative combinations (see Chapter 4, Section 4.4.1) was added to the area disturbed by other DOE activities at Hanford and non-DOE activities within the ROI. Thirty-one projects within the ROI were analyzed with regard to the area of land they would disturb. These projects either were recently completed or are reasonably certain of being completed in the near future (see Appendix T, Table T–1). It should be noted that the projects evaluated do not represent the only activities affecting land use within the ROI. For example, the addition of many smaller subdivisions and commercial developments within the region and the conversion of vacant land to agricultural use would have a direct, but unknown, additive effect on land use. Uncertainties also exist regarding implementation of a number of large projects within the ROI; information sufficient to project their impacts on land use was not available when this EIS was prepared. A number of these projects are addressed separately in the following text because they have the potential for cumulative impacts on future regional land use.

Certain activities occurring at Hanford and within the ROI may positively affect future land use. For example, remediation efforts at Hanford could support potential reuse or restoration of land consistent with the land use designations described in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)* (DOE 1999a). Reuse of land would negate the need to develop other possibly undisturbed areas. Restoration of remediated sites would return some land to more natural conditions (e.g., shrub-steppe habitat).

Table 6–1 presents the results of the cumulative land use analysis within the ROI. Cumulative actions may disturb from 9,260 to 10,051 hectares (22,881 to 24,836 acres) of land in the approximately 2.0 million hectare (5.0 million acre) area up to 80 kilometers (50 miles) from Hanford. *TC & WM EIS* alternatives would use from 2 to 793 hectares (4.9 to 1,960 acres). To determine the contribution of the three alternative combinations to the cumulative land requirement, the area disturbed by each combination was divided by the total land requirement. Thus, Combination 1 represents 0.02 percent of the cumulative land requirement brought about by recent past, present, or reasonably foreseeable future actions within the ROI; Combination 2 represents 3.2 percent; and Combination 3 represents 7.9 percent. Although not one of the three alternative combinations, the greatest land area requirement under the *TC & WM EIS* alternatives would occur under a combination of alternatives that includes the Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford); and Waste Management Alternative 3 (with Disposal Group 2 or 3). Such a combination would represent 11 percent of the cumulative land requirement within the ROI. As noted above, these are conservative estimates because actual land use changes in the region would be greater than those reported for the 31 analyzed projects and some activities within the ROI could have a net positive impact on land use.

Table 6–1. Cumulative Land Area Disturbed

Actions/Activities	Land Area Disturbed (hectares)
***TC & WM EIS* Combined Impacts (see Chapter 4, Table 4–151)**	
Alternative Combination 1	2
Alternative Combination 2	307
Alternative Combination 3	793
Other DOE Actions at the Hanford Site (see Appendix T, Table T–1)	650
Non-DOE Actions at the Hanford Site (see Appendix T, Table T–1)	445
Other Projects/Activities in the Region of Influence (see Appendix T, Table T–1)	8,162
Cumulative Totals[a]	
Alternative Combination 1	9,260
Alternative Combination 2	9,565
Alternative Combination 3	10,051

[a] The "cumulative totals" are the sums of the impacts under the alternative combinations and the "Other DOE" and "Non-DOE" activities.

Note: To convert hectares to acres, multiply by 2.471. Totals may not equal the sum of the contributions due to rounding.

Key: DOE=U.S. Department of Energy; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Because the total area of developed land within the ROI is unknown, the change in the proportion of developed land within the region resulting from the 31 analyzed projects cannot be determined. However, considering the size of the ROI and the amount of past development, the additional disturbance of the land by the evaluated projects would be small. Because the extent of past development at Hanford (6 percent of the total land area [Neitzel 2005:4.144]) is known, it is possible to determine the effect that recent past, present, and reasonably foreseeable future development may have on the site. Thus, considering the land requirement of each of the three alternative combinations, as well as the other projects and activities occurring at the site, the total area of land disturbed at Hanford would increase to between 6.7 and 7.2 percent of the site for the three alternative combinations evaluated. Under the maximum foreseeable impact alternative combination (Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 3 [with all facilities to be built at Hanford]; and Waste Management Alternative 3 [with Disposal Group 2 or 3]—not included in the alternative combinations tables), the total area of disturbed land would increase to 7.5 percent. As noted above, these are conservative estimates because credit was not taken for future remediation and restoration efforts.

Additional actions that may impact land use within the ROI include decisions made in the ROD (64 FR 61615) and amended ROD (73 FR 55824) for the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), urban expansion, closure of the Umatilla Army Depot, the Columbia River Water Management Program, and a number of power-related projects.

The generalized land use plan implemented by the RODs for the *Hanford Comprehensive Land-Use Plan EIS* is shown in Appendix R, Figure R–1, of this *TC & WM EIS*. While there is minimal potential for development in certain areas of Hanford (e.g., the Hanford Reach National Monument, Gable Mountain, and Gable Butte) due to the applicable land-use designations described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), other areas of the site could undergo future land use changes. For example, areas designated as Industrial-Exclusive and Industrial are suitable for the treatment, storage, and disposal of various wastes, as well as activities such as reactor operations, rail and barge transport facilities, mining, manufacturing, and distribution operations, respectively. In addition, areas designated

Conservation (Mining), while principally set aside for management and protection of cultural, ecological, and natural resources, may be utilized for mining operations. Other land use designations, including Research and Development and Recreation, would permit various levels of future development. Thus, the land use plan allows for as yet unspecified future changes at the site.

The 1990 Washington State Growth Management Act (RCW 36.70A) requires counties in the region around Hanford to have comprehensive land use plans. Cities and other government jurisdictions adopt such comprehensive plans to guide future activities within their jurisdictions. These plans project land development, housing, infrastructure, and community services needs 20 years into the future. Generally, the plans encourage growth in urban growth areas (lands set aside or designated as necessary for future population growth beyond those undeveloped lands already within city boundaries) and discourage growth outside these areas. As an example, the *City of Richland Comprehensive Land Use Plan, Final* (Richland 2002:3-4) has designated urban growth areas that cover an area of 8,954 hectares (22,125 acres). Of that area, 4,563 hectares (11,275 acres) are developed and 4,391 hectares (10,850 acres) are vacant and available for future development. While the designation of such areas helps planners with long-range planning efforts, specific details regarding future development are uncertain; thus, these county comprehensive land use plans cannot be used to project reasonably foreseeable future actions.

In May 2005, the Department of Defense announced its latest round of Base Realignment and Closure actions (AFIS 2005; BRAC 2005). The 7,972-hectare (19,700-acre) Umatilla Army Depot, located about 48 kilometers (30 miles) to the south of Hanford, is the only major military facility in the ROI that would be affected. While closure of the depot is expected to result in a loss of jobs (BRAC 2005:Ind-14, C-20) and an eventual reduction in activities that cause environmental impacts, the specific impacts of its closure and reuse have not been evaluated. Thus, although this action is likely to impact future land use in the ROI, it cannot be evaluated at this time.

The Columbia River Water Management Act (RCW 90.90) requires the Washington State Department of Ecology (Ecology) to "aggressively pursue the development of water supplies to benefit both in-stream and out-of-stream uses." Ecology is currently in the process of developing a Columbia River Water Management Program to facilitate implementation of the legislation. No specific storage or conservation projects have been identified for implementation under the Management Program; however, such projects would have clear implications for changes in future land use (Ecology 2007:1).

A number of power-related projects have been proposed for the ROI, but have been put on hold. These include the Plymouth Generation Facility (a 306-megawatt, natural gas-fired turbine electric generating facility [Benton and BPA 2003; BPA 2008]); the Wanapa Energy Center (a 1,200-megawatt gas/steam turbine electric generating facility) (BIA 2004; BPA 2008); and the 127-kilometer (79-mile) McNary to John Day 500-kilovolt line transmission line project (BPA 2008). If completed, these projects would result in additional changes in land use within the ROI.

6.3.1.2 Visual Resources

One measure of cumulative impacts is whether the visual character of the ROI would change as a result of implementation of recent past, present, and reasonably foreseeable future actions. Because of the limited size of many of the projects, their distance from Hanford, and their occurrence near areas that are presently developed, the overall change to the viewshed within the ROI is likely to be minimal. Further, many activities at Hanford would not be visible from public viewpoints (e.g., nearby higher elevations, highways, or the Columbia River) and; thus, would contribute little to overall cumulative impacts on visual resources.

As noted above, the location of new facilities relative to public points of observation is an important consideration in determining cumulative visual impacts. One of the few locations that would permit a

relatively unobstructed view of much of the ROI is the top of Rattlesnake Mountain. From this location, many activities at Hanford would be visible (see Chapter 4, Section 4.4.1.2), as would a number of offsite projects. For example, an observer atop Rattlesnake Mountain would be able to observe Borrow Area C, some of the larger projects within the 200 Areas, Black Rock Reservoir, and the Red Mountain American Viticulture Area near Benton City, Washington. These activities would replace existing views with ones that would be different than those currently experienced. Implications of cumulative visual impacts on American Indians who consider Rattlesnake Mountain an important cultural property are addressed in Section 6.3.8.3.

The relative cumulative visual impacts of the three *TC & WM EIS* alternative combinations would be similar to the combined impacts addressed in Chapter 4, Section 4.4.1.2, because all other recent past, present, and reasonably foreseeable future non-DOE actions within the ROI would remain the same for all of the alternative combinations evaluated. Thus, development associated with Combination 1 would contribute the most to cumulative visual impacts, and Combination 3 would contribute the least. As noted in the discussion of combined visual impacts, a combination of alternatives involving Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford); and Waste Management Alternative 3 (with Disposal Group 2 or 3) would disturb the greatest area and alter the existing viewshed to the greatest extent.

Completion of remediation and restoration activities at Hanford would positively impact the visual environment. These activities would include, for example, decommissioning of the reactors in the 100 Areas, closure of the canyon facilities in the 200 Areas, and restoration of the borrow areas following completion of mining activities. While remediated and restored areas would not precisely replicate past conditions, they would improve the viewshed overall and lessen the cumulative visual impacts. However, not all remediation actions would lead to the restoration of more natural conditions because some facilities or sites are located within areas designated in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a) as Industrial-Exclusive or Industrial. These areas would continue to be available for further development, as noted in Section 6.3.1.1.

In most cases, activities within the ROI would not change the U.S. Bureau of Land Management Visual Contrast Ratings because projects would be located in or adjacent to areas that are already developed. However, the rating for Borrow Area C would change from Class II to Class III under Alternative Combination 1 and Class IV under Combinations 2 and 3. In the later case, mining activities would dominate an area that had previously undergone minimal development.

6.3.2 Infrastructure

For the purpose of providing the most meaningful analysis, electricity and water were selected as key resource indicators for assessing potential cumulative effects on utility infrastructure systems. For electric power, the ROI includes the electric power distribution and transmission system and associated power capacity that supplies the Hanford 100, 200, 300, and 400 Areas. For water, the affected ROI includes the Hanford Export Water System that supplies the Hanford 100, 200, and part of the 600 Areas. Projected requirements for these utility resources under each of the *TC & WM EIS* alternative combinations (see Chapter 4, Section 4.4.2) were added to the demands of other DOE and non-DOE activities at Hanford, all of which have the potential to impact the associated utility system and utility resource consumption within the defined ROI. The ROIs for electric power and water supply were determined to provide the most meaningful analyses of potential cumulative effects on utility infrastructure because the affected utility systems are relatively confined to Hanford and otherwise well defined, and projected demands can be quantified with the least amount of uncertainty.

Table 6–2 presents the results of the cumulative impacts analysis for utility infrastructure. The utility requirements presented in Table 6–2 represent the peak annualized utility resource demands for the three

TC & WM EIS alternative combinations, baseline demands from Chapter 3 as appropriate, and projected utility demands for various DOE activities and non-DOE activities that have the potential to occur within the same timeframe. Appendix R, Table R–4, details the actions and activities that were evaluated to determine their possible contributions to cumulative impacts at Hanford. As specifically noted in that table, many of the listed actions are already either wholly or partially accounted for in the Hanford baseline in terms of their contribution to cumulative impacts.

Table 6–2. Potential Cumulative Utility Infrastructure Requirements

Actions/Activities[a]	Peak Annualized Requirement	
	Electricity (million megawatt-hours)	**Water (million liters)**
***TC & WM EIS* Combined Impacts[b] (see Chapter 4, Table 4–152)**		
Alternative Combination 1	0.04	1,200
Alternative Combination 2	1.18	3,670
Alternative Combination 3	1.26	3,800
Other DOE Actions at the Hanford Site		
Hanford Site baseline[c]	0.17	817
Cleanup and restoration activities (2006–2035)	No data	No data
Actions to empty the K Basins in the 100-K Area (2006–2036)	−0.013	0.90
Deactivation of FFTF in the 400 Area (2006–2036)[d]	−0.020	−116
Retrieval of retrievably stored TRU waste (2017–2018) (SAIC 2007a)	0.000024	0.99
Excavation and use of geologic materials (2006–2013) (DOE 2001; 2003a)	No data	No data
Construction and Operation of the ERDF (2006–2024) (DOE 1994)	No data	No data
PNNL Physical Sciences Facility (2006–2011) (DOE 2007a)	No data	No data
Other DOE Subtotals	0.14	702
Non-DOE actions in the Region of Influence		
US Ecology Low-Level Radioactive Waste Facility (2006–2056) (Ecology and WSDOH 2004:140)	0.00045	0.076
Hanford Reach National Monument (2006–2022) (USFWS 2008)	No data	No data
Non-DOE Subtotals	0.00045	0.076
Cumulative Totals[e]		
Alternative Combination 1	0.18	1,900
Alternative Combination 2	1.32	4,370
Alternative Combination 3	1.40	4,500
Utility system capacity[f]	1.74	18,500

a Activities/actions as identified in Appendix R, Table R–5. Years in parentheses reflect the timeframe in which the resource demand may potentially occur.

b From Chapter 4, Section 4.4.2, Table 4–144.

c From Chapter 3, Section 3.2.2, Table 3–2.

d Assumes future decommissioning of the FFTF and 400 Area with the resulting cessation of pre-deactivation levels of utility consumption (based on fiscal year 2006 reporting).

e The "cumulative totals" are the sums of the impacts under the alternative combinations and the "Other DOE" and "Non-DOE" activities.

f Capacity of the electric power and water supply systems serving Hanford from Chapter 3, Section 3.2.2, Table 3–2.

Note: To convert liters to gallons, multiply by 0.26417. Subtotals or totals may not equal the sum of the contributions due to rounding.

Key: DOE=U.S. Department of Energy; ERDF=Environmental Restoration Disposal Facility; FFTF=Fast Flux Test Facility; PNNL=Pacific Northwest National Laboratory; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; TRU=transuranic.

Projected changes in cumulative utility resource demands over the period of analysis reflect operational activities as well as finite actions (such as final closure actions) that may result in a spike and/or subsequent reduction in demands as activities are performed or final actions are completed. The potential for the cumulative demand to exceed the capacity of the utility system that supplies the resource within the Hanford utility infrastructure ROI was assessed. In short, the focus of this analysis was to forecast the potential maximum annual utility resource demand that could occur as a basis for assessing cumulative impacts on utility infrastructure. The totals presented represent upper limits of utility demands at Hanford.

As indicated in Table 6–2, neither the capacity of the Hanford electric transmission system (1.74 million megawatt-hours per year) nor the capacity of the Hanford Export Water System (18,500 million liters per year [4,887 million gallons per year]) would be exceeded on a cumulative basis. For electric power, peak cumulative demands would range from about 10 percent of capacity under Alternative Combination 1 to 80 percent under Combination 3. For water supply, peak cumulative demands would range from about 10 percent under Combination 1 to 24 percent under Combination 3.

Based on the analysis performed, only the electric power system would be substantially impacted by the cumulative effects of the *TC & WM EIS* alternative combinations and present and future actions; up to 93 percent of the cumulative effect on electric power capacity would be attributable to *TC & WM EIS* activities alone. As referenced in this chapter and in Appendix R, proposed wind energy projects by Bonneville Power Administration and others could help alleviate any electric power shortages that could otherwise indirectly affect the Hanford electric power system in the future.

Cumulative peak annual utility demands approaching the capacity of the utility system that supplies the resource would be indicative of the need for DOE and utility providers, to consider project changes, resource conservation, augmentation of utility capacity, or some combination of measures to ensure that utility demands can be met at Hanford to support ongoing and future tank closure, waste treatment, and other related actions.

Historically, electric power consumption across Hanford and the capacity of the transmission and distribution systems was much greater, especially when the 100 Area reactors were in operation (see Chapter 3, Section 3.2.2.2). This is also true for the Hanford Export Water System, which withdraws water from the Columbia River and once supplied water to the 100 Areas, but has been reconfigured over time (see Chapter 3, Section 3.2.2.4). As indicated in Appendix R, decommissioning of the 100 Area reactor facilities is ongoing. Prior to 1990, the 200 Areas alone had annual water demands of more than 22,700 million liters (6,000 million gallons), which was supplied via the Hanford Export Water System.

As indicated in Chapter 4, Section 4.4.2, the projected resource demands from the three *TC & WM EIS* alternative combinations would be very conservative because contributing peak utility demands are likely to occur in different timeframes and not overlap. In addition, the Hanford baseline already includes utility impacts associated with existing and ongoing tank closure activities that cannot be separated out; therefore, their addition to the impacts of the *TC & WM EIS* alternative combinations unavoidably reflects some level of double counting. Future actions associated with sitewide waste cleanup and restoration activities, including proposed closure of the Central Plateau, are expected to cause a temporary increase in utility demands followed by a decline and even cessation of resource consumption after specified cleanup actions are completed. The timing and duration of associated peaks in utility consumption and subsequent reduction in utility demands upon completion of activities, are very speculative and no data are available for calculating such estimates.

Similarly, utility resource requirements for cleanup of the balance of Hanford and decontamination and decommissioning (D&D) of individual facilities have not been well quantified in available documentation such as the *Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land*

Use Plan (DOE 1996a) or subsequent plans or studies. While there would likely be an incremental increase in utility demands in the short term to complete individual cleanup and facility D&D actions, the net effect over the longer term would be a sitewide reduction in utility demands once activities have ceased. While individual future cleanup and facility disposition and D&D actions were considered in this *TC & WM EIS* (see Appendix R, Table R–4), they are not specifically listed in Table 6–2 and their cumulative effect on utility infrastructure presents another point of uncertainty and possible conservatism in the analysis.

Some actions will undoubtedly also result in reduced resource consumption where existing facilities and infrastructure are upgraded and/or replaced with modern, more resource-efficient facilities. Such is the case with the relocation of Pacific Northwest National Laboratory (PNNL) personnel and activities from the 300 Area to the new PNNL Physical Sciences Facility to be constructed adjacent to the existing PNNL campus. Except for relatively minor construction-related impacts and utility demands, net operational impacts on Hanford utility infrastructure would be lower once the transition is complete (DOE 2007a:S-3, 15). Nevertheless, this reduction in utility resource demands has not been quantified. In any event, as the city of Richland, Washington, provides utility services to the site (DOE 2007a: 5-13, 15), any operational impacts would not directly affect the utility systems serving Hanford facilities. Such circumstances further add to the conservative nature of this analysis.

Excavation of geologic and soil resources for use across Hanford in support of ongoing activities necessarily entail some consumption of utility resources, including water for dust control and to aid crushing and sorting operations and liquid fuels for operation of heavy equipment. While not separately quantified from available data, these demands were assumed to be at least partially captured in the Hanford baseline value presented in Table 6–2. Utility resource consumption would likely increase in proportion to the excavation and conveyance of greater volumes of material to support future actions (see Section 6.3.5), and these utility requirements were already quantified to some extent within the requirements of the three *TC & WM EIS* alternative combinations.

As stated previously, the analysis also considered utility infrastructure impacts from non-DOE activities. Ongoing operations and utility resource consumption associated with the US Ecology Commercial Low-Level Radioactive Waste Disposal Facility are included in the Hanford baseline. Future closure actions would result in additional, short-term demands, but are difficult both to quantify and to separate from operational demands already included in the Hanford baseline. Estimates for these incremental demands are included in Table 6–2, where available, and likely further enhance the conservative nature and uncertainty of the analysis presented.

In addition, U.S. Fish and Wildlife Service personnel working at the Hanford Reach National Monument are using existing Hanford facilities that have been declared surplus to DOE needs, including maintenance shops, a pump house, and a reservoir, as well as sharing space with other entities such as the Bonneville Power Administration (USFWS 2008:3-145, 3-146). Utility demands associated with operation of these facilities are assumed to be part of the Hanford baseline. Nonetheless, the U.S. Fish and Wildlife Service's preferred alternative for management of the Hanford Reach National Monument would entail construction and maintenance of new facilities and other improvements, including interpretive sites, parking and boat access areas, trails, and a possible visitor center to enhance visitor use and access to areas within the Hanford Reach National Monument (USFWS 2008:4-225–4-227). While these activities would add to the cumulative demand for utility resources, the demand cannot be quantified at this time.

6.3.3 Noise and Vibration

Noise impacts from activities under the *TC & WM EIS* alternatives would primarily result from changes in vehicle traffic on access roads to Hanford, as discussed in Chapter 4, Sections 4.1.3, 4.2.3, and 4.3.3.

Based on information provided in the NEPA documents that are available (see Appendix R, Table R–4), noise impacts on the public from other DOE activities are primarily related to vehicle traffic. Impacts on wildlife could occur from various construction activities, including remediation, closure, and operation of the various borrow areas.

Noise impacts from non-DOE construction and operation activities were also considered, including impacts on the public and wildlife from construction-related activities and future industrial operations at the 300 Area. Noise impacts from existing non-DOE activities at Hanford, such as traffic noise from the Columbia Nuclear Generating Station and operation of the AREVA Nuclear Fuel Fabrication Facility, the Perma-Fix Northwest Waste Treatment Facility, and the US Ecology Low-Level Radioactive Waste Disposal Facility, are part of the existing background sound environment near Hanford.

Future activities at Hanford and in the areas near the site, such as new industries, oil and gas development, agriculture, offices, schools, residential development, new roads, and other infrastructure improvements, could result in variations in the levels of traffic noise along access roads to the site and increased noise levels near these developments. Some of the proposed developments in the area that are expected to result in increased noise levels include various wind energy projects; the Columbia Ethanol Plant in Finley, Washington; the Southridge, Hansen Park, and Clearwater Park developments in Kennewick, Washington; and the new PNNL Physical Sciences Facility at Hanford.

As such, the cumulative impact on noise levels in the region from the activities described above is expected to result in some increase in traffic noise and localized changes in noise levels from new facilities and developments. Because of the distance to the site boundary, little or no change in overall offsite noise levels is expected due to construction, operations, and decommissioning activities at Hanford.

DOE activities, other activities at Hanford, traffic through Hanford, and road work at Hanford could result in ground vibration that could affect the operation of the Laser Interferometer Gravitational-Wave Observatory (LIGO) facility. Most of the activities that were identified to have impacts on this facility result from heavy vehicles and large construction equipment. It is expected that blasting during building and road construction and during mining could also have an impact on this facility. Although DOE will coordinate vibration-producing activities with the operators of the LIGO facility, cumulative impacts from these activities are expected to result in some interference with its operations.

6.3.4 Air Quality

Cumulative impacts of criteria air pollutants are shown in Table 6–3 for DOE actions at Hanford and non-DOE actions in the region for those pollutant concentrations that have been quantified. Cumulative impacts of radiological air emissions on public and occupational health and safety are discussed in Section 6.3.10. The concentrations presented in Table 6–3 represent the maximum concentrations under the three *TC & WM EIS* alternative combinations, the baseline concentration from Chapter 3, the estimated maximum concentrations for various DOE activities and non-DOE activities that have been presented in NEPA documents, and the estimated concentrations for retrieval of retrievably stored transuranic (TRU) waste. Concentrations also are presented for operations activities.

Table 6–3 indicates that cumulative concentrations of carbon monoxide, nitrogen oxides, and sulfur oxides could be up to 495, 112, and 74 percent of applicable standards, respectively. Cumulative concentrations of particulate matter (PM) with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) could be up to 155 times the applicable standard.

Table 6–3. Cumulative Impacts of Criteria Air Pollutants

Actions/Activities	Maximum Average Concentration (micrograms per cubic meter)			
	Carbon Monoxide (8 hours)	**Nitrogen Oxides (Annual)**	**Particulate Matter (PM_{10}) (24 hours)**	**Sulfur Oxides (1 hour)**
***TC & WM EIS* Combined Impacts[a] (see Chapter 4, Table 4–153)**				
Alternative Combination 1	3,480	9.8	**1,050**	24.7
Alternative Combination 2	**16,700**	45.9	**8,650**	222
Alternative Combination 3	**49,500**	**112**	**23,200**	486
Other DOE Actions at the Hanford Site				
Hanford Site baseline[b]	40	0.26	0.88	4.6
Existing borrow areas (DOE 2001)[c]	NR	NR	4.03	NR
Retrieval of retrievably stored TRU waste (based on SAIC 2007a) (2017–2018)	1.54	0.0195	22.8	0.0023
Other DOE Subtotals	42	0.28	28	4.6
Non-DOE Actions in the Region of Influence				
Pacific EcoSolutions offsite thermal treatment of Hanford Site LLW (DOE 1999b)	0.24	0.0283	0.000442	0.0398
Pacific EcoSolutions nonthermal treatment of Hanford Site LLW (DOE 1998a)	NR	NR	0.0026	NR
Non-DOE Subtotals[d]	0.24	0.028	0.003	0.040
Cumulative Totals[e]				
Alternative Combination 1	3,520	10.1	**1,080**	29.3
Alternative Combination 2	**16,700**	46.2	**8,680**	227
Alternative Combination 3	**49,500**	**112**	**23,200**	491
Most Stringent Standard	*10,000*	*100*	*150*	*660*

a See Chapter 4, Table 4–153.

b See Chapter 3, Section 3.2.4.

c Particulate matter concentration at the pit. Value is not representative of the concentration to which the public would be exposed.

d The maximum from these non-DOE facilities is presented because the location of these estimated concentrations is not presented in the source documents.

e The "cumulative totals" are the sums of the impacts under the alternative combinations and the "Other DOE" and "Non-DOE" activities.

Note: To convert cubic meters to cubic yards, multiply by 1.308. Values that exceed the standard value are shown in **bold** text. Subtotals or totals may not equal the sum of the contributions due to rounding.

Key: DOE=U.S. Department of Energy; LLW=low-level radioactive waste; NR=not reported; PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; TRU=transuranic.

The 16,700 micrograms per cubic meter carbon monoxide concentration under *TC & WM EIS* Alternative Combination 2 and the 49,500 micrograms per cubic meter carbon monoxide concentration under Alternative Combination 3 could exceed the 10,000-micrograms-per-cubic-meter 8-hour standard for carbon monoxide. The nitrogen oxide concentration under Alternative Combination 3 could exceed the 100-micrograms-per-cubic-meter standard for nitrogen oxides. The peak concentration for carbon monoxide and nitrogen oxide under the *TC & WM EIS* alternatives would result primarily from fuel-burning activities. Carbon monoxide and nitrogen oxide concentrations could be reduced by applying appropriate administrative control measures (see Chapter 7, Section 7.1.4).

PM concentrations under the *TC & WM EIS* alternative combinations could exceed the 150-micrograms-per-cubic-meter 24-hour standard for PM_{10}, ranging from 1,080 micrograms per cubic meter under Alternative Combination 1 to 23,200 micrograms per cubic meter under Alternative Combination 3. The

peak concentration for PM from the *TC & WM EIS* alternatives would result primarily from construction and earthmoving activities. PM concentrations could be reduced by applying appropriate dust control measures (see Chapter 7, Section 7.1.4).

The cumulative impacts analysis is very conservative because many of the air pollutant releases would occur at different times, and the peak concentrations would occur at different locations and may not be additive. The estimates of air pollutant concentrations for the *TC & WM EIS* alternative combinations were based on conservative analyses that would be refined in future design documents. If the more refined future analyses still predict exceedance of air quality standards, then additional measures (e.g., location changes, use of additional pollution control equipment, or administrative controls) would be instituted to reduce emissions to an acceptable level. Activities that would cause air quality standards to be exceeded would not be allowed.

Hanford facilities that are permitted in the Hanford Air Operating Permit were included in the estimate of the Hanford baseline concentrations (see Chapter 3**,** Section 3.2.4**,** of this *TC & WM EIS*) based on the annual emissions inventory.

Impacts from other onsite activities are discussed below based on the information provided in the environmental impact documents that are available.

In the 100 Area, there would be continuing fugitive dust emissions and emissions from reactor decommissioning over the next 50 years or more (DOE 1999a:3-61, 5-45) and dust from waste site excavation (DOE 2006a). In the 200 Areas, there would be ongoing fugitive dust emissions and equipment emissions from various borrow area and construction sites (DOE 1999a:3-61, 5-45), dust and equipment emissions from ongoing construction and operation of the Environmental Restoration Disposal Facility (ERDF) (DOE 1994), emissions from canyon disposition (221-U closure) (DOE 2004b); emissions from facility demolition and remediation, including excavation, backfill, and capping; (Fluor Hanford 2004), and emissions from Plutonium Finishing Plant above-grade structure removal (DOE 2003a). In the 300 Area, there would be fugitive dust emissions and other emissions from surplus facilities closure and future uses (DOE 1999a).

Other DOE activities at Hanford include activities at existing active borrow pits and quarries (DOE 2001), as well as reactivation of former borrow areas in the 100-F, 100-H, and 100-N Areas (DOE 2003b), which would produce emissions of fugitive dust and other pollutants from excavation equipment and trucks. Construction and operation of the relocated PNNL Physical Sciences Facility from the 300 Area to the PNNL campus would result in some fugitive dust emissions and other construction emissions during the period 2007 to 2008, as well as emissions of other criteria pollutants from boiler use and emergency generator operation. Maximum concentrations resulting from operation of this facility were estimated to be about 4 percent of the 8-hour carbon monoxide standard and 4 percent of the PM_{10} 24-hour standard and are not included in Table 6–3 (DOE 2007a).

Non-DOE activities that would emit fugitive dust and other pollutants include AREVA operation, from which there are nitrogen oxides emissions; Perma-Fix nonthermal and thermal treatment of mixed low-level radioactive waste (MLLW), which may produce some combustion emissions (DOE 1998a, 1999b; Pacific EcoSolutions 2007); Volpentest Training and Education Center activities, from which emissions would be negligible except for vehicular emissions (DOE 2002a); and operation of the US Ecology Commercial Low-Level Radioactive Waste Disposal Facility, from which there are fugitive dust emissions (Ecology and WSDOH 2004). The proposed Wanapa Energy Center, if built, would be a major source of air pollutant emissions, but would not significantly deteriorate the quality of the air surrounding the proposed site or lead to deterioration of air quality in nearby pristine areas (BIA 2004:3.5-1, 3.5-2). The proposed Plymouth Generating Facility, if built, would not significantly deteriorate the quality of the

air surrounding the proposed site (Benton and BPA 2003:II–4**)**. The Wanapa Energy Center and Plymouth Generating Facility projects are currently on hold.

Oil and gas development, including exploration and production activities, could result in fugitive dust emissions and other air pollutant emissions from drilling equipment, compressor stations, and other equipment. Maximum impacts of these activities generally occur close to the source; therefore, they are not expected to contribute substantially to impacts near Hanford. Facility conversion of waste to energy and biofuels could result in fugitive dust emissions from construction and other air pollutant emissions from operations. The Columbia Ethanol Plant in Finley, when completed, would emit annual emissions of approximately 29 metric tons of nitrogen oxides, 19 of sulfur oxides, 64 of carbon monoxide, 89 of volatile organic compounds, and 63 of particulates from vents, the stack, and roads (total particulate and PM_{10}). Emission of ethanol and other organic compounds would be below the levels of concern for human health risk (Columbia Ethanol Plant Holdings, LLC 2006). Other proposed or recently permitted biofuels facilities in the region would emit similar air pollutants.

Mobile source emissions in Benton County account for about 95 percent of annual emissions of carbon monoxide, 72 percent of nitrogen oxides, 76 percent of sulfur oxides, and 59 percent of volatile organic compounds (EPA 2007a). In addition to the industrial sources of air pollutants discussed above, there are industries that produce asphalt paving material and block, nitrogen fertilizer, crushed stone, canned fruits and vegetables, frozen foods, and nonferrous metal sheet, as well as grain storage facilities and natural gas transmission facilities (EPA 2007b).

Other development in the region could result in increases in air pollutant emissions from construction activities, vehicle traffic, and other sources related to new housing, businesses, and industries. For example, in Kennewick, the subarea plans for Southridge, Hansen Park, and Clearwater Park include the development of over 648 hectares (1,600 acres) for housing, 142 hectares (350 acres) for commercial and business use, and 81 hectares (200 acres) for industrial use (Kennewick 1999, 2002). In addition, increased mining activity and reclamation of mined areas could lead to increases in air pollutant emissions.

6.3.5 Geology and Soils

Existing conditions with regard to geology and soils are presented in Chapter 3, Section 3.2.5. These existing conditions define the Hanford baseline that was considered for this cumulative impacts analysis. The Hanford baseline already reflects past actions that have directly impacted geology and soils. Therefore, past activities were not further considered; rather, this discussion focuses on the potential for cumulative impacts on geology and soils resulting from ongoing and future actions. As such, the ROI for geologic and soil resources encompasses all of Hanford, including the proposed *TC & WM EIS* action areas and any ongoing or future actions across Hanford that may require excavation of geologic and soil resources from Borrow Area C and additional materials from Gravel Pit No. 30.

Table 6–4 presents the results of the cumulative impacts analysis for geologic and soil resources. The resource requirements presented in Table 6–4 represent the total projected material demands from the three *TC & WM EIS* alternative combinations and the projected demands to support various DOE activities and non-DOE activities that could potentially occur within the same timeframe. The potential for the cumulative demand to exceed the available reserves of geologic and soil resources at Hanford was also assessed. Appendix R, Table R–4, details the actions and activities that were considered for their possible contribution to cumulative impacts at Hanford.

Table 6–4. Potential Cumulative Geologic and Soil Resource Requirements

Actions/Activities[a]	Total Geologic and Soil Resource Requirements (cubic meters)
TC & WM EIS Combined Impacts (see Chapter 4, Table 4–154)	
Alternative Combination 1	99,000
Alternative Combination 2	6,450,000
Alternative Combination 3	18,700,000
Other DOE Actions at the Hanford Site	
Hanford Site baseline[b]	Not applicable
Excavation and use of geologic materials (2006–2013) (DOE 2001:2-2; DOE 2003a:2-2)	1,175,000
Cleanup and restoration activities (2006–2035) (DOE 1996a:5-40, 5-93)	17,820,000
Final disposition of the canyons, PUREX Plant, PUREX tunnels, and other facilities (2006–2035) (Fluor Hanford 2004:2-13, 2-15)	30,940,000
Retrieval of retrievably stored TRU waste (2017–2018) (based on SAIC 2007a)	No data
Construction and operation of the ERDF (2006–2024) (DOE 1994:9T-6)	6,420,000
PNNL Physical Sciences Facility (2006–2011) (DOE 2007a)	No data
Other DOE Subtotals	56,355,000
Non-DOE Actions in the Region of Influence	
US Ecology Low-Level Radioactive Waste Facility (2006–2056) (Ecology and WSDOH 2004:140)	552,000
Hanford Reach National Monument (2006–2022) (USFWS 2008)	No data
Non-DOE Subtotals[c]	552,000
Cumulative Totals[c]	
Alternative Combination 1	57,006,000
Alternative Combination 2	**63,360,000**
Alternative Combination 3	**75,600,000**
Site Resource Availability[d]	57,900,000

[a] Actions/activities as identified in Appendix R, Table R–4. Years in parentheses reflect the timeframe in which the resource demand may occur.

[b] Past and present geologic and soil resource consumption is not applicable to the analysis of cumulative impacts. The ROI for this analysis consists of Borrow Area C, which has not been impacted to date, and gravel pit No. 30, from which Waste Treatment Plant construction materials have been extracted to date.

[c] The "cumulative totals" are the sums of the impacts under the alternative combinations and the "Other DOE" and "Non-DOE" activities.

[d] Combined resource reserves from Borrow Area C and gravel pit No. 30 (see Chapter 3, Section 3.2.5).

Note: Values that exceed the established resource capacity are shown in **bold** text. Subtotals or totals may not equal the sum of the contributions due to rounding. To convert cubic meters to cubic yards, multiply by 1.308.

Key: DOE=U.S. Department of Energy; ERDF=Environmental Restoration Disposal Facility; PNNL=Pacific Northwest National Laboratory; PUREX=Plutonium-Uranium Extraction; ROI=region of influence; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; TRU=transuranic.

Projected cumulative impacts on geologic and soils resources over the period of analysis mainly reflect demands for sitewide cleanup and closure actions and facility D&D. Added to these demands are those associated with construction, operation, and future deactivation and closure of facilities under the three *TC & WM EIS* alternative combinations. Future closure actions, including final capping of closed disposal facilities or facilities that have undergone D&D, but contain residual waste, represent the largest activity demands for geologic and soil resources (see Table 6–4).

As for the other DOE actions considered, construction of the new PNNL Physical Sciences Facility south of the 300 Area would require geologic and soil resources as part of site preparation, including crushed stone and structural fill, dense-graded aggregate, and other materials needed to meet geotechnical specifications (DOE 2007a:15). These requirements have not been quantified as shown in Table 6–4, but the related demand would add to Hanford's overall geologic and soil resource requirements.

Closure actions associated with non-DOE activities were also considered, including final closure of the US Ecology Commercial Low-Level Radioactive Waste Disposal Facility (see Table 6–4). As noted in Section 6.3.2, implementation of the *Hanford Reach National Monument Final Comprehensive Conservation Plan and Environmental Impact Statement, Adams, Benton, Grant and Franklin Counties, Washington* (USFWS 2008) would entail construction and maintenance of new facilities and other improvements such as interpretive sites, parking and boat access areas, trails, and a possible visitor center. These proposed activities would consume geologic and soil resources. However, these needs, as well as the ongoing demand for maintenance of existing assets, cannot be quantified at this time.

As indicated in Table 6–4, projected demands for other DOE and non-DOE activities would approach the 57.9 million cubic meters (75.7 million cubic yards) of established geologic and soil reserves from Borrow Area C and Gravel Pit No. 30 without the additional contribution from the *TC & WM EIS* alternative combinations. Projected cumulative demands for geologic and soil resources would range from about 98 percent of established reserves under Combination 1 to 31 percent in excess of established reserves under Combination 3. Although the projected volumes for geologic and soil resources for the activities listed in Table 6–4 are believed to be conservative, the analysis does indicate that completion of all contemplated future actions could require use and development of additional borrow areas beyond Borrow Area C and Gravel Pit No. 30. Geologic and soil resources, including relatively large volumes of gravel, sand, and silt, are available from the suprabasalt sediments and associated soils across Hanford and elsewhere in the region. Rock in the form of basalt is also plentiful. Alternatively, any shortfall, if realized, could be fully or partially provided from offsite commercial quarries, but would result in additional transportation impacts due to increased truck transportation to and from Hanford, as well as additional costs for obtaining these materials from commercial sources.

6.3.6 Water Resources

This section addresses the potential cumulative impacts of past, present, and reasonably foreseeable future actions on water resources, including surface water (with a special focus on the Columbia River) and the Hanford groundwater system (including the vadose zone). Existing conditions with regard to water use and surface and groundwater quality are presented in Chapter 3, Sections 3.2.2.4, 3.2.6.1, and 3.2.6.3, respectively. These existing conditions define the Hanford baseline that was considered for this cumulative impacts analysis. The Hanford baseline already reflects past DOE and non-DOE actions that have directly impacted existing surface waters, such as alteration of Columbia River hydrology, as well as historical contaminant releases from DOE or other facilities that have impacted surface and groundwater quality. Therefore, past activities are not further considered here, and this discussion is focused on the potential for ongoing and future actions to have short-term cumulative impacts on water resources.

Cumulative water resources impacts from ongoing and future DOE and non-DOE activities were considered, including individual future cleanup and facility disposition activities and D&D actions identified in Appendix R, Table R–4. Ongoing and future actions to cleanup the Central Plateau, as well as individual facility D&D actions, combined with actions associated with the *TC & WM EIS* alternative combinations (see Chapter 4, Section 4.4.5), are not expected to contribute to direct cumulative impacts on water resources. This is because, other than the Columbia River, water courses are essentially nonexistent at Hanford; surface-water drainage patterns are poorly developed to convey potentially contaminated stormwater or other effluents; the depth to groundwater across much of the site is such that any effluents would be unlikely to affect groundwater; and the most intensive cleanup and D&D activities

(on the Central Plateau) are located at some distance from the Columbia River. In addition, the application of best management practices and other mitigation measures, as well as compliance with applicable permit provisions, would be employed to ensure that stormwater runoff and infiltration does not convey soil, sediments, and other pollutants to any nearby surface water or groundwater. Furthermore, compliance with applicable permit provisions would help ensure that any generated effluents from ongoing and future actions are treated and disposed of so as to have no additional impact on surface water, the vadose zone, and groundwater. Additionally, while not easily quantified, future non-DOE activities near the site (new industries, oil and gas development, agriculture, residential development, new road construction, and other infrastructure improvements) are likely to be the larger contributors to cumulative impacts on surface water and groundwater over the timeframe considered in this analysis.

As quantified in Section 6.3.2, projected water use from the Columbia River associated with the *TC & WM EIS* alternative combinations, coupled with other future actions at Hanford, is not expected to have a substantial cumulative impact on the availability of water for downstream users. This is because the projected, cumulative demands by all DOE and non-DOE actions would only be about 20 percent of the pre-1990 water demands of the Hanford 200 Area facilities. While water use by communities that utilize the Columbia River as a water source is expected to rise commensurate with land use development and general population increases in the region, as discussed in Section 6.3.2, contemplated actions at Hanford would actually reduce the overall impact on surface-water and groundwater availability and quality.

Ongoing and future DOE actions, including many associated with the *TC & WM EIS* alternative combinations, would have a positive, short-term and long-term effect on water resources. Site-wide cleanup and closure actions and facility D&D would remove and immobilize contaminants in the Hanford vadose zone and prevent or delay their entry into the groundwater and ultimately to the Columbia River. In addition, such remedial actions, coupled with DOE efforts across Hanford to significantly curtail wastewater discharge to surface-water impoundments and the subsurface water (see Chapter 3, Section 3.2.6.3.1), have slowed and will continue to slow the migration of existing groundwater contaminant plumes to the Columbia River. Long-term impacts on water resources, including projected changes in groundwater hydrology and transport of contaminants through the Hanford groundwater system and ultimately to the Columbia River, are addressed in Section 6.4.1.

6.3.7 Ecological Resources

Although ecological resources include terrestrial resources, wetlands, aquatic resources, and threatened and endangered species, cumulative impacts were addressed only for terrestrial resources and threatened and endangered species. Because there would be no direct or indirect short-term impacts to wetlands and aquatic resources under any of the *TC & WM EIS* alternatives, actions associated with them would not contribute to cumulative impacts within the ROI. For terrestrial resources, the cumulative impacts to terrestrial habitat as a whole, and more specifically to shrub-steppe habitat, were examined. For threatened and endangered species, the analysis included federally and state-listed threatened and endangered species and other special status species. The ROI for both terrestrial resources and threatened and endangered species included the proposed *TC & WM EIS* action areas, the site, and areas up to 80 kilometers (50 miles) from the site. The analysis was limited to an 80-kilometers (50-miles) radius because that distance included a large portion of southeastern Washington, an area within which shrub-steppe habitat historically has occurred.

6.3.7.1 Terrestrial Resources

Thirty-one projects within the ROI were analyzed with regard to the area of terrestrial and shrub-steppe habitat that they would disturb. These projects either were recently completed or are reasonably certain of being completed in the near future (see Appendix T, Table T–1). It should be noted that the projects evaluated do not represent the only activities affecting terrestrial habitat within the ROI. For example, construction of many smaller subdivisions and commercial developments and conversion of land to agricultural use would also impact terrestrial habitat; however, the number and extent of these smaller activities cannot be readily determined. In addition, uncertainties exist relative to implementation of a number of large projects within the ROI; specific information regarding their impacts on ecological resources is not available at this time.

Studies have estimated that 6.07 million hectares (15 million acres) of shrub-steppe habitat (60 percent of the landscape) existed in eastern Washington before land conversion began with the arrival of white settlers. Recent studies have estimated that only about 30 percent of the landscape now consists of this habitat type. Thus, there has been a 50 percent decrease in the historical occurrence of shrub-steppe habitat since the 1840s (Jacobson and Snyder 2000:1, 20). Beyond the loss of shrub-steppe habitat, much of that which remains has been fragmented. Shrub steppe is a fragile habitat, and many of the animal species that have evolved with it require large contiguous areas to survive. Thus, fragmentation, which results in small blocks of habitat, can seriously impact wildlife populations (Dobler et al. 1996:21).

Table 6–5 presents estimates of the area of terrestrial and shrub-steppe habitat impacted by the 31 projects analyzed within the ROI. Projects are grouped by the three *TC & WM EIS* alternative combinations, other DOE activities at Hanford, non-DOE activities at Hanford, and other projects and activities within the ROI. The term, terrestrial habitat, is used in a broader sense to include shrub-steppe habitat, other native and non-native habitat, grazing land, and cropland. Because of the importance of shrub-steppe habitat, it is identified separately in the table. While it was possible to calculate the specific area of terrestrial and shrub-steppe habitat lost for the three alternative combinations, such information was not always available for other projects identified within the ROI. As these projects were not generally located in highly developed portions of the region, the entire project area was classified as terrestrial habitat. This approach is conservative because it likely overestimates the acreage of terrestrial habitat lost.

The cumulative total terrestrial habitat that could be disturbed ranges from 9,260 hectares (22,881 acres) including Alternative Combination 1 to 10,006 hectares (24,725 acres) including Combination 3. The cumulative total shrub-steppe habitat that could be disturbed ranges from 3,839 hectares (9,486 acres) under Combination 1 to 4,185 hectares (10,341 acres) under Combination 3. To determine the contribution of the three TC & WM EIS alternative combinations to the cumulative disturbance of terrestrial habitat within the ROI, the area impacted by each of the three combinations was divided by the total area of terrestrial habitat disturbed. Similarly, the contribution of the three alternative combinations to the cumulative disturbance of shrub-steppe habitat was determined. Thus, Combination 1 respectively represents 0.02 and 0 percent of the cumulative terrestrial and shrub-steppe habitat impacted in the ROI. Combination 2 represents 2.2 and 1.7 percent of the cumulative terrestrial and shrub-steppe habitat impacted, and Combination 3 represents 7.5 and 8.3 percent of each type, respectively. Although not one of the three alternative combinations, the greatest area of habitat affected would be under a combination of alternatives that includes Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 3 (with all facilities to be built at Hanford), and Waste Management Alternative 3 (with Disposal Group 2 or 3). Such a combination would represent 10.5 and 10.2 percent of cumulative terrestrial and shrub-steppe habitat affected, respectively.

Table 6–5. Cumulative Area of Terrestrial Habitat Disturbed

Actions/Activities	Total Terrestrial Habitat Disturbed[a]	Shrub-Steppe Habitat Disturbed[b]
	hectares	
***TC & WM EIS* Combined Impacts (see Chapter 4, Table 4–155)**		
Alternative Combination 1[c]	2	0
Alternative Combination 2	207	66
Alternative Combination 3	749	346
Other DOE Actions at the Hanford Site (see Appendix T, Table T−1)	650	511
Non-DOE Actions at the Hanford Site (see Appendix T, Table T−1)	445	142
Other Projects/Activities in the Region of Influence (see Appendix T, Table T−1)	8,162	3,187
Cumulative Totals[d]		
Alternative Combination 1	9,260	3,839
Alternative Combination 2	9,465	3,905
Alternative Combination 3	10,006	4,185

[a] For those cases where the area of undeveloped land impacted by project implementation was not reported, it was conservatively assumed that the entire project area could be classified as terrestrial habitat. Terrestrial habitat could include shrub-steppe habitat, other native and nonnative habitat, grazing land, and cropland.

[b] Shrub-steppe habitat includes areas specifically described as such in project documents, as well as areas conservatively estimated to be shrub steppe.

[c] The specific elements of the *TC & WM EIS* alternative combinations are addressed in Chapter 4, Section 4.4**.**

[d] The cumulative totals are the sums of the impacts under the alternative combinations and the "Other DOE" and "Non-DOE" activities. Totals may not equal the sum of the contributions due to rounding.

Note: To convert hectares to acres, multiply by 2.471.

Key: DOE=U.S. Department of Energy; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

The total area of terrestrial and shrub-steppe habitat within the ROI is unknown, so the change in the proportion of habitat disturbed within the region resulting from the 31 analyzed projects cannot be determined. However, because the approximate area of terrestrial habitat at Hanford is known (144,000 hectares [356,000 acres] [Neitzel 2005:4.144]), as is the aerial extent of shrub-steppe habitat (approximately 27,924 hectares [69,000 acres] [DOE and Ecology 1996:5-70; Neitzel 2005:4.75]), it is possible to determine the effect that recent past, present, and reasonably foreseeable future development may have on the site. Thus, considering the land requirement of each of the three alternative combinations, as well as other projects and activities occurring at the site, the total area of terrestrial habitat would be reduced by 0.8, 0.9, and 1.3 percent under Combinations 1 through 3, respectively. With respect to shrub-steppe habitat, onsite activities would decrease existing habitat by 2.3, 2.6, and 3.6 percent, respectively. Considering the alternative combination that would disturb the greatest land area (see above), terrestrial habitat and shrub-steppe habitat would be reduced by 1.5 and 3.9 percent, respectively. These estimates are conservative because they do not account for the restoration or compensation of lost shrub-steppe habitat that is required for most projects carried out at Hanford (DOE 2003c).

6.3.7.2 Threatened and Endangered Species

As noted above, the ROI for threatened and endangered species includes the proposed *TC & WM EIS* action areas, the site, as well as areas up to 80 kilometers (50 miles) from the site. Due to differences in the levels of reporting for the 31 analyzed projects, the ability to assess cumulative impacts on threatened and endangered species is limited. For example, of the projects reviewed, 13 did not report on the status of listed species and, of those that did, 10 indicated there would be no impacts and 8 indicated that impacts were possible.

As no federally listed or state-listed threatened or endangered species would be impacted by any of the *TC & WM EIS* alternatives, actions associated with these alternatives would not contribute to cumulative impacts within the ROI (see Chapter 4, Sections 4.1.7, 4.2.7, 4.3.7, and 4.4.6.3). However, cumulative impacts on a number of other special status species observed within areas affected by activities associated with the *TC & WM EIS* alternatives are possible. These species include: Piper's daisy (state sensitive), crouching milkvetch (state watch), stalked-pod milkvetch (state watch), loggerhead shrike (Federal species-of-concern and state candidate), sage sparrow (state candidate), long-billed curlew (state monitor), and black-tailed jackrabbit (state candidate). Of these species, crouching milkvetch was not mentioned in any of the 31 projects reviewed, and Piper's daisy, stalked milkvetch, the long-billed curlew, and the black-tailed jackrabbit were mentioned in only one study each. The sage sparrow and loggerhead shrike were noted as potentially impacted in three and six of the studies reviewed, respectively. Thus, while the available data are limited, they suggest it is unlikely that cumulative impacts to populations of five of the special status species (i.e., piper's daisy, crouching milkvetch, stalked-pod milkvetch, long-billed curlew, and black-tailed jackrabbit) would occur. Cumulative impacts to the two remaining special status species (i.e., sage sparrow and loggerhead shrike) would be limited.

Although none of the federally listed and state-listed species noted above receives legal protection such as that afforded threatened or endangered species, they should be considered in project planning. Such planning is undertaken at Hanford when a comprehensive mitigation action plan is developed and projects may impact listed species (or shrub-steppe habitat). Mitigation planning related to potentially affected plants and animals was also noted for a number of the regional projects reviewed. Mitigation plans would act to limit potential impacts to species within a project area and, therefore, also act to limit cumulative impacts within the ROI.

6.3.8 Cultural and Paleontological Resources

The assessment of short-term cumulative impacts on cultural and paleontological resources includes prehistoric, historic, and paleontological resources, as well as American Indian interests, each of which will be discussed individually below. A general description of cultural and paleontological resources and American Indian interests on and in the vicinity of Hanford is presented in Chapter 3, Section 3.2.8. Cumulative impacts related to cultural and paleontological resources and American Indian interests were evaluated in an ROI that includes Hanford and nearby offsite areas. The potential for cumulative impacts on cultural resources is discussed qualitatively. These cumulative impacts are additive to the impacts of the *TC & WM EIS* alternative combinations described in Chapter 4, Section 4.4.7.

Construction of new facilities and disturbance of previously undeveloped land would have the greatest potential for cumulative impacts on cultural and paleontological resources and American Indian interests. Approximately 50 actions, including the *TC & WM EIS* alternative combinations, other DOE and non-DOE activities at Hanford, and other activities in the ROI were considered with regard to their cumulative impacts on cultural resources (see Appendix R, Table R–4). Those activities that have a potential cumulative impact are discussed further below (also see Appendix T, Table T–2).

6.3.8.1 Prehistoric Resources

The cumulative impacts of the three *TC & WM EIS* alternative combinations would be similar to the combined impacts addressed in Chapter 4, Section 4.4.7.1. Cumulative impacts that include Alternative Combination 1 would involve the least land disturbance and so would have the least potential to add to cumulative impacts. Cumulative impacts that include Alternative Combinations 2 and 3 would disturb a larger area of land.

As past surveys have indicated, prehistoric resources have a low potential of being present for the majority of DOE and non-DOE activities at Hanford. Isolated finds within the ROI have not been deemed eligible for the National Register of Historic Places.

Two activities listed in Appendix T, Table T–2, could possibly add to the impacts on prehistoric resources. Both the Hanford Reach National Monument at Hanford and Black Rock Reservoir, which is planned for construction in Yakima County, are or would be located on land that potentially could contain prehistoric resources.

6.3.8.2 Historic Resources

The cumulative impacts of the three *TC & WM EIS* alternative combinations would be similar to the combined impacts addressed in Chapter 4, Section 4.4.7.2. Other DOE activities at Hanford could have an impact on historical properties as well. Decommissioning of the eight surplus production reactors and their support facilities in the 100 Areas may have a possible impact on the 100-B Reactor Building, which is listed on the National Register of Historic Places and, on August 19, 2008, was designated as a National Historic Landmark (DOE and DOI 2008). The rail line associated with construction and operation of the ERDF near the 200-West Area could adversely affect a portion of historic White Bluffs Road. The Atmospheric Dispersion Grid would have been affected by project activities; however, the impacts were mitigated and no further mitigation is required (Poston et al. 2007). A select representative number of artifacts were removed and curated into the Hanford collection (Prendergast-Kennedy 2003:2).

The management plan for the Hanford Reach National Monument, a non-DOE project, specifies the requirement to: "Protect and acknowledge the Native American, settler, atomic and Cold War histories of the Monument…" (USFWS 2008:2-6). Cultural resources became more visible following wildfire events of August 2007 and are more vulnerable to vandalism.

The proposed Yakima County Black Rock Reservoir would be situated in a location that has a high potential for historic resources. Many of the other non-DOE activities within the ROI would have little or no impact on historic resources because they would not take place in or near areas that contain historic resources.

6.3.8.3 American Indian Interests

Effects on American Indian areas of interest can occur from cumulative impacts on the visual character of the land. Construction of new facilities and disturbance of previously undeveloped land are likely to have the greatest impacts. Many of the projects and activities assessed for cumulative impacts are of limited size, occur in presently developed areas, or are located at a distance from Hanford. These activities would produce no-to-minimal change in the viewshed.

The cumulative impacts of the three *TC & WM EIS* alternative combinations would be similar to the combined impacts addressed in Chapter 4, Section 4.4.7.3. Accordingly, Alternative Combination 1 would have the least cumulative impact, and Combination 3 the greatest due to disturbance of the largest area and the most extensive alteration of the existing viewshed among the alternative combinations.

The location of facilities is important in determining the cumulative visual impacts on American Indian areas of interest. Some activities at Hanford, as well as some offsite projects and activities, would be visible from Rattlesnake Mountain, Gable Mountain, or Gable Butte, all of which are areas of noted cultural and religious significance to American Indians. Onsite DOE projects and activities that may be visible include excavation and use of geologic materials from borrow pits, transport of materials on the borrow site haul road from Route 240 through Borrow Area C, and construction and operation of the ERDF. Reasonably foreseeable future actions affecting the viewshed also include remediation efforts at

Hanford that may produce short-term adverse impacts, but would generally result in removal of buildings and other structures and return of the environment to more natural conditions.

Construction and operation of facilities for the Hanford Reach National Monument, a non-DOE activity at Hanford, could affect American Indian interests because the Columbia River has special significance to American Indians in the region. Increased access to the Columbia River corridor by visitors could impact the area.

Other reasonably foreseeable future activities located off site, but nearby, are likely to be visible from Rattlesnake Mountain. These would include Black Rock Reservoir and the Red Mountain American Viticulture Area near Benton (see Appendix T, Table T–2).

6.3.8.4 Paleontological Resources

No paleontological resources of significance have been discovered within any of the areas potentially disturbed by the *TC & WM EIS* alternatives. Other activities listed in Appendix T, Table T–2, would not likely add to the cumulative impacts on paleontological resources.

6.3.9 Socioeconomics

The existing site activities and current socioeconomic status of the ROI are described in Chapter 3, Section 3.2.9, and the impacts of the three alternative combinations are described in detail in Chapter 4, Section 4.4.8. The ROI for the cumulative socioeconomic analysis was Benton and Franklin counties, where the majority of Hanford workers currently reside.

Those actions that could potentially have impacts on the socioeconomics of the ROI are listed in Appendix T, Table T–3. These impacts might affect local employment figures, subsequent commuter traffic, and/or offsite truck activity. For example, completion of some activities may reduce employment (e.g., after deactivation of the Plutonium Finishing Plant is completed). Uncertainties in this analysis result in additional conservatism in the cumulative impacts estimates. For example, some or all of the construction workers for the K Basins' fuel storage activity may already be employed in other construction activities described in this cumulative impacts section. There is no indication whether future milestones related to this activity will require additional full-time employees or equivalents (FTEs). As a result, those workers performing K Basins' fuel storage activities may be doubly counted in the analysis.

Some activities analyzed have already occurred or have been suspended; therefore, their impacts were not included in this cumulative impacts analysis. For example, Hanford's cleanup, restoration, and facility decommissioning activities are ongoing activities that are already included in the existing site activity statistics. In addition, projects that did not identify quantitative employment figures and/or traffic or truck load estimates were not included in the analysis. For example, plans to create 10 more wineries in the near future in the Red Mountain American Viticulture Area in Benton County could increase the number of employees and tourists in the ROI, but quantitative estimates were not available for this activity (Benton County 2006:B-14). Another example, the Clover Island project in the city of Kennewick, would increase public amenities and add a mix of water-oriented land uses and recreational uses that would support the existing waterfront and boating and increase visitors to that area, but again quantitative estimates were not available (Kennewick 2006:126). Therefore, these types of activities were not included in the quantitative cumulative impacts analysis.

Table 6–6 summarizes indicator parameters for socioeconomic cumulative impacts. The estimated direct peak employment from activities analyzed under the *TC & WM EIS* alternative combinations, plus selected site and regional activities in the ROI, would range from 4,080 FTEs for Combination 1 to 14,700 FTEs for Combination 3. This represents as high as 9.8 percent of the projected labor force in the region (150,000 in 2021, the peak year for Tank Closure Alternative 6B, Base Case). *TC & WM EIS*

alternatives would employ from 1,840 to 12,500 FTEs. The total projected number of employees from reasonably foreseeable future activities (2,235) is small when compared to the number of employees from *TC & WM EIS* Alternative Combination 3 (12,500), the highest alternative combination. Because the timing of peak employment would vary for each activity, these projections are likely to be conservative. In addition, some of the projected employees could be drawn from the existing workforce and so would not represent additional employees moving into the ROI. For comparison, in 2006, employment of approximately 10,000 people at Hanford represented about 10 percent of employment in the Hanford ROI.

Table 6–6. Cumulative Socioeconomic Impacts

Actions/Activities	Peak Annual Employment (FTEs)	Peak Daily Traffic	
		Employee Trips[a]	Offsite Truck Trips
***TC & WM EIS* Combined Impacts (see Chapter 4, Table 4–156)**			
Alternative Combination 1	1,840	1,470	4
Alternative Combination 2	8,190	6,550	79
Alternative Combination 3	12,500	10,000	102
Other DOE Actions at the Hanford Site (from Appendix T, Table T–3)	1,882	1,810	68
Non-DOE Actions at the Hanford Site (from Appendix T, Table T–3)	41	76	4
Other Projects/Activities in the Region of Influence (from Appendix T, Table T–3)	312	225	39
Cumulative Totals[b]			
Alternative Combination 1	4,080	3,580	115
Alternative Combination 2	10,400	8,660	189
Alternative Combination 3	14,700	12,100	212

a Employee trips were calculated based on FTE numbers.

b The cumulative totals are the rounded sums of the impacts under the alternative combinations and the "Other DOE" and "Non-DOE" activities. Totals may not equal the sum of the contributions due to rounding.

Key: DOE=U.S. Department of Energy; FTE=full-time employees or equivalents; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

Foreseeable future activities analyzed included construction activities that have short-term impacts, including construction of a PNNL Physical Sciences Facility, biofuels facilities, and ongoing activities (e.g., K Basins' fuel storage). Other activities resulting from implementing the ROD (64 FR 61615) and amended ROD (73 FR 55824) for the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), as well as other non-DOE activities in the ROI, could have longer-term impacts. The non-DOE activities analyzed included management of the Hanford Reach National Monument and Saddle Mountain National Wildlife Refuge and increased operations at the Pacific EcoSolutions Waste Treatment Facility. The total projected number of employees from these future activities would be small compared to the impacts from Alternative Combination 3 (approximately 2,240 compared to 12,500 FTEs), the alternative combination with the highest employment requirement.

The level of service on offsite roads in the Hanford ROI is expected to be impacted from the peak daily traffic resulting from all activities analyzed in this cumulative impacts section. The bulk of daily traffic (as high as 12,100 vehicles per day) would come from commuters. Additional truck trip activity off site could be as high as 212 daily truck trips. These trip totals would be variable; both employee and truck trips would increase to the peak figures during large construction projects.

6.3.10 Public and Occupational Health and Safety – Normal Operations

This section evaluates short-term public and occupational health and safety cumulative impacts to the Hanford worker population, a maximally exposed individual (MEI) in the public, and the population occurring within an 80-kilometers (50-miles) radius of influence. Radiological and nonradiological impacts were analyzed.

6.3.10.1 Cumulative Radiological Impacts

Table 6–7 presents the estimated cumulative impacts from radiological emissions and direct radiation exposure. The worker population dose of 320 person-rem for Alternative Combination 1 would represent a negligible contribution to the total cumulative dose received by workers of 99,000 person-rem since the beginning of Hanford operations in 1944. Alternative Combinations 2 and 3 would represent 12 percent and 47 percent of the cumulative doses of 113,000 and 188,000 person-rem, respectively. The cumulative worker population dose would occur to several generations of workers and would not impact the same worker population.

Table 6–7. Cumulative Radiological Human Health Impacts to Hanford Site Workers and the Public

Actions/Activities	Hanford Involved Workers		Public		
	Collective Dose (person-rem)	LCF Risk[a]	MEI Dose (millirem per year)	Collective Dose (person-rem)	LCF Risk[a]
***TC & WM EIS* Combined Impacts[b] (see Chapter 4, Tables 4–157 and 4–158)**					
Alternative Combination 1	320	0 (2×10^{-1})	0.13	600	0 (4×10^{-1})
Alternative Combination 2	14,000	9	1.7	460	0 (3×10^{-1})
Alternative Combination 3	89,000	50	1.7	600	0 (4×10^{-1})
Other DOE Actions at the Hanford Site					
Historical cumulative dose 1944–1972 (DOE 1995)	90,000	50	N/A	106,000	60
Historical cumulative dose 1972–2007 (using annual 2006 data over 36 years) (Poston et al. 2007:10.144)[b]	6,876	4	N/A	23	0 (1.4×10^{-2})
Canyon disposition (DOE 2004b:4-31 to 4-32; 5-28 to 5-29)	210	1×10^{-1}	NR[c]	NR	NR
Surplus production reactor decommissioning for nine reactors (DOE 2005a: 21)	14.1	8×10^{-3}	NR	NR	NR
Naval reactor disposal (Navy 1996:2-2; 4–34)	1,505	9×10^{-1}	NR	5.1[d]	0 (3×10^{-3})
300-Area facilities: 313 and 314 facilities and the Fuel Supply Shutdown Facilities only (DOE 2005b:B-3)	NR	NR	0.12	NR	NR
Retrieval of TRU waste (SAIC 2007a; DOE 2002b:5-2 to 5-3)	106	6×10^{-2}	NR	NR	NR
Other DOE Subtotals[e]	99,000	60	0.12[f]	106,000	60

Table 6–7. Cumulative Radiological Human Health Impacts to Hanford Site Workers and the Public *(continued)*

Actions/Activities	Hanford Involved Workers		Public		
	Collective Dose (person-rem)	LCF Risk[a]	MEI Dose (millirem per year)	Collective Dose (person-rem)	LCF Risk[a]
Non-DOE Actions in the Region of Influence					
US Ecology Low-Level Radioactive Waste Facility (US Ecology 2007:2-6)	N/A	N/A	<0.01	NR	NR
Energy Northwest Columbia Generating Station (Energy Northwest 2007:51, 53; Poston et al. 2007:10.149; Rhoads 2007)	N/A	N/A	0.02[g]	2.11[h]	0 (1×10^{-3})
AREVA NP, Inc., Fuel Fabrication Facility (Poston et al. 2007:10.149; Rhoads 2007)	N/A	N/A	0.02[h]	NR	NR
Perma-Fix Northwest Waste Processing Facility (Poston et al. 2007:10.149, Rhoads 2007)	N/A	N/A	0.02[h]	NR	NR
IsoRay Medical, Inc. (Boyce 2007)	N/A	N/A	0.005[i]	NR	NR
Moravek Biochemicals (Moravek 2005)	N/A	N/A	1.5	NR	NR
Non-DOE Subtotals	N/A	N/A	1.53[f]	2.11	0 (1×10^{-3})
Cumulative Totals[j]					
Alternative Combination 1	99,000	60	2	107,000	60
Alternative Combination 2	113,000	70	3	106,000	60
Alternative Combination 3	188,000	100	3	107,000	60
Most Stringent Standard or Guideline	*N/A*	*N/A*	*10[k]*	*N/A*	*N/A*

[a] The reported value is the projected number of LCFs in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor of 0.0006 LCFs per person-rem is shown in parentheses (see Appendix K, Section K.1.1.3).

[b] Worker dose obtained from Chapter 3, Section 3.2.10.1. The Hanford baseline represents all exposure pathways and includes doses attributed to portions of the "Other DOE Actions" that occurred in 2006.

[c] For cells stating "NR," no values are provided in the documentation, but it is generally assumed that, because no air releases would occur, there would be little to no public exposure.

[d] Includes dose to the public during transportation of the reactor packages to the Hanford Site.

[e] Figures do not include the Hanford 1-year baseline. Values were rounded.

[f] For conservatism, it was assumed that the MEI for all activities would be in the same location. In reality, each individual activity would have a different location.

[g] Reflects the combined dose to the Hanford MEI from operations at the Columbia Generating Station, AREVA fuel fabrication facility, and Perma-Fix Northwest (Poston et al. 2007:10.149; Rhoads 2007).

[h] The annual population dose from 2006 was multiplied by 17 years, the time left on the Columbia Generating Station operating license, which expires in 2024 (Energy Northwest 2006a:9).

[i] This dose was calculated at the emission point and assumes emissions are at detection limits. In reality, few measurable detections are recorded, and the dose would be less at the MEI location.

[j] The cumulative totals are the sums of the impacts under the alternative combinations and the "Other DOE" and "Non-DOE" activities. Subtotals or totals may not equal the sum of the contributions due to rounding.

[k] The regulatory limit for exposure of an individual to radiological air emissions from DOE facilities is 10 millirem per year (40 CFR 61.90–61.97, Subpart H).

Key: DOE=U.S. Department of Energy; Hanford=Hanford Site; LCF=latent cancer fatality; MEI=maximally exposed individual; N/A=not applicable; NR=not reported; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; TRU=transuranic.

The cumulative dose to the offsite MEI of 2 to 3 millirem per year would be below the 10 millirem per year limit established in the National Emission Standards for Hazardous Air Pollutants (40 CFR 61.90–61.97, Subpart H). This conclusion conservatively assumes that the dose to the MEI for each DOE and non-DOE action are additive, despite the fact that the MEI location for most actions listed in Table 6–7

would be different. For comparison, the background radiation dose a person may receive near Hanford is estimated to be 365 millirem per year (see Chapter 3, Table 3–12 and Section 3.2.10.1.1).

The cumulative population dose to the public would be dominated by the historical cumulative dose received by the public (approximately 106,000 person-rem) since the beginning of Hanford operations in 1944. The 460 to 600 person-rem contributed by the three *TC & WM EIS* alternative combinations would increase the cumulative population dose received by less than 1 percent. Implementation of Combinations 2 or 3, while slightly increasing the cumulative dose to the public in the short term, would decrease the long-term impacts, as discussed in Chapter 5.

6.3.10.1.1 Historical Exposures

Estimates of the potential cumulative dose to the population within 80 kilometers (50 miles) of Hanford for the period running from 1944 through 1972 were calculated to be approximately 106,000 person-rem (DOE 1995), which could result in up to approximately 60 latent cancer fatalities (LCFs). The majority of this dose was received through air pathways in 1945. The cumulative population dose through the water pathway during this period was estimated to be about 6,000 person-rem (which could result in approximately 4 LCFs), most of which was received between 1954 and 1964 as a result of higher production reactor power levels for Cold War plutonium production. Since 1972, this cumulative population dose increased by less than 0.1 percent based on data from Hanford annual environmental reports. The primary contributors to the population and MEI doses in 2006 were activities in the 300 Areas, a release of iodine-129 from the 200 Areas, consumption of food grown downwind, and consumption of water from the Columbia River (Poston et al. 2007:10.144).

Cancer incidence and mortality rates in the Hanford region can be used as possible indicators of cumulative impacts caused by past operational practices at Hanford. As discussed in Chapter 3, Section 3.2.10.3, the question of whether the population surrounding Hanford is subject to elevated cancer incidence or mortality rates is unresolved. Some studies indicate that there are no statistically significant increases in cancer rates; in fact, one study concluded that workers that have routine potential exposure to plutonium have lower mortality rates than other Hanford workers (NIOSH 2005).

Other epidemiological studies have shown a statistically significant elevated risk of death from multiple myeloma associated with radiation exposure among male Hanford workers. The elevated risk was observed only among workers exposed to approximately 10 rem or more. Other studies also identified an elevated risk of death from pancreatic cancer, but a recent reanalysis did not conclude there was an elevated risk. Studies of female Hanford workers have shown an elevated risk of death from musculoskeletal system and connective tissue conditions (DOE 1996b:M-224 through M-230).

In addition to those studies summarized in Chapter 3, Section 3.2.10.3, a Hanford Birth Cohort study was conducted by the Agency for Toxic Substances and Disease Registry to address public concerns related to public exposure to iodine-131 primarily in the years 1944 through 1957. Preliminary results from this study showed a small increased risk for certain men to develop a thyroid disease, although a final determination has yet to be published (ATSDR 2006).

Because studies have been inconclusive regarding whether cancer incidence or mortality rates have risen due to Hanford operations, no definitive conclusions can be made in this EIS concerning the cumulative effects of radiation exposure to Hanford workers or the public from historical environmental releases and occupational exposures.

6.3.10.1.2 Other DOE Activities at Hanford

Other DOE activities at Hanford that are not within the scope of this EIS (i.e., activities that are not part of DOE's proposed actions) include environmental restoration activities being performed under RCRA and CERCLA in accordance with the TPA requirements. Major environmental restoration activities currently planned or underway that could cause exposures to radiation include environmental restoration activities in the 100 and 200 Areas, disposition of the five canyon facilities, decommissioning of eight surplus production reactors, remediation and closure of 300 Area facilities and operable units, retrieval of TRU waste, and operation of the ERDF. Table 6–7 summarizes the contributions to cumulative impacts from these activities. Some activities described in Appendix R are not included in Table 6–7 because applicable information was not available. Note that it is difficult to differentiate between the human health impacts of DOE Hanford operations and non-DOE activities using actual monitoring data due to the proximity of effluents from the various operations.

Five canyon buildings (U, B, T, the PUREX Plant, and the Reduction-Oxidation [REDOX] Facility) are located at Hanford. All five of these buildings will eventually undergo CERCLA closure. Closure of only one of these buildings, 221-U, has been studied in detail. The selected remedy for 221-U includes demolishing the canyon to the canyon deck, filling portions of the canyon with rubble, grouting empty spaces, constructing an engineered barrier over the remnants of the canyon, and performing postclosure activities. Worker exposure from performing these activities at Building 221-U is estimated to be 42 person-rem (DOE 2004b:4-31, 4-32, 5-28, 5-29). Information regarding exposures to the public due to remediating implementation is not available, but is expected to be minimal due to the inaccessibility of Building 221-U to the public and limited radiological air emissions. The results from the analysis of remediating Building 221-U may be applied to the other four canyon buildings for a total worker population exposure of 168 person-rem, but due to the varying types and locations of radiological materials and contamination at these buildings, actual exposures could vary significantly (DOE 2004b:1-1). Canyon demolition activities have yet to commence, but demolition of 10 of the 17 U Plant ancillary facilities has been completed (DOE 2006a:2.50).

Nine surplus production reactors (B, C, D, DR, F, H, N, KE, and KW) are located at Hanford. These reactors are in various stages of decommissioning and are being placed in a safe storage condition for a period of approximately 75 years. After 75 years, it is assumed that the reactor core for each reactor will be removed in one piece for disposal in the 200 Areas. An EIS for decommissioning eight of these reactors (excluding the N Reactor) was completed in 1992. The information in that EIS was re-evaluated to update estimates and include the N Reactor. Assuming one-piece removal, the dose to workers from decommissioning the nine reactors would be 14.1 person-rem. There would be little or no radiation exposure to the public. Currently, five of the nine reactors have been placed into safe storage; one of the reactors (the B reactor) is currently being considered as a museum and may not be dismantled (DOE 2005a:10, 21, 22).

Reactor compartments removed from decommissioned nuclear ships and submarines will continue to be transported to Hanford for disposal. Future Naval Reactor program shipments will consist of naval reactor compartments from which the spent nuclear fuel has been removed. There have been approximately 117 naval reactor compartments disposed of at Hanford as of 2007 (Poston, Duncan, and Dirkes 2008). Occupational exposures to onsite and transportation workers have been estimated to be 1,505 rem for the 100 naval reactor compartment packages to be disposed of over several decades (Navy 1996:2-2; 4-34). This radiation exposure equates to approximately one (0.9) LCF (DOE 2003d). Radiation exposure to the public due to transportation and disposal of the reactors has been calculated to be 5.1 rem, and no (0.003) LCFs (Navy 1996:2-2).

The 300 Area facilities currently undergoing decontamination, decommissioning, and removal include 82 buildings and structures in the northern portion of the 300 Area, the 324 and 327 buildings, and

145 buildings and structures located primarily in the southern portion of the 300 Area (DOE 2004c, 2006b, 2006c). These 300 Area cleanup activities have the potential for creating radiation and chemical exposures to workers and the public. These exposures have not been quantified, with the exception of deactivation, decontamination, and decommissioning of the 313 and 314 facilities and the Fuel Supply Shutdown Facilities. The radiation dose to the MEI for removing each of these facilities was calculated to be 0.04 millirem per year over three years (DOE 2005b:B–3).

Per the TPA Milestone, retrieval of the 200 Area remote-handled, retrievably stored TRU waste in burial ground 218-W-4B is required to be completed by December 31, 2018. Some of this waste is located in four caissons. A Caisson Retrieval Facility will be constructed, operated, and decommissioned to retrieve the TRU waste containers from the four caissons. A total of 100 person-rem of worker exposure is expected (SAIC 2007a). A public dose was not calculated, but is expected to be negligible due to the location of this activity at burial ground 218-W-4B. Drummed TRU waste in burial grounds 218-W-4B and 218-W-4C is also being retrieved. Retrieval of this waste could incur a projected total worker dose of approximately 6 person-rem over the 5-year period (DOE 2002b:5-2, 5-3).

Operation of the ERDF involves the potential for exposure during waste transport to and placement in the ERDF. The *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility* (DOE 1994) predicted that health risks to ERDF workers, other Hanford workers, and the public due to exposure to contaminants would be significantly less than generally accepted standards. Annual environmental monitoring (Poston, Hanf, and Dirkes 2005; Poston et al. 2006, 2007) has confirmed these predictions.

6.3.10.1.3 Non-DOE Activities

In addition to the radiological dose from DOE activities at Hanford, a dose to DOE workers and the public could also occur due to radiological releases from non-DOE operations occurring within and near Hanford. These releases are associated with the US Ecology Low-Level Radioactive Waste Disposal Facility; Energy Northwest Columbia Generating Station; AREVA NP, Inc., fuel fabrication facility; Perma-Fix Northwest waste processing facility; IsoRay Medical facility; and Moravek Biochemicals facility. Table 6–7 summarizes the actual exposures from these facilities.

US Ecology operates the Low-Level Radioactive Waste Disposal Facility at Hanford near the 200 Areas. Doses to the general public from air emissions have been calculated to be indistinguishable (less than 0.01 millirem) from background levels. For direct radiation, the maximum net (background subtracted) radiation exposure as measured at the site boundary west of trench 18 was 55 millirem per year for exposure 24 hours a day, 365 days a year. As this location is within the boundaries of Hanford, a Hanford employee would be exposed to 13 millirem, assuming the employee were present at this location 40 hours per week. This radiation exposure level is consistent with levels measured in past years. There was no facility impact on groundwater in 2006 (US Ecology 2007:1-2, 2-3, 2-6, 2-11). Potential long-term impacts of the waste disposed of at this location are included in the evaluation of long-term cumulative impacts in Section B4.

The Columbia Generating Station is located at Hanford northeast of the FFTF. This nuclear plant is licensed for operations through 2024 (Energy Northwest 2006a:9). The maximum annual dose at the Columbia Generating Station site boundary from air releases was estimated to be 0.0194 millirem. The 80-kilometer (50-mile) population collective dose in 2006 was estimated to be 0.124 person-rem, with the average individual in that population receiving 3.49×10^{-4} millirem during that year (Energy Northwest 2007:51, 53). There has been no measurable impact to other potential human exposure pathways such as food, surface water, groundwater, and soils (Energy Northwest 2006b:5-5−5-7).

AREVA NP, Inc. (formerly Framatome ANP, Inc.), operates a fuel fabrication facility just south of Hanford on Horn Rapids Road. This facility produces nuclear fuel for sale to commercial nuclear power

plants. Calculated doses to the theoretical MEI from this facility's radioactive stack emissions (ignoring radon) from 2000 to 2005 ranged from 0.000164 to 0.012 millirem per year, indicating negligible impacts from radioactive point source emissions. Environmental monitoring activities have provided no indication of air pollutant deposition in the surrounding environs, and liquid waste discharges have been within the allowed limits for radioactivity, indicating negligible impacts to human health (AREVA 2006:3-5).

The Perma-Fix Northwest (formerly known as Pacific EcoSolutions) facility is located south of Hanford in Horn Rapids Industrial Park. The site houses processing facilities for the treatment of low-level radioactive waste (LLW) and MLLW. In 2006, the calculated dose to the MEI from radiological air emissions was 0.1 millirem where the MEI was assumed to reside in a theoretical resident located 100 meters (110 yards) from the stacks. The MEI dose from direct radiation was calculated to be 1.63 millirem per year; this MEI was assumed to be a local business employee who takes daily walks during lunch along the northern perimeter of the Perma-Fix site (Pacific EcoSolutions 2007:6).

The radiological emissions reported by the Columbia Generating Station, AREVA, and Perma-Fix were used to compute a non-DOE source dose to the Hanford MEI. In 2006, this value was 0.02 millirem (Poston et al. 2007:10.149, Rhoads 2007).

IsoRay Medical, Inc., produces medical isotopes for commercial use. The facility is located at Energy Northwest's Applied Process Engineering Laboratory in Richland, Washington, just east of the Hanford boundary. Based on the two primary isotopes cesium-131 and barium-131, the dose at the emission point would be less than 0.005 millirem per year, assuming these isotopes were emitted within the detection limits. In reality, few, if any, detections have been recorded for these isotopes, and the dose to the MEI would be much less due to dilution prior to reaching the MEI (Boyce 2007).

Moravek Biochemicals, located in the Richland Industrial Center in Richland, Washington, manufactures radiochemicals and inorganic compounds for industrial use (Moravek 2009). The calculated radiological dose to an MEI 40 meters (130 feet) to the north of the facility is 1.5 millirem per year based on actual emissions of hydrogen (tritium) and carbon-14 in 2004 (Moravek 2005).

6.3.11 Public and Occupational Health and Safety – Transportation

The assessment of cumulative impacts from radioactive material transportation concentrated on impacts from offsite transportation, which would result in the greatest potential radiation exposure from non-incident transportation and fatalities from traffic accidents. The collective dose to the general population and workers was the primary measure used to quantify cumulative transportation impacts. This measure of impact was chosen because it can be directly related to LCFs using a cancer risk coefficient.

Table 6–8 summarizes the cumulative impacts from transportation activities. The cumulative impacts of the transportation of radioactive material consists of impacts from historical shipments of radioactive waste and spent nuclear fuel, general radioactive material transportation unrelated to a particular action, and reasonably foreseeable actions. The duration of impacts was assumed to begin in 1943, when Hanford began operation, and continue to an end date of about 2073. It should be noted that the estimated end dates for Tank Closure Alternatives 2A, 6A, and 6B are beyond 2073 (up to 2193). It should be further noted that Table 6-8 does not consider transportation activities that occur on Hanford roads closed to the public. An example of such actions would be intrasite transportation of waste to the ERDF. As presented in Chapter 4, Table 4–159, transportation of materials and waste to and from INL is included in Alternative Combinations 2 and 3.

Table 6–8. Cumulative Transportation Impacts

Actions/Activities	Worker		General Population		Traffic Fatalities
	Collective Dose (person-rem)	Risk (LCFs)	Collective Dose (person-rem)	Risk (LCFs)	
***TC & WM EIS* Combined Impacts (see Chapter 4, Table 4–159)**					
Alternative Combination 1	2.62	0.00	0.08	0.00	0.00
Alternative Combination 2	2,884	1.7	425	2.6×10^{-1}	1.8
Alternative Combination 3	3,183	1.9	441	2.6×10^{-1}	2.7
Other Transportation Impacts Not Related to This *TC & WM EIS* (see Appendix T, Table T–4)[a]					
Historical shipments to the Hanford Site	292	1.7×10^{-1}	317	1.9×10^{-1}	NL
General radioactive material transport	374,000	224	338,000	203	116
Reasonably foreseeable actions	29,214	18	39,936	24	88
Subtotals, Other Transportation Impacts	403,500[b]	242	378,300[b]	227	204
Cumulative Totals[c]					
Alternative Combination 1	403,500[b]	242	378,300[b]	227	204
Alternative Combination 2	406,400[b]	243	378,700[b]	227	206
Alternative Combination 3	406,700[b]	244	378,700[b]	227	207

[a] Appendix T, Table T–4, provides a detailed compilation of the transportation impacts from other activities that are not related to this *TC & WM EIS.*

[b] The dose values are rounded to the nearest hundred.

[c] The "cumulative totals" are the sums of the impacts under the alternative combinations and the other, unrelated transportation activities. The dose values were rounded to the nearest 10. Subtotals or totals may not equal the sum of the contributions due to rounding.

Key: LCF=latent cancer fatality; NL=not listed; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

6.3.11.1 Historical Shipments to Hanford

The impact values provided for historical shipments to Hanford include shipments of spent nuclear fuel and radioactive waste from 1943 through 1993 (DOE 1995:Appendix I). Over the years, Hanford has received various types of wastes from Government, research institutes, and commercial nuclear facilities for disposal as well as testing purposes. A survey of Hanford's Solid Waste Information and Tracking System (SWITS) indicates about 60,000 cubic meters (78,500 cubic yards) of solid waste from offsite generators has been disposed of at Hanford (CEES 2007). The list of offsite generators indicates locations all across the United States. The transportation risk analysis in the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (WM PEIS)* (DOE 1997), which included analyses of waste transportation from multiple locations in the United States to Hanford, was used to estimate collective worker and population doses for the historical shipments. As SWITS does not identify the number of shipments, the waste volume per truck shipment assumption in the *WM PEIS* was used to estimate the number of historical shipments, resulting in an estimate of 3,750 shipments from 1944 through 1993. Using the estimated doses to workers and the general population in the *WM PEIS*, conservative collective doses to workers and the general population from historical shipments were estimated to be 292 and 317 person-rem, respectively.

It should be noted that there are considerable uncertainties in these historical estimates of collective dose. For example, the population densities and transportation routes used in the dose assessment were based on 1990 census data and the U.S. highway system as it existed in 1995. Using the 1990 census data results in an overestimate of historical collective doses because the U.S. population has increased since 1990. In contrast, using the interstate highway system as it existed in 1995 may slightly underestimate doses for shipments that occurred in the 1940s, 1950s, and 1960s because a larger portion of the transport

routes would have used non-interstate highways where the population may have been closer to the road. By the 1970s, the structure of the interstate highway system was largely fixed and most shipments would have been made on interstate highways.

6.3.11.2 General Radioactive Materials Transport

General radioactive material transports are shipments that are not related to a particular action and include shipments of radiopharmaceuticals to nuclear medicine laboratories, industrial and radiography sources, fresh and spent nuclear fuel, and LLW. Collective dose estimates from transportation of these types of materials during 1943 through 1982 were based on a U.S. Nuclear Regulatory Commission (NRC) analysis of shipments made in 1975 as documented in NUREG-0170 (NRC 1977). Collective dose estimate projections for shipments of these types of materials from 1983 through 2043 were based on analyses of unclassified shipments made in 1983, as documented in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995). The NRC report estimated collective doses to the workers and general population of 5,600 and 4,200 person-rem, respectively, for truck, train, and airplane transports in 1975. Collective doses to workers and the general population for transports from 1943 through 1982 (39 years) were estimated to be 220,000 and 170,000 person-rem, respectively.

Collective doses to workers and the general population from truck and airplane shipments in 1983 were estimated to be 1,690 and 1,850 person-rem, respectively (DOE 1995). These doses were calculated using more refined models than those used in the NRC report. Even though the number of shipments was higher than those analyzed for the NRC report, the estimated doses were smaller by a factor of two to three. The collective doses over 91 years from 1983 through 2073 were estimated to be 154,000 and 168,000 person-rem for workers and the general population, respectively. Neither of these reports provided specific estimates for nonradiological traffic fatalities. Most of the radioactive materials are shipped incidental to other freight shipments (i.e., the shipment is non-exclusive-use and would take place whether or not the radioactive materials were on board). For exclusive-use shipments (i.e., those materials requiring exclusive use of the transport vehicle, such as spent nuclear fuel, uranium fuel cycle materials, and radioactive waste), there is a potential for non-radiological risks (traffic fatalities). Historically, there have been few accidents involving radioactive material transportation and few non-occupational fatalities (DOT 2009). Therefore, only potential future traffic fatalities were estimated for this category of transport. Using the estimated transport distances for the exclusive-use shipments (fuel cycle and wastes) from the NRC report (NRC 1977), an average traffic fatality per kilometer (1.5 fatalities per 100 million kilometers [62.1 million miles]; see Appendix H), and 91 years experience transporting materials, anticipated nonradiological traffic fatalities were estimated to be 116.

6.3.11.3 Reasonably Foreseeable Actions

Appendix T, Table T–4, lists the reasonably foreseeable actions that were considered in the cumulative transportation impacts analysis. The values provided for reasonably foreseeable actions could lead to some double-counting of impacts. For example, LLW transportation impacts addressed in the *WM PEIS* (DOE 1997) may also be included in the individual DOE facilities' sitewide EISs.

6.3.11.4 Conclusions

Table 6–8 shows that the *TC & WM EIS* alternative combination impacts, including the impacts of shipments of materials to and from INL, would be quite small compared to the overall cumulative transportation impacts. For these alternative combinations, the cumulative worker dose from all types of shipments was estimated to range between 406,400 and 406,700 person-rem (about 244 LCFs). The cumulative dose to the general population was estimated to be about 378,700 person-rem (about 227 LCFs). The cumulative nonradiological impacts (traffic fatalities), were estimated to be about 210.

To place these numbers in perspective, the National Center for Health Statistics states that the annual cancer death rate in the United States between 1999 and 2004 was about 554,000, with less than 1 percent fluctuations in the number of cancer deaths in any given year (CDC 2007). A total of about 470 LCFs among the workers and general population were estimated to result from radioactive material transportation from 1943 to 2073, an average of about 4 LCFs per year. Transportation-related LCFs represented about 0.0007 percent of the annual number of cancer deaths and were indistinguishable from the natural fluctuation in the total annual cancer death rate. The estimated number of traffic fatalities of about 210 over a period of more than 100 years was also small compared to the average annual traffic fatalities of 40,000 in the United States. Note that the majority of the cumulative risks to workers and the general population were due to the general transportation of radioactive material that is unrelated to the activities evaluated in this *TC & WM EIS*.

To provide a full range of cumulative impacts, other alternative combinations were also examined. The cumulative worker dose from all types of shipments was estimated to range up to a maximum of 407,400 person rem (about 244 LCFs). The cumulative dose to the general population was estimated to range up to 379,100 person rem (about 227 LCFs). Again, the total estimated number of LCFs among the workers and the general population (about 470, or an average of about 4 LCFs per year) was very small and is indistinguishable from the natural fluctuation in the total annual death rate from cancer. The estimated number of traffic fatalities of about 210 over a period of more than 100 years (an average of less than 4 per year) was also small compared to the total average annual traffic fatalities of 40,000 in the United States. This information shows that the impacts of the activities evaluated in this *TC & WM EIS* would be quite small compared to the overall cumulative impacts of radioactive materials transportation, and the cumulative impacts of radioactive materials transportation are only a small component of the overall transportation impacts.

6.3.12 Waste Management

Expected cumulative waste generation is presented in Table 6–9. It is unlikely that there would be major impacts on the waste management infrastructure at Hanford because sufficient capacity exists or would be constructed under the proposed Waste Management alternatives.

To estimate the cumulative waste management impacts, the waste generated by the *TC & WM EIS* alternative combinations (see Chapter 4, Section 4.4.12) and other past, present, and reasonably foreseeable future actions were summed. The cumulative waste volumes included all known or possible future actions that would generate and/or dispose of waste. These cumulative waste volumes also included past waste already disposed of in the 600 Area and the low-level radioactive waste burial grounds (LLBGs); CERCLA waste resulting from closure of the Columbia River Corridor for the 100 and 300 Areas (the volumes of CERCLA waste from the 200 Areas are unknown at this time); possible disposal of greater-than-Class C (GTCC) waste; and Naval Reactor program waste that is being disposed of at Hanford.

Table 6–9. Cumulative Waste Volumes

Actions/Activities	Waste Type (cubic meters)				
	HLW[a]	TRU Mixed	LLW/MLLW	Hazardous[b]	Nonradioactive/ Nonhazardous[c]
***TC & WM EIS* Alternative Combinations (see Chapter 4, Table 4–160)**					
Alternative Combination 1	0	22,500	7,100	1,320	307
Alternative Combination 2	16,000	22,700	854,000	80,200	2,740
Alternative Combination 3	790,000	22,900	2,710,000	81,900	2,490,000
Other DOE Actions at the Hanford Site					
200 Area LLBGs[d]	N/A	NR	405,240	N/A	N/A
600 Area Nonradioactive Dangerous Waste Landfill	N/A	N/A	N/A	141[e]	N/A
600 Area Central Landfill	N/A	N/A	N/A	N/A	596,000
CERCLA waste[f]	N/A	NR	21,400,000	NR	NR
Decommissioned, defueled naval reactor compartments	N/A	N/A	121,625	N/A	N/A
Other Possible Future DOE Actions at Hanford					
Disposal of GTCC waste[g]	N/A	N/A	11,000	N/A	N/A
Subtotals, Other DOE Actions and Possible Future Actions	N/A	N/A	21,937,865	141	596,000
Cumulative Totals[h]					
Alternative Combination 1	0	22,500	21,970,000	1,460	596,000
Alternative Combination 2	16,000	22,700	22,791,000	80,300	599,000
Alternative Combination 3	790,000	22,900	24,648,000	82,000	3,090,000

[a] Includes HLW canisters, cesium and strontium canisters, HLW melters, and other HLW. Also includes ILAW and tank debris for Alternative Combination 3.

[b] Dangerous waste generated at the site is shipped off site for disposal or for recycling.

[c] Nonradioactive, nonhazardous, and nondangerous waste is disposed of off site at municipal or commercial solid waste disposal facilities and is generally not held in long-term storage.

[d] Total estimated waste buried in the 200-East and 200-West Area burial grounds: (200-East Area) 218-E-2, 218-E-4, 218-E-5, 218-E-5A, 218-E-10 trench, 218-E-1, 218-E-8, 218-E-12A, and 218-E-12B; (200-West Area) 218-W-1, 218-W-1A, 218-W-2, 218-W-2A, 218-W-3, 218-W-3A, 218-W-4A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, 218-W-7, and 218-C-9. Some of the burial grounds may contain TRU waste.

[e] The volume of buried waste in the Nonradioactive Dangerous Waste Landfill originally was 141,000 kilograms. A conversion using the density of water was used to get 141 cubic meters.

[f] Total estimated CERCLA waste (LLW and MLLW) to be generated for the 100 and 300 Areas only; the amount of waste from the 200 Areas is unknown (Wood et al. 1995). Total waste disposed of from the 100 and 300 Areas as of 2007 was 6.5 million tons.

[g] This is an estimate of GTCC and similar DOE waste that could be disposed of at Hanford (Joyce 2009).

[h] The "cumulative totals" are the sums of the impacts under the alternative combinations and the "Other DOE" and "Other Possible Future DOE" activities. Subtotals or totals may not equal the sum of the contributions due to rounding.

Note: All values are in cubic meters except as noted. To convert cubic meters to cubic yards, multiply by 1.308.

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; DOE=U.S. Department of Energy; GTCC=greater-than-Class C; Hanford=Hanford Site; HLW=high-level radioactive waste; ILAW=immobilized low-activity waste; LLBG=low-level radioactive waste burial ground; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; NR=not reported; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; TRU=transuranic.

Source: DOE 2007b; SAIC 2007b, 2007c, 2007d, 2008.

A general description of the existing waste management infrastructure is presented in Chapter 3, Section 3.2.12. Additional detailed information on the cumulative impacts methodology and past, present, and reasonably foreseeable future actions is provided in Appendix R.

6.3.12.1 *TC & WM EIS* Alternative Combinations

Chapter 4, Section 4.4.12, describes the three alternative combinations and the impacts they might have on the waste management system. Although generation of both primary and secondary waste would contribute to the overall combined impact on existing Hanford facilities devoted to treatment, storage, and disposal, as described in Chapter 4, Section 4.3.14, the Waste Management alternatives were developed to accommodate this additional generation of waste. Therefore, none of the three alternative combinations would exceed the capacity of the current or planned Hanford waste management infrastructure.

6.3.12.2 Other DOE Actions at Hanford

6.3.12.2.1 200 Area Burial Grounds

The LLBGs consist of eight burial grounds located in the 200-East and 200-West Areas that are used for disposal of LLW and MLLW. The LLBGs have been permitted under an RCRA Part A permit since 1985.

Three trenches receive mixed waste regulated by WAC 173-303, "Dangerous Waste Regulations." Trenches 31 and 34 in burial ground 218-W-5 are lined trenches with leachate collection and removal systems. Trench 94 in burial ground 218-E-12B is used for disposal of defueled U.S. Naval reactor compartments (see below). LLW and TRU waste have been placed in the other burial grounds. The TRU waste was placed in a manner that allows future retrieval and/or removal. Soil was placed over some of the waste containers to provide radiological protection (Poston et al. 2007). TRU waste has not been placed in the LLBGs without specific DOE approval since August 19, 1987.

DOE Order 435.1, *Radioactive Waste Management*, requires a disposal authorization statement authorizing operation (or continued operation) for LLW disposal facilities. In fulfillment of these requirements, a disposal authorization statement was issued on October 25, 1999, authorizing Hanford to transfer, receive, possess, and dispose of LLW at the 200-East Area and 200-West Area LLBGs. By agreement between DOE and Ecology, use of the LLBGs as disposal facilities for LLW and MLLW has been restricted to lined trenches and the Naval reactor-compartment trench only. Hence, as of July 2004, only the two lined trenches in burial ground 218-W-5 (trenches 31 and 34) and the Naval reactor-compartment trench in burial ground 218-E-12B (trench 94) are allowed to receive waste. When the two lined trenches are filled, the LLBGs will cease to operate except for reactor compartment disposal at trench 94. The remaining operational lifetimes of the LLBGs depend on the waste volume disposal rates (DOE 2006d).

The LLBGs are included in a draft remedial investigation/feasibility study work plan completed in September 2007 (DOE 2007b). The remedial investigation/feasibility study process will be used to reach a decision that will meet requirements for both National Priorities List cleanup and RCRA corrective action. Retrieval of suspect-TRU retrievably stored waste in burial ground 218-W-4C was initiated in October 2003 in accordance with TPA Milestone M-91-03-01.

6.3.12.2.2 600 Area Nonradioactive Dangerous Waste Landfill and 600 Area Central Landfill

The Nonradioactive Dangerous Waste Landfill (NRDWL) is an inactive landfill. Although an NRDWL site closure plan was written in 1990 (DOE 1990), the closure plan has not been approved. The landfill provided a site for disposal of dangerous waste generated from process operations, research and development laboratory maintenance activities, and transportation functions throughout Hanford. The NRDWL is located about 5.6 kilometers (2.5 miles) southeast of the 200-East Area on Army Loop Road, southwest of the Route 4 intersection and southeast of the 200-East Area. It began operation in 1975 and occupies an area of 4.5 hectares (11 acres). It consists of 19 parallel trenches, each 122 meters (400 feet) long, 4.9 meters (18 feet) wide at the base, and 4.6 meters (15 feet) deep. A triangular column of

undisturbed soil with approximately 1:1 side slopes separated the trenches as they were constructed. The final profile of the trench varied depending on the type of waste received. The trenches typically were backfilled and covered with 2 to 3 meters (6 to 10 feet) of soil at the end of each operating day. Beginning in 1975, chemical waste was disposed of in six trenches, asbestos in nine trenches, and nonhazardous solid waste in one trench; three were unused. The last receipt of dangerous waste was in May 1985; the last receipt of asbestos occurred in May 1988 (DOE 2007b).

The 600 Central Landfill is a non-RCRA solid waste landfill adjacent to NRDWL on the south side. It is a larger facility (27 hectares [67 acres]) that received principally solid waste, including paper, construction debris, asbestos, and lunchroom waste. It also received up to 5,000,000 liters (1,320,000 gallons) of sewage and 380,000 liters (100,000 gallons) of garage wash water. The liquid waste was discharged to east-west oriented trenches at the perimeter of the main solid-waste area, along the northeast and northwest boundaries of the 600 Central Landfill. The 600 Central Landfill is regulated under WAC 173-304, "Minimum Functional Standards for Solid Waste Handling" (DOE 2007b).

The two landfills (NRDWL and the 600 Central Landfill) were operated as a single landfill that was originally known as the Central Landfill. Because of the presence of dangerous waste in the chemical trenches, the 19 northernmost trenches were designated as the NRDWL under the Hanford Facility RCRA Permit. The southern two-thirds of the area were later designated as the 600 Central Landfill, which is a treatment, storage, and disposal unit (DOE 1990).

The TPA outlines the approach that DOE will take for permitting and closure of the Hanford RCRA regulated treatment, storage, and disposal units. These two landfills are included in a draft remedial investigation/feasibility study work plan completed in September 2007 (DOE 2007b). The remedial investigation/feasibility study process will be used to reach a decision that will meet requirements for both National Priorities List cleanup and RCRA corrective action (DOE 2007b).

6.3.12.2.3 CERCLA Waste: Closure of the Columbia River Corridor

Other DOE actions at Hanford include cleanup and closure of the Columbia River corridor, an area of roughly 210 square miles along the outer edge of Hanford that includes major portions of the Hanford Reach National Monument. These actions include:

- Deactivating, decommissioning, decontaminating, and demolishing 510 facilities, many of which are contaminated with radioactive and/or hazardous materials.

- Remediating and closing 486 waste sites, including trenches where plutonium production reactor liquid wastes were discharged.

- Placing the K-East and K-West reactors in interim safe storage. (The K-East and K-West were large plutonium production reactors that operated from 1955 until the early 1970s. A "cocooning" method will be used that will involve in situ encapsulation of the reactor piles. Five of eight reactors have already been cocooned.)

- Remediating burial grounds 618-10 and 618-11. (The 618-10 and 618-11 burial grounds contain some highly radioactive irradiated nuclear fuel, hazardous chemicals and plutonium, cesium and other radioactive material.)

- Operating the ERDF.

In 1988, Hanford was scored using the U.S. Environmental Protection Agency (EPA) hazard ranking system. Based on the scoring, Hanford was added to the National Priorities List in July 1989 as four sites: the Richland North Area, formerly the 1100 Area; 100 Areas; 200 Areas; and 300 Area. Each of

these areas was further divided into operable units (groupings of individual waste units based primarily on geographic area and common waste sources). These operable units contain contamination in the form of hazardous waste, radioactive/hazardous mixed waste, and other CERCLA hazardous substances. In anticipation of Hanford's addition to the National Priorities List, DOE, EPA, and Ecology entered into the TPA in May 1989. This agreement established a procedural framework and schedule for developing, implementing, and monitoring remedial response actions at Hanford. The TPA also addresses RCRA compliance and permitting.

Wastes from cleanup and closure of the Columbia River corridor are being disposed of in the ERDF, a CERCLA disposal facility in the Hanford 200 Areas. The ERDF is also designed and operated to meet the substantive RCRA requirements. Construction of the first two cells began in May 1995, and the first shipment of waste was received on July 1, 1996. Each cell is 152 meters (500 feet) wide at the bottom, 21 meters (70 feet) deep, and over 304 meters (1,000 feet) wide at the surface. The ERDF's liner is a system composed of multiple barriers that form a primary and secondary protection system. Each system is designed to contain and collect moisture to prevent migration of contaminants to the soil and groundwater. Once the ERDF is filled with waste, an RCRA-compliant engineered barrier will be placed on top to prevent rain infiltration. The ERDF is expected to receive about 10 million tons of waste from Hanford cleanup activities. DOE has disposed of approximately 6.5 million tons of Hanford cleanup waste in the ERDF since the facility started operations in 1996 (an average of 625,000 tons per year). The inventory included in Table 6–9 is the cumulative total for only the 100 and 300 areas. Inventories for the 200 Areas are unknown at this time. However it is anticipated that the 200 Areas will generate a large quantity of waste (Poston et al. 2007).

6.3.12.2.4 Disposal of Decommissioned, Defueled Naval Reactor Compartments

The retirement of aging weapon systems and cutbacks in the number of U.S. Navy ships in the post-Cold War era have resulted in reductions in the Naval nuclear fleet. On August 9, 1996, a ROD was issued for disposal of defueled reactor plants from U.S. Navy nuclear-powered cruisers and Ohio Class and Los Angeles class submarines (61 FR 41596). The Navy, with DOE's concurrence, decided to dispose of these reactor compartments at LLBG 218-W-5, trench 34, at Hanford. This method has very small environment impacts and provides permanent disposal of the defueled reactor compartments. In 1999, under this ROD, DOE began accepting an additional 100 reactor compartments for disposal at LLBG 218-E-12B, a 70-hectare (173-acre) waste disposal facility in the 200-East Area of Hanford. This would add to the 55 pre–Los Angeles Class submarine reactor compartments already disposed of in this facility. Through September 2007, 117 reactor compartments have been transported safely and disposed of. On average, between six and eight shipments had been made each year; however, in recent years, that number has dropped to only one or two each year, with no shipments in 2005, one in 2006, and two in 2007 (Poston, Duncan, and Dirkes 2008). The reactor compartments are classified as LLW. The iron and metal alloys within the reactor vessel have become radioactive after years of reactor operations; their exteriors are not contaminated. The reactor compartments are estimated to include a total of approximately 120,000 cubic meters (4,240,000 cubic feet) of LLW.

DOE oversees placement of reactor compartments into this area of the disposal facility and manages the disposal operations in accordance with all applicable requirements. Ecology regulates the reactor compartment disposal packages as a dangerous waste under WAC 173-303, "Dangerous Waste Regulations," due to the over 100 tons of permanent lead shielding in each reactor compartment. Treatment before disposal is not required because the solid elemental lead shielding is encapsulated by thick metal sheathing plates that meet RCRA treatment standards for disposal of radioactive lead solids.

The *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, OHIO Class, and LOS ANGELES Class Naval Reactor Plants* (Navy 1996) indicated that the EPA review did not identify any potential environmental impacts requiring substantive changes for the preferred

alternative. The EIS states that, based on the Navy's past method of disposing of pre–Los Angeles class submarine reactor compartments with very conservative engineering practices, the environmental impacts will be very small for the additional 100 reactor compartments. These conservative engineering practices have been incorporated in the Navy's preferred alternative. No additional mitigative measures were identified to further reduce the small impacts which were described in the EIS (Navy 1996).

6.3.12.3 Other Possible Future DOE Actions at Hanford

6.3.12.3.1 Greater-Than-Class-C Low-Level Radioactive Waste

The Low-Level Radioactive Waste Policy Act of 1980, as amended (42 U.S.C. 2021 et seq.), assigned the U.S. Government the responsibility for disposing of GTCC LLW generated by activities licensed by NRC or Agreement States. The act requires the Federal Government to provide for the disposal of GTCC LLW in a facility that adequately protects the safety and health of the public and is licensed by NRC. As part of its assigned responsibilities under act, DOE has begun the EIS process for development of a disposal capability for GTCC LLW and similar DOE waste (DOE-owned or -generated LLW or TRU waste with characteristics similar to GTCC LLW that may not have an identified path to disposal). Sites under consideration for disposal of GTCC LLW include the Waste Isolation Pilot Plant near Carlsbad, New Mexico; other DOE sites; and generic commercial sites (72 FR 40135).

Hanford is being considered as a candidate location for a new GTCC waste disposal facility in the *Environmental Impact Statement for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste (GTCC EIS)*, DOE/EIS-0375 (72 FR 40135). Such a facility is not expected to be operational until after 2013. As described in Table 6–9, it could receive about 11,000 cubic meters (388,000 cubic feet) of GTCC LLW and similar DOE waste (Joyce 2009) already in storage or projected to be generated from facilities already in operation or that could result from proposals being analyzed in other NEPA reviews, including the *Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center*, DOE/EIS-0226-D (Revised) (DOE and NYSERDA 2008), and the *Environmental Impact Statement for the Proposed Consolidation of Nuclear Operations Related to Production of Radioisotope Power Systems*, DOE/EIS-0373 (69 FR 67139).

6.3.12.3.2 Long-Term Management and Storage of Elemental Mercury

DOE is preparing an *Environmental Impact Statement for the Long-Term Management and Storage of Elemental Mercury* (DOE/EIS-0423) (74 FR 31723). This EIS will evaluate alternatives for a facility (or facilities) for the long-term management and storage of elemental mercury generated within the United States as required by the Mercury Export Ban Act of 2008 (P.L. 110-414). Hanford is being considered in this EIS as a candidate host site for the long-term management and storage of elemental mercury. Any facility selected must comply with applicable requirements of the Mercury Export Ban Act of 2008; the Solid Waste Disposal Act, as amended by RCRA (42 U.S.C. 6901 et seq.); and other permitting requirements. It is estimated that the total amount of elemental mercury that would be eligible for DOE storage is between 7,500 and 10,000 metric tons over a 40-year period. DOE intends to identify the facility (or facilities) through the NEPA process.

6.3.12.4 Summary

Because the Waste Management alternatives were developed to accommodate this additional waste generation, the cumulative waste management impacts would not exceed the capacity of the planned Hanford waste management infrastructure and would therefore be unlikely to have any major impacts. As stated in Chapter 4, Section 4.4.12, Alternative Combination 3 reflects the upper end of the three combinations, but does not maximize waste management infrastructure demands. A combination that would include Tank Closure Alternative 6A, Base or Option Cases; FFTF Decommissioning

Alternative 2 (with all facilities to be built at Hanford); and Waste Management Alternatives 2 or 3 (with Disposal Group 3) would have the greatest combined impact on the waste management infrastructure for high-level radioactive waste, MLLW, and hazardous and liquid LLW. It is unlikely that there would be major cumulative impacts on the waste management infrastructure at Hanford because sufficient capacity exists or would be constructed under the Waste Management alternatives.

6.3.13 Industrial Safety

This section identifies the cumulative industrial safety impacts to Hanford workers. Appendix K contains the methodology used in estimating industrial safety impacts. Chapter 4, Sections 4.1.15, 4.2.15, and 4.3.15, provide the impacts and projected Total Recordable Cases (TRCs) for each alternative. Chapter 4, Section 4.4.13, presents the impacts for the three alternative combinations.

Hanford has experienced a decrease in the number of TRCs over the period from 1993 through 2006, as reported in the DOE *Computerized Accident Incident Reporting and Recordkeeping System* (DOE 2008). This decline reflects the type and scope of work that has been conducted in the past and is currently being conducted at Hanford. Other factors contributing to the decrease include safe work procedures, policies, and practices observed by the work force. Figure 6–1 shows the number of TRCs, and the incidence rate per 200,000 labor hours. Baseline TRCs and fatalities are 22,996 and 0.025, respectively.

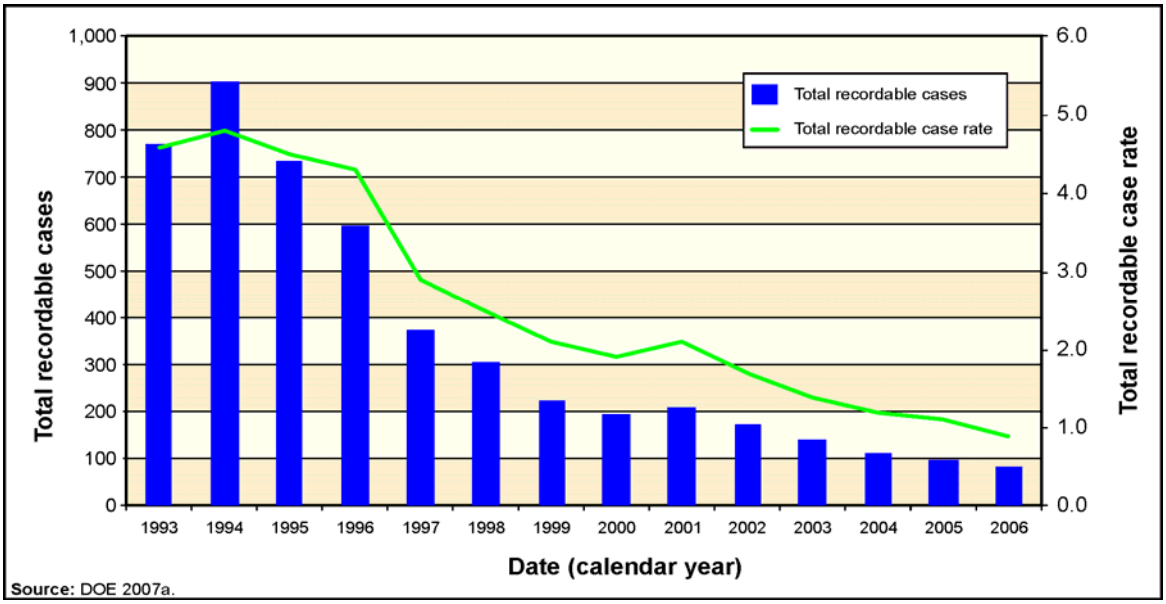


Figure 6–1. Richland Operations Industrial Safety Total Recordable Cases and Incident Rate Between 1993 and 2006

Table 6–10 shows the potential cumulative impacts to Hanford worker industrial safety for each of the alternative combinations. As shown in Table 6–10, the baseline projection of TRCs and number of fatalities for site activities is the total TRCs and number of fatalities projected to occur over the same time period as the alternative combinations. The baseline TRCs and number of fatalities were then added to the combinations. This is likely to be conservative because the baseline values include workers performing Waste Treatment Plant construction activities.

Table 6–10. Estimated Industrial Safety Cumulative Impacts

Actions/Activities	Number of Total Recordable Cases	Number of Fatalities
***TC & WM EIS* Alternative Combinations (see Chapter 4, Table 4–161)**		
Alternative Combination 1	173	0.02
Alternative Combination 2	4,540	0.60
Alternative Combination 3	6,870	0.88
Other DOE Actions at the Hanford Site		
Hanford Site baseline	22,996	0.025
Cumulative Totals[a]		
Alternative Combination 1	23,170	0.05
Alternative Combination 2	27,540	0.63
Alternative Combination 3	29,870	0.91

[a] The "cumulative totals" are the sums of the impacts under the alternative combinations and the "Other DOE" activities. Totals may not equal the sum of the contributions due to rounding.

Key: DOE=U.S. Department of Energy; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Alternative Combination 1 (No Action) would not have an impact on the number or rate of TRCs. It can reasonably be expected that future TRCs would remain equal to or decline from present levels. Factors influencing this include the anticipated work effort in terms of the type and amount required in the foreseeable future. Although projected to generate approximately 173 TRCs over the duration of the selected alternatives, Combination 1 includes a 100-year administrative control period that restricts access to and use of the site. Averaging the number of TRCs over the duration of the alternative combinations would increase the recordable cases by one to two per year. Other activities taking place at the same time were included as part of the baseline accounted for in the current TRCs rate and number.

The impact of Alternative Combination 2 would result in an increase in the cumulative number of illnesses, injuries, and fatalities. The magnitude of the increase would be influenced by the number of workers, hours worked, and type of work. Typically, the greatest increase would be realized during the construction phase. Averaging the number of additional recordable cases over all phases of the alternative combinations would increase the TRCs by 25 to 27 annually. However, that number would be greater during the peak construction periods and less during the operation and decommissioning phases. The lowest number of recordable cases is expected during the closure phase. Assuming current safe work policies and practices are continued, cumulative fatalities are not expected from the additional recordable cases associated with this alternative combination.

Alternative Combination 3 would generate the greatest increase in the cumulative number of recordable cases. An overall increase of approximately 6,900 TRCs over all phases of work activity was projected for Combination 3. The increased TRCs would be influenced by the annual changes in the size of the work force and the type of work performed. The construction phase of the project would generate the most cases, while postclosure care of the site would result in the fewest cases. The magnitude of the increase, when averaged over the entire duration, would be approximately 40 to 42 additional cases annually. Similar to Alternative Combination 2, the greatest increase in TRCs would occur during the construction phase, while the fewest TRCs would occur during the postclosure phase. Although the possibility of fatalities is always present during the construction of any large facility, this cumulative impacts analysis indicates a fatality would be unlikely over the entire period of analysis, assuming that safe work policies, procedures, and techniques remain in force throughout the duration of work.

6.4 LONG-TERM CUMULATIVE IMPACTS

Long-term cumulative impacts occur following the active project phase for each alternative. For this *TC & WM EIS*, long-term cumulative impacts were assessed out to approximately 10,000 years in the future.

This section presents long-term cumulative impacts for the following resource areas: groundwater quality, public health, ecological risk, and environmental justice. The detailed tables that support the long-term cumulative impacts analyses are presented in Appendix U.

6.4.1 Groundwater Quality

In this section, the cumulative long-term groundwater quality impacts are presented in conjunction with the long-term impacts of three alternative combinations. The results for the three alternative combinations are presented in Section 5.4. The results for the long-term groundwater impacts associated with the past, present, and reasonably foreseeable future action (non-*TC & WM EIS*) sources are presented in Appendix U. As discussed in Appendix U, the methodology for calculating the cumulative long-term groundwater impacts of non-*TC & WM EIS* sources is fully consistent with the methodology for calculating the impacts of the *TC & WM EIS* alternatives.

6.4.1.1 Alternative Combination 1

This section presents the results of the cumulative long-term groundwater impacts analysis including Alternative Combination 1. All of the non-*TC & WM EIS* sources discussed in Appendix S are included.

This discussion of long-term impacts is focused on the following constituent of potential concern (COPC) drivers:

- radiological risk drivers: hydrogen-3 (tritium), iodine-129, technetium-99, and uranium-238
- chemical hazard drivers: carbon tetrachloride, chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose Alternative Combination 1 and the COPC drivers for the non-*TC & WM EIS* sources. They fall into three categories. Iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Tritium is also mobile, but short lived. The half-life of tritium is about 12.3 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors. The level of protection provided for the drinking water pathway was evaluated by comparison against the maximum contaminant levels provided in 40 CFR 141 and other benchmarks presented in Appendix O.

6.4.1.1.1 Analysis of Release and Mass Balance

This section presents the total amount of the COPC drivers released to the vadose zone, to groundwater, and to the Columbia River. Releases of radionuclides are totaled in curies, and releases of chemicals are totaled in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 6–11 lists the release to the vadose zone for the COPC drivers. For Alternative Combination 1 and non-*TC & WM EIS* sources, the release to the vadose zone is controlled by inventory; the entire inventory for all sources was released to the vadose zone during the period of analysis. The release to the vadose zone for Alternative Combination 1 and non-*TC & WM EIS* sources is dominated by non-*TC & WM EIS* sources for tritium, by sources associated with Tank Closure Alternative 1 for technetium-99, and by a combination of non-*TC & WM EIS* sources and Tank Closure Alternative 1 for the other COPCs. For all of the COPC drivers, releases from FFTF Decommissioning alternative and Waste Management alternative sources account for less than 1 percent of the total.

Table 6–11. Alternative Combination 1 Release to Vadose Zone for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other Activities	3.43×10^{6}	2.49×10^{1}	7.33×10^{2}	3.13×10^{3}	3.35×10^{5}	7.38×10^{7}	2.53×10^{5}
Tank Closure Alternative 1	5.75×10^{4}	4.78×10^{1}	2.58×10^{4}	9.38×10^{2}	6.94×10^{5}	9.74×10^{7}	6.32×10^{5}
FFTF Decommissioning Alternative 1	2.29	0	2.72×10^{1}	0	5.72×10^{-3}	0	2.79×10^{-2}
Waste Management Alternative 1	3.52×10^{3}	1.32×10^{-3}	1.21	7.35×10^{-1}	1.80×10^{2}	2.98×10^{3}	9.47×10^{-1}
Total	3.49×10^{6}	7.27×10^{1}	2.66×10^{4}	4.07×10^{3}	1.03×10^{6}	1.71×10^{8}	8.85×10^{5}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

Table 6–12 lists the release to groundwater for the COPC drivers. In addition to the inventory consideration discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, the amount released to groundwater is attenuated by radioactive decay during transit through the vadose zone. About 60 percent of the tritium released to the vadose zone reaches the unconfined aquifer. Because of retardation, less than 15 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 6–12. Alternative Combination 1 Release to Groundwater for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other Activities	2.06×10^{6}	2.48×10^{1}	7.12×10^{2}	1.48×10^{2}	3.40×10^{5}	7.42×10^{7}	1.05×10^{5}
Tank Closure Alternative 1	3.23×10^{4}	4.65×10^{1}	2.51×10^{4}	2.57×10^{1}	6.34×10^{5}	9.40×10^{7}	2.86×10^{4}
FFTF Decommissioning Alternative 1	5.30×10^{-3}	0	2.67×10^{1}	0	5.61×10^{-3}	0	2.35×10^{-2}
Waste Management Alternative 1	1.76×10^{3}	1.31×10^{-3}	1.21	3.09×10^{-5}	1.77×10^{2}	2.94×10^{3}	4.39×10^{-5}
Total	2.10×10^{6}	7.13×10^{1}	2.58×10^{4}	1.74×10^{2}	9.74×10^{5}	1.68×10^{8}	1.34×10^{5}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

Table 6–13 lists the release to the Columbia River for the radiological risk drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers in the unconfined aquifer. For iodine-129, technetium-99, chromium, and nitrate, the amount released to Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 5 percent of the tritium released to groundwater reaches the Columbia River. Because of retardation, about 80 percent of the uranium-238 and total uranium released to groundwater during the period of analysis reaches the Columbia River.

Table 6–13. Alternative Combination 1 Release to Columbia River for Radiological Risk Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other activities	1.11×10^{5}	2.46×10^{1}	7.26×10^{2}	1.40×10^{2}	3.51×10^{5}	7.47×10^{7}	9.28×10^{4}
Tank Closure Alternative 1	8.68×10^{2}	4.54×10^{1}	2.46×10^{4}	6.26	6.52×10^{5}	9.42×10^{7}	6.87×10^{3}
FFTF Decommissioning Alternative 1	3.15×10^{-4}	0	2.72×10^{1}	0	5.73×10^{-3}	0	2.20×10^{-2}
Waste Management Alternative 1	0	1.28×10^{-3}	1.18	2.67×10^{-6}	1.75×10^{2}	2.90×10^{3}	3.50×10^{-6}
Total	1.12×10^{5}	7.00×10^{1}	2.53×10^{4}	1.46×10^{2}	1.00×10^{6}	1.69×10^{8}	9.97×10^{4}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

6.4.1.1.2 Analysis of Concentration Versus Time

This section presents groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid in interpreting data with a considerable amount of random fluctuation (noise). The confidence interval was calculated when: the concentration had a considerable amount of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 6–14 lists the maximum concentrations for the COPCs at the peak year for the Core Zone Boundary and the Columbia River nearshore.

Table 6–14. Alternative Combination 1 Maximum Concentrations for COPCs[a]

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration[b]
Radionuclide (picocuries per liter)			
Hydrogen-3 (Tritium)	104,000,000	4,190,000	20,000
	(1996)	(1986)	
Carbon-14	46,700	196	2,000
	(1998)	(2013)	
Strontium-90	181,000	4,160,000	8
	(1998)	(1991)	

Table 6–14. Alternative Combination 1 Maximum Concentrations for COPCs[a] *(continued)*

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration[b]
Radionuclide (picocuries per liter)			
Technetium-99	350,000	5,360	900
	(3837)	(4032)	
Iodine-129	697	18.3	1
	(3801)	(4411)	
Cesium-137	0[c]	1,310,000	200
	(1997)	(1985)	
Uranium isotopes (includes U-233, -234, -235, -238)	2,200	22,400	15
	(1991)	(1973)	
Neptunium-237	114	16	15
	(2066)	(2004)	
Plutonium isotopes (includes Pu-239, -240)	2,660	4,250	15
	(11,848)	(2983)	
Chemical (microgram per liter)			
1-Butanol	17,200	49	3,600
	(1998)	(11,243)	
Acetonitrile	121	9	100
	(3338)	(3285)	
Carbon tetrachloride	3,350	60.7	5
	(2270)	(2527)	
Chromium[d]	29,400	16,100	100
	(1956)	(1978)	
Dichloromethane	0.7	0.1	5
	(3286)	(4711)	
Fluoride	90,200	14,500	4,000
	(2003)	(1982)	
Hydrazine/Hydrazine Sulfate	0.030	0.088	0.022
	(3343)	(3627)	
Lead	0[c]	9,080	15
	(2021)	(2374)	
Manganese	392	242	1,600
	(8610)	(2286)	
Mercury	183	25.5	2
	(2015)	(1997)	
Nickel (soluble salts)	0[c]	8,310	700
	(11,871)	(3877)	
Nitrate	13,600,000	505,000	45,000
	(1956)	(1973)	
Total Uranium	3,290	15,400	30
	(1991)	(1964)	
Trichloroethylene (TCE)	0.1	0.2	5
	(3404)	(3764)	

[a] The peak cumulative concentration for some constituents occurs in the past. The relationship of past to future cumulative constituent concentrations is presented in the time versus concentration plots in Figures 6–2 through 6–9.

[b] The sources of the benchmark concentrations are provided in Appendix O**,** Section O.3**.**

[c] Values that are less than 0.001 are reported as zero.

[d] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert liters to gallons, multiply by 0.26417.

Key: COPC=constituent of potential concern.

Figure 6–2 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from 1940 through 5940 rather than the full 10,000-year period of analysis.

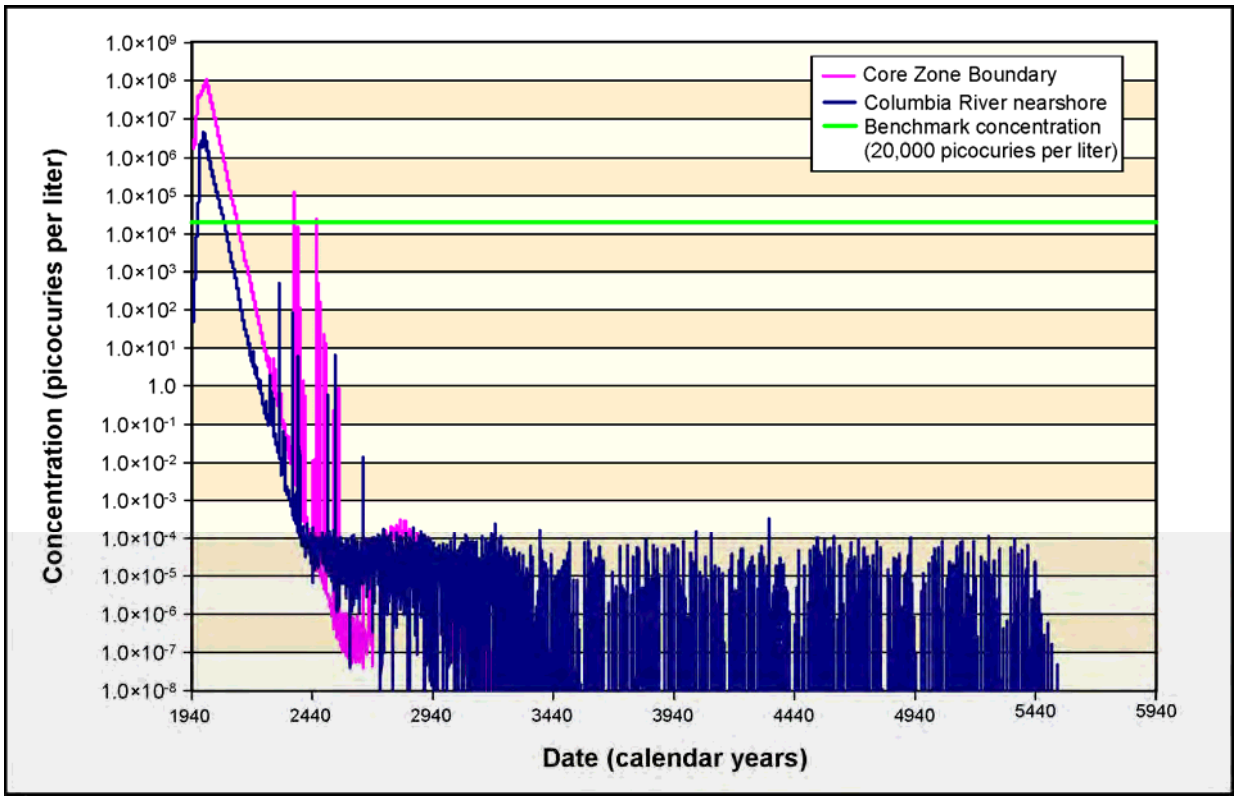


Figure 6–2. Alternative Combination 1 Cumulative Concentration Versus Time for Tritium

Concentrations at the Core Zone Boundary exceed the benchmark concentration by about three orders of magnitude for a short period of time during the early part of the period of analysis. During this time groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude above the benchmark concentration. Because the half-life of tritium is less than thirteen years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than calendar year (CY) 2100.

Figures 6–3 through 6–7 show concentration versus time for iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate. Groundwater concentrations of iodine-129 exceed benchmark concentrations by more than two orders of magnitude during the first several thousand years of the analysis. During this time groundwater concentrations at the Columbia River nearshore exceed the benchmark concentration by about an order of magnitude. During later times in the analysis the concentrations at the Core Zone Boundary exceed the benchmark by about an order of magnitude, and are on the same order of magnitude as the benchmark at the Columbia River nearshore. Technetium-99, carbon tetrachloride, chromium, and nitrate concentrations show a similar curve, with chromium and nitrate concentrations at the Columbia River nearshore dropping below the benchmark concentrations.

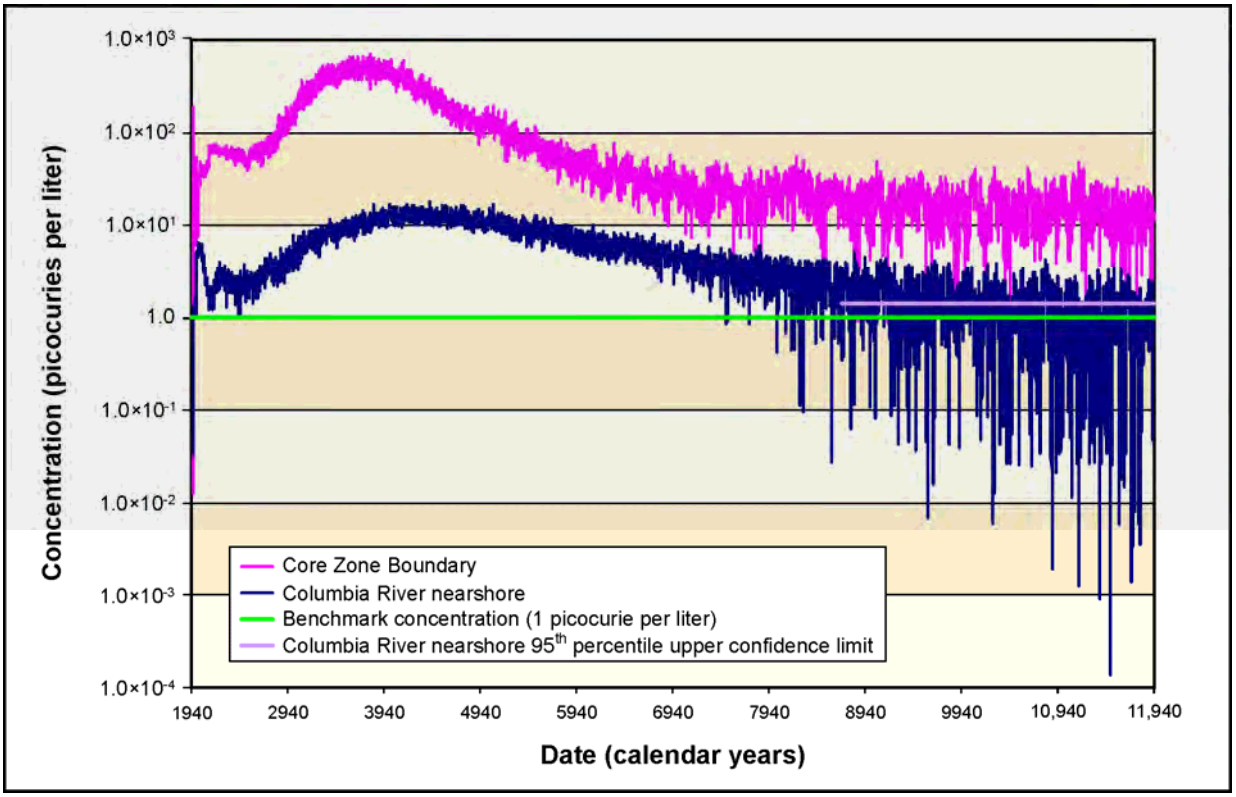


Figure 6–3. Alternative Combination 1 Cumulative Concentration Versus Time for Iodine-129

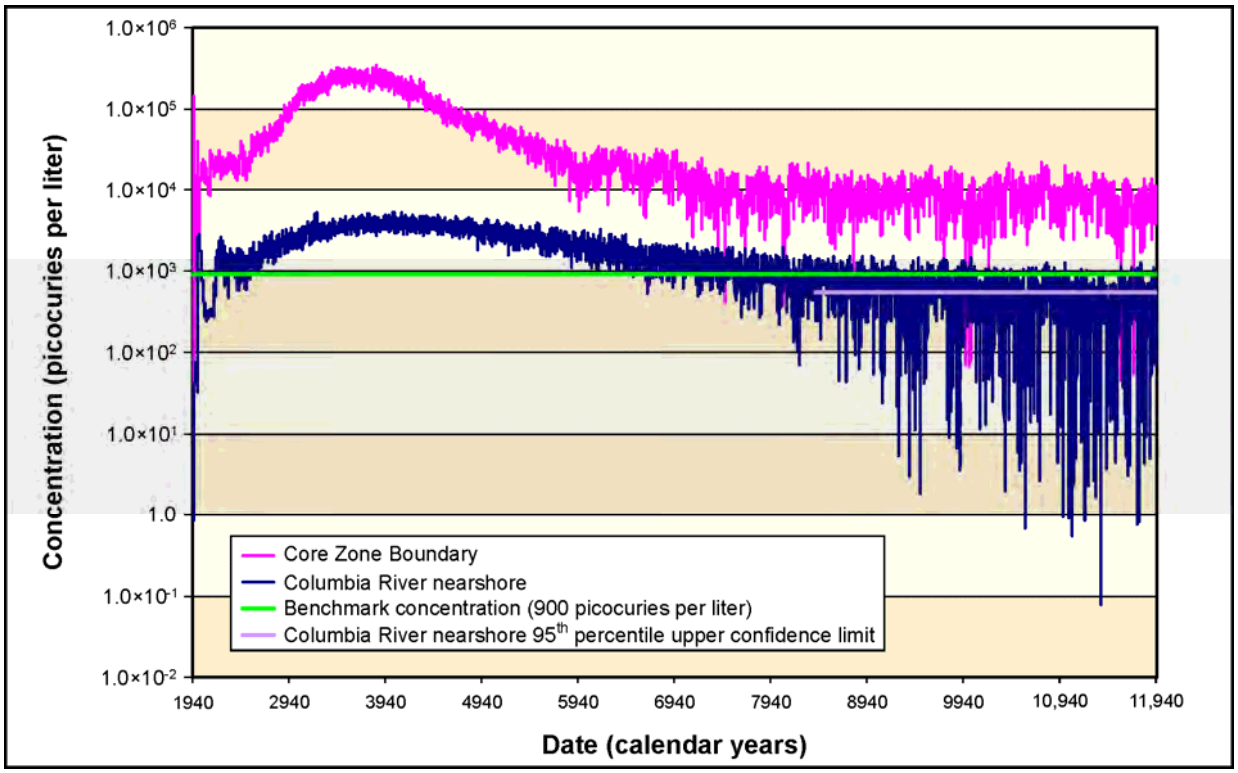


Figure 6–4. Alternative Combination 1 Cumulative Concentration Versus Time for Technetium-99

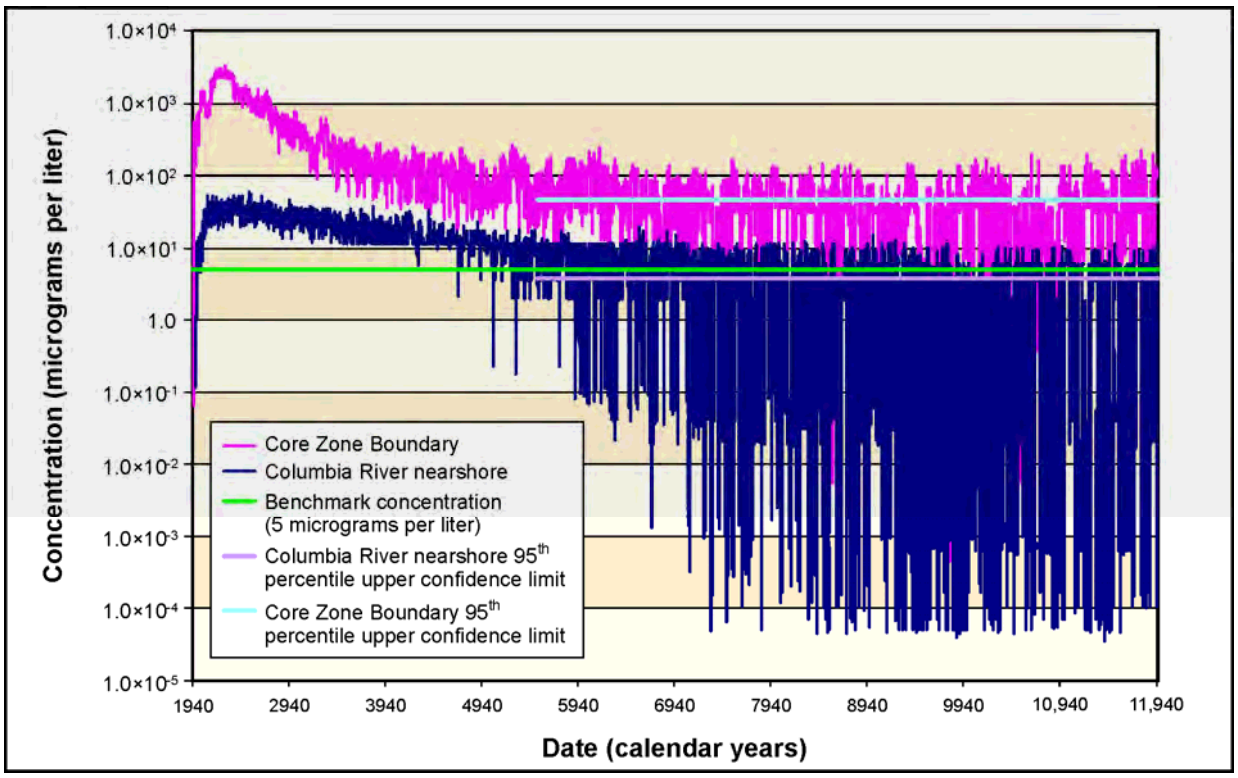


Figure 6–5. Alternative Combination 1 Cumulative Concentration Versus Time for Carbon Tetrachloride

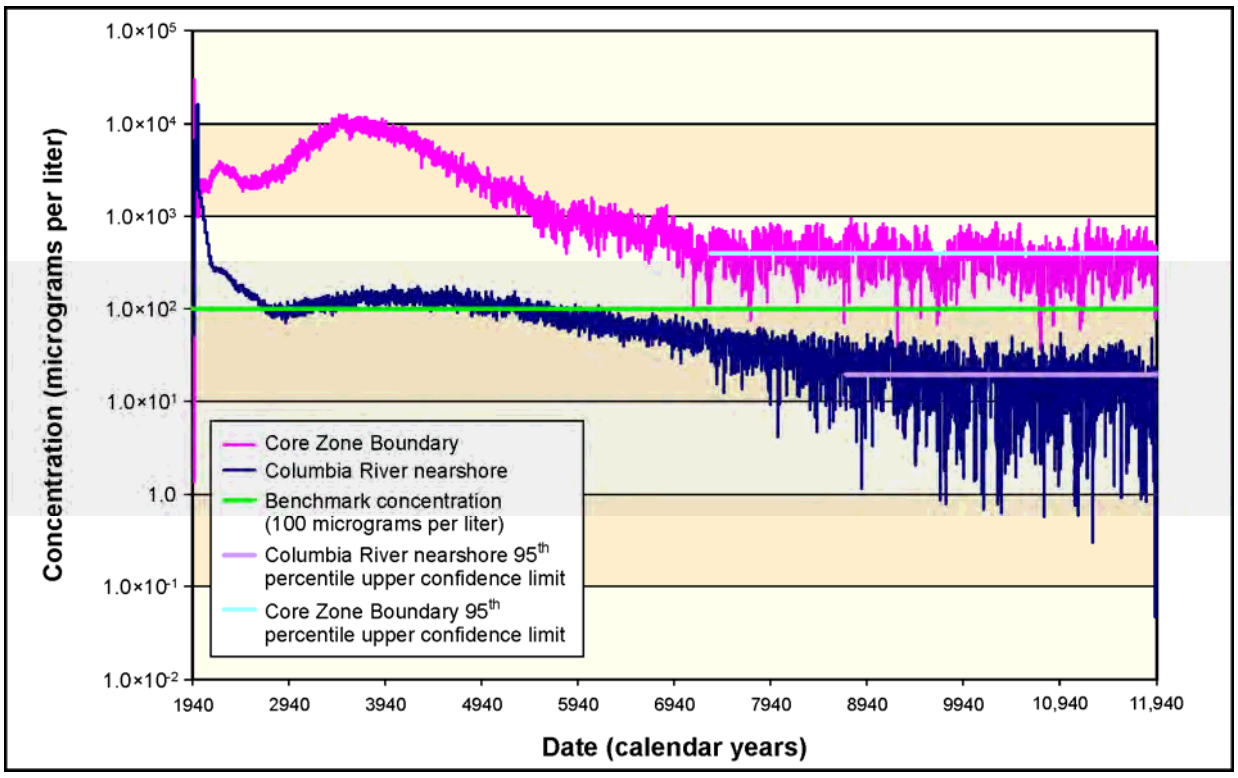


Figure 6–6. Alternative Combination 1 Cumulative Concentration Versus Time for Chromium

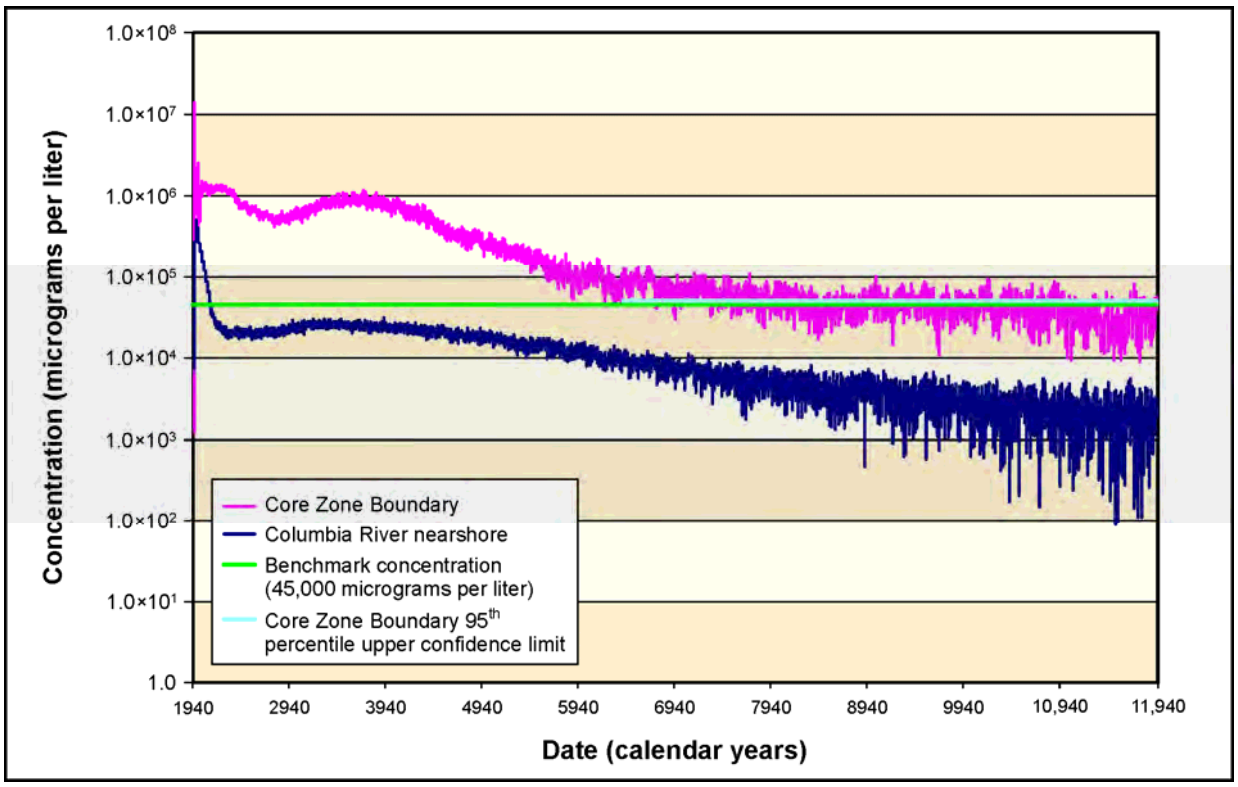


Figure 6–7. Alternative Combination 1 Cumulative Concentration Versus Time for Nitrate

Figures 6–8 and 6–9 show concentration versus time for uranium-238 and total uranium. Concentrations of uranium-238 and total uranium peak early in the period of analysis, and then maintain relatively constant for the remainder of the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and Columbia River is slowed relative to the groundwater flow by a factor of about seven. After about 1,000 years, concentrations of both uranium-238 and total uranium exceed the benchmark concentration at the Core Zone Boundary by one to two orders of magnitude. Groundwater concentrations at the Columbia River nearshore remain within an order of magnitude of the benchmark during this time.

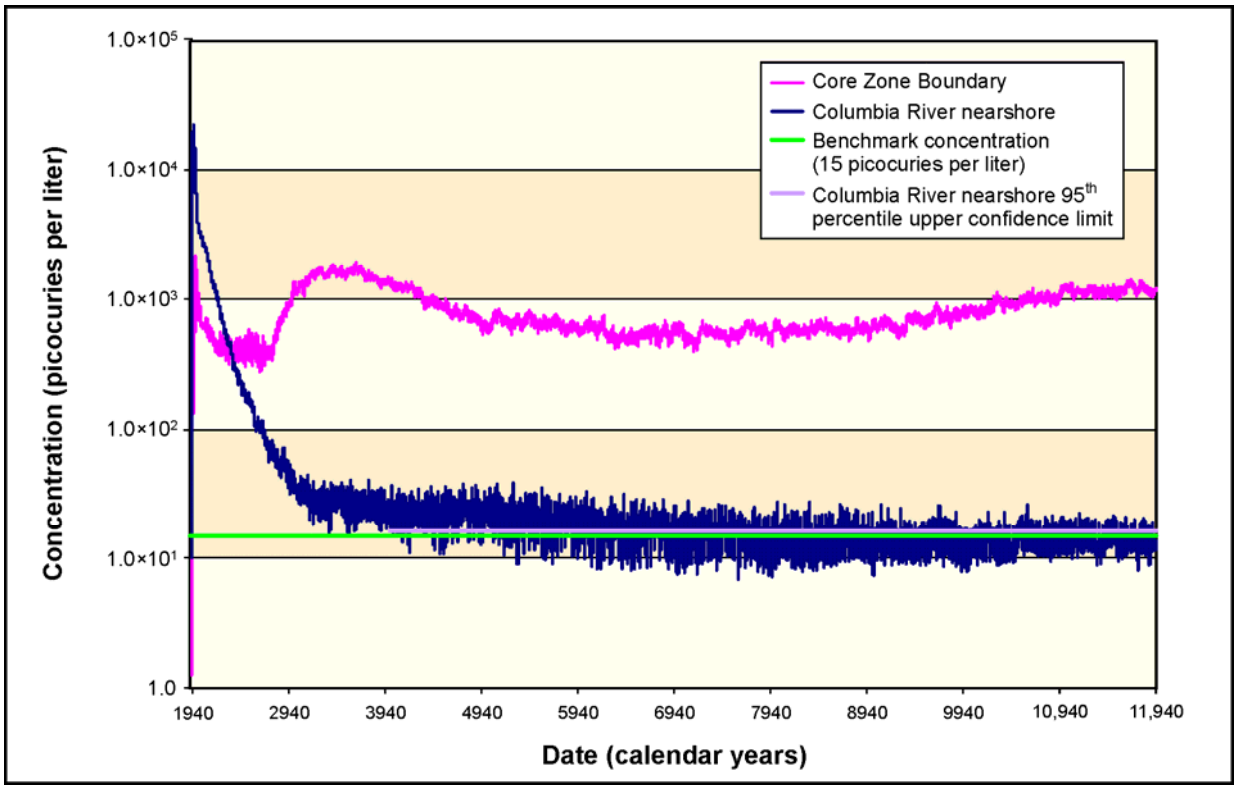


Figure 6–8. Alternative Combination 1 Cumulative Concentration Versus Time for Uranium-238

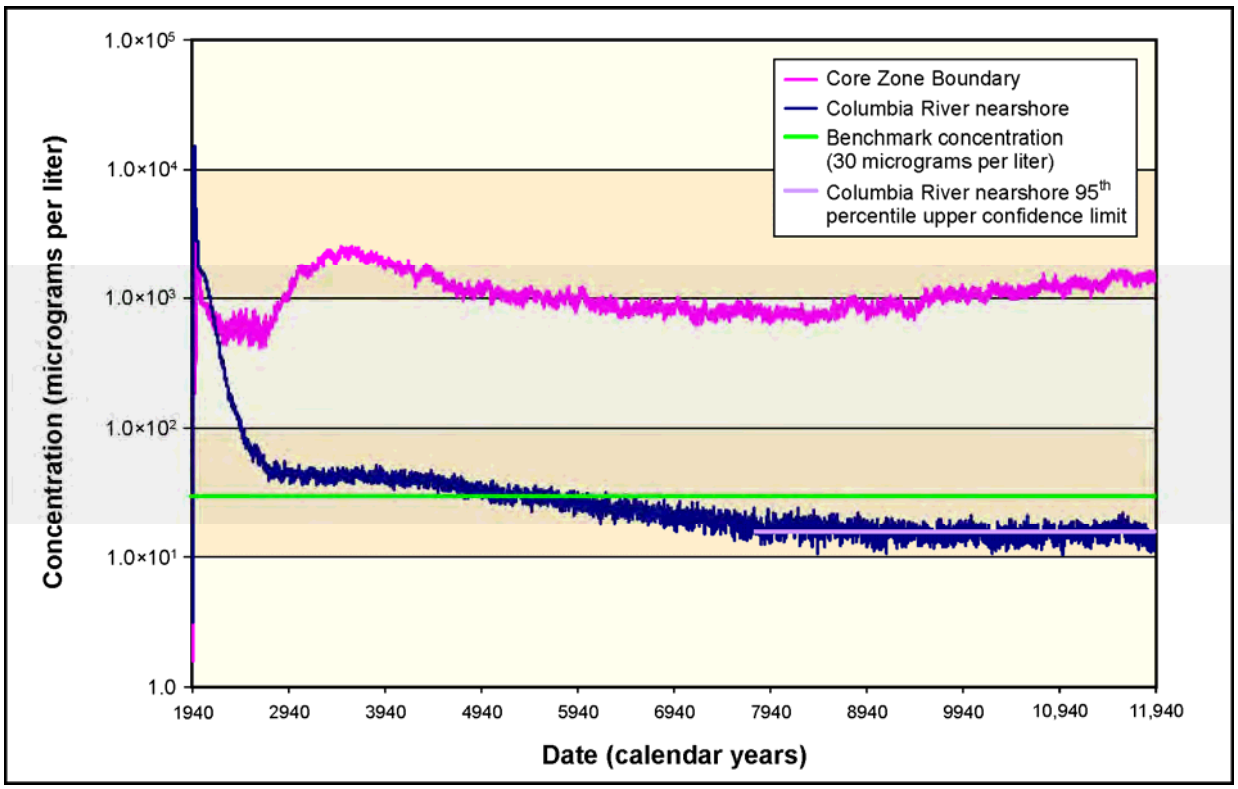


Figure 6–9. Alternative Combination 1 Cumulative Concentration Versus Time for Total Uranium

6.4.1.1.3 Analysis of Spatial Distribution of Concentration

This section presents the spatial distribution of contaminant concentrations in groundwater at selected times. Concentrations for each radionuclide and chemical are indicated by a color scale which is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentrations ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 6–10 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Releases from cribs and trenches (ditches), primarily associated with non-*TC & WM EIS* sources within the PUREX Plant and the REDOX Facility areas, result in groundwater concentration plumes (exceeding the benchmark concentration) that extend from the southern part of the 200-West Area across the Core Zone, and extending from the eastern part of the Core Zone southeast to the Columbia River. Peak concentrations in this plume are about ten to fifty times greater than the benchmark. Tritium concentrations are attenuated by radioactive decay to levels less than one twentieth of the benchmark concentration by CY 2135.

Figure 6–11 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceeding the benchmark concentration associated with the T Barrier, the B Barrier, and the A Barrier. Peak concentrations in this plume are about ten to fifty times greater than the benchmark, and mostly contained within the Core Zone. Releases from the PUREX Plant area (non-*TC & WM EIS* sources) produce a plume extending south and east of the Core Zone with peak concentrations about one to five times the benchmark concentration. Around CY 3890 releases from other tank farm sources create a large iodine-129 plume extending from the Tank Farm Barriers to the Columbia River (see Figure 6–12). By CY 7140 most of the mass in the plume has reached the Columbia River, with only isolated pockets of high concentration areas where the groundwater flow velocities are extremely small (see Figure 6–13). Figure 6–14 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. After an early peak related to releases from the PUREX Plant area, the area of exceedance peaks between CY 3240 and CY 4540 driven primarily by releases from other tank farm sources. Figures 6-15 through 6–18 show the spatial distribution at the same three times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 does not include contributions from the PUREX Plant sources (compare to iodine-129 distributions) and is dominated by releases from other tank farm sources. Chromium (see Figures 6–19 through 6–21) and nitrate (see Figures 6–22 through 6–24) show similar spatial distributions to technetium-99.

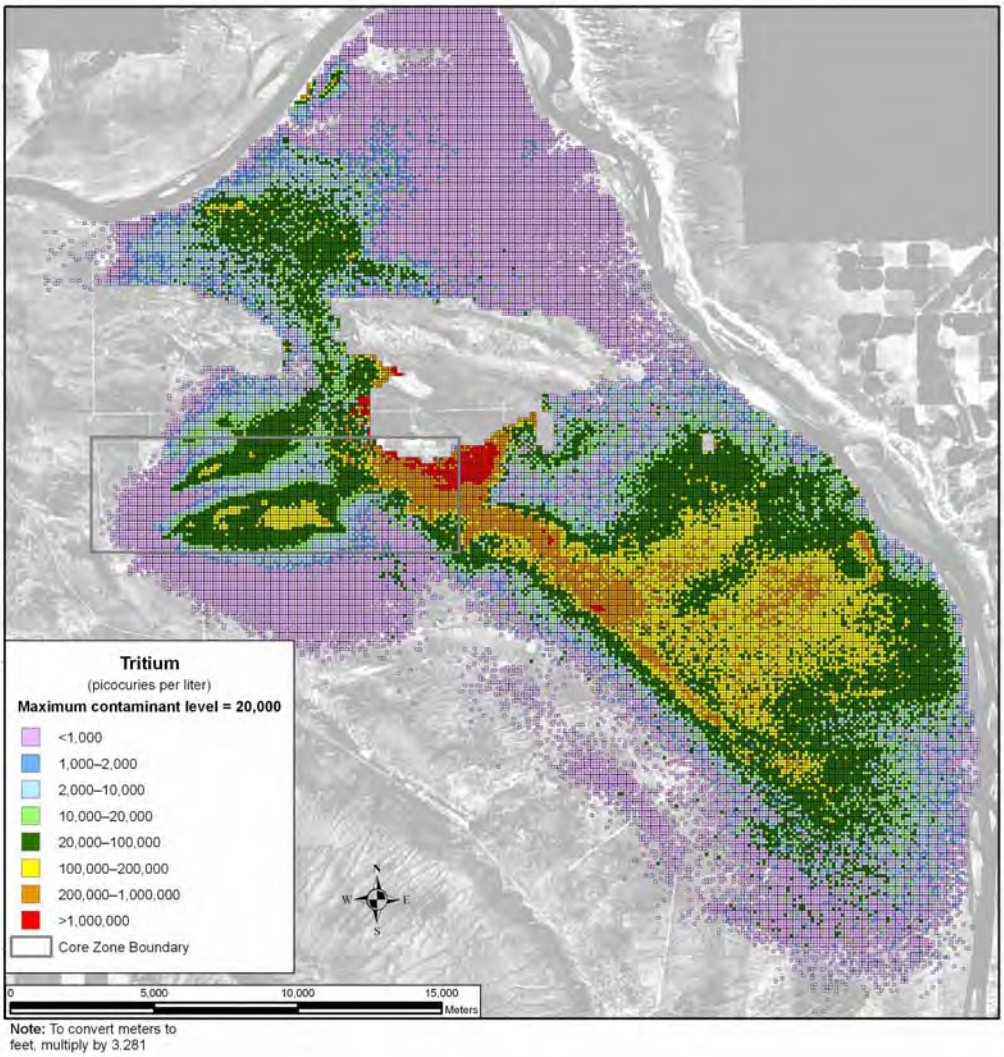


Figure 6–10. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Tritium During Calendar Year 2005

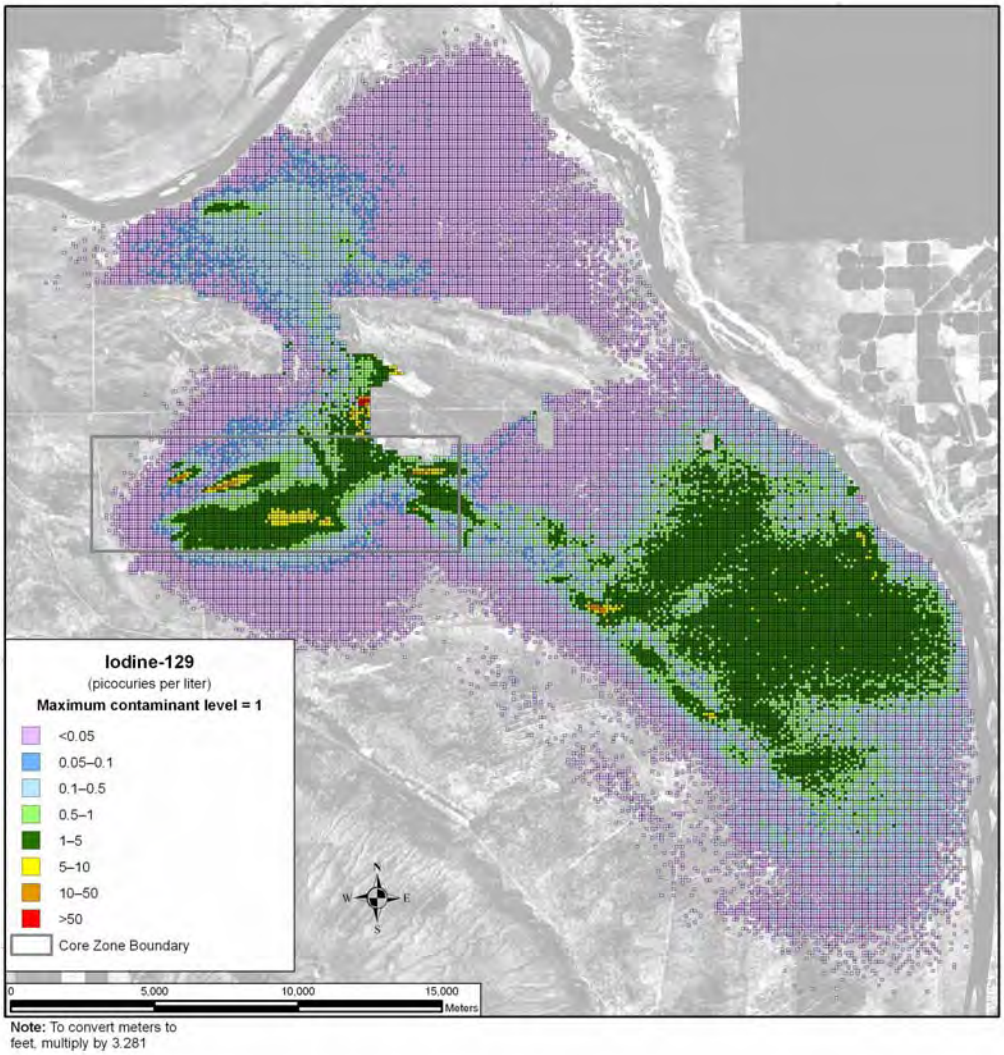


Figure 6–11. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 2005

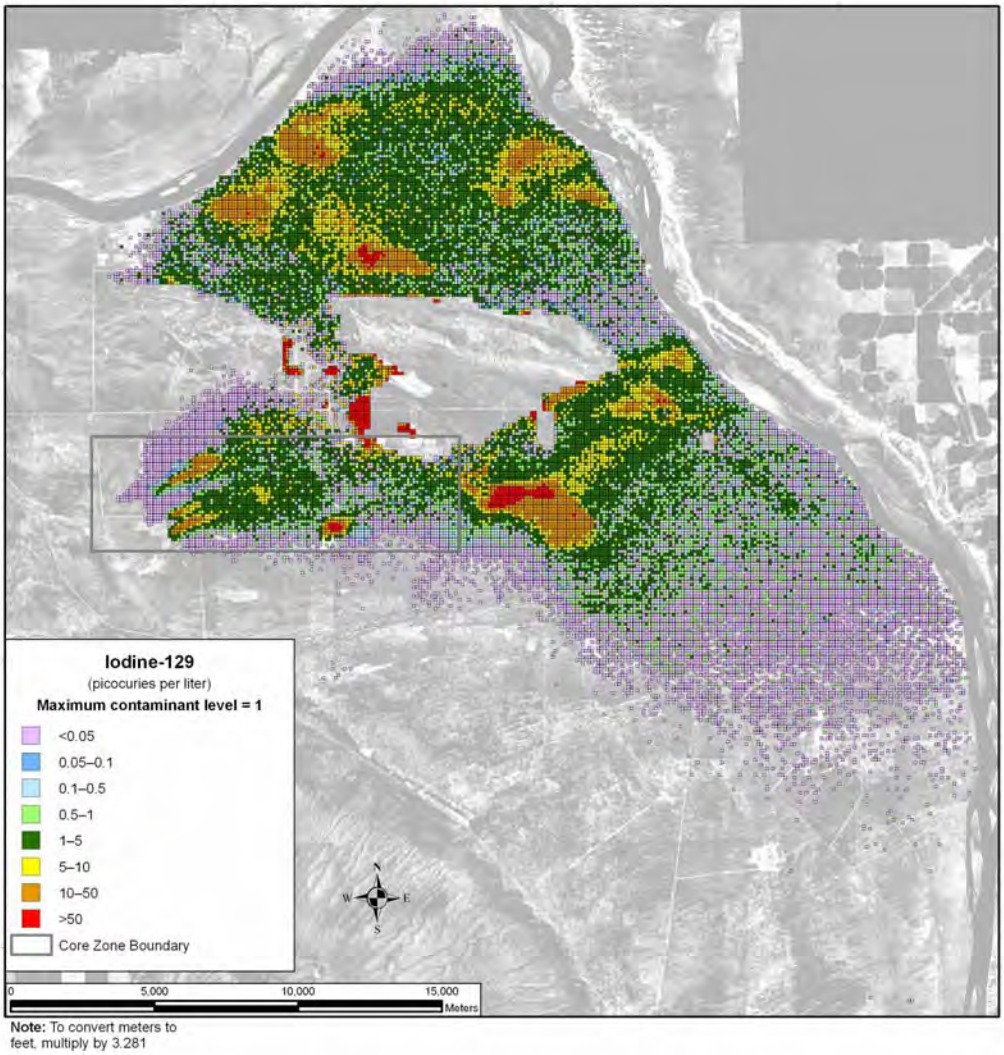


Figure 6–12. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 3890

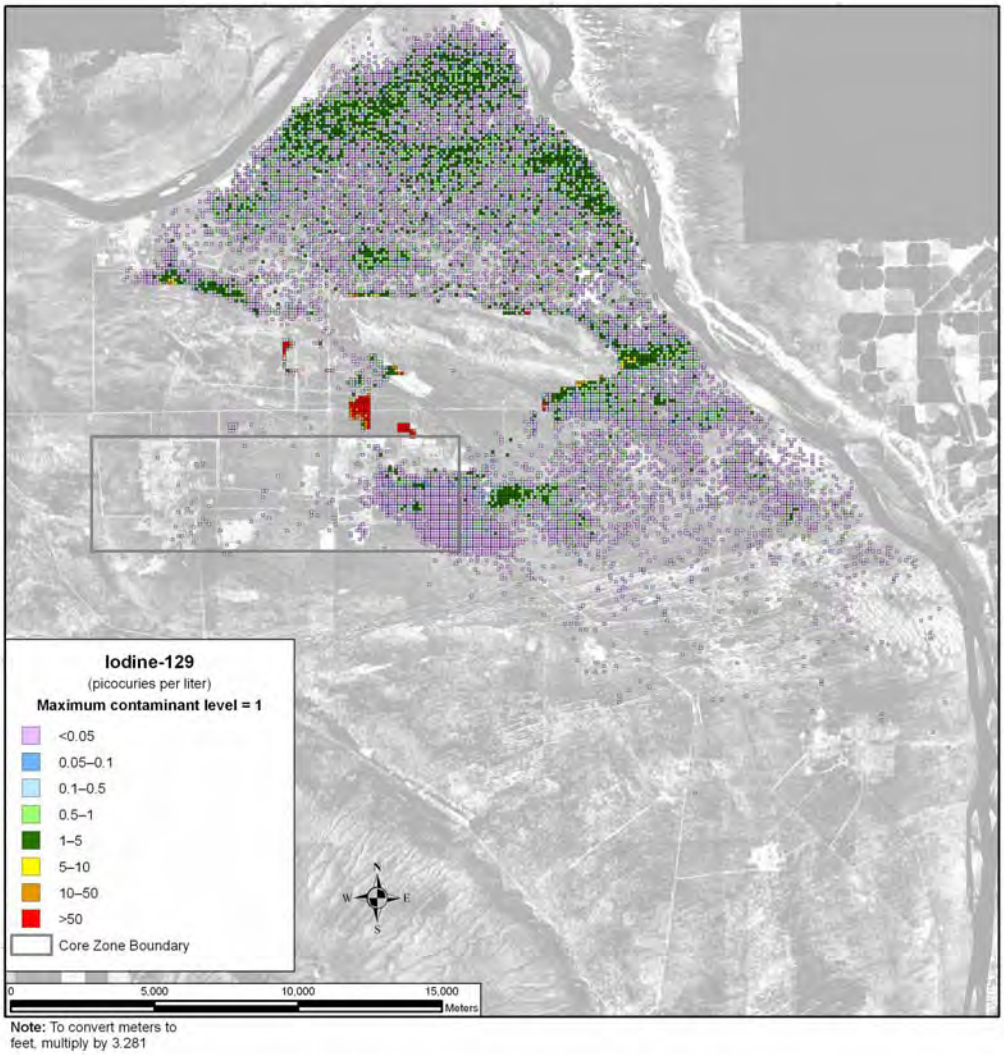


Figure 6–13. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 7140

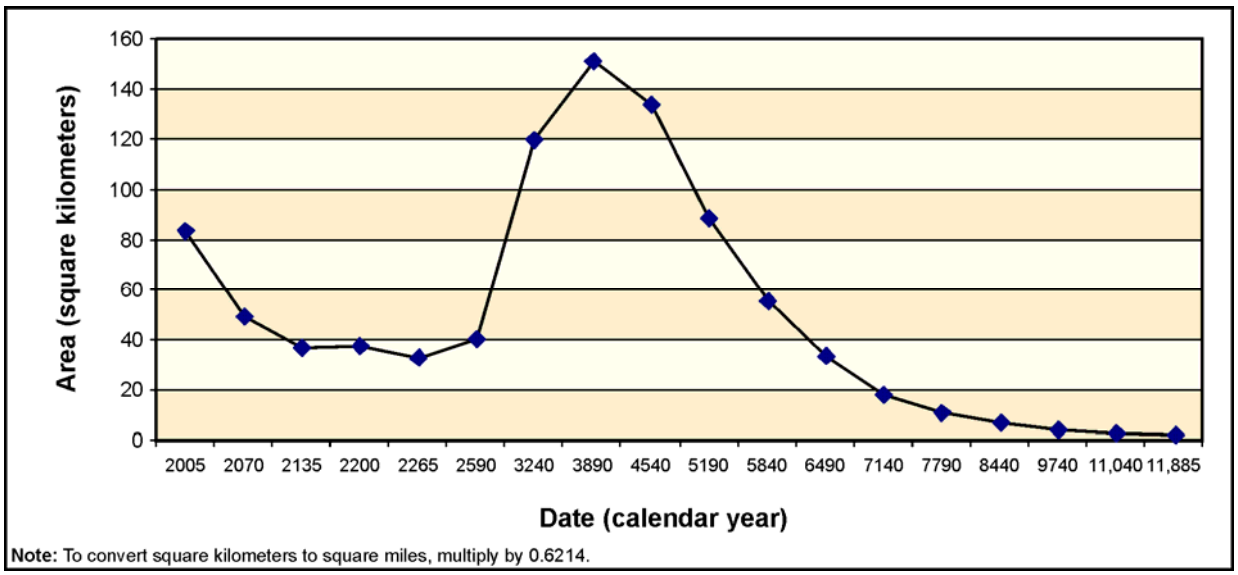


Figure 6–14. Alternative Combination 1 Total Area for Which Cumulative Groundwater Concentrations of Iodine-129 Exceed the Benchmark Concentration as a Function of Time

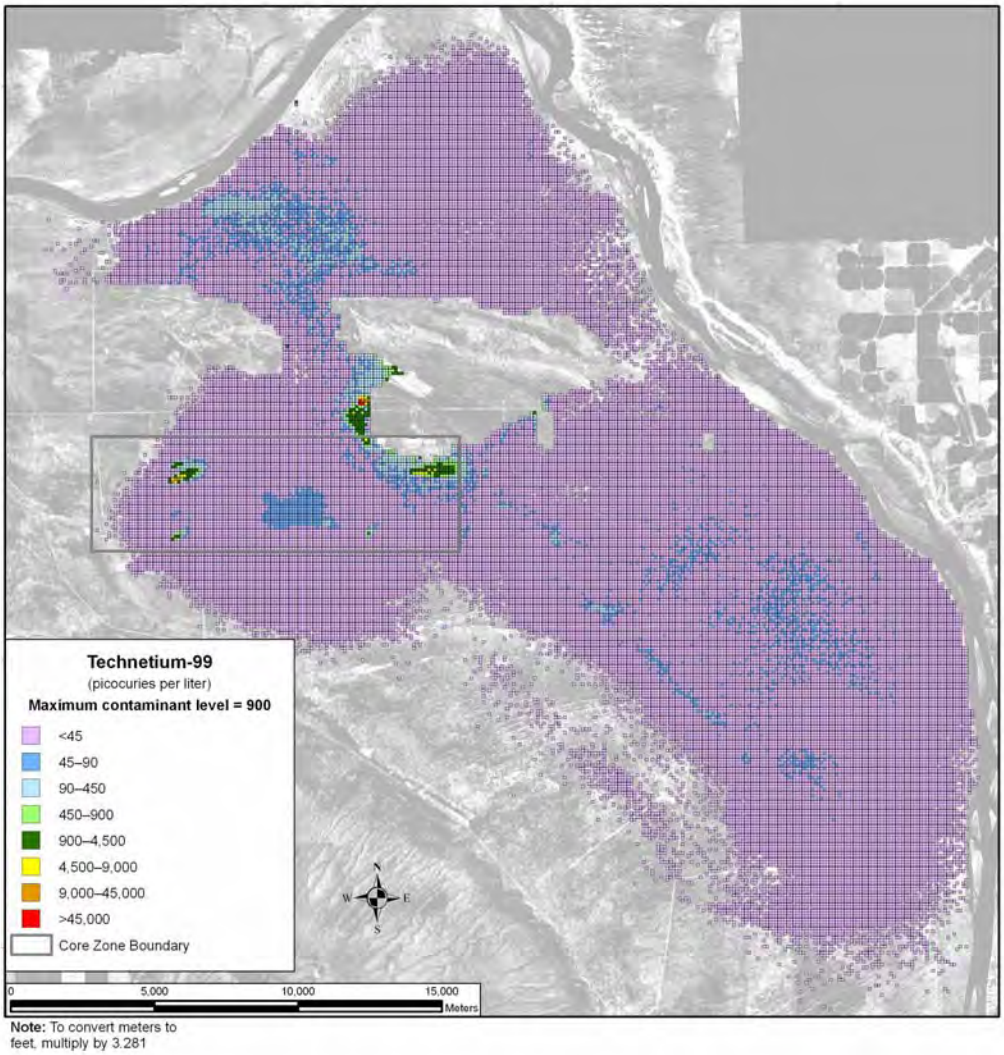


Figure 6–15. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 2005

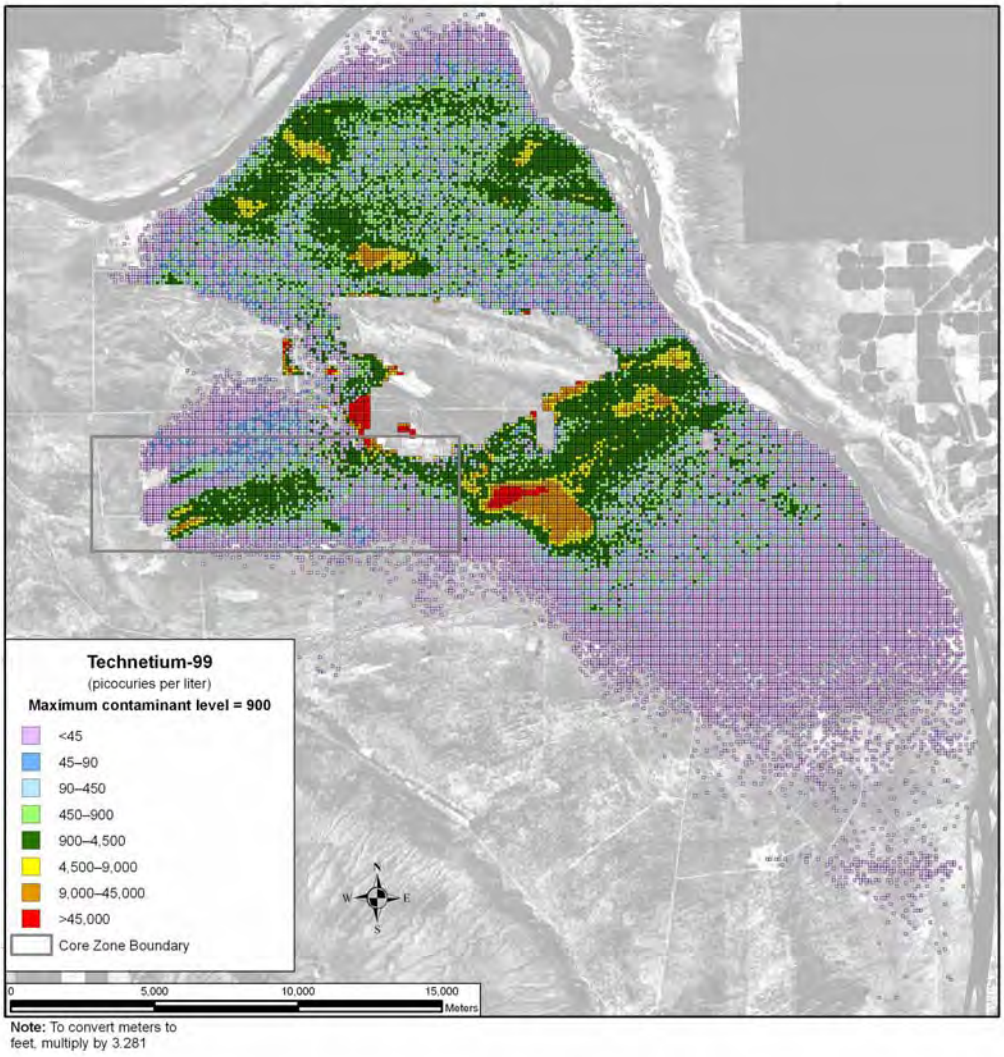


Figure 6–16. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 3890

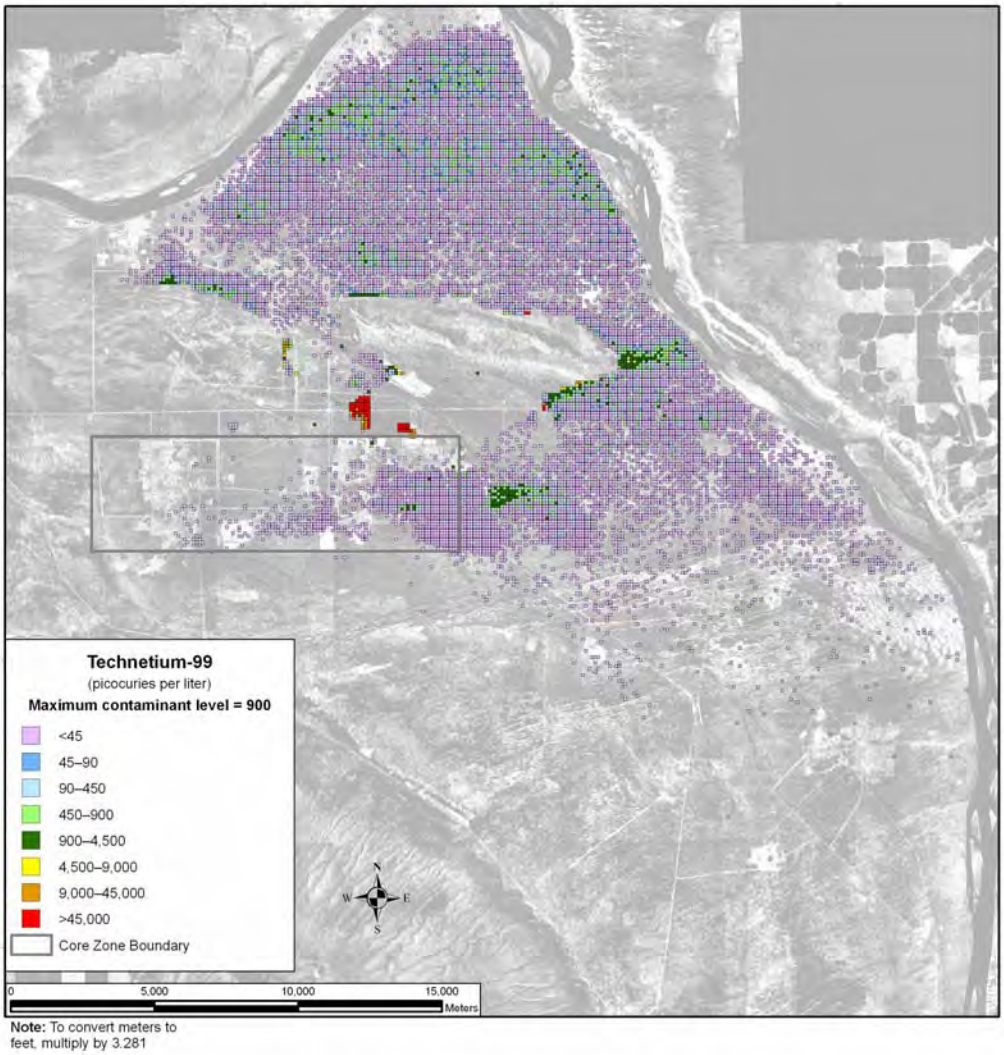


Figure 6–17. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 7140

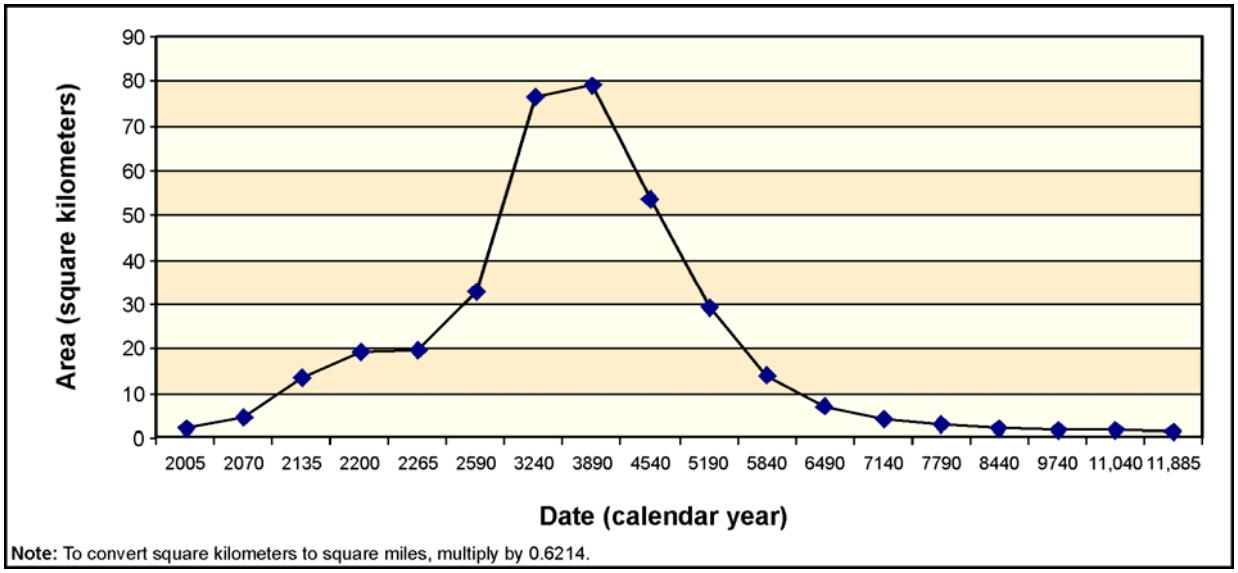


Figure 6–18. Alternative Combination 1 Total Area for Which Cumulative Groundwater Concentrations of Technetium-99 Exceed the Benchmark Concentration as a Function of Time

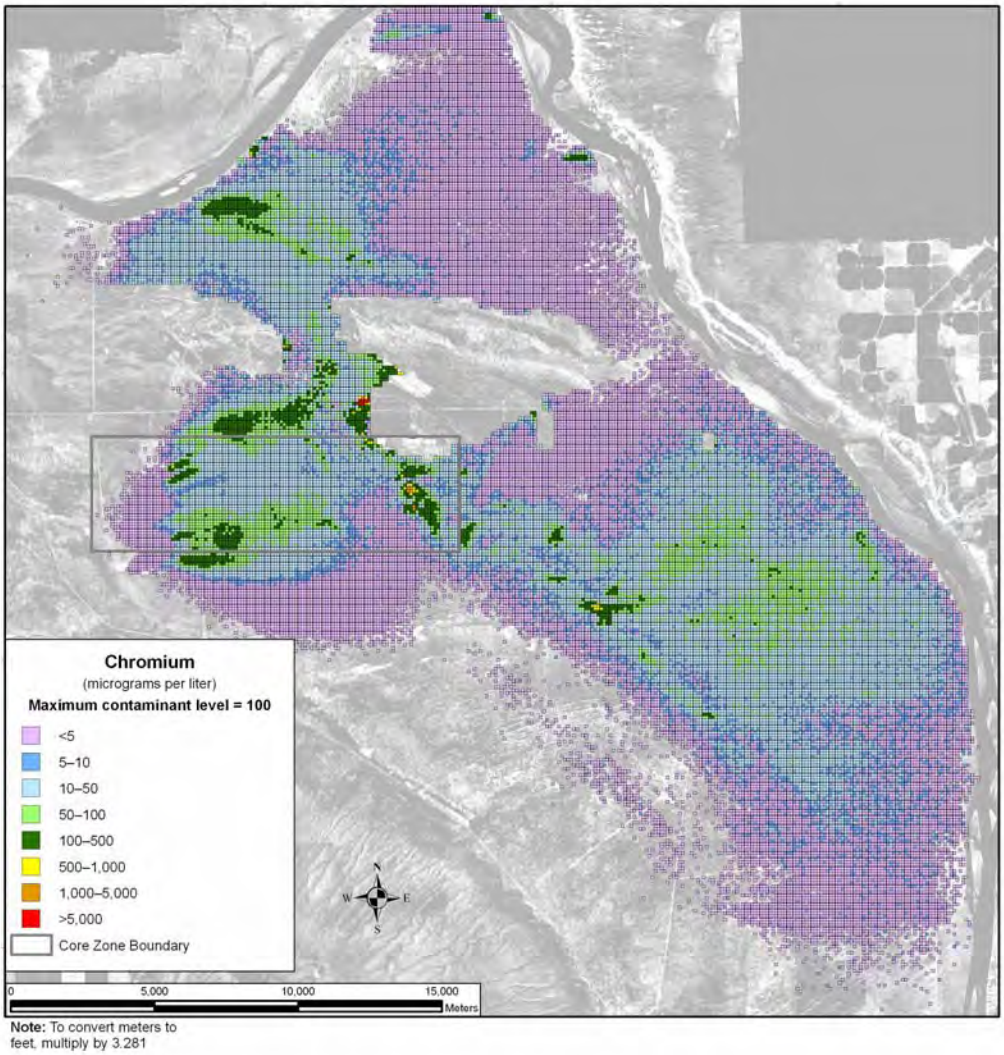


Figure 6–19. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 2005

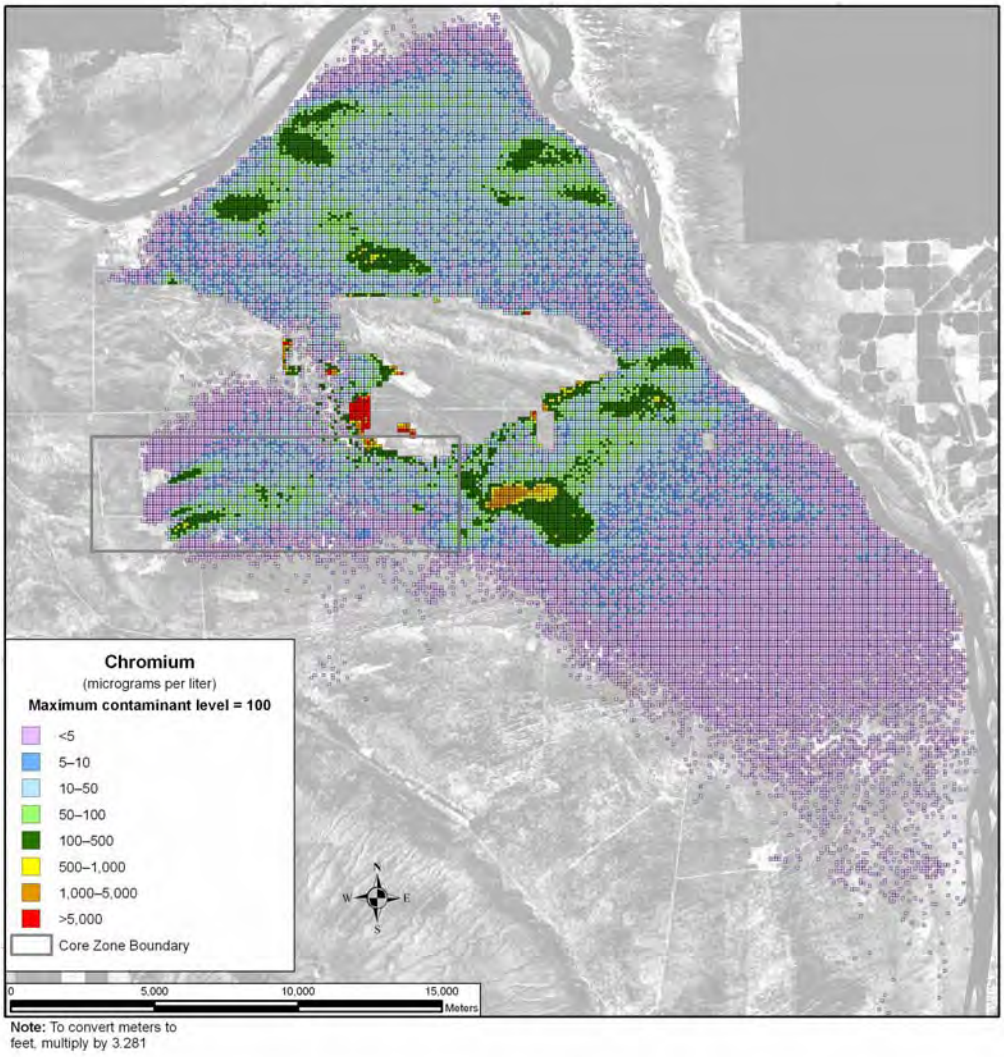


Figure 6–20. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 3890

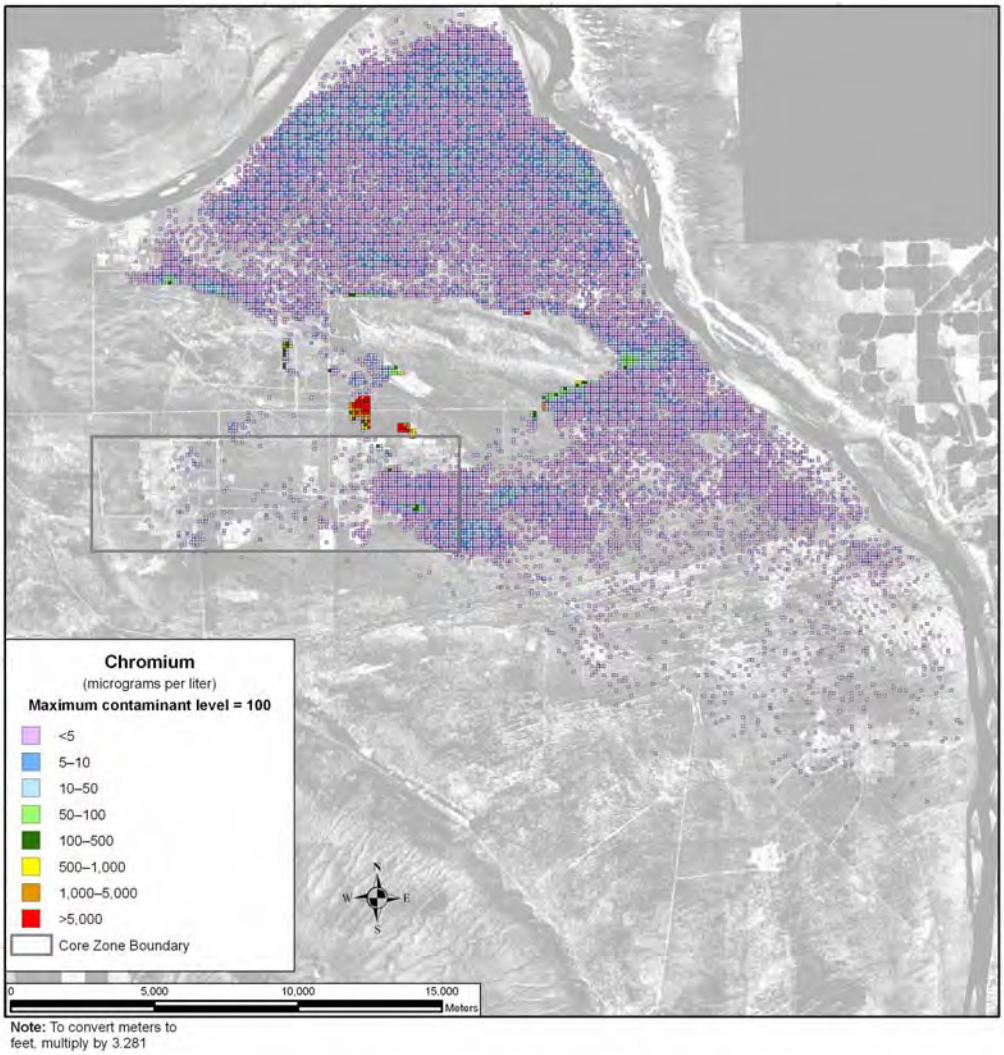


Figure 6–21. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 7140

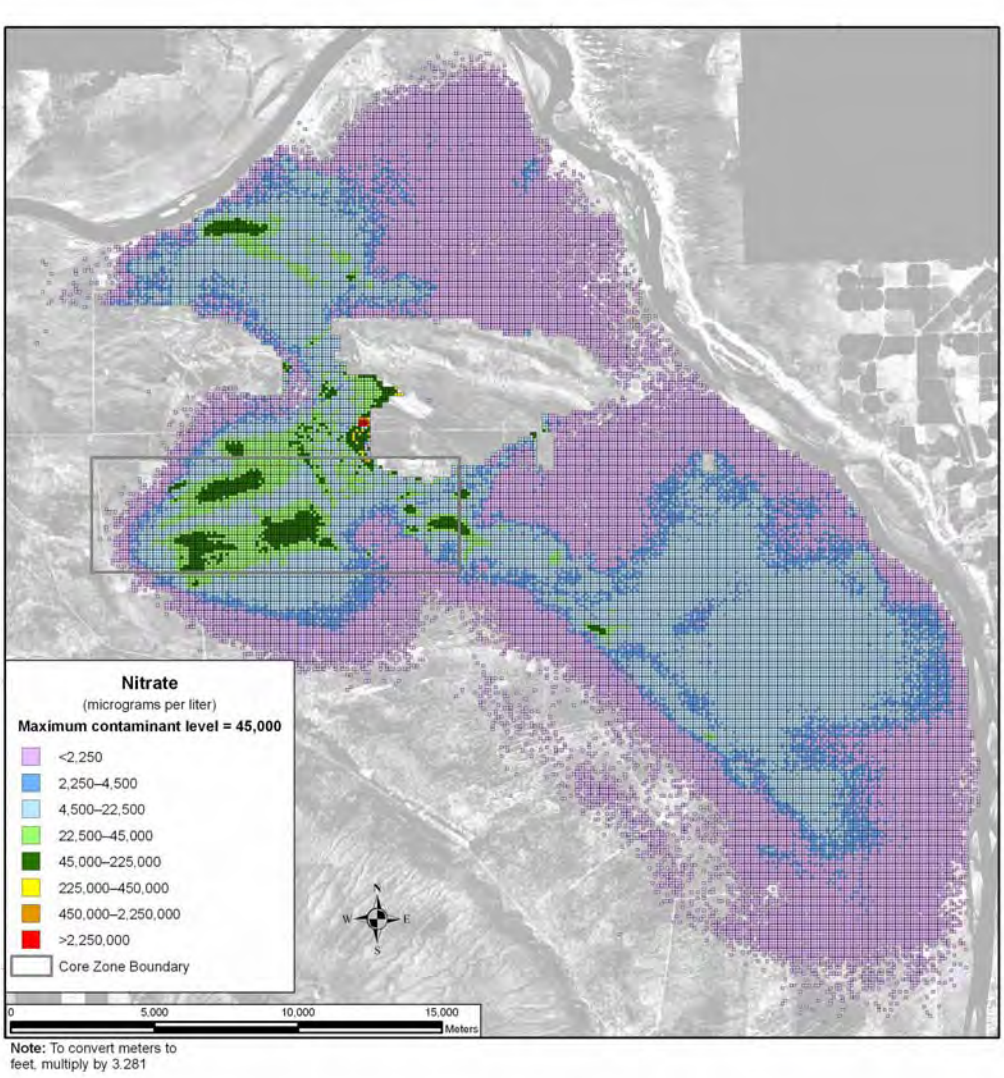


Figure 6–22. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 2005

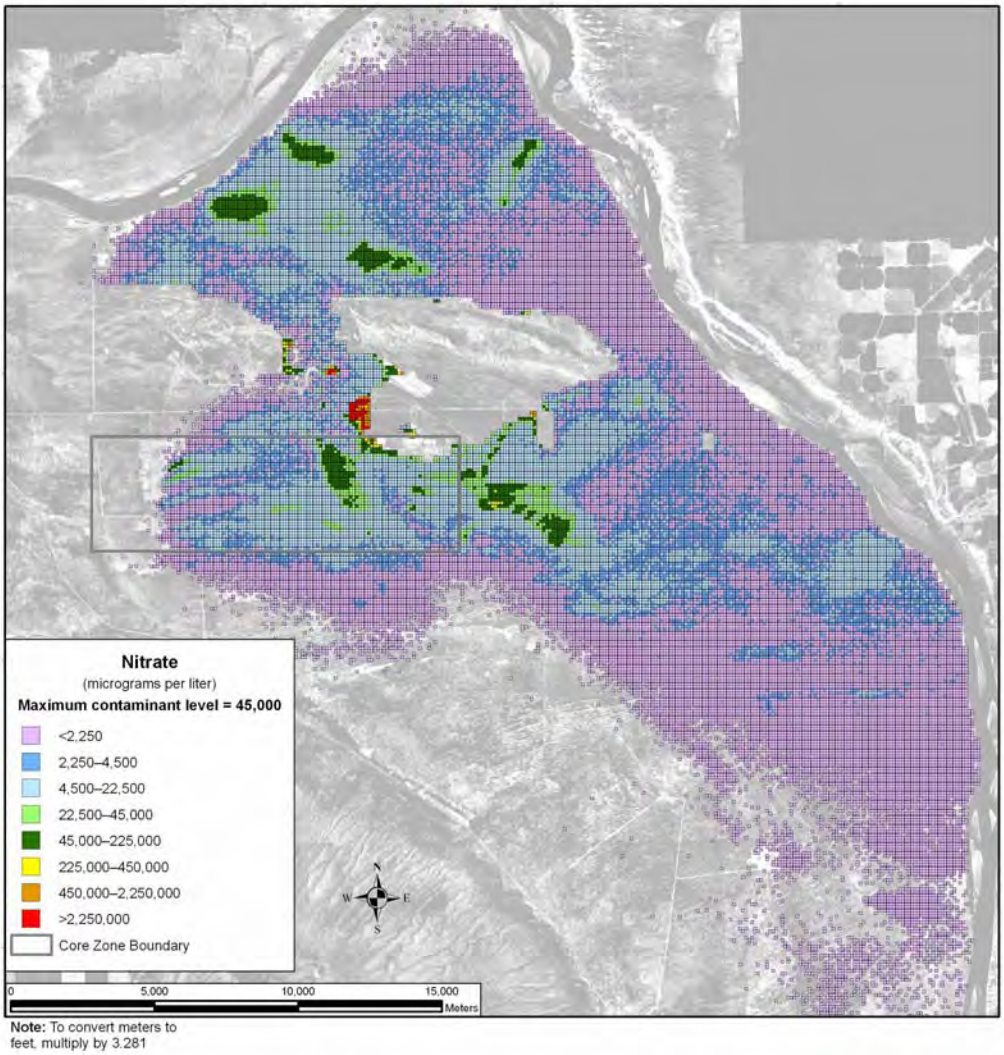


Figure 6–23. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 2135

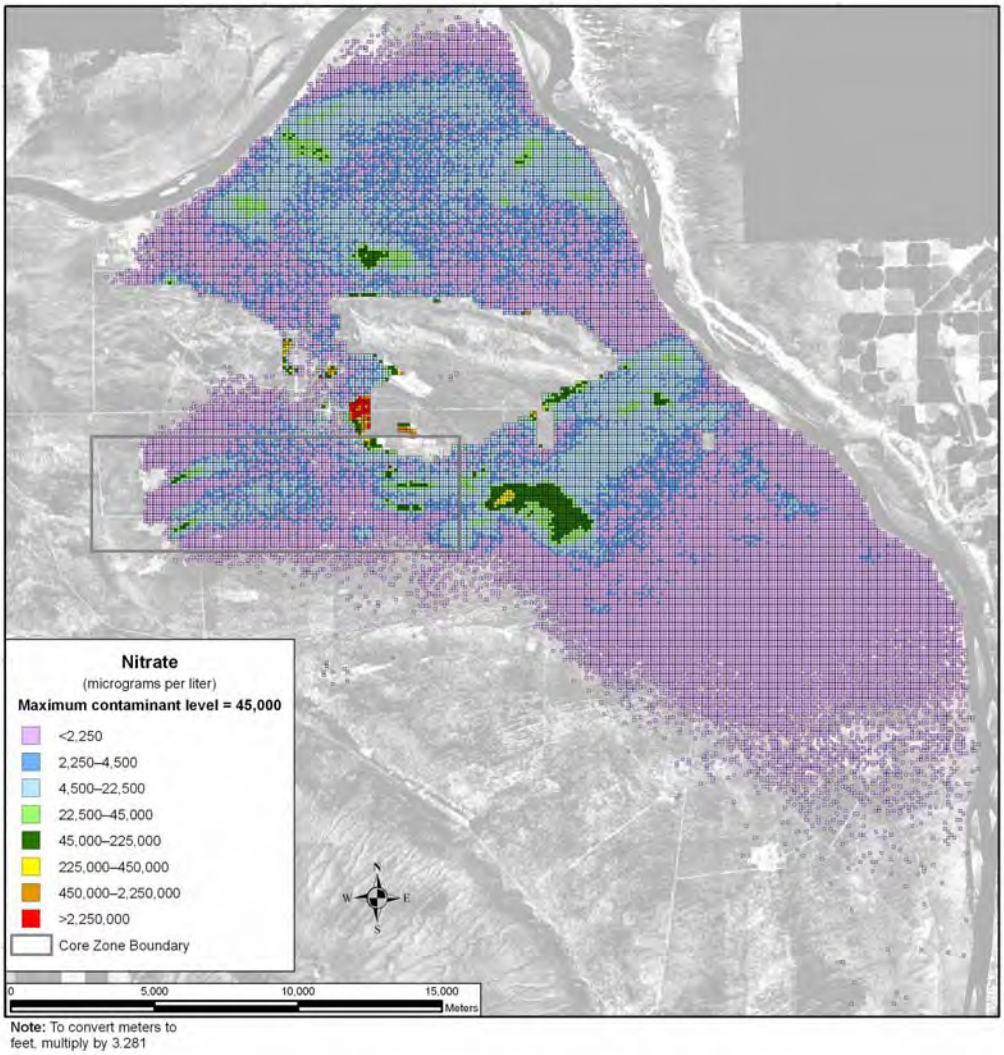


Figure 6–24. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 3890

The carbon tetrachloride distribution is dominated by non-*TC & WM EIS* sources associated with the Z Area within the 200-West Area. The spatial distribution during CY 2005, shown in Figure 6–25, is a large plume covering most of the 200-West Area, with peak concentrations over an order of magnitude greater than the benchmark concentration. Note that this model result does not include the effects of carbon tetrachloride removal and containment in the 200-West Area. Figures 6–26 and 6–27 show the dissipation of the plume over time at CY 2135 and CY 3890, respectively.

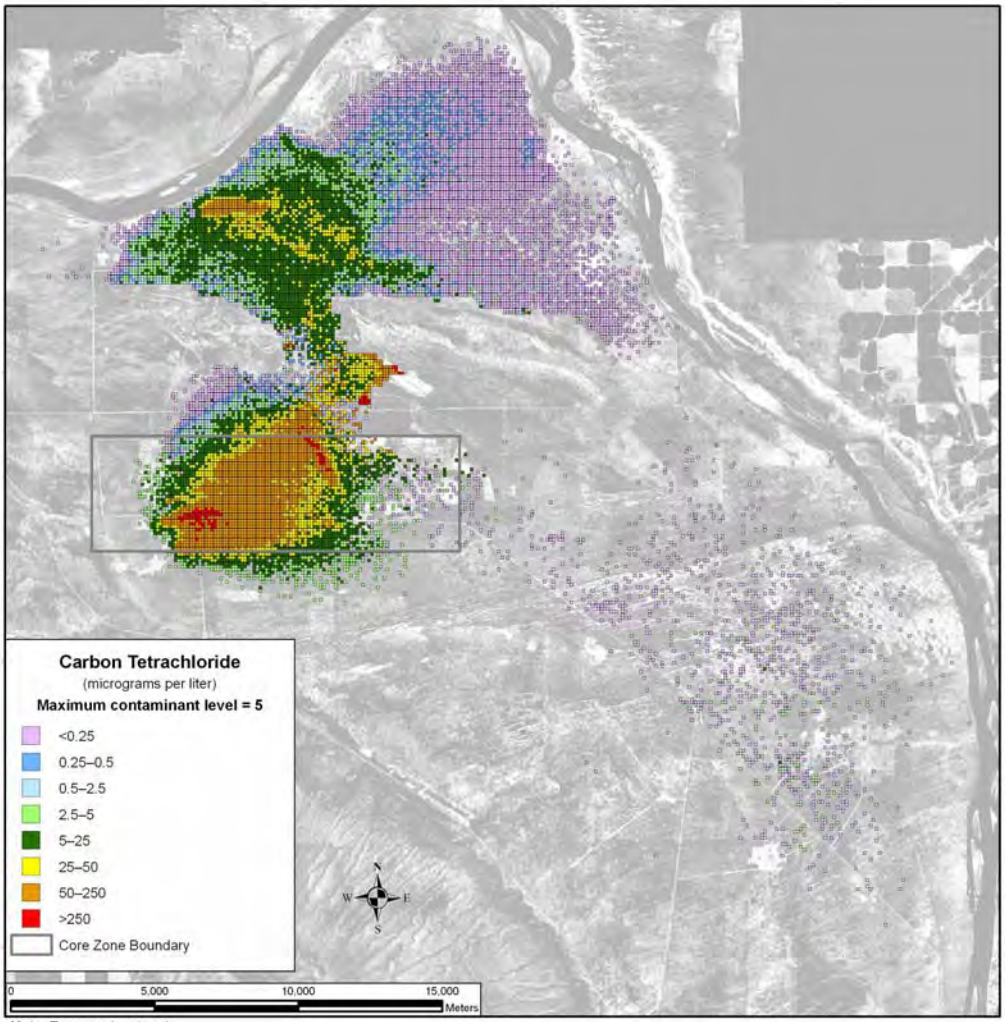


Figure 6–25. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 2005

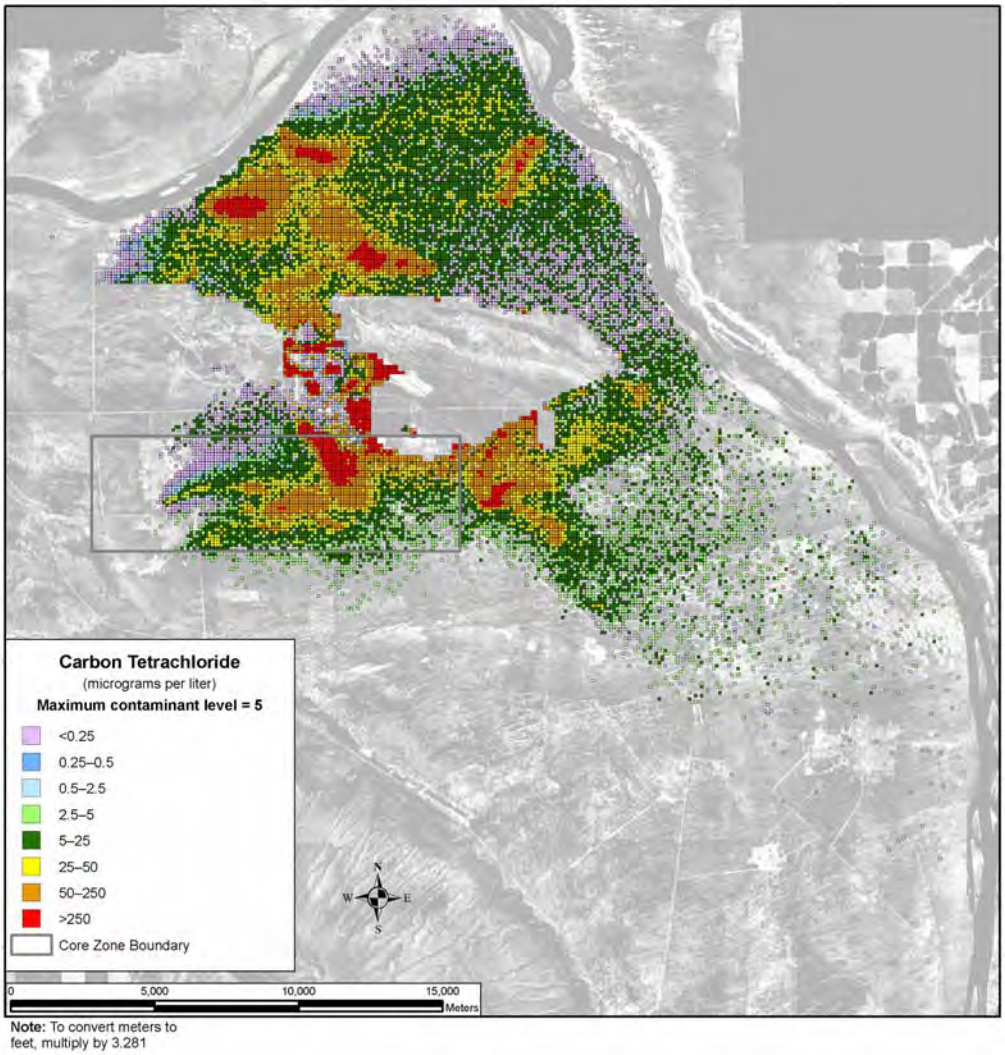
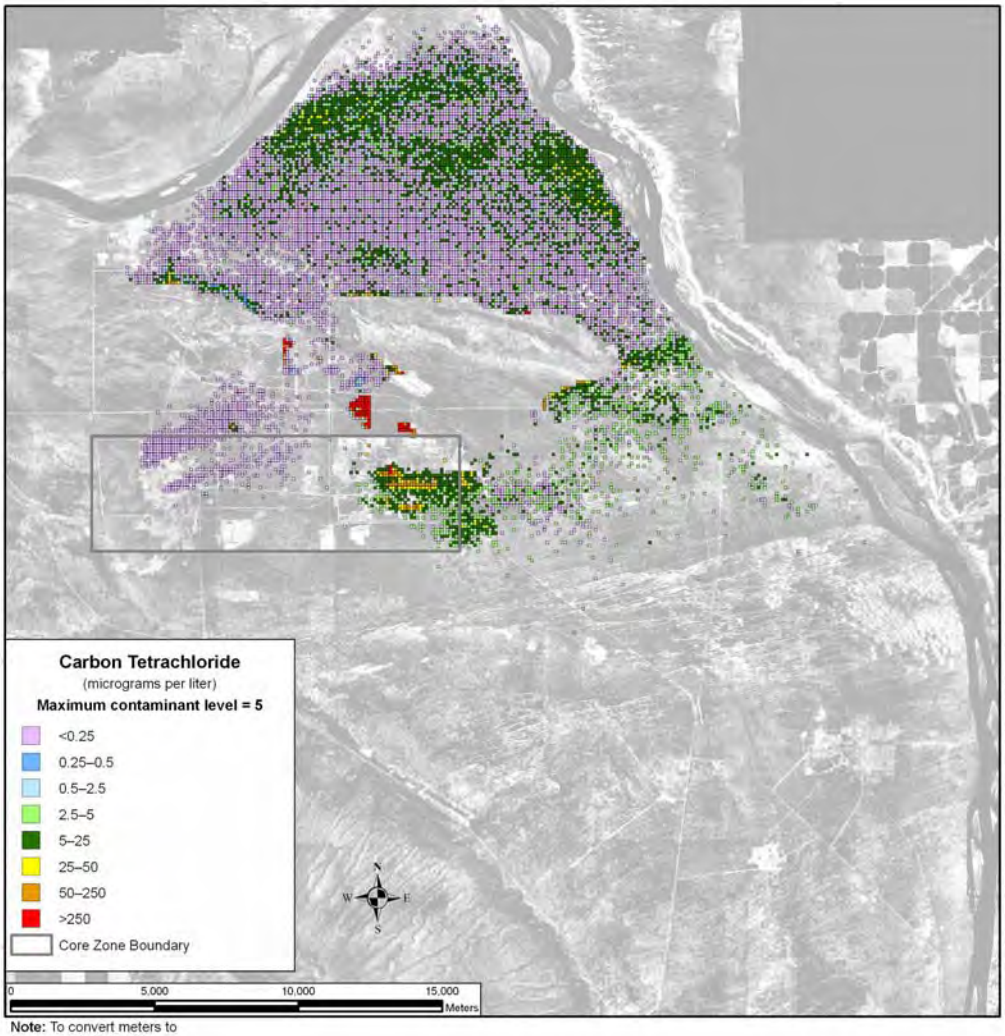


Figure 6–26. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 6–27. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 3890

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the porewater velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 6–28 shows the distribution of uranium-238 during CY 2135. There are two plumes associated with releases from the ponds (non-*TC & WM EIS* sources) in the 200-East and 200-West Areas with peak concentrations that exceed the benchmark by an order of magnitude. By CY 3890 (see Figure 6–29) these plumes have dissipated, but releases from other tank farm sources (primarily within the A Barrier) have produced a second plume east of the Core Zone, with peak concentrations about an order of magnitude greater than the benchmark. At CY 11,885 (see Figure 6–30) the plumes from other tank farm sources have extended this plume and produced additional plumes in the 200-West Area. Figure 6–31 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest early in the analysis (non-*TC & WM EIS* sources, primarily ponds) with an upward trend toward the end of the period of analysis (other tank farm sources). Figures 6–32 through 6–34 show the corresponding spatial distributions for total uranium.

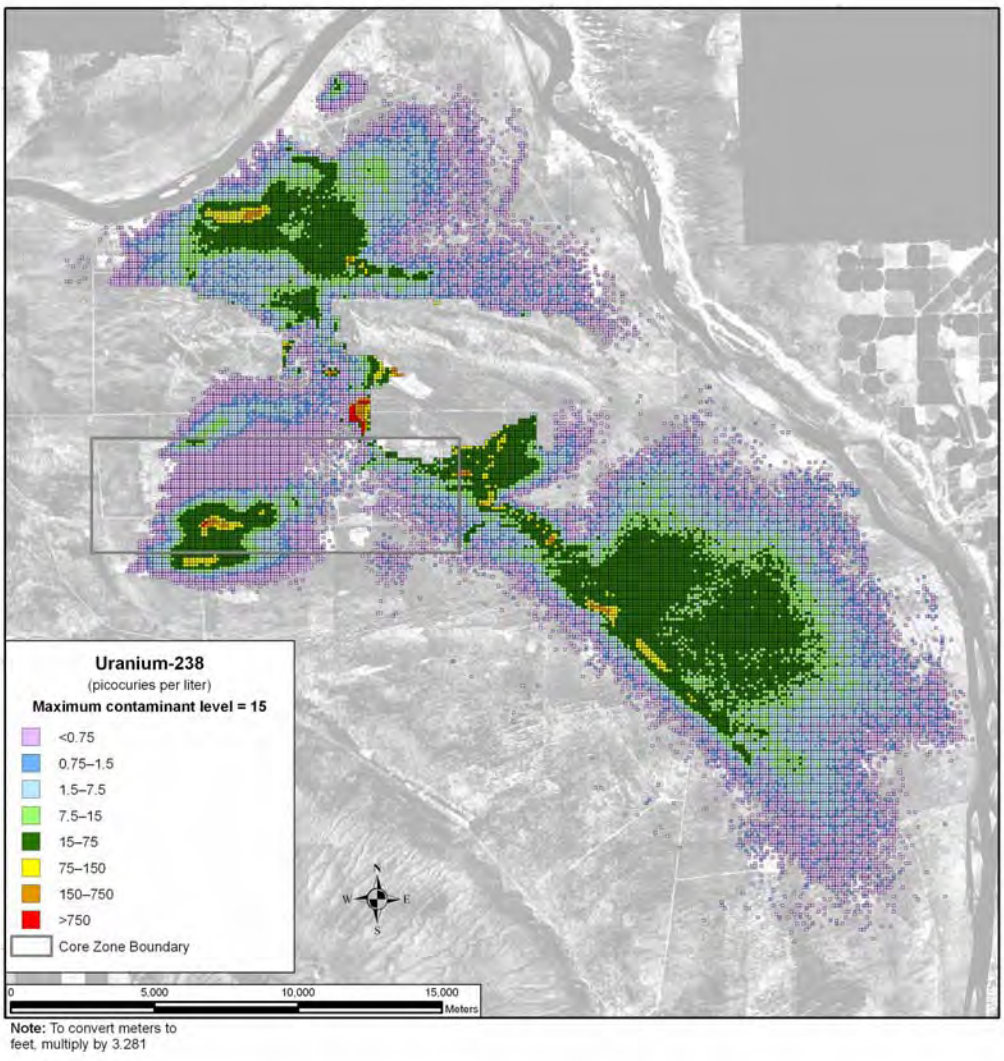


Figure 6–28. Alternative Combination/Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 2135

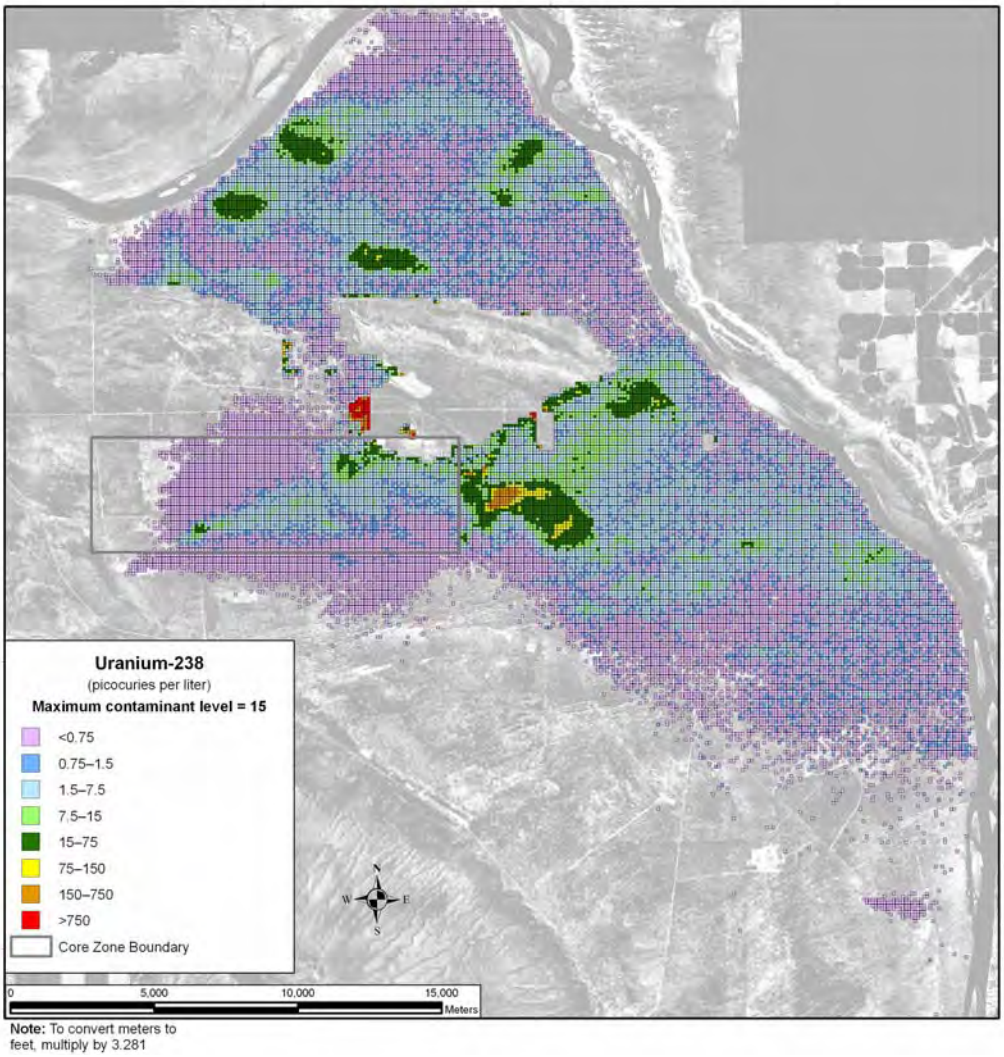


Figure 6–29. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 3890

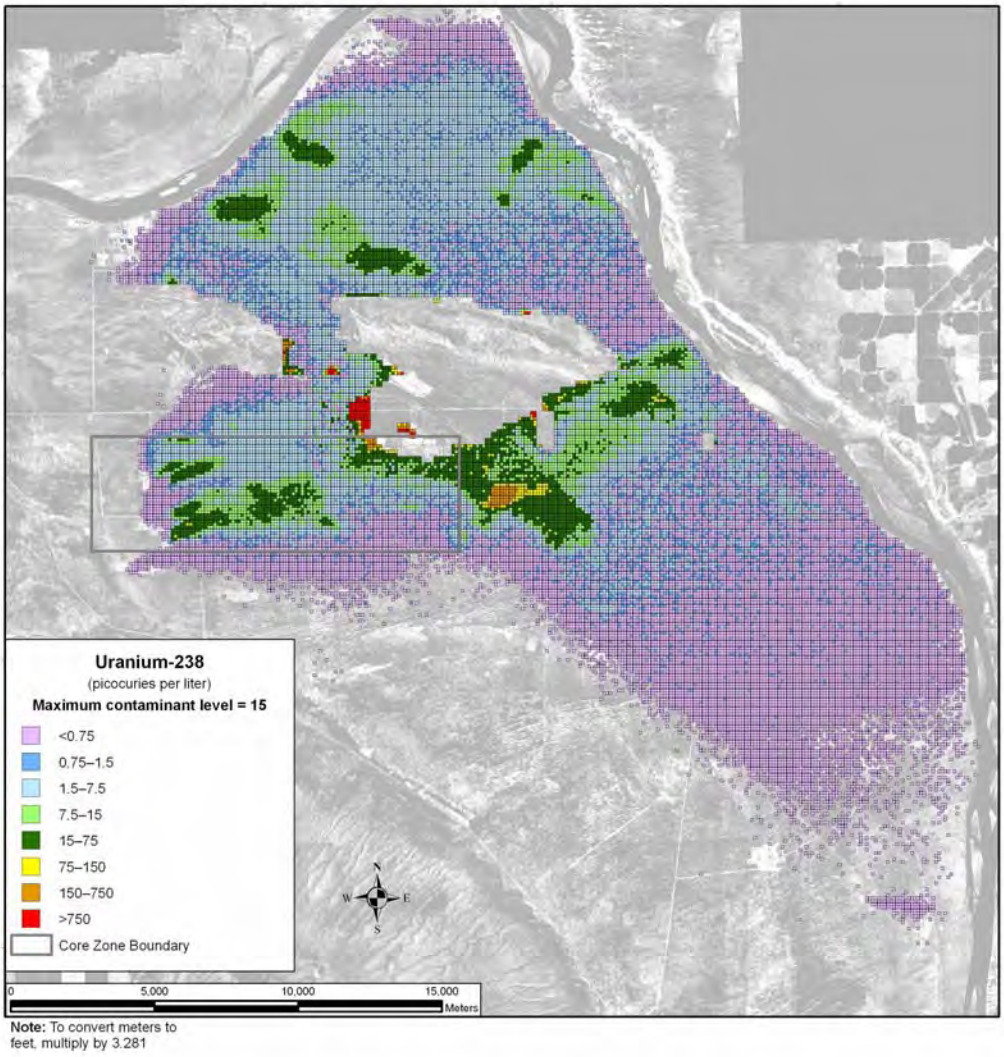


Figure 6–30. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 11,885

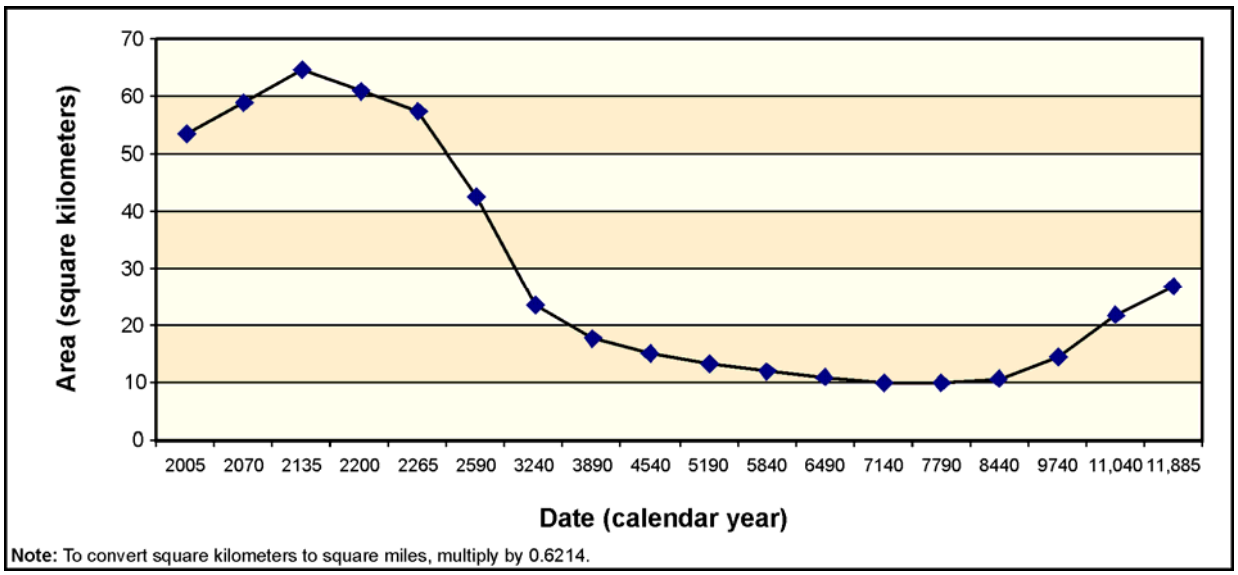


Figure 6–31. Alternative Combination 1 Total Area for Which Cumulative Groundwater Concentrations of Uranium-238 Exceed the Benchmark Concentration as a Function of Time

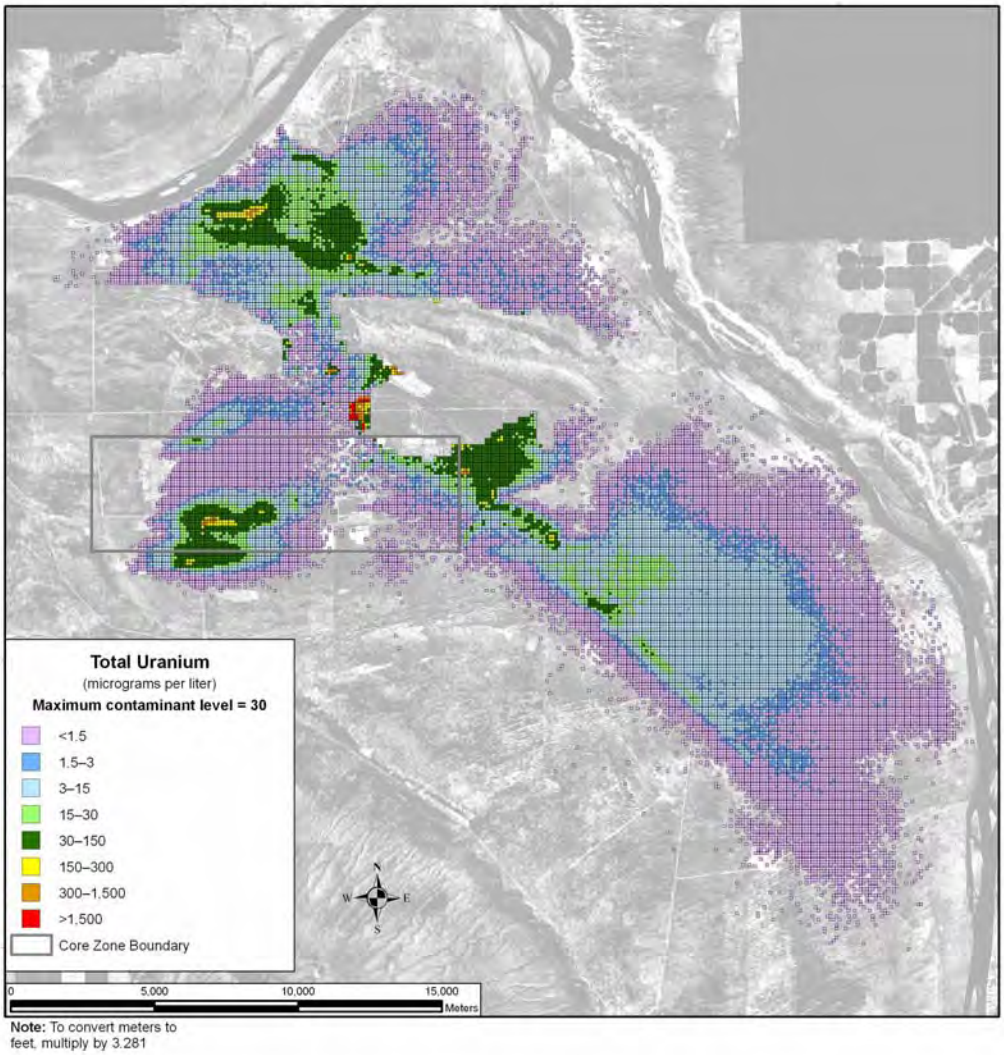


Figure 6–32. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 2135

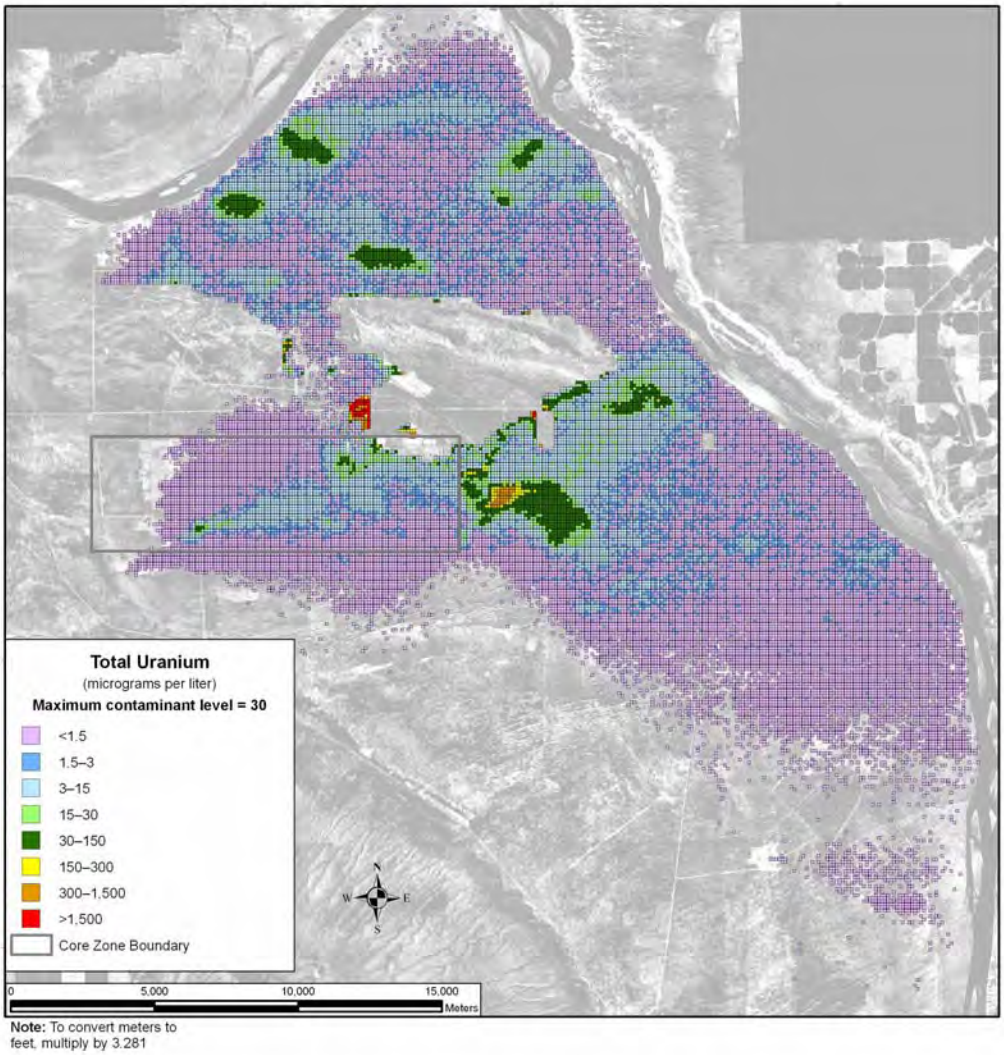


Figure 6–33. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 3890

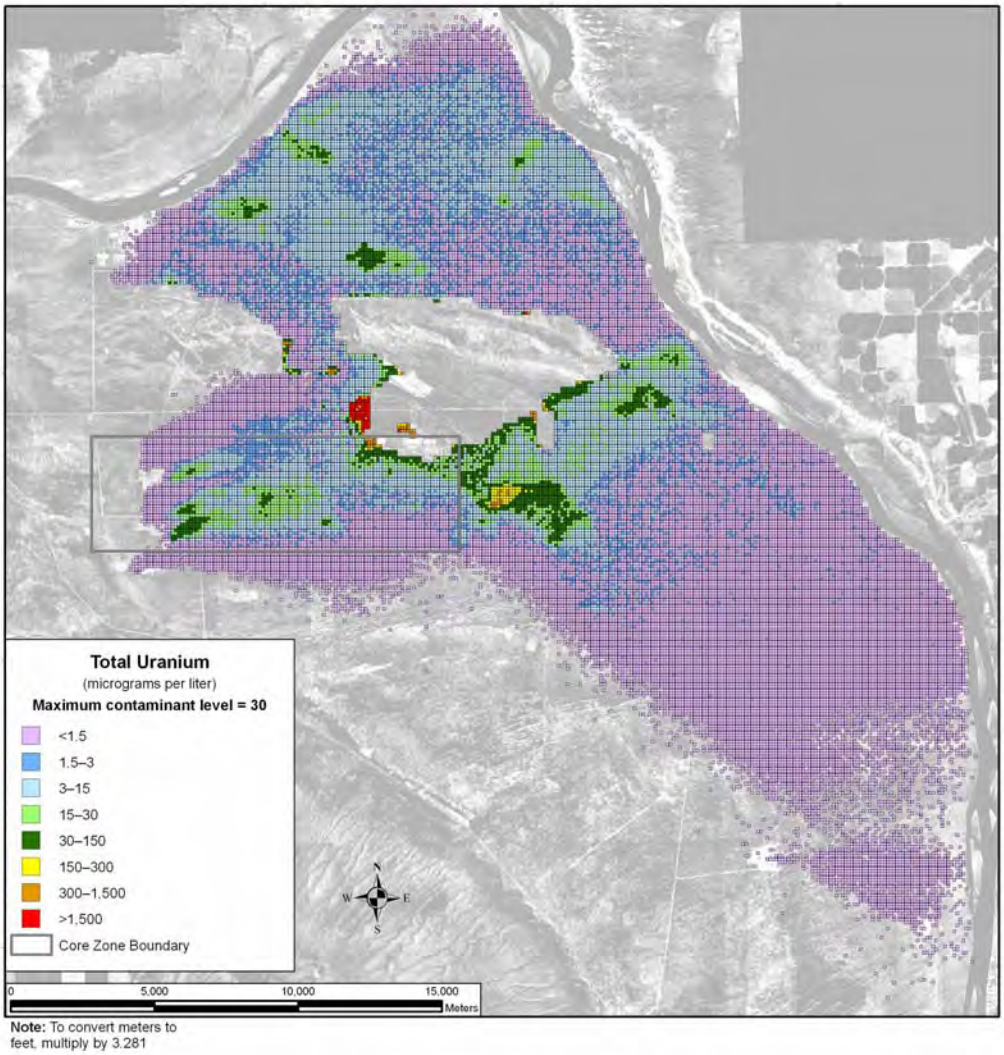


Figure 6–34. Alternative Combination 1 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 11,885

6.4.1.1.4 Summary of Impacts

The long-term cumulative impacts including Alternative Combination 1 are dominated by sources in Tank Farm Alternative 1 (technetium-99), non-*TC & WM EIS* sources (tritium and carbon tetrachloride), or a combination of both (iodine-129, uranium-238, chromium, nitrate, and total uranium). Contributions from Waste Management Alternative 1 sources and FFTF Decommissioning Alternative 1 sources account for well under 1 percent of the total amount released to the environment.

For iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate, concentrations at the Core Zone Boundary exceed benchmark standards by two to three orders of magnitude during most of the period of analysis. Concentrations at the Columbia River are about two orders of magnitude smaller. The intensities and areas of these groundwater plumes peak between CY 3200 and CY 4000.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River exceed the benchmark by about two orders of magnitude during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts by tritium. After CY 2100 tritium impacts are essentially negligible.

For uranium-238 and total uranium, discharges from ponds (non-*TC & WM EIS* sources) are the dominant contributors during the early period of the analysis. Other tank farm sources are a secondary contributor, for which limited mobility is an important factor governing the timeframes and scale of groundwater impacts.

6.4.1.2 Alternative Combination 2

This section presents the results of the cumulative long-term groundwater impacts analysis including Alternative Combination 2. This section focuses on the cumulative long-term groundwater impacts of these Alternative Combination 2 and non-*TC & WM EIS* sources, which are discussed in Chapter 5, Section 5.4. All of the non-*TC & WM EIS* sources discussed in Appendix S are included.

This discussion of long-term impacts is focused on the following COPC drivers:

- radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- chemical hazard drivers: carbon tetrachloride, chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose Alternative Combination 2 and the COPC drivers for the non-*TC & WM EIS* sources. They fall into three categories. Iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. Tritium is also mobile, but short lived. The half-life of tritium is about 12.3 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors. The level of protection provided for the drinking water pathway was evaluated by comparison against the maximum contaminant levels provided in 40 CFR 141 and other benchmarks presented in Appendix O.

6.4.1.2.1 Analysis of Release and Mass Balance

This section presents the total amount of the COPC drivers released to the vadose zone, to groundwater, and to the Columbia River. Releases of radionuclides are totaled in curies, and releases of chemicals are totaled in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 6–15 lists the release to the vadose zone for the COPC drivers. For Alternative Combination 2, the release to the vadose zone is controlled by a combination of inventory and waste form. For tank closure and FFTF decommissioning sources, the entire inventory was released to the vadose zone during the period of analysis. For some waste management sources (e.g., ILAW glass), some of the inventory was not released to the vadose zone during the 10,000-year period of analysis because of retention in the waste form. The release to the vadose zone for Alternative Combination 2 and non-*TC & WM EIS* sources is dominated by non-*TC & WM EIS* sources for tritium, uranium-238, chromium, and total uranium; by non-*TC & WM EIS* and waste management sources for iodine-129; by non-*TC & WM EIS* sources and tank closure sources for nitrate; and a combination of all three types of sources for technetium-99.

Table 6–15. Alternative Combination 2 Release to Vadose Zone for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other activities	3.43×10^{6}	2.49×10^{1}	7.33×10^{2}	3.13×10^{3}	3.35×10^{5}	7.38×10^{7}	2.53×10^{5}
Tank Closure Alternative 2B Base	4.60×10^{4}	1.51	8.67×10^{2}	4.54×10^{1}	1.00×10^{5}	2.70×10^{7}	4.13×10^{4}
FFTF Decommissioning Alternative 2	1.73×10^{-5}	0	2.72×10^{1}	0	0	0	0
Waste Management Alternative 2 Disposal Group 1-A	6.27×10^{4}	1.80×10^{1}	2.39×10^{3}	3.17×10^{2}	2.97×10^{3}	9.05×10^{6}	2.65×10^{3}
Total	3.54×10^{6}	4.43×10^{1}	4.02×10^{3}	3.49×10^{3}	4.38×10^{5}	1.10×10^{8}	2.97×10^{5}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

Table 6–16 lists the release to groundwater for the COPC drivers. In addition to the inventory consideration discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, the amount released to groundwater is attenuated by radioactive decay during transit through the vadose zone. About 60 percent of the tritium released to the vadose zone reaches the unconfined aquifer. Because of retardation, less than 40 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 6–17 lists the release to the Columbia River for the COPC drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers in the unconfined aquifer. For iodine-129, technetium-99, chromium, and nitrate, the amount released to Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 5 percent of the tritium released to groundwater reaches the Columbia River. Because of retardation, about 90 percent of the uranium-238 and total uranium released to groundwater during the period of analysis reaches the Columbia River.

Table 6–16. Alternative Combination 2 Release to Groundwater for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other activities	2.06×10^{6}	2.48×10^{1}	7.12×10^{2}	1.48×10^{2}	3.40×10^{5}	7.42×10^{7}	1.05×10^{5}
Tank Closure Alternative 2B Base	3.23×10^{4}	1.51	8.61×10^{2}	2.91	1.04×10^{5}	2.80×10^{7}	2.96×10^{3}
FFTF Decommissioning Alternative 2	2.58×10^{-8}	0	2.62×10^{1}	0	0	0	0
Waste Management Alternative 2 Disposal Group 1-A	0	1.64×10^{1}	2.10×10^{3}	3.02×10^{-10}	2.89×10^{3}	9.03×10^{6}	5.14×10^{-5}
Total	2.09×10^{6}	4.26×10^{1}	3.70×10^{3}	1.51×10^{2}	4.46×10^{5}	1.11×10^{8}	1.08×10^{5}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.
Note: To convert kilograms to pounds, multiply by 2.2046.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

Table 6–17. Alternative Combination 2 Release to Columbia River for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other activities	1.11×10^{5}	2.46×10^{1}	7.26×10^{2}	1.40×10^{2}	3.51×10^{5}	7.47×10^{7}	9.28×10^{4}
Tank Closure Alternative 2B Base	8.70×10^{2}	1.45	8.37×10^{2}	8.46×10^{-1}	1.03×10^{5}	2.78×10^{7}	8.54×10^{2}
FFTF Decommissioning Alternative 2	0	0	2.72×10^{1}	0	0	0	0
Waste Management Alternative 2 Disposal Group 1-A	0	1.59×10^{1}	2.04×10^{3}	0	2.80×10^{3}	8.89×10^{6}	3.77×10^{-6}
Total	1.12×10^{5}	4.20×10^{1}	3.62×10^{3}	1.41×10^{2}	4.57×10^{5}	1.11×10^{8}	9.37×10^{4}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.
Note: To convert kilograms to pounds, multiply by 2.2046.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

6.4.1.2.2 Analysis of Concentration Versus Time

This section presents groundwater concentrations versus time at the Core Zone Boundary and the Columbia River. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid in interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when: the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 6–18 lists the maximum concentrations for the COPCs at the peak year for the Core Zone Boundary and the Columbia River nearshore.

Table 6–18. Alternative Combination 2 Maximum Concentrations for COPCs[a]

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration[b]
Radionuclide (picocuries per liter)			
Hydrogen-3 (Tritium)	104,000,000 (1996)	4,190,000 (1986)	20,000
Carbon-14	46,700 (1998)	196 (2013)	2,000
Strontium-90	181,000 (1998)	4,160,000 (1991)	8
Technetium-99	144,000 (1956)	2,870 (1999)	900
Iodine-129	190 (1956)	9.4 (4540)	1
Cesium-137	0[c] (1997)	1,310,000 (1985)	200
Uranium isotopes (includes U-233, -234, -235, -238)	2,200 (1991)	22,400 (1973)	15
Neptunium-237	114 (2066)	16 (2004)	15
Plutonium isotopes (includes Pu-239, -240)	2,660 (11,848)	4,250 (2983)	15
Chemical (microgram per liter)			
1-Butanol	17,200 (1998)	49 (11,243)	3,600
Acetonitrile	1 (3829)	0 (4021)	100
Carbon tetrachloride	3,350 (2270)	60.7 (2527)	5
Chromium[d]	28,800 (1956)	16,100 (1978)	100
Dichloromethane	0.7 (3286)	0.1 (4711)	5
Fluoride	90,200 (2003)	14,500 (1982)	4,000
Hydrazine/Hydrazine Sulfate	0.030 (3343)	0.088 (3627)	0.022
Lead	0[c] (2021)	9,080 (2374)	15
Manganese	392 (8610)	242 (2286)	1,600
Mercury	183 (2015)	25.5 (1997)	2
Nickel (soluble salts)	0[c] (11,871)	8,310 (3877)	700
Nitrate	13,100,000 (1956)	505,000 (1973)	45,000
Total Uranium	3,290 (1991)	15,400 (1964)	30
Trichloroethylene (TCE)	0.1 (3404)	0.2 (3764)	5

[a] The peak cumulative concentration for some constituents occurs in the past. The relationship of past to future cumulative constituent concentrations is presented in the time versus concentration plots in Figures 6–35 through 6–42.

[b] The sources of the benchmark concentrations are provided in Appendix O, Section O.3.

[c] Values that are less than 0.001 are reported as zero.

[d] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert liters to gallons, multiply by 0.26417.

Key: COPC=constituent of potential concern.

Figure 6–35 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from 1940 through 2540 rather than the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about three orders of magnitude for a short period of time during the early part of the period of analysis. During this time groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude above the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

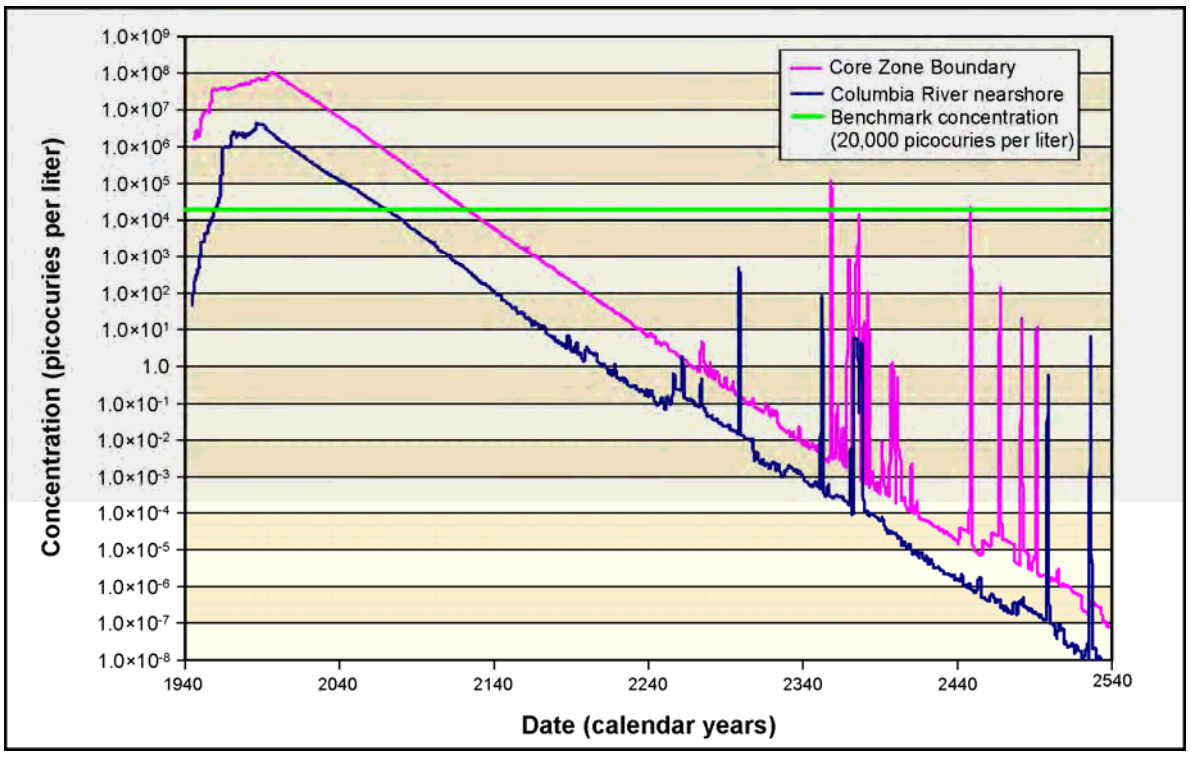


Figure 6–35. Alternative Combination 2 Cumulative Concentration Versus Time for Tritium

Figures 6–36 through 6–40 show concentration versus time for iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate (the conservative tracers). Groundwater concentrations of iodine-129 to exceed benchmark concentrations by more than an order of magnitude during the first several thousand years of the analysis. During this time groundwater concentrations at the Columbia River nearshore exceed the benchmark concentration by about an order of magnitude. During later times in the analysis the concentrations are on the same order of magnitude as the benchmark at the Core Zone Boundary and the Columbia River nearshore. Technetium-99, carbon tetrachloride, chromium, and nitrate concentrations show a similar curve, with technetium-99, chromium and nitrate concentrations at the Columbia River nearshore dropping below the benchmark concentrations.

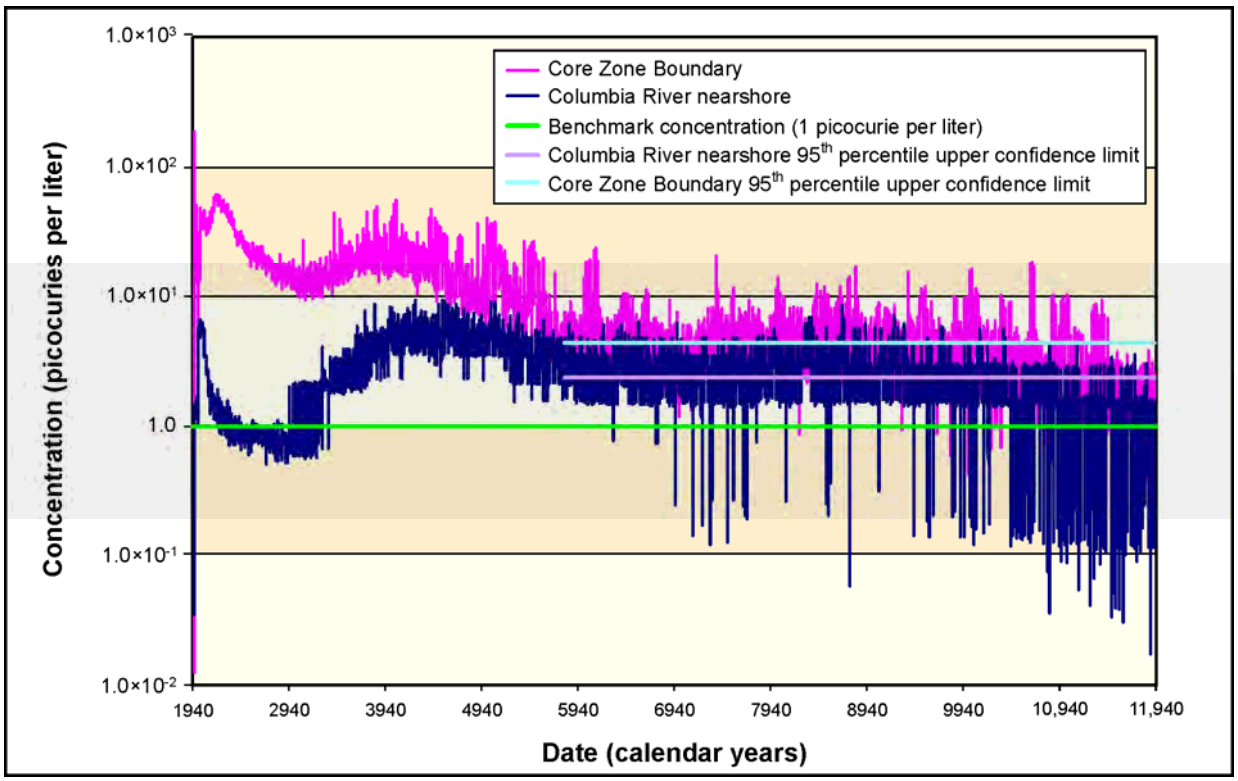


Figure 6–36. Alternative Combination 2 Cumulative Concentration Versus Time for Iodine-129

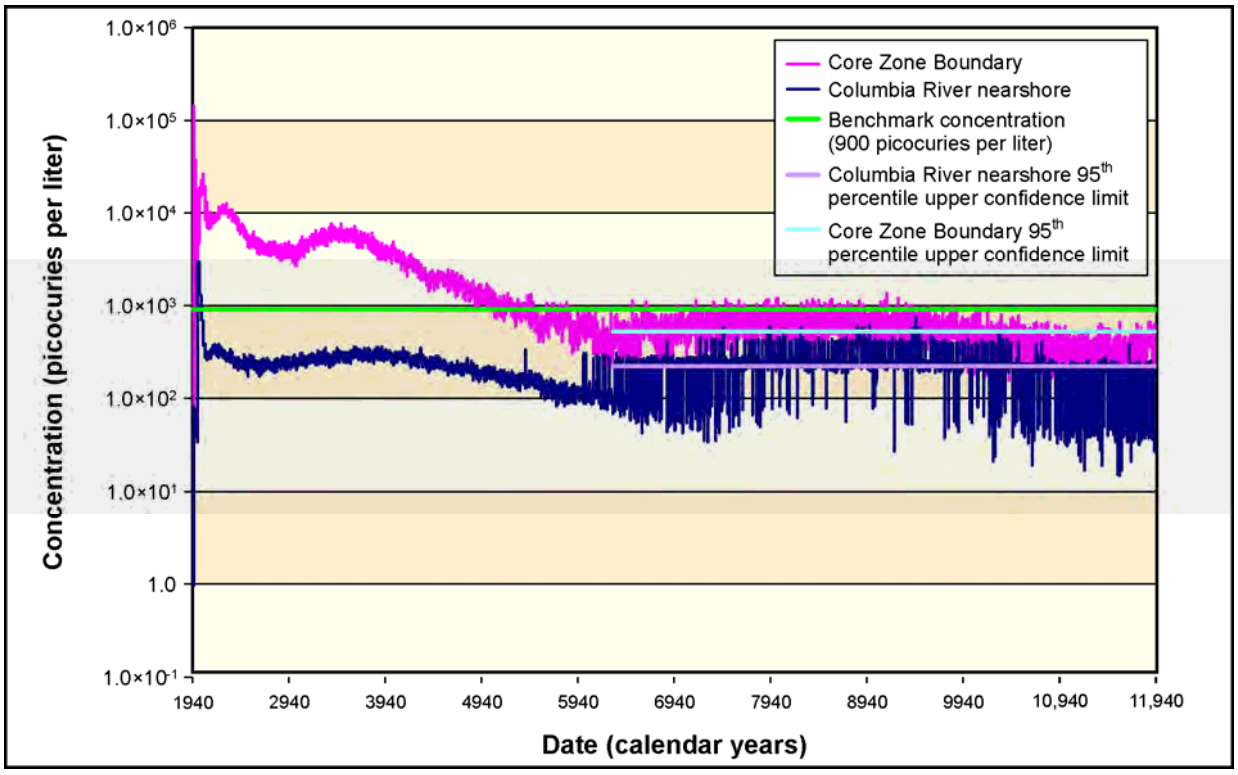


Figure 6–37. Alternative Combination 2 Cumulative Concentration Versus Time for Technetium-99

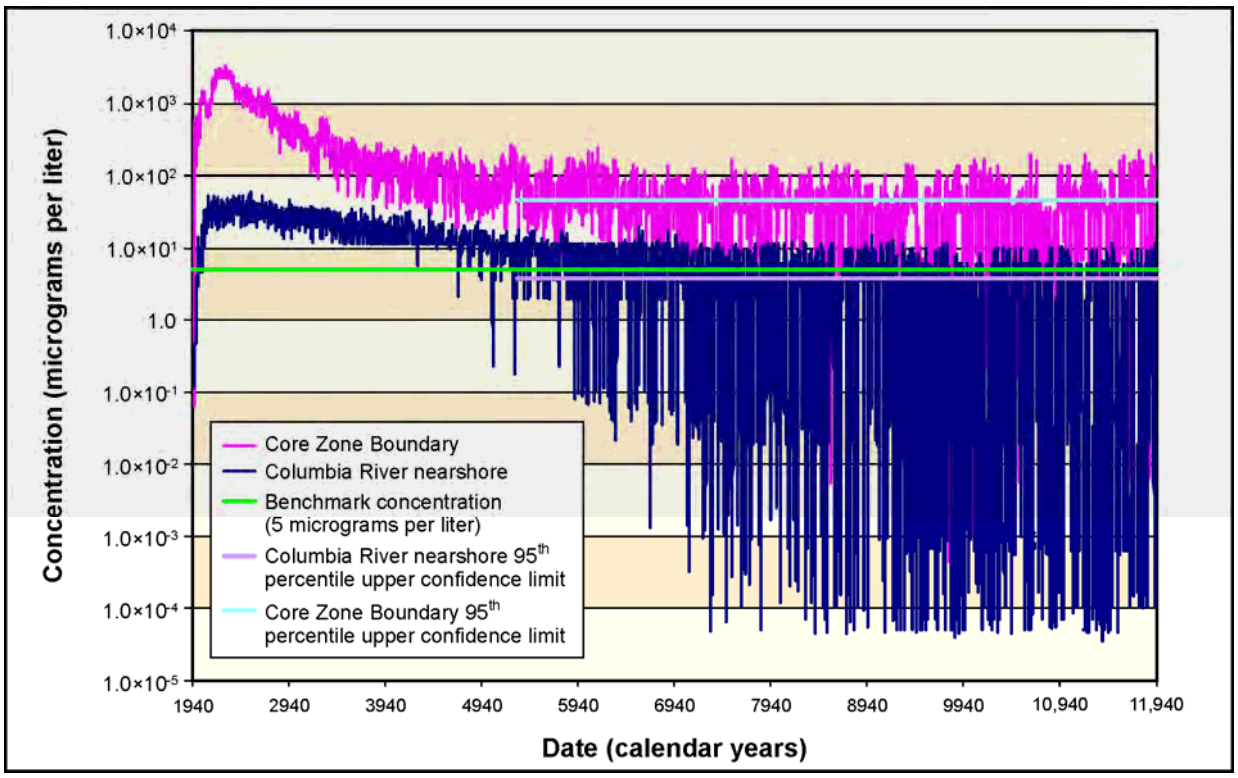


Figure 6–38. Alternative Combination 2 Cumulative Concentration Versus Time for Carbon Tetrachloride

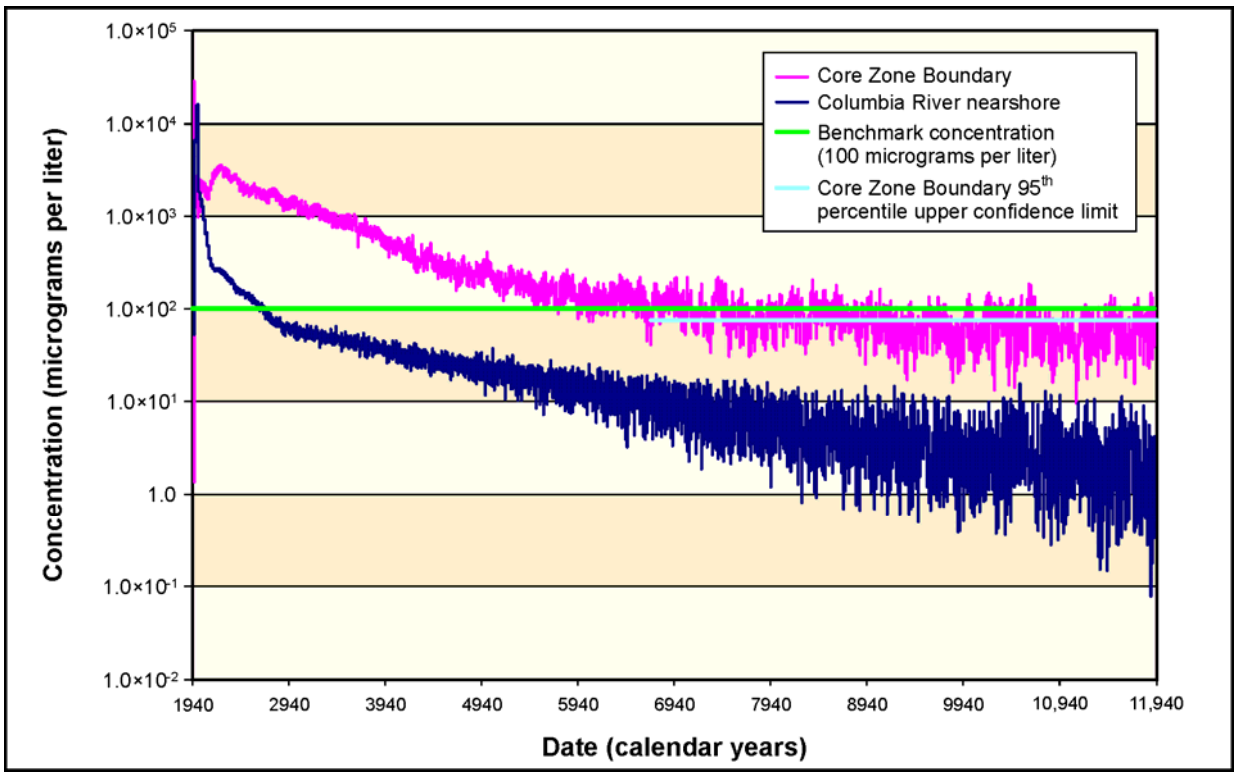


Figure 6–39. Alternative Combination 2 Cumulative Concentration Versus Time for Chromium

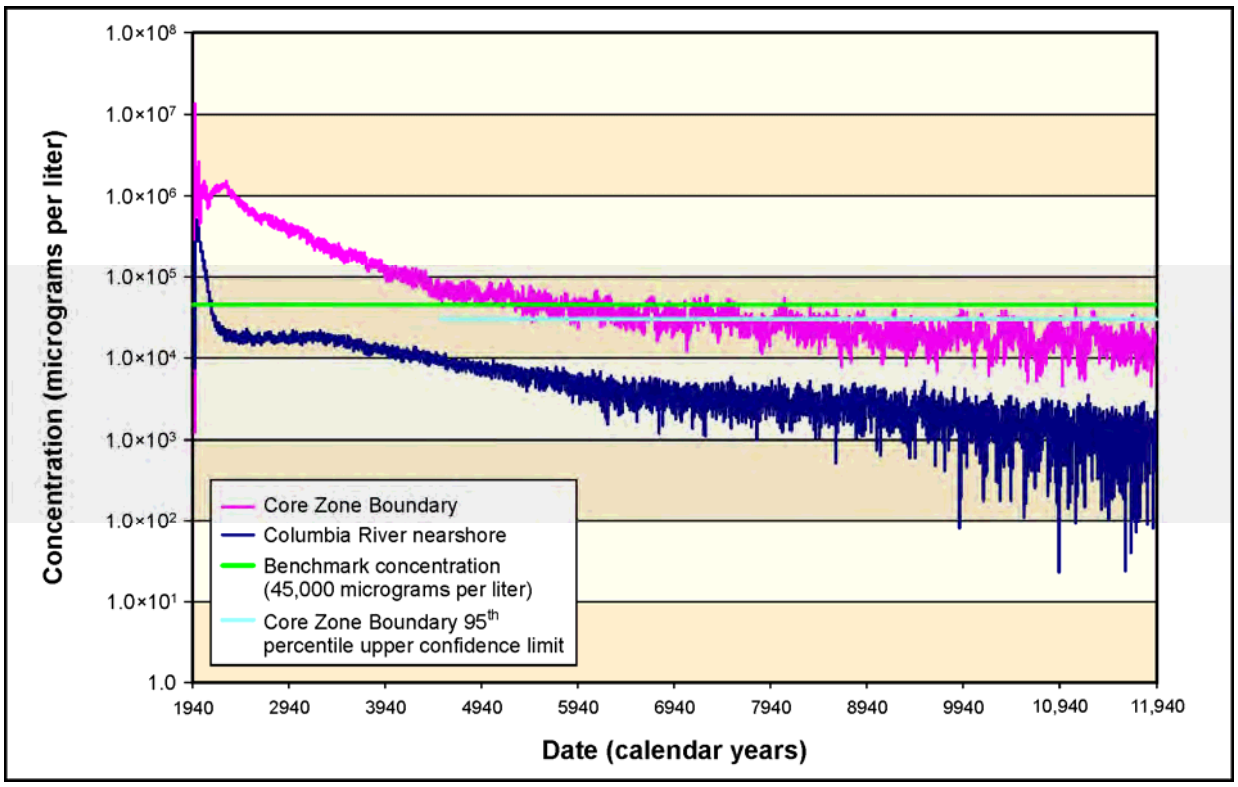


Figure 6–40. Alternative Combination 2 Cumulative Concentration Versus Time for Nitrate

Figures 6–41 and 6–42 show concentration versus time for uranium-238 and total uranium. Concentrations of uranium-238 and total uranium peak early in the period of analysis, and then maintain relatively constant for the remainder of the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and Columbia River is slowed relative to the groundwater flow by a factor of about seven. After about 1,000 years, concentrations of both uranium-238 and total uranium exceed the benchmark concentration at the Core Zone Boundary by about an order of magnitude. Groundwater concentrations at the Columbia River nearshore remain within an order of magnitude of the benchmark during this time.

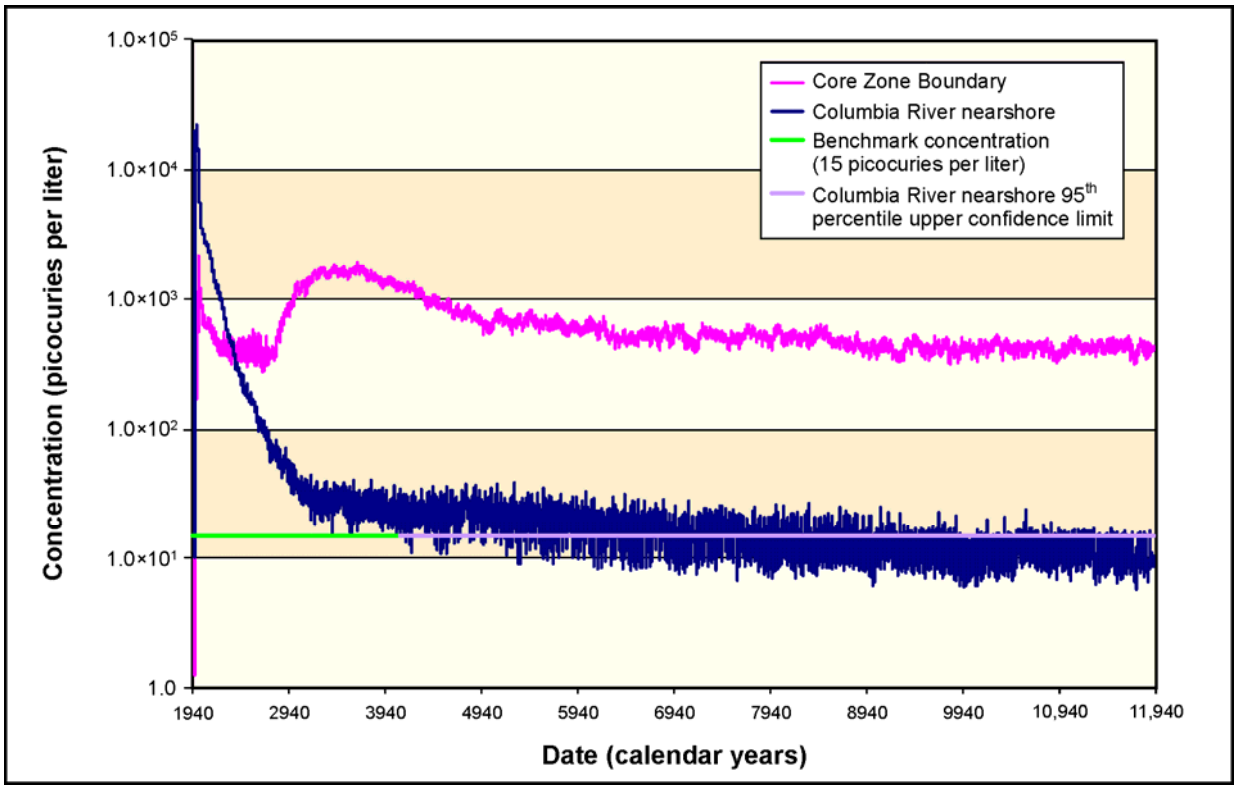


Figure 6–41. Alternative Combination 2 Cumulative Concentration Versus Time for Uranium-238

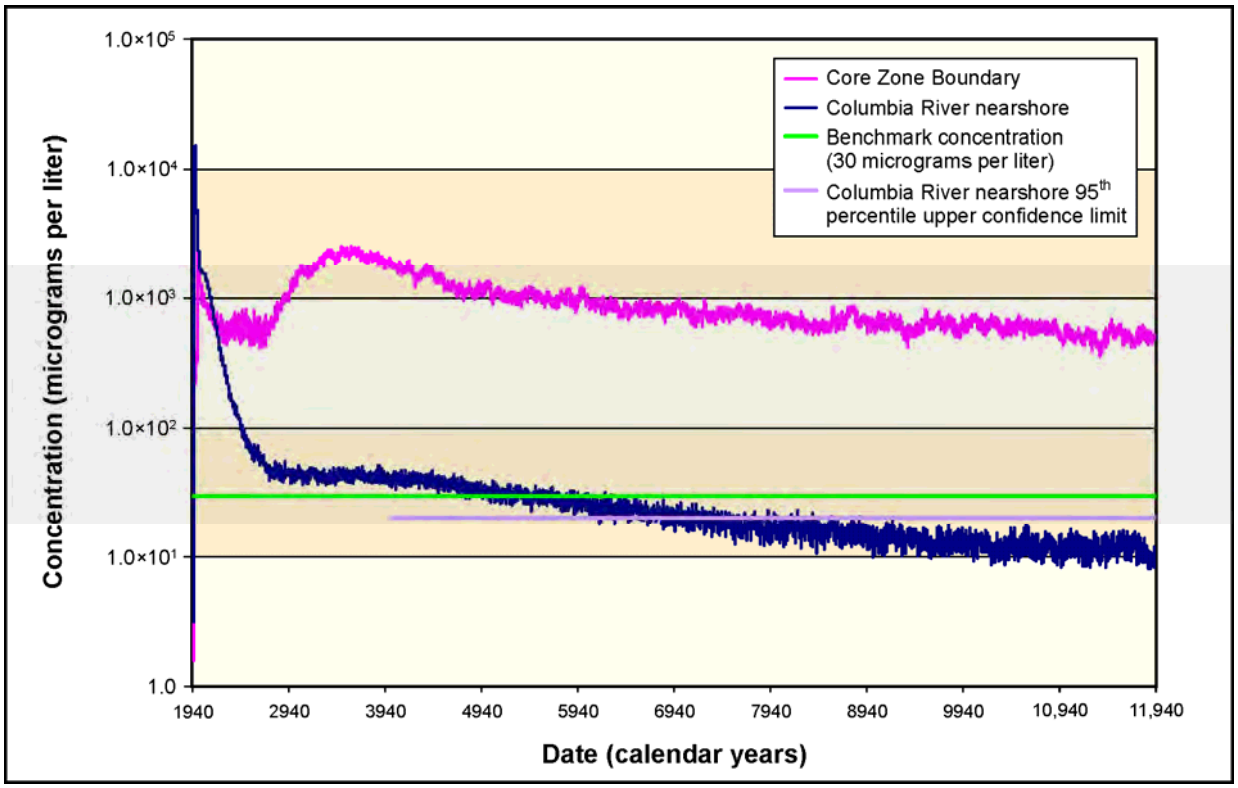


Figure 6–42. Alternative Combination 2 Cumulative Concentration Versus Time for Total Uranium

6.4.1.2.3 Analysis of Spatial Distribution of Concentration

This section the spatial distribution of contaminant concentrations in groundwater at selected times. Concentrations for each radionuclide and chemical are indicated by a color scale which is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentrations ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 6–43 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Releases from cribs and trenches (ditches), primarily associated with non-*TC & WM EIS* sources within the PUREX Plant and the REDOX Facility areas, result in groundwater concentration plumes (exceeding the benchmark concentration) that extend from the southern part of the 200-West Area across the Core Zone, and extending from the eastern part of the Core Zone southeast to the Columbia River. Peak concentrations in this plume are about ten to fifty times greater than the benchmark. Tritium concentrations are attenuated by radioactive decay to levels less than one twentieth of the benchmark concentration by CY 2135.

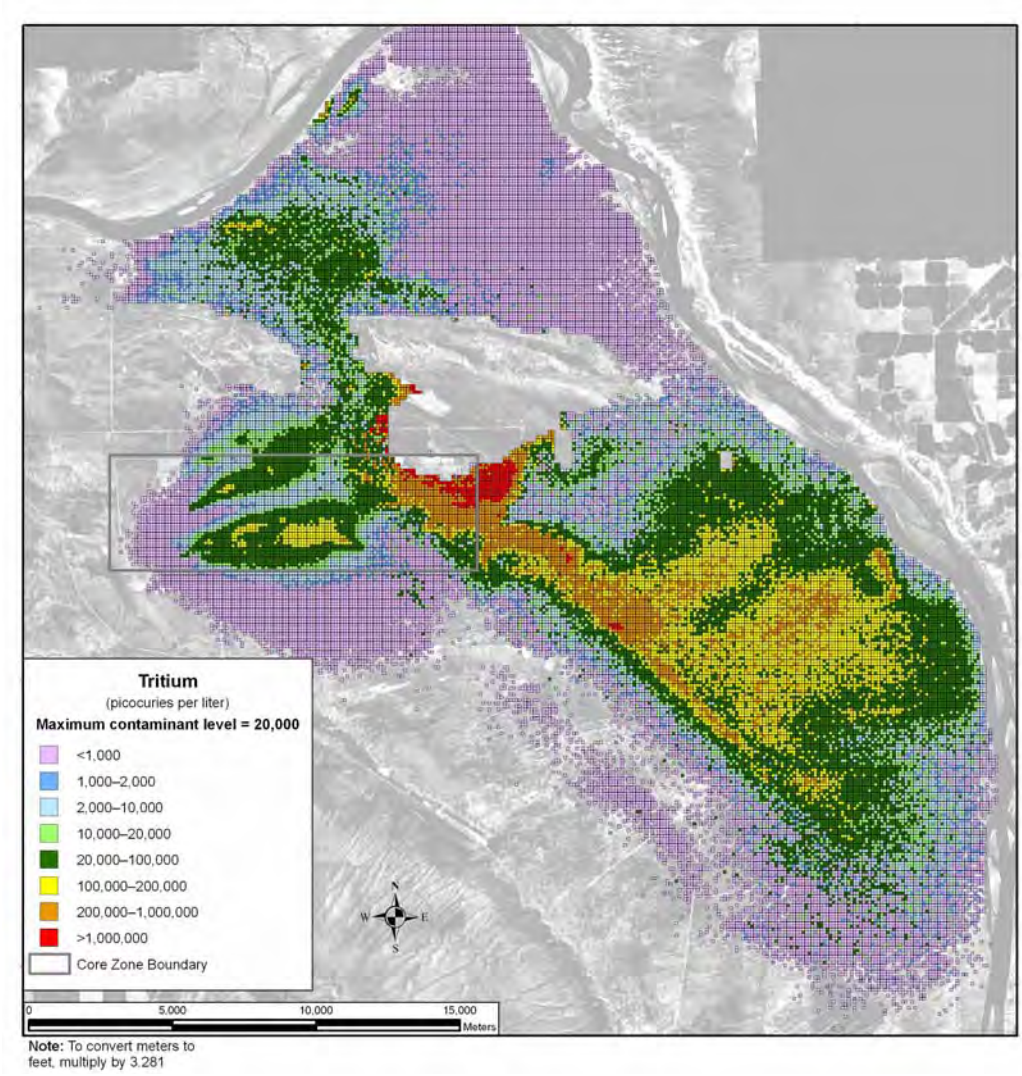


Figure 6–43. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Tritium During Calendar Year 2005

Figure 6–44 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceeding the benchmark concentration associated with the T Barrier, the B Barrier, and the A Barrier. Peak concentrations in this plume are about ten to fifty times greater than the benchmark, and mostly contained within the Core Zone. Releases from the PUREX Plant area (non-*TC & WM EIS* sources) produce a plume extending south and east of the Core Zone with peak concentrations about one to five times the benchmark concentration. Around CY 3890 releases from other tank farm sources create an iodine-129 plume extending east of the Core Zone Boundary (see Figure 6–45). By CY 7140 the groundwater concentration distribution is driven primarily by waste management sources located at the Integrated Disposal Facility (IDF) in the 200-East Area (see Figure 6–46). The impact is characterized by a plume exceeding the benchmark concentration by more than an order of magnitude that is located east of the Core Zone. Because of retention in the waste forms, this impact lasts to the end of the 10,000-year period of analysis (see Figure 6–47). Figure 6–48 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. After an early peak related to releases from the PUREX Plant area, the area of exceedance peaks between CY 3240 and CY 4540 driven primarily by releases from other tank farm sources. A secondary peak at later times

results from releases at IDF. Figures 6–49 through 6–53 show the spatial distribution at the same four times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 does not include contributions from the PUREX Plant sources (compare to iodine-129 distributions) and is dominated by releases from other tank farm sources and IDF. Chromium (see Figures 6–54 through 6–57) and nitrate (see Figures 6–58 through 6–61) show similar spatial distributions to technetium-99.

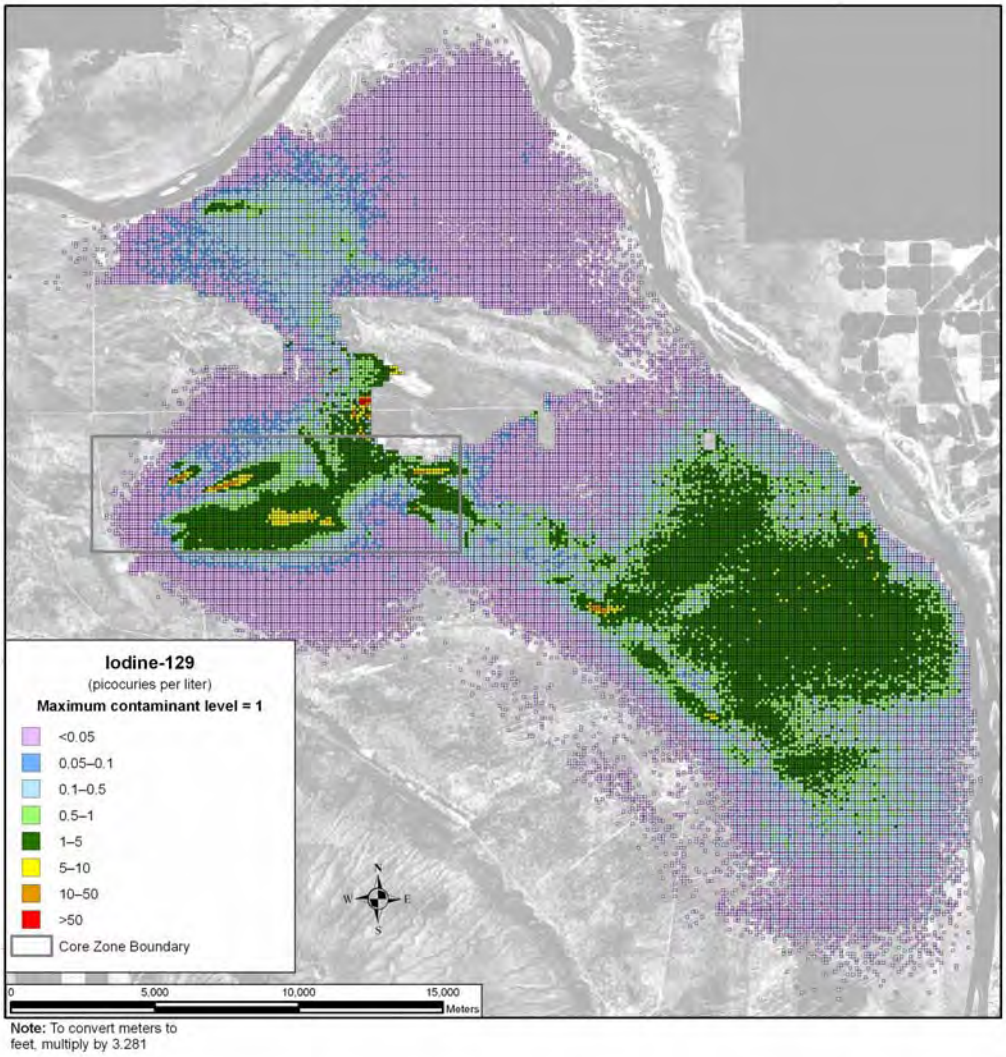


Figure 6–44. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 2005

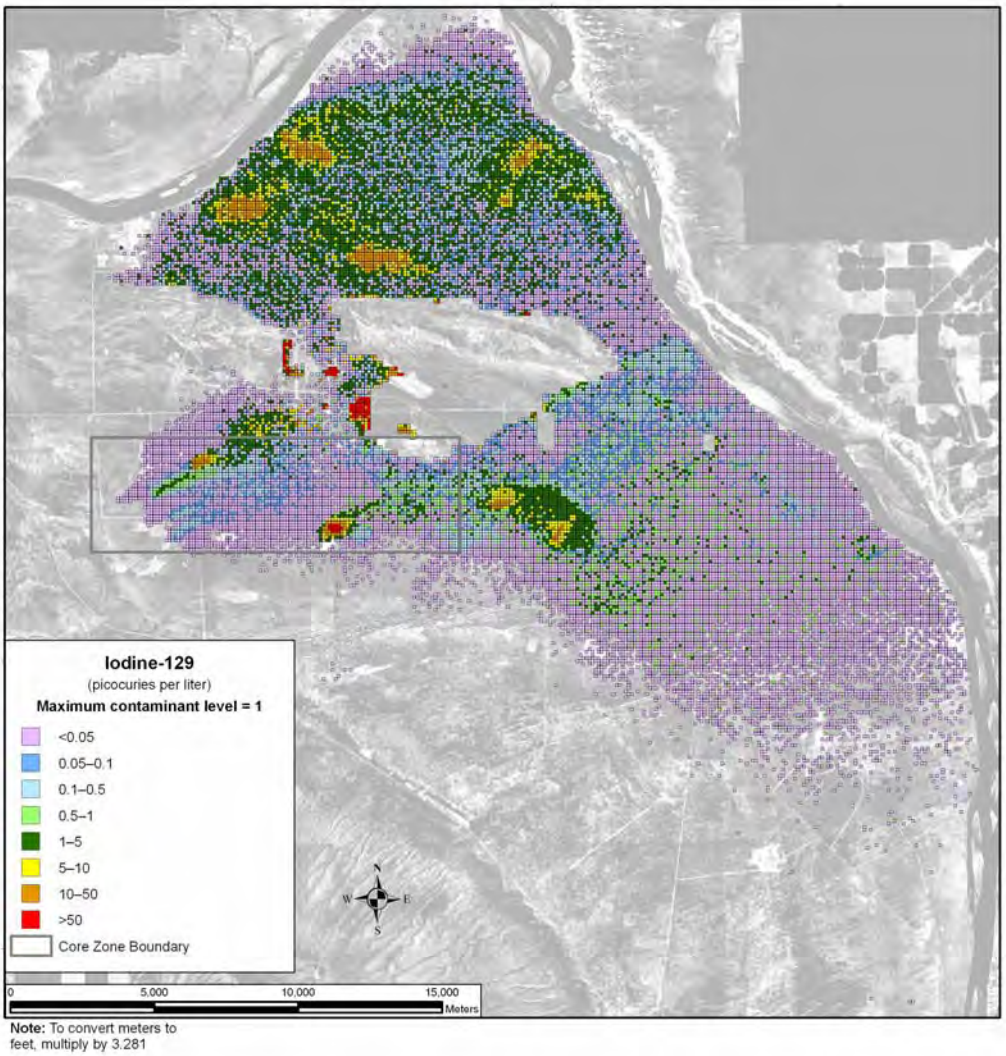


Figure 6–45. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 3890

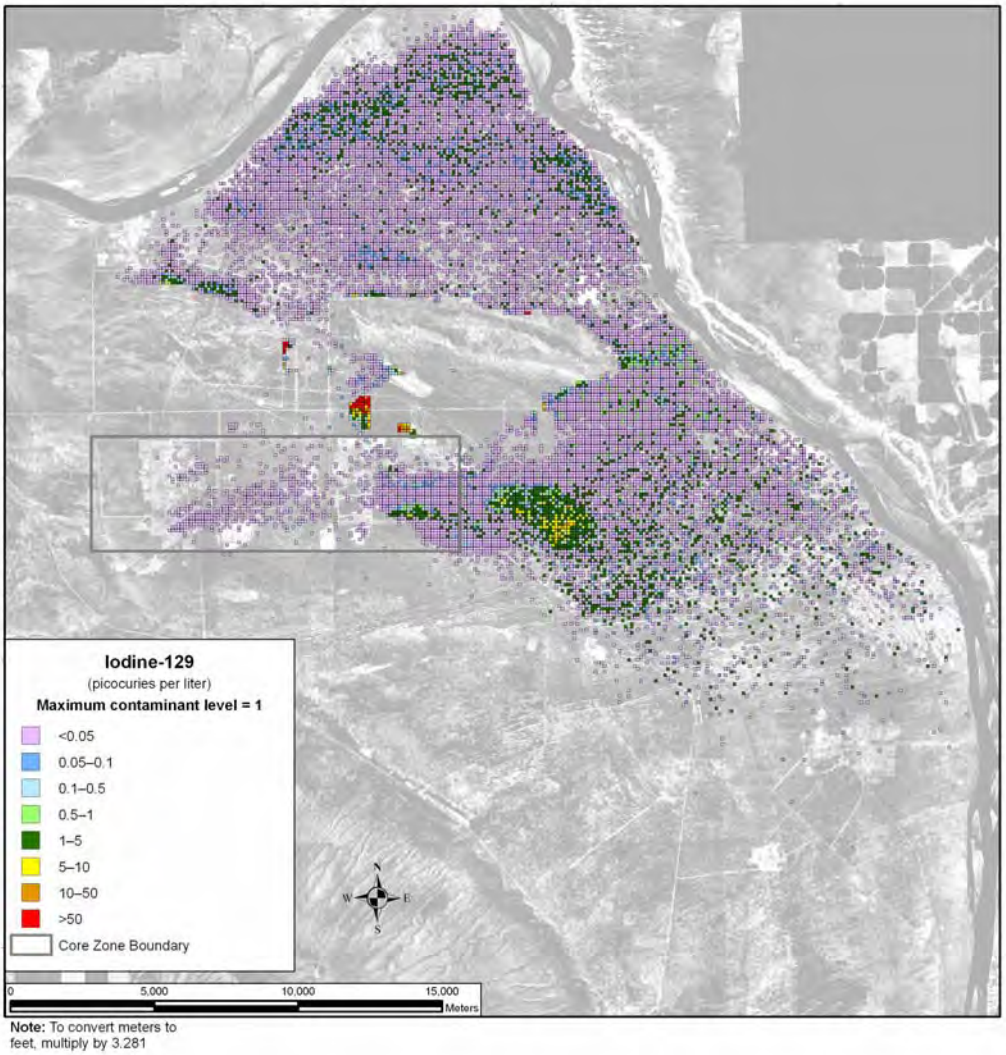


Figure 6–46. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 7140

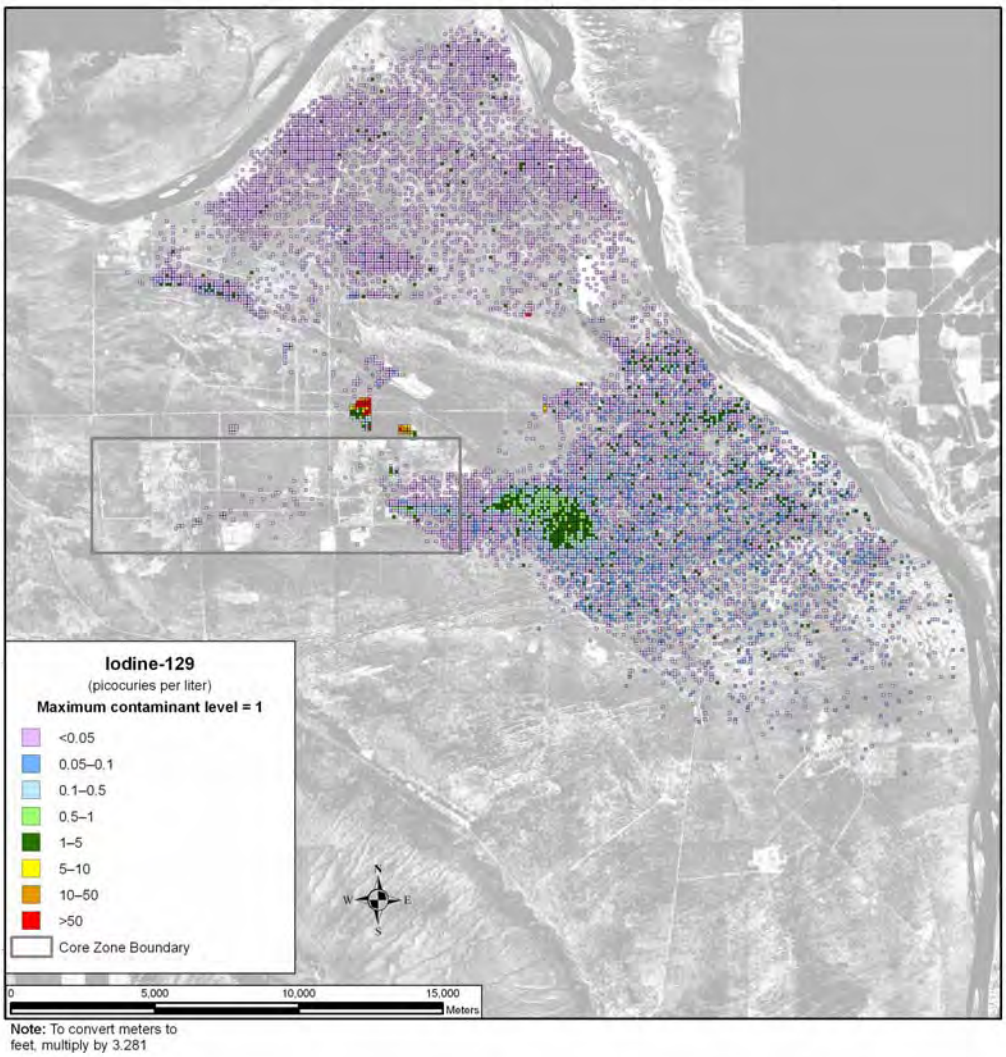


Figure 6–47. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 11,885

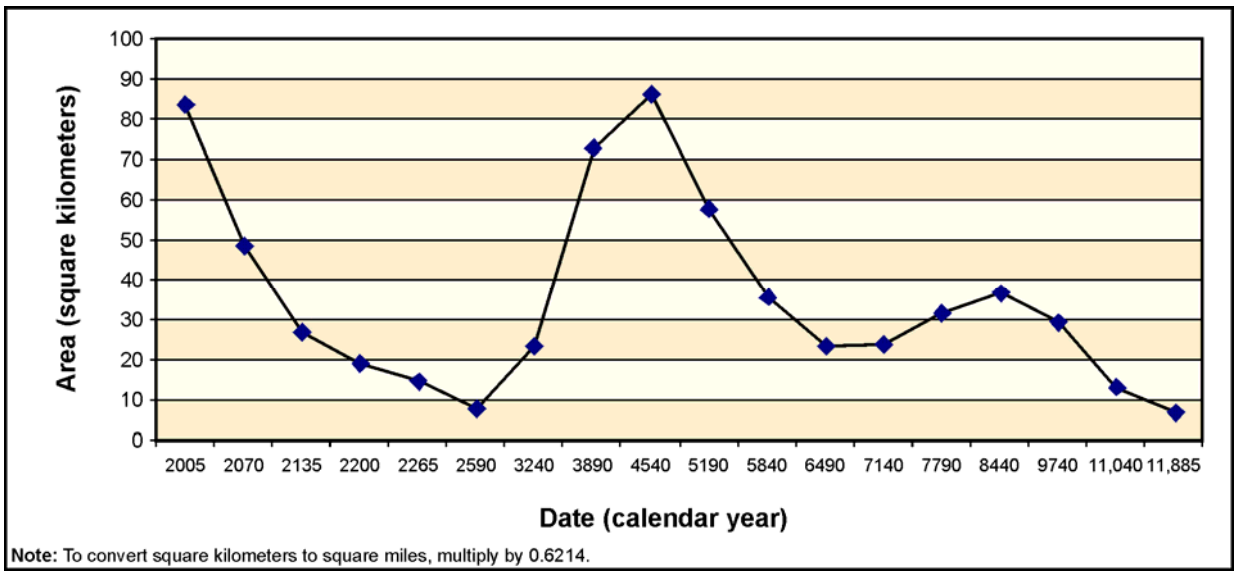


Figure 6–48. Alternative Combination 2 Total Area for Which Cumulative Groundwater Concentrations of Iodine-129 Exceed the Benchmark Concentration as a Function of Time

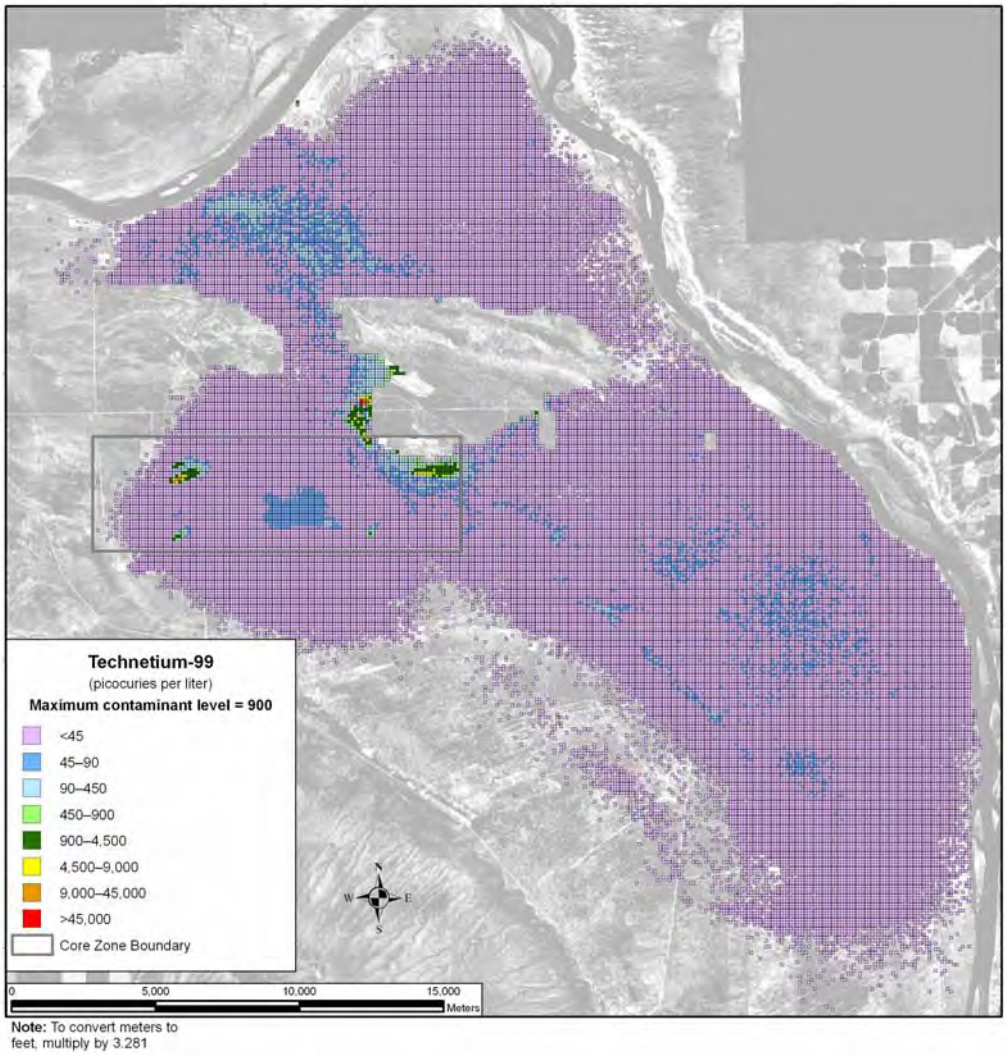


Figure 6–49. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 2005

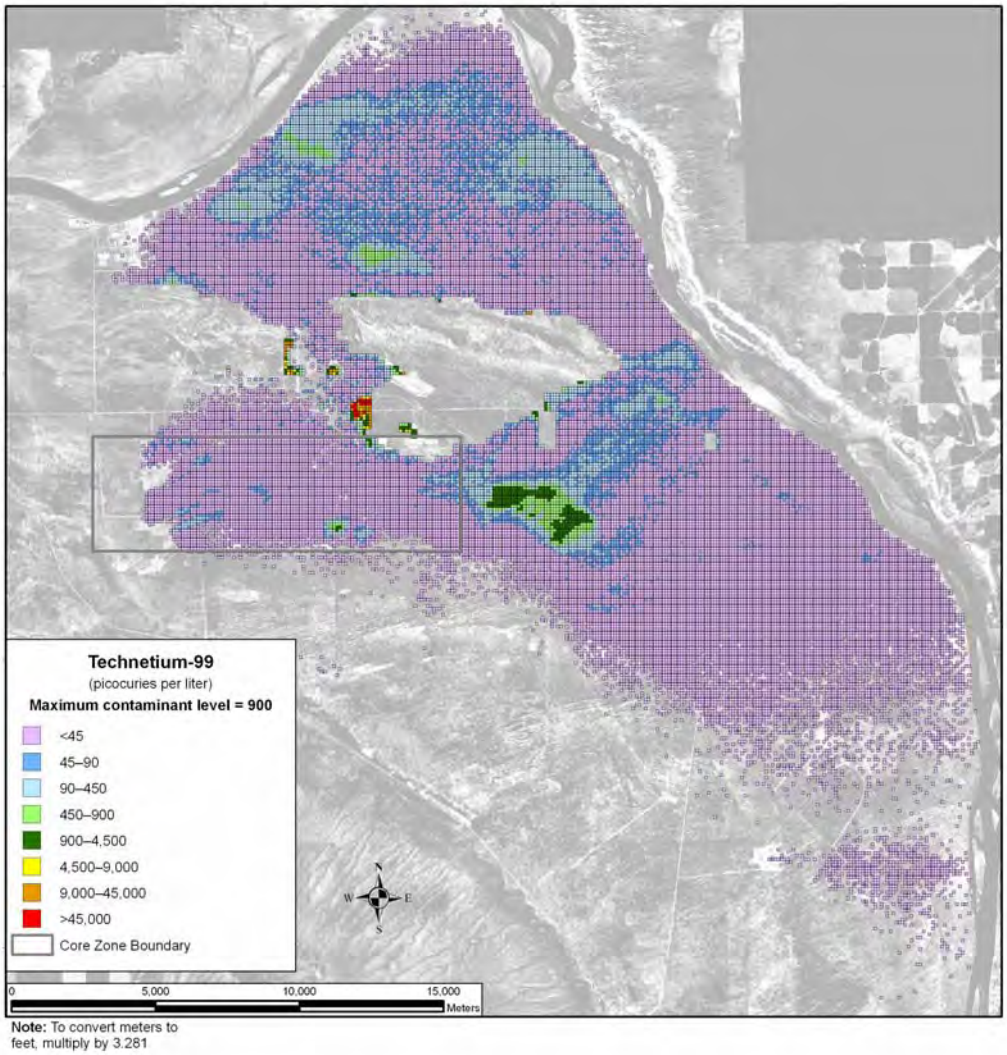


Figure 6–50. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 3890

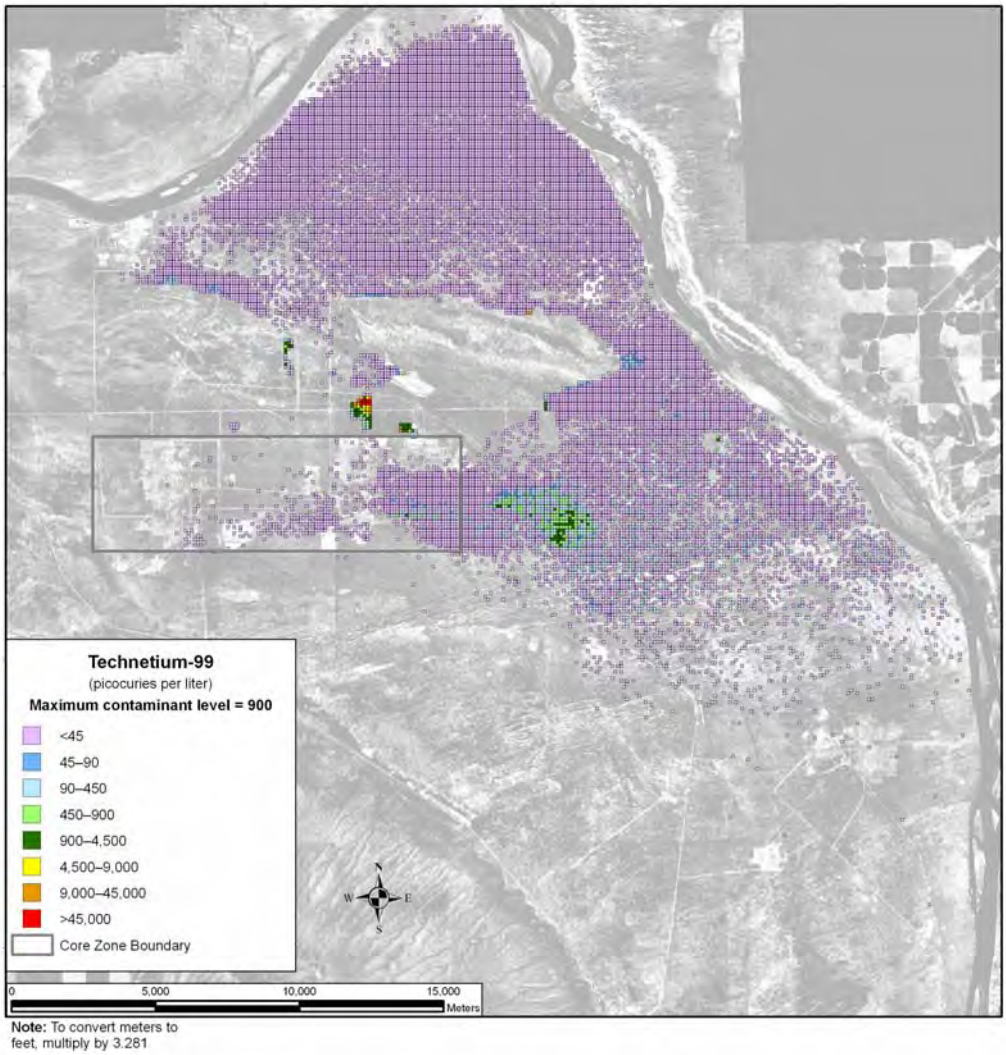


Figure 6–51. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 7140

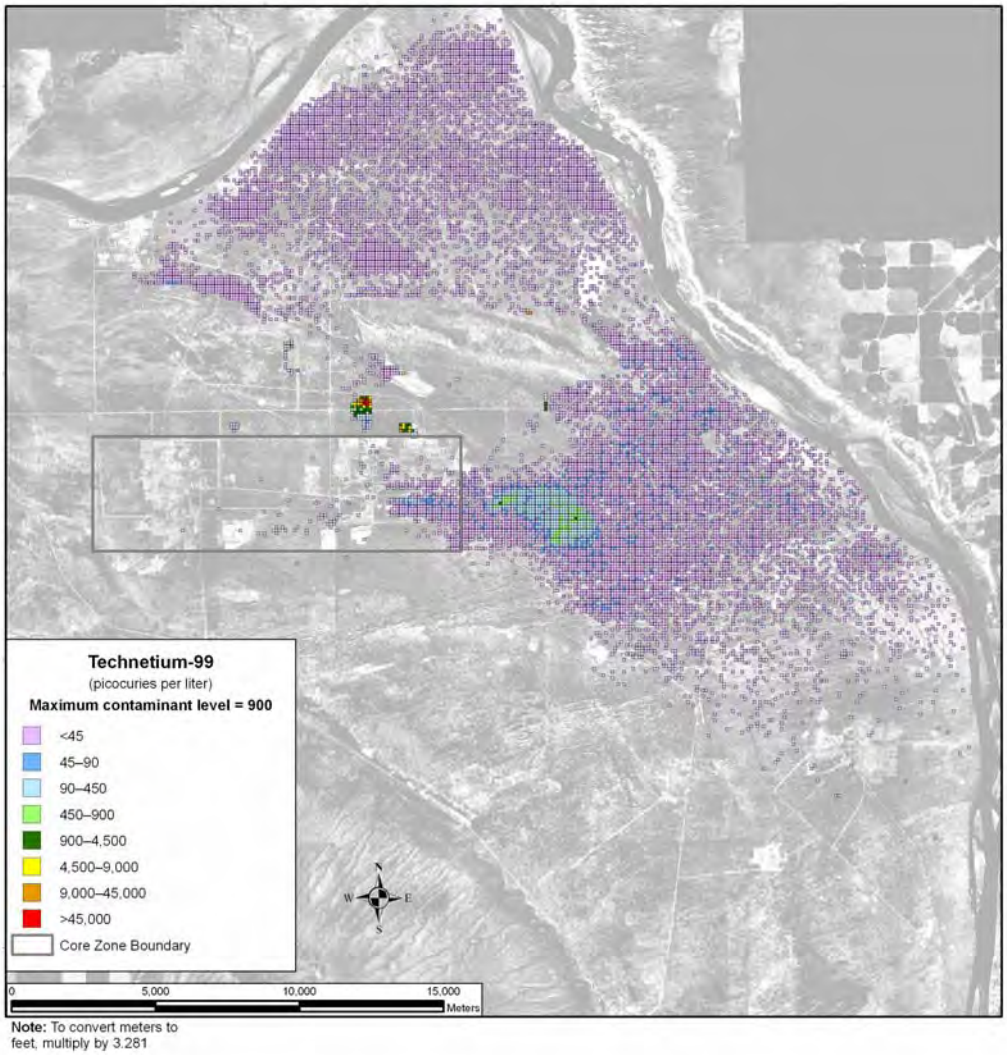


Figure 6–52. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 11,885

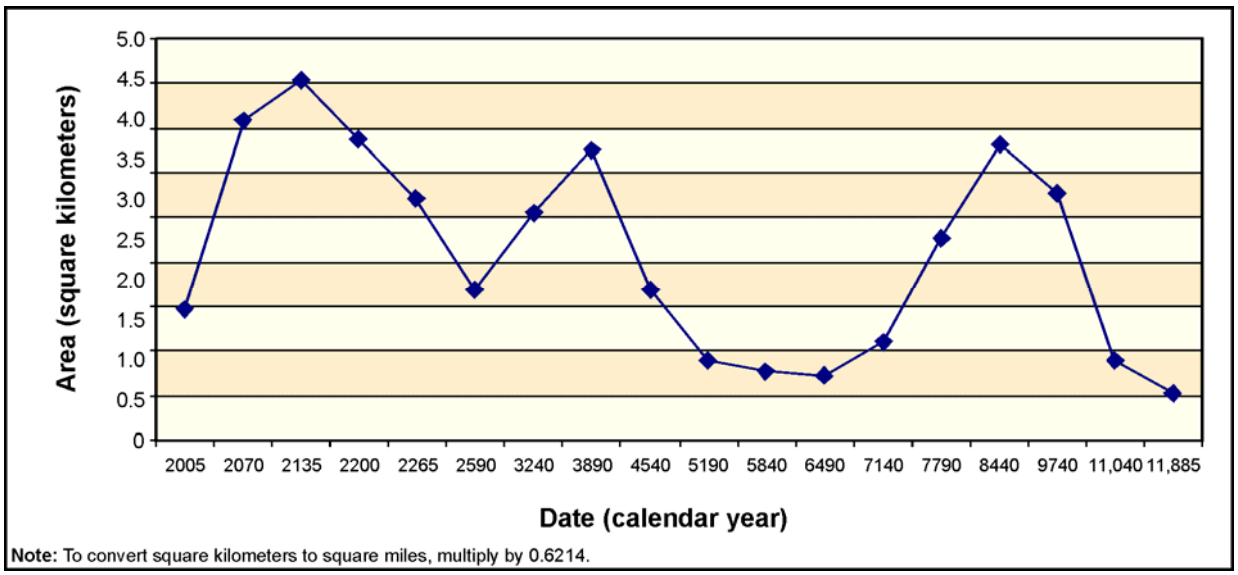


Figure 6–53. Alternative Combination 2 Total Area for Which Cumulative Groundwater Concentrations of Technetium-99 Exceed the Benchmark Concentration as a Function of Time

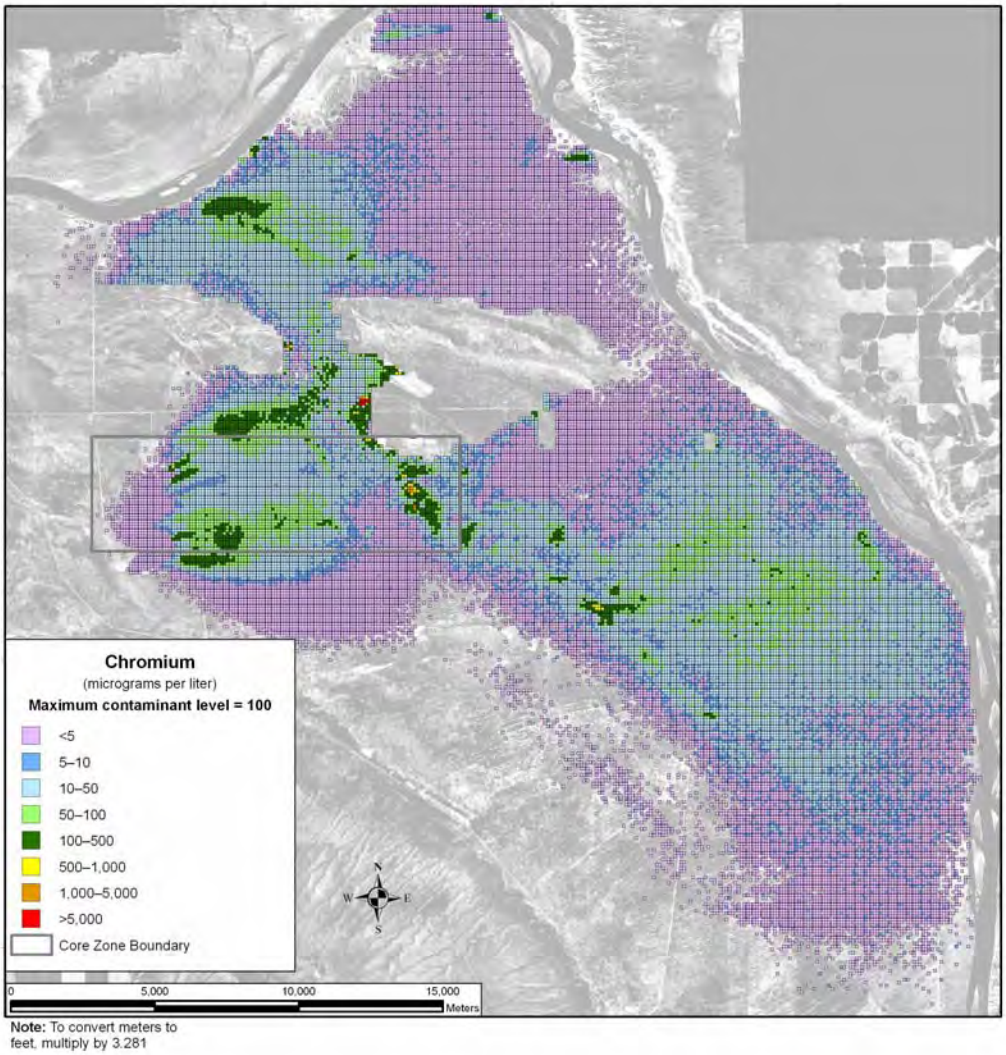


Figure 6–54. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 2005

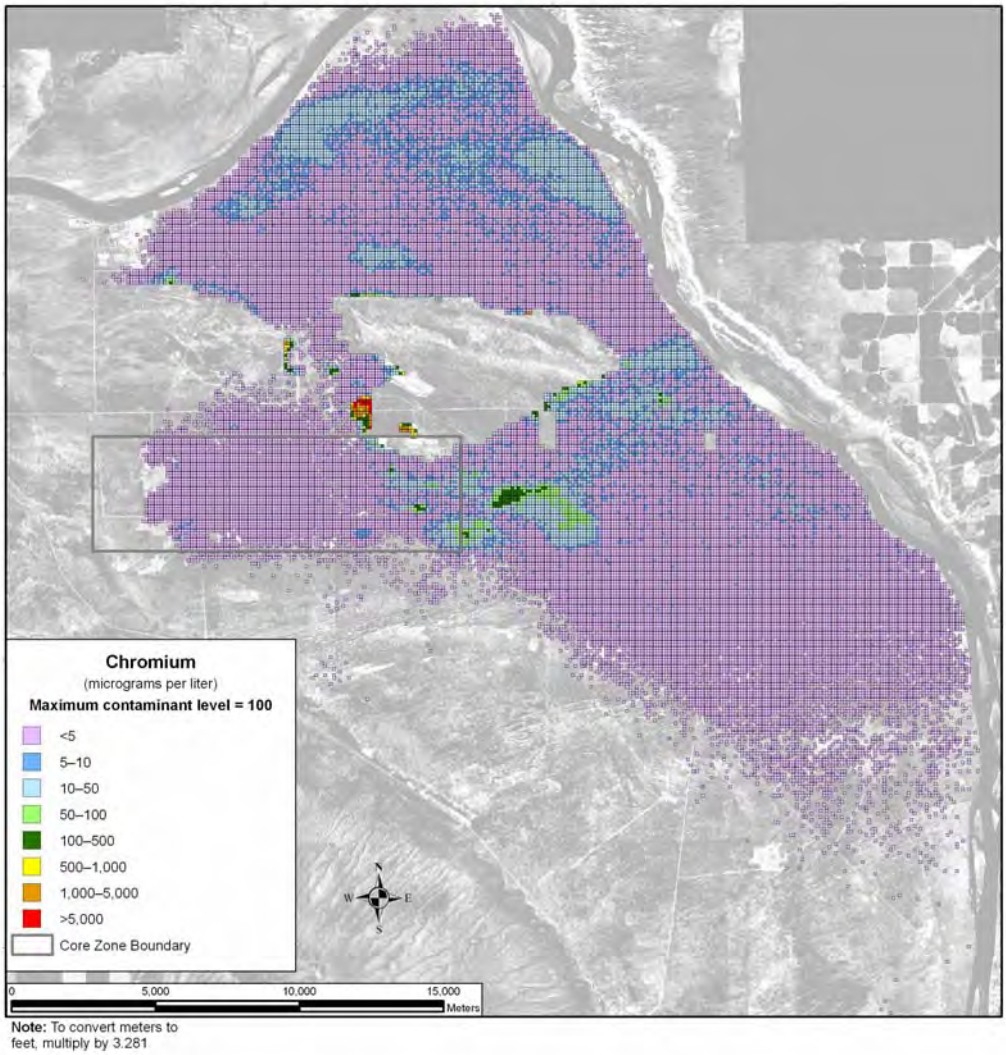


Figure 6–55. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 3890

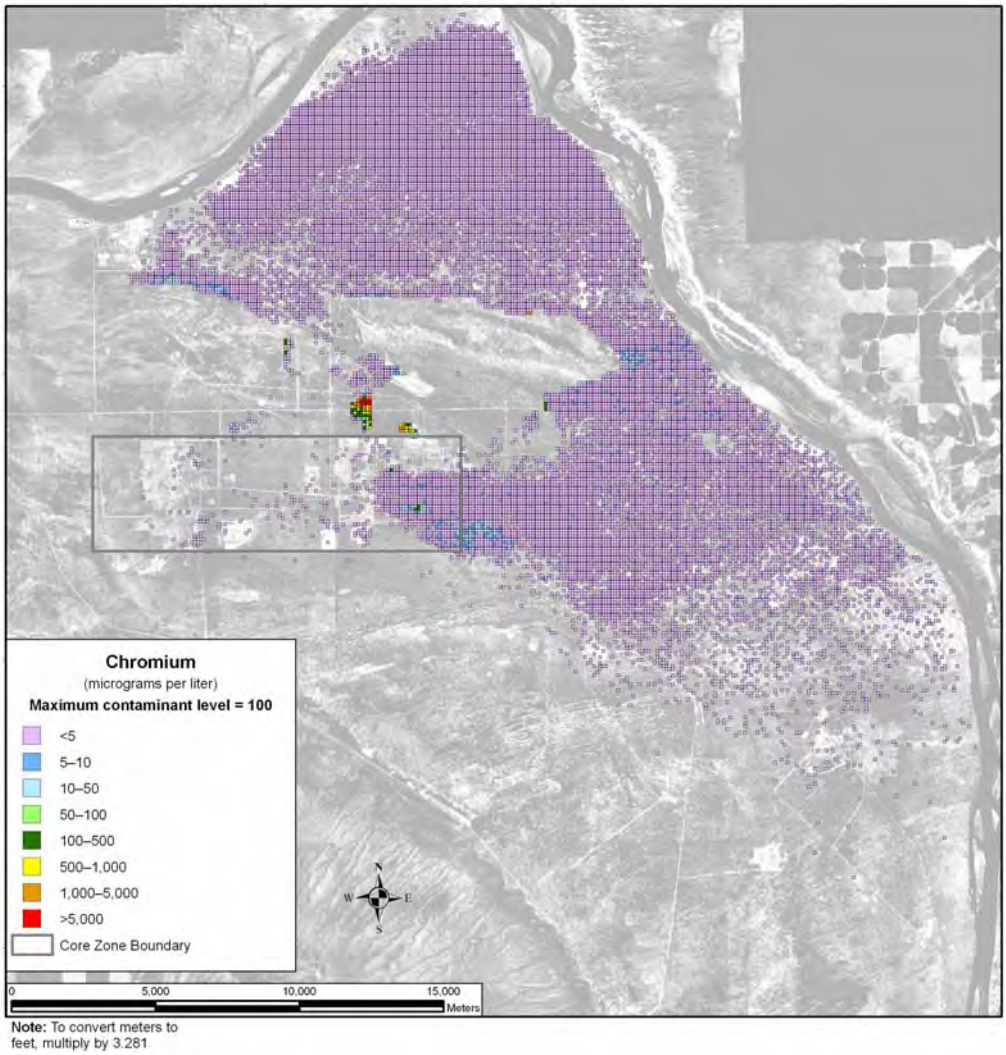


Figure 6–56. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 7140

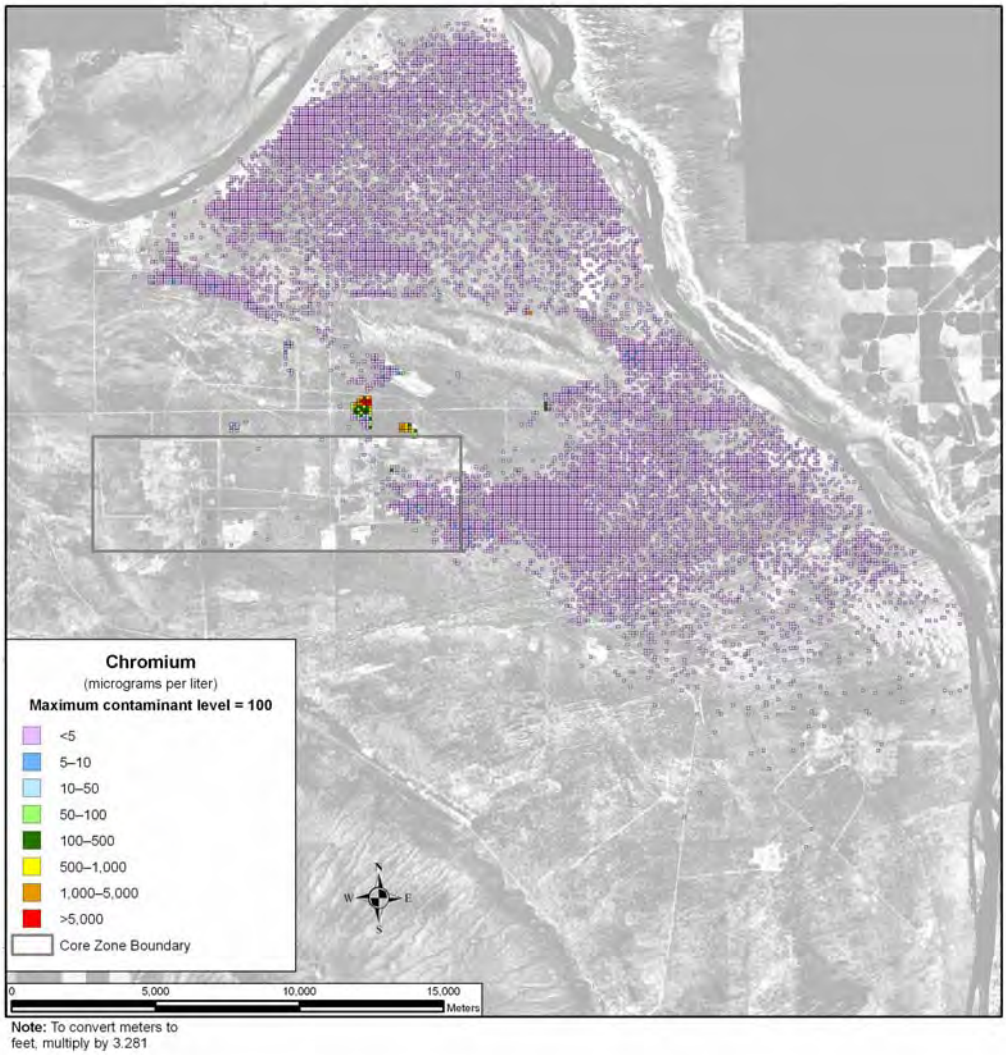


Figure 6–57. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 11,885

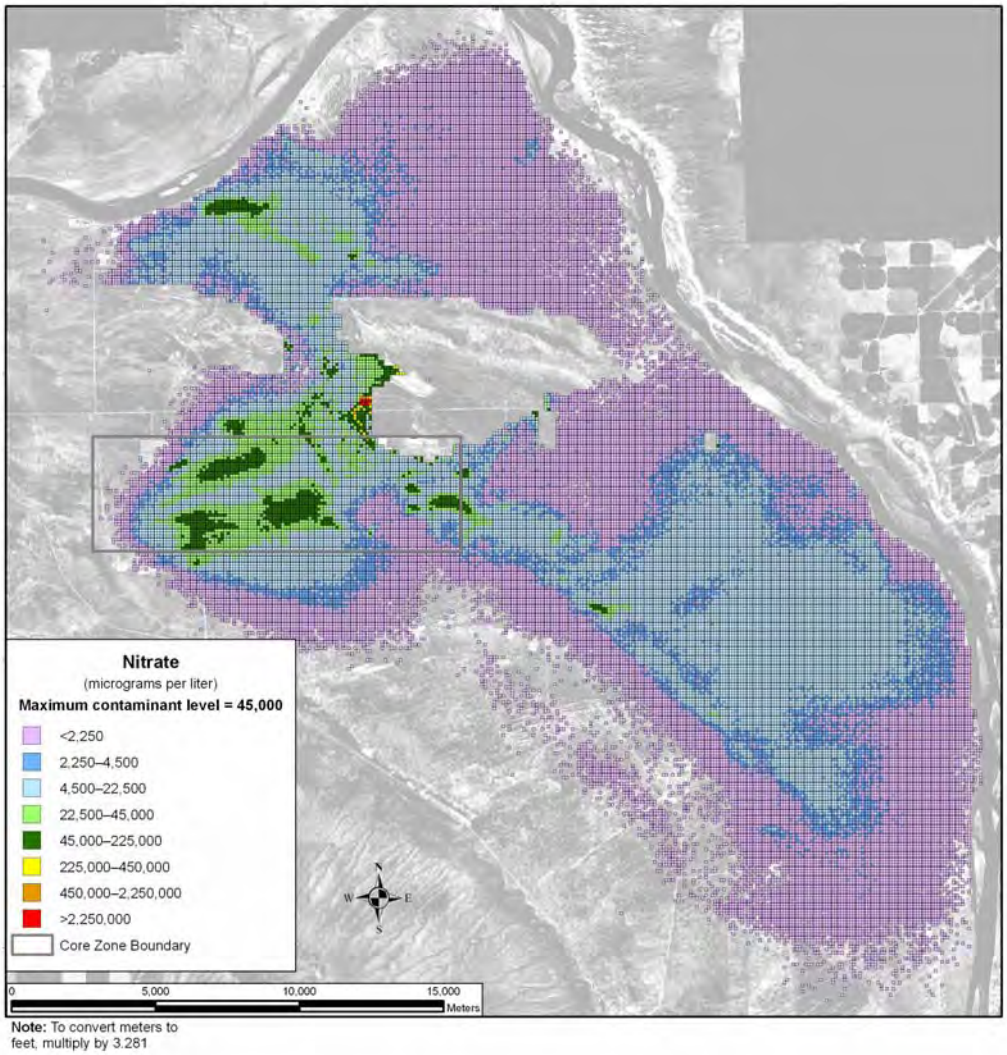


Figure 6–58. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 2005

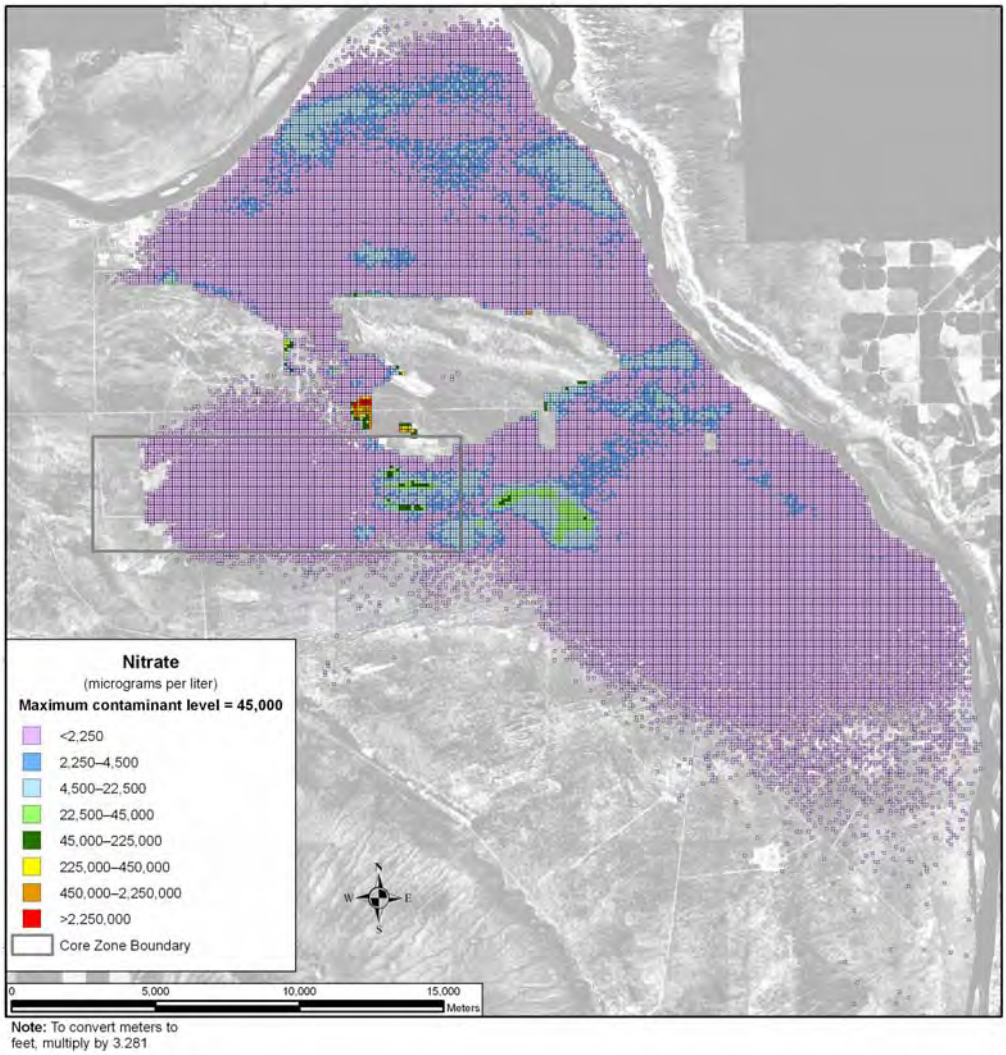


Figure 6–59. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 3890

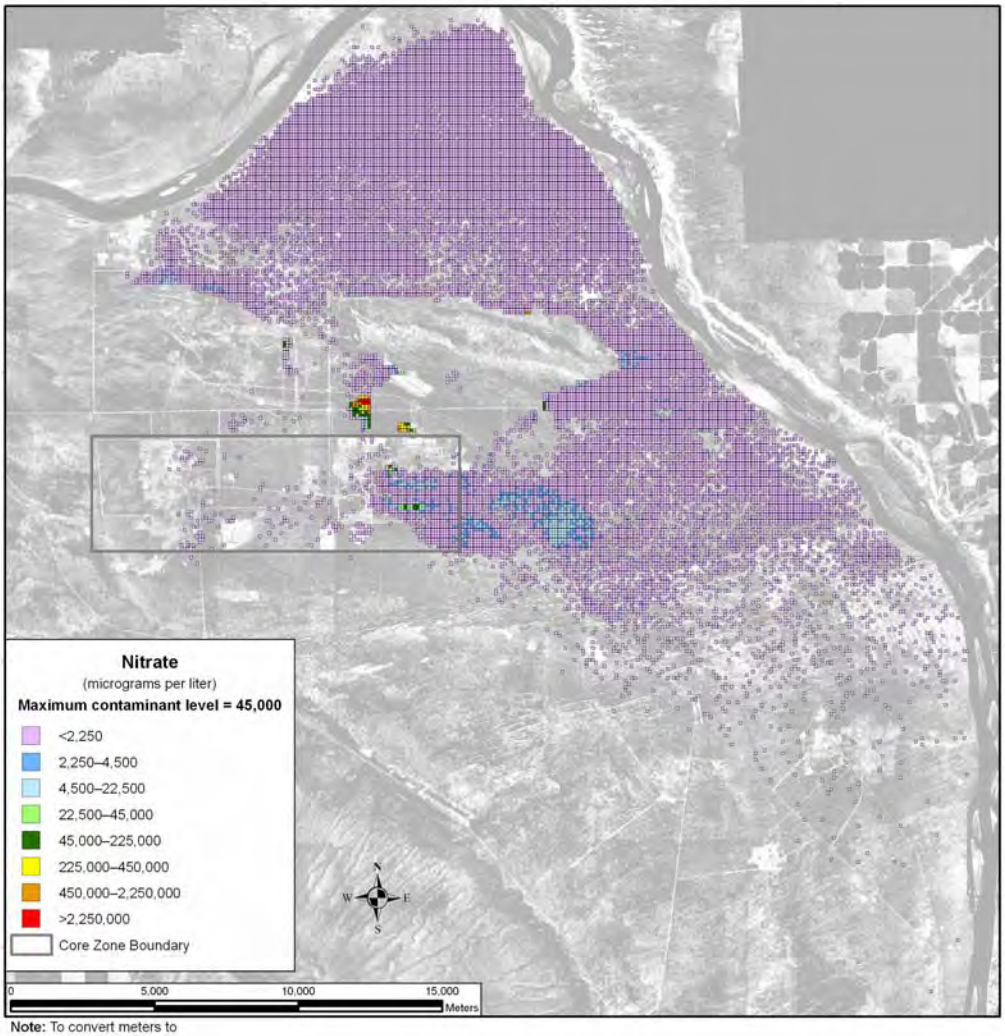


Figure 6–60. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 7140

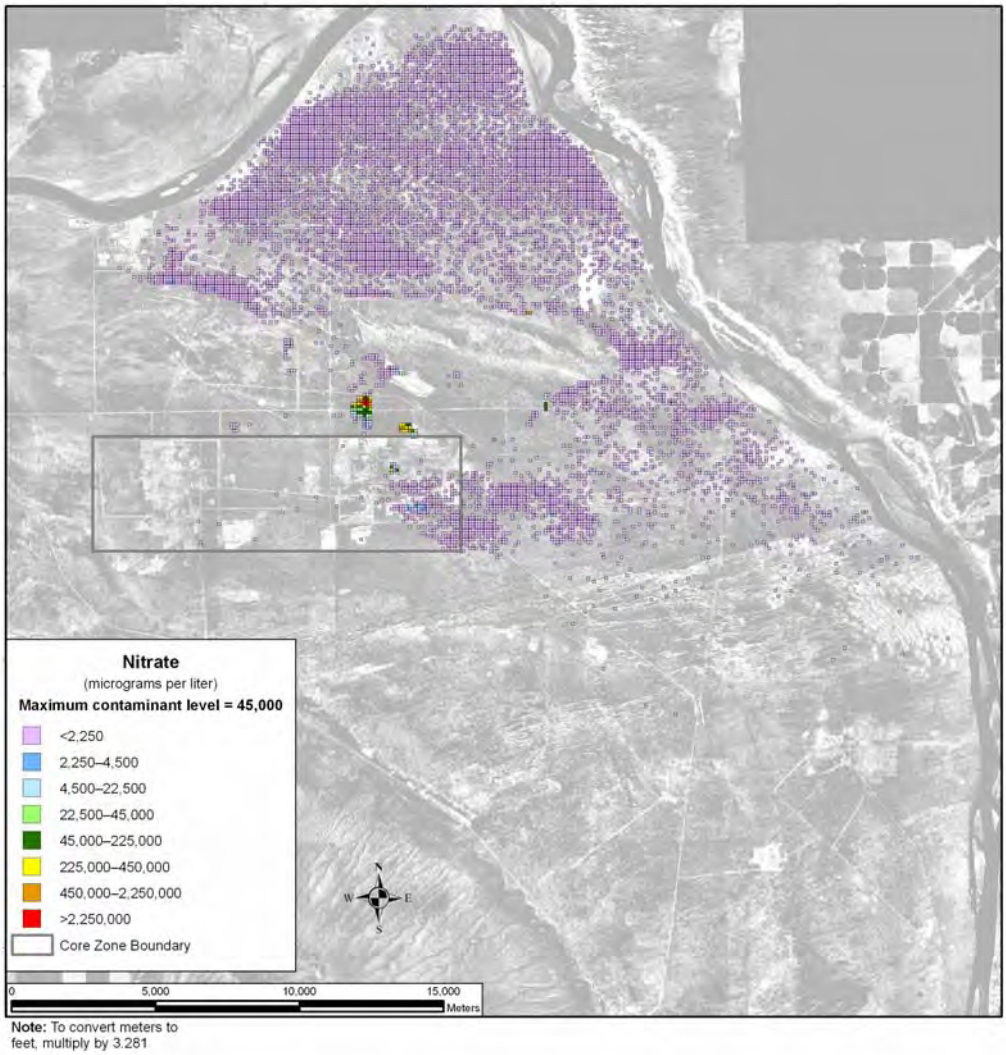


Figure 6–61. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 11,885

The carbon tetrachloride distribution is dominated by non-*TC & WM EIS* sources associated with the Z Area within the 200-West Area. The spatial distribution during CY 2005, shown in Figure 6–62, is a large plume covering most of the 200-West Area, with peak concentrations over an order of magnitude greater than the benchmark concentration. Note that this model result does not include the effects of carbon tetrachloride removal and containment in the 200-West Area. Figures 6–63 and 6–64 show the dissipation of the plume over time at CY 2135 and CY 3890, respectively.

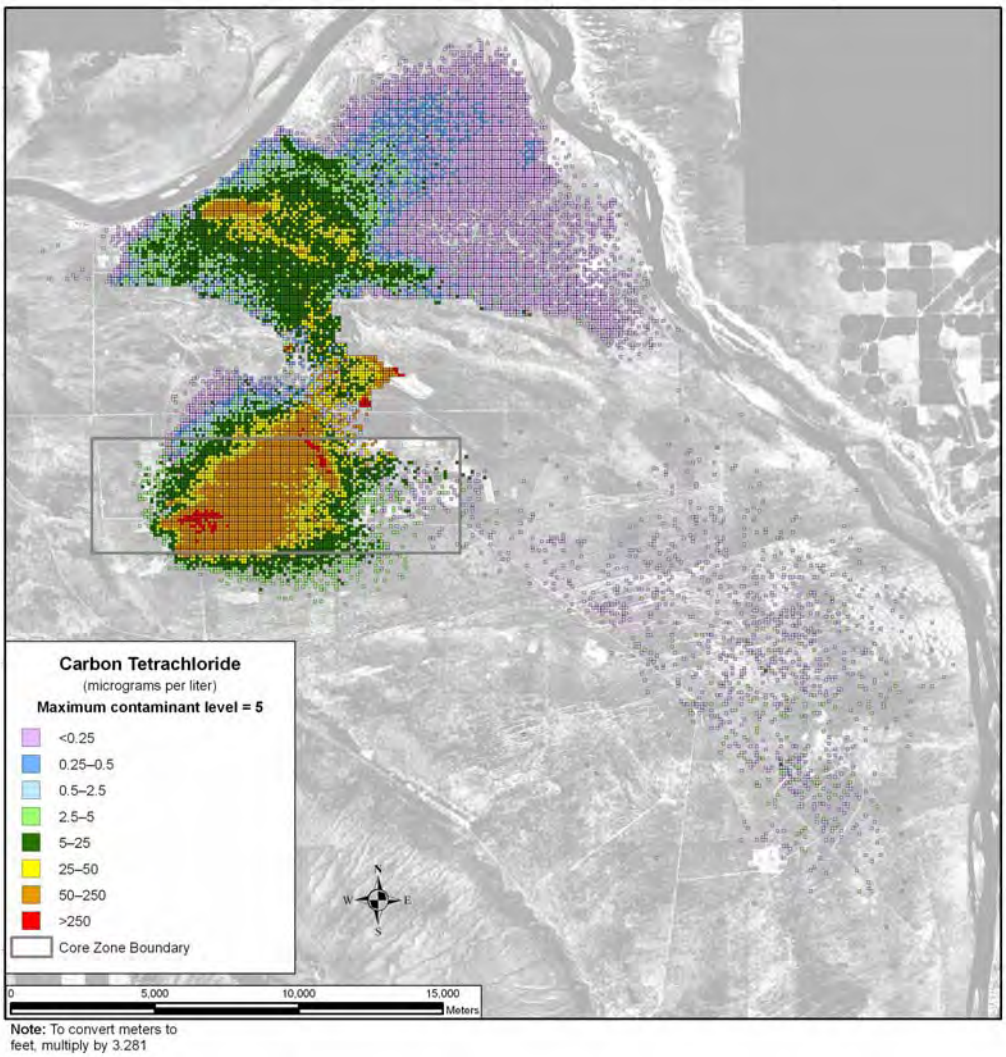


Figure 6–62. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 2005

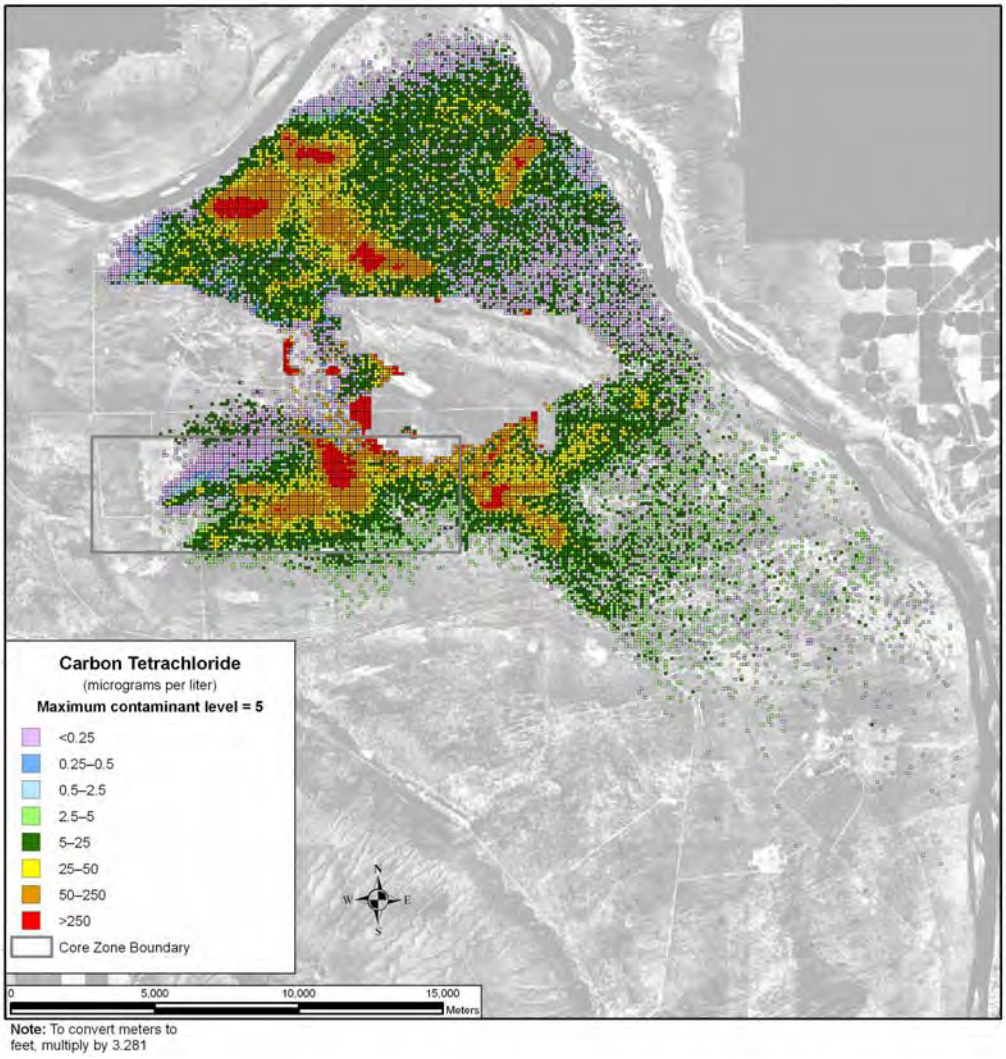


Figure 6–63. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 2135

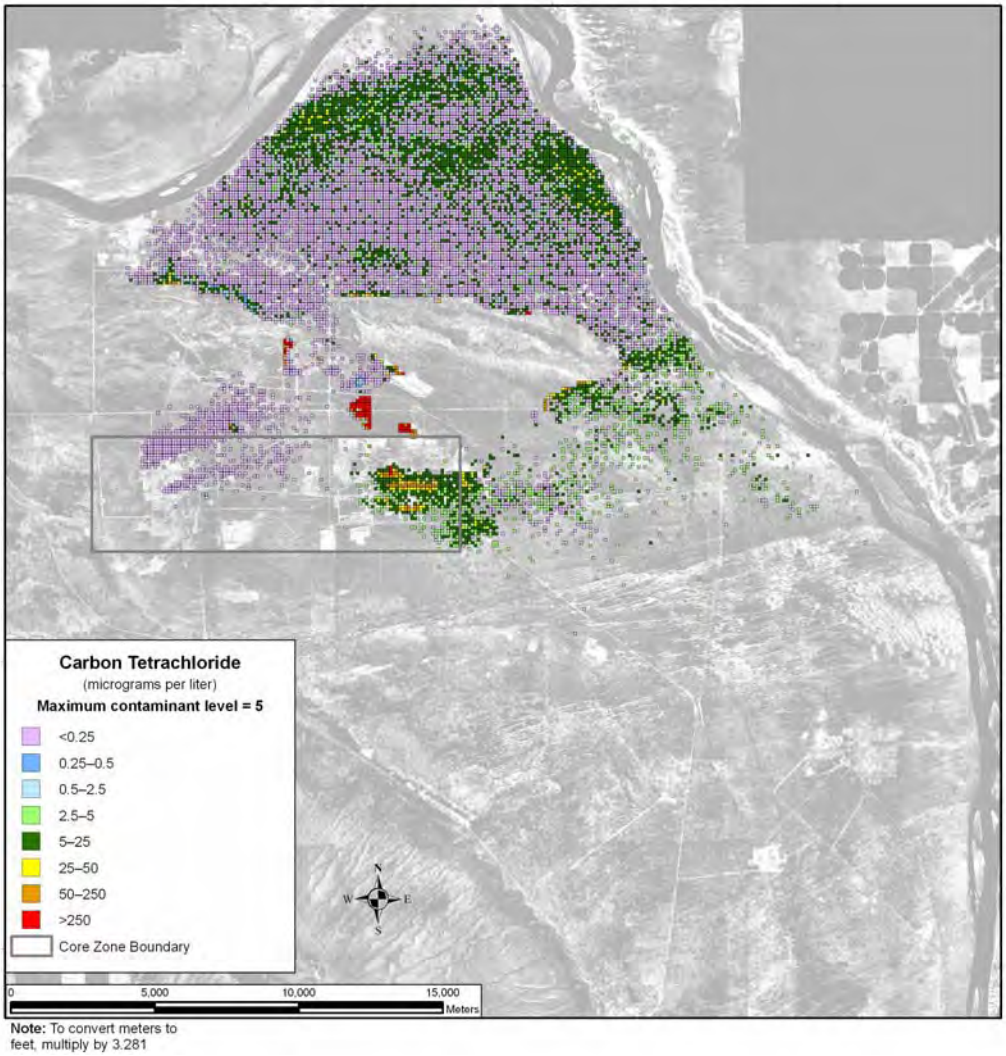


Figure 6–64. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 3890

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the porewater velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 6–65 shows the distribution of uranium-238 during CY 2135. There are two plumes associated with releases from the ponds (non-*TC & WM EIS* sources) in the 200-East and 200-West Areas with peak concentrations that exceed the benchmark by an order of magnitude. By CY 3890 (see Figure 6–66) these plumes have dissipated, but releases from other tank farm sources (primarily within the A Barrier) have produced a second plume east of the Core Zone, with peak concentrations about an order of magnitude greater than the benchmark. At CY 11,885 (see Figure 6–67) the plumes from other tank farm sources have extended this plume and produced additional plumes in the 200-West Area. Figure 6–68 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest early in the analysis (non-*TC & WM EIS* sources, primarily ponds) with an upward trend toward the end of the period of analysis (other tank farm sources). Figures 6–69 through 6–71 show the corresponding spatial distributions for total uranium.

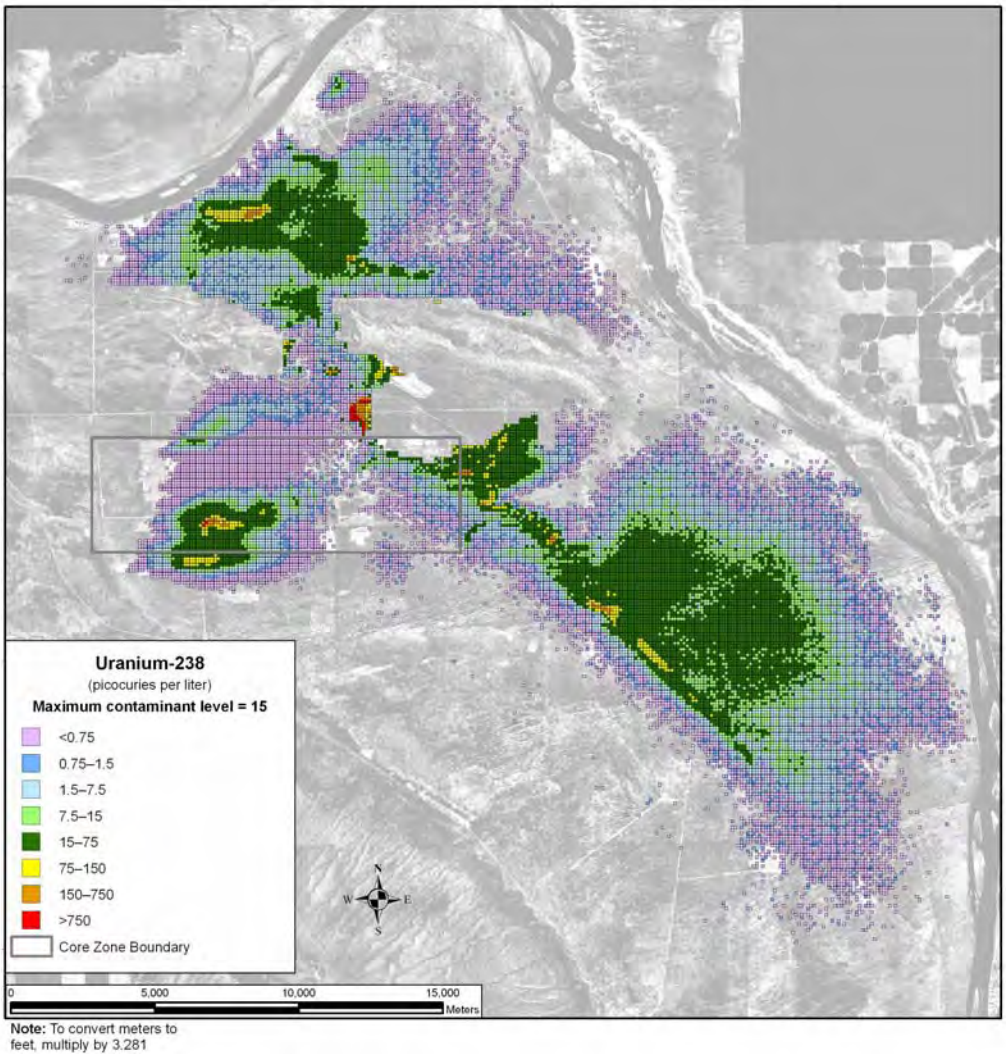


Figure 6–65. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 2135

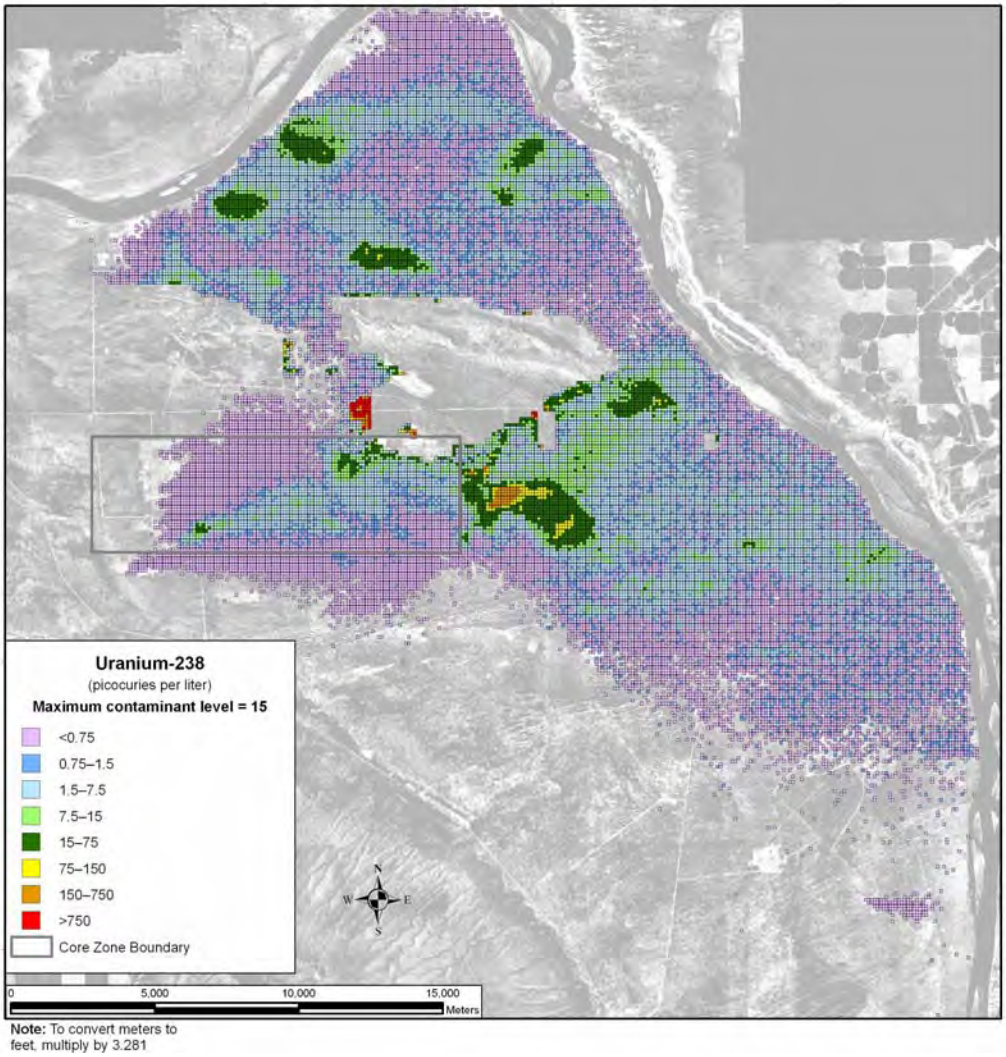


Figure 6–66. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 3890

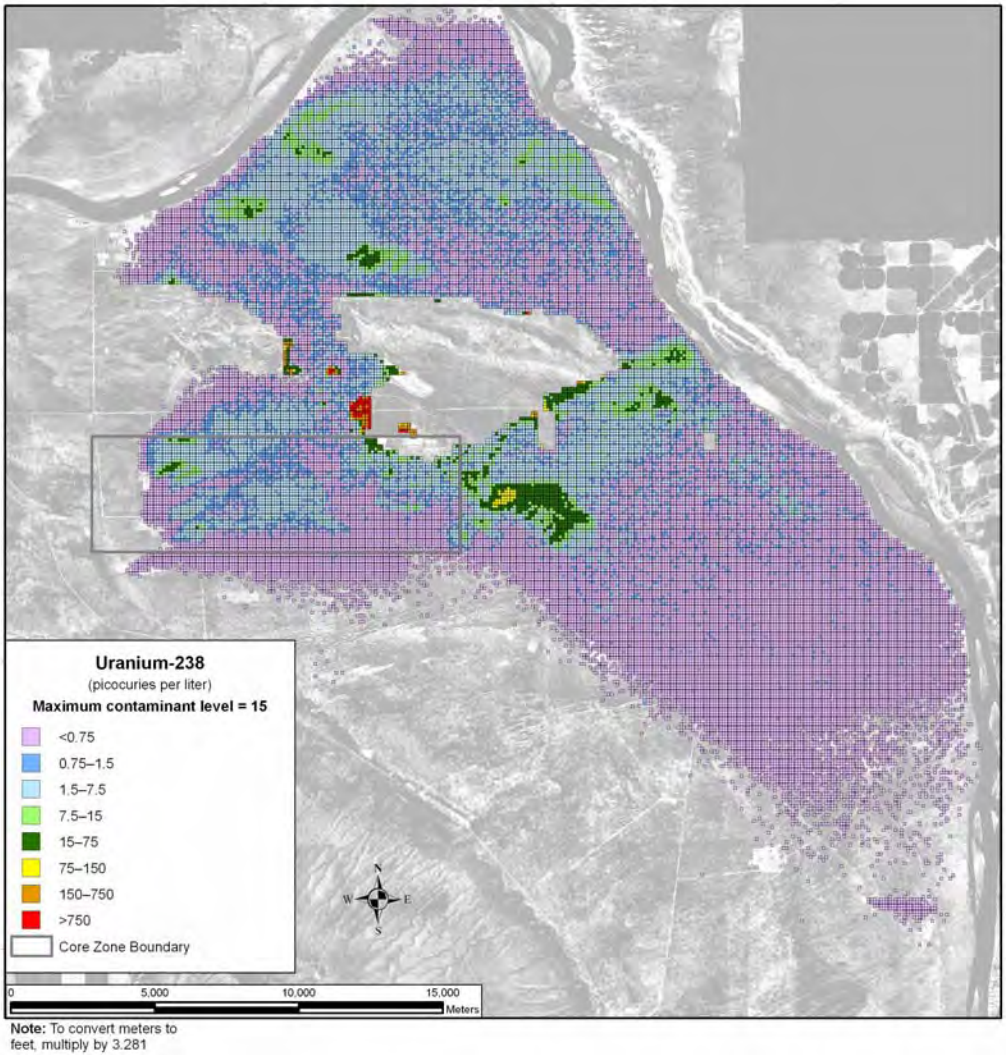


Figure 6–67. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 11,885

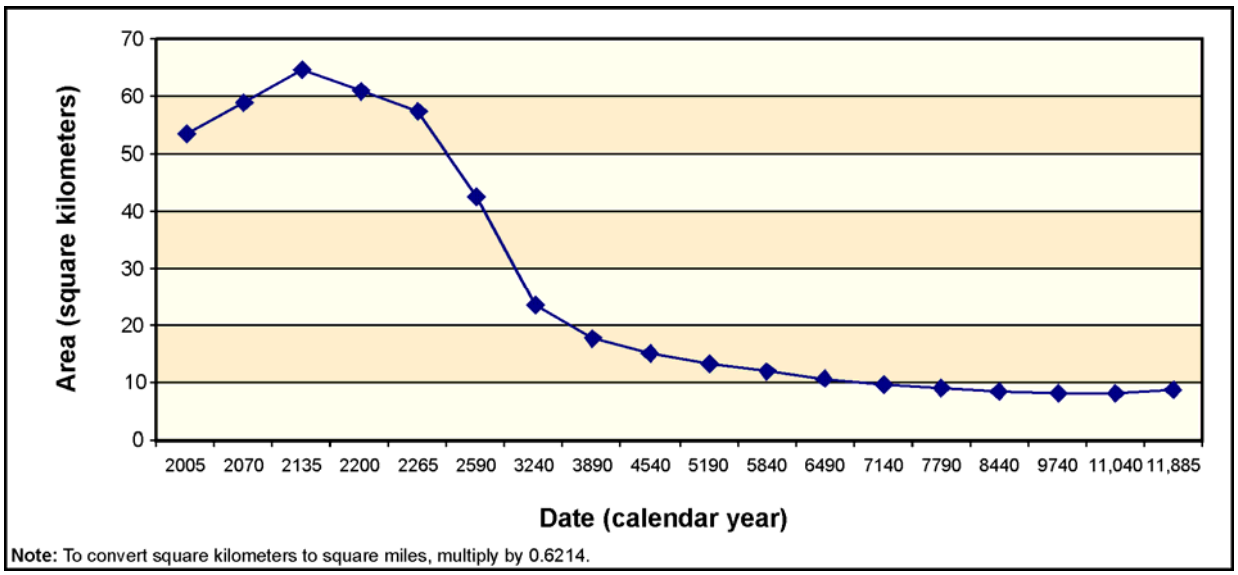


Figure 6–68. Alternative Combination 2 Total Area for Which Cumulative Groundwater Concentrations of Uranium-238 Exceed the Benchmark Concentration as a Function of Time

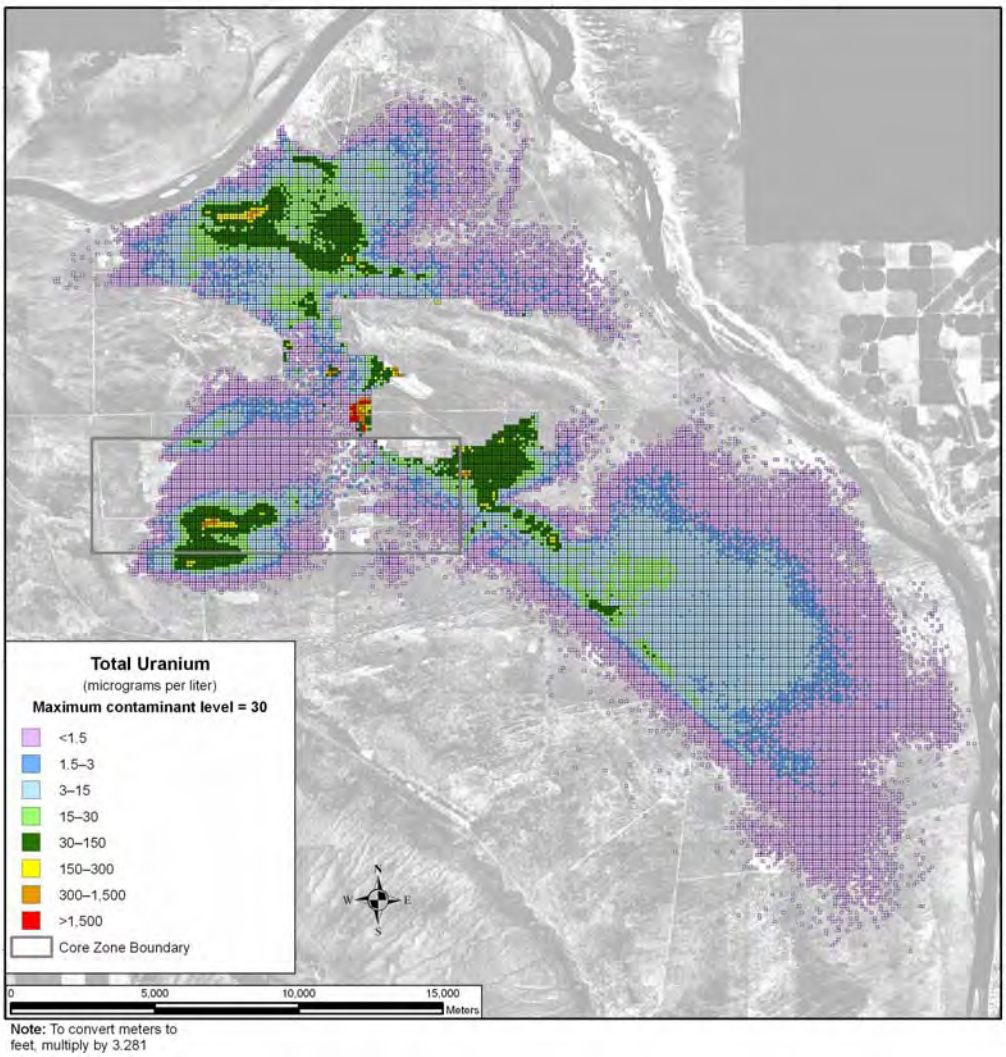


Figure 6–69. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 2135

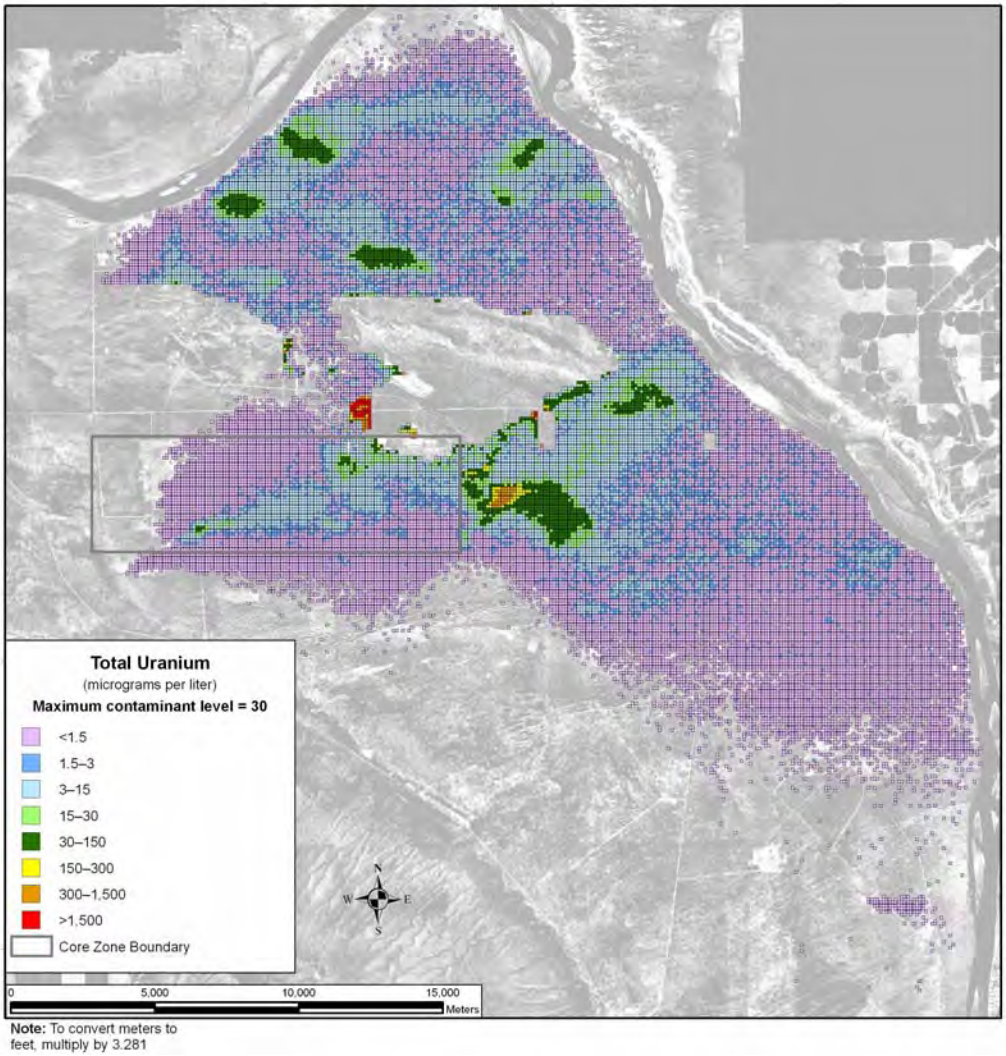


Figure 6–70. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 3890

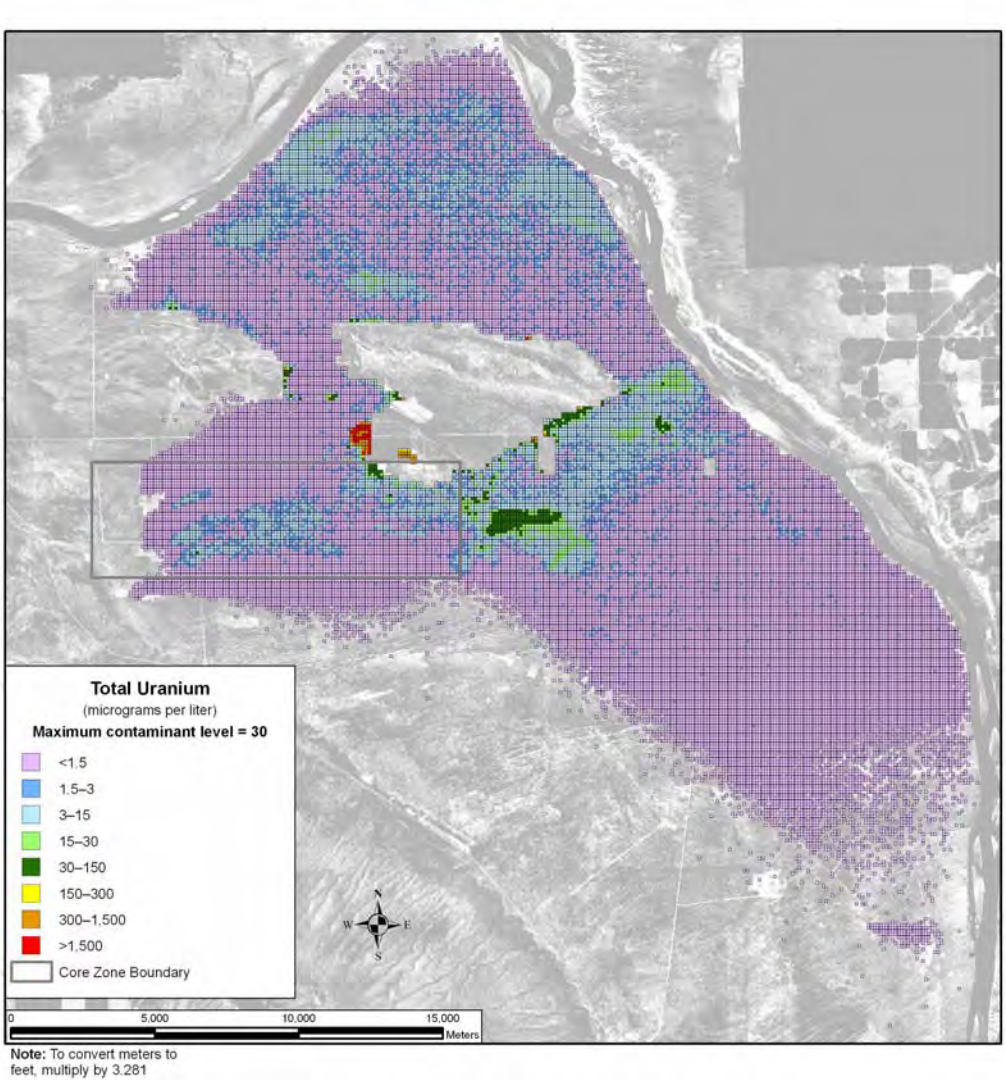


Figure 6–71. Alternative Combination 2 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 11,885

6.4.1.2.4 Summary of Impacts

The cumulative long-term impacts for Alternative Combination 2 and non-*TC & WM EIS* sources are dominated by non-*TC & WM EIS* sources (tritium, uranium-238, carbon tetrachloride, chromium, and total uranium); a combination of non-*TC & WM EIS* sources and Waste Management alternative sources (iodine-129); a combination of non-*TC & WM EIS* sources and tank closure sources (nitrate); or all three (technetium-99). Contributions from FFTF Decommissioning Alternative 2 sources account for well under 1 percent of the total amount released to the environment.

For iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate, concentrations at the Core Zone Boundary exceed benchmark standards by an order of magnitude during most of the period of analysis. Concentrations at the Columbia River are somewhat lower. The intensities and areas of these groundwater plumes peak between CY 3200 and CY 4000.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River exceed the benchmark by about two orders of magnitude during this time. Attenuation by radioactive

decay is a predominant mechanism that limits the intensity and duration of groundwater impacts by tritium. After CY 2100 tritium impacts are essentially negligible.

For uranium-238 and total uranium, discharges from the ponds (non-*TC & WM EIS* sources) are the dominant contributors during the early period of the analysis. Other tank farm sources are a secondary contributor, for which limited mobility is an important factor governing the time frames and scale of groundwater impacts.

6.4.1.3 Alternative Combination 3

This section presents the results of the cumulative long-term groundwater impacts analysis including Alternative Combination 3. This section focuses on the combined long-term groundwater impacts of Alternative Combination 3 and non-*TC & WM EIS* sources, which are discussed in Chapter 5, Section 5.4. All of the non-*TC & WM EIS* sources discussed in Appendix S are included.

This discussion of long-term impacts is focused on the following COPC drivers:

- radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- chemical hazard drivers: carbon tetrachloride, chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose the Alternative Combination and the COPC drivers for the non-*TC & WM EIS* sources. They fall into three categories. Iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. Tritium is also mobile, but short lived. The half-life of tritium is about 12.3 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors. The level of protection provided for the drinking water pathway was evaluated by comparison against the maximum contaminant levels provided in 40 CFR 141 and other benchmarks presented in Appendix O.

6.4.1.3.1 Analysis of Release and Mass Balance

This section presents the total amount of the COPC drivers released to the vadose zone, to groundwater, and to the Columbia River. Releases of radionuclides are totaled in curies, and releases of chemicals are totaled in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 6–19 lists the release to the vadose zone for the COPC drivers. For Alternative Combination 3, the release to the vadose zone is controlled by a combination of inventory and waste form. For tank closure and FFTF decommissioning sources, the entire inventory was released to the vadose zone during the period of analysis. For some waste management sources (e.g., ILAW glass) some of the inventory was not released to the vadose zone during the 10,000-year period of analysis because of retention in the waste form. The release to the vadose zone for Alternative Combination 3 and non-*TC & WM EIS* sources is dominated by sources associated with non-*TC & WM EIS* sources for tritium, uranium-238, chromium, and total uranium; by non-*TC & WM EIS* and waste management sources for iodine-129; by non-*TC & WM EIS* sources and tank closure sources for nitrate; and a combination of all three types of sources for technetium-99.

Table 6–19. Alternative Combination 3 Release to Vadose Zone for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other activities	3.43×10^{6}	2.49×10^{1}	7.33×10^{2}	3.13×10^{3}	3.35×10^{5}	7.38×10^{7}	2.53×10^{5}
Tank Closure Alternative 2B Base	4.59×10^{4}	8.35×10^{-1}	4.53×10^{2}	2.59×10^{1}	9.07×10^{4}	2.56×10^{7}	2.93×10^{4}
FFTF Decommissioning Alternative 2	1.73×10^{-5}	0	2.72×10^{1}	0	0	0	0
Waste Management Alternative 2 Disposal Group 1-A	6.29×10^{4}	1.84×10^{1}	2.53×10^{3}	3.30×10^{2}	6.48×10^{3}	9.38×10^{6}	1.27×10^{4}
Total	3.54×10^{6}	4.41×10^{1}	3.75×10^{3}	3.48×10^{3}	4.32×10^{5}	1.09×10^{8}	2.95×10^{5}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

Table 6–20 lists the release to groundwater for the COPC drivers. In addition to the inventory consideration discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, the amount released to groundwater is attenuated by radioactive decay during transit through the vadose zone. About 60 percent of the tritium released to the vadose zone reaches the unconfined aquifer. Because of retardation, less than 35 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 6–20. Alternative Combination 3 Release to Groundwater for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other activities	2.06×10^{6}	2.48×10^{1}	7.12×10^{2}	1.48×10^{2}	3.40×10^{5}	7.42×10^{7}	1.05×10^{5}
Tank Closure Alternative 2B Base	3.23×10^{4}	7.49×10^{-1}	4.08×10^{2}	7.31×10^{-1}	9.27×10^{4}	2.64×10^{7}	2.42×10^{2}
FFTF Decommissioning Alternative 2	2.58×10^{-8}	0	2.62×10^{1}	0	0	0	0
Waste Management Alternative 2 Disposal Group 1-A	0	1.68×10^{1}	2.27×10^{3}	2.68×10^{-7}	6.46×10^{3}	9.36×10^{6}	4.64×10^{-4}
Total	2.09×10^{6}	4.23×10^{1}	3.42×10^{3}	1.49×10^{2}	4.39×10^{5}	1.10×10^{8}	1.05×10^{5}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

Table 6–21 lists the release to the Columbia River for the COPC drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers in the unconfined aquifer. For iodine-129, technetium-99, chromium, and nitrate, the amount released to Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 5 percent of the tritium released to groundwater reaches the Columbia River. Because of retardation, about 90 percent of the uranium-238 and total uranium released to groundwater during the period of analysis reaches the Columbia River.

Table 6–21. Alternative Combination 3 Release to Columbia River for COPC Drivers

	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium[a]**	**Nitrate**	**Total Uranium**
Other activities	1.11×10^{5}	2.46×10^{1}	7.26×10^{2}	1.40×10^{2}	3.51×10^{5}	7.47×10^{7}	9.28×10^{4}
Tank Closure Alternative 2B Base	8.70×10^{2}	7.23×10^{-1}	3.94×10^{2}	2.44×10^{-1}	9.23×10^{4}	2.63×10^{7}	7.87×10^{1}
FFTF Decommissioning Alternative 2	0	0	2.72×10^{1}	0	0	0	0
Waste Management Alternative 2 Disposal Group 1-A	0	1.63×10^{1}	2.20×10^{3}	0	6.22×10^{3}	9.21×10^{6}	3.05×10^{-5}
Total	1.12×10^{5}	4.16×10^{1}	3.35×10^{3}	1.40×10^{2}	4.50×10^{5}	1.10×10^{8}	9.29×10^{4}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

6.4.1.3.2 Analysis of Concentration Versus Time

This section presents the contaminant concentrations in groundwater versus time at the Core Zone Boundary and the Columbia River. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid in interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when: the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 6–22 lists the maximum concentrations for the COPCs at the peak year for the Core Zone Boundary and the Columbia River nearshore.

Table 6–22. Alternative Combination 3 Maximum Concentrations for COPCs[a]

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration[b]
Radionuclide (picocuries per liter)			
Hydrogen-3 (Tritium)	104,000,000	4,190,000	20,000
	(1996)	(1986)	
Carbon-14	46,700	196	2,000
	(1998)	(2013)	
Strontium-90	181,000	4,160,000	8
	(1998)	(1991)	
Technetium-99	144,000	2,870	900
	(1956)	(1999)	
Iodine-129	190	9.4	1
	(1956)	(4540)	
Cesium-137	0[c]	1,310,000	200
	(1997)	(1985)	
Uranium isotopes (includes U-233, -234, -235, -238)	2,200	22,400	15
	(1991)	(1973)	

Table 6–22. Alternative Combination 3 Maximum Concentrations for COPCs[a] *(continued)*

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration[b]
Radionuclide (picocuries per liter) *(continued)*			
Neptunium-237	114	16	15
	(2066)	(2004)	
Plutonium isotopes (includes Pu-239, -240)	2,660	4,250	15
	(11,848)	(2983)	
Chemical (microgram per liter)			
1-Butanol	17,200	49	3,600
	(1998)	(11243)	
Carbon tetrachloride	3,350	60.7	5
	(2270)	(2527)	
Chromium[d]	28,800	16,100	100
	(1956)	(1978)	
Dichloromethane	0.7	0.1	5
	(3286)	(4711)	
Fluoride	90,200	14,500	4,000
	(2003)	(1982)	
Hydrazine/Hydrazine Sulfate	0.030	0.088	0.022
	(3343)	(3627)	
Lead	0[c]	9,080	15
	(2021)	(2374)	
Manganese	392	242	1,600
	(8610)	(2286)	
Mercury	183	25.5	2
	(2015)	(1997)	
Nickel (soluble salts)	0[c]	8,310	700
	(11871)	(3877)	
Nitrate	13,100,000	505,000	45,000
	(1956)	(1973)	
Total Uranium	3,290	15,400	30
	(1991)	(1964)	
Trichloroethylene (TCE)	0.1	0.2	5
	(3404)	(3764)	

a The peak cumulative concentration for some constituents occurs in the past. The relationship of past to future cumulative constituent concentrations is presented in the time versus concentration plots in Figures 6–72 through 6–79.

b The sources of the benchmark concentrations are provided in Appendix O, Section O.3.

c Values that are less than 0.001 are reported as zero.

d It was assumed, for the purposes of analysis, that all chromium was hexavalent.

Note: To convert from liters to gallons, multiply by 0.26417.

Key: COPC=constituent of potential concern.

Figure 6–72 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from 1940 through 2540 rather than the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about three orders of magnitude for a short period of time during the early part of the period of analysis. During this time groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude above the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

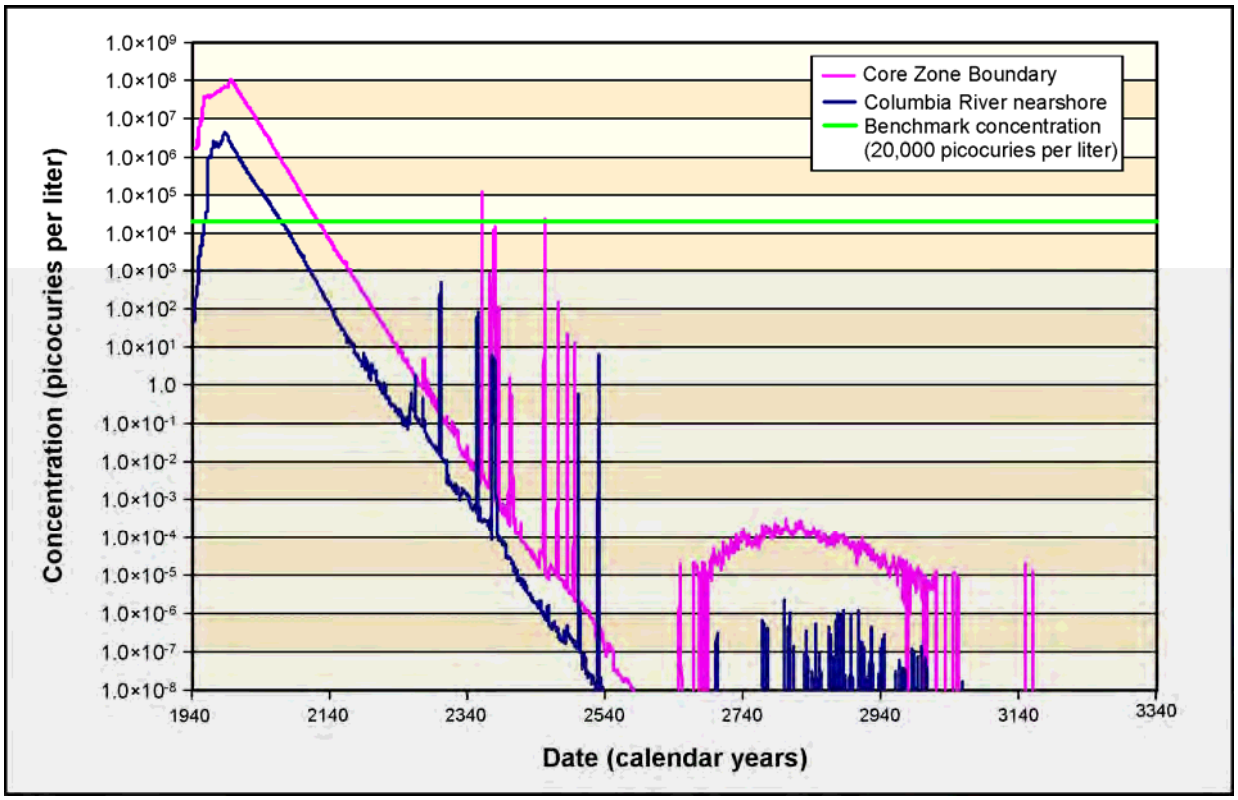


Figure 6–72. Alternative Combination 3 Cumulative Concentration Versus Time for Tritium

Figures 6–73 through 6–77 show concentration versus time for iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate. Groundwater concentrations of iodine-129 exceed benchmark concentrations by more than an order of magnitude during the first several thousand years of the analysis. During this time groundwater concentrations at the Columbia River nearshore exceed the benchmark concentration by about an order of magnitude. During later times in the analysis the concentrations are on the same order of magnitude as the benchmark at the Core Zone Boundary and the Columbia River nearshore. Technetium-99, carbon tetrachloride, chromium, and nitrate concentrations show a similar curve, with technetium-99, chromium and nitrate concentrations at the Columbia River nearshore dropping below the benchmark concentrations.

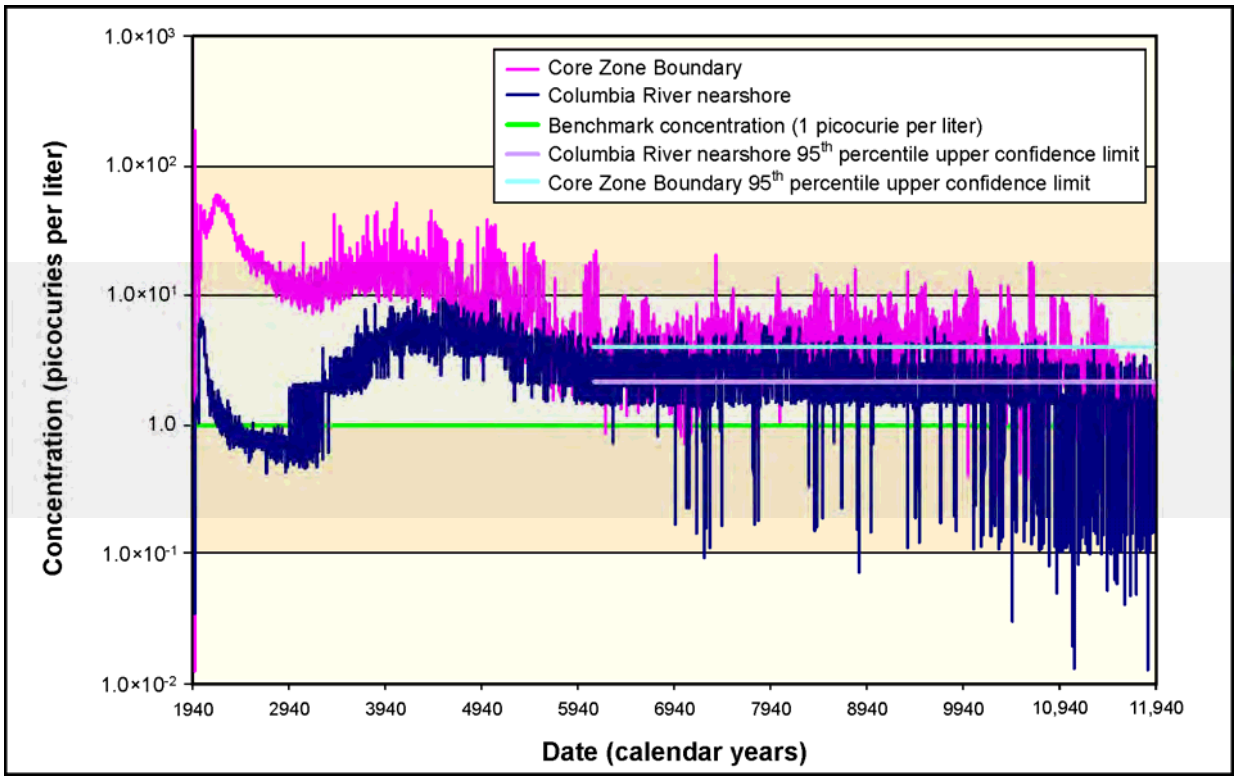


Figure 6–73. Alternative Combination 3 Cumulative Concentration Versus Time for Iodine-129

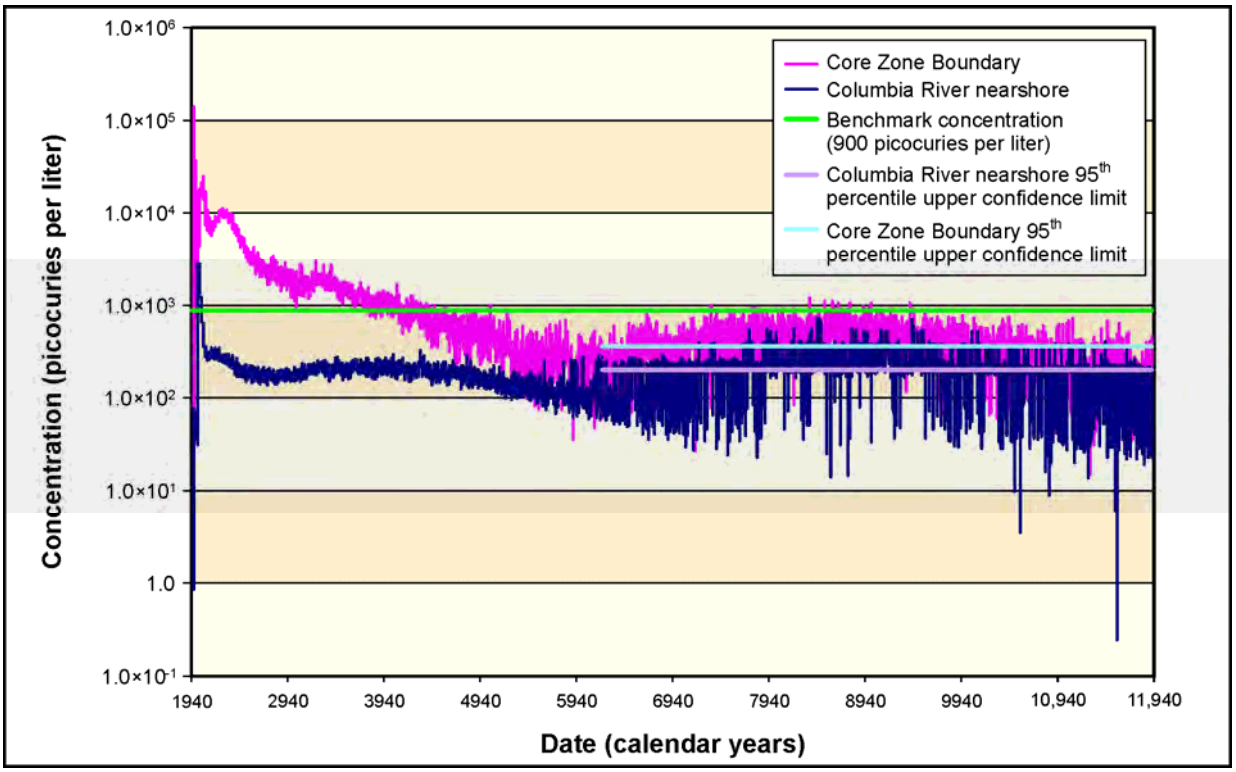


Figure 6–74. Alternative Combination 3 Cumulative Concentration Versus Time for Technetium-99

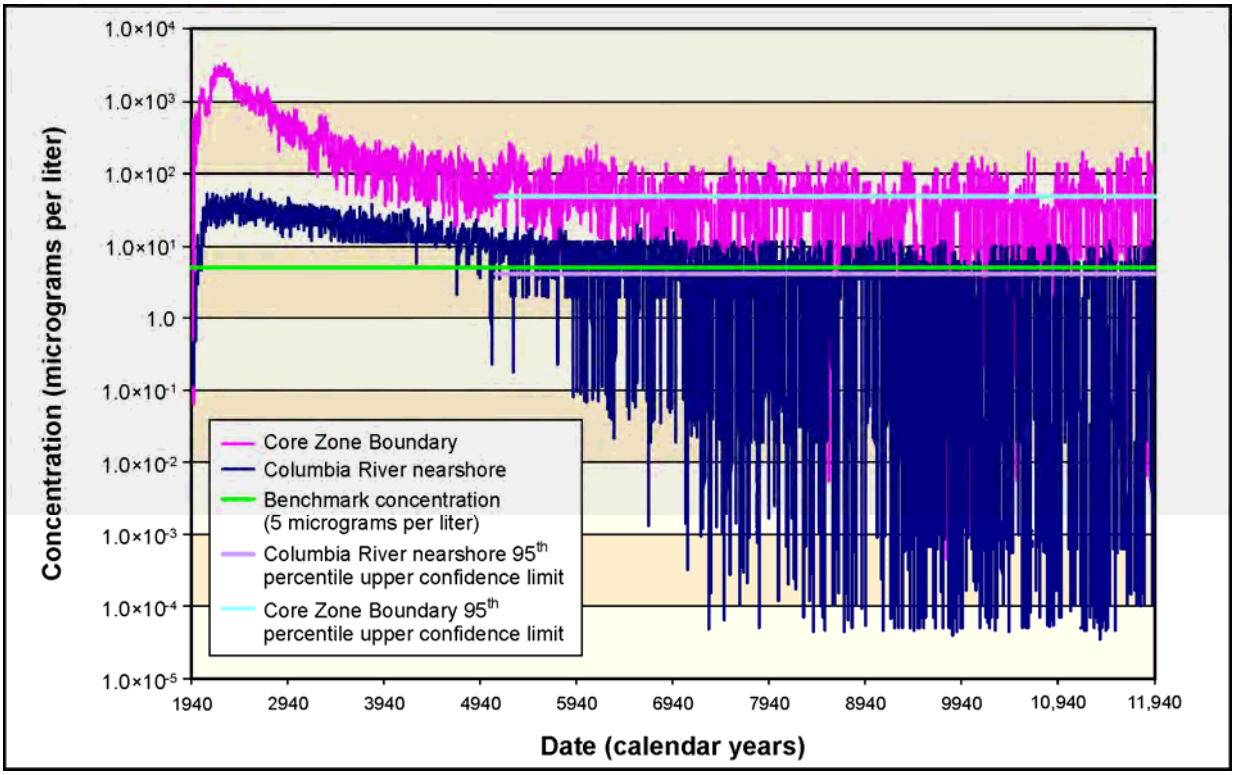


Figure 6–75. Alternative Combination 3 Cumulative Concentration Versus Time for Carbon Tetrachloride

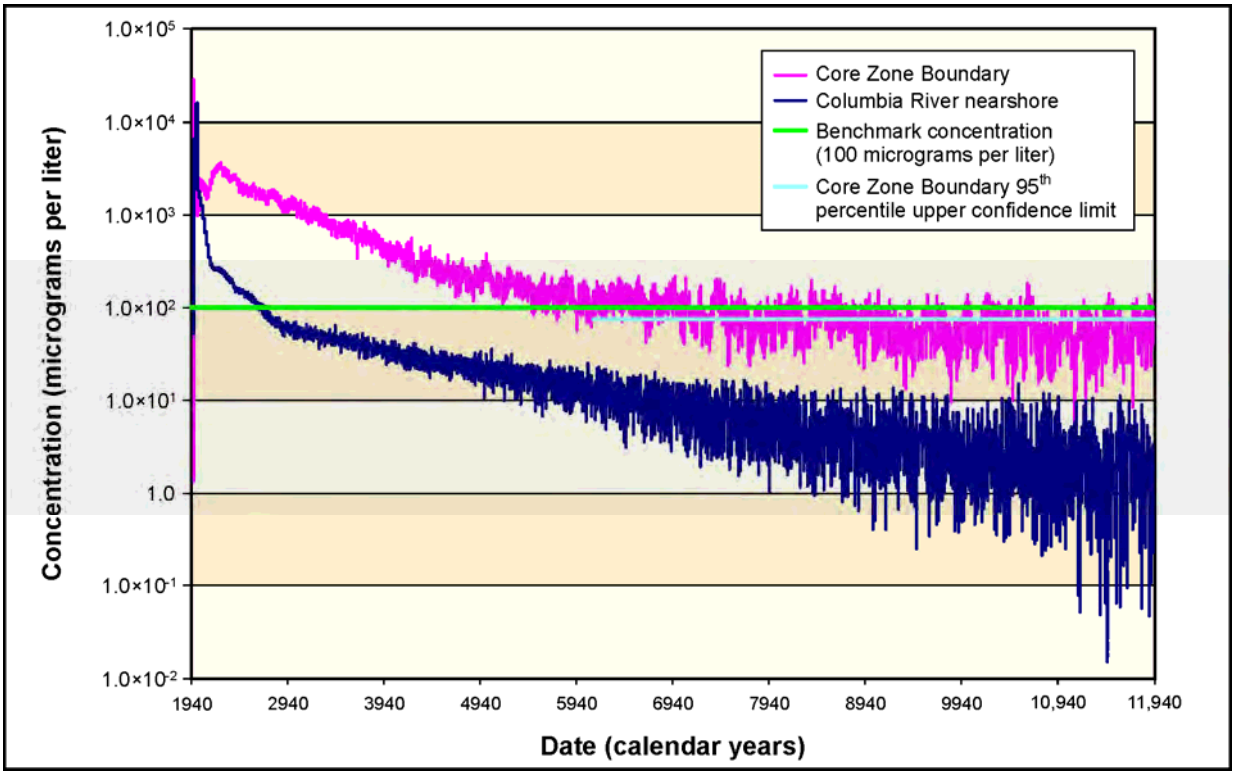


Figure 6–76. Alternative Combination 3 Cumulative Concentration Versus Time for Chromium

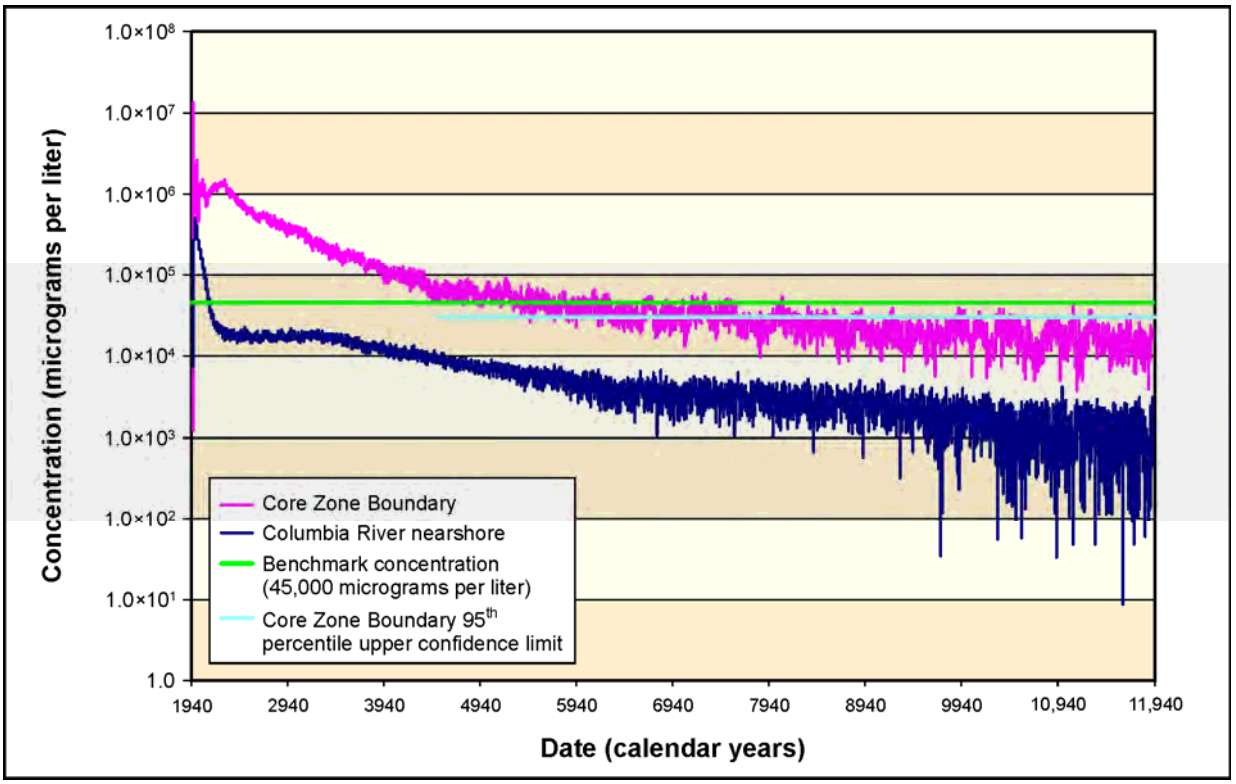


Figure 6–77. Alternative Combination 3 Cumulative Concentration Versus Time for Nitrate

Figures 6–78 and 6–79 show concentration versus time for uranium-238 and total uranium. Concentrations of uranium-238 and total uranium peak early in the period of analysis, and then maintain relatively constant for the remainder of the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and Columbia River is slowed relative to groundwater flow by a factor of about seven. After about 1,000 years, concentrations of both uranium-238 and total uranium exceed the benchmark concentration at the Core Zone Boundary by about an order of magnitude. Groundwater concentrations at the Columbia River nearshore remain within an order of magnitude of the benchmark during this time.

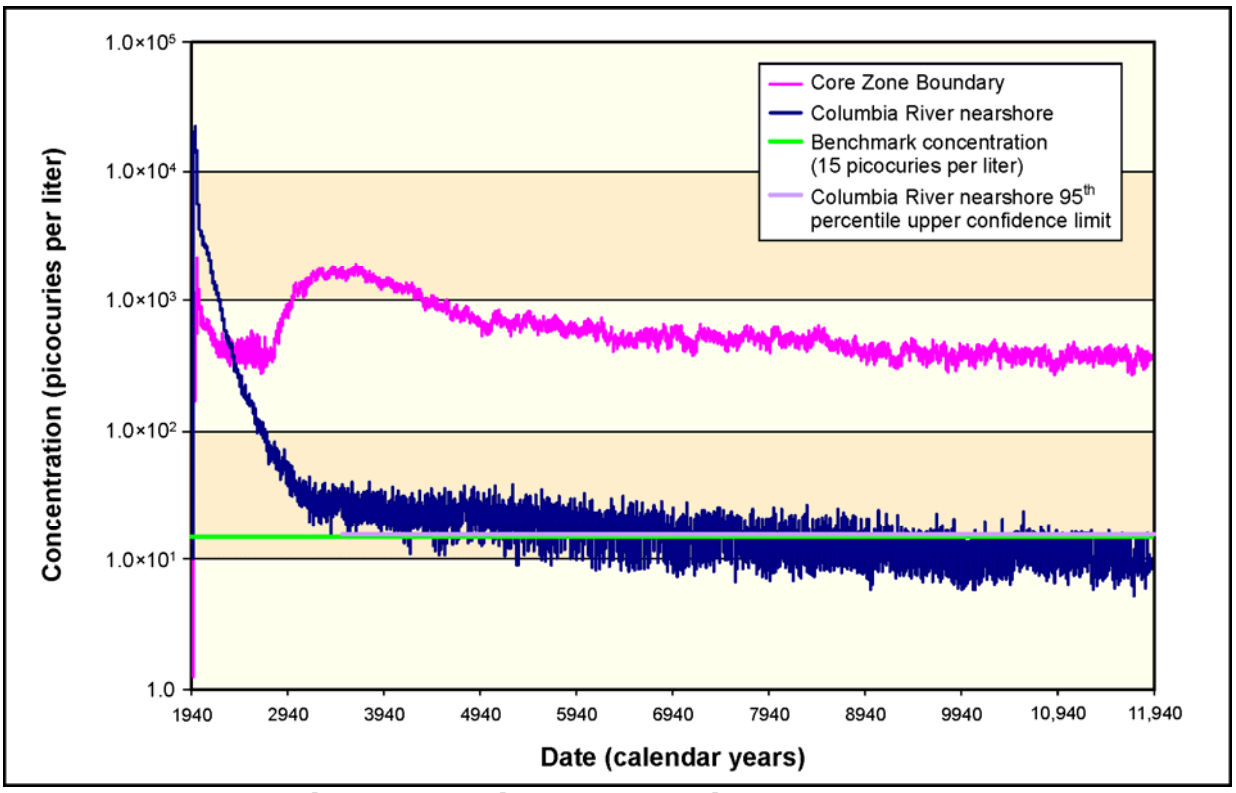


Figure 6–78. Alternative Combination 3 Cumulative Concentration Versus Time for Uranium-238

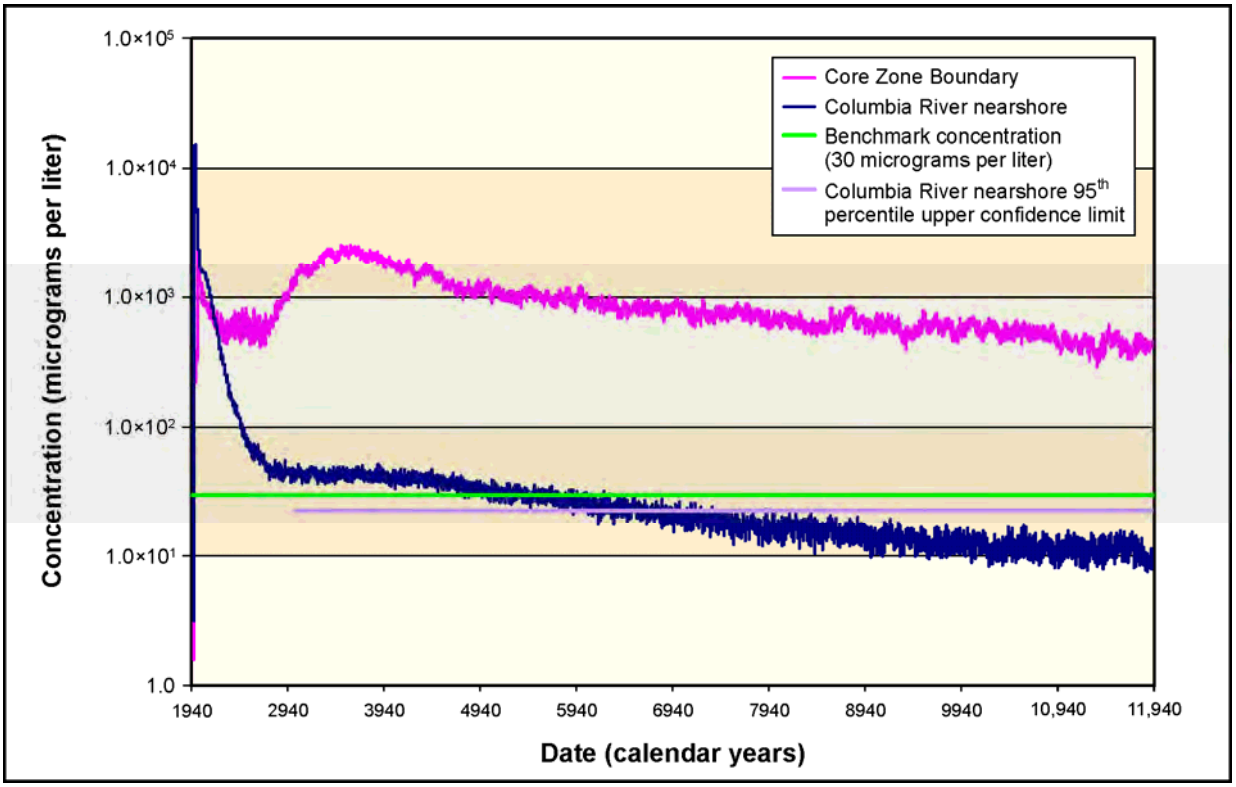


Figure 6–79. Alternative Combination 3 Cumulative Concentration Versus Time for Total Uranium

6.4.1.3.3 Analysis of Spatial Distribution of Concentration

This section presents the spatial distribution of groundwater concentrations at selected times. Concentrations for each radionuclide and chemical are indicated by a color scale which is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentrations ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 6–80 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Releases from cribs and trenches (ditches), primarily associated with non-*TC & WM EIS* sources within the PUREX Plant and the REDOX Facility areas, result in groundwater concentration plumes (exceeding the benchmark concentration) that extend from the southern part of the 200-West Area across the Core Zone, and extending from the eastern part of the Core Zone southeast to the Columbia River. Peak concentrations in this plume are about ten to fifty times greater than the benchmark. Tritium concentrations are attenuated by radioactive decay to levels less than one twentieth of the benchmark concentration by CY 2135.

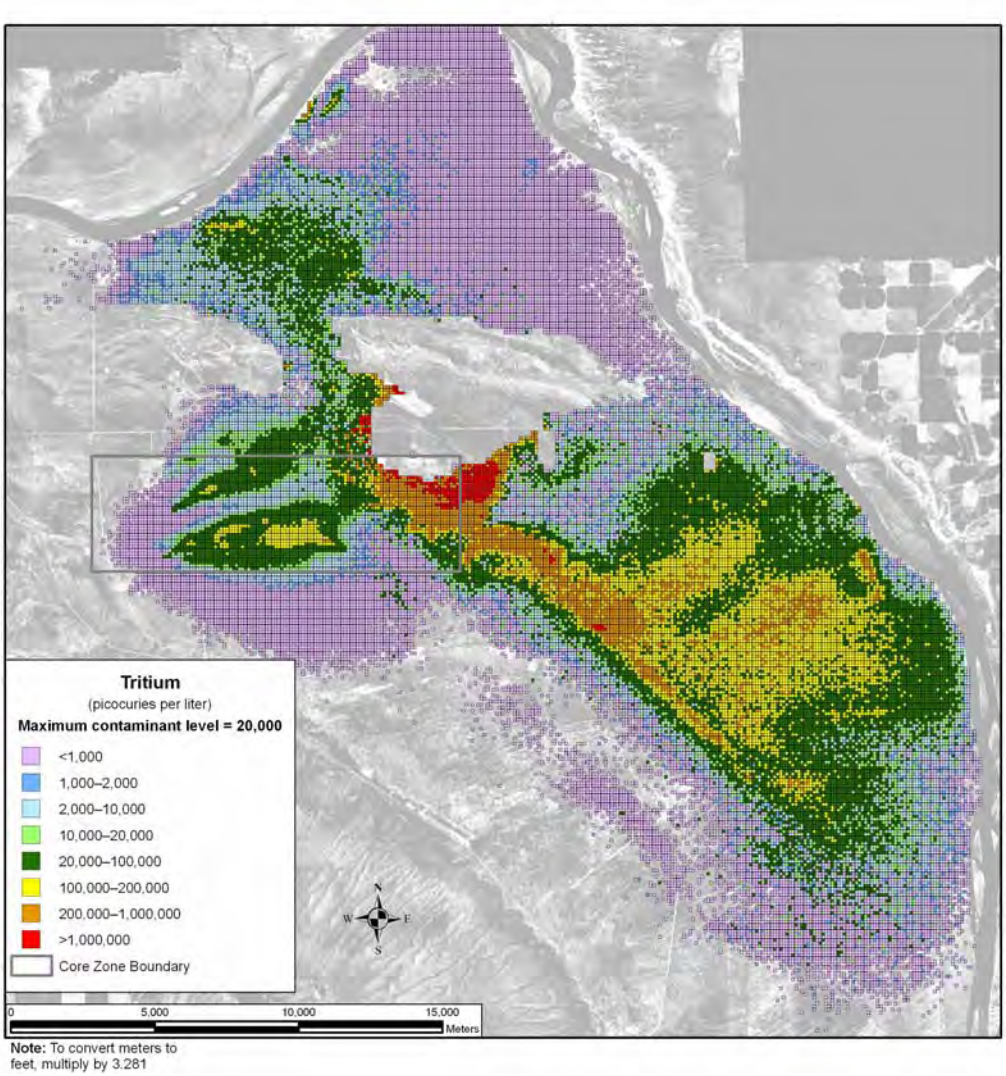


Figure 6–80. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Tritium During Calendar Year 2005

Figure 6–81 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceeding the benchmark concentration associated with the T Barrier, the B Barrier, and the A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone. Releases from the PUREX Plant area (non-*TC & WM EIS* sources) produce a plume extending south and east of the Core Zone with peak concentrations about 1 to 5 times the benchmark concentration. Around CY 3890 releases from other tank farm sources create an iodine-129 plume east of the Core Zone Boundary (see Figure 6–82). By CY 7140 the groundwater concentration distribution is driven primarily by waste management sources located at the IDF in the 200-East Area (see Figure 6–83). The impact is characterized by a plume exceeding the benchmark concentration by more than an order of magnitude that is located east of the Core Zone. Because of retention in the waste forms, this impact lasts to the end of the 10,000-year period of analysis (see Figure 6–84). Figure 6–85 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. After an early peak related to releases from the PUREX Plant area, the area of exceedance peaks between CY 3240 and CY 4540 driven primarily by releases from other tank farm sources. A secondary peak at later times results from releases at IDF. Figures 6–86 through 6–90 show the spatial distribution at the same three times and the total area of

exceedance versus time for technetium-99. The spatial distribution of technetium-99 does not include contributions from the PUREX Plant sources (compare to iodine-129 distributions) and is dominated by releases from other tank farm sources and IDF. Chromium (see Figures 6–91 through 6–94) and nitrate (see Figures 6–95 through 6–98) show similar spatial distributions to technetium-99.

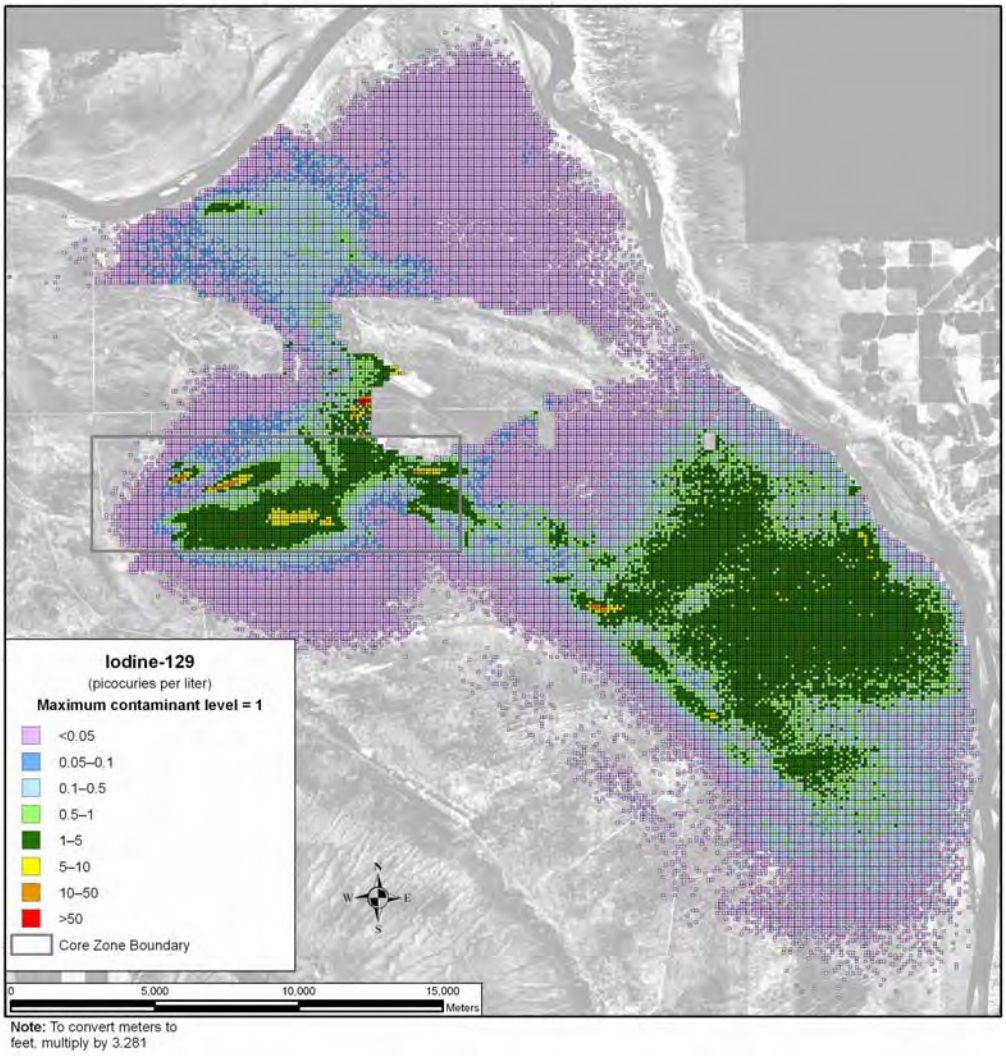


Figure 6–81. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 2005

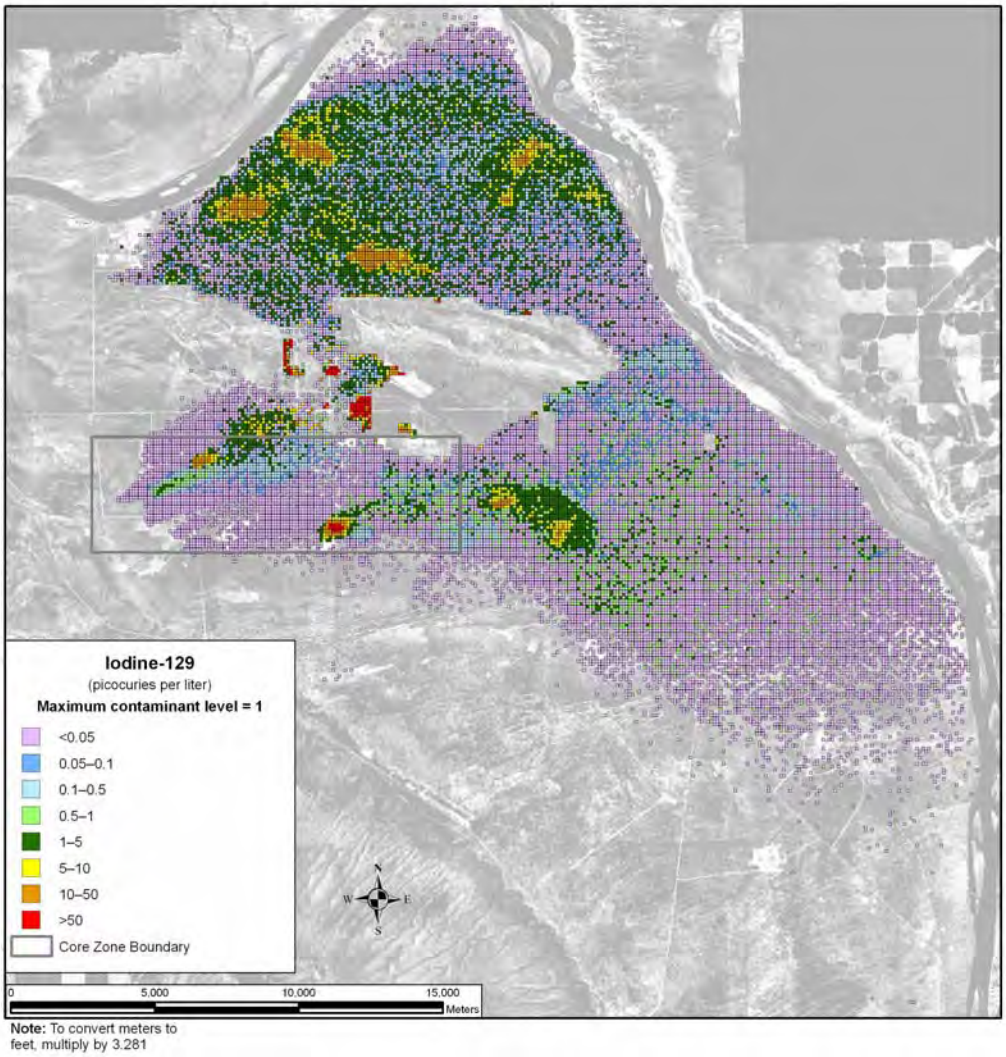


Figure 6–82. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 3890

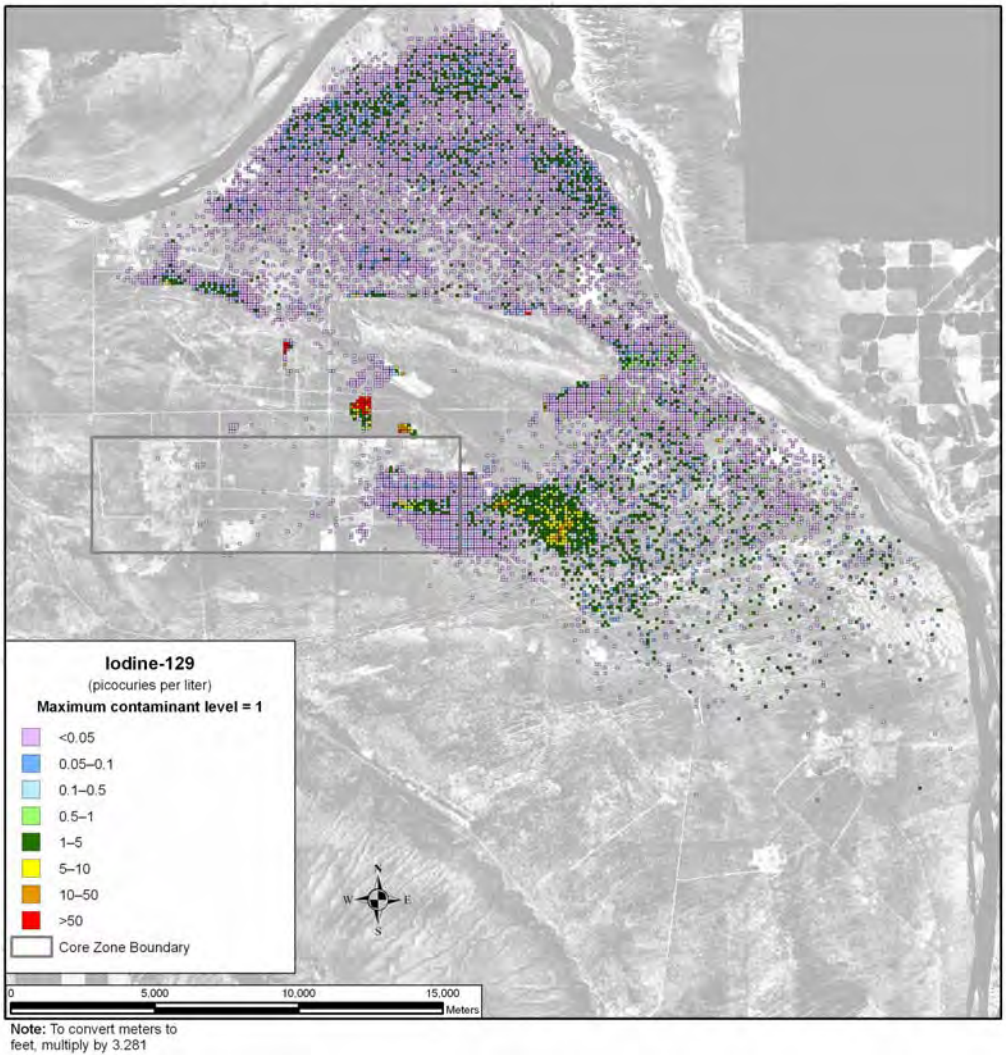


Figure 6–83. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 7140

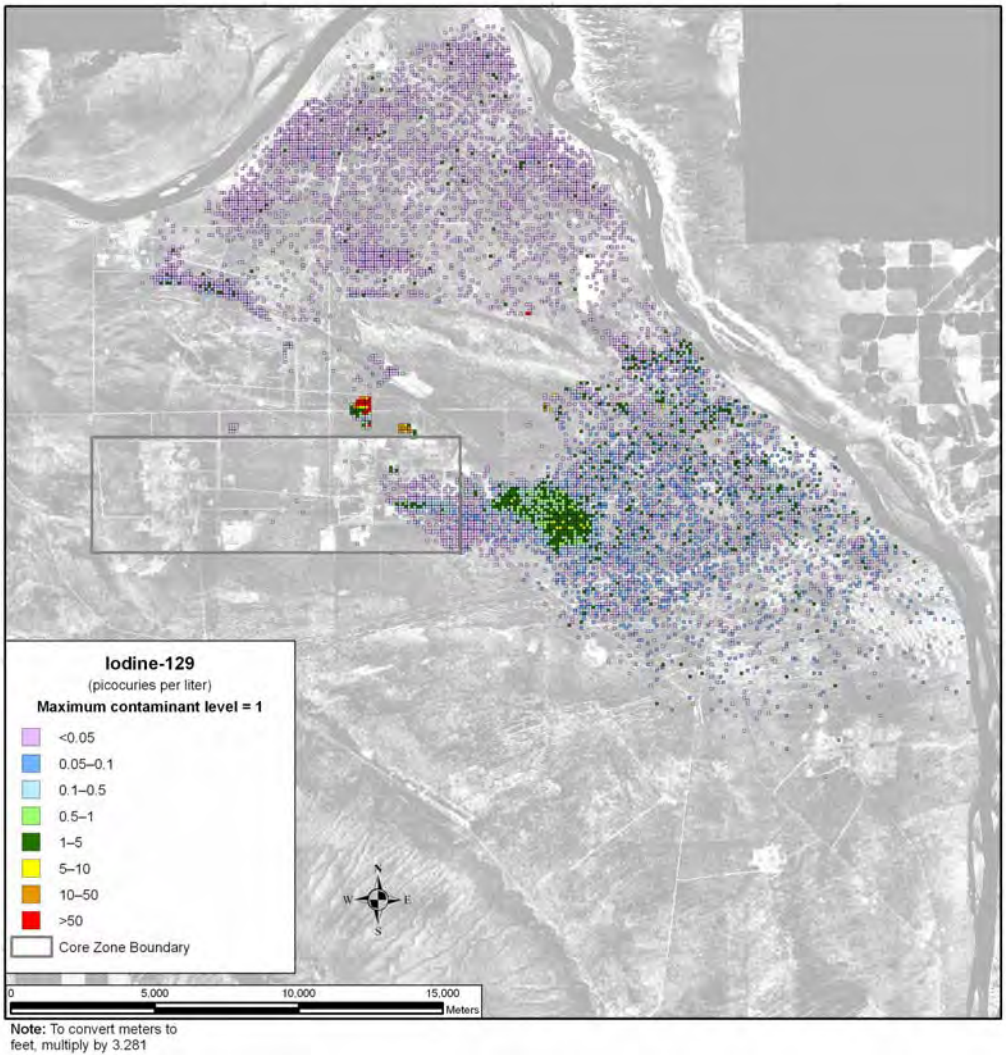


Figure 6–84. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Iodine-129 During Calendar Year 11,885

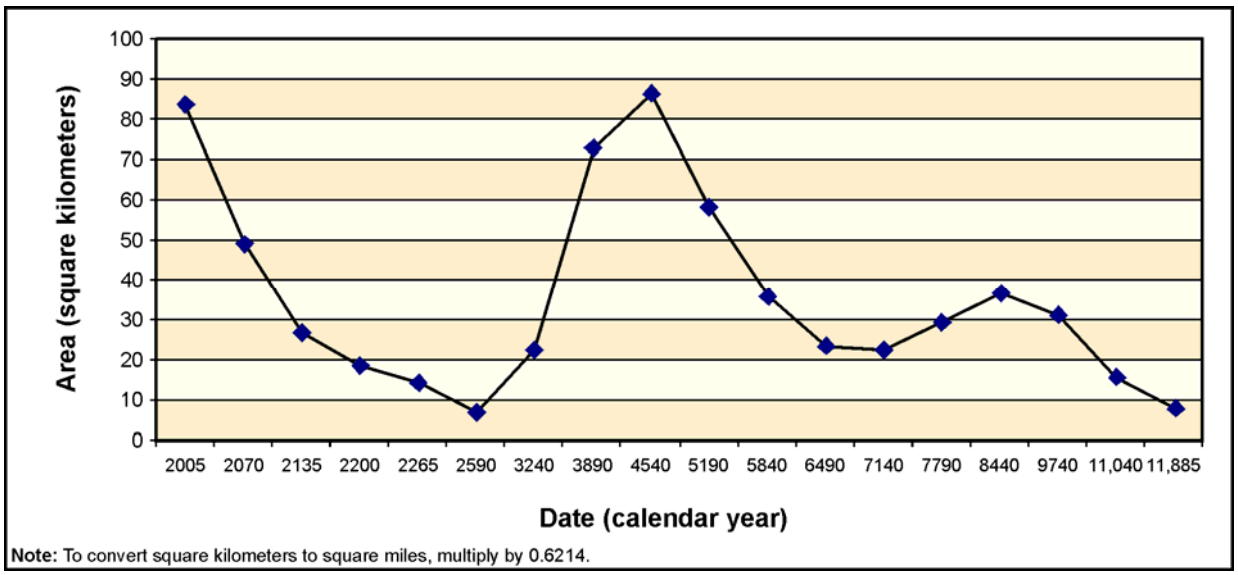


Figure 6–85. Alternative Combination 3 Total Area for Which Cumulative Groundwater Concentrations of Iodine-129 Exceed the Benchmark Concentration as a Function of Time

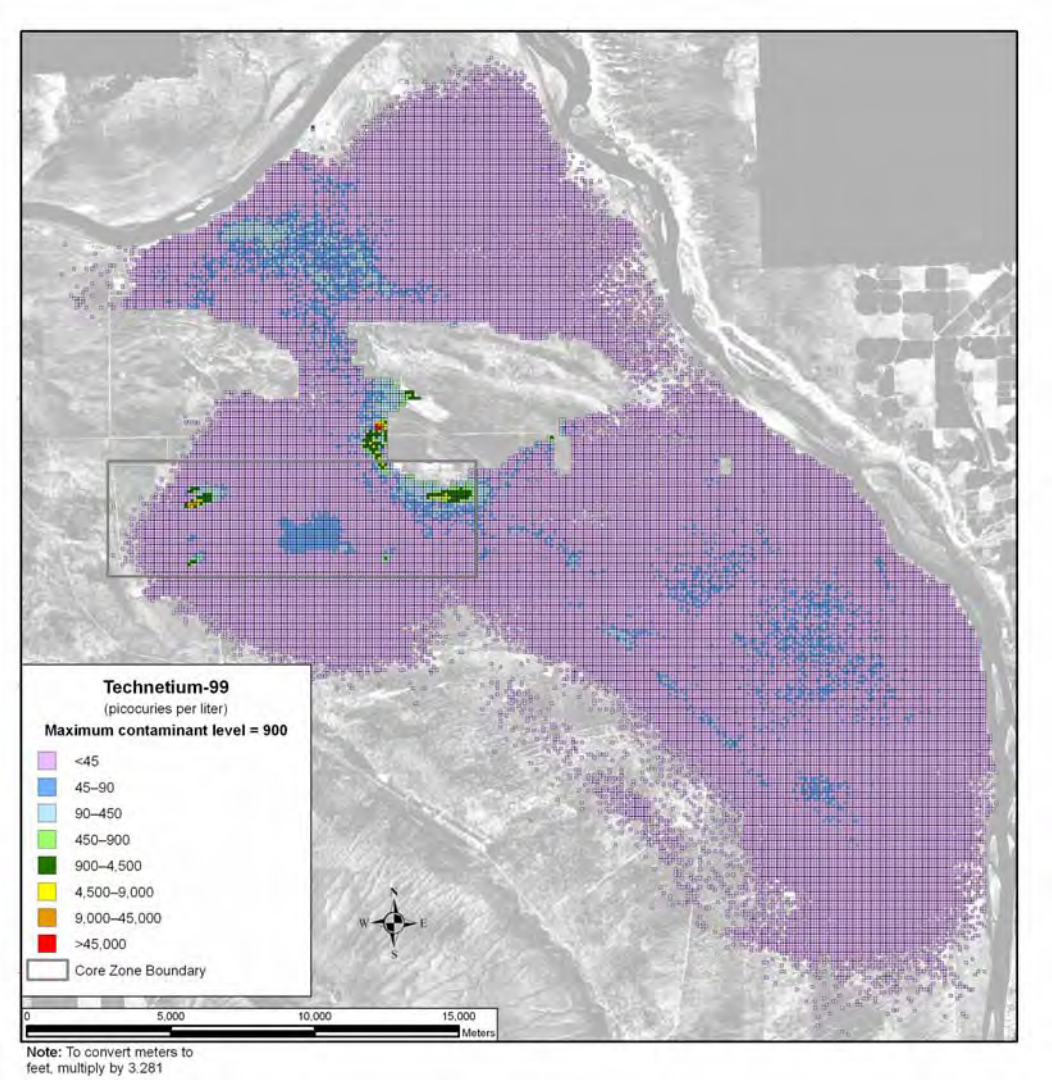


Figure 6–86. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 2005

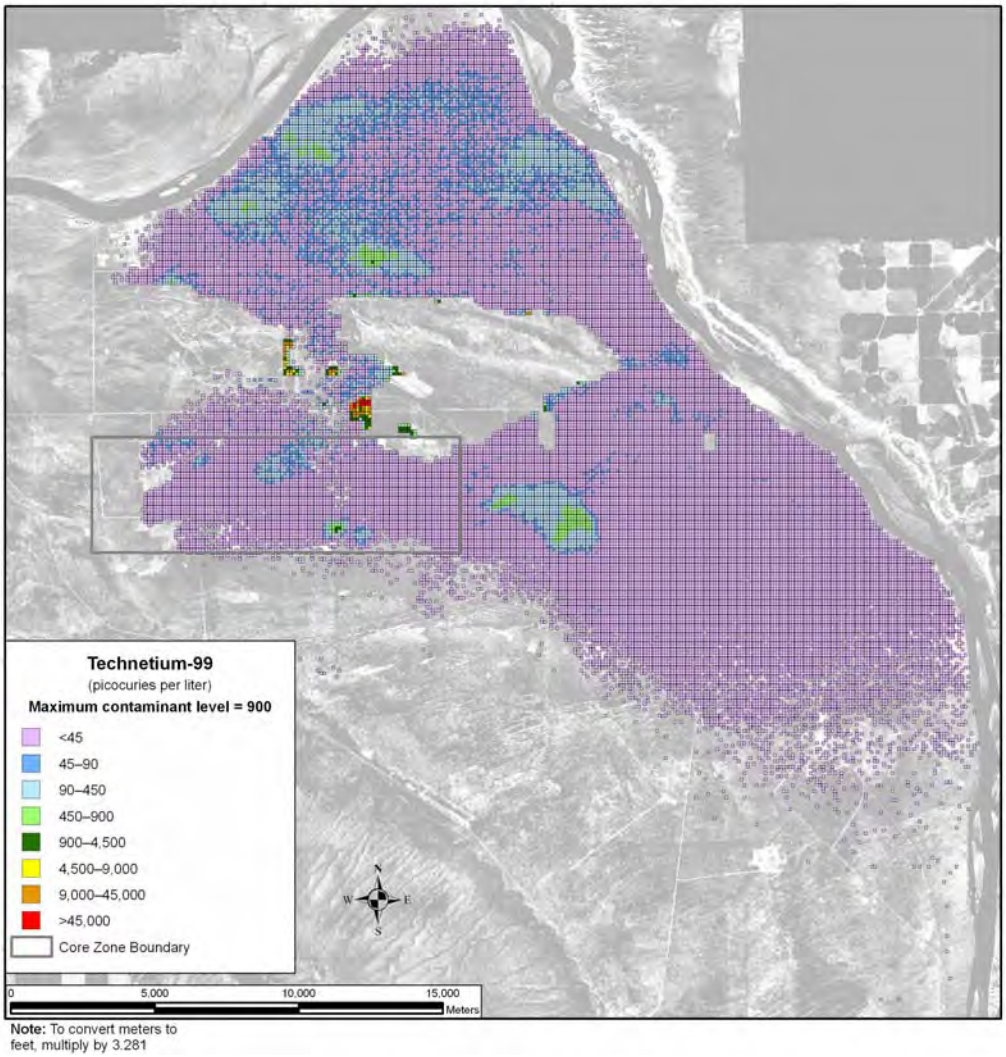


Figure 6–87. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 3890

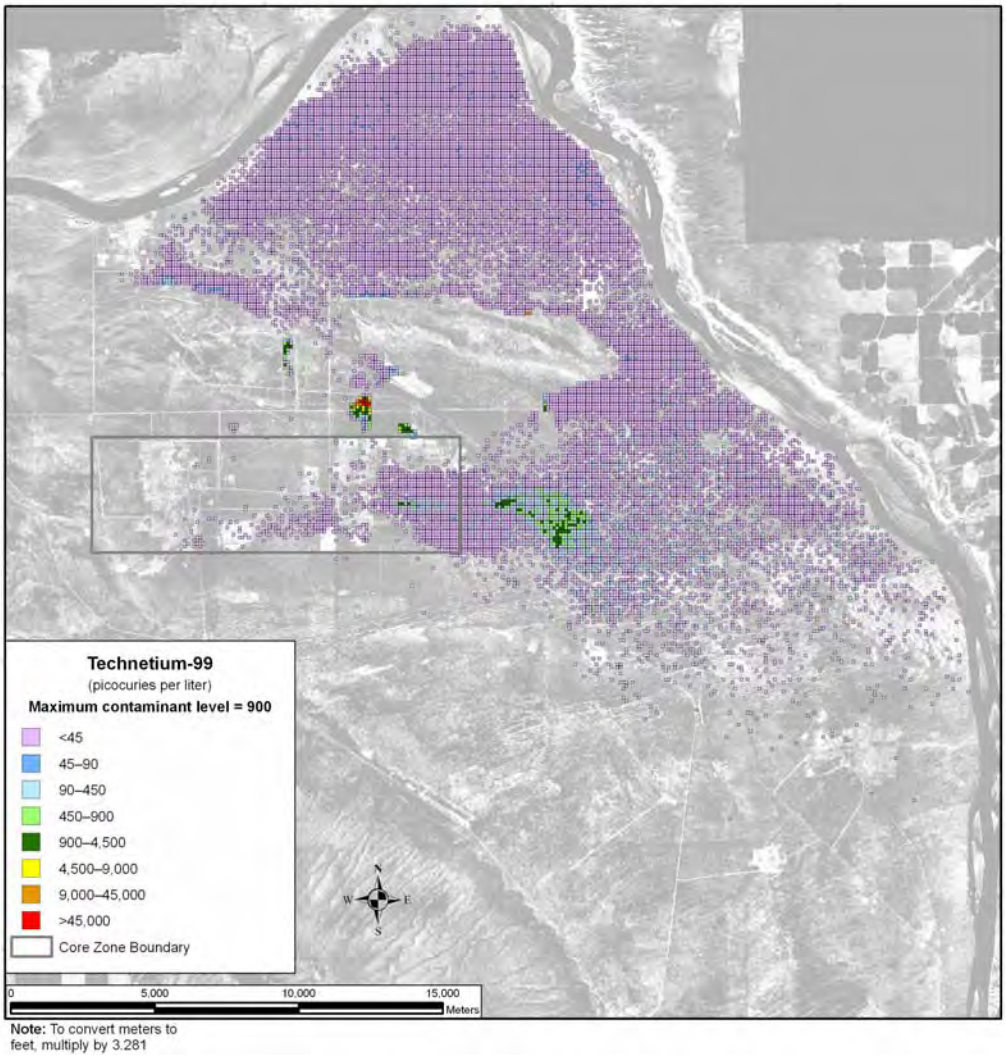


Figure 6–88. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 7140

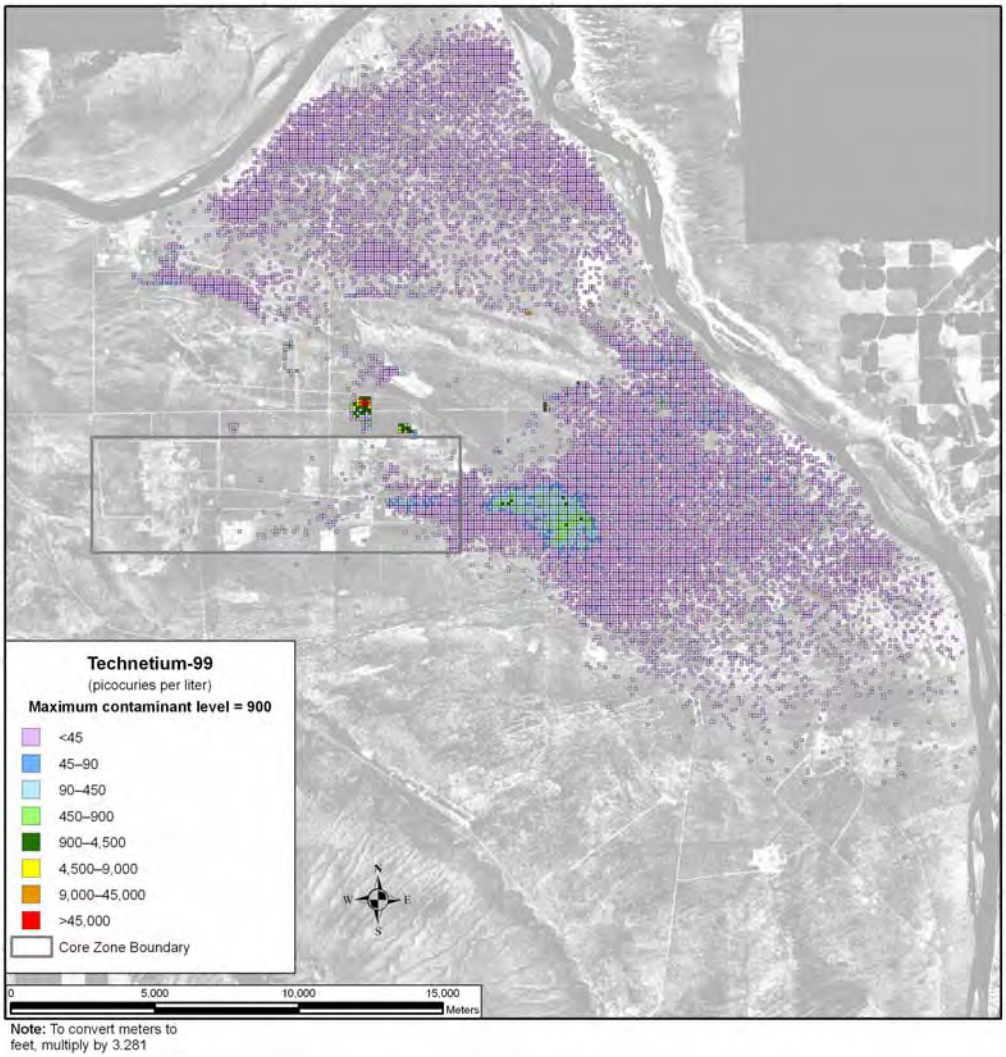


Figure 6–89. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Technetium-99 During Calendar Year 11,885

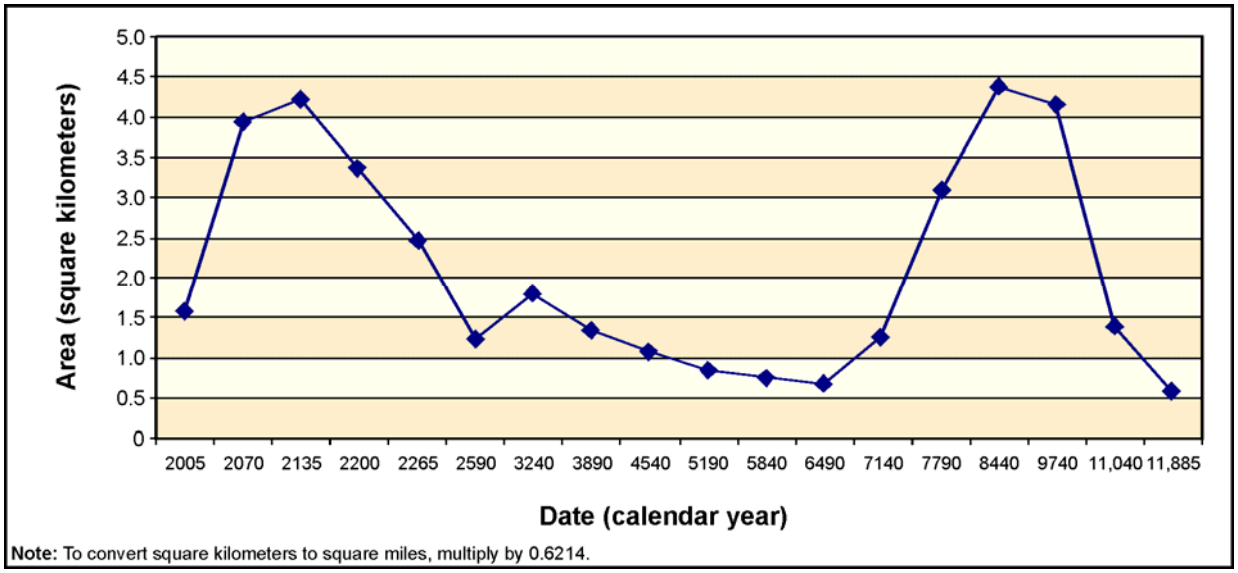


Figure 6–90. Alternative Combination 3 Total Area for Which Cumulative Groundwater Concentrations of Technetium-99 Exceed the Benchmark Concentration as a Function of Time

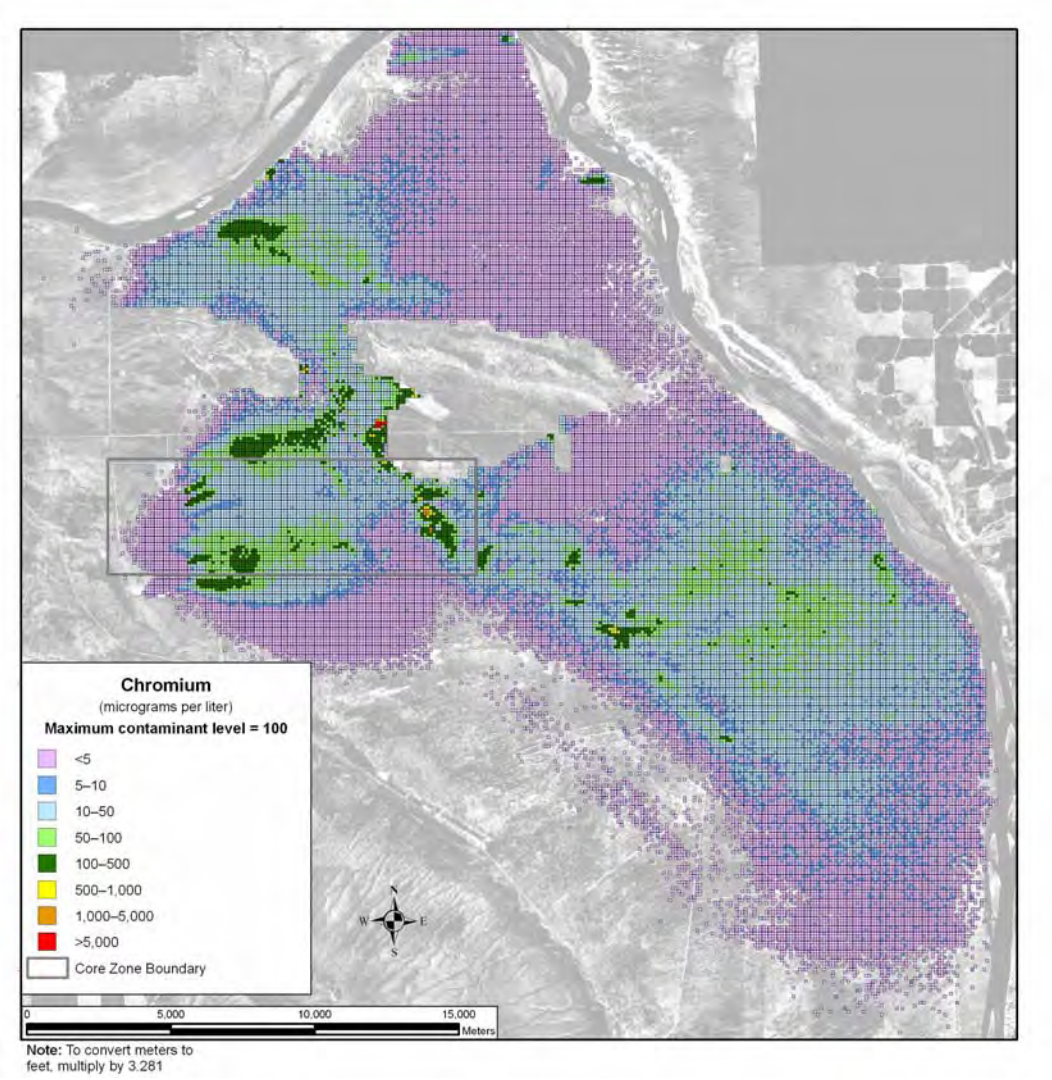


Figure 6–91. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 2005

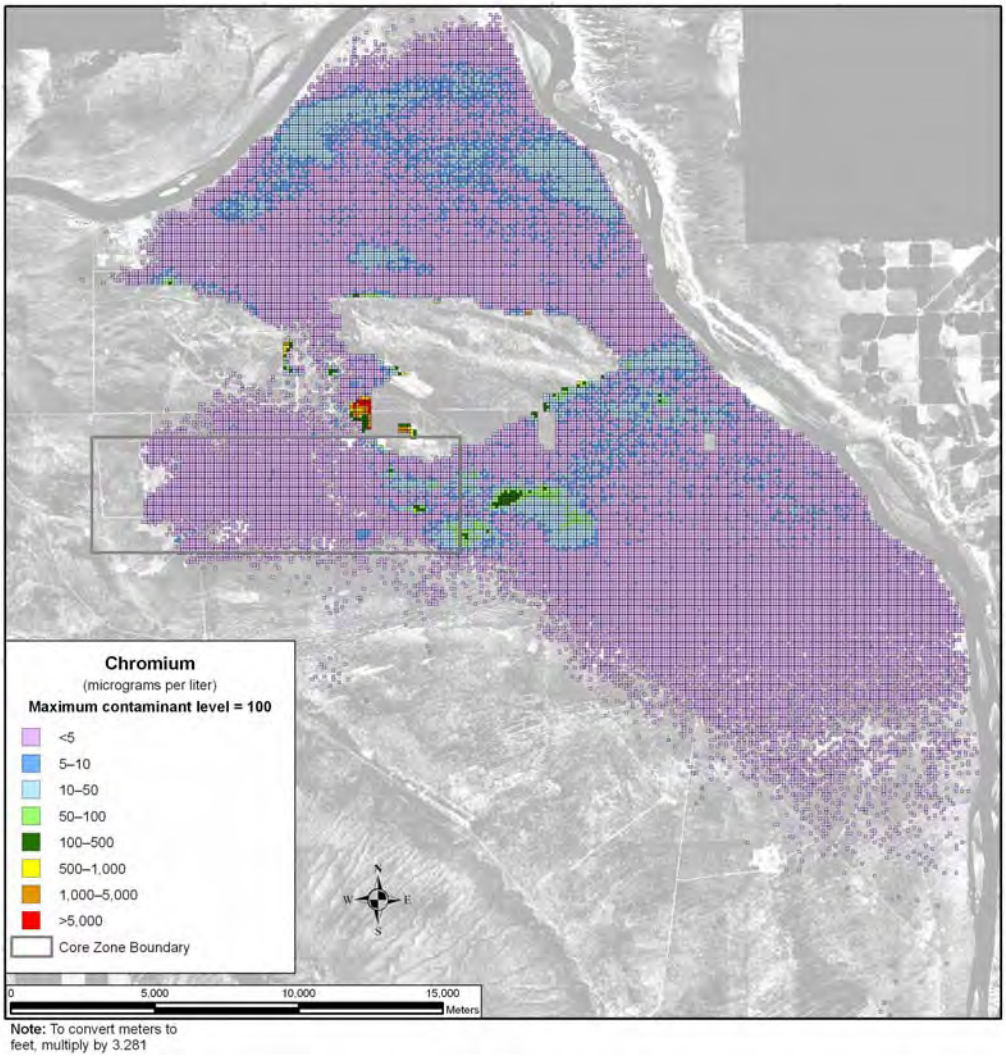


Figure 6–92. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 3890

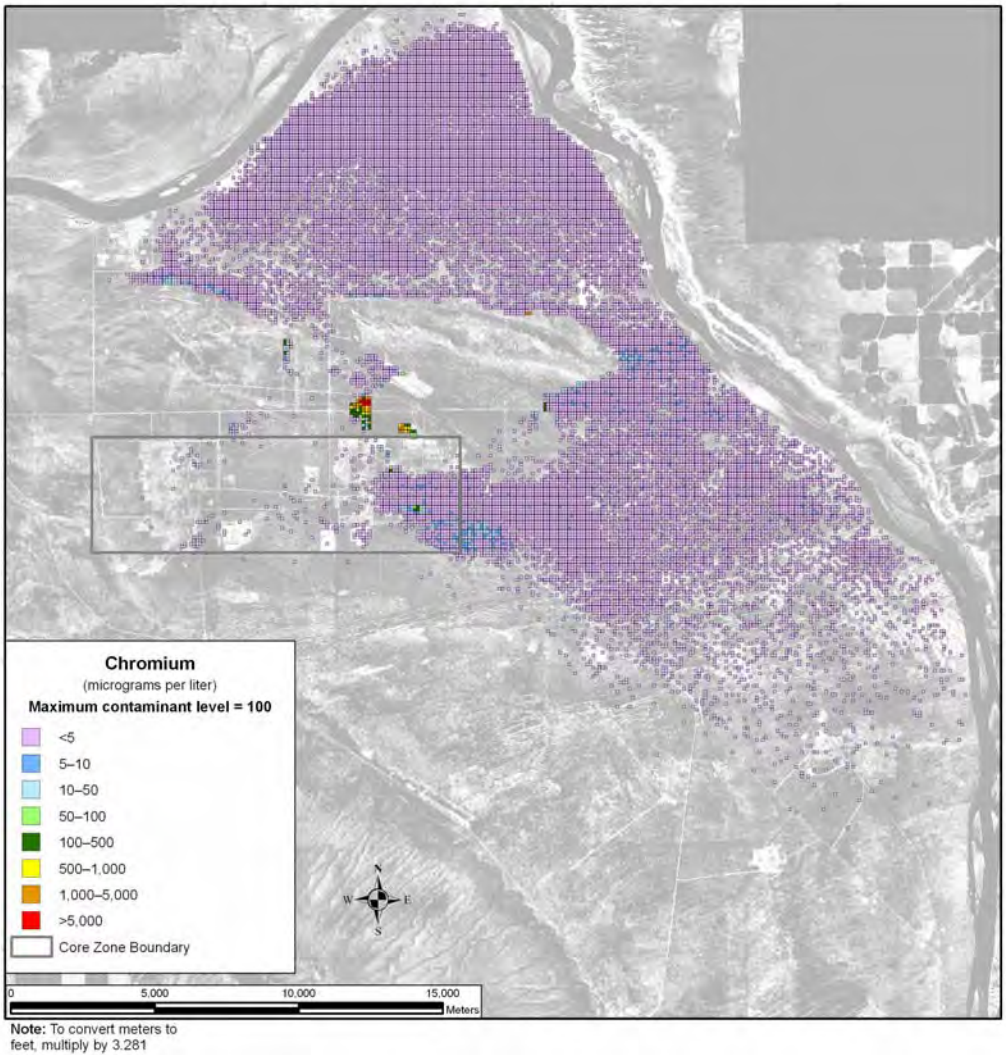


Figure 6–93. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 7140

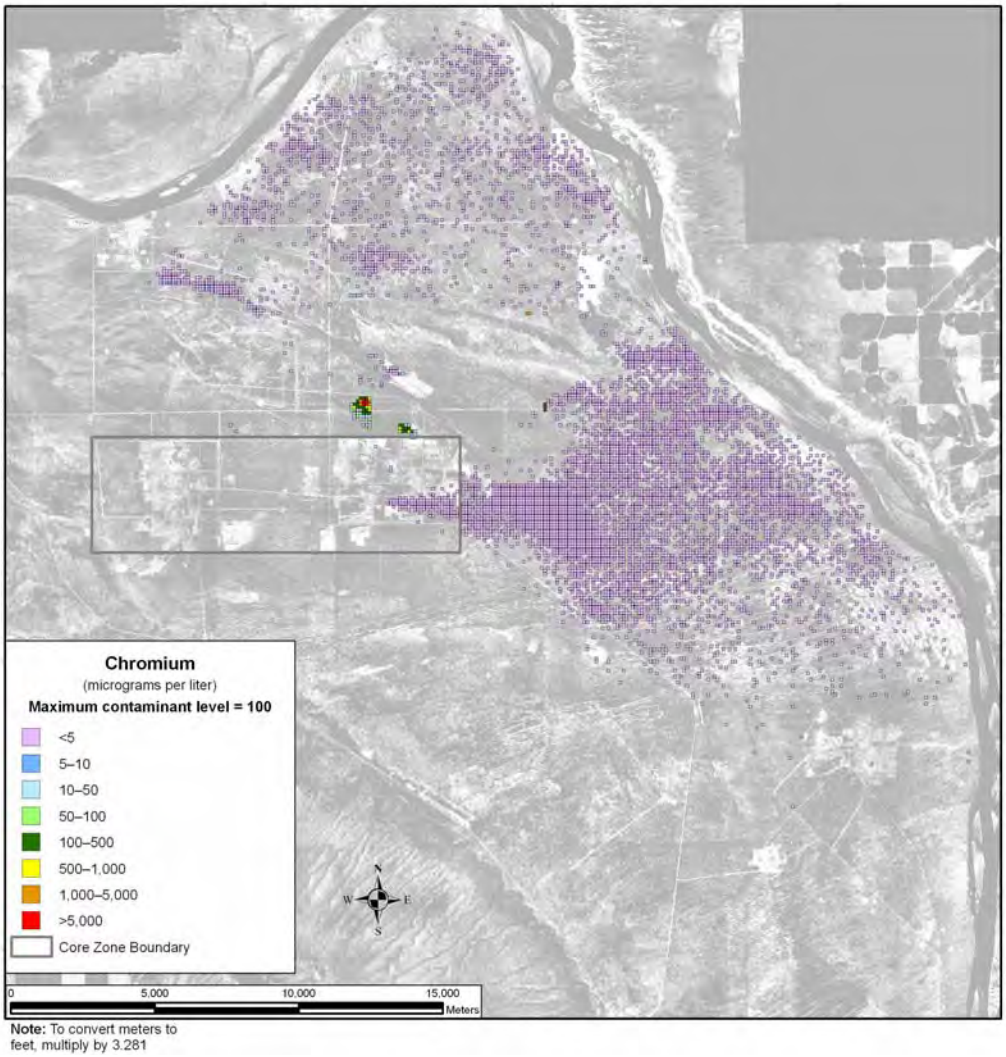


Figure 6–94. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Chromium During Calendar Year 11,885

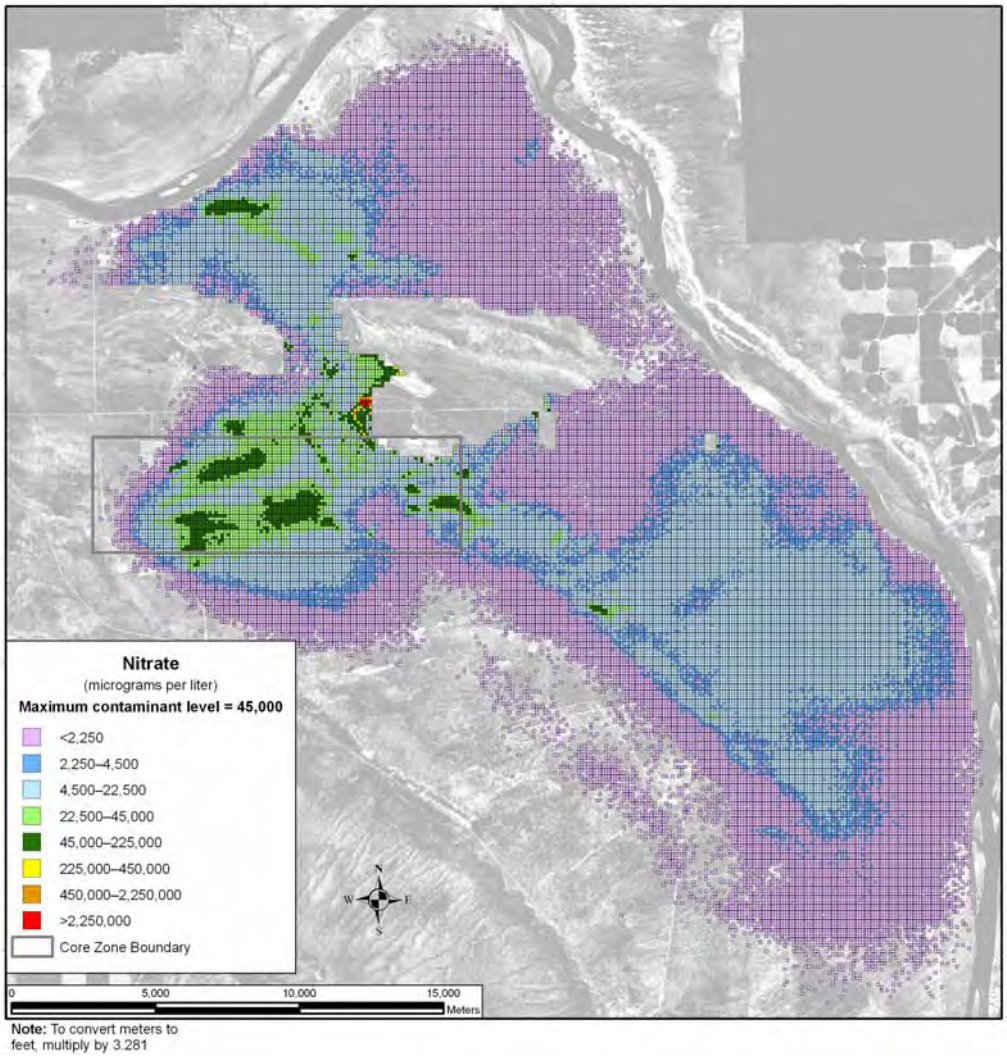


Figure 6–95. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 2005

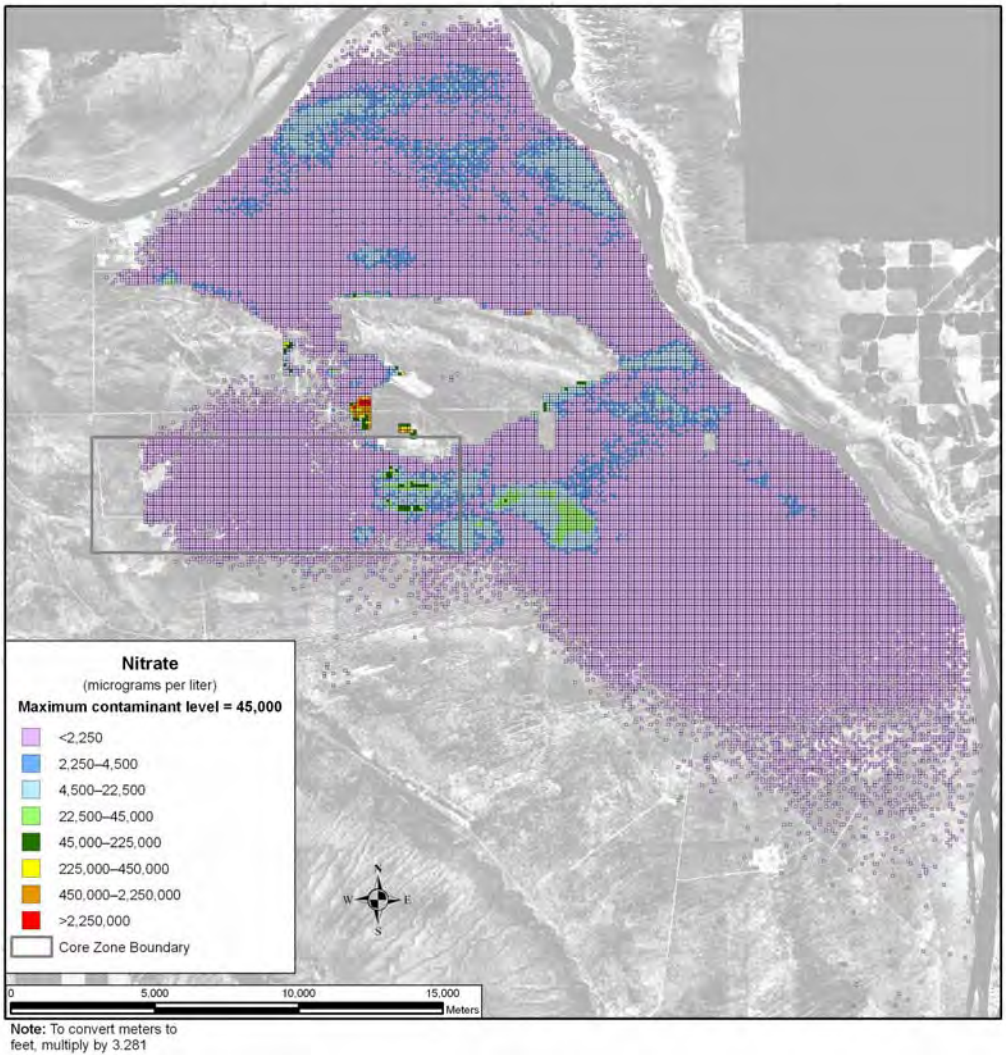


Figure 6–96. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 3890

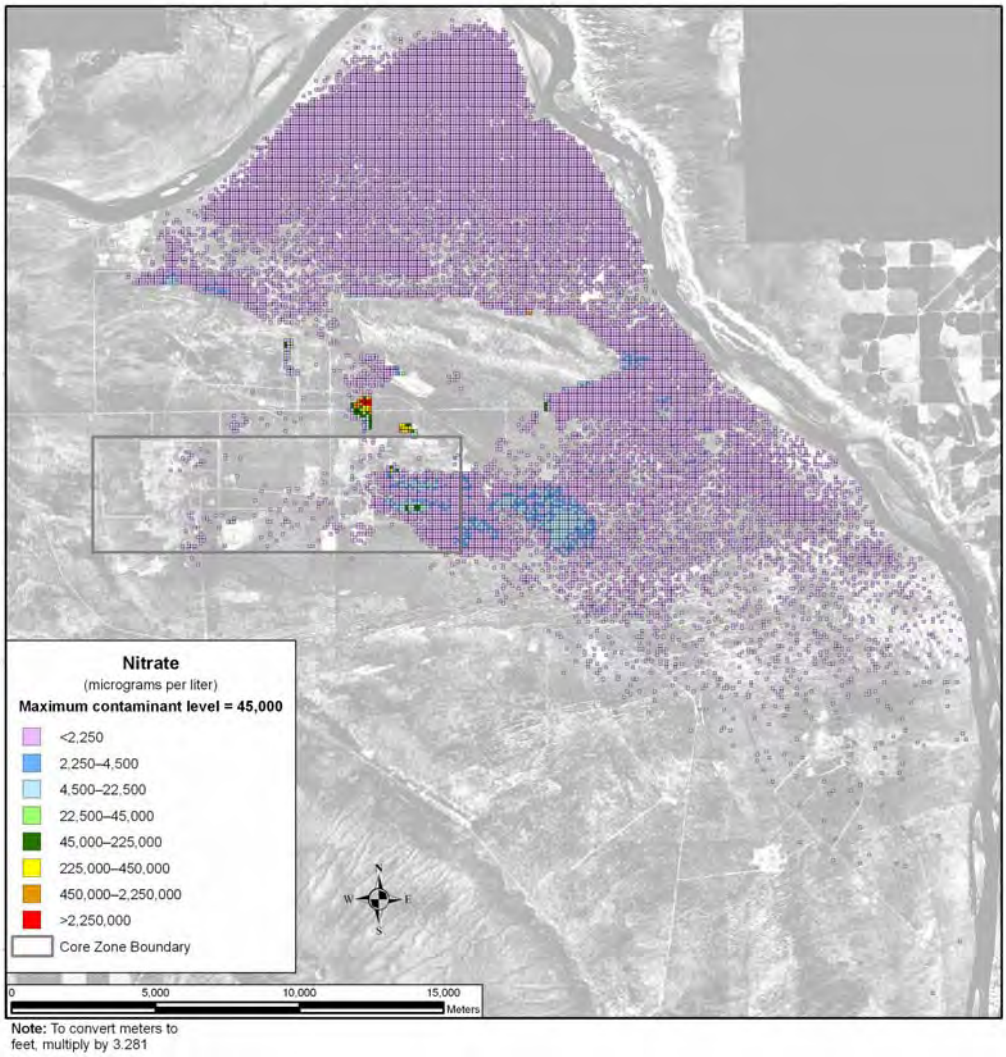


Figure 6–97. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 7140

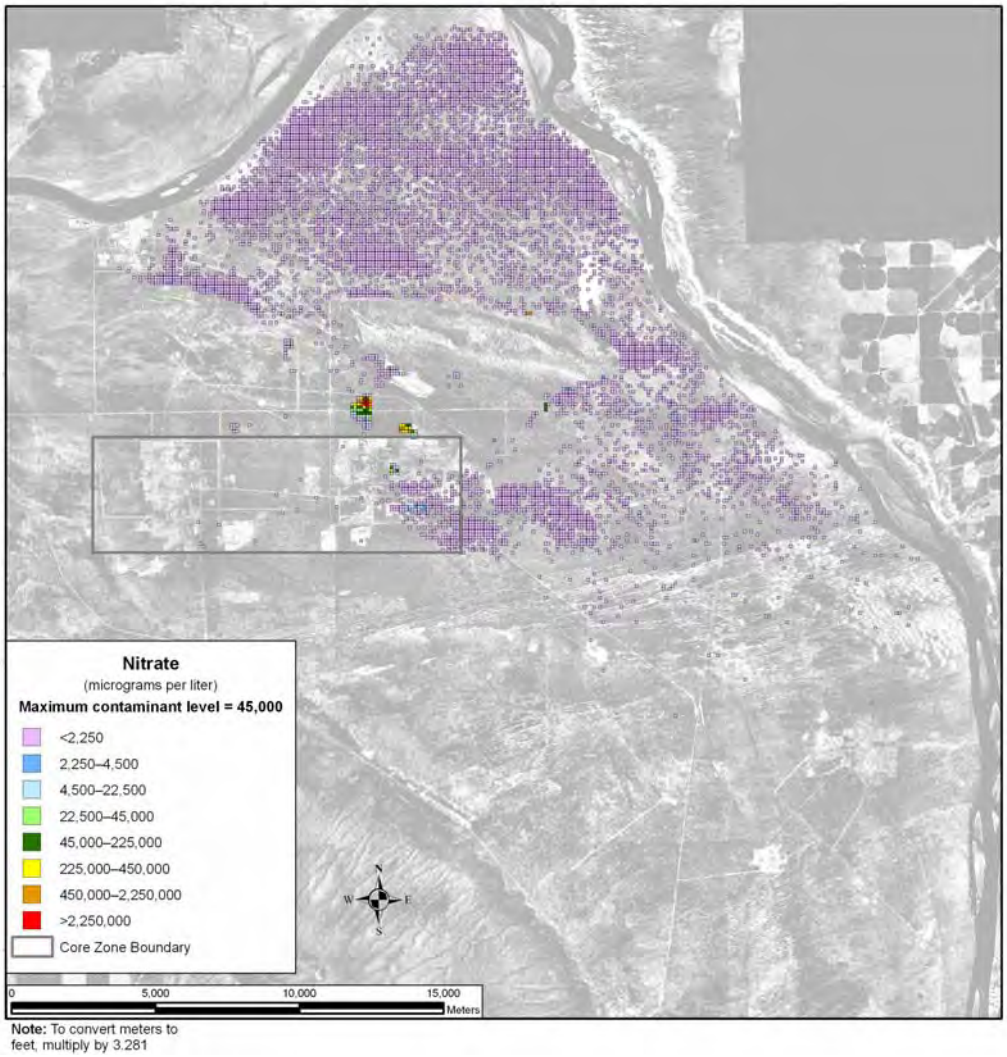


Figure 6–98. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Nitrate During Calendar Year 11,885

The carbon tetrachloride distribution is dominated by non-*TC & WM EIS* sources associated with the Z Area within the 200-West Area. The spatial distribution during CY 2005, shown in Figure 6–99, is a large plume covering most of the 200-West Area, with peak concentrations over an order of magnitude greater than the benchmark concentration. Note that this model result does not include the effects of carbon tetrachloride removal and containment in the 200-West Area. Figures 6–100 and 6–101 show the dissipation of the plume over time at CY 2135 and CY 3890, respectively.

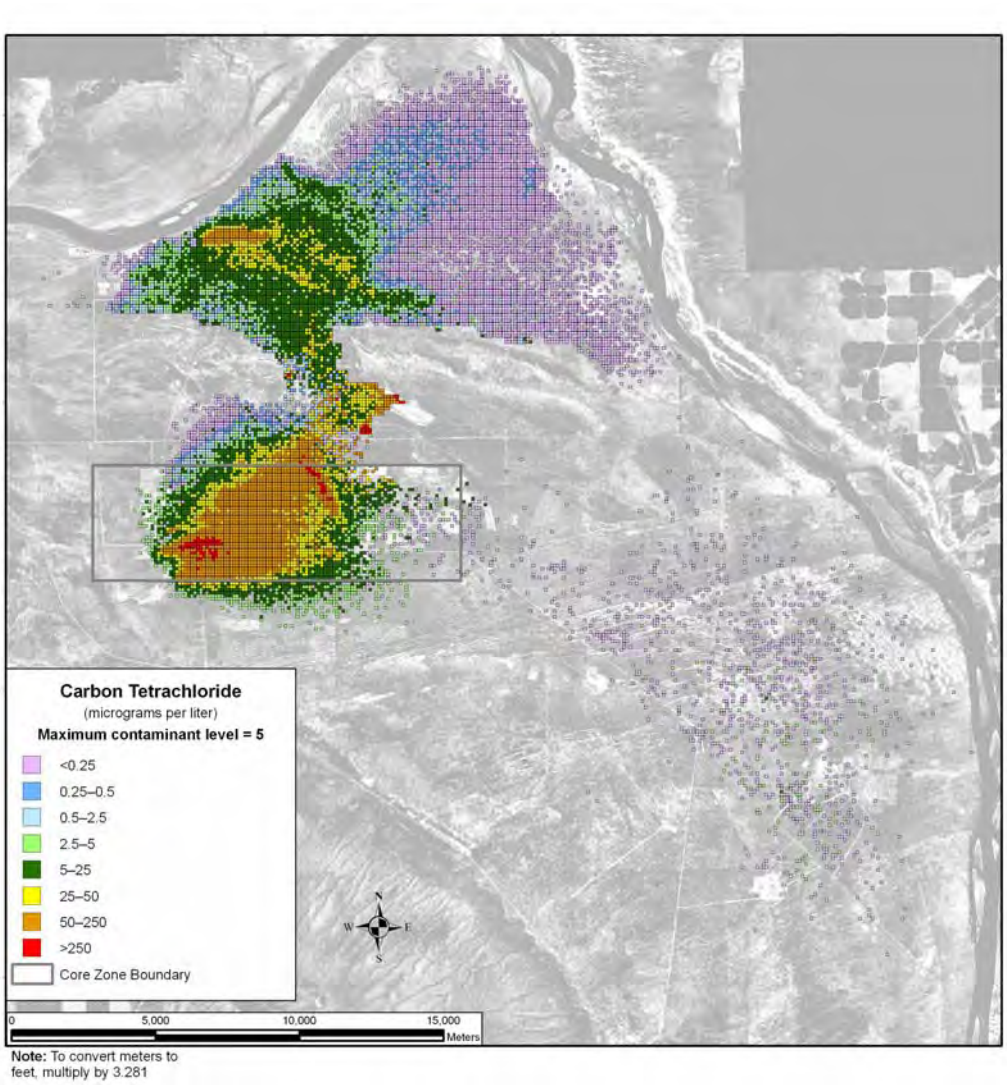


Figure 6–99. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 2005

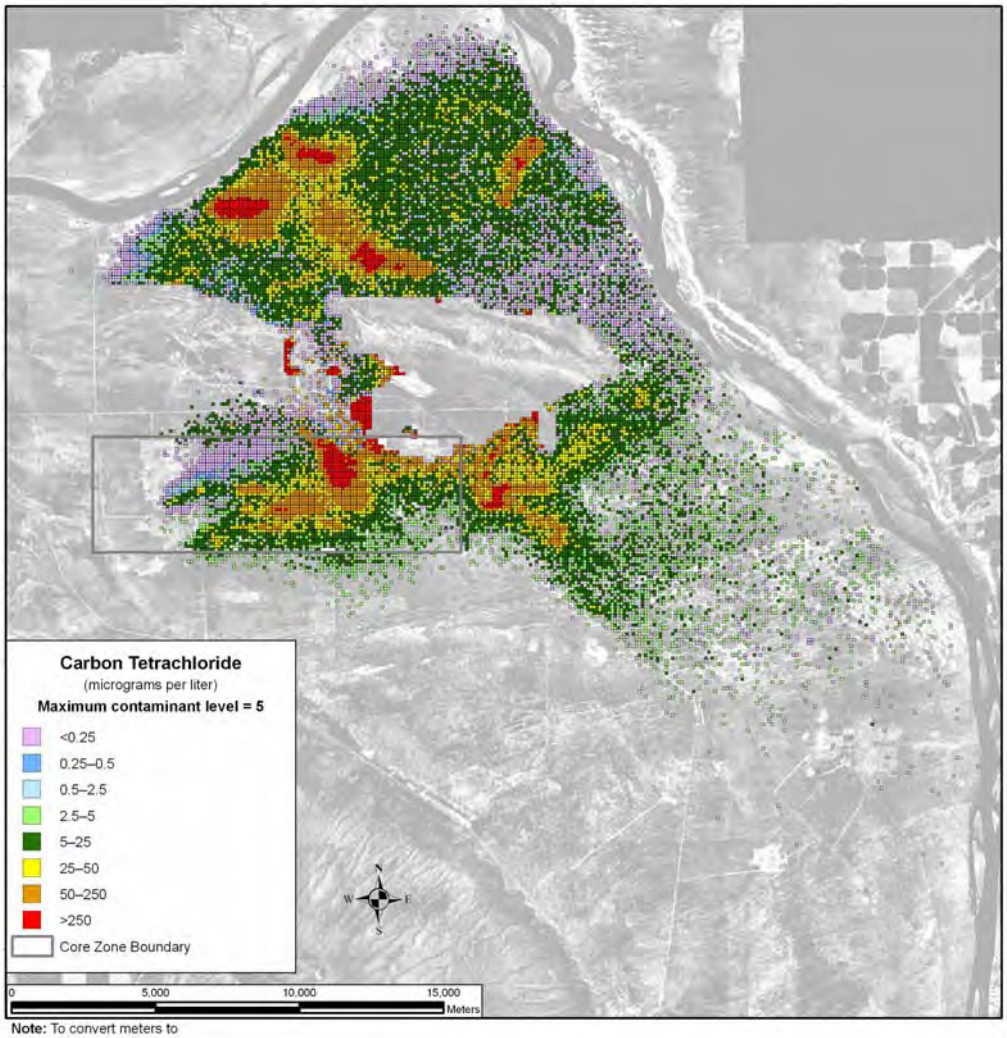


Figure 6–100. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 2135

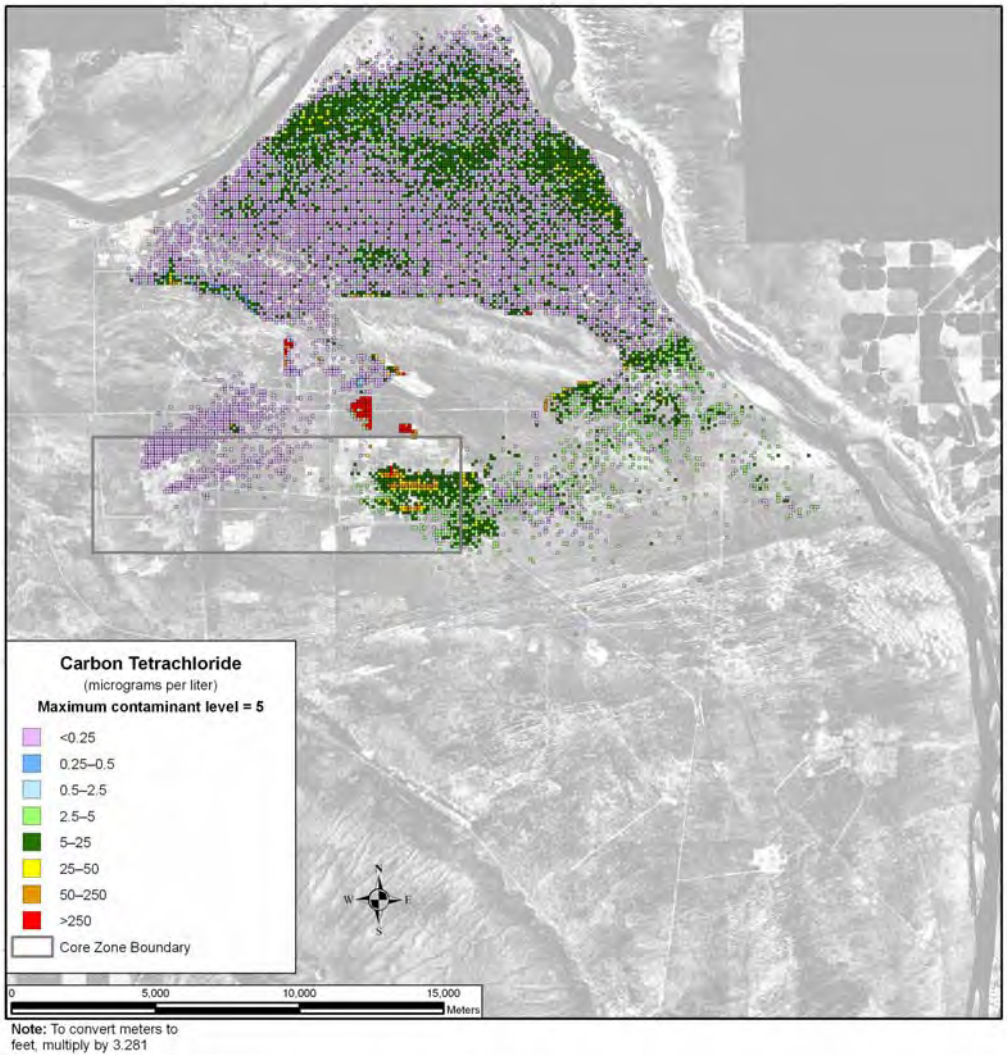


Figure 6–101. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Carbon Tetrachloride During Calendar Year 3890

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the porewater velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 6–102 shows the distribution of uranium-238 during CY 2135. There are two plumes associated with releases from the ponds (non-*TC & WM EIS* sources) in the 200-East and 200-West Areas with peak concentrations that exceed the benchmark by an order of magnitude. By CY 3890 (see Figure 6–103) these plumes have dissipated, but releases from other tank farm sources (primarily within the A Barrier) have produced a second plume east of the Core Zone, with peak concentrations about an order of magnitude greater than the benchmark. At CY 11,885 (see Figure 6–104) the plumes from other tank farm sources have extended this plume and produced additional plumes in the 200-West Area. Figure 6–105 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest early in the analysis (non-*TC & WM EIS* sources, primarily ponds) with an upward trend toward the end of the period of analysis (other tank farm sources). Figures 6–106 through 6–108 show the corresponding spatial distributions for total uranium.

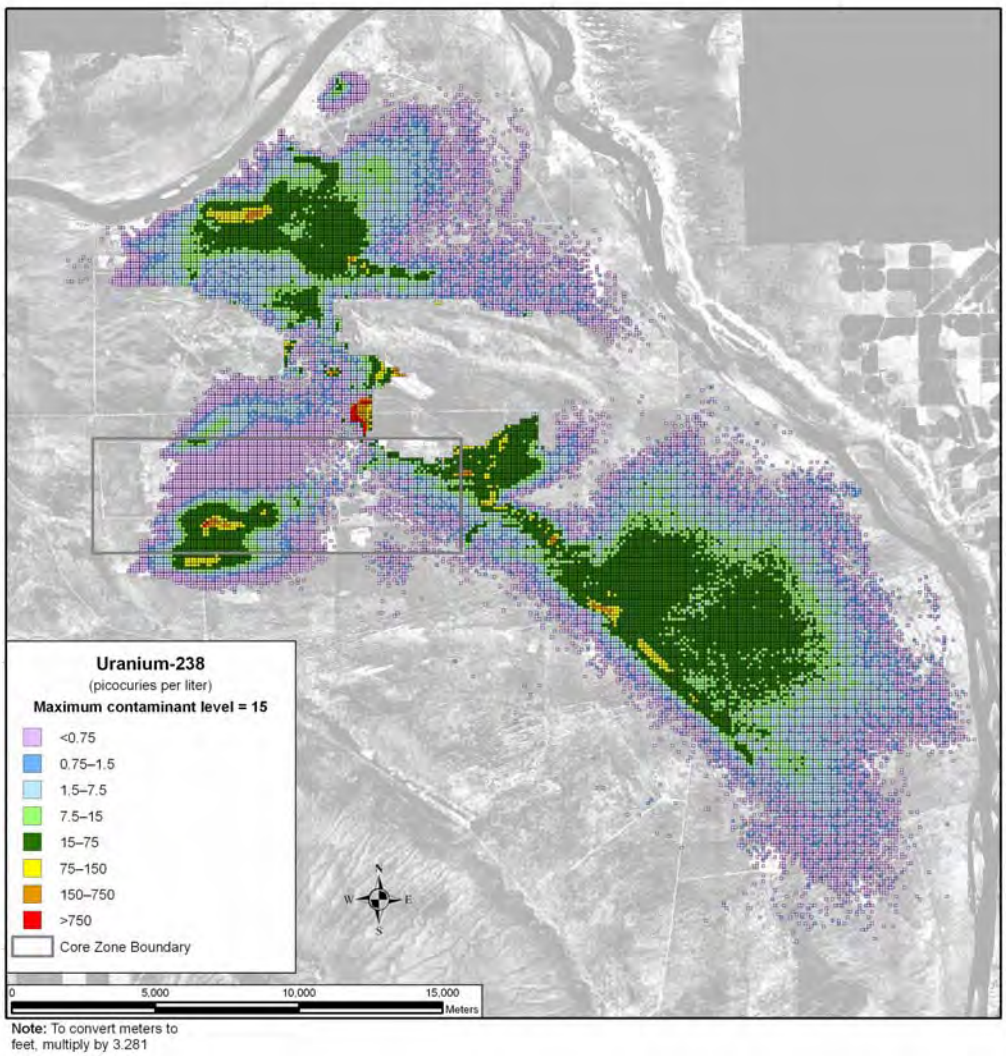


Figure 6–102. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 2135

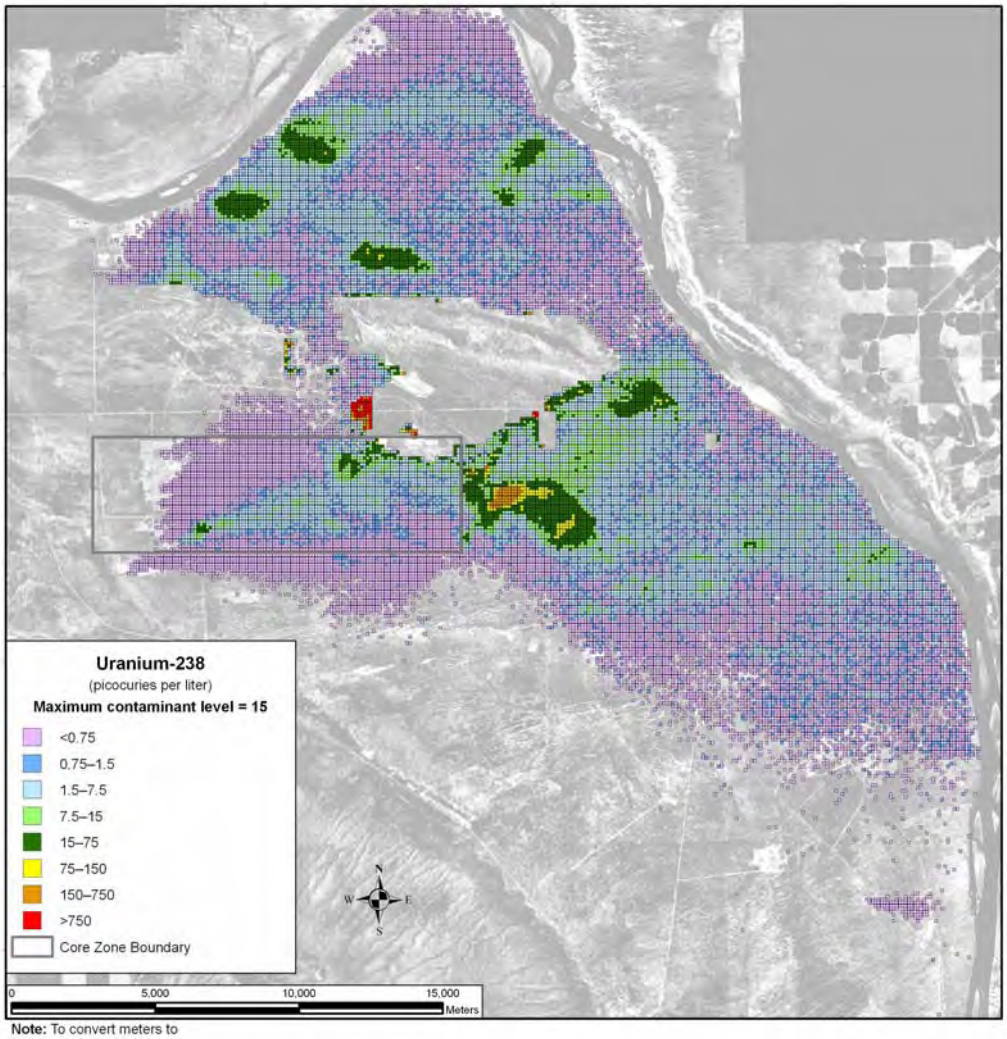


Figure 6–103. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 3890

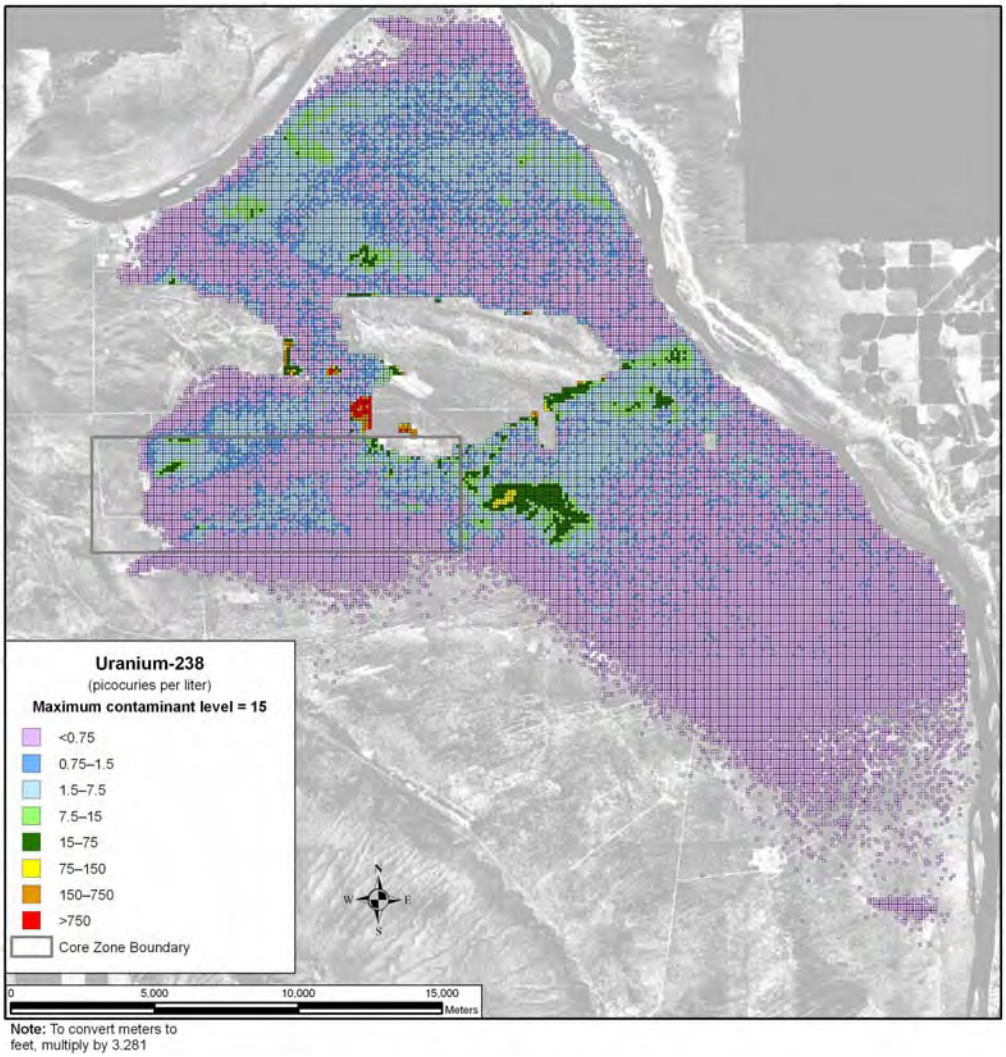


Figure 6–104. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Uranium-238 During Calendar Year 11,885

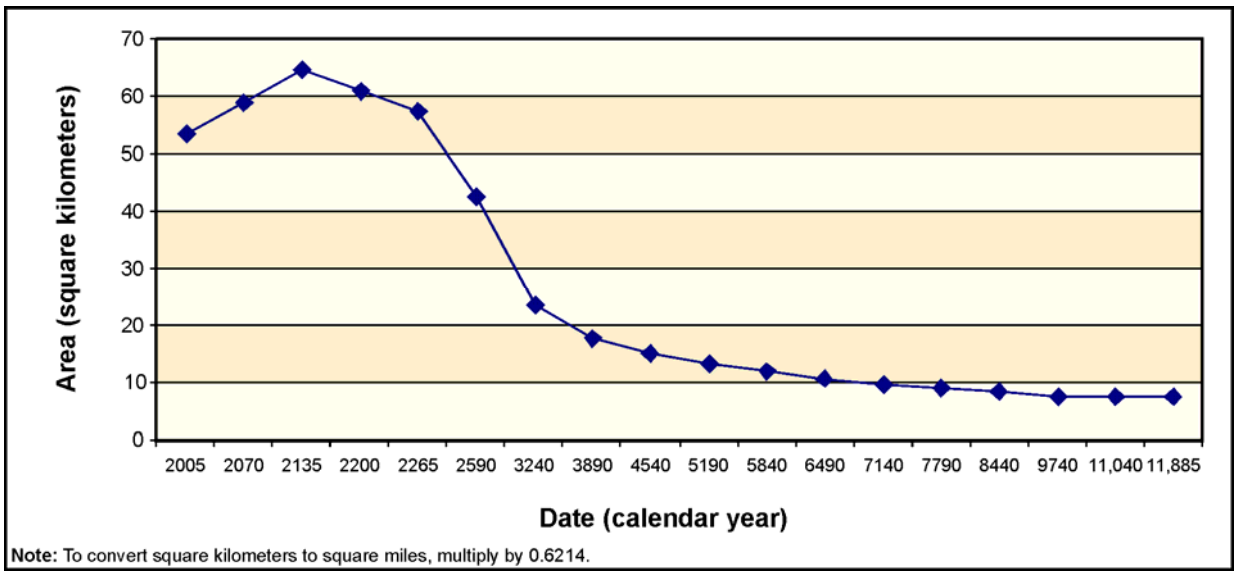


Figure 6–105. Alternative Combination 3 Total Area for Which Cumulative Groundwater Concentrations of Uranium-238 Exceed the Benchmark Concentration as a Function of Time

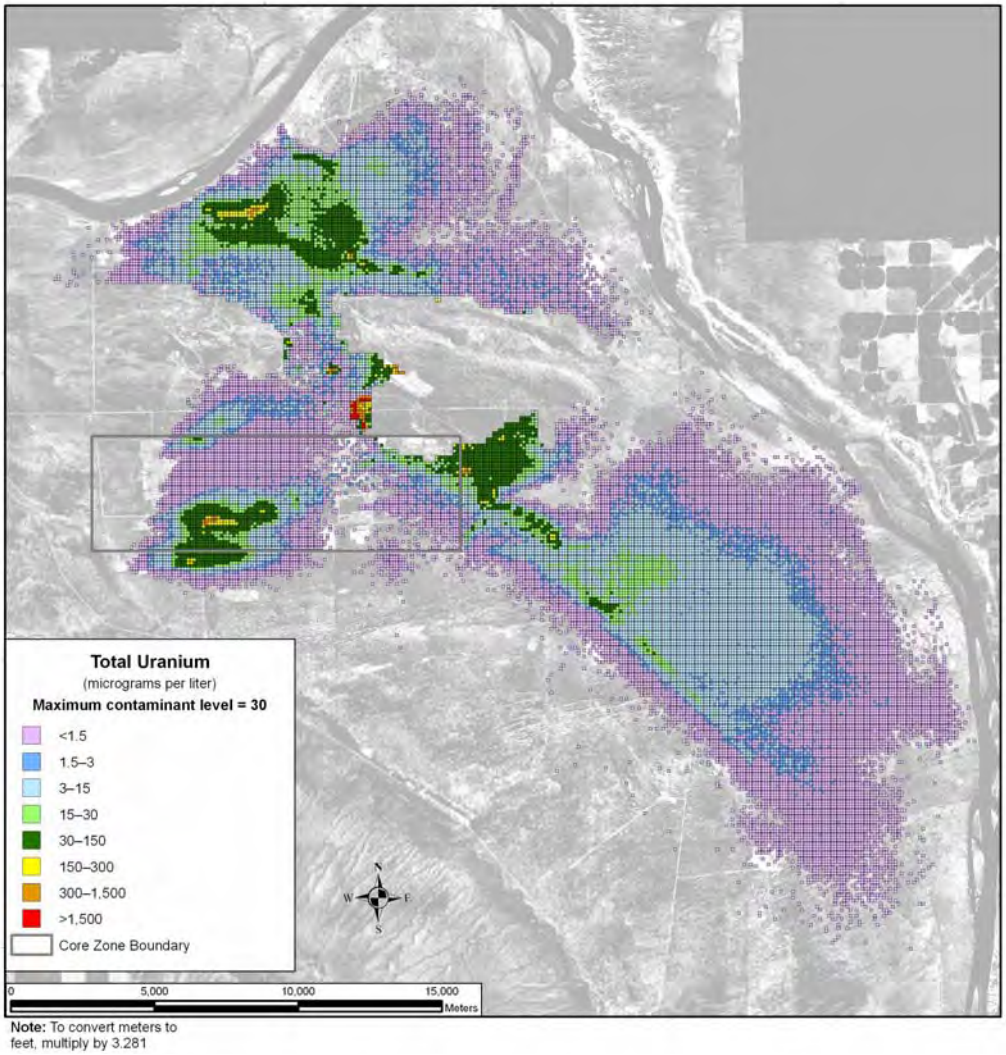


Figure 6–106. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 2135

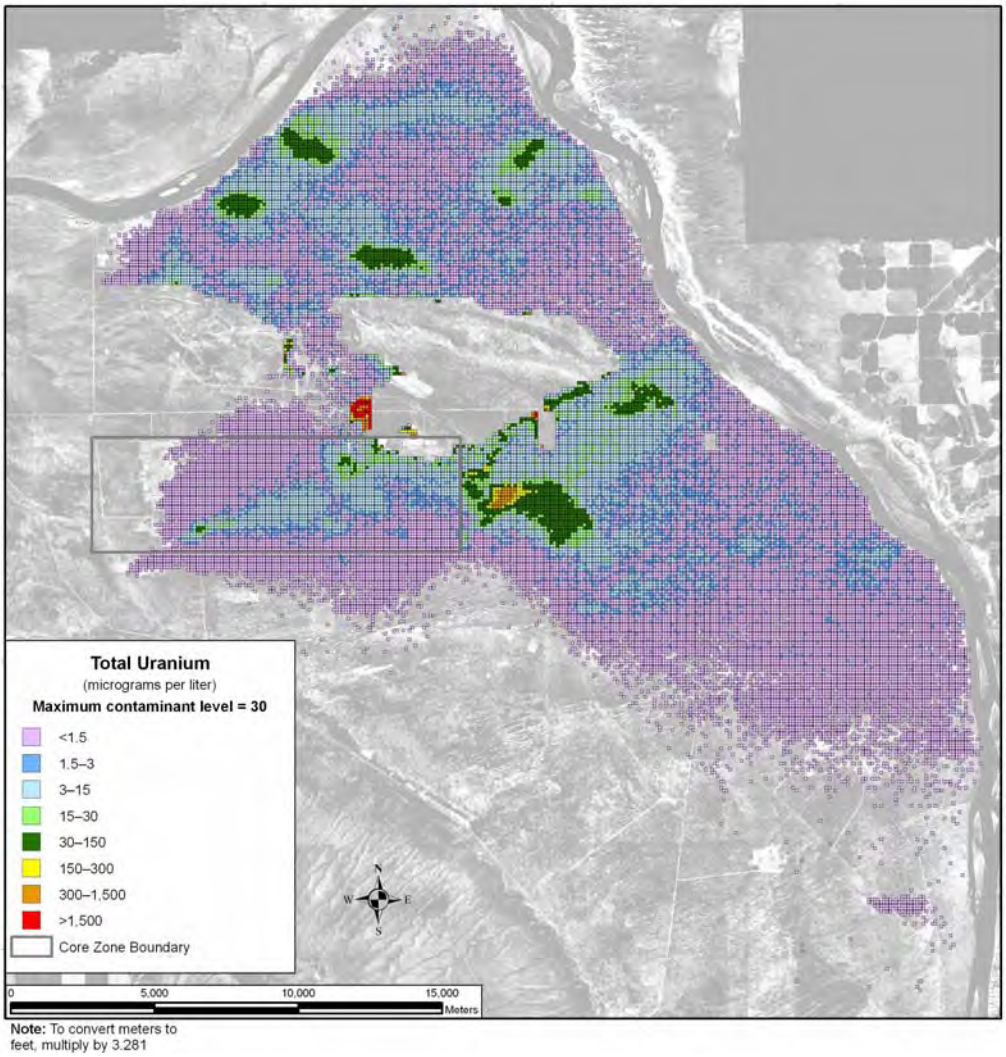


Figure 6–107. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 3890

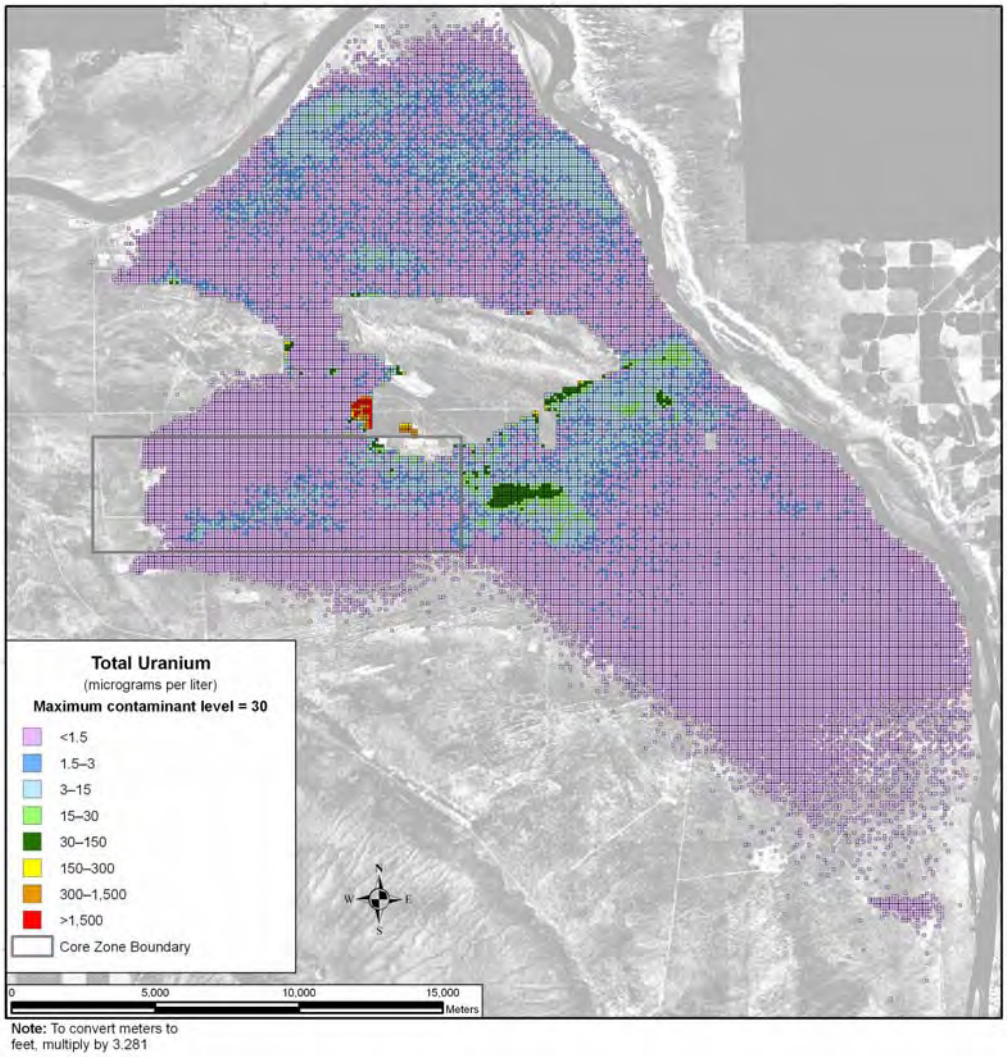


Figure 6–108. Alternative Combination 3 Spatial Distribution of Cumulative Groundwater Concentration for Total Uranium During Calendar Year 11,885

6.4.1.3.4 Summary of Impacts

The cumulative long-term impacts for Alternative Combination 3 and non-*TC & WM EIS* sources are dominated by non-*TC & WM EIS* sources (tritium, uranium-238, carbon tetrachloride, chromium, and total uranium); a combination of non-*TC & WM EIS* sources and Waste Management alternative sources (iodine-129); a combination of non-*TC & WM EIS* sources and tank closure sources (nitrate); or all three (technetium-99). Contributions from FFTF Decommissioning Alternative 3 sources account for well under 1 percent of the total amount released to the environment.

For iodine-129, technetium-99, carbon tetrachloride, chromium, and nitrate, concentrations at the Core Zone Boundary exceed benchmark standards by an order of magnitude during most of the period of analysis. Concentrations at the Columbia River are somewhat lower. The intensities and areas of these groundwater plumes peak at various times during the 10,000-year period of analysis, depending on the combination of alternative-related and non-alternative-related sources.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River

exceed the benchmark by about two orders of magnitude during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts by tritium. After CY 2100 tritium impacts are essentially negligible.

For uranium-238 and total uranium, discharges from the ponds (non-*TC & WM EIS* sources) are the dominant contributors during the early period of the analysis. Other tank farm sources are a secondary contributor, for which limited mobility is an important factor governing the time frames and scale of groundwater impacts.

6.4.2 Human Health Impacts

This section presents the results of the long-term cumulative impacts analysis for human health. The same methodology used for the alternatives analysis was used to analyze cumulative impacts. A description of this methodology is presented in Appendix Q, including estimates of the impacts of radiological and chemical constituents on each receptor, location, and alternative for the year of peak impact. Supporting information for the analysis of cumulative impacts on human health, including contributions from the major radionuclides and chemical constituents at the year of peak cumulative impact, is presented in Appendix U, Section U.2.

The long-term human health impacts due to release of radionuclides were estimated as dose and as lifetime risk of incidence of cancer. Potential human health impacts due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals were estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects were estimated as a Hazard Quotient, the ratio of the long-term intake of an individual chemical to the intake that produces no observable effect, and as a Hazard Index, the sum of the Hazard Quotients of a group of individual chemical constituents.

As with the individual *TC & WM EIS* alternatives, four measures of human health impacts were considered in this analysis: lifetime risks of developing cancer from radiological constituents, lifetime risks of developing cancer from chemical constituents, dose from radiological constituents, and Hazard Indices from chemical constituents. These measures were calculated for each year over 10,000 years for applicable receptors at three locations of analysis (i.e., the Core Zone Boundary, Columbia River nearshore, and Columbia River surface water). This large amount of information must be summarized to allow an interpretation of results. The method chosen was to present the dose for the year of maximum dose, the risk for the year of maximum risk, and the Hazard Index for the year of maximum Hazard Index. This choice was based on regulation of radiological impacts as dose and the observation that peak risk and peak noncarcinogenic impacts expressed as a Hazard Index may occur at times other than that of peak dose.

The three onsite locations of analysis were the Core Zone Boundary, the Columbia River nearshore, and the Columbia River. The offsite locations of analysis were population centers downstream of Hanford. The total offsite population assumed for this analysis was 5 million people. Consistent with DOE guidance (DOE Guide 435.1-1), the potential consequences of loss of administrative or institutional controls were considered by estimating the impacts on onsite receptors. Because DOE does not anticipate loss of control of the site, these onsite receptors were considered hypothetical and were applied to develop estimates for past and future time periods.

Four types of hypothetical receptors were considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking water consumption and irrigation of crops. It was assumed that garden size and crop yield were adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, uses groundwater for both drinking water

consumption and irrigation of crops. In this case, it was assumed that garden size and crop yield were adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he drinks surface water and consumes both wild plant materials, which use groundwater, and game, which drink surface water.

The significance of the dose impacts was evaluated by comparing doses with the 100 millirem per year all-pathway standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and Environment*. Perspective on the radiological dose to the offsite population of 5 million individuals potentially using water from the Columbia River is provided by comparison with the background dose for the average individual of 365 millirem per year. The level of protection provided for the drinking water pathway was evaluated by comparison against the applicable drinking water standards presented in Chapter 5, Section 5.1.1. The significance of noncarcinogenic chemical health impacts was evaluated by comparison with a Hazard Index guideline value of less than unity.

6.4.2.1 Other Past, Present, and Reasonably Foreseeable Future Actions

The potential cumulative human health impacts of the past, present, and reasonably foreseeable future actions due to releases from non-*TC & WM EIS* sources are summarized in Table 6–23, for the drinking-water well user and resident farmer and Table 6–24 for the American Indian resident farmer and American Indian hunter-gatherer. The key radiological constituents contributing to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium-237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butonal, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. For all locations and all receptors, the peak radiological dose and risk have already occurred. For the peak Hazard Index and nonradiological risk, the peak has either already occurred or would occur between the years 2200 and 2500. For the period prior to CY 2000, lifetime radiological risks for the year of peak risk at the Core Zone Boundary and Columbia River locations were high, approaching unity. For the period after calendar year 2000, risks remain high, with values between 1×10^{-3} and 1×10^{-2}. The estimated offsite population dose of 215 person-rem per year for the year of peak dose is approximately 0.01 percent of the average background dose for the population.

Table 6–23. Summary of Peak Impacts of Releases from Non-*TC & WM EIS* Sources for the Drinking-Water Well User and Resident Farmer Receptors

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	2.55×10^{4}	1.84×10^{2}	3.38×10^{-1}	5.33×10^{-3}	3.39×10^{-1}	3.65×10^{4}	9.13×10^{2}	5.22×10^{-1}	3.35×10^{-2}	5.24×10^{-1}
Columbia River Nearshore	3.42×10^{5}	2.17×10^{2}	1.0	9.66×10^{-5}	1.0	4.51×10^{6}	2.21×10^{2}	1.0	6.07×10^{-4}	1.0
Columbia River	N/A	N/A	N/A	N/A	N/A	4.29×10^{-2}	1.14×10^{-3}	7.71×10^{-7}	3.41×10^{-8}	8.04×10^{-7}

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

Table 6–24. Summary of Peak Impacts of Releases from Non-*TC & WM EIS* Sources for the American Indian Resident Farmer and American Indian Hunter-Gatherer Receptors

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	6.42×10^{4}	3.83×10^{3}	1.0	1.46×10^{-1}	1.0	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.31×10^{7}	3.05×10^{2}	1.0	2.95×10^{-3}	1.0	8.56×10^{6}	6.71×10^{1}	1.0	5.95×10^{-3}	1.0

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

6.4.2.2 Alternative Combination 1

The potential cumulative human health impacts associated with Alternative Combination 1, together with the impacts of past, present, and reasonably foreseeable future actions (discussed above), are summarized in Table 6–25 for the drinking-water well user and resident farmer and Table 6–26 for the American Indian resident farmer and American Indian hunter-gatherer. The key radiological constituent contributors to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium-237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butonal, acetonitrile, boron and boron compounds, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. The impacts of Alternative Combination 1 are dominated by the impacts of releases from the non-*TC & WM EIS* sources. The estimate of the offsite population dose of 215 person-rem per year for the year of peak dose is approximately 0.01 percent of the average background dose for the population.

Table 6–25. Alternative Combination 1 Summary of Peak Cumulative Impacts for the Drinking-Water Well User and Resident Farmer Receptors

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	2.55×10^{4}	5.42×10^{2}	3.38×10^{-1}	5.33×10^{-3}	3.39×10^{-1}	3.66×10^{4}	9.34×10^{2}	5.22×10^{-1}	3.35×10^{-2}	5.25×10^{-1}
Columbia River Nearshore	3.42×10^{5}	2.17×10^{2}	1.0	9.66×10^{-5}	1.0	4.51×10^{6}	2.21×10^{2}	1.0	6.07×10^{-4}	1.0
Columbia River	N/A	N/A	N/A	N/A	N/A	4.30×10^{-2}	1.24×10^{-3}	7.73×10^{-7}	3.41×10^{-8}	8.05×10^{-7}

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable.

Table 6–26. Alternative Combination 1 Summary of Peak Cumulative Impacts for the American Indian Resident Farmer and American Indian Hunter-Gatherer Receptors

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	6.42×10^{4}	3.86×10^{3}	1.0	1.47×10^{-1}	1.0	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.31×10^{7}	3.05×10^{2}	1.0	2.95×10^{-3}	1.0	8.56×10^{6}	6.76×10^{1}	1.0	5.95×10^{-3}	1.0

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable.

6.4.2.3 Alternative Combination 2

The potential cumulative human health impacts including Alternative Combination 2, together with the impacts of past, present, and reasonably foreseeable future actions (discussed above), are summarized in Table 6–27 for the drinking-water well user and resident farmer and Table 6–28 for the American Indian resident farmer and American Indian hunter-gatherer. The key radiological constituent contributors to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium--237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butonal, boron compounds, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. The impacts of Alternative Combination 2 are dominated by the impacts of releases from the non-*TC & WM EIS* sources. The estimate of the offsite population dose of 215 person-rem per year for the year of peak dose is approximately 0.01 percent of the average background dose for the population.

Table 6–27. Alternative Combination 2 Summary of Peak Cumulative Impacts for the Drinking-Water Well User and Resident Farmer Receptors

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	2.55×10^{4}	5.27×10^{2}	3.38×10^{-1}	5.33×10^{-3}	3.39×10^{-1}	3.66×10^{4}	9.34×10^{2}	5.22×10^{-1}	3.35×10^{-2}	5.25×10^{-1}
Columbia River Nearshore	3.42×10^{5}	2.17×10^{2}	1.0	9.66×10^{-5}	1.0	4.51×10^{6}	2.21×10^{2}	1.0	6.07×10^{-4}	1.0
Columbia River	N/A	N/A	N/A	N/A	N/A	4.30×10^{-2}	1.25×10^{-3}	7.73×10^{-7}	3.41×10^{-8}	8.05×10^{-7}

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable.

Table 6–28. Alternative Combination 2 Summary of Peak Cumulative Impacts for the American Indian Resident Farmer and American Indian Hunter-Gatherer Receptors

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	6.42×10^{4}	3.86×10^{3}	1.0	1.46×10^{-1}	1.0	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.31×10^{7}	3.05×10^{2}	1.0	2.95×10^{-3}	1.0	8.56×10^{6}	6.74×10^{1}	1.0	5.95×10^{-3}	1.0

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable.

6.4.2.4 Alternative Combination 3

The potential cumulative human health impacts of Alternative Combination 3, together with the impacts of past, present and reasonably foreseeable future actions (discussed above), are summarized in Table 6–29 for the drinking-water well user and resident farmer and Table 6–30 for the American Indian resident farmer and American Indian hunter-gatherer. The key radiological constituent contributors to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium-237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butonal, boron and boron compounds, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. The impacts of Alternative Combination 3 are dominated by the impacts of releases from the non-*TC & WM EIS* sources. The estimate of the offsite population dose of 215 person-rem per year for the year of peak dose is approximately 0.01 percent of the average background dose for the population.

Table 6–29. Alternative Combination 3 Summary of Peak Cumulative Impacts for the Drinking-Water Well User and Resident Farmer Receptors

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	2.55×10^{4}	5.27×10^{2}	3.38×10^{-1}	5.33×10^{-3}	3.39×10^{-1}	3.66×10^{4}	9.33×10^{2}	5.22×10^{-1}	3.35×10^{-2}	5.25×10^{-1}
Columbia River Nearshore	3.42×10^{5}	2.17×10^{2}	1.0	9.66×10^{-5}	1.0	4.51×10^{6}	2.21×10^{2}	1.0	6.07×10^{-4}	1.0
Columbia River	N/A	N/A	N/A	N/A	N/A	4.30×10^{-2}	1.25×10^{-3}	7.73×10^{-7}	3.41×10^{-8}	8.05×10^{-7}

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable.

Table 6–30. Alternative Combination 3 Summary of Peak Cumulative Impacts for the American Indian Resident Farmer and American Indian Hunter-Gatherer Receptors

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (millirem per year)	Hazard Index at Year of Peak Hazard Index (unitless)	Radiological Risk at Year of Peak Radiological Risk (unitless)	Nonradiological Risk at Peak Nonradiological Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	6.42×10^{4}	3.86×10^{3}	1.0	1.46×10^{-1}	1.0	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.31×10^{7}	3.05×10^{2}	1.0	2.95×10^{-3}	1.0	8.56×10^{6}	6.74×10^{1}	1.0	5.95×10^{-3}	1.0

Note: The total risk for the year of peak total risk may not equal the sum of the radiological and nonradiological risks for the year of peak risk, because the peak radiological and nonradiological risks are likely to occur at different times.

Key: N/A=not applicable.

6.4.3 Ecological Risk

This section presents the results of the analysis of cumulative long-term impacts on ecological resources from exposure to chemicals and radionuclides released to the environment as a result of past, present, and reasonably foreseeable future actions. The cumulative impacts analysis incorporates estimated cumulative concentrations of chemicals and radionuclides in soil and estimated peak concentrations in air, water, and sediment from the ecological risk analysis for the *TC & WM EIS* alternatives. Detailed information on the ecological risk analysis for the *TC & WM EIS* alternatives appears in Appendix P.

As described in Appendix R, cumulative impacts are evaluated in an ROI that includes the proposed *TC & WM EIS* action areas, Hanford, and the Hanford Reach of the Columbia River. A general description of ecological resources at Hanford and within the region is presented in Chapter 3, Section 3.2.7. The long-term ecological risk from releases to air and groundwater as a result of the three combinations of Tank Closure, FFTF Decommissioning, and Waste Management alternatives is summarized in Chapter 5, Section 5.4. Section 6.3.7 presents the analysis of cumulative impacts to ecological resources that may occur as a result of land use changes in the ROI.

The analysis of long-term cumulative impacts to ecological receptors presented here focuses on risk from exposure to chemicals and radionuclides released to air and groundwater as a result of DOE actions at Hanford. The releases to air from Waste Treatment Plant operations are summarized in Chapter 2, Section 2.8.3.4. The releases to groundwater are summarized in Chapter 2, Section 2.9.1. The cumulative impacts analysis assumes impacts from contaminant releases of a given type (air or groundwater) from different sources coincide, even though many would not. This provides the most conservative estimate of cumulative impacts. The combined cumulative long-term impacts of releases to air and groundwater were not analyzed because groundwater impacts to ecological resources are not expected to occur until hundreds or thousands of years after the air impacts.

For air releases, cumulative impacts were evaluated by combining estimated media concentrations resulting from *TC & WM EIS* alternative combinations with reported baseline media concentrations resulting from past and current practices. Maximum soil concentrations from samples collected by Hanford environmental monitoring program (Poston et al. 2006, 2007; Poston, Hanf, and Dirkes 2005) were used to estimate baseline conditions. Estimated media concentrations for the *TC & WM EIS* alternative combinations came from models of transport and deposition of contaminants released to air and deposited on soil, sediment and surface water. There are no comparable estimated concentrations of chemical and radiological contaminants in air or soil from other future DOE actions at Hanford and non-DOE actions in the ROI. Therefore, estimated concentrations for the *TC & WM EIS* alternative combinations were added to reported maximum measured baseline concentrations. The addition of estimated *TC & WM EIS* alternative combinations to measured baseline concentrations focuses attention on those instances where the cumulative impacts pose a potential risk when there is little to no risk from either measured baseline conditions or the *TC & WM EIS* alternative combinations separately. No such cases were found (see Section 6.4.3.1).

For groundwater releases, cumulative impacts were estimated as the sum of impacts from predicted contaminant releases associated with *TC & WM EIS* alternative combinations (see Appendix D) and from past, present, and reasonably foreseeable future non-*TC & WM EIS*-related releases at Hanford as captured in the cumulative contaminant inventory (see Appendix S). Estimated media concentrations for the *TC & WM EIS* alternative combinations and cumulative impacts analysis came from models of release and transport through the vadose zone, groundwater transport, and eventual discharge of contaminants to the Columbia River and its riparian zone. Hazard Quotients were calculated for the cumulative impacts under the three Tank Closure, FFTF Decommissioning, and Waste Management alternative combinations (see Appendix P). Cumulative impacts for groundwater are discussed in Section 6.4.3.2.

6.4.3.1 Air

The cumulative long-term impacts on ecological receptors of estimated media concentrations resulting from air releases and actual media concentrations are not different from their separate long-term impacts. Where there is not already a potential risk from either actual media concentrations or the *TC & WM EIS* alternative combination, there would be no risk from the cumulative impacts. Where there would be a potential risk to ecological receptors, the risk would result from either concentrations from actual media concentrations or the estimated concentrations from the *TC & WM EIS* alternative combination, but not both.

Table 6–31 presents the maximum concentrations for select *TC & WM EIS* chemical and radiological COPCs with corresponding data from Hanford Site Environmental Surveillance Data Reports for 2004, 2005, and 2006 (Poston et al. 2006, 2007; Poston, Hanf, and Dirkes 2005). The selected COPCs are those with the highest Hazard Quotients under the three alternative combinations: mercury for receptors exposed to soil and air at the onsite maximum-impact location (see Chapter 5, Table 5–6), and mercury and benzene for receptors exposed to sediment and Columbia River surface water. For these analytes, only the estimated cumulative concentrations of mercury in onsite surface soil for Alternative Combinations 2 and 3 pose a potential for adverse impacts to ecological receptors. Comparing the estimated mercury soil concentrations for Combinations 2 and 3 to the maximum mercury concentration reported for the Hanford monitoring program shows that the latter is three orders of magnitude smaller than the estimated value and does not pose a risk to ecological receptors. Conversely, maximum baseline concentrations of mercury and benzene (as well as ammonia) in Columbia River surface water could potentially have adverse impacts on ecological receptors because they exceed published benchmarks (e.g., maximum Hazard Quotient = 172 for side-blotched lizard) (see Table 6–32), but the estimated concentrations resulting from the *TC & WM EIS* alternative combinations would contribute insignificantly to the risk. Maximum baseline concentrations of mercury in sediment, which are nearly 20 times larger than those estimated for Combinations 2 and 3, are nearly equal to the benchmark.

Table 6–31. Potential Cumulative Impacts on Ecological Risk from Releases to Air

Action/Activity	Concentration of COPC in the Environmental Medium			
	Mercury			Benzene
	Soil (mg/kg)	Surface Water (mg/L)	Sediment (mg/kg)	Surface Water (mg/L)
***TC&WM EIS* Alternative Combinations**[a]				
Alternative Combination 1	0	0	0	5.1×10^{-8}
Alternative Combination 2	**2.46**	2.4×10^{-9}	8.9×10^{-3}	4.6×10^{-8}
Alternative Combination 3	**2.56**	3.7×10^{-9}	9.2×10^{-3}	6.9×10^{-8}
Other DOE Actions at the Hanford Site				
Hanford Site baseline[a]	7.0×10^{-3}	**6.3×10^{-6}**	2.0×10^{-1}	**1.7×10^{-4}**
Other DOE Actions Subtotal	7.0×10^{-3}	**6.3×10^{-6}**	2.0×10^{-1}	**1.7×10^{-4}**
Cumulative Totals[b]				
Alternative Combination 1	7.0×10^{-3}	**6.3×10^{-6}**	2.0×10^{-1}	**1.7×10^{-4}**
Alternative Combination 2	**2.47**	**6.3×10^{-6}**	**2.1×10^{-1}**	**1.7×10^{-4}**
Alternative Combination 3	**2.57**	**6.3×10^{-6}**	**2.1×10^{-1}**	**1.7×10^{-4}**
Benchmark Concentration[c]	1.5×10^{-2}	2.8×10^{-6}	2.0×10^{-1}	3.16×10^{-5}

[a] Maximum onsite and Columbia River values in Hanford Site Environmental Reports for calendar years 2004, 2005, and 2006 (Poston, Hanf, and Dirkes 2005; Poston et al. 2006, 2007).
[b] Sum of *TC & WM EIS* and Hanford Site baseline values.
[c] From Table 6–32.

Note: Concentrations exceeding the benchmark values are shown in **bold** text. To convert kilograms to pounds, multiply by 2.2046; liters to gallons, by 0.26417.

Key: COPC=constituent of potential concern; DOE=U.S. Department of Energy; mg/kg=milligrams per kilogram; mg/L=milligrams per liter; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Source: Poston, Hanf, and Dirkes 2005; Poston et al. 2006, 2007.

Table 6–32. Toxicity Benchmark Concentrations for Ecological Receptors Exposed to Chemicals in Soil, Water, and Sediment

Chemical	Water (mg/L)		Soil (mg/kg)		Sediment (mg/kg)	
	Value	Source	Value	Source	Value	Source
Chromium[a]	2.7×10^{-4}	Suter and Tsao 1996[b]	–	–	–	–
Lead	–	–	–	–	3.1×10^{1}	EPA 1999
Mercury	2.8×10^{-6}	EPA 1999[c]	1.5×10^{-2}	c, d	2.0×10^{-1}	EPA 1999[c]
Uranium	–	–	–	–	1.3×10^{1}	e
Benzene	3.16×10^{-5}	Suter and Tsao 1996[f]	–	–	–	–

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

[b] Sensitive Species Test 20 percent Effect Concentration for chromium.

[c] Value for methyl mercury.

[d] Soil mercury concentration producing HQ = 1 for side-blotched lizard: C_{soil} = TRV/(IR_{food} × *BAF-S* + IR_{soil}); *TRV* = 0.0064 mg/kg body weight/day (Sample, Opresko, and Suter 1996); IR_{food} = 0.05 kg food/kg body weight/day (Sample et al. 1997); *BAF-S* = 8.5 kg dry soil/kg tissue (EPA 1999); IR_{soil} = IR_{food} × *SF*; *SF* = 0.011 kg dry soil/kg food (DOE 1998b).

[e] Sediment uranium concentration producing HQ = 1 for raccoon: $C_{sediment}$ = *TRV*/(IR_{food} × *BASF* + $IR_{sediment}$); *TRV* = 3.07 mg/kg body weight/day (Sample, Opresko, and Suter 1996); IR_{food} = 0.26 kg food/kg body weight/day (Sample et al. 1997); BASF = 0.893 kg dry sediment/kg tissue (EPA 1999); $IR_{sediment}$ = IR_{food} × *SF*; *SF* = 0.018 kg dry soil/kg food (DOE 1998b).

[f] Acute lowest observed adverse effect level for rainbow trout × 0.1 acute-to-chronic conversion factor.

Note: To convert liters to gallons, multiply by 0.26417; kilograms to pounds, by 2.2046.

Key: BAF=bioaccumulation factor; BAF-S=soil-to-soil invertebrate BAF; BASF=sediment-to-benthic-invertebrate BAF; C=concentration; HQ=Hazard Quotient; IR=ingestion rate; mg/kg=milligrams per kilogram; mg/L=milligrams per liter; TRV=toxicity reference value.

Source: DOE 1998b; EPA 1999; Sample, Opresko, and Suter 1996; Sample et al. 1997, Suter and Tsao 1996.

The relationship between reported data for non-DOE facilities in or near the ROI and the estimated cumulative values for this *TC & WM EIS* is similar to that for the Hanford onsite baseline data. Soil grab samples at the AREVA NP fuel fabrication facility between 2000 and 2005 did not exceed 3.75 picocuries per gram uranium (AREVA 2006), which is 10 times smaller than the maximum estimated onsite soil concentration for *TC & WM EIS* alternative combinations (Alternative Combination 1, onsite soil, 32.2 picocuries per gram). Plant stack data for air emissions from the Perma-Fix Northwest (formerly known as Pacific EcoSolutions) low-level radioactive and mixed waste processing facilities in 2006 did not exceed 0.0042 picocuries per cubic meter cobalt-60 (Pacific EcoSolutions 2007), which is over 10 times less than the maximum estimated onsite air concentration for the *TC & WM EIS* alternative combinations (Combination 1, onsite air, 0.096 picocuries per cubic meter). Soil samples at the US Ecology Commercial Low-Level Radioactive Waste Disposal Facility have activities less than the maximum estimated *TC & WM EIS* values and Hanford baseline values for all radiological COPCs (Ecology and WSDOH 2004); with the exception of total uranium for 1998 (maximum 0.8 picocuries per cubic meter), which exceeded the baseline uranium-238 value (maximum 0.31 picocuries per cubic meter). Tritium in water (Stormwater Outfall Sample 101) from the Energy Northwest Columbia Generating Station was measured as high as 17,100 picocuries per liter (Energy Northwest 2006b), exceeding the Hanford baseline maximum by a factor of 25 (594 picocuries per liter) and the estimated *TC & WM EIS* value by a factor of 240,000 (0.07 picocuries per liter). Not one of these cobalt-60, tritium and uranium activities pose a risk to ecological receptors (see Chapter 5, Section 5.4), thus, there is unlikely to be a cumulative impact. Moravek Biochemicals reported 2004 air releases of tritium and carbon-14 within permissible levels (Moravek 2005). Future releases from the Moravek facility could potentially add to impacts from estimated air emissions of tritium and carbon-14 for the *TC & WM EIS* alternatives.

Cumulative impacts from air emissions from construction projects and operation activities off site could potentially increase impacts to ecological receptors exposed to nitrogen oxides and sulfur oxides from burning diesel fuel. Emissions of volatile organic carbon compounds such as acetaldehyde, acetic acid, ethyl acetate, formaldehyde, ethanol, and methanol from biofuel plants (e.g., the Columbia Ethanol Plant) may have impacts on ecological receptors. The magnitude of those impacts cannot be estimated using the available information. In general, potential offsite sources of air emissions (see Appendix R, Table R–5) are not expected to contribute significantly to cumulative ecological risk at Hanford.

6.4.3.2 Groundwater

Cumulative impacts on ecological resources from releases to groundwater were calculated for the three *TC & WM EIS* alternative combinations. The largest risk indices for each aquatic and riparian receptor exposed to chemical COPCs in groundwater discharging at the Columbia River are summarized in Table 6–33. Impacts are presented in Table 6–33 for the three *TC & WM EIS* alternative combinations and the cumulative releases (i.e., releases associated with the three alternative combinations plus non-*TC & WM EIS*-related releases). Impacts from radiological COPCs are never as high as those from chemical COPCs.

Table 6–33. Summary of Long-Term Impacts of Alternative Combinations and Cumulative Impacts on Aquatic and Riparian Resources at the Columbia River Resulting from Contaminant Releases to Groundwater

	Hazard Quotient for Maximum Reasonably Foreseeable COPC						
	Benthic Invertebrate	**Muskrat**	**Spotted Sandpiper**	**Raccoon**	**Least Weasel**	**Bald Eagle**	**Aquatic Biota/ Salmonids**
Alternative Combinations							
	Chromium[a]			**Uranium**	**Nitrate**	**Chromium[a]**	
Alternative Combination 1	1.20×10^{-1}	4.71×10^{-3}	8.17×10^{-1}	2.95×10^{-1}	6.31×10^{-1}	2.08×10^{-2}	**2.14×10^{1}**
Alternative Combination 2	2.56×10^{-2}	1.00×10^{-3}	1.74×10^{-1}	2.88×10^{-2}	6.43×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
Alternative Combination 3	2.60×10^{-2}	1.02×10^{-3}	1.77×10^{-1}	2.72×10^{-3}	6.44×10^{-1}	1.52×10^{-2}	**2.23×10^{1}**
Cumulative Impacts with Alternative Combinations							
	Lead						**Chromium[a]**
Alternative Combination 1	**2.64×10^{2}**	**2.42×10^{1}**	**1.29×10^{5}**	**3.68×10^{4}**	**4.76×10^{2}**	**1.71×10^{2}**	**2.28×10^{2}**
Alternative Combination 2	**2.64×10^{2}**	**2.42×10^{1}**	**1.29×10^{5}**	**3.68×10^{4}**	**4.76×10^{2}**	**1.71×10^{2}**	**2.29×10^{2}**
Alternative Combination 3	**2.64×10^{2}**	**2.42×10^{1}**	**1.29×10^{5}**	**3.68×10^{4}**	**4.76×10^{2}**	**1.71×10^{2}**	**2.29×10^{2}**

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.
Note: Hazard Quotient is unitless. Values greater than 1 are shown in **bold** text.
Key: COPC=constituent of potential concern.

The highest risk indexes for the alternative combinations for benthic invertebrates, muskrat, spotted sandpiper, bald eagle and aquatic biota, including salmonids, are those for chromium. The highest index for raccoons is that for uranium in sediment, and the highest for the least weasel is that for nitrate in seeps at the Columbia River. Chromium in aquatic biota, including salmonids, is the only COPC with an Hazard Quotient exceeding 1 for the alternative combinations. Hazard Quotients less than 1 indicate no risk to the receptor.

The highest risk index for the cumulative impacts would result from lead for all receptors except aquatic biota and salmonids. For the latter, the highest risk index for the cumulative impact analysis would be

from chromium. All of the maximum risk indices for the cumulative impacts would exceed 1. Other COPCs identified in the cumulative impacts analysis as potentially causing adverse impacts on aquatic and riparian receptors (risk index greater than 10) would include the chemicals fluoride, mercury, nickel, and uranium, as well as the radionuclides cesium-137, plutonium-239 and uranium-238 (see Table 6–34).

Table 6–34. Risk Indices for Aquatic and Riparian Receptors and Selected Chemical and Radiological Constituents of Potential Concern – Cumulative Impacts with Alternative Combinations

Constituents of Potential Concern	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Bald Eagle	Least Weasel	Aquatic Biota/ Salmonids
Cumulative Impacts with Alternative Combination 1							
Chemical COPCs							
Carbon tetrachloride	**6.19**	8.55×10^{-3}	No TRV	**1.63**	No TRV	4.44×10^{-2}	2.29×10^{-1}
Chromium[a]	**1.19×10^{1}**	4.65×10^{-1}	**8.06×10^{1}**	**9.76**	9.05×10^{-1}	8.92×10^{-1}	**2.28×10^{2}**
Fluoride	No TRV	4.64×10^{-2}	**1.54×10^{2}**	**1.65×10^{1}**	**1.65**	**1.22**	No TRV
Lead	**2.64×10^{2}**	**2.42×10^{1}**	**1.29×10^{5}**	**3.68×10^{4}**	**1.71×10^{2}**	**4.76×10^{2}**	1.74×10^{-1}
Mercury	**1.27×10^{2}**	7.96×10^{-2}	**1.22×10^{3}**	**1.03×10^{2}**	**2.29**	**1.86**	3.97×10^{-1}
Nickel	**3.38×10^{1}**	1.66×10^{-2}	**4.63**	**2.59**	8.85×10^{-3}	4.35×10^{-2}	1.21×10^{-3}
Nitrate	No TRV	1.04×10^{-1}	No TRV	3.34×10^{-1}	No TRV	**1.51**	No TRV
Uranium	No TRV	5.02×10^{-1}	**2.38×10^{2}**	**5.35×10^{2}**	2.96×10^{-1}	**6.02**	**4.20**
Radiological COPCs							
All radionuclides combined (rad/d)[b]	**1.58×10^{2}**	1.03×10^{-1}	**4.07×10^{2}**	**1.92×10^{2}**	4.12×10^{-1}	**1.58**	**1.76**
Cesium-137	**5.12×10^{1}**	5.02×10^{-2}	**3.85×10^{2}**	**1.83×10^{2}**	3.90×10^{-1}	**1.49**	**1.70**
Plutonium-239	**2.25×10^{1}**	5.60×10^{-7}	1.39×10^{-2}	5.97×10^{-3}	1.23×10^{-5}	5.21×10^{-5}	2.16×10^{-5}
Strontium-90	**7.53**	2.51×10^{-3}	**2.79**	**1.20**	3.48×10^{-3}	1.38×10^{-2}	1.40×10^{-3}
Uranium-238	**7.72×10^{1}**	9.60×10^{-4}	**1.88×10^{1}**	**8.11**	1.76×10^{-2}	7.34×10^{-2}	5.75×10^{-2}
Cumulative Impacts with Alternative Combination 2							
Chemical COPCs							
Carbon tetrachloride	**6.19**	8.55×10^{-3}	No TRV	**1.63**	No TRV	4.44×10^{-2}	2.29×10^{-1}
Chromium[a]	**1.18×10^{1}**	4.61×10^{-1}	**8.00×10^{1}**	**9.69**	8.99×10^{-1}	8.86×10^{-1}	**2.29×10^{2}**
Fluoride	No TRV	4.64×10^{-2}	**1.54×10^{2}**	**1.65×10^{1}**	**1.65**	**1.22**	No TRV
Lead	**2.64×10^{2}**	**2.42×10^{1}**	**1.29×10^{5}**	**3.68×10^{4}**	**1.71×10^{2}**	**4.76×10^{2}**	1.74×10^{-1}
Mercury	**1.27×10^{2}**	7.96×10^{-2}	**1.22×10^{3}**	**1.03×10^{2}**	**2.29**	**1.86**	3.97×10^{-1}
Nickel	**3.38×10^{1}**	1.66×10^{-2}	**4.63**	**2.59**	8.85×10^{-3}	4.35×10^{-2}	1.21×10^{-3}
Nitrate	No TRV	1.01×10^{-1}	No TRV	3.26×10^{-1}	No TRV	**1.52**	No TRV
Uranium	No TRV	5.01×10^{-1}	**2.38×10^{2}**	**5.35×10^{2}**	2.96×10^{-1}	**6.01**	**4.19**
Radiological COPCs							
All radionuclides combined (rad/d)[b]	**1.58×10^{2}**	1.03×10^{-1}	**4.07×10^{2}**	**1.92×10^{2}**	4.11×10^{-1}	**1.58**	**1.76**
Cesium-137	**5.12×10^{1}**	5.02×10^{-2}	**3.85×10^{2}**	**1.83×10^{2}**	3.90×10^{-1}	**1.49**	**1.70**
Plutonium-239	**2.25×10^{1}**	5.60×10^{-7}	1.39×10^{-2}	5.97×10^{-3}	1.23×10^{-5}	5.21×10^{-5}	2.16×10^{-5}
Strontium-90	**7.53**	2.51×10^{-3}	**2.79**	**1.20**	3.48×10^{-3}	1.38×10^{-2}	1.40×10^{-3}
Uranium-238	**7.72×10^{1}**	9.59×10^{-4}	**1.88×10^{1}**	**8.11**	1.76×10^{-2}	7.34×10^{-2}	5.75×10^{-2}

Table 6–34. Risk Indices for Aquatic and Riparian Receptors and Selected Chemical and Radiological Constituents of Potential Concern – Cumulative Impacts with Alternative Combinations *(continued)*

Constituents of Potential Concern	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Bald Eagle	Least Weasel	Aquatic Biota/ Salmonids
Cumulative Impacts with Alternative Combination 3							
Chemical COPCs							
Carbon tetrachloride	**6.19**	8.55×10^{-3}	No TRV	**1.63**	No TRV	4.44×10^{-2}	2.29×10^{-1}
Chromium[a]	**1.18×10^{1}**	4.61×10^{-1}	**8.00×10^{1}**	**9.69**	8.99×10^{-1}	8.86×10^{-1}	**2.29×10^{2}**
Fluoride	No TRV	4.64×10^{-2}	**1.54×10^{2}**	**1.65×10^{1}**	**1.65**	**1.22**	No TRV
Lead	**2.64×10^{2}**	**2.42×10^{1}**	**1.29×10^{5}**	**3.68×10^{4}**	**1.71×10^{2}**	**4.76×10^{2}**	1.74×10^{-1}
Mercury	**1.27×10^{2}**	7.96×10^{-2}	**1.22×10^{3}**	**1.03×10^{2}**	**2.29**	**1.86**	3.97×10^{-1}
Nickel	**3.38×10^{1}**	1.66×10^{-2}	**4.63**	**2.59**	8.85×10^{-3}	4.35×10^{-2}	1.21×10^{-3}
Nitrate	No TRV	1.01×10^{-1}	No TRV	3.26×10^{-1}	No TRV	**1.53**	No TRV
Uranium	No TRV	5.01×10^{-1}	**2.38×10^{2}**	**5.35×10^{2}**	2.96×10^{-1}	**6.01**	**4.18**
Radiological COPCs							
All radionuclides combined (rad/d)[b]	**1.58×10^{2}**	1.03×10^{-1}	**4.07×10^{2}**	**1.92×10^{2}**	4.11×10^{-1}	**1.58**	**1.76**
Cesium-137	**5.12×10^{1}**	5.02×10^{-2}	**3.85×10^{2}**	**1.83×10^{2}**	3.90×10^{-1}	**1.49**	**1.70**
Plutonium-239	**2.25×10^{1}**	5.60×10^{-7}	1.39×10^{-2}	5.97×10^{-3}	1.23×10^{-5}	5.21×10^{-5}	2.16×10^{-5}
Strontium-90	**7.53**	2.51×10^{-3}	**2.79**	**1.20**	3.48×10^{-3}	1.38×10^{-2}	1.40×10^{-3}
Uranium-238	**7.72×10^{1}**	9.59×10^{-4}	**1.88×10^{1}**	**8.11**	1.76×10^{-2}	7.34×10^{-2}	5.75×10^{-2}

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

[b] Includes the contribution from radiological COPCs not shown in the table.

Note: Risk indices exceeding 1 are shown in **bold** text; risk indices are unitless.

Key: COPC=constituent of potential concern; rad/d=rads per day; TRV=toxicity reference value.

Estimated impacts from groundwater releases that are not associated with the *TC & WM EIS* alternatives, e.g., past leaks, are greater than estimated impacts from releases associated with the *TC & WM EIS* alternatives. For example, impacts from estimated concentrations of uranium in sediment and chromium in surface water that are associated with the *TC & WM EIS* alternatives would represent a small fraction of the cumulative impacts (see Table 6–35). Estimated concentrations resulting from groundwater releases that are not associated with the *TC & WM EIS* alternatives are approximately 10 times the estimated concentrations associated with the *TC & WM EIS* alternatives for chromium and several orders of magnitude greater than estimated concentrations of uranium. Other COPCs showing this pattern are fluoride and uranium-238. Nitrate concentrations in groundwater associated with the *TC & WM EIS* alternatives are estimated to be about 2 to 5 percent of the concentrations in groundwater due to releases not associated with the *TC & WM EIS* alternatives. Lead is not estimated to occur in groundwater discharging at the Columbia River under the *TC & WM EIS* alternative combinations, but it is a source of cumulative impact to aquatic and riparian receptors exposed to sediment as a result of past leaks (see Table 6–35). Other constituents showing this pattern are mercury, nickel, cesium-137, and plutonium-239.

Estimated cumulative long-term impacts from chromium, lead, and uranium releases exceed benchmark concentrations. The cumulative impacts from these COPCs in groundwater result from the high concentrations associated with non-*TC & WM EIS*-related releases (see Table 6–35). For groundwater releases associated with the *TC & WM EIS* alternative combinations, only chromium exceeds toxicity benchmarks.

Table 6–35. Summary of Long-Term Impacts of Alternative Combinations and Cumulative Impacts on Aquatic and Riparian Resources at the Columbia River Resulting from Contaminant Releases to Groundwater

Action/Activity	Concentration of COPCs in Environmental Medium			
	Groundwater (mg/L Nitrate)	Sediment (mg/kg Uranium)	Surface Water (mg/L Chromium[a])	Sediment (mg/kg Lead)
This *TC & WM EIS*				
Alternative Combination 1	23.5	3.8	**0.0057**	0
Alternative Combination 2	11.0	0.37	**0.0059**	0
Alternative Combination 3	11.7	0.035	**0.0059**	0
Other DOE Actions at Hanford				
Past Leaks and Other[b]	502	**6,927**	**0.055**	**8,176**
Other DOE Actions Subtotal	502	**6,927**	**0.055**	**8,176**
Cumulative Total[c]				
Alternative Combination 1	526	6,931	**0.06**	**8,176**
Alternative Combination 2	513	6,927	**0.06**	**8,176**
Alternative Combination 3	514	6,927	**0.06**	**8,176**
Benchmark[d]	No data	**13**	0.00027	31

[a] It was assumed, for the purposes of analysis, that all chromium was hexavalent.

[b] Difference of concentrations for *TC & WM EIS* alternative combinations and Past Leaks and Other releases combined and concentrations for *TC & WM EIS* alternative combinations.

[c] Sum of *TC & WM EIS* alternative combinations and other DOE actions.

[d] From Table 6–32.

Note: Concentrations exceeding the benchmark concentrations are shown in **bold** text.

Key: COPC=constituent of potential concern; DOE=U.S. Department of Energy; Hanford=Hanford Site; mg/kg=milligrams per kilogram; mg/L=milligrams per liter; *TC & WM EIS =Tank Closure and Waste Management Environmental Impact Statement*.

Impacts from releases to groundwater from upstream sources are discussed in Section 6.4.2. These releases are not expected to contribute substantially to impacts to the Hanford Reach of the Columbia River given the distances and river-flow volumes. In addition, the proposed Black Rock Reservoir could change the groundwater flow field, which could, in turn, alter the contaminant concentrations and timing of discharges of peak concentrations to the Columbia River (see Appendix V).

6.4.4 Environmental Justice

This section presents the cumulative impacts analysis for environmental justice. Sections 6.4.1 and 6.4.2 evaluate cumulative groundwater impacts and associated potential human health effects. The receptors analyzed with the potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater. The American Indian hunter-gatherer does not cultivate crops, but rather gathers food from indigenous plants and harvests fish from the Columbia River; he is assumed to be exposed to a combination of surface water and groundwater. Based on these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater.

As demonstrated by Tables 6–14, 6–18, and 6–22, which show the maximum cumulative concentrations of the COPCs, as well as Figures 6–2 through 6–9, 6–35 through 6–42, and 6–72 through 6–79, which show cumulative concentrations versus time, for all locations and all receptors, the peak radiological

impacts have already occurred. Cumulative releases of radiological materials results in the doses to the resident farmer, the American Indian resident farmer, and the American Indian hunter-gatherer exceeding regulatory standards at the applicable Core Zone Boundary and the Columbia River nearshore locations. In all instances, these releases exceed regulatory limits by several orders of magnitude.

Peak nonradiological impacts have either already occurred or would occur between the years 2200 and 2500. Releases of nonradiological materials from cumulative analysis sources result in Hazard Index guidelines being exceeded for the resident farmer, the American Indian resident farmer, and the American Indian hunter-gatherer at the applicable Core Zone Boundary and the Columbia River nearshore locations.

The human health risk analysis determined that releases from cumulative analysis sources would result in impacts in excess of regulatory limits only if an individual were located on site at the Core Zone Boundary and the Columbia River nearshore location and if all of their food and water were exposed to contaminated groundwater and surface water. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected within a reasonably foreseeable timeframe because the Core Zone is designated for Industrial-Exclusive use, the Columbia River nearshore location is designated for Preservation (Hanford Reach National Monument), and the area between them is designated for Conservation (Mining) (DOE 1999a). Therefore it is unlikely that cumulative releases would pose a disproportionately high and adverse long-term human health risk to the American Indian population. As discussed in Chapter 5, the alternative combination with the greatest impact on long-term human health would be Alternative Combination 1. Cumulative impacts, including Alternative Combination 1, would be dominated by impacts due to releases from past, present, and reasonably foreseeable future non-*TC & WM EIS*-related actions.

6.5 REGIONAL AND GLOBAL CUMULATIVE IMPACTS

6.5.1 Ozone Depletion

The *TC & WM EIS* alternatives are not expected to use or discharge substantial quantities of any ozone-depleting compounds. Construction and operations activities would be accomplished using materials and equipment formulated to be compliant with laws and regulations to reduce the use of ozone-depleting compounds. Any release of ozone-depleting compounds would be incidental to the conduct of the *TC & WM EIS* activities, such as releases that might occur during demolition of older air conditioning systems that contain unrecovered, ozone-depleting compounds. Emissions of carbon tetrachloride from groundwater plume vapor extraction in the 200-West Area are below reportable quantities (Poston et al. 2007:10.10). Emissions of ozone-depleting compounds would be very small and would represent a negligible contribution to the destruction of the Earth's protective ozone layer.

6.5.2 Global Climate Change

The "natural greenhouse effect" is the process by which part of terrestrial radiation is absorbed by gases in the atmosphere, warming the Earth's surface and atmosphere. This greenhouse effect and the Earth's radiation balance are affected largely by water vapor, carbon dioxide, and trace gases, which absorb infrared radiation and are referred to as greenhouse gases. Other greenhouse gases include nitrous oxide, halocarbons, and methane.

There is consensus among scientists, including those on the Intergovernmental Panel on Climate Change (IPCC), that increases in atmospheric concentrations of certain pollutants can produce changes in the Earth's atmospheric energy balance and thereby influence global climate. These pollutants are commonly referred to as greenhouse gases, and this warming effect is referred to as global warming. Water vapor

(1 percent of the atmosphere) is the most common and dominant greenhouse gas; only small amounts of water vapor are produced as the result of human activities. The principal greenhouse gases resulting from human activities are carbon dioxide, methane, nitrous oxide, and halocarbons. Halocarbons include chlorofluorocarbons; hydrofluorocarbons, which are replacing chlorofluorocarbons as refrigerants; and perfluorocarbons, which are a byproduct of aluminum smelting. Other gases of concern include sulfur hexafluoride, which is widely used in insulation for electrical equipment. These gases are released in different quantities and have different potencies in their contributions to global warming (IPCC 2007a; Justus and Fletcher 2006).

Sources of anthropogenic carbon dioxide include combustion of fossil fuels such as natural gas, oil, gasoline, and coal. It is estimated that carbon dioxide atmospheric levels have risen by more than 35 percent since the preindustrial period (since 1750) as a result of human activities. Emissions of other greenhouse gases have also risen. Annual global emissions of carbon dioxide are estimated to be 26.4 billion metric tons from fossil fuel use (IPCC 2007a:3). Carbon dioxide is the most important anthropogenic greenhouse gas and is therefore of primary concern in this EIS.

The IPCC concluded that warming of the earth's climate system is unequivocal, and that most of the observed increase in global average temperatures is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. The IPCC reports potential impacts from warming of the climate system, including expansion of sea water volume; decreases in mountain glaciers and snow cover resulting in sea level rise; changes in arctic temperatures and ice; changes in precipitation, ocean salinity, and wind patterns; and changes in extreme weather (IPCC 2007a:3-8).

As described in Appendix G, the *TC & WM EIS* alternatives could produce 2.75 metric tons (under FFTF Decommissioning Alternative 1 over a period of 100 years) to 0.246 million metric tons (under Tank Closure Alternative 6A, Option Case, over a period of 257 years) of carbon dioxide per year. Based on Hanford fuel use in 2006 (see Chapter 3, Section 3.2), baseline carbon dioxide emissions are 14,200 metric tons per year. Based on fuel consumption averages for INL (see Chapter 3, Section 3.3), baseline carbon dioxide emissions are 35,200 metric tons per year. The emissions under the alternatives would add to global annual emissions of carbon dioxide, which are estimated to be 26.4 billion metric tons from fossil fuel use worldwide (IPCC 2007a:3). The emission estimates for the *TC & WM EIS* alternatives account for facility specific fuel-burning and process sources from construction and operations activity and mobile source emissions from material and waste shipments. Emissions from employee vehicles and indirect emissions from electricity use were not estimated. Table 6–36 summarizes the estimated annual average carbon dioxide emissions by *TC & WM EIS* alternative.

Cumulative impacts of the emission of carbon dioxide and other greenhouse gases from *TC & WM EIS* alternatives and other activities at Hanford and throughout the region would contribute to changes related to global climate discussed above. Although the cumulative emissions of greenhouse gases and the impacts on the global climate and the resulting environmental, economic, and social consequences could be significant, there is currently no threshold or standard against which to evaluate the significance of such emissions from a specific local project.

Greenhouse gas emissions in the Hanford region include carbon dioxide from multiple sources, including the burning of natural gas and fuel oil for home and commercial heating and the use of gasoline and diesel fuel to power automobiles, trucks, construction equipment, and other vehicles. Generation of electricity results in carbon dioxide emissions in parts of the State of Washington and the

Table 6–36. Estimated Annual Average Carbon Dioxide Emissions by Alternative

Alternative	Emissions (metric tons per year)
Tank Closure (TC)	
TC Alternative 1	1.07×10^4
TC Alternative 2A	7.03×10^4
TC Alternative 2B	7.59×10^4
TC Alternative 3A	3.53×10^4
TC Alternative 3B	3.6×10^4
TC Alternative 3C	5.39×10^4
TC Alternative 4	3.92×10^4
TC Alternative 5	8.29×10^4
TC Alternative 6A, Base Case	2.39×10^5
TC Alternative 6A, Option Case	2.46×10^5
TC Alternative 6B, Base Case	5.81×10^4
TC Alternative 6B, Option Case	6.85×10^4
TC Alternative 6C	7.61×10^4
FFTF Decommissioning	
FFTF Decommissioning Alternative 1	2.75
FFTF Decommissioning Alternative 2[a]	1.98×10^3
FFTF Decommissioning Alternative 3[a]	1.54×10^2
Waste Management (WM)	
WM Alternative 1	1.23×10^3
WM Alternative 2	4.1×10^4
WM Alternative 2, Disposal Group 1	4.11×10^3
WM Alternative 2, Disposal Group 2	2.02×10^4
WM Alternative 2, Disposal Group 3	2.33×10^4
WM Alternative 3	4.1×10^4
WM Alternative 3, Disposal Group 1	5.03×10^3
WM Alternative 3, Disposal Group 2	2.11×10^4
WM Alternative 3, Disposal Group 3	2.38×10^4

[a] Including emissions for options at Idaho National Laboratory.

Key: FFTF=Fast Flux Test Facility.

United States. In the region near Hanford, most of the electricity (97 percent) is supplied by a combination of hydroelectric dams, nuclear power plants, and wind turbines (BPUD 2006). These types of power production generate little carbon dioxide. The *TC & WM EIS* alternative combinations could require a total of 0.0032 megawatt-hours (under FFTF Decommissioning Alternative 2) to 188 million megawatt-hours (under Tank Closure Alternative 6A, Option Case) of electricity. The State of Washington has implemented regulations to mitigate emissions of carbon dioxide from certain fossil-fueled thermal electric generating facilities larger than the station-generating capability of 25 megawatts of electricity. Recently adopted amendments to these regulations are intended to establish goals for statewide reduction of greenhouse gases emissions and immediately reduce greenhouse gas emissions from electric power generation (WAC 173-407). Participation of Washington State in the Western Climate Initiative's proposed Cap-and-Trade Program may also result in a reduction in greenhouse gas emissions (Ecology 2009).

There also are emissions of chlorofluorocarbons and hydrofluorocarbons, which are used locally in refrigeration and air conditioning units at residential, commercial, industrial, and government facilities.

A number of opportunities for reductions in greenhouse gases at Hanford have been pursued, including the reduction and phaseout of chlorofluorocarbon use and the reduction of carbon dioxide emissions and other trace gases through energy conservation. Other potential mitigation technologies that are currently available and could be applicable at Hanford include alternative fuels and renewable heat and power sources, carbon capture and storage, more fuel-efficient vehicles, cleaner diesel vehicles, hybrid vehicles, biofuels, efficient lighting and daylighting, more-efficient electrical equipment, improved insulation, passive and active solar design for heating and cooling, and use of alternative refrigeration fluids (IPCC 2007b).

6.6 REFERENCES

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CHAPTER 7
ENVIRONMENTAL CONSEQUENCES DISCUSSION

Chapter 7 discusses environmental consequences that would occur from implementation of the reasonable alternatives for each of the following: (1) Hanford Site single-shell tank system closure (i.e., tank closure), (2) decommissioning of the Fast Flux Test Facility and auxiliary facilities (i.e., Fast Flux Test Facility decommissioning), and (3) management of waste resulting from other Hanford Site activities and limited volumes from other U.S. Department of Energy sites (i.e., waste management). Chapter 4 presents more-detailed analysis of short-term impacts and Chapter 5 presents more-detailed analysis of long-term impacts. As previously discussed in Chapter 4, Section 4.4, three representative scenarios, or combinations of alternatives, were selected to facilitate comparison of the alternatives and discussion of the analyses.

Section 7.1 discusses those mitigation measures that could be implemented to reduce or avoid environmental impacts by resource area and identifies those resource areas where impacts are significant enough to warrant consideration of additional mitigation measures. Section 7.2 discusses those adverse impacts that are unavoidable and would occur even after implementation of all of the reasonable mitigation measures discussed in Section 7.1. Section 7.3 presents the major irreversible and irretrievable resource commitments that would occur for all alternatives. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Detailed analyses and discussions of the impacts on environmental justice are provided in Chapter 4, Sections 4.1.13, 4.2.13, and 4.3.13, and are not repeated in this chapter. The discussion presented in this chapter on public health and occupational safety includes normal operations, facility accidents, and waste transportation-related impacts.

7.1 MITIGATION

This section describes the mitigation measures that could be used to avoid or reduce environmental impacts resulting from implementation of the alternatives described in previous chapters. As specified in Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1508.20), mitigation includes:

- Avoiding the impact altogether by not taking a certain action or parts of an action
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments

All of the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* alternatives, including the No Action Alternative, have the potential to impact one or more resource areas over the timeframes analyzed for this environmental impact statement (EIS). Resources that could be negatively impacted include land; infrastructure; noise; air; geology and soils; water; ecology; cultural and paleontological aspects; socioeconomics and local transportation; public and occupational health and safety (human health); and waste management. To mitigate impacts on resource areas, activities associated with the *TC & WM EIS* proposed action alternatives would follow standard procedures and best management practices for facility construction and would consider incorporating, where applicable, the best demonstrated available technologies for facility operations and closure. The U.S. Department of Energy (DOE) is already applying best management practices to minimize environmental impacts in association with ongoing Waste Treatment Plant (WTP) construction. These practices are required by Federal and state licensing and permitting requirements, as described in Chapter 8.

The 1996 *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement (TWRS EIS)* (DOE and Ecology 1996) described possible mitigation measures for the projected short- and long-term impacts of the proposed action alternatives for tank waste retrieval and treatment. DOE committed to these mitigation measures, as documented in the 1997 *TWRS EIS* Record of Decision (ROD) (62 FR 8693). These mitigation measures would continue to be implemented, as applicable, for the tank waste retrieval and treatment activities discussed in this EIS.

The 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)* (DOE 1999a) identifies specific mitigation measures, policies, and management controls that direct land use at the Hanford Site (Hanford). DOE committed to these mitigation measures, as documented in the 1999 *Hanford Comprehensive Land-Use Plan EIS* ROD (64 FR 61615). These commitments were reaffirmed in the 2008 *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS SA)* (DOE 2008) and in the associated ROD (73 FR 55824). These mitigation measures would continue to be implemented, where applicable, for the tank waste retrieval and treatment activities discussed in this EIS.

Following completion of this *TC & WM EIS* and its associated ROD, DOE would be required to prepare a mitigation action plan that addresses mitigation commitments expressed in the ROD (10 CFR 1021.331). This mitigation action plan would be prepared before DOE would implement any *TC & WM EIS* alternative actions that are the subject of a mitigation commitment.

DOE has incorporated several mitigation measures into the alternatives proposed in this EIS to prevent or reduce the short- and long-term environmental impacts. Some mitigation measures were incorporated for all of the alternatives, and some represent variations in one or more of the elements or technologies used to construct the alternatives. Table 7–1 summarizes the potential mitigation measures by resource area; these mitigation measures are discussed in more detail in the sections to follow. The table is divided into three groups: the first group presents those mitigation measures that would normally be considered regardless of impact severity; the second group presents additional mitigation measures that may be necessary where specific short-term impacts are projected to approach or exceed existing capacities, regulatory thresholds, or other guidelines; and the third group presents additional mitigation measures where specific long-term impacts may require special consideration.

While some mitigation measures have already been incorporated within the actions proposed under the *TC & WM EIS* alternatives, some may yet be identified and implemented after issuance of the ROD. Furthermore, because of the relatively long timeframes required to conclude each alternative's life cycle, additional and more effective mitigation measures may become available in the future that could reduce the environmental impacts associated with a proposed action. DOE will continue to identify and incorporate new technologies or practices that could potentially reduce the impacts throughout the life cycle of a selected alternative.

Table 7–1. Summary of Potential Mitigation Measures

Resource Area	Consideration for Normal Mitigation Measures
Land	• Locate facilities in proximity to related activities. • Maintain and coordinate land use as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824). • Use existing buildings or disturbed land. • Use existing permitted facilities to supplement activities. • Use existing infrastructure and right-of-ways. • Expedite restoration of land upon completion of mission.
Infrastructure	• Incorporate high-efficiency motors, pumps, lights and other energy conservation measures into the design of new facilities. • Schedule operations during non-peak times. • Sequence operations to minimize peak use of utilities.
Noise and Vibration	• Limit construction to daylight hours. • Maintain equipment mufflers. • Restrict use of horns and use appropriately sized heavy equipment. • Plan truck routes and timing of traffic.
Air Quality	• Implement dust suppression techniques such as application of water or surfactants. • Use low-sulfur fuels. • Maintain equipment in peak working condition. • Implement zone ambient air monitoring to monitor effectiveness of engineering controls. • Sequence and time construction and/or operations of activities. • Limit the amount of disturbed land areas and revegetating land as soon as possible. • Incorporate best available air pollution control technologies into design of new facilities. • Use containment structures whenever appropriate for excavation activities.
Geology and Soils	• Manage borrow materials as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824) to address requirements such as contouring and revegetating the landscape to match the natural surroundings. • Use disturbed land areas whenever possible. • Limit the time disturbed soils are exposed and/or using protective covers over denudes areas and stockpiles. • Adhere to best management practices for erosion and sedimentation control. • Restore disturbed areas to pre-existing conditions to the maximum extent possible.
Water	• Implement spill prevention and control and storm water pollution prevention plans. • Incorporate water conservation practices into routine operations. • Adhere to strict waste acceptance criteria for burial at one of the proposed or existing waste disposal facilities. • Compare the impacts on groundwater for various levels of tank waste retrieval (e.g., 90 percent, 99 percent, and 99.9 percent). • Implement groundwater monitoring programs. • Construct engineered surface barriers with liners and leachate collections systems. • Extend post-closure care or administrative control durations.

Table 7–1. Summary of Potential Mitigation Measures *(continued)*

Resource Area	Consideration for Normal Mitigation Measures *(continued)*
Ecology	• Implement similar mitigation measures as those listed for land. • Provide compensatory mitigation of sagebrush habitat or other sensitive plant species encountered. • Demarcate construction and land disturbance zones clearly to limit intrusion into non-work areas. • Avoid special status plant and animal species whenever possible. • Implement spill prevention and control plans. • Avoid areas of, and periods of animal breeding or nesting.
Cultural and Paleontological	• Assign an archaeological monitor during construction and other earth-disturbing activities. • Perform surveys to identify prehistoric or cultural resources prior to initiating earth-disturbing activities and avoid any discovered resources. Visual Aspects: • Removal of unnecessary facilities/infrastructure when no longer needed. • Consolidation of facilities/infrastructure where appropriate. • Restoration and/or revegetation of disturbed areas. • Minimal maintenance of exterior building, equipment, and roads to reduce disturbed areas.
Socioeconomics and Local Transportation	• Construct and operate new facilities in sequence, whenever possible, to level the demand on employment resources and associated public services. • Upgrade select traffic routes or intersections. • Use alternate work schedules or expand the existing carpool and commuter program in accordance with Washington's commute trip reduction policy. • Coordinate shipment of materials and waste with heavy commute or public traffic timeframes.
Public and Occupational Health and Safety	• Incorporate best available demonstrated technologies for reducing release of radiological emission. • Maintain acceptable worker doses by implementing ALARA techniques (e.g., reducing time of exposure, increasing number of workers, shielding, remote operations, etc.). • Prepare shipments of waste in containers certified for the intended purpose and train and license handlers and transporters.
Waste Management	• Continue use of existing permitted disposal facilities (e.g., LLBG trenches 31 and 34) for burial of waste to decrease reliance on IDF and/or RPPDF. • Implement pollution prevention and waste minimization techniques. • Investigate technologies that have the potential to increase WTP melter life and increase waste loading (e.g., sulfate removal).
Additional Considerations for Short-Term Mitigation Measures	
Infrastructure	WTP operations would place a high demand on Hanford's electrical grid for an extended amount of time and are projected to approach or, in some alternatives, exceed existing peak capacity. To mitigate this impact, the following steps could be taken: (1) prepare an energy consumption plan; (2) supplement electric supply from alternate sources; and (3) upgrade Hanford's distribution system.
Air Quality	Construction activities are projected to exceed ambient air quality standards for particulate matter under most alternatives, and in a few cases, carbon monoxide as well. However, the projections do not take into account the implementation of any mitigation measures. Mitigation measures may be necessary to ensure applicable standards are met. A more-refined analysis, assuming the implementation of reasonable engineering controls, would likely result in a substantial reduction in projected emissions or criteria air pollutants.

Table 7–1. Summary of Potential Mitigation Measures *(continued)*

Resource Area	Additional Considerations for Short-Term Mitigation Measures *(continued)*
Geology and Soils	The analysis in this *TC & WM EIS* assumes all borrow material would come from Borrow Area C, and no excavation spoils from waste management disposal facility or new facility construction would be used. To mitigate this impact, the extraction and management of geologic materials would be executed in a manner consistent with the policies and resource management plans as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824).
Public and Occupational Health and Safety	Under *TC & WM EIS* Tank Closure Alternatives 4, 6A, and 6B, which would either partially or completely clean-close the tank farms, the average worker dose for the alternatives' activities would approach, and in some cases potentially exceed DOE's Administrative Control Level of 500 millirem per year. In these cases, a comprehensive evaluation of worker exposures may be warranted to determine which activities are the largest contributors to worker dose and to implement aggressive ALARA techniques to ensure worker doses remain below the appropriate levels. In addition, public exposure during the peak year of activities, although low, would coincide with the relatively short operation of the cesium and strontium capsule processing campaign in the WTP. The processing of this material could be spread over a longer timeframe, thus mitigating the peak impact on the public.
Waste Management	Under *TC & WM EIS* Tank Closure Alternatives 6A, 6B, and 6C, all tank waste would be managed as HLW, representing a significant increase in waste volume managed as HLW by a factor of at least 14 times more than other action alternatives. In these alternatives, the treated radioactive tank waste would be stored on site. To mitigate potential impacts from storing large quantities of HLW, waste management areas could be modified as necessary.
Additional Considerations for Long-Term Mitigation Measures	
Water	Several COPCs are predicted to exceed or approach benchmark concentrations in groundwater at the Core Zone Boundary and/or the Columbia River nearshore at various dates. The COPCs resulting in the majority of impacts include the radionuclides hydrogen-3 (tritium), iodine-129, technetium-99, and uranium-238 and the chemicals chromium, nitrate, and total uranium. These COPC drivers are consistent across all *TC & WM EIS* alternatives. Potential mitigation measures that could be considered include the following: • Increase partitioning of target COPCs into ILAW and/or IHLW waste forms by recycling secondary waste streams into primary waste feeds or adopt pretreatment removal technologies that would target COPCs (e.g., technetium removal). • Continue research and development for more robust, long-term performing secondary waste forms and supplemental treatment primary waste forms. • Design and construct more robust surface barrier designs or require periodic replacements of engineered barriers. • Restrict the receipt of offsite waste to waste that would have low impacts on groundwater over the long term at Hanford (e.g., limit or restrict receipt of offsite waste containing iodine-129 or technetium-99 at Hanford). • Implement comprehensive groundwater monitoring programs with contingency corrective action plans.
Ecology	Long-term impacts on ecological receptors from air emissions and groundwater are expected to be minor; however, because a reduction in impacts on air and water resources would result in a corresponding reduction in ecological receptor risk, the mitigation measures discussed under Air Quality and Water Resources could also reduce ecological resource impacts. Additionally, periodic monitoring programs for ecological receptors could provide early detection of decline and, if necessary, implementation of corrective actions.

Table 7–1. Summary of Potential Mitigation Measures *(continued)*

Resource Area	Additional Considerations for Short-Term Mitigation Measures *(continued)*
Public and Occupational Health and Safety	Impacts to offsite receptors would be negligible when compared with background exposures; however, impacts on onsite receptors that would consume groundwater as a drinking source would exceed dose standards for one or more COPCs. Long-term impacts on human health receptors (e.g., resident farmer) are indirect impacts that would result from long-term impacts on other resources such as groundwater (e.g., water used for irrigating land or drinking water) or ecological resources (e.g., consumption of animals or fish). As such, any potential mitigation measures that could reduce impacts on water resources and/or ecological resources may also be applicable for mitigation of human health impacts.

Key: ALARA=as low as is reasonably achievable; COPC=constituent of potential concern; CTR=commute trip reduction; DOE=U.S. Department of Energy; EIS=environmental impact statement; Hanford=Hanford Site; *Hanford Comprehensive Land-Use Plan EIS=Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement; Hanford Comprehensive Land-Use Plan EIS SA=Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement;* HLW=high level radioactive waste; IDF=Integrated Disposal Facility; IHLW=immobilized high level radioactive waste; ILAW=immobilized low activity waste; LLBG=low-level radioactive waste burial ground; ROD=Record of Decision; RPPDF=River Protection Project Disposal Facility; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; WTP=Waste Treatment Plant.

DOE has prepared or will potentially prepare a number of area and resource management plans as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824). These plans are currently in draft form, have been completed, are being revised, or are waiting on available funds and program prioritization (DOE 2008). These plans and their status as of 2008 are summarized as follows:

- *Hanford Cultural Resources Management Plan (HCRMP)*: Final pending revision
- *Gable Mountain and Gable Butte Resource Management Plan (sub-tier to HCRMP):* Final
- *Rattlesnake Mountain Cultural Resource Management Plan (sub-tier to HCRMP):* Draft pending
- *Aesthetic and Visual Resources Management Plan (sub-tier to HCRMP):* Draft pending revision
- *Hanford Site Biological Resources Management Plan (BRMaP)*: Final pending revision
- *Hanford Site Biological Resources Mitigation Strategy (sub-tier to BRMaP)*: Final pending revision
- *Fire Management Plan (sub-tier to BRMaP)*: Final pending revision
- *Noxious Weed Management Plan (sub-tier to BRMaP)*: Final pending revision
- *Ecological Compliance Assessment Management Plan:* Final
- *Hanford Bald Eagle Management Plan*: Final pending revision
- *Threatened and Endangered Species Management Plan, Salmon and Steelhead (T&ESMP-SS):* Final
- *Chinook Salmon-Upper Columbia River Spring Run Hanford Management Plan (sub-tier to T&ESMP-SS)*: Final
- *Steelhead-Middle Columbia River Run Hanford Management Plan (sub-tier to T&ESMP-SS):* Final
- *Facility and Infrastructure Assessment and Strategy*: Draft
- *Mineral Resources Management Plan*: Draft

- *Hanford Site Watershed Management Plan*: Pending available funds and program prioritization
- *Hanford Site Ground-Water Protection Management Plan*: Final
- *Groundwater Vadose Zone Integration Project Summary Description*: Final
- *Hanford Institutional Control Plan*: Final
- *ALE Reserve Comprehensive Conservation Plan*: Draft
- *Wahluke Slope Comprehensive Conservation Plan*: Draft
- *Columbia River Corridor Area Management Plan*: Draft
- *South 600 Area Management Plan*: Pending available funds and program prioritization
- *Hanford Long-Term Stewardship Program and Transition: Preparing for Environmental Cleanup Completion*: Final

As these management plans become available, special management or mitigation required by the procedures outlined in the plans would be implemented for the proposed *TC & WM EIS* activities, as appropriate.

7.1.1 Land Resources

Land resources would be used to construct facilities for the treatment, storage, or retrieval of tank closure or Fast Flux Test Facility (FFTF) decommissioning and closure waste. The duration and amount of land used would vary depending on the alternative. Land resources would also be used to construct permanent disposal facilities for the Waste Management alternatives. Construction of tank waste retrieval, treatment, storage, and permanent disposal facilities would occur primarily within the 200 Areas encompassed by the Central Plateau. In the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a) and associated ROD (64 FR 61615), the Central Plateau was designated for Industrial-Exclusive use and the 400 Area was designated for Industrial use. There are two exceptions where new facilities would be constructed outside the Central Plateau. The first exception would be the construction of the Remote Treatment Project (RTP), which would be built either in the 400 Area under the Hanford Option or at Idaho National Laboratory (INL) under the Idaho Option for the FFTF Decommissioning action alternatives. The RTP would be located within Hanford's existing T Plant complex or within INL's existing Materials and Fuel Complex. The second exception would occur under Tank Closure Alternative 6A, where all tank waste would be treated and immobilized as high-level radioactive waste (IHLW). This would require that a portion of the IHLW Interim Storage Modules be constructed outside and east of the Central Plateau (i.e., 86.2 hectares [213 acres]).

In addition to the construction of new facilities, land resources would be mined for geologic materials necessary for implementation of the alternatives. Borrow Area C is an approximately 930-hectare (2,300-acre) borrow area designated to provide all borrow materials, including rock riprap (basalt), aggregate (gravel and sand), and soil (silt and loam), for the facility construction and associated activities described in this EIS. In the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a) and associated ROD (64 FR 61615), Borrow Area C is designated as Conservation (Mining).

As described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824) to mitigate impacts, representative locations for new facilities to support tank waste retrieval, treatment, storage, and waste disposal under each of the alternatives may have been chosen based on the following factors or by taking the following steps:

- Location of all facilities, to the maximum extent practical, within the Central Plateau Industrial-Exclusive land use zone (e.g., the 200-East and 200-West Areas and those areas in between).
- Proximity to similar facilities (e.g., landfills near landfills), supporting infrastructure, or the tank farms.
- Proximity of Borrow Area C to the Central Plateau.
- Availability of sufficient uncontaminated space not reserved for use by other Hanford projects.
- Maintenance of proposed land use with the Industrial-Exclusive and Conservation (Mining) land use zones.
- Selection and use of existing buildings whenever possible.
- Collocation of related actions and interdependent facilities to reduce the aerial extent of land disturbance (e.g., supplemental treatment facilities and Cesium and Strontium Capsule Processing Facility adjacent to WTP).
- Use of existing infrastructure and rights-of-way.
- Use of existing and permitted facilities to augment alternatives (e.g., waste burial in low-level radioactive waste burial ground (LLBG) trenches 31 and 34.
- Expedient restoration and relandscaping of open areas upon completion of construction-related activities or upon termination and closure of a facility at the completion of its mission.
- Restoration of Borrow Area C, including regrading, contouring the landscape, revegetation to match the natural landscape, and adherence to best management practices for soil erosion and sediment control in accordance with appropriate resource management plans such as a final adopted version of the *Draft Industrial Mineral Resources Management Plan* (Reidel, Hathaway, and Gano 2001).

Several Tank Closure alternatives would require the construction of more facilities than others; however, such construction would be designed to make use of options that could help mitigate impacts on other resource areas. For example, Tank Closure Alternatives 3A, 3B, and 3C all analyze the construction of supplemental treatment facilities for treating tank waste. Supplemental treatment would shorten the length of time required to treat tank waste, which may help reduce impacts on other resource areas. In other cases, the treatment of all tank waste through the WTP or the clean closure alternatives for tank closure would require long implementation timeframes. This may lead to better performing waste forms, but as a consequence of the longer implementation timeframes, replacement facilities or construction of new double-shell tanks (DSTs) may become a necessity.

Land resources located in the Industrial Exclusive land use area and dedicated to permanent waste management or buffer areas in the long term would not be available for unrestricted use. This particular impact cannot be mitigated and would be considered a long-term impact or commitment of land resources, as discussed in Section 7.3.

7.1.2 Infrastructure

With the exception of electrical power required under Tank Closure Alternative 6A, Base and Option Cases, where all tank waste would be treated as high-level radioactive waste (HLW) in the WTP, none of the other *TC & WM EIS* alternatives are expected to consume energy, fuel, or water resources exceeding that which can be provided through existing infrastructure. Existing facilities and infrastructure could be utilized whenever possible to mitigate any necessary changes or upgrades. Necessary and new facilities associated with the *TC & WM EIS* action alternatives could be constructed within areas that have existing infrastructure and rights-of-way whenever possible. If needed, new infrastructure would be constructed consistent with the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824).

For short-lived demands on utilities (such as those typically experienced during construction), portable generators, temporary work lighting, portable water and fuel storage vessels, and portable sanitary facilities could be used to mitigate the need for upgrades to the existing, permanent infrastructure. This would be especially true for those activities that would occur in locations that do not have readily available tie-ins to the existing infrastructure.

The estimated peak electrical usages for the Tank Closure action alternatives range from 27 percent to 113 percent of available capacity, as discussed in Chapter 4, Section 4.1.2. The demand for electrical power would be dominated by WTP operations, particularly operation of the HLW melters. For Tank Closure Alternative 6A, Base and Option Cases, which would vitrify all tank waste in the WTP HLW melters, demand is projected to exceed the peak electrical capacity of Hanford's electrical power distribution system. Even though activities under the other Tank Closure alternatives are not projected to exceed the available peak capacity, electrical consumption is expected to remain near Hanford's peak capacity for the duration of the WTP operations analyzed under each alternative. The consumption of electrical power during WTP operations may require mitigation or the implementation of an energy consumption plan. The following steps could be taken to mitigate electrical consumption:

- Incorporate high-efficiency motors, pumps, lights, and other energy-saving equipment into the design of new facilities.
- Schedule operations during off peak times.
- Sequence operations to minimize peak use of utilities.
- Use alternative or supplemental methods to supply electricity that would not disrupt or threaten to disrupt the regional supply grid.

Infrastructure demands under the FFTF Decommissioning and Waste Management alternatives are expected to be relatively low, and so would not require implementation of additional mitigation measures.

7.1.3 Noise and Vibration

Generally, noise impacts to residential developments and other offsite public areas under the proposed *TC & WM EIS* alternatives are expected to be negligible because most activities would take place in the interior portion of Hanford (the Central Plateau) and away from these sensitive locations. The noise impacts projected to occur in the Central Plateau areas would not represent a significant increase over those levels currently experienced. However, noise impacts would be the greatest for wildlife near Borrow Area C. Activities in Borrow Area C could be limited to daylight hours. Noise impacts during construction would be minimized by maintaining the equipment to ensure that the mufflers and other components are operating properly, by restricting the use of vehicle horns, and using appropriately sized

equipment. Noise from truck traffic coming and going from work sites could be mitigated by planning the routes and timing of truck traffic.

7.1.4 Air Quality

The *TC & WM EIS* action alternatives would involve construction of (1) new facilities over varying timeframes, (2) large permanent disposal facilities, and (3) surface barriers for tank farms, cribs and trenches (ditches) and disposal facilities. Construction activities would generate criteria and hazardous air pollutants. Emissions would be associated with diesel fueled construction equipment and other fuel-burning equipment (e.g., generators) and vehicles. Construction equipment emissions can be minimized by using more-refined fuels (e.g., low-sulfur diesel fuel) and by maintaining the equipment to ensure that its emissions control systems and other components are functioning at peak efficiency. Most notably, fugitive dust emissions would occur as a result of land disturbance by heavy equipment and vehicles, causing suspension of particulate matter from exposed soil in the air. Ambient monitoring and engineering controls may be necessary to maintain pollutants below acceptable levels. Engineering controls could include watering and/or use of surfactants to control dust emissions from exposed areas, revegetation of exposed areas, sequencing and timing of work, watering of roadways, and minimizing construction activity under dry or windy conditions (during late summer and fall). DOE is currently applying these measures in constructing the WTP. For those activities where contaminated dust may be disturbed (e.g., removal of tank farms), excavation work could take place beneath domed containment structures using negative pressure systems, airlocks, and water sprays.

As discussed in Chapter 4, Sections 4.1.4 and 4.3.4, construction activities and other earth-disturbing actions associated with all Tank Closure and Waste Management alternatives, including No Action, have the potential for particulate matter to exceed standards. The 1-hour average for carbon monoxide is also projected to exceed standards under several Tank Closure alternatives. However, the analysis of emissions did not consider the emissions controls described above that could be employed in construction areas to mitigate impacts. Before implementation of any Tank Closure or Waste Management alternative, a more refined analysis of emissions utilizing reasonable control technologies and more-detailed construction activities would need to be performed, and is expected to result in substantially lower estimates of emissions and ambient concentrations of criteria pollutants under all *TC & WM EIS* alternatives. Concentrations of other hazardous air pollutants are projected to be within acceptable levels under all *TC & WM EIS* alternatives and below any published acceptable source impact levels.

New facility process operations (especially operations of the WTP and its supporting facilities) and subsequent facility deactivation would generate airborne emissions of various pollutants, including radionuclides as well as nonradioactive organic and inorganic chemicals. Due to the variety of air pollutant contributors and processes that could be operating under the action alternatives, there are a variety of air pollutant control technologies that could be considered. For example, for removal of airborne particulates and gaseous emissions, the following control technologies could be considered in process design:

- The cyclone precipitator is a common industrial technology used as a precleaning step ahead of more expensive and effective control systems for removal of particulates. This technology would be a good candidate as a precleaning step for emissions emanating from nonthermal treatment systems, such as the Cast Stone Facility, because it is commonly used at commercial concrete production facilities. It would generally not be a useful control technology for thermal waste treatment systems, such as the WTP and its use in radiological environments may be limited as well.

- The electrostatic precipitator is another useful technology for control of particulate emissions. The current WTP design calls for installation of wet electrostatic precipitators. This technology

would remove particulates and some of the vapor included in the air stream and could provide effective treatment for all of the air emissions generated from all waste treatment systems currently considered in this *TC & WM EIS*.

- Direct filtration can also be effective in controlling particulates. One typical industrial application is a baghouse filter system. Direct filtration via high-efficiency particulate air (HEPA) filters has been shown to be very effective at controlling particulates at Hanford. HEPA filters can be used (and will probably be required) for all of the waste treatment systems analyzed in this EIS as long as the exhaust stream temperature can be properly tempered.

- Scrubber systems are another effective air treatment control technology. Currently, the WTP design includes two kinds of scrubbers: caustic and submerged bed. Scrubbers can be used with all currently planned waste treatment technologies. Submerged bed scrubbers are effective at reducing particulate loading in the airborne emissions stream. They can be used on any of the waste treatment technologies considered in this EIS. Caustic scrubbers are effective in treating acid gases produced as part of the thermal treatment system. They would be an effective control on all of the thermal waste treatment system facilities (e.g., WTP, bulk vitrification), but would not provide any additional reduction to the nonthermal systems (e.g., cast stone).

- Thermal oxidation systems are an important treatment technology for controlling emissions of organic chemicals and vapors because they burn these emissions. The current WTP design calls for inclusion of a thermal catalytic oxidizer.

- Carbon adsorption is another treatment technology that helps remove organics from the air emissions stream. This technology is very effective at removing organics and other vapors with the proper chemical affinity. However, as with HEPA filters, carbon adsorption systems are not very effective with high-temperature or liquid-saturated air streams; therefore, the stream must be properly tempered for this technology to be effective. Current WTP design calls for inclusion of a carbon-bed adsorption unit for removal of mercury vapor from the emissions stream.

- The current WTP plan calls for inclusion of a selective catalytic reduction unit for control of nitrous oxide. This type of system can be designed to treat specific chemicals in the airborne stream by using different catalysts and can help reduce acid gases in the emissions stream. This treatment technology could be an effective addition to most of the waste treatment systems and can be effectively implemented to address specific chemicals of concern.

- Pretreatment of waste streams prior to introduction to the WTP or other supplemental treatment processes also can help reduce airborne contaminants and gaseous emissions. Pretreatment would be employed to remove problematic toxic and radiological air pollutants from the waste stream prior to treatment, thus eliminating or reducing the potential for emissions of target contaminants from the process stacks.

7.1.5 Geology and Soils

Impacts on geology and soils would generally be proportional to the total area of land disturbed by construction of new treatment, storage, and disposal facilities, the depth and lateral extent of excavations of the tank farms and other contaminated soils, and the total amount of geologic resources that would be mined from Borrow Area C. Excavation depths for new facility construction generally would not exceed about 12 meters (40 feet); however, deep soil excavation to depths of 20 meters (65 feet) to as much as 78 meters (255 feet) below land surface may be required for clean closure of the single-shell tank (SST) farms under Tank Closure Alternatives 6A and 6B or the clean closure of the BX and SX tank farms under Tank Closure Alternative 4. The majority of impacts on geology and soils would occur from

mining of materials for backfilling tank farm excavations and permanent disposal facilities, providing engineered backfill for construction of the WTP and related facilities, and constructing engineered barriers for closure of the tank farms, cribs and trenches (ditches), River Protection Project Disposal Facility (RPPDF), and an Integrated Disposal Facility (IDF). For analysis purposes, it was assumed that all required geologic resources for the *TC & WM EIS* alternatives would come only from Borrow Area C and would potentially involve disturbance of up to 730 hectares (1,800 acres) of land excavated to a depth of approximately 4.6 meters (15 feet) deep. The greatest impact on Borrow Area C would occur for the alternative combination involving Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 3; and Waste Management Alternative 2, Disposal Group 3. The following mitigating factors could possibly reduce the overall impact of mining operations from Borrow Area C:

- Extraction and management of geologic materials would be executed in a manner consistent with the policies and resource management plans described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824).

- Borrow Area C would be restored, including regrading, contouring the landscape, revegetation to match the natural landscape, and adherence to best management practices for soil erosion and sediment control in accordance with appropriate resource management plans such as a final adopted version of the *Draft Industrial Mineral Resources Management Plan* (Reidel, Hathaway, and Gano 2001).

Regardless of the use of borrow materials sources other than Borrow Area C, geologic resources would still be required in large quantities under some alternatives and the long-term impacts of mining these materials would be realized.

Surface soils and unconsolidated sediments exposed in excavations and cut slopes during new facility construction would be subject to wind and water erosion if left exposed over an extended period of time. In all cases, adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. Due to the number of construction projects that would be ongoing during the early years of each of the action alternatives, erosion of exposed soils cannot be completely eliminated during construction, but a number of practices could reduce overall impacts. Temporary soil disturbance outside the eventual footprint of new facilities could be limited by using inactive areas within the building footprints for material laydown, storage, and parking, as well as by using narrow access and egress corridors for construction equipment usage. In general, limiting the amount of time soils are exposed, limiting the area disturbed during any phase of a construction project, and applying protective coverings to denuded areas during construction (e.g., mulching and/or geotextiles) until the disturbed areas can be revegetated or otherwise covered by facilities could reduce the potential for soil loss. Soil loss and offsite transport could be further reduced by appropriate sedimentation and soil erosion and control devices, including sediment traps, sediment fences, staked hay bales, or other methods that Hanford's arid conditions may dictate. Stockpiles of soil removed during construction could be covered with a geotextile or temporary vegetative covering to protect it from erosion. This material would normally be reclaimed for reuse on site, such as backfill for facility excavations. To reduce the risk from exposing contaminated soils, areas in which new facilities would be constructed would be surveyed prior to any ground disturbance, and any contamination could be remediated as necessary.

Mitigation measures such as controlling the spread of contaminated soil or preventing the recontamination of remediated areas during decommissioning could be implemented through the use of work sequencing, soil stabilization measures, temporary covers, and exclusion zones to reduce contaminant spread. Impacts on soils could also be mitigated by grading the land to create contours

consistent with the surrounding environment. This could be accomplished by grading the land to its preconstruction topography.

7.1.6 Water Resources

There would be no direct discharge of effluents to either surface waters or groundwater during new facility construction, operations, or subsequent deactivation, and no appreciable impact on water quality is expected to result from routine activities. Nonhazardous process wastewater would be discharged to the Treated Effluent Disposal Facility in the 200-East Area, while radioactive liquid effluents would be discharged to the 200 Area Liquid Effluent Retention Facility prior to treatment in the Effluent Treatment Facility. It was assumed that these facilities, or their equivalents, would continue to be available to manage process liquids generated under the action alternatives and that any necessary life extensions or replacements would be completed as needed.

Surface water and groundwater would be protected from hazardous materials spills by development and implementation of spill prevention and contingency plans for instances where hazardous materials are being handled. These plans to minimize the potential for hazardous materials spills would include provisions for storage of hazardous materials and refueling of construction equipment within the confines of protective berms, as well as cleanup and recovery plans and emergency response notification plans and procedures. Spills would also be reduced by keeping vehicles and equipment in good working order to prevent oil and fuel leaks. Soil erosion and sediment control plans and stormwater pollution prevention plans would be implemented as required for any earth-disturbing activity to minimize the transport of suspended sediment or other deleterious materials to surface or groundwater bodies.

Portions of the probable maximum flood zone associated with Cold Creek lie within the confines of Borrow Area C. Mining of geologic materials to support tank closure and waste management activities would include consideration of impacts on the watercourse and associated floodplain. Any changes in the extent and nature of predicted mining that could impact the floodplain would be evaluated, and a floodplain assessment would be prepared as required by Executive Order 11988, *Floodplain Management*, and other Federal regulations (10 CFR 1022).

Water resources requirements under any of the *TC & WM EIS* alternatives would be well below available resources; therefore, no mitigation would be required to provide alternate supplies. However, whenever possible, water conservation practices could be implemented.

Impacts on groundwater would occur over the long term under all of the alternatives. Contaminants from past SST system leaks and releases and other historic waste discharges in the 200 Areas that are already resident in the vadose zone would continue migrating downgradient to the unconfined aquifer and toward the Columbia River. Any future leaks from the SST or DST systems and onsite disposal of waste would add to these impacts. The Tank Closure No Action Alternative would have the largest additional incremental contribution to existing contaminant releases over the long term because no tank waste retrieval and treatment or SST system closure would be performed. Even after implementation of corrective action measures to fill deteriorating tanks with grout or gravel, Hanford SSTs, DSTs, and miscellaneous underground storage tanks would fail over time, resulting in the unmitigated release of their entire contents to the vadose zone and unconfined aquifer system. However, elements of the Tank Closure action alternatives for tank waste storage, retrieval, treatment, disposal, and SST closure that are analyzed in this *TC & WM EIS* incorporate mitigation measures to varying degrees for attenuating long-term groundwater quality impacts. Under all of the Tank Closure action alternatives, waste residing in the SSTs and DSTs would be retrieved for treatment, leaving residual waste ranging from 0.1 to 10 percent of the waste volume in place. Although leaks from the SST system were assumed to occur during retrieval operations, overall retrieval and treatment of tank waste would reduce the incremental contribution to past leaks and releases over the long term.

Waste forms generated as a result of tank waste treatment and from contaminated soil and debris would be disposed of in an onsite, engineered disposal facility (either an IDF or the RPPDF). Use of liners and leachate collection systems would be used to control infiltration of surface water, prevent effluent releases to the vadose zone, and actively monitor contaminant release levels so that appropriate corrective actions can be implemented. Corrective actions could include installation of additional containment barriers (e.g., grout curtains) to halt contaminant migration or exhumation of waste for further treatment before redisposal, if necessary. WTP immobilized low-activity waste (ILAW) forms could be formulated to preferentially retain contaminants to retard their release to the subsurface, or pretreatment steps could be employed to remove problematic constituents prior to treatment and disposal. Similarly, grouting of certain mixed low-level radioactive waste (MLLW) streams could prove successful in delaying release of some contaminants. However, in the long-term, contaminants would eventually be released as systems fail and would eventually impact the vadose zone and groundwater.

DOE uses a proactive approach to protecting groundwater through the performance assessment process. Disposal facility performance assessments are routinely reviewed to ensure that facilities meet requirements established in DOE Orders 435.1, *Radioactive Waste Management*, and 5400.5, *Radiation Protection of the Public and the Environment*. Changes in disposal facility waste acceptance criteria could be enforced, if a review indicated that groundwater contamination might exceed applicable requirements. As a result, some waste could require further treatment prior to disposal, additional confinement (such as disposal in high-integrity containers), or the development and use of better long-term performing waste forms. Waste that does not meet the waste acceptance criteria for immediate disposal could be stored until another treatment or disposition method was found.

Most Tank Closure alternatives would employ landfill closure of the tank farms, which would include placing an engineered surface barrier (either the modified Resource Conservation and Recovery Act [RCRA] Subtitle C barrier or the Hanford barrier design) over the tank farms to minimize water infiltration through the residual tank waste inventories and its subsequent transport through the vadose zone. The surface barrier would be monitored and maintained during a 100-year postclosure care period to ensure its structural integrity. For those Tank Closure alternatives that would employ clean closure of the tank farms, the impacts were analyzed without assessment of such barriers. In addition, engineered surface barriers would be constructed for FFTF entombment and closure of waste management disposal facilities such as one or more IDFs and the RPPDF. The analysis of the Hanford barrier, designed to be a more robust surface barrier, under Tank Closure Alternative 5, is a potential mitigating measure that could be incorporated into all alternatives for closure of tank farms, cribs and trenches (ditches), and waste management disposal facilities, depending on its performance compared to the RCRA Subtitle C barrier design.

The engineered surface barriers that would be constructed for in-place closure of the tank farms, FFTF entombment, or closure of the waste management disposal facilities would have an extensive groundwater monitoring network of observation wells to detect contaminant releases. Given that releases of contaminants from the closed disposal facilities or tank farms would occur hundreds or thousands of years into the future, groundwater quality monitoring systems may need to remain in place far beyond the 30- or 100-year periods assumed under current regulations and incorporated into these alternatives. Should the monitoring system detect releases that could lead to significant deterioration of groundwater quality, DOE could implement one or more of the following mitigation measures:

- The same types of technologies that could be implemented to address existing groundwater contamination could be implemented to remediate potential future groundwater contamination under any *TC & WM EIS* alternative.

- The same technologies and actions described under the clean closure alternatives for tank, ancillary equipment, and contaminated soil removal could be implemented to remove the source(s) of all or part of the exceedances on a location-by-location basis.

- Surface controls (e.g., hydraulic barriers, water run-on and runoff management systems, and leachate collection systems) implemented to limit and control infiltration through engineered barriers could be replaced by more robust and effective systems and/or subsurface contaminant migration control systems (e.g., grout curtains, chemical barriers, or sequestering-agent injection).

- Postclosure care, associated administrative controls, and monitoring and maintenance of the closure systems (e.g., groundwater monitoring, restricting access to the surface of the sites, and routine repair of remediation systems, including surface barrier lobes), which are assumed to end after 100 years, could be extended and/or implemented to restrict access to groundwater by future site users.

Of particular interest when considering long-term impacts on groundwater, and as discussed in detail in Chapter 5, are hydrogen-3 (tritium), iodine-129, technetium-99, chromium, nitrate, uranium-238, and total uranium. Collectively, these constituent of potential concern (COPCs) account for essentially 100 percent of the risk and hazard drivers when analyzing long-term groundwater impacts for the *TC & WM EIS* alternatives. Tritium is a short-lived radionuclide (e.g., half-life of 12.7 years) that is projected to sufficiently decay below benchmark concentrations before reaching the Columbia River. Iodine-129, technetium-99, chromium, and nitrate are referred to as conservative tracers due to their mobility and because they are long-lived or persistent in the environment. Under the clean-closure Tank Closure Alternatives 6A and 6B, the peak concentrations at the Core Zone Boundary for conservative tracers was projected to have occurred during the past-practice period due to past leaks from SST farms and discharges to cribs and trenches (ditches). Under all other Tank Closure alternatives, the peak concentration at the Core Zone Boundary would occur shortly after the post–administrative control period ends, when any residual waste in the SSTs or DSTs would be released into the vadose zone. The end of the post–administrative control period ranges from calendar year 2107 under Tank Closure Alternative 1 to calendar year 2193 under Tank Closure Alternative 2A. Uranium-238 and total uranium are characterized with limited mobility and are projected to reach peak concentrations at the Core Zone Boundary at a much later date than the other more-mobile COPCs (i.e., after calendar year 5000).

Under the FFTF Decommissioning alternatives, tritium and technetium-99 are the risk drivers; however, neither of these COPCs are projected to exceed benchmark concentrations within the 400-Area Property Protected Area or at the Columbia River.

The same COPCs as discussed above for Tank Closure alternatives are also the risk and hazard drivers for the Waste Management action alternatives. However, the performance of an IDF in the 200-East Area (IDF-East), an IDF in the 200-West Area (IDF-West) under Waste Management Alternative 3, and the RPPDF and their related impacts on groundwater are largely influenced by waste form performance and the partitioning of COPCs between the various waste forms. Generally, ILAW (e.g., vitrified waste) are superior-performing waste forms compared to supplemental treatment and secondary waste forms. Major contributing factors to the groundwater-related impacts of the Waste Management alternatives are the disposal of offsite waste from other DOE facilities. Under the Waste Management action alternatives, iodine-129 and technetium-99 from an IDF would result in the majority of impacts when compared with other *TC & WM EIS* sources (e.g., Tank Closure and FFTF Decommissioning action alternatives).

This *TC & WM EIS* shows that receipt of offsite waste streams that contain specific amounts of certain isotopes, specifically iodine-129 and technetium-99, could cause an adverse impact on the environment. As evaluated in this EIS, 15 curies of iodine-129 from offsite waste streams show impacts above the MCLs, regardless of whether this waste stream is disposed of in the 200-East Area under Waste

Management Alternative 2 or in the 200-West Area under Waste Management Alternative 3. The technetium-99 inventory of 1,790 curies evaluated in this EIS from offsite waste streams shows impacts that are less significant than those of iodine-129. However, when the impacts of technetium-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of offsite waste streams containing iodine-129 or technetium-99 at Hanford.

Appendix D provides detailed discussion and assumptions regarding the partitioning of COPCs between the various waste form products. One of the assumptions of the *TC & WM EIS* analysis is that approximately 20 percent of iodine-129 would be captured in primary waste forms (e.g., ILAW, bulk vitrification, or steam reforming waste forms), with the balance due to volatization recovered in secondary waste forms. The only exception would be under Tank Closure Alternatives 3B, 4, and 5, where cast stone would capture a higher percentage of iodine-129 due to the nonthermal nature of this treatment technology. Iodine-129, as mentioned above, is one of the conservative tracers with a half-life of approximately 17 million years and is projected to exceed benchmark concentrations. As such, reasonable mitigation measures could be considered that would recycle secondary waste streams into the primary waste stream feeds within the WTP to increase iodine-129 capture in ILAW and bulk vitrification, which are considered more stable waste forms than those associated with secondary waste. The current WTP design supports the ability to recycle. For example, one method would involve the recycling of iodine within the WTP by capturing it in the submerged bed scrubber and returning it to pretreatment. This recycling could theoretically concentrate the iodine in the feed stream, which, in turn, could put more iodine in a specific volume of glass product. Also, the development of more robust, longer-performing waste forms, particularly with regard to cast stone, steam reforming, and grouted secondary waste, could be pursued.

Another assumption detailed in Appendix D of this *TC & WM EIS* is partitioning of technetium-99 in IHLW, ILAW, and supplemental treatment primary waste forms. Without technetium-99 removal as a pretreatment step in WTP, the analysis assumes that roughly 97 to 98 percent of the technetium-99 from treated tank waste would be captured in ILAW or supplemental treatment waste products, 1 to 2 percent would be captured in secondary waste forms, and less than 1 percent would be captured in IHLW. The further partitioning of technetium-99 among ILAW and supplement treatment waste forms would be generally proportional to the volume of waste that would be treated in each of the facilities. For example, under Tank Closure Alternative 3A, technetium-99 was assumed to partition at 28 percent, 38 percent, and 32 percent between ILAW, the 200-East Area Bulk Vitrification Facility, and the 200-West Area Bulk Vitrification Facility, respectively. However, under Tank Closure Alternative 2B, where technetium-99 removal would be incorporated as a pretreatment step in WTP, 97.5 percent of technetium-99 is expected to be captured in IHLW and only 1 percent in ILAW. In addition, under Tank Closure Alternative 3B, where technetium-99 removal would be employed in the WTP, 99 percent of the technetium-99 in the waste treated in the 200-East Area would be incorporated in IHLW. Similar to iodine-129 above, technetium-99 is a conservative tracer with a long half-life (211,000 years) and is projected to exceed benchmark concentrations. Potential mitigation measures that could be considered include technetium-99 removal as a pretreatment option in the WTP. Also, the development of more robust, longer-performing waste forms, particularly for supplemental treatment technologies and grouted secondary waste, could be pursued.

7.1.7 Ecological Resources

The short-term impacts on ecological resources would largely depend on the amount of new land disturbance that would occur under each *TC & WM EIS* alternative and would potentially upset terrestrial habitats and threatened and endangered species. Disturbance of new land could be minimized by employing the same mitigation measures discussed in Section 7.1.1.

Ecological resources in the Industrial-Exclusive Zone of the Central Plateau have been adversely affected from previous disturbances of the area and from the 24 Command Fire (see Chapter 3, Section 3.2.7). However, the fire did not affect the 200-East Area. New facility construction under the Tank Closure and Waste Management alternatives would impact sagebrush habitat to varying degrees depending on the alternative. Chapter 4, Sections 4.1.7 and 4.3.7, discuss the total area of sagebrush habitat that would be affected under each alternative. This loss may be subject to compensatory mitigation at a ratio of 1:1 to 3:1, as prescribed in the *Hanford Site Biological Resources Management Plan* (DOE 2001) and the *Hanford Site Biological Resources Mitigation Strategy* (DOE 2003a). In addition, some habitats and species that have repopulated the burned areas could also be subject to mitigation under existing biological conditions and current mitigation guidelines. Within the Central Plateau, several state-listed, special status species of plant and wildlife have been observed or have the potential for inhabiting the areas of disturbance. The noted species include two state watch plant species; the stalked-pod milkvetch and crouching milkvetch, which would not require mitigation, although they could be considered in project planning. Other, more protected species that are considered Level III resources under the *Hanford Site Biological Resources Management Plan* (DOE 2001) would potentially require active mitigation (e.g. Piper's daisy [state sensitive], loggerhead shrike and northern sagebrush lizard [Federal species of concern and state candidates], and black-tailed jackrabbit, sage sparrow, striped whipsnake, and sage thrasher [state candidates]. No significant ecological impacts, and therefore no mitigation, is expected to occur in the 400 Area under any of the FFTF Decommissioning alternatives.

The extent of ecological impacts on Borrow Area C would depend on the amount of geologic materials that would need to be mined to support backfilling needs, construction of new facilities, and construction of engineered surface barriers. The maximum impacts would occur under the Tank Closure alternatives that involve clean closure of the tanks, cribs, and trenches, and under Disposal Groups 2 and 3 for the Waste Management action alternatives (where one or two IDFs and the RPPDF would be sized for the largest capacities). Vegetation communities located within Borrow Area C include cheatgrass/bluegrass and needle-and-thread grass/Indian ricegrass. The latter represents an unusual and relatively pristine community type at Hanford and is more highly valued. In addition to Piper's daisy, stalked-pod milkvetch, and crouching milkvetch, which are also found in the Central Plateau as discussed above, the long-billed curlew (state monitor) has been identified in Borrow Area C.

Biological surveys of areas potentially affected under the action alternatives have been completed (Sackschewsky 2003a, 2003b). While current biological conditions and mitigation guidelines are appropriate for determining mitigation requirements for near-term impacts, they are not suitable for judging long-term mitigation requirements because habitats and species assemblages may change over time. Consequently, actual mitigation requirements for later activities that would occur under the alternatives considered would depend on the results of field surveys conducted just prior to initiating ground-disturbing activities and the mitigation guidelines in effect at Hanford at that time.

In addition to preparing a comprehensive mitigation action plan to address the impacts on Level III resources (Piper's daisy, black-tailed jackrabbit, loggerhead shrike, and sage sparrow) and sagebrush habitat, the following mitigation measures could also be implemented to minimize short-term impacts on terrestrial resources and threatened and endangered species:

- Conduct proper maintenance of heavy equipment and clearly mark construction zones to prevent intrusion into sensitive areas or outside work areas.
- Implement noise reduction measures, as discussed in Section 7.1.3.
- Implement spill prevention and control plans, as discussed in Section 7.1.6.

- Avoid, to the maximum extent possible, disturbance of the needle-and-thread grass/Indian ricegrass communities in Borrow Area C.
- Perform land-disturbing activities at times that avoid animal breeding and nesting periods.

The long-term impacts on ecological receptors from air emissions and groundwater are correlated to the amount and timing of air emissions and releases of contaminants to the vadose zone and underlying aquifers. As discussed in Chapter 5, radiological COPCs from air emissions are not projected to be a risk to ecological receptors. Groundwater impacts at the Columbia River for nonradiological and radiological COPCs are also not projected to be a significant risk; however, a slightly elevated risk exists for chromium on aquatic biota at the Columbia River under most Tank Closure and Waste Management alternatives. In some cases, moderate risks for nonradiological COPCs from air emissions are projected. The majority of impacts are associated with mercury and xylene under the Tank Closure alternatives and with xylene under the FFTF Decommissioning and Waste Management alternatives. However, as presented in Appendix D and for conservative analysis, the mercury inventory was assumed both to be captured in waste forms and be emitted into the air. The assumption for most action alternatives that essentially 100 percent of the mercury inventory should be included in air emission analysis (i.e., almost 100 percent of the mercury inventory was assumed to be captured in waste form products) suggests that the risk from mercury is conservatively overstated. Implementing any of the mitigation measures discussed in Sections 7.1.4 and 7.1.6, which would reduce air and groundwater impacts, would also serve to reduce impacts on ecological receptors. Other mitigation measures could include performing periodic ecological surveys to monitor trends in terrestrial, riparian, and aquatic populations.

7.1.8 Cultural and Paleontological Resources

Although no alternative is expected to impact any prehistoric or other significant cultural resource, the potential for inadvertent discovery of prehistoric resources exists. Avoidance of identified resources would be the primary form of mitigation wherever practical. To avoid loss of cultural resources during new facility construction, cultural resource surveys have been and may be conducted in areas of interest. An archaeological monitor could be assigned onsite during ground-disturbing activities of any highly sensitive areas to ensure that, whenever possible, construction impacts would be limited to the project area. If any cultural resources were discovered during construction, construction would be halted, and procedures set forth in the *Hanford Cultural Resources Management Plan* (DOE 2003b) would be implemented.

The construction of new facilities in the Central Plateau would increase the industrial profile of the area from higher elevations. Likewise, excavation of Borrow Area C would alter the view of this area from higher elevations, such as Rattlesnake Mountain, which is of cultural interest to local American Indian tribes. The consolidation of existing activities/facilities and the removal of unnecessary facilities/infrastructure on Rattlesnake Mountain would tend to improve the visual profile of the mountain, allow restoration of the natural habitat, and enhance tribal religious and cultural experiences. The restoration of land used for *TC & WM EIS* activities as well as restoration of Borrow Area C in accordance with the appropriate resource management plans, such as a final adopted version of the *Draft Industrial Mineral Resources Management Plan* (Reidel, Hathaway, and Gano 2001), would lessen these visual impacts. DOE will continue its ongoing practice of consulting with American Indian tribes concerning potential impacts that may affect traditional cultural properties, including visual impacts. Where needed, measures to avoid or minimize these impacts would be developed and implemented in coordination with area tribes.

7.1.9 Socioeconomics

The potential exists for substantial impacts on regional socioeconomic conditions under all of the *TC & WM EIS* alternatives. Under the Tank Closure No Action Alternative, termination of WTP

construction would lead to a noticeable and immediate short-term effect on the regional economy due to loss of employment and revenue. This loss of jobs could not be easily mitigated, as workers with certain skill sets could find it difficult to find comparable employment in the region. In contrast, implementation of any of the action alternatives would significantly increase the demand for professional, skilled, and unskilled labor. This would affect the regional economy, demographic characteristics, and housing and community services in the socioeconomic region of influence for the foreseeable future. Construction activities would cause short-term spikes in employment and demands on the regional economy. These short-term spikes could place a strain on the availability of housing and cause large upward and downward swings in housing prices. These spikes could also strain local school districts and other public services. Secondary effects on housing and community services would be somewhat mitigated by the fact that the spike in employment would be associated with construction. The long duration of some alternatives during the operations phase would lead to a more stable, long-term demand on regional socioeconomics. Data indicate that vacant permanent housing for sale and rent in the region may be insufficient to meet the demand under some action alternatives (see Chapter 3, Section 3.2.9.3, and Chapter 4, Sections 4.1.9, 4.2.9, and 4.3.9). It is anticipated that additional demand would stimulate construction of permanent and other forms of housing to meet the influx of construction workers, thereby producing a positive effect on the regional economy. Similarly, the direct and indirect income associated with procurement of equipment and supplies for completion of the WTP and associated new facility construction would be another economic benefit. Nevertheless, school enrollments associated with the influx of construction and operations workers and their families are expected to increase, and utility, community safety, and police and fire services may need to be expanded to meet demand.

Careful scheduling of activities, particularly during the construction phases, could reduce the severity of short-term spikes. Certain facilities could be built in sequence, rather than concurrently, although this could cause some small delays in initiation or completion of the projects and increases in project cost.

Implementing any action alternatives could impact local transportation infrastructure, especially during commuting periods. The local transportation system has additional capacity during noncommuting periods, but has no additional capacity during the morning and evening peaks (see Chapter 4, Sections 4.1.9, 4.2.9, and 4.3.9). As also described in these subsections, employee commuter traffic and truck traffic would peak at various times depending on the nature and intensity of the activities being conducted under each alternative. This combined effect would decrease the available capacity of site access roads during the morning and evening rush hours. Possible measures that could be used to mitigate traffic volume impacts are physical improvements to local and onsite roads to increase capacity, including construction of additional vehicle lanes throughout road segments; construction of passing lanes in certain locations; or realignment of roadways to reduce points of congestion. Employee programs that provide flexible hours or staggered work shifts to reduce peak traffic volumes also could reduce local transportation impacts. In addition, employee programs and incentives encouraging ridesharing could be established, and existing bus and/or vanpool programs could be expanded. Under Washington State law, Benton and Franklin Counties and the cities of Kennewick, Pasco, Richland, and West Richland must adopt commute trip reduction program plans for major employers. The intent of the commute trip reduction plan is to reduce commutes by workers from their homes to major work sites during the peak period of 6:00 A.M. to 9:00 A.M. on weekdays. Construction work sites are generally excluded under the law, provided the construction duration is less than 2 years. The ongoing construction of the Hanford WTP would likely not be exempt. The current anticipated deadline for the Tri-Cities commute trip reduction plan is February 2009, and the ordinance deadline is September 2009 (BFCOG 2006:2-5, 2-6).

Transport of geologic materials from Borrow Area C across State Route 240 to the 200 Areas presents a particular concern for its potential to cause traffic congestion and accidents and may require specific mitigation measures. Safety measures could include dust control; restrictions on crossings to non-shift-change hours; signs and warning lights along State Route 240 to the north, south, and well in advance of the crossing; and a traffic control light at the crossing itself.

7.1.10 Public and Occupational Health and Safety

Current and anticipated design, construction, and operation of waste treatment and disposal facilities could incorporate the best available technology and engineering controls to limit the discharge of potentially hazardous materials to the environment. The peak annual dose for the maximally exposed individual for both the onsite and offsite receptor for the air pathway was projected to be well below the regulatory limit of 10 millirem per year (DOE Order 5400.5) under all alternatives analyzed.

Although below any regulatory limits, the peak years for radiological impacts on the public coincide with the year of strontium and cesium processing. One option for mitigating this impact could be to alter the treatment strategy by distributing the treatment of strontium and cesium capsules over a longer period of time or by incorporating more aggressive air pollution control technology designed to target cesium and strontium emissions.

Workers would receive radiological doses under the *TC & WM EIS* alternatives. For all work activities involving radiation, the principle of maintaining doses as low as is reasonably achievable (ALARA) would be followed. This principle would involve formal analysis by workers, supervisors, and radiation and/or chemical protection personnel of the work in a hazardous environment to reduce exposure of workers to the lowest practicable level. Examples of ALARA measures could include minimizing time spent in the field of radiation, maximizing distances from sources of radiation, using shielding whenever possible, and/or reducing the radiation source. Mitigation measures also would be used to protect workers from radiological and chemical exposure hazards during construction, operation, and demolition activities. These mitigation measures would be derived from formal radiation protection programs and chemical hazards management programs. Examples of specific measures could include personal protective equipment (e.g., Tyvek suits, face masks), shielding (e.g., earth berms, concrete walls, steel plates, lead bricks), remotely operated robotic machinery, training, and spreading the work across a larger number of workers. All activities that affect the handling, treatment, storage, or disposal of radioactive waste would be performed within the limits of a DOE-approved safety basis. The safety basis would be established by evaluating potential accidents and defining appropriate controls to ensure that accident impacts are below required levels.

The regulatory limit for a worker dose is 5,000 millirem per year (10 CFR 835). The recommended DOE Administrative Control Level for a worker dose is 500 millirem per year (DOE Standard 1098-99). The analysis for worker dose presented in Chapter 4, Sections 4.1.10, 4.2.10, and 4.3.10, calculated an aggregated average dose for a full-time equivalent (FTE) worker over all activities included under each alternative. For example, an average annual dose reported to be 500 millirem per year would indicate that, unless mitigation measures were taken, a portion of an alternative's activities would exceed DOE's Administrative Control Level and a portion would be below this level. For Tank Closure Alternatives 4 and 6B, the average annual dose would exceed 500 millirem per year without mitigation measures. For Tank Closure Alternative 6A, the average annual dose would approach 500 millirem per year. The high average FTE worker dose experienced in these cases would be primarily due to the exhumation of tank farms and underlying radiologically contaminated soils. In these cases, a comprehensive evaluation of worker exposures may be warranted and, whenever possible, applicable ALARA techniques or other mitigation measures similar to those discussed above may be necessary to ensure the worker dose is reduced and maintained below 500 millirem per year. For all other *TC & WM EIS* alternatives, the FTE worker dose would be sufficiently low that the probability of any worker dose exceeding 500 millirem per year would be low.

Long-term impacts on human health were analyzed using a variety of receptors and receptor locations, as discussed in Chapter 5 and detailed further in Appendix K. In summary, the offsite receptor locations are the Columbia River itself and downstream population centers. One receptor is an American Indian hunter-gatherer, who, like the population centers, would consume water from the Columbia River. In

contrast, the onsite receptors (i.e., the drinking-water well user, resident farmer, and American Indian resident farmer) would directly consume groundwater for drinking water, and, in some cases, would use groundwater to irrigate crops. The exposure scenarios for onsite receptors involve several locations within the Core Zone Boundary and the nearshore of the Columbia River. The COPCs that are drivers for groundwater impacts, briefly discussed in Section 7.1.6, are also the drivers for human health impacts.

Because of the substantial dilution that would take place as groundwater seeps into the Columbia River, impacts on downstream population centers and the American Indian hunter-gatherer, both of whom would use surface water as a source of drinking water or might consume fish from the Colombia River, would be negligible compared to background exposures. However, impacts on any receptor that consumes groundwater as a drinking water source and uses groundwater to irrigate crops within the Core Zone Boundary would exceed dose standards and Hazard Indices for either one or multiple COPCs. These impacts on receptors at onsite locations could not be directly mitigable because the underlying assumption is that access to the site and its groundwater resources would be attainable at some future date after all institutional controls are no longer in force. However, implementing any of the mitigation measures discussed in Section 7.1.4, which would reduce groundwater impacts, may also reduce impacts on human health.

All shipments of radioactive or hazardous materials on public roads would be performed within applicable regulatory requirements that address the following:

- Waste packaging in containers certified for use in waste transport.
- Training and licensing requirements for transporters.
- Notification of potentially affected organizations.

Potential mitigation measures to reduce impacts on workers and the public could include packaging the waste to reduce radiation doses below regulatory limits, selecting transportation routes to minimize exposure to populations along the route, and scheduling transport to avoid high traffic times and locations. The latter could also reduce congestion and transportation delays; thereby, reducing radiation exposure and the potential for traffic accidents.

7.1.11 Waste Management

This *TC & WM EIS* analyzes the construction, operation, and closure of permanent disposal facilities to support the disposal of the waste that would be generated under each of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives. These permanent disposal facilities would include IDF-East, IDF-West, and the RPPDF, which would be located in an area between the 200-East and 200-West Areas. A more-detailed description of the IDF and RPPDF disposal facilities is provided in Chapter 2 and Appendix E. This *TC & WM EIS* analyzes several configurations of the IDF and RPPDF, depending on the size and length of operations required; these configurations are referred to as disposal groups. A disposal group is designed to conservatively provide disposal capacity to multiple Tank Closure alternatives; thus, under some Tank Closure alternatives, the full capacity of the disposal facilities, as analyzed in this EIS, may not be used. Chapter 2 provides a more-detailed description of the disposal groups, how they were determined, and which Tank Closure alternatives would be supported. Furthermore, the continued use of LLBG trenches 31 and 34 until filled to capacity could mitigate the amount of space required in an IDF or the RPPDF.

Permanent disposal facilities (i.e., one or two IDFs and the RPPDF) would be constructed with an RCRA-compliant liner and leachate collection system to manage infiltration and prevent the release of contaminants into the vadose zone. Each permanent disposal area would be closed and covered with an engineered modified RCRA Subtitle C barrier. Tank Closure Alternative 5 analyzes the emplacement of a more robust Hanford barrier design, which may further mitigate infiltration of surface water and extend

the lifetime of the structural integrity of the barrier. These engineered surface barriers constructed for in-place closure of the tank farms, entombment of the FFTF, or closure of the waste management disposal facilities could have an extensive groundwater monitoring network of observation wells to detect contaminant releases.

With the exception of the Tank Closure No Action Alternative, all of the Tank Closure alternatives would generate HLW. Under Tank Closure Alternative 6A, all tank waste would be treated and formed into IHLW in the WTP. Under Tank Closure Alternatives 6A, 6B, and 6C all treated tank waste would be managed as HLW. In addition to the IHLW, HLW melters taken out of service would be generated over time from WTP operations and would require disposal. The amount of treated tank waste managed as HLW under Tank Closure Alternatives 6A, 6B, and 6C would represent a significant increase in waste volume managed as HLW by a factor of at least 14 times more than other action alternatives. In these alternatives, the treated tank waste would be stored on site. To mitigate potential impacts from storing large quantities of HLW, waste management areas could be modified as necessary. The increase in volume of waste managed as HLW under Tank Closure Alternatives 6A, 6B, and 6C would also result in a corresponding reduction in the volume of glass ILAW that would require onsite disposal in an IDF.

Sulfate removal is a WTP pretreatment step analyzed under Tank Closure Alternative 5. Sulfate removal has the potential to mitigate impacts on the waste management system (see Appendix E, Section E.1.2.3.9). This technology would remove sulfates from the tank waste stream, thereby reducing corrosivity and potentially extending melter life. This may lead to a reduction in melters taken out of service that would otherwise require disposal. The removal of sulfates may also enable increased waste loading from 14 weight-percent sodium oxide loading to 20 weight-percent sodium oxide loading, thereby potentially reducing the number of IHLW and/or ILAW canisters that would be produced (CEES 2007). However, a grouted sulfate waste form would be generated that would require disposal in an IDF.

DOE has a longstanding policy to minimize waste generation. DOE is implementing Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, by conducting its environmental, transportation, and energy-related activities under the law in an environmentally, economically and fiscally sound, integrated, continuously improving, efficient, and sustainable manner. Hanford has a pollution prevention program that was formalized in the *Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan* (DOE 1999b). Program components include waste minimization, recycling, source reduction, and buying practices that prefer products made from recycled materials. Implementation of the pollution prevention and waste minimization plans could minimize the generation of secondary wastes.

7.1.12 Alternative Combinations

Generally, potential mitigation measures for each resource area would remain the same regardless of the selected combination of alternatives; therefore, additional discussion of mitigation measures across the three alternative combinations would be unnecessarily redundant. However, wherever appropriate in the previous subsections of Section 7.1, mitigation measures may be specifically discussed for a particular alternative (e.g., Tank Closure), when analysis suggests an impact may need more emphasis. The alternative combinations and their affects on short-term impacts are discussed in more detail in Chapter 4, Section 4.4.

7.2 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

Unavoidable adverse environmental impacts are those that would occur after implementation of all feasible mitigation measures, including those design elements incorporated in and analyzed under the individual *TC & WM EIS* alternatives. Implementing any of the alternatives considered in this

TC & WM EIS would result in unavoidable adverse impacts on the human environment. A summary discussion of these impacts is included in this section; however, a more-detailed impacts discussion can be found for each resource area in the appropriate sections in Chapter 4 for short-term impacts and Chapter 5 for long-term impacts.

Unavoidable adverse environmental impacts may occur in either the short or long term. For analysis purposes in this EIS, "short-term" refers to the complete project life cycle under each alternative during which construction, operations, decommissioning, deactivation, and closure activities would take place. All of the *TC & WM EIS* alternatives require either a 100-year postclosure care period or storage of HLW for a significant period of time, either of which would contribute very little to impacts. Thus, the most significant unavoidable adverse environmental impacts would occur in the earlier years of the short-term timeframes for the *TC & WM EIS* alternatives, during which all construction, operations, and deactivation activities would be completed and only postclosure care or storage activities would remain. A Tank Closure, FFTF Decommissioning, and Waste Management alternative would be implemented concurrently as an alternative combination, so while short-term impacts may end for one *TC & WM EIS* alternative, they may continue for another.

"Long-term" refers to the timeframe that extends beyond conclusion of the short-term project life cycle period for each alternative. For any viable alternative, it is expected that an increase in short-term adverse impacts would lead to an overall decrease in long-term adverse impacts (see Section 7.4).

7.2.1 Land Resources

Construction, consolidation, operations, maintenance and deactivation of new or existing facilities would be required to support the action alternatives and would result in short-term adverse impacts on land and visual resources, including the development or use of undisturbed land. Visual impacts from existing structures and maintenance activities on Rattlesnake and Gable Mountains and land use for construction of new facilities are considered a short-term impact because, after a facility's mission has been completed, it would be deactivated and demolished and vegetation and habitat would be re-established to recreate the natural condition. Many of the facilities currently reside on or would be constructed on land that has been disturbed; thus, while this would be considered a short-term commitment of land, it would not necessarily be considered an adverse impact. With the exception of the FFTF Decommissioning alternatives, the IHLW Interim Storage Modules constructed under Tank Closure Alternative 6A, and Borrow Area C, new and existing facilities would be situated in the *Hanford Comprehensive Land-Use Plan EIS* Industrial-Exclusive designated area. This area has been set aside for waste management activities. FFTF decommissioning activities would take place within the 400 Area Property Protected Area, which is in the *Hanford Comprehensive Land-Use Plan EIS* Industrial-Exclusive designated area (DOE 1999a). Borrow Area C is located at the end of Beloit Avenue, just south of Route 240. Other land resource impacts are presented and discussed in Chapter 4, Sections 4.1.1, 4.2.1, and 4.3.1.

The amount of new land disturbance required for construction of facilities to support the Tank Closure alternatives ranges from 3.2 hectares (8 acres) under Alternative 2B to 184 hectares (454.8 acres) under Alternative 6A. Under Tank Closure Alternatives 6A, 6B, and 6C, where all tank waste would be managed as HLW and would require substantial facility storage space, the disturbance of new land would be very high compared to the remainder of the Tank Closure alternatives. The Tank Closure No Action Alternative would terminate construction of the WTP and the Canister Storage Building and would not require any new disturbance of land. New land disturbance would not be necessary under any of the FFTF Decommissioning alternatives. The Waste Management No Action Alternative would not disturb any new land areas and would only utilize existing disposal facilities. The amount of new land disturbance for the Waste Management action alternatives ranges from 64 hectares (158 acres) under Alternative 2, Disposal Group 1 to 253 hectares (624 acres) under Alternative 3, Disposal Group 3. All newly disturbed land under the Tank Closure alternatives would be used to construct treatment and

storage facilities; as such, this disturbance would be considered a short-term adverse impact. The vast majority of newly disturbed land under the Waste Management alternatives would be used for construction of permanent disposal facilities, which would be considered a long-term impact. Less than 1 percent of the new land disturbed under the Waste Management alternatives, or 0.4 hectares (1 acre), would be used for construction of new treatment facilities.

Borrow Area C is the designated source for the geologic materials that would be used for construction, operation, deactivation, and closure activities. Geologic materials from Borrow Area C would be used for concrete and grout, backfill, and construction of engineered barriers. The unavoidable adverse impacts would be the aerial extent of land disturbance and the mining of geologic materials to a maximum depth of 6 meters (15 feet) in some locations. Despite any restoration efforts, the land contours and visual references would be unavoidably altered for the long term; however, the potential use of the land would remain as Conservation (Mining), as designated by the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a). Borrow Area C land disturbance required to support tank closure would range from 2 hectares (5 acres) under the Tank Closure No Action Alternative to 568 hectares (1,405 acres) under Tank Closure Alternative 6A, Option Case. The FFTF Decommissioning No Action Alternative would not require any geologic materials, but FFTF Decommissioning Alternative 3 would disturb up to 3 hectares (8 acres) of Borrow Area C. Geologic materials would not be required under the Waste Management No Action Alternative, but Waste Management Alternative 2, Disposal Groups 2 and 3, would disturb up to 158 hectares (392 acres) of Borrow Area C. The aerial extent of land disturbance impacts would be commensurate with the total amount of geologic resources consumed, as discussed in more detail in Section 7.2.4.

7.2.2 Infrastructure

Implementation of the *TC & WM EIS* alternatives would not adversely affect the current infrastructure's long-term ability to provide energy, fuel, or water resources to support future actions. In the short term, under Tank Closure Alternative 6A, Base and Option Cases, which would vitrify all tank waste in WTP HLW melters, demand was projected to exceed the peak electrical capacity of Hanford's electrical power distribution system. Even though the available peak capacity was not projected to be exceeded under other tank closure activities, electrical consumption is expected to remain near Hanford's peak capacity for the duration of the WTP operations analyzed under each alternative. However, this short-term adverse impact on electrical distribution can be mitigated, as discussed in Section 7.1.2.

7.2.3 Noise and Vibration

Increases in noise levels would be relatively low outside of immediate areas of construction; however, the combination of construction noise and associated human activity would likely displace small numbers of animals surrounding the work areas. Heavy diesel equipment used for construction under most of the alternatives is expected to result in the highest noise levels. The most obvious reaction of wildlife would be a startle or fright response resulting from transient, unexpected noise. Such noise could cause animals to flee the area. Lower, more constant noise levels may cause wildlife to temporarily avoid the construction zone. None of the construction activities are located near residential areas. Noise impacts would be considered a short-term impact that would be experienced mainly during the construction phases of an alternative. Noise impacts are presented and discussed in Chapter 4, Sections 4.1.3, 4.2.3, and 4.3.3.

7.2.4 Air Quality

Implementation of the *TC & WM EIS* alternatives would cause unavoidable adverse impacts on air quality for various criteria and toxic chemical constituents. The peak impact for criteria pollutants is expected to occur during construction activities. For select Tank Closure alternatives, unmitigated air quality could

exceed standards for particulate matter, and in some cases, carbon monoxide. The FFTF Decommissioning alternatives were not projected to exceed standards for criteria pollutants. All Waste Management alternatives were projected to exceed standards for particulate matter.

The peak impacts for toxic pollutants are expected to occur during routine waste retrieval, waste treatment, and supporting facility operations. All toxic air pollutants were projected to be below acceptable source impact levels.

Even after employing the best available technology and management practices to bring air contaminants down to acceptable levels, complete elimination of criteria and toxic air pollutants would not be possible and some unavoidable adverse impacts would still occur. Nonradiological air quality impacts are presented and discussed in Chapter 4, Sections 4.1.4, 4.2.4, and 4.3.4.

In addition to nonradiological air pollutants, unavoidable adverse impacts on air quality would occur as a result of radiological emissions. Unavoidable impacts due to radiological air emissions are discussed in Section 7.2.7.

7.2.5 Geology and Soils

Large volumes of geologic resource materials would be required for construction of facilities, backfilling excavations, construction of engineered barriers for closure of tank systems, entombment of facilities, and closure of landfill disposal sites. Such geologic resource materials would include rock, gravel, sand, clays, and soil. Under Tank Closure Alternatives 3A, 4, and 5, when bulk vitrification is employed as a supplemental treatment option, geologic resources would also be consumed. Section 7.4 and Chapter 4, Sections 4.1.5, 4.2.5, and 4.3.5, discuss impacts on geology and soils resources in more detail. Borrow Area C is the designated source of geologic materials for the activities discussed in this *TC & WM EIS*. This *TC & WM EIS* assumed that all geologic materials would be supplied from Borrow Area C.

The utilization of geologic materials would be the most significant under Tank Closure Alternatives 6A and 6B and Disposal Groups 2 and 3 under the Waste Management action alternatives, both of which involve clean closure of the SST farms.

7.2.6 Water Resources

Adverse impacts on subsurface soils and groundwater, and subsequently the Columbia River, would be unavoidable over the long term under all of the *TC & WM EIS* alternatives due to historical releases of contaminants and the ongoing presence of onsite disposal areas. The greatest impact on water resources would be experienced under the No Action Alternative for each set of proposed actions, where the storage tanks would be left to degrade over time, leading to the eventual release of untreated tank waste into the subsurface; where the remote-handled special components (RH-SCs) and bulk sodium would not be properly dispositioned; and where construction of modern landfill facilities would not be completed. All of the action alternatives are designed to enhance waste form and disposal area performance. Discussions of the long-term performance assessment, the projected impacts, and whether these impacts would exceed existing health- and risk-based standards are found in Chapter 4, Sections 4.1.6, 4.2.6, and 4.3.6, as well as in Chapter 5.

The unavoidable adverse impacts on groundwater that would be experienced from implementation of any of the *TC & WM EIS* action alternatives would be proportional to the amount of tank waste that would be retrieved for treatment and the performance of the primary and secondary waste forms. Even the high performance of ILAW that would be disposed of on site would eventually leach some COPCs into the subsurface. During any post–administrative control period, the eventual failure of engineered barriers followed by infiltration of water through the permanent disposal facilities or in-place closure of other facilities would facilitate migration of contaminants into the groundwater.

In addition to waste generated under the *TC & WM EIS* alternatives, the onsite non-Comprehensive Environmental Response, Compensation, and Liability Act-generated waste and any offsite waste that would be received and disposed of in an IDF or the RPPDF would contribute to any unavoidable impacts on groundwater.

7.2.7 Ecological Resources

Unavoidable adverse impacts on ecological resources would be commensurate with the amount of new land disturbance that would occur as a result of a particular action, as previously discussed in Section 7.2.1. This would cause short-term unavoidable impacts on the natural habitat in these areas, affecting both plant and wildlife ecosystems. Microbiotic crusts, which are expected to occur only on undisturbed sites within the 200 Areas and Borrow Area C, would be destroyed by new construction and excavation activities. Ground disturbance would also result in the loss of less-mobile species such as small mammals, reptiles, and amphibians. Larger, more-mobile species, including many mammals and birds, would be displaced to similar surrounding habitat. Their ultimate survival would depend on whether the areas into which they moved were at their carrying capacity (i.e., contained the maximum number of individual animals that the habitat is capable of supporting). Over the long term, with the exception of areas used for waste disposal, vegetation and wildlife would be re-established to recreate the natural condition on land disturbed for construction of treatment facilities, including Borrow Area C.

Federally and state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas or Borrow Area C; therefore, long-term impacts on these groups of plants and animals are not expected. However, there are several state-listed species of interest that may be adversely affected in newly disturbed land areas such as the stalked-pod milkvetch, crouching milkvetch, Piper's Daisy, black-tailed jackrabbit, loggerhead shrike, sage sparrow, or the long-billed curlew.

The five ponds associated with the Liquid Effluent Retention Facility and Treated Effluent Disposal Facility, located within and adjacent to the 200-East Area, would receive effluent discharges. These ponds are lined and covered and are generally not accessible to wildlife. Potential long-term indirect impacts on ecological life that depends on Columbia River aquatic resources are discussed in Chapter 4, Sections 4.1.7, 4.2.7, and 4.3.7.

In addition to new land disturbance, air and groundwater impacts over the long term would cause limited unavoidable adverse impacts on ecological receptors. Even after implementation of air pollution technologies, air emissions from facility operations would deposit radiological and nonradiological COPCs into area soils and the Columbia River. Furthermore, under all *TC & WM EIS* alternatives, some COPCs would eventually migrate to and seep into the Columbia River. However, as discussed in Chapter 5, most of these impacts for all *TC & WM EIS* alternatives are not projected to be a risk to ecological receptors. In a few cases, the impacts would represent a very small risk. Implementing the mitigation measures discussed in Section 7.1.7 would further reduce these impacts.

7.2.8 Cultural and Paleontological Resources

None of the *TC & WM EIS* alternatives or ongoing maintenance and operational activities are expected to significantly impact any prehistoric, historic, cultural, paleontological, or visual resources. Given that ground disturbance would be required under most alternatives, the potential for inadvertent discovery of prehistoric resources exists. If discovered, the mitigation steps described in Section 7.1.2 of this chapter would be implemented. Excavation of Borrow Area C would alter the view of this area from higher elevations, such as Rattlesnake Mountain, which is of cultural interest to local American Indians, even after restoration efforts would be completed. The consolidation of existing activities/facilities, removal of unnecessary facilities/infrastructure on Rattlesnake Mountain, and maintenance of firebreaks and access

roads on Rattlesnake and Gable Mountains would constitute unavoidable adverse short-term impacts, but over the long term would tend to improve the visual profiles on or from these natural features and allow restoration of natural habitat, thus enhancing tribal religious and cultural experiences.

7.2.9 Socioeconomics

The potential exists for substantial impacts on regional socioeconomic conditions under all of the *TC & WM EIS* alternatives. Under the Tank Closure No Action Alternative, termination of WTP construction would lead to a noticeable and immediate short-term effect on the regional economy due to the loss of employment and revenue. In contrast, implementation of any of the action alternatives would result in a significant increase in demand for professional, skilled, and unskilled labor. This would affect the regional economy, demographic characteristics, and housing and community services in the socioeconomic region of influence for the foreseeable future. Construction activities would cause short-term spikes in employment and demands on the regional economy. These short-term spikes could strain the availability of housing and cause large upward and downward swings in housing prices. These spikes could also cause strains on local school districts and other public services. Additionally, the influx of people to the region would strain the local transportation system. These unavoidable impacts could not be easily mitigated; however, implementing the mitigation measures discussed in Section 7.1.9 of this chapter could reduce their effect on the region.

7.2.10 Public and Occupational Health and Safety

Normal facility operations and deactivation, including some closure activities, would result in unavoidable radiation exposure to workers and the general public. The general public would be exposed to radiation from facility air emissions. Impacts on the general population and maximally exposed individuals are discussed in Chapter 4, Sections 4.1.10, 4.2.10, and 4.3.10. Workers would be exposed to radiation from routine operations dealing with the processing of radiological wastes. Workers would have the highest levels of exposure due to proximity and length of exposure, but doses would be administratively controlled to ensure radiation exposure levels would not exceed occupational health and safety standards. In addition to radiological exposures, workers would be exposed to chemical hazards and would also experience injuries, possibly even fatalities, while performing routine work-related tasks. With the exception of Tank Closure Alternative 6A, Base and Option Cases, where there would be about three projected fatalities, projected fatalities for routine work-related incidents were calculated to be less than one under all other *TC & WM EIS* alternatives. Work-related accidents are discussed in Chapter 4, Sections 4.1.15, 4.2.15, and 4.3.15.

The risk from transportation of radioactive materials is categorized as either radiological impacts or nonradiological impacts. Radiological impacts are those associated with the accidental release of radioactive materials or the effects from low levels of radiation emitted during normal, or incident-free, transportation. Nonradiological impacts are those associated with transportation itself, regardless of the nature of the cargo being transported, such as accidents resulting in death or injury when there is no release of radioactive material. Shipping packages containing radioactive materials emit low levels of radiation during incident-free transportation. The amount of radiation emitted depends on the kind and amounts of materials being transported. U.S. Department of Transportation regulations require that shipping packages containing radioactive materials have sufficient radiation shielding to limit the radiation to an acceptable level of 10 millirem per hour at 2 meters (6.6 feet) from the transporter. Incident-free exposure and accident-related fatalities while shipping both radiological waste and nonradiological materials are discussed in Chapter 4, Sections 4.1.12, 4.2.12, and 4.3.12.

Even after implementing all of the potential mitigation measures discussed in Section 7.1.6 in order to reduce groundwater impacts, some unavoidable impacts would still occur on the groundwater, as discussed in Section 7.2.6. Likewise, any impact on groundwater, even if below benchmark

concentrations, would result in some impacts on human health even if these impacts were acceptable from a dose perspective or negligible when compared to background exposures.

7.2.11 Waste Management

Secondary waste, including LLW, MLLW, and hazardous waste, would be an unavoidable byproduct generated during construction, operations, deactivation, and closure activities. Examples of secondary waste include personal protective equipment, rags, tools, filters, and empty containers. This secondary waste would be in addition to the primary waste forms produced as a result of tank waste treatment or FFTF decommissioning activities. Secondary waste generation would be greatest during the operations and deactivation phases of each alternative. Secondary waste would be managed, treated, and/or stored for eventual recycling or disposal in accordance with applicable Federal and State of Washington regulations. Waste management impacts are discussed in Chapter 4, Sections 4.1.14, 4.2.14, and 4.3.14.

Primary waste is generally not considered an unavoidable adverse environmental impact because this waste already exists in one form or another and, consequently, would require management and disposal. However, depending on the treatment method implemented, the volumes of primary waste may increase. This could result from the addition of binding agents (e.g., glass formers and/or grout), treatment by acid wash, or WTP and/or Preprocessing Facility (PPF) melters taken out of service. The increased volumes of waste would lead to a larger demand for landfill space. The increase in landfill loading would be considered an unavoidable consequence, although not necessarily an adverse consequence, because the overall performance of the final waste form would be enhanced.

7.2.12 Alternative Combinations

For comparison purposes, three alternative combinations were selected for discussion in this section. A summary of overall projected unavoidable adverse impacts for these alternative combinations is presented in Table 7–2. A detailed discussion of short-term impacts under the alternative combinations is presented in Chapter 4, Section 4.4. Long-term impacts under the alternative combinations are presented in Chapter 5, Section 5.4.

Alternative Combination 1, which represents all the No Action Alternatives, would have the least unavoidable impacts on most resource areas in the short term, but conversely would also have the greatest overall adverse impacts on the environment over the long term. Until construction of the WTP and Canister Storage Building could be terminated under the Tank Closure No Action Alternative, some land disturbance and mining of geologic materials would occur in Borrow Area C. This would result in relatively small, but unavoidable short-term impacts on land, noise, air, and ecological resources. Approximately 2 hectares (5 acres) of new land disturbance would take place solely in Borrow Area C. Because of the limited disturbance of land in Borrow Area C, it is expected that native vegetation and natural species habitat would reclaim the disturbed areas relatively quickly, especially after restoration efforts are completed. Noise impacts would remain in the general vicinity of construction zones, but were not projected to exceed guidelines at receptor locations. Air quality would be adversely affected, with the possibility that particulate matter could exceed existing standards. Noise and air impacts would end with the cessation of construction activities. Over the long term, untreated tank waste would eventually be released from all the tank systems, migrate through the subsurface into groundwater, and unavoidably and adversely impact the Columbia River and the Hanford Reach ecosystem.

Alternative Combination 2 represents a midrange set of alternatives. The majority of short-term impacts would be experienced between 2006 and 2051, after which most activities would have been completed and the 100-year administrative monitoring period for this set of alternatives would collectively begin. In the short term, 66 hectares (163 acres) of new land would be disturbed in the 200 Areas, disrupting mostly sagebrush habitat and potentially several species of interest. In Borrow Area C, 139 hectares (344 acres)

of new land would be permanently disturbed, altering the aesthetic quality of this area from several vantage points. Most of the 6.4 million cubic meters (8.4 million cubic yards) of geologic resources utilized would come from Borrow Area C. Electricity demand for WTP operations would approach site capacities and would need to be sustained for as long as the WTP was operating. Noise and air impacts would not necessarily increase in acuity, but the effects would be experienced over a prolonged period of time, compared to Alternative Combination 1. Particulate matter could exceed air quality standards at times. Vitrification of tank waste would eliminate the threat of untreated tank waste being released into the subsurface, but subsequent burial in an onsite disposal facility would be an unavoidable consequence of such treatment. As a result of tank waste treatment, secondary waste and ILAW glass melters taken out of service would be generated, thereby increasing the need for onsite disposal capacity. The transportation risk assessment projected two fatalities from radiological doses to workers and three fatalities due to nonradiological accidents. The majority of projected transportation risks are associated with the receipt of offsite LLW and MLLW from other DOE facilities, an activity that is not associated with tank closure.

Alternative Combination 3 represents the set of alternatives that would produce the greatest impacts on most resource areas; therefore, it most closely resembles a scenario where the maximum reasonably foreseeable unavoidable consequences occur in the short term. The duration of short-term impacts resulting from construction, operations, and deactivation would be extended through 2101. Unavoidable impacts on land and ecological resources would be similar to those under Alternative Combination 2, but would be magnified. New land disturbance would increase to 340 hectares (841 acres) in the 200 Areas and to 401 hectares (991 acres) in Borrow Area C. Geologic material consumption would increase to 18.8 million cubic meters (24.6 million cubic yards). Depending on the timing of construction activities, particulate matter and carbon monoxide emissions could exceed air quality standards. The management of all treated tank waste as HLW would balance the reduction in necessary onsite LLW disposal capacity with an increase in demand for onsite HLW storage facilities. Secondary waste would be generated in greater quantities due to the significant increase in waste treatment associated with clean closure of the tank systems. WTP LAW melters taken out of service would be managed as HLW and would not require onsite disposal, but would be replaced with PPF melters taken out of service that would be disposed of on site. Transportation risks would increase for tank closure activities, but the majority of the projected risk would still be from receipt of offsite LLW and MLLW. The projected transportation related fatalities associated with radiological doses would be two workers; for nonradiological accidents, the projected fatalities would be four.

Table 7–2. Unavoidable Adverse Environmental Impacts for Alternative Combinations

Resource Area	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Land	2 hectares of new land would be disturbed in Borrow Area C only.	66 hectares of new land would be disturbed within the 200 Areas. 139 hectares would be disturbed in Borrow Area C.	340 hectares of new land would be disturbed within the 200 Areas. 400 hectares would be disturbed in Borrow Area C.
Infrastructure	Demand would remain well below capacities; therefore, no adverse impacts would be experienced.	Demand would remain well below capacities, except electrical demand would be approximately 68 percent of site capacities during WTP operations. This impact would not be permanent, but would require infrastructure upgrades or supplemental electrical supply to prevent a potential disruption in the local electrical supply grid.	Demand would remain well below capacities, except electrical demand would be approximately 72 percent of site capacities during WTP operations. This impact would not be permanent, but would require infrastructure upgrades or supplemental electrical supply to prevent a potential disruption in the local electrical supply grid.
Noise and Vibration	Increases in noise levels would be relatively low outside immediate areas of construction and would be barely discernible at the Hanford site boundaries. All combinations of alternatives at the site boundaries are projected to be below the Washington State standard daytime maximum noise level limitation of 60 dBA for industrial sources impacting residential receptors. Noise levels are expected to be the highest during the construction phase. Since the activities for each scoping area of the *TC & WM EIS* (tank closure, FFTF decommissioning, and waste management) occur in different geographic areas, the impacts on noise levels would not be additive.		
Air Quality	Particulate matter emissions may require additional analysis or engineering controls.	Particulate matter emissions may require additional analysis or engineering controls.	Particulate matter and carbon monoxide emissions may require additional analysis or engineering controls.
Geology and Soils	99,030 cubic meters of geologic resources would be consumed for partial construction of the WTP and Canister Storage Building until terminated.	6,435,000 cubic meters of geologic resources would be consumed.	18,780,000 cubic meters of geologic resources would be consumed.

Table 7–2. Unavoidable Adverse Environmental Impacts for Alternative Combinations *(continued)*

Resource Area	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Water	All tank waste would eventually leak into the subsurface, adversely affecting groundwater quality and the Columbia River. The majority of long-term impacts would be from the eventual release of tank waste. Tank Closure Alternative 1 would account for more than 99 percent of impacts on groundwater under this alternative combination.	All tank waste would be vitrified in the WTP and disposed of in 200 Area disposal facilities or stored on site until disposition decisions are made and implemented. Some leaching of contaminants would occur prior to decay. The majority of long-term impacts would be from tank farm sources for hydrogen-3 (tritium), uranium-238, chromium, nitrate, and total uranium. The largest contributors for iodine-129 and technetium-99 are waste management sources, particularly offsite waste disposed of at the 200-East Area IDF.	All tank waste would be vitrified and managed as HLW, requiring long-term, onsite storage in aboveground HLW storage facilities. PPF glass and deep soil removal would be disposed of in 200 Area disposal facilities. Some leaching of contaminants would occur prior to decay, although less than under Alternative Combination 2, due to aboveground storage of vitrified tank waste. Long-term impacts would be similar to those under Alternative Combination 2.
Ecology	Negligible ecological impacts would occur to grasslands and state-listed species within Borrow Area C. However, long-term impacts could occur along the Columbia River due to release of untreated tank waste. Negligible ecological long-term impacts would occur from air emissions. Due to unmitigated release of tank waste into the subsurface, impacts on ecological resources in the Columbia River might occur from migration of contaminants through groundwater.	Grassland and sagebrush habitat would be adversely impacted along with several state-listed species. Some long-term impacts would occur to ecological resources from air emissions associated mainly with WTP operations. Although less, but more prolonged than under Alternative Combination 1, impacts on ecological resources in the Columbia River might occur from releases from tank farm sources and waste management sources into the groundwater. Overall, ecological resource impacts would be the greatest, although very low, under this alternative combination.	Grassland and sagebrush habitat would be adversely impacted along with several state-listed species. This alternative combination's impact would be greatest due to the length of short-term activities and the amount of new land disturbance when compared to Alternative Combination 2. Some long-term impacts would occur to ecological resources from air emissions associated with WTP, PPF, and clean closure operations. Overall, long-term impacts of groundwater would be similar to those under Alternative Combination 2, although somewhat less due to disposal of more treated tank waste off site as HLW.
Cultural and Paleontological	No impacts are expected to occur for this alternative combination.	Excavation of Borrow Area C would alter the view of this area from higher elevations, such as Rattlesnake Mountain, which is of cultural interest to local American Indians, even after completion of restoration efforts.	

Table 7–2. Unavoidable Adverse Environmental Impacts for Alternative Combinations *(continued)*

Resource Area	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Socioeconomic	With the termination of WTP construction, the loss of jobs in the short term would negatively impact the local economy and could possibly suppress growth within the ROI. At its peak and prior to terminating construction, the workforce would be approximately 1,850 FTEs and would represent 1.5 percent of the projected 2008 labor force within the ROI.	Significant growth in the workforce would be necessary and would fuel regional growth. The peak workforce would represent approximately four to five times the peak workforce that would be experienced under Alternative Combination 1, although the peak would occur around 2040. The number of daily commuter vehicles would correlate with the increase in the workforce and could affect commute times.	Major growth in the workforce would be necessary and would fuel regional growth. The peak workforce would represent approximately seven times the peak workforce that would be experienced under Alternative Combination 1, although the peak would occur around 2021. The number of daily commuter vehicles would correlate with the increase in the workforce and could affect commute times.
Public and Occupational Health and Safety	Normal facility operations and deactivation, including some closure activities, would result in unavoidable radiation exposure to workers and the general public: the total estimated latent cancer fatalities to workers would be less than one person. Any increase in transportation risks would be negligible because they would be limited to continued operation of the low-level radioactive waste burial grounds and because no tank waste would be treated and/or transported. No fatalities were projected. Comparatively, this alternative combination would lead to the maximum potential for long-term impacts on the public due to unmitigated releases of radiological contaminants from the storage tanks. Impacts to groundwater from releases of tank inventories within the Core Zone Boundary would potentially increase risks to onsite receptors that attempt to use groundwater as a source of drinking water or for irrigation of crops. Negligible impacts on downstream populations are projected.	Normal facility operations and deactivation, including some closure activities would result in unavoidable radiation exposure to workers and the general public: the total estimated latent cancer fatalities to workers would be 9 persons. The majority of transportation risks would be associated with receipt of offsite waste. Impacts to groundwater within the Core Zone Boundary from waste management areas would potentially increase risks to onsite receptors that attempt to use groundwater as a source of drinking water or for irrigation of crops. Negligible impacts on downstream populations are projected.	Normal facility operations and deactivation, including some closure activities would result in unavoidable radiation exposure to workers and the general public: the total estimated latent cancer fatalities to workers would be increased to 53 persons due to activities associated with clean closure of the storage tanks. The majority of transportation risks would be associated with the receipt of offsite waste, with a minor increase due to the local transportation of additional waste for achieving clean closure of the tanks. Comparatively, this alternative combination would have a lower potential for long-term impacts on the public due to the management of treated tank waste as HLW. Although less than Alternative Combination 2, impacts on groundwater within the Core Zone Boundary and waste management areas would potentially increase risks to onsite receptors that attempt to use groundwater as a source of drinking water or for irrigation of crops. Negligible impacts on downstream populations are projected.

Table 7–2. Unavoidable Adverse Environmental Impacts for Alternative Combinations *(continued)*

Resource Areas	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Waste Management	Any increase in secondary waste generation is expected to be negligible during ongoing administrative activities related to maintaining existing tank systems. In time, as efforts to maintain existing tank systems would likely intensify, the rate of secondary waste generation would also increase.	Secondary waste generation and low-activity waste melters taken out of service from WTP operations are projected.	All tank waste would be managed as HLW; a possible long-term consequence would be the requirement for long-term care and management of large quantities of HLW in onsite, aboveground storage facilities. Increased secondary waste generation and PPF melters taken out of service are projected due to the operation of the PPF for clean closure activities. WTP melters taken out of service would also be managed as HLW.

Note: To convert hectares to acres, multiply by 2.471; cubic meters to cubic yards, by 1.308.

Key: dBA=decibels A-weighted; FFTF=Fast Flux Test Facility; FTE=full-time equivalent; HLW=high-level radioactive waste; IDF=Integrated Disposal Facility; PPF=Preprocessing Facility; ROI=region of influence; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; WTP=Waste Treatment Plant.

7.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

This section describes the major irreversible and irretrievable commitments of resources that have been identified under each alternative considered in this *TC & WM EIS*. A commitment of resources is irreversible when primary or secondary impacts limit future options for a resource. An irretrievable commitment refers to the use or consumption of resources that is neither renewable nor recoverable for future use. In general, the commitment of capital, land, energy, labor, and materials during implementation of the activities in support of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives would be irreversible or irretrievable. This section discusses the commitments of major resources that would result from implementation of the proposed actions and alternatives for four categories: land, materials, utilities, and labor.

Implementation of any of the alternatives considered in this *TC & WM EIS*, including the No Action Alternatives, would entail the irreversible and irretrievable commitment of land; construction materials (e.g., steel, concrete), chemicals, and geologic resources; utility resources (electricity, fossil fuels, and water); and labor. These resources would be committed over the entire life cycle of the alternatives described in this *TC & WM EIS* and would essentially be unrecoverable. The life cycle of an alternative includes construction, operation, decommissioning, and closure of facilities used to accomplish the objectives included in the scope of this *TC & WM EIS*.

7.3.1 Tank Closure Alternatives

Implementation of the Tank Closure No Action Alternative would continue both ongoing partial construction of new facilities and routine tank operations until these activities are terminated, followed by administrative controls for 100 years. Implementation of Tank Closure Alternatives 2 through 6C would specifically require construction, operation, and deactivation of new facilities to support tank waste retrieval, treatment, and disposal and SST system closure. For some facilities, construction of multiple replacements would be necessary because the life cycle of a particular alternative would exceed the design life of the facility.

7.3.1.1 Land Resources

The irreversible and irretrievable commitment of land resources (see Table 7–3) would occur from land use commitments for construction of new facilities on undisturbed land, for the permanent in-place closure of existing facilities and for borrow areas that would be used to supply geologic materials (e.g., sand, gravel, and soil).

Land use commitments for the Tank Closure No Action Alternative represent the area currently occupied by the SST farms and the B and T cribs and trenches (ditches) that would not be closed. Under Tank Closure Alternatives 2A through 5 and 6C, land use commitments would include new treatment and storage facilities constructed on undisturbed land. Under Tank Closure Alternative 2A, land use commitments would also include the SST tank farms and cribs and trenches (ditches), where waste would be left in place. Under Tank Closure Alternatives 2B through 5 and 6C, land use commitments would also include those areas where engineered barriers would be placed over the SST farms and cribs and trenches (ditches). Under Tank Closure Alternatives 6A and 6B, clean closure of the SST farms would be achieved, thereby eliminating the need for engineered barriers. However, management and subsequent storage of all tank waste as IHLW under these alternatives would require a substantial amount of land until permanent waste disposition could be realized. Tank Closure Alternatives 6A and 6B, Base Cases, however, would still require the emplacement of an engineered barrier over the cribs and trenches (ditches). Tank Closure Alternative 6A and 6B Option Cases would achieve clean closure of the SST farms and the B and T cribs and trenches (ditches).

New disturbance of land for construction of facilities would be considered an irreversible impact. The in-place closure of SST farms and cribs and trenches (ditches), with or without the emplacement of engineered barriers, would be considered an irreversible and irretrievable commitment of land. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Construction of new facilities, emplacement of engineered surface barriers, and/or partial or complete clean closure of the SST system would require relatively large volumes of geologic materials from Borrow Area C for backfilling of excavations. While this land would not be irreversibly or irretrievably committed to some use, the area would be irreversibly altered. The consumption of geologic materials including soil, gravel, sand, and rock/basalt is covered in Section 7.3.1.2 below.

The estimated areas of land that may be permanently committed or newly disturbed while supporting the Tank Closure alternatives are presented in Table 7–3. With the exception of Borrow Area C and the construction of IHLW Interim Storage Modules under Tank Closure Alternative 6A, all land commitments would be within the Central Plateau (200 Areas). This area has been designated by the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a) for Industrial-Exclusive use and has been set aside for *TC & WM EIS* activities. For a detailed discussion of land-use impacts of construction of new and existing facilities and Borrow Area C operations under the Tank Closure alternatives, see Chapter 4, Section 4.1.1. Table 7–3 may differ from the presentation analysis in Chapter 4, Section 4.1.1, because Table 7–3 does not include committed land for construction of new facilities where the land is known to have already been disturbed.

Table 7–3. Irreversible and Irretrievable Commitment of Land Resources for Tank Closure Alternatives[a]

Alternative	Land Resource (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1	17	2
2A	33	27
2B	108	95
3A	110	101
3B	111	94
3C	111	94
4	86	102
5	111	118
6A-Base Case	209	492
6A-Option Case	184	568
6B-Base Case	126	239
6B-Option Case	100	316
6C	153	104

a Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure. Does not include land area already committed for construction of the original WTP.

b This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; or (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself.

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2007a, 2008.

7.3.1.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, materials used for construction that cannot be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to unrecoverable waste forms, and geologic borrow materials. Project demands for primary material resources resulting from implementation of each of the Tank Closure alternatives are shown in Table 7–4 for construction and Table 7–5 for nonconstruction-related activities.

Principal construction materials would include steel, asphalt, and concrete and grout constituents such as cement, gravel and sand. Although other materials including wood, plastics, and other metals would be used, these quantities are not considered a primary demand. Concrete, steel, and other materials incorporated into the framework of new facilities such as the WTP and supplemental treatment facilities would be irretrievably lost, whether or not operations would result in direct contamination of the materials. Cement would be used to formulate concrete for construction of new facilities and in the grouting of SSTs and ancillary equipment in the tank farms. Concrete would be manufactured in batch plants located throughout the 200 Areas. The management of all tank waste as IHLW under Tank Closure Alternatives 6A and 6B would require construction of additional IHLW shipping/transfer facilities and interim storage facilities, as well as ILAW storage facilities, which would increase the steel, asphalt, and concrete commitments. Significant quantities of grout would be utilized under Tank Closure Alternatives 2B through 6C to fill the SSTs in place or the ancillary equipment associated with the tank system and/or cribs and trenches (ditches). The Tank Closure No Action Alternative and Alternative 2A would not utilize comparable amounts of grout because the SSTs would not be closed under these alternatives.

Geologic materials would include sand, gravel, soil, and rock mined from Borrow Area C for the construction of engineered barriers and for specification and nonspecification backfill (e.g., other borrow materials). Specification backfill has been designated for construction of the WTP due to the sensitivity of the melters to facility settling. Under the appropriate alternatives, nonspecification backfill would be used to replenish voids resulting from excavation and removal of the SST farms and cribs and trenches (ditches). For example, Tank Closure Alternatives 6A and 6B, where deep soil removal would be required for the tank systems and/or cribs and trenches (ditches), would require a notable increase in soil commitments (shown under 'other borrow materials' in Table 7–4) for backfilling the excavation. In addition, construction of shipping/transfer facilities and interim storage facilities under Tank Closure Alternative 6A to manage the additional IHLW that would be produced specifically requires 'rock' as a backfill for facility construction. With the exception of the Tank Closure No Action Alternative, Alternative 2A, and the Alternative 6A and 6B Option Cases, engineered barriers would be constructed and emplaced. The Tank Closure Alternative 6A and 6B, Base Cases, would not require engineered barriers for the SST farms; however, these alternatives would still require placement of engineered barriers over the cribs and trenches (ditches).

The consumption of various materials would be necessary to support nonconstruction-related activities for the Tank Closure alternatives. For the Tank Closure No Action Alternative, there would be no retrieval or treatment of tank waste; therefore, the consumption of materials would be below notable quantities. The WTP, which would be required under Tank Closure Alternatives 2A through 6C, as well as the PPF, which would be required under Tank Closure Alternatives 4, 6A, and 6B, would utilize glass formers for the vitrification of tank waste into a high-performance waste form. The operations of the WTP low activity waste melters would require the use of ion exchange resins to remove cesium-137 from the waste feed prior to treatment, except under Tank Closure Alternative 6A where all tank waste would be treated as HLW. To achieve 99.9 percent tank waste retrieval under Tank Closure Alternatives 4, 6A, and 6B, chemical washing would be employed, requiring the use of miscellaneous retrieval chemicals (e.g., oxalic acid). The consumption of nitric acid (3 percent and 57 percent solution) and caustics (50 percent

solution) would support operation of the PPF under Tank Closure Alternatives 4, 6A, and 6B. Tank Closure Alternatives 3A through 5 would separate transuranic (TRU) waste from other tank waste using dedicated contract-handled- and remote-handled-Mixed TRU Waste Facilities. The TRU waste processing facilities required for these alternatives would use appreciable quantities of sorbent materials and sodium hydroxide.

The various supplemental treatment technologies (bulk vitrification, cast stone, steam reforming, and sulfate removal) would all consume additional materials to expedite treatment of tank waste. The bulk vitrification technology, implemented under Tank Closure Alternatives 3A, 4, and 5, would utilize soil and sand as an insulator in the large bulk vitrification containers during the melt process. The cast stone technology, implemented under Tank Closure Alternatives 3B, 4, and 5, would utilize fly ash, slag, and cement to encapsulate the waste feed and produce a solid waste form. The steam reforming technology, implemented under Tank Closure Alternative 3C, would consume sucrose (sugar), kaolin clay, iron oxide, oxygen, and nitrogen as chemical additives at various stages of the treatment process. Finally, sulfate removal, implemented under Tank Closure Alternative 5, would consume nitric acid (12.2 molar), strontium nitrate (41.5 weight-percent), sodium hydroxide (30 weight-percent), and grout. The chemicals would be used to react and precipitate sulfates from the waste feed, and the grout would be used to stabilize the sulfate precipitate after it is removed from the waste stream. Appendix E provides a more-detailed analysis of the operations and chemical uses for each of the tank waste treatment technologies.

Table 7–4. Irreversible and Irretrievable Commitment of Construction Materials for Tank Closure Alternatives[a, b]

Resource (×1,000)	Tank Closure Alternative												
	1	2A	2B	3A	3B	3C	4	5	6A-Base Case	6A-Option Case	6B-Base Case	6B-Option Case	6C
Construction Materials (metric tons)													
Steel	4	78	70	69	68	75	168	63	1,940	2,440	530	1,030	140
Asphalt	0	4	5	1	5	5	5	0	240	240	5	5	5
Concrete (cubic meters)[c]													
Cement	8	146	97	94	94	95	120	88	2,550	2,580	340	369	190
Sand	16	297	196	188	188	192	240	178	5,070	5,130	675	732	378
Gravel	21	388	255	246	245	251	312	233	6,610	6,690	876	952	494
Fly ash	0	0	0	0	0	0	0	0	0	0	0	0	0
Grout (cubic meters)[c]													
Cement	0	0.01	13	13	13	13	20	13	28	93	28	93	13
Sand	0	0.05	774	774	774	774	661	772	116	384	116	384	774
Fly ash	0	0.04	166	166	166	166	182	163	140	463	140	463	166
Bentonite clay	0	0	6	6	6	6	7	6	7	9	7	9	6
Water reducing agent	0	0	0.22	0.22	0.22	0.22	0.19	0.22	0.04	0.14	0.04	0.14	0.22
Engineered Barrier (cubic meters)													
Sand (cubic meters)	0	0	1,060	1,060	1,060	1,060	591	1,760	317	0	317	0	1,060
Gravel (cubic meters)	0	0	253	253	253	253	141	421	76	0	76	0	253
Soil (cubic meters)	0	0	850	850	850	850	475	1,416	255	0	255	0	850
Asphalt (cubic meters)	0	0	138	138	138	138	77	230	41	0	41	0	138
Other Borrow Material (cubic meters)													
Rock (cubic meters)	0	10	13	13	13	13	13	10	671	671	13	13	13
Sand (cubic meters)	0.19	1	4	4	4	4	4	4	1	1	1	1	4
Gravel (cubic meters)	0.25	6	8	8	8	8	11	8	11	11	9	9	8
Soil (cubic meters)	0.17	1	529	529	529	529	1,740	1	8,300	12,100	8,300	12,100	529
Specification Backfill (cubic meters)	55	549	254	220	220	220	220	220	1,019	1,019	254	254	254

[a] Resources listed are calculated as total life-cycle requirements for construction related activities.

[b] Values presented in this table are in thousands, multiply by 1,000 to obtain actual value of resource commitment.

[c] Concrete and grout are presented as premixed constituents.

Note: To convert cubic meters to cubic yards, multiply by 1.308.

Source: SAIC 2007a, 2008.

Table 7–5. Irreversible and Irretrievable Commitment of Nonconstruction Materials for Tank Closure Alternatives[a, b]

Resource (×1,000)	Tank Closure Alternative												
	1	2A	2B	3A	3B	3C	4	5	6A-Base Case	6A-Option Case	6B-Base Case	6B-Option Case	6C
Materials													
Glass formers (metric tons)[c]	0	190	190	190	190	190	191	171	194	264	194	264	190
Ion exchange resins (liters)[d]	0	1,580	2,440	1,590	1,590	1,590	1,960	1,600	0	0	2,440	2,440	2,440
Retrieval chemicals, e.g., oxalic acid (liters)[e]	0	0	0	0	0	0	189,000	0	244,000	244,000	189,000	189,000	0
Nitric acid 3 percent and 57 percent solution (liters)[e]	0	0	0	0	0	0	5,680	0	1,790	62,700	1,790	62,700	0
Caustic 50 percent solution (liters)[e]	0	0	0	0	0	0	2,430	0	61	2,120	61	2,120	0
Sorbent (liters)	0	0	0	984	984	984	1,010	894	0	0	0	0	0
Sodium hydroxide (kilograms)	0	0	0	22	22	22	22	22	0	0	0	0	0
Soil (cubic meters)[f]	0	0	0	187	0	0	63	63	0	0	0	0	0
Sand (cubic meters)[f]	0	0	0	148	0	0	50	50	0	0	0	0	0
Fly ash (cubic meters)[g]	0	0	0	0	233	0	149	149	0	0	0	0	0
Slag (cubic meters)[g]	0	0	0	0	233	0	149	149	0	0	0	0	0
Cement (cubic meters)[g]	0	0	0	0	28	0	18	18	0	0	0	0	0
Sucrose (metric tons)[h]	0	0	0	0	0	1,130	0	0	0	0	0	0	0
Kaolin clay (metric tons)[h]	0	0	0	0	0	207	0	0	0	0	0	0	0
Oxygen (metric tons)[h]	0	0	0	0	0	1,070	0	0	0	0	0	0	0
Nitrogen (metric tons)[h]	0	0	0	0	0	460	0	0	0	0	0	0	0
Nitric acid (12.2 Molar (liters)[i]	0	0	0	0	0	0	0	91,600	0	0	0	0	0
Strontium nitrate (41.5 percent-weight) (liters)[i]	0	0	0	0	0	0	0	42,800	0	0	0	0	0
Grout mix (kilograms)[i]	0	0	0	0	0	0	0	28,000	0	0	0	0	0
Sodium hydroxide (30 percent-weight) (liters)	0	0	0	0	0	0	0	3,800	0	0	0	0	0

[a] Resources listed are calculated as total life-cycle requirements for nonconstruction-related activities.

[b] Values presented in this table are in thousands, multiply by 1,000 to obtain actual value of resource commitment.

[c] WTP and PPF utilize glass formers for vitrification process. These values do not include materials for processing cesium and strontium capsules. The values under Tank Closure Alternatives 3A through 5 do not reflect a reduction due to treatment of some tank waste using supplemental treatment.

[d] Cesium removal retreatment.

[e] Chemical washing needed to achieve 99.9 percent retrieval of tank waste.

[f] Bulk vitrification insulating materials.

[g] Cast stone materials.

[h] Stream reforming materials (table does not include small amount of iron oxide that would also be consumed by this process).

[i] Sulfate removal materials.

Note: To convert liters to gallons, multiply by 0.26417; cubic meters to cubic yards, by 1.308; kilograms to pounds, by 2.2046.

Key: PPF=Preprocessing Facility; WTP=Waste Treatment Plant.

Source: SAIC 2007a, 2008.

7.3.1.3 Utility Resources

Key utility infrastructure resources would include the projected activity demands for water, electricity, and fuel over the life cycle of each Tank Closure alternative. Projected demands for key utility infrastructure resources that would result from implementation of each of the Tank Closure alternatives are shown in Table 7–6.

Table 7–6. Utility Resource Commitments for Tank Closure Alternatives[a, b]

Alternative	Resource (×1,000,000)			
	Water (liters)	Electricity (kilowatt-hours)	Fuel	
			Diesel (liters)	Gasoline (liters)
1	3,300	115	36	5
2A	208,000	35,600	4,950	221
2B	86,300	17,900	4,040	156
3A	77,000	14,100	1,860	116
3B	77,000	12,100	1,860	116
3C	77,300	20,100	1,980	116
4	82,200	14,800	2,050	133
5	92,500	12,200	4,110	124
6A-Base Case	644,000	186,000	23,100	723
6A-Option Case	644,000	188,000	23,200	720
6B-Base Case	92,600	21,100	4,360	216
6B-Option Case	92,800	23,800	4,440	212
6C	86,300	17,900	4,040	156

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[b] Values presented in this table are in millions, multiply by 1,000,000 to obtain actual value of resource commitment.

Note: To convert liters to gallons, multiply by 0.26417.

Source: SAIC 2007a, 2008.

Water would be required during construction for soil compaction, dust control, and possibly for work surface and equipment washdown. Concrete and grout would be produced in onsite batch plants that would require large volumes of water. During operations, water would be required to support process makeup requirements and facility cooling, as well as for the potable and sanitary needs of the operations workforce and other uses. Water would also be consumed during facility deactivation activities to stabilize and partially decontaminate waste retrieval, treatment, and disposal facilities.

Energy expended would be in the form of electricity for construction equipment and facility operations and fuel for equipment, vehicles, and process operations. The energy required to support the activities under each alternative would be a large fraction of the total energy used at Hanford. The high demand for electricity for Tank Closure Alternatives 2A through 6C would largely be attributed to operation of the WTP and PPF melters, as well as the bulk vitrification or steam reforming supplemental treatment processes implemented under Tank Closure Alternatives 3A, 3C, 4, and 5. Electricity and fuels would be purchased from commercial sources.

For a detailed discussion of the impacts on the existing infrastructure from implementing the Tank Closure alternatives, see Chapter 4, Section 4.1.2.

7.3.1.4 Labor Resources

Labor associated with the Tank Closure alternatives would be required over the entire life cycle of the alternatives, although more labor resources would be required during the construction and operation phases. Under Tank Closure Alternative 6A, the treatment and management of all tank waste as HLW and the duration of all life-cycle phases of this alternative (156 years) would require a substantially larger commitment of labor. The labor requirements for all of the Tank Closure alternatives are shown in Table 7–7. These labor requirements have the potential to generate economic impacts that may affect the need for housing units and public services and local transportation in the region. For a detailed analysis of the labor impacts associated with the Tank Closure alternatives, see Chapter 4, Section 4.1.9.

Table 7–7. Labor Resource Commitments for Tank Closure Alternatives[a]

Alternative	Labor Hours	Labor (FTEs)
1	16,300,000	8,160
2A	704,000,000	352,000
2B	394,000,000	197,000
3A	357,000,000	178,000
3B	352,000,000	176,000
3C	365,000,000	183,000
4	455,000,000	227,000
5	333,000,000	166,000
6A-Base Case	2,550,000,000	1,270,000
6A-Option Case	2,620,000,000	1,310,000
6B-Base Case	520,000,000	260,000
6B-Option Case	577,000,000	288,000
6C	395,000,000	198,000

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

Note: To convert FTE to labor hours, multiply by 2,000.

Key: FTE=full-time equivalent.

Source: SAIC 2007a, 2008.

7.3.2 FFTF Decommissioning Alternatives

Implementation of the FFTF Decommissioning No Action Alternative would involve completion of deactivation activities and site monitoring under administrative controls for 100 years. The deactivation activities would include removal and storage of the four FFTF RH-SCs and bulk sodium. A complete description of the four FFTF RH-SCs is provided in Appendix E, Section E.2.3. FFTF Decommissioning Alternative 2 would involve demolition of structures to grade and entombment in-place. FFTF Decommissioning Alternative 3 would involve complete removal of all above- and below-grade structures. Both FFTF Decommissioning Alternatives 2 and 3 would require disposition of the four RH-SCs in an RTP at either Hanford or INL, as well as bulk sodium processing in a new Sodium Reaction Facility (SRF) at Hanford or in the existing Sodium Processing Facility (SPF) at INL. As a result of the proposed locations of these facilities at either Hanford or INL, FFTF Decommissioning Alternatives 2 and 3 have four different scenarios depending on the potential location combinations.

7.3.2.1 Land Resources

The irreversible and irretrievable commitment of land resources (see Table 7–8) would occur from land use commitments for construction of new facilities on undisturbed land, for the permanent in-place closure of existing facilities and for borrow areas that would be used to supply geologic materials (e.g., sand, gravel, and soil).

FFTF is located in Hanford's 400 Area. None of the FFTF Decommissioning alternatives involve new disturbance of land for construction of an RTP at Hanford or INL, the construction of an SRF at Hanford, or the construction of as SPF at INL. Construction of these facilities would be within existing buildings or on disturbed land. Land area where engineered barriers would be placed over the Reactor Containment Building (RCB) and buildings 491E and 491W would be considered an irreversible and irretrievable commitment of land as a permanent waste management area. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity.

The construction of new facilities, backfilling of sub-grade void spaces, and emplacement of engineered surface barriers would require relatively large volumes of geologic materials from Borrow Area C. While this land would not be irreversibly or irretrievably committed to some use, the area would be irreversibly altered. The consumption of geologic materials including soil, gravel, sand, and rock/basalt is covered in Section 7.3.2.2.

The estimated areas of land that may permanently be committed or newly disturbed while supporting the FFTF Decommissioning alternatives are presented in Table 7–8. With the exception of Borrow Area C, all land use would occur within the FFTF Property Protected Area (e.g., 400 Area). For a detailed discussion of land use impacts of construction of new and existing facilities and Borrow Area C operations under the FFTF Decommissioning alternatives, see Chapter 4, Section 4.2.1. Table 7–8 may differ from the presentation of analysis in Chapter 4, Section 4.2.1, because Table 7–8 does not include committed land for construction of new facilities where the land is known to have already been disturbed.

7.3.2.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, construction materials that would not be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to unrecoverable waste forms, and geologic borrow materials. Project demands for primary material resources resulting from implementation of each of the FFTF Decommissioning alternatives are shown in Table 7–9. The commitment of material resources would be for the entire life cycle of each FFTF Decommissioning alternative including construction, operations, deactivation and closure.

Table 7–8. Irreversible and Irretrievable Commitment of Land Resources for FFTF Decommissioning Alternatives[a]

Alternative (with Options)	Land Resource (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1–No Action	18	0
2–Hanford RTP and SRF	0.7	2.8
2–Hanford RTP and Idaho SPF	0.7	2.8
2–Idaho RTP and Hanford SRF	0.7	2.8
2–Idaho RTP and SPF	0.7	2.8
3–Hanford RTP and SRF	0	3.2
3–Hanford RTP and Idaho SPF	0	3.2
3–Idaho RTP and Hanford SRF	0	3.2
3–Idaho RTP and SPF	0	3.2

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[b] This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; or (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself.

Note: To convert hectares to acres, multiply by 2.47.

Key: FFTF=Fast Flux Test Facility; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2007b, 2008.

Regardless of whether the SRF is built at Hanford or INL's SPF is reactivated, modified, and used, some nitrogen would be necessary for the operation of either bulk sodium processing facility. Principal construction materials would include steel and concrete and grout constituents such as cement, gravel, and sand. Although other materials including wood, plastics, and other metals would be used, the use of these materials would be minor. For practical purposes, concrete, steel, and other materials incorporated into the framework of new facilities such as the RTP and SRF at Hanford would be irretrievably lost, regardless of whether or not operations would result in the direct contamination of the materials. In general, the RTP and SRF would be of comparable size and complexity; therefore, similar quantities of construction materials would be required for their respective construction.

Geologic materials including sand, gravel, and soil would be mined from Borrow Area C for the construction of engineered barriers and for nonspecification backfill, as presented in Table 7–9 under 'Other Borrow Materials.' The amount of nonspecification backfill required for filling sub-grade void spaces would be higher under FFTF Decommissioning Alternative 3, where the structures would be completely removed. For all of the FFTF Decommissioning Alternative 2 scenarios, entombment would require the construction of an engineered barrier.

Table 7–9. Irreversible and Irretrievable Commitment of Materials for FFTF Decommissioning Alternatives[a, b]

Resource (×1,000)	Alternative								
	1	2–Entombment (with Options)				3–Removal (with Options)			
	No Action	Hanford RTP and SRF	Hanford RTP and Idaho SPF	Idaho RTP and Hanford SRF	Idaho RTP and SPF	Hanford RTP and SRF	Hanford RTP and Idaho SPF	Idaho RTP and Hanford SRF	Idaho RTP and SPF
Process Chemicals (metric tons)									
Nitrogen	0.14	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Construction Materials (metric tons)									
Steel	0	1	1	1	1	1	1	1	1
Asphalt	0	0	0	0	0	0	0	0	0
Concrete (cubic meters)[c]									
Cement	0	1	1	1	1	1	1	1	1
Sand	0	1	1	1	1	1	1	1	1
Gravel	0	2	2	2	2	2	2	2	2
Fly Ash	0	0	0	0	0	0	0	0	0
Grout (cubic meters)[c]									
Cement	0	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Sand	0	23	23	23	23	23	23	23	23
Fly Ash	0	12	12	12	12	12	12	12	12
Bentonite Clay	0	0	0	0	0	0	0	0	0
Water Reducing Agent	0	0	0	0	0	0	0	0	0
Engineered Barrier (cubic meters)									
Sand	0	9	9	9	9	0	0	0	0
Gravel	0	2	2	2	2	0	0	0	0
Soil	0	7	7	7	7	0	0	0	0
Asphalt	0	1	1	1	1	0	0	0	0
Other Borrow Material (cubic meters)									
Rock	0	0	0	0	0	0	0	0	0
Sand	0	0	0	0	0	0	0	0	0
Gravel	0	2	1	1	1	2	1	1	1
Soil	0	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Specification Backfill	0	80	80	80	80	120	120	120	120

[a] Values presented in this table are in thousands, multiply by 1,000 to obtain actual value of resource commitment.

[b] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[c] Concrete and grout are presented as pre-mixed constituents.

Note: To convert cubic meters to cubic yards, multiply by 1.308.

Key: FFTF=Fast Flux Test Facility; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2007b, 2008.

7.3.2.3 Utility Resources

Key utility infrastructure resources would include projected activity demands for water, electricity, and fuel over the life cycle considered for each FFTF Decommissioning alternative. Projected demands for key utility infrastructure resources resulting from implementation of each of the FFTF Decommissioning alternatives are shown in Table 7–10.

Table 7–10. Utility Resource Commitments for FFTF Decommissioning Alternatives[a, b]

Alternatives	Resources (×1,000)			
			Fuel	
	Water (liters)	Electricity (kilowatt-hours)	Diesel (liters)	Gasoline (liters)
1–No Action	7,980,000	600,000	0	114
2–Hanford RTP and SRF	31,100	4,530	5,350	872
2–Hanford RTP and Idaho SPF	30,900	4,530	4,380	466
2–Idaho RTP and Hanford SRF	31,100	4,530	5,360	871
2–Idaho RTP and SPF	30,900	4,530	4,390	465
3–Hanford RTP and SRF	30,400	7,720	5,090	880
3–Hanford RTP and Idaho SPF	30,100	7,710	4,120	474
3–Idaho RTP and Hanford SRF	30,300	7,720	5,090	879
3–Idaho RTP and SPF	30,100	7,710	4,120	474

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[b] Values presented in this table are in thousands, multiply by 1,000 to obtain actual value of resource commitment.

Note: To convert liters to gallons, multiply by 0.26417.

Key: FFTF=Fast Flux Test Facility; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2007b, 2008.

The consumption of water and electricity under the FFTF Decommissioning No Action Alternative would be relatively high compared to the action alternatives due to the long-term management requirements for 100 years of administrative controls. Conversely, to effect entombment or complete removal under FFTF Decommissioning Alternatives 2 and 3, fuel consumption would increase. Essentially, the differences in utility consumption between FFTF Decommissioning Alternatives 2 and 3 are negligible.

For a detailed discussion of impacts on the existing infrastructure from implementing the FFTF Decommissioning alternatives, see Chapter 4, Section 4.2.2.

7.3.2.4 Labor Resources

Labor requirements associated with the FFTF Decommissioning alternatives would be required over the entire life cycle of each alternative. The FFTF Decommissioning No Action Alternative would require less labor, but labor would be extended over a long period of time. FFTF Decommissioning Alternatives 2 and 3 would require much more short-term labor to achieve either entombment or removal of the FFTF structures. To achieve removal under FFTF Decommissioning Alternative 3, a slight increase in construction labor would be required compared to FFTF Decommissioning Alternative 2. These labor requirements are shown in Table 7–11. Labor requirements have the potential to generate economic impacts that may affect the need for housing units and public services and local transportation in the region. For a detailed analysis of the labor impacts associated with the FFTF Decommissioning alternatives, see Chapter 4, Section 4.2.9.

Table 7–11. Labor Resource Commitments for FFTF Decommissioning Alternatives[a]

Alternative	Labor Hours	Labor (FTEs)
1–No Action	41,600	21
2–Hanford RTP and SRF	1,860,000	929
2–Hanford RTP and Idaho SPF	1,540,000	772
2–Idaho RTP and Hanford SRF	1,810,000	906
2–Idaho RTP and SPF	1,500,000	749
3–Hanford RTP and SRF	2,000,000	999
3–Hanford RTP and Idaho SPF	1,680,000	976
3–Idaho RTP and Hanford SRF	1,950,000	842
3–Idaho RTP and SPF	1,640,000	819

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

Note: To convert FTE to labor hours, multiply by 2,000.

Key: FFTF=Fast Flux Test Facility; FTE=full-time equivalent; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2007b, 2008.

7.3.3 Waste Management Alternatives

Expansion of Hanford's waste disposal capacity would be necessary to support implementation of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives, as well as to receive and dispose of offsite waste. The Waste Management No Action Alternative would not expand the current disposal capacity at Hanford. Burial in LLBG trenches 31 and 34 would continue until 2035, followed by 100 years of administrative controls. Construction of IDF-East would also be terminated by backfilling of the site with native soils. Under Waste Management Alternatives 2 and 3, disposal groups were developed to support particular Tank Closure alternatives based on size and operational timeframe needs. Three disposal groups were developed as a subset of both Waste Management Alternatives 2 and 3; all involve construction, operation, deactivation, closure, and postoperational monitoring of additional disposal facilities (e.g., one or two IDFs and the RPPDF). Additionally, Waste Management Alternatives 2 and 3 would require new facility construction, operation, and deactivation to expand the T Plant, Waste Receiving and Processing Facility (WRAP), and storage capacities for processing and handling TRU waste, LLW, and MLLW.

7.3.3.1 Land Resources

The irreversible and irretrievable commitment of land resources (see Table 7–12) would occur from land use commitments for construction of new facilities on undisturbed land, for areas of permanent land disposal facilities, and for borrow areas that would be used to supply geologic materials. Geologic materials (e.g., sand, gravel, soil, and rock) would be used to construct disposal areas and to emplace engineered barriers over disposal areas.

The Waste Management No Action Alternative would not require construction of any new facilities or disposal facilities. In addition, construction of IDF-East would cease without burial of waste and would be backfilled with native soils. Waste Management Alternatives 2 and 3 would require expansion or new construction of the T Plant, WRAP, and waste processing and storage facilities within the 200-West Area. The only new disturbance of land that would be required under both Waste Management Alternatives 2 and 3 would be the construction of a portion of the WRAP TRU Remote-Handled Processing Facility in the 200-West Area. Waste Management Alternatives 2 and 3 would also involve construction of

additional disposal facilities, IDF-East for Waste Management Alternative 2 and two IDFs, IDF-East and IDF-West, for Waste Management Alternative 3. The RPPDF would be situated between 200-East and 200-West Areas regardless of the alternative selected.

Table 7–12. Irreversible and Irretrievable Commitment of Land Resources for Waste Management Alternatives[a]

Alternative	Land Resource (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1–No Action	0	0
2–Disposal Group 1	64	42
2–Disposal Group 2	247	159
2–Disposal Group 3	247	159
3–Disposal Group 1	77	37
3–Disposal Group 2	253	157
3–Disposal Group 3	253	157

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[b] This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; or (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself.

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2007c, 2008.

New disturbance of land for construction of facilities would be considered an irreversible impact. Land used for permanent disposal facilities is considered an irreversible and irretrievable commitment of land. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity.

The construction of new facilities and emplacement of engineered surface barriers over disposal areas would require relatively large volumes of geologic materials from Borrow Area C. While this land would not be irreversibly or irretrievably committed to some use, the area would be irreversibly altered. The consumption of geologic materials including soil, gravel, sand, and rock/basalt is covered in Section 7.3.3.2.

The estimated areas of land that may be permanently committed or newly disturbed while supporting the Waste Management alternatives are presented in Table 7–12. With the exception of Borrow Area C, all land use would occur within the Central Plateau. For a detailed discussion of land use impacts of construction of new and existing facilities and Borrow Area C operations under the Waste Management alternatives, see Chapter 4, Section 4.3.1. Table 7–12 may differ from the presentation of analysis in Chapter 4, Section 4.3.1, because Table 7–12 does not included committed land for construction of new facilities where the land is known to have already been disturbed.

7.3.3.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, construction materials that could not be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to unrecoverable waste forms, and geologic borrow materials. Projected demands for primary material resources resulting from implementation of each of the Waste Management alternatives are

shown in Table 7–13. The commitment of material resources would be for the entire life cycle of each Waste Management alternative including construction, operations, deactivation, and closure.

Geologic materials would include sand, gravel, and soil mined from Borrow Area C for the construction of disposal areas and engineered barriers for one or two IDFs and the RPPDF, as presented in Table 7–13 under 'Other Borrow Materials.' The gravel listed under 'Other Borrow Materials' would be used to construct a drain layer as part of the disposal area liners. For Disposal Groups 2 and 3 under both Waste Management action alternatives, the aggregate size of the IDF(s) and RPPDF would increase significantly to accommodate clean closure of the tank farms and cribs and trenches (ditches), resulting in a proportional increase in the consumption of geologic resources necessary to construct the engineered barriers.

Nitrogen would be used for operation of the expanded WRAP. Principal construction materials would include steel and concrete and grout constituents such as cement, gravel, and sand. Although other materials including wood, plastics, and other metals would be used, the use of these materials would be minor. For practical purposes, concrete, steel, and other materials incorporated into the framework of new facilities such as the T Plant, WRAP, and waste storage facilities would be irretrievably lost, regardless of whether or not operations would result in direct contamination of the materials.

Table 7–13. Irreversible and Irretrievable Commitment of Materials for Waste Management Alternatives[a, b]

Resource (×1,000)	Waste Management Alternative						
	1	2–200-East Area IDF Only			3–200-East and 200-West Area IDFs		
	No Action	Disposal Group 1	Disposal Group 2	Disposal Group 3	Disposal Group 1	Disposal Group 2	Disposal Group 3
Process Chemicals (metric tons)							
Nitrogen	0	1	1	1	1	1	1
Construction Materials (metric tons)							
Steel	2	8	8	8	8	8	8
Asphalt	0	0	0	0	0	0	0
Concrete (cubic meters)[c]							
Cement	1	4	4	4	4	4	4
Sand	3	9	9	9	9	9	9
Gravel	4	11	11	11	11	11	11
Fly ash	0	0	0	0	0	0	0
Grout (cubic meters)[c]							
Cement	0	0	0	0	0	0	0
Sand	0	0	0	0	0	0	0
Gravel	0	0	0	0	0	0	0
Fly ash	0	0	0	0	0	0	0
Bentonite clay	2	5	20	20	5	20	20
Water reducing agent	0	0	0	0	0	0	0
Engineered Barrier (cubic meters)							
Sand	0	814	3,150	3,150	599	3,070	3,070
Gravel	0	195	755	755	195	755	755
Soil	0	651	2,520	2,520	649	2,520	2,520
Asphalt	0	98	377	377	101	382	382
Other Borrow Material (cubic meters)							
Rock	0	0	0	0	0	0	0
Sand	0	0	0	0	0	0	0
Gravel	0.034	209	808	808	208	809	809
Soil	0	0	0	0	0	0	0

[a] Values presented in this table are in thousands, multiply by 1,000 to obtain actual value of resource commitment.

[b] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[c] Concrete and grout are presented as pre-mixed constituents.

Note: To convert cubic meters to cubic yards, multiply by 1.308.

Key: IDF= Integrated Disposal Facility.

Source: SAIC 2007c, 2008.

7.3.3.3 Utility Resources

Key utility infrastructure resources include projected activity demands for water, electricity, and fuel over the life cycle considered for each Waste Management alternative and respective disposal group. Projected demands for key utility infrastructure resources resulting from implementation of each of the Waste Management alternatives are shown in Table 7–14.

Table 7–14. Utility Resource Commitments for Waste Management Alternatives[a, b]

Alternative	Resource (×1,000)			
	Water (liters)	Electricity (kilowatt-hours)	Fuel	
			Diesel (liters)	Gasoline (liters)
1–No Action	35,700	5,630	13,900	1,230
2–Disposal Group 1	3,050,000	556,000	257,000	21,700
2–Disposal Group 2	21,200,000	556,000	1,460,000	83,100
2–Disposal Group 3	37,200,000	556,000	2,220,000	109,000
3–Disposal Group 1	3,040,000	556,000	257,000	21,200
3–Disposal Group 2	21,100,000	566,000	1,460,000	83,100
3–Disposal Group 3	36,900,000	566,000	2,220,000	109,000

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[b] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.

Note: To convert liters to gallons, multiply by 0.26417.

Source: SAIC 2007c, 2008.

The consumption of utility resources under the Waste Management No Action Alternative would be relatively low compared to the action alternatives as new waste processing, storage, and disposal facilities would not be constructed. Disposal Group 1 under both Waste Management action alternatives would involve increased consumption of utility resources. Compared to Disposal Group 1, consumption of water and fuel would increase significantly for Disposal Groups 2 and 3 in proportion to the large increase in disposal area capacities required. Electricity consumption would not increase because it would not be a primary utility necessary for construction and operation of the disposal areas; rather, it would be consumed for operation of the new T Plant, WRAP, and waste storage facilities that would be implemented regardless of the disposal group selected.

For a detailed discussion of impacts on the existing infrastructure from implementing the Waste Management alternatives, see Chapter 4, Section 4.3.2.

7.3.3.4 Labor Resources

Labor associated with the Waste Management alternatives would be required over the entire life cycle of the alternatives. The Waste Management No Action Alternative would require less labor, due to the lack of additional waste processing, storage, and disposal facilities to be constructed and operated. The labor requirements would be proportionally influenced by the size of the disposal areas and the length of operation. The difference in labor requirements between Waste Management Alternatives 2 and 3, where the only difference is the locations of the disposal areas, would be very minor. The labor requirements for the Waste Management Alternatives are shown in Table 7–15. Labor requirements have the potential to generate economic impacts that may affect the need for housing units and public services and local transportation in the region. For a detailed analysis of the labor impacts associated with the Waste Management alternatives, see Chapter 4, Section 4.3.9.

Table 7–15. Labor Resource Commitments for Waste Management Alternatives[a]

Alternative	Labor Hours	Labor (FTEs)
1–No Action	1,000,000	502
2–Disposal Group 1	57,700,000	28,900
2–Disposal Group 2	166,000,000	82,800
2–Disposal Group 3	242,000,000	121,000
3–Disposal Group 1	59,000,000	29,500
3–Disposal Group 2	167,000,000	83,400
3–Disposal Group 3	243,000,000	122,000

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

Note: To convert FTE to labor hours, multiply by 2,000.
Key: FTE=full-time equivalent.
Source: SAIC 2007c, 2008.

7.3.4 Alternative Combinations

For comparison purposes, three alternative combinations were selected. The alternative combinations are described in detail in Chapter 4, Section 4.4. The combined irreversible and irretrievable commitments of resources for these alternative combinations are discussed below.

7.3.4.1 Land Resources

The irreversible and irretrievable commitment of land resources would occur from land use commitments for construction of new facilities, for areas of permanent disposal and for borrow areas used to supply geologic materials (e.g. sand, gravel, soil, and rock). The estimated areas of land that may be permanently committed or newly disturbed while supporting the representative alternative combinations are presented in Table 7–16. The values presented in Table 7–16 do not include the commitment of land for construction of new facilities where the land is known to have already been disturbed.

Table 7–16. Irreversible and Irretrievable Commitment of Land Resources for Alternative Combinations[a]

Alternative Combination	Land Resources (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1	35	2
2	173	140
3	373	401

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[b] This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; or (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself.

Notes: To convert hectares to acres, multiply by 2.471.
Source: SAIC 2007a, 2007b, 2007c, 2008.

7.3.4.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, construction materials that cannot be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to unrecoverable waste forms, and geologic borrow materials. Projected demands for primary material resources resulting from implementation of the representative combination of alternatives are presented in Table 7–17.

Table 7–17. Irreversible and Irretrievable Commitment of Materials for the Alternative Combinations[a, b]

Resources (×1,000)	Alternative Combination		
	1	2	3
Materials			
Glass formers (metric ton)	0	190	194
Ion exchange resins (liter)	0	2,440	2,440
Retrieval chemicals (e.g., oxalic acid) (liter)	0	0	189,000
Nitric acid 3 percent and 57 percent solution (liter)	0	0	1,790
Caustic 50 percent solution (liter)	0	0	61
Nitrogen (metric tons)	0.14	1.05	1.05
Construction Materials (metric tons)			
Steel	6	79	539
Asphalt	0	5	5
Concrete (cubic meters)[c]			
Cement	9	102	345
Sand	19	206	685
Gravel	25	268	889
Grout (cubic meters)[c]			
Cement	0	13.2	28.2
Sand	0	797	139
Fly ash	0	178	152
Bentonite clay	2	11	27
Water reducing agent	0	0.22	0.04
Engineered Barriers (cubic meters)			
Sand	0	1,880	3,467
Gravel	0	450	831
Soil	0	1,510	2,775
Asphalt	0	237	418
Other Borrow Materials (cubic meters)			
Rock	0	13	13
Sand	0.19	4	1
Gravel	0.284	218	818
Soil	0.17	529	8,300
Specification backfill	55	262	266

[a] Calculated as total alternative life-cycle requirements encompassing construction operations, deactivation, and closure.

[b] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.

[c] Concrete and grout are presented as premixed constituents.

Note: To convert liters to gallons, multiply by 0.26417; cubic meters to cubic yards, by 1.308; kilograms to pounds, by 2.2046.

Source: SAIC 2007a, 2007b, 2007c, 2008.

7.3.4.3 Utility Resources

Key utility infrastructure resources would include projected activity demands for water, electricity, and fuel over the life cycle considered for each alternative combination. The irreversible and irretrievable commitments of utility resources that would result from implementation of the representative alternative combinations are presented in Table 7–18.

Table 7–18. Utility Resource Commitments for Alternative Combinations[a, b]

Alternative Combination	Resource (×1,000,000)			
	Water (liters)	Electricity (kilowatt-hours)	Fuel	
			Diesel (liters)	Gasoline (liters)
1	11,300	721	50	6
2	89,400	18,500	4,300	179
3	114,000	21,700	5,825	300

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

[b] Values presented in this table are in thousands; multiply by 1,000,000 to obtain actual value of resource commitment.

Note: To convert liters to gallons, multiply by 0.26417.

Source: SAIC 2007a, 2007b, 2007c, 2008.

7.3.4.4 Labor Resources

Labor associated with the alternative combinations would be required over the entire life cycle of each combination, although more labor resources would be required during the construction and operation phases. Labor requirements have the potential to generate economic impacts that may affect the need for housing units and public services and local transportation in the region. The labor requirements for the representative alternative combinations are shown in Table 7–19.

Table 7–19. Labor Resource Commitments for Alternative Combinations[a]

Alternative Combination	Labor Hours	Labor (FTEs)
1	17,300,000	8,680
2	454,000,000	227,000
3	688,000,000	344,000

[a] Calculated as total alternative life-cycle requirements encompassing construction, operations, deactivation, and closure.

Note: To convert FTE to labor hours, multiply by 2,000.

Key: FTE=full-time equivalent.

Source: SAIC 2007a, 2007b, 2007c, 2008.

7.4 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

Pursuant to National Environmental Policy Act regulations (40 CFR 1502.16) an EIS must consider the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity. Potential short-term impacts related to the Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Chapter 4. For analysis purposes, "short term" refers to the active project phase under each alternative during which construction, operations, deactivation, and closure activities would take place. Short-term timeframes would include any administrative control, postclosure care, or onsite storage activities for treated waste pending final disposition. "Long term" is defined as the timeframe that extends beyond conclusion of the short-term activities proposed under each alternative. Long-term impacts are discussed in Chapter 5.

The objective of any proposed action is to demonstrate and implement the alternative(s) that, on balance, would result in the least overall adverse impact on the environment. For the proposed *TC & WM EIS* action alternatives, an increase in worker and public exposure under controlled circumstances (i.e., tank waste retrieval, treatment, and disposal) and in compliance with applicable legal requirements in the short term would lead to a decrease in exposure of the unprotected public to unmitigated releases of contaminants into the environment over the long-term.

Under certain *TC & WM EIS* alternatives, and in addition to short-term use of the environment, the emplacement of engineered barriers over tank farm systems, cribs and trenches (ditches), the FFTF RCB, and/or permanent waste disposal sites would be considered a long-term use of the environment, and thus, a decrease in long-term productivity for these locations. Short-term and long-term uses of the environment in the broader context would include elements of unavoidable adverse impacts and an irreversible and irretrievable commitment of resources to enhance the long-term productivity of the environment. Previously, unavoidable adverse environmental impacts were discussed in Section 7.2. Irreversible and irretrievable commitments of resources are discussed in Section 7.3.

7.4.1 Tank Closure Alternatives

The short-term durations for each of the Tank Closure alternatives are presented in Table 7–20. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase when most activities would take place and (2) the closure phase when administrative controls, postclosure care, and/or long-term storage would be continued. Most impacts and short-term uses of the environment would occur during the construction, operations, and deactivation phase. Under the Tank Closure No Action Alternative and Tank Closure Alternative 2A, administrative controls would be required because tank farm closure would not be achieved. Tank Closure Alternatives 2B through 5 would close the SST farms with emplacement of an engineered barrier followed by postclosure care. Tank Closure Alternatives 6A and 6B, Base Cases, would emplace an engineered barrier over the cribs and trenches (ditches). Tank Closure Alternatives 6A and 6B, Option Cases, would clean-close all tank farms and cribs and trenches (ditches) and, therefore, would not require construction of an engineered barrier and postclosure care. In contrast, Tank Closure Alternative 6C would require an engineered barrier over the tank farms and cribs and trenches (ditches) and, as a result, postclosure care. Tank Closure Alternatives 6A through 6C would manage all tank waste as HLW, which would require construction and operations of long-term, onsite storage facilities.

Table 7–20. Short-Term Life Cycles for Tank Closure Alternatives

Alternative	Construction, Operations, and Deactivation Phase	Closure Phase (Activity Type)[a]
1	2006–2008	2008–2107 (AC)
2A	2006–2094	2094–2193 (AC)
2B	2006–2046	2046–2145 (PM)
3A	2006–2043	2042–2141 (PM)
3B	2006–2043	2042–2141 (PM)
3C	2006–2043	2042–2141 (PM)
4	2006–2045	2045–2144 (PM)
5	2006–2039	2040–2139 (PM)
6A-Base Case	2006–2165	2151–2250 (PM) Until 2262 (ST)
6A-Option Case	2006–2167	Until 2262 (ST)
6B-Base Case	2006–2101	2102–2201 (PM) Until 2199 (ST)
6B-Option Case	2006–2101	Until 2199 (ST)
6C	2006–2046	2046–2145 (PM) Until 2145 (ST)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring; ST=onsite storage.

Source: SAIC 2007a, 2008.

Short-term commitments of resources would include the space and materials required to construct new facilities and the commitment of new support facilities, transportation infrastructure, and other resources and materials for waste storage, retrieval, treatment, and disposal, as well as tank closure. Certain resource commitments would be substantially greater under Tank Closure Alternatives 2B through 6C than under the Tank Closure No Action Alternative or Tank Closure Alternative 2A because construction of an engineered surface barrier for landfill closure and/or partial or complete clean closure of the SST system would be required. Tank Closure Alternative 2A would involve a commitment of resources to treat and stabilize the tank waste, but would not follow through with closure of the SST farms. Depending on the alternative, workers, the public, and the environment would be exposed to various amounts of hazardous and radioactive materials over the short term from tank waste retrieval, treatment, and disposal activities and from SST system closure operations.

Table 7–21 presents the amounts of land that would be committed in the short term to accomplish the objectives of each Tank Closure alternative. This area includes land for existing facilities and for new facilities that would be constructed to support a particular alternative. The land use amounts are presented as aggregate values over the entire short-term life cycles of the alternatives; however, in practice, most facilities would operate at various timeframes. Table 7–21 also presents the long-term land commitments that would continue indefinitely for each alternative, including all permanent disposition areas where engineered barriers would preclude the use of the site for other productive purposes and all areas where tank farms and cribs and trenches (ditches) would not be closed under certain alternatives. Borrow Area C is not included in the short-term commitments of land. Excavation activities conducted at Borrow Area C, while taking place in the short-term, can be terminated at any time. The amount of land disturbance required at Borrow Area C to support each Tank Closure alternative was previously discussed in Section 7.3.1.1.

Table 7–21. Short- and Long-Term Commitments of Land for Tank Closure Alternatives

Alternative	Land Commitment (hectares)	
	Short-Term[a]	Long-Term[b]
1	0	17
2A	32	17
2B	16	84
3A	17	84
3B	19	84
3C	18	84
4	18	61
5	20	84
6A-Base Case	210	25
6A-Option Case	210	0
6B-Base Case	117	25
6B-Option Case	117	0
6C	61	84

[a] Short-term includes entire life cycle of the construction, operations, deactivation and closure phases. Alternative 1, No Action, short-term use does not include partial construction of the Waste Treatment Plant because this action has already been initiated.

[b] Long-term is the period following completion of all alternatives' scheduled activities. Long-term use for Alternatives 1 through 3C, 5, and 6C represent the footprints of the SST tank farms and B and T cribs and trenches (ditches) with or without engineered barriers, as applicable. Alternative 4 does not include the BX and SX tank farms. Alternatives 6A and 6B, Base Case only represent the footprints of the B and T cribs and trenches (ditches). Alternatives 6A and 6B, Option Case indicate clean closure of all tank farms and cribs and trenches (ditches).

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2007a, 2008.

Although this EIS considers only facility deactivation and not decontamination and decommissioning of waste treatment, storage, or disposal facilities, DOE could decontaminate and decommission major facilities at the end of their life cycle and restore adjacent area brownfield sites, which would then be available for future industrial use. However, it would be unlikely for any of the facility sites to be restored to their original predevelopment states or natural, terrestrial habitats.

The Tank Closure No Action Alternative would likely incur additional and indefinite commitments of land over the long term, when degradation of tank farms would lead to eventual release of unmitigated contaminants into the subsurface environment, potentially impacting the Columbia River. Except for Tank Closure Alternatives 6A and 6B, under which clean closure of all SST farms would occur, as well as Tank Closure Alternative 4, under which clean closure of the BX and SX tank farms would occur, the remaining action alternatives would leave SST system components and residual tank waste (ranging from 0.01 to 10 percent by volume) in place. Any land areas where tank farms would be left in place would represent a long-term commitment of land and terrestrial resources for waste management. In addition, with the exception of Tank Closure Alternatives 6A and 6B, Option Cases, the areas occupied by the cribs and trenches (ditches) would represent a long-term commitment of land. Therefore, these areas would be

removed from long-term productivity considerations. However, these areas would likely be reclaimed by native vegetation and wildlife in the absence of human intervention over the very long term following the end of any administrative control or postclosure care period.

Air emissions associated with waste retrieval, treatment, and disposal and SST system closure would introduce small amounts of radiological and nonradiological constituents to the regional airshed around Hanford. Over time, these emissions would result in additional loading and exposure, but would not impact air quality or radiation exposure standards at Hanford to the extent that long-term productivity of the environment would be impaired.

Chemical and radiological contamination of the vadose zone and groundwater below and downgradient of the 200 Areas would occur over time under all of the Tank Closure alternatives due to the release of residual tank contaminants, disposal of treated tank waste, and disposal of contaminated soil. The long-term performance of waste forms and their impacts on the vadose zone and groundwater receptors are discussed in detail in Chapter 5. Depending on the extent and magnitude of resultant groundwater contaminant plumes, it may be necessary to place land use or other institutional controls on the overlying land areas for an indefinite period, thereby reducing the overall long-term productivity of the affected areas.

Radiological and chemical doses to aquatic and terrestrial receptors at seeps along the Columbia River and in the receiving water were evaluated as part of the ecological risk portion of the analysis. Under all scenarios and alternatives, results indicated that calculated absorbed doses to referenced organisms would be below regulatory limits and/or reference standards and, therefore, would likely have no impact on the long-term productivity of the Columbia River ecosystem.

Continued employment, expenditures, and tax revenues generated during implementation of any of the action alternatives would directly benefit local, regional, and state economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could facilitate economic productivity. Nearby townships and geographic provinces have experienced a recent surge in growth, and the availability of employment opportunities would further sustain and foster regional development.

Management and disposal of LLW, MLLW, mixed TRU waste, IHLW, ILAW, and secondary waste generated as a result of waste retrieval, treatment, and disposal and SST system closure would increase energy demand and consume space at treatment, storage, or disposal facilities. Regardless of the location, the land required to meet waste management needs would require a longer-term commitment of terrestrial resources. Primary waste (e.g., IHLW canisters) and HLW melters taken out of service would be stored on site. All treated tank waste under Tank Closure Alternatives 6A, 6B, and 6C would be managed as HLW and require storage at Hanford until disposition decisions are made and implemented.

The short-term use of the environment would be evaluated against the maintenance and enhancement of long-term productivity, as demonstrated by the performance assessment for untreated and treated tank waste forms. When considering the relationship between short-term uses of the environment and maintenance and enhancement of long-term productivity, consideration must be given to similar relationships discussed in Section 7.3.3 for waste management. In a simple sense, the Tank Closure alternatives represent most of the short-term uses of the environment, and most of the resultant long-term commitments from tank closure are represented in the Waste Management alternatives. These actions are mutually dependent on each other.

7.4.2 FFTF Decommissioning Alternatives

The short-term durations for the FFTF Decommissioning alternatives are presented in Table 7–22. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase

when most activities would take place and (2) the closure phase when administrative controls or postclosure care would need to be continued. Most impacts and short-term uses of the environment would occur during the construction, operations, and deactivation phase. Under the FFTF Decommissioning No Action Alternative, administrative controls would be required to maintain the facility in its existing state for 100 years. FFTF Decommissioning Alternatives 2 and 3 would require 100 years of postclosure care, although this activity would be reduced under FFTF Decommissioning Alternative 3, for which emplacement of an engineered barrier would not be required.

Table 7–22. Short-Term Life Cycles for FFTF Decommissioning Alternatives

Alternatives	Construction, Operations, and Deactivation Phase	Closure Phase (Activity Type)[a]
1	Not Applicable	2008–2107 (AC)
2[b]	2013–2021	2022–2121 (PM)
3[b, c]	2012–2021	2022–2121 (PM)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring.

[b] Life-cycle durations are the same for all Hanford and Idaho Options.

[c] Alternative 3 includes a 100-year postclosure care period even though this alternative does not have an engineered barrier.

Key: FFTF=Fast Flux Test Facility.

Source: SAIC 2007b, 2008.

Short-term commitments of resources would include the space and materials required to expand or construct facilities for treatment of the four FFTF RH-SCs and processing of bulk sodium at Hanford or INL. The only facility under the FFTF Decommissioning alternatives that would require new construction is the SRF at Hanford, although construction would still occur within disturbed areas. The RTP at either Hanford or INL or the SPF at INL would be located within or adjacent to existing facilities. Depending on the alternative, workers, the public, and the environment would be exposed to various amounts of hazardous and radioactive materials over the short term from FFTF decommissioning activities such as decontamination, demolition, and excavation.

Table 7–23 presents the amounts of land that would be committed in the short term to accomplish the objectives of each of the FFTF Decommissioning alternatives, including land use at both Hanford and INL locations. Table 7–23 also presents those long-term land commitments that would continue indefinitely for each alternative, including all permanent disposition areas where engineered barriers would preclude the use of the site for other productive purposes, all areas where buildings would not be decommissioned, and all bulk sodium storage areas. Borrow Area C is not included in the short term commitments of land. Excavation activities conducted at Borrow Area C, while taking place in the short term, can be terminated at any time. The amount of land disturbance required at Borrow Area C to support each FFTF Decommissioning alternative was previously discussed in Section 7.3.2.1.

The FFTF Decommissioning No Action Alternative would likely incur additional and indefinite long term commitments of land because, after the end of the 100-year administrative control period, contaminants would be released into the environment. FFTF Decommissioning Alternative 2 would provide for complete removal of some facilities and entombment of other buildings (e.g., the RCB and reactor support buildings 491E and 491W). Long-term commitments of land under FFTF Decommissioning Alternative 2 represent an engineered barrier that would be placed over the RCB and 491E and 491W buildings. Therefore, the FFTF Decommissioning No Action Alternative, and to a lesser extent FFTF Decommissioning Alternative 2, would remove land areas within the 400 Area from long term productivity considerations. However, these areas would likely be reclaimed by native vegetation and wildlife in the absence of human intervention over the very long term following the end of any

administrative control or postclosure care period. FFTF Decommissioning Alternative 3 represents removal of all buildings, including the RCB and 491E and 491W buildings, with the exception of the RCB's sub-grade concrete shell. In this case, an engineered barrier would not be constructed; however, a limited-scope postclosure care period would still be necessary, after which the land could be returned to productive use.

Table 7–23. Short- and Long-Term Commitments of Land for FFTF Decommissioning

Alternative (with Options)	Land Commitment (hectares)	
	Short-Term[a]	Long-Term[b]
1–No Action	0	18
2–Hanford RTP and SRF	0.2	0.7
2–Hanford RTP and Idaho SPF	0.1	0.7
2–Idaho RTP and Hanford SRF	0.2	0.7
2–Idaho RTP and SPF	0.1	0.7
3–Hanford RTP and SRF	0.2	0
3–Hanford RTP and Idaho SPF	0.1	0
3–Idaho RTP and Hanford SRF	0.2	0
3–Idaho RTP and SPF	0.1	0

[a] Short-term includes entire life cycle of construction, operations, deactivation and closure phases.

[b] Long-term is after all alternatives' scheduled activities have been completed. Long-term use for Alternative 1, No Action, represents the footprint of the existing FFTF Property Protected Area. Alternative 2 represents the engineered barrier over the FFTF Reactor Containment Building, and support buildings 491E and 491W. Alternative 3 represents removal of all FFTF and associated support structures.

Note: To convert hectares to acres, multiply by 2.471.

Key: FFTF=Fast Flux Test Facility; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2007b, 2008.

Air emissions associated with building demolition, closure, and site restoration activities, as well as emissions associated with construction, operations, and deactivation of an RTP and SRF/SPF would introduce small amounts of radiological and nonradiological constituents to the regional airshed around Hanford. If the RTP is constructed at INL and INL's SPF is reactivated and modified for bulk sodium processing, air emissions would contribute to cumulative impacts with air emissions from other sources at INL. Over time, these emissions would result in additional loading and exposure, but would not impact air quality or radiation exposure standards to the extent that long-term productivity of the environment would be impaired at either Hanford or INL.

Chemical and radiological contamination of the vadose zone and groundwater below and downgradient from the 400 Area would occur over time under all but FFTF Decommissioning Alternative 3, where removal of all of the structures would take place. Impacts would be the most significant under the FFTF Decommissioning No Action Alternative. FFTF Decommissioning Alternative 2, where the four FFTF RH-SCs and bulk sodium would be removed, long-term impacts on the vadose zone and groundwater would be reduced. The long-term performance of waste forms and their impacts on the vadose zone and groundwater receptors are discussed in detail in Chapter 5. Depending on the extent and magnitude of resultant groundwater contaminant plumes, it may become necessary for land use or other institutional

controls to be placed on the overlying land areas for an indefinite period, thereby reducing overall long-term productivity of the affected areas.

No additional short-term or long-term impacts on ecological receptors were projected to occur as a result of implementing any of the FFTF Decommissioning alternatives.

Any impacts on socioeconomic factors are expected to be negligible in the context of activities occurring across Hanford and would be confined within short-term construction, operations, and deactivation phase, ending no later than 2021 for all alternatives.

Management and disposal of LLW, MLLW, and the secondary waste generated would be required under all FFTF Decommissioning alternatives. The FFTF Decommissioning No Action Alternative would require indefinite storage of the four FFTF RH-SCs within the 400 Area and bulk sodium within the 200-West and 400 Areas, removing these areas from other long-term productive use. Under both action alternatives, the specialized components would be decontaminated and repackaged for disposal in an IDF, and the bulk sodium would be processed to produce a caustic sodium hydroxide solution for treating tank waste in the WTP, thereby, eliminating the requirement for long-term operations and maintenance of storage facilities. FFTF Decommissioning Alternative 2 would result in the entombment of LLW and MLLW within the sub-grade void spaces of the RCB, essentially committing the RCB and buildings 491W and 491E for the long term. Comparatively, FFTF Decommissioning Alternative 3 would extricate all internal reactor core components, demolish all buildings, and dispose of all decommissioning debris as LLW or MLLW in an IDF, potentially enabling future productive use of land in the 400 Area.

Short-term use of the environment for removing and processing the four FFTF RH-SCs and the bulk sodium would be evaluated against the potential adverse impacts on long-term productivity that would result from the eventual release of contaminants into the environment. For the action alternatives, the increase in short-term impacts of removal of all FFTF structures would be evaluated against the emplacement of an engineered barrier and long-term lost productivity of the FFTF land areas. An additional long-term consideration is performance assessment and the effect of additional waste loading on an IDF from the generation of decommissioning waste and secondary waste under the action alternatives.

7.4.3 Waste Management Alternatives

The short-term durations for each of the Waste Management alternatives are presented in Table 7–24. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase when most activities would take place and (2) the closure phase when administrative controls or postclosure care would be performed. Most impacts and short-term uses of the environment would occur during the construction, operations, and deactivation phase. All Waste Management alternatives would continue to use LLBG trenches 31 and 34 until filled, before using an IDF or the RPPDF. The Waste Management No Action Alternative would not include construction or operation of any new disposal facilities; however, it would require a 100-year administrative control period after the LLBG trenches become full. Under the remaining Waste Management alternatives and their associated disposal groups, permanent disposal facilities would be constructed in the 200 Areas that ultimately would be closed under engineered barriers followed by postclosure care.

Short-term commitments of resources for the Waste Management action alternatives would include the space and materials required to construct expansion facilities for processing high-dose LLW and MLLW waste in the T Plant; processing, packaging, and certifying TRU waste in WRAP; and storing waste in the Central Waste Complex. Other short-term uses of resources would be limited to those required for constructing and operating the disposal facilities.

Table 7–24. Short-Term Life Cycles for Waste Management Alternatives

Alternative	Construction, Operations, and Deactivation Phase	Closure Phase (Activity Type)[a]
1–No Action	2007–2035	2036–2135 (AC)
2–Disposal Group 1	2006–2052	2053–2152 (PM)
2–Disposal Group 2	2006–2102	2103–2202 (PM)
2–Disposal Group 3	2006–2167	2168–2267 (PM)
3–Disposal Group 1	2006–2052	2053–2152 (PM)
3–Disposal Group 2	2006–2102	2103–2202 (PM)
3–Disposal Group 3	2006–2167	2168–2267 (PM)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring.
Source: SAIC 2007c, 2008.

Table 7–25 presents the amounts of land that would be committed in the short term to accomplish the objectives of each of the Waste Management alternatives. This short-term use of land would be for expansion of the T Plant, WRAP, and Central Waste Complex facilities under the action alternatives. Table 7–25 also presents those long-term land commitments that would occur indefinitely under each of the disposal groups for the action alternatives. All areas where permanent disposal facilities would be located would be indefinitely removed from long-term productive use. Under the Waste Management action alternatives, engineered barriers would be constructed over the RPPDF and IDF(s). LLBG trenches 31 and 34 are not included in long-term commitments of land in this *TC & WM EIS*, because this facility is a permitted facility and has already been committed in the long-term. Borrow Area C is not included in the short-term commitments of land. Excavation activities conducted at Borrow Area C, while taking place in the short-term, can be terminated at any time. The amount of land disturbance required at Borrow Area C to support each Waste Management alternative was previously discussed in Section 7.3.3.1.

The waste management disposal groups were developed and the waste disposal facilities (the RPPDF and IDF[s]) were sized to primarily support the Tank Closure alternatives and to accept some offsite waste for disposal. The Waste Management No Action Alternative would only be implemented if the corresponding Tank Closure No Action Alternative were selected for implementation. Under Waste Management Alternative 2, only IDF-East would be constructed. Under Waste Management Alternative 3, disposal capacity would be divided between IDF-East and IDF-West. The RPPDF would be constructed between the 200-East and 200-West Areas, regardless of the action alternative selected. Closure of the RPPDF and IDF(s) would be accomplished with the emplacement of an engineered barrier. Therefore, the land areas associated with each of the permanent waste disposal facilities would be removed from long-term productivity considerations. However, these areas would likely be reclaimed by native vegetation and wildlife in the absence of human intervention over the very long term following the end of any administrative control or postclosure care period.

Air emissions associated with the Waste Management alternatives would introduce small amounts of radiological and nonradiological constituents to the regional airshed around Hanford. Radiological air emissions would result from expanded operations of the T Plant and WRAP. Nonradiological air emissions would be the greatest during initial construction of the waste disposal facilities, and then again during closure of the facilities and the construction of engineered barriers. Over time, these emissions would result in additional loading and exposure, but would not impact air quality or radiation exposure standards at Hanford to the extent that long-term productivity of the environment would be impaired.

Table 7–25. Short- and Long-Term Commitments of Land for Waste Management

Alternative	Land Commitment (hectares)	
	Short-Term Use[a]	Long-Term Use[b]
1–No Action	0	0
2–Disposal Group 1	2.7	64
2–Disposal Group 2	2.7	247
2–Disposal Group 3	2.7	247
3–Disposal Group 1	2.7	77
3–Disposal Group 2	2.7	253
3–Disposal Group 3	2.7	253

[a] Short-term includes the entire life cycle of the construction, operations, deactivation, and closure phases. For Alternatives 2 and 3, the land use requirements for the Waste Receiving and Processing Facility, T Plant, and Central Waste Complex construction and operations would be equivalent. Alternative 1, No Action, short-term use does not include partial construction of the 200-East Area Integrated Disposal Facility because this action has already been initiated.

[b] Long-term represents the permanent disposal sites (e.g., one or both of the Integrated Disposal Facilities and the River Protection Project Disposal Facility) after closure by emplacement of engineered barrier.

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2007c, 2008.

Chemical and radiological contamination of the vadose zone and groundwater below and downgradient of the 200 Areas would occur over time under all of the alternatives from release of contaminants from tank closure waste, FFTF decommissioning waste, and offsite waste disposed of in the LLBGs, IDF(s), and RPPDF. The amounts and timing of contaminants that would leach from the waste disposal sites would largely depend on long-term waste form performance, as dictated by the waste treatment methodologies analyzed for the Tank Closure alternatives. Long-term performance of waste forms and their impacts on the vadose zone and groundwater receptors are discussed in detail in Chapter 5. Depending on the extent and magnitude of resultant groundwater contaminant plumes, it may become necessary for land use or other institutional controls to be placed on the overlying land areas for an indefinite period, thereby reducing overall long-term productivity of the affected areas.

The radiological and chemical doses to aquatic and terrestrial receptors at seeps along the Columbia River and in the receiving water were evaluated as part of the ecological risk portion of the analysis. Under all scenarios and alternatives, results indicated that calculated absorbed doses to referenced organisms would be below regulatory limits and/or reference standards and, therefore, would have no impact on long-term productivity of the Columbia River ecosystem.

Continued employment, expenditures, and tax revenues generated during implementation of any of the action alternatives would directly benefit local, regional, and state economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could facilitate economic productivity. Nearby townships and geographic provinces have experienced a recent surge in growth, and the availability of employment opportunities would further sustain and foster regional development.

In addition to the waste generated under the Tank Closure and FFTF Decommissioning alternatives, discussed in Sections 7.3.1 and 7.3.2 above, some quantities of LLW and MLLW would be generated from expanded T Plant operations and would be disposed of in an IDF. TRU waste processed at the expanded WRAP would be stored on site until it can be transported off site for disposal at the Waste

Isolation Pilot Plant. A certain amount of offsite waste would be received under Waste Management Alternatives 2 and 3 and disposed of in an IDF, a long-term commitment at Hanford that would result in comparable enhancement of long-term productivity at other DOE facilities.

The short-term use of the environment for treating waste would be evaluated against the maintenance and enhancement of long-term productivity, as demonstrated by the performance assessment for the final waste forms that would be disposed of in an IDF and the RPPDF.

7.4.4 Alternative Combinations

For comparison purposes, three alternative combinations were selected. The alternative combinations are described in detail in Chapter 4, Section 4.4. This section discusses the relationship between short-term uses of the environment and maintenance and enhancement of long-term productivity for the alternative combinations.

The short-term durations for three alternative combinations are presented in Table 7–26. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase when most activities would take place and (2) the closure phase when administrative controls, postclosure care, and/or long-term storage would be continued. Alternative Combination 1 would terminate the construction of the WTP, Canister Storage Building, and IDF-East. The only activity that would continue would be disposal of waste in LLBG trenches 31 and 34 until 2035, followed by a 100-year administrative control period. Alternative Combination 2 represents an expanded WTP vitrification that would significantly reduce the short-term actions, which would end in 2052. Alternative Combination 3 would extend the short-term activities until 2102 to accommodate clean closure of the SST farms, followed by a 100-year postclosure care and monitoring period.

Table 7–26. Short-Term Life Cycles for Alternative Combinations

Alternative Combination	Alternative	Construction, Operations and Deactivation Phase	Closure Phase (Activity Type)[a]
1	Tank Closure Alternative 1	2006–2008	2008–2107 (AC)
	FFTF Decommissioning Alternative 1	Not Available	2008–2107 (AC)
	Waste Management Alternative 1	2007–2035	2036–2135 (AC)
2	Tank Closure Alternative 2B	2006–2046	2046–2145 (PM)
	FFTF Decommissioning Alternative 2	2013–2021	2022–2121 (PM)
	Waste Management Alternative 2, Disposal Group 1	2006–2052	2053–2152 (PM)
3	Tank Closure Alternative 6B, Base Case	2006–2101	2102–2201 (PM) Until 2199 (ST)
	FFTF Decommissioning Alternative 3	2012–2021	2022–2121 (PM)
	Waste Management Alternative 2, Disposal Group 2	2006–2102	2103–2202 (PM)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring, ST=onsite storage.
Key: FFTF=Fast Flux Test Facility.
Source: SAIC 2007a, 2007b, 2007c, 2008.

Table 7–27 presents the amounts of land that would be committed in the short term for each of the three representative alternative combinations, including the land area required for existing facilities and construction of new facilities to support a particular alternative combination. The land use amounts are presented as aggregate values over the entire short-term life cycles of the alternatives; however, in practice, most facilities would operate at various timeframes. Borrow Area C is not included in the short

term commitments of land. Excavation activities conducted at Borrow Area C, while taking place in the short-term, can be terminated at any time. The amount of land disturbance required at Borrow Area C to support each alternative combination was previously discussed in Section 7.3.4.1. Table 7–27 also presents those long-term land commitments that would continue indefinitely under the alternatives, including all permanent disposition areas where engineered barriers would preclude the use of the site for other productive purposes and all areas where the tank farms and cribs and trenches (ditches) or facilities within the FFTF Property Protected Area would not be closed under certain alternatives. Alternative Combination 1 would construct or operate no new facilities in the short term; however, it would result in a commitment of 35 hectares (86.5 acres) of land as waste management areas for the SST farms, cribs and trenches (ditches), and FFTF Property Protected Area. Alternative Combination 2 would increase land use in both the short and long terms for construction of new disposal facilities and emplacement of engineered barriers over the SST farms and cribs and trenches (ditches). The increase in long-term commitments of land for Alternative Combination 2 over Alternative Combination 1 would occur due to retrieval, treatment, and disposal of all tank waste. Treating the tank waste and disposing of it in an engineered disposal facility reduce the long-term effects of radiological and chemical contaminants leaching into the subsurface and groundwater. Alternative Combination 3 would further increase both short- and long-term commitments of land. In this case, the increase in short- and long-term use would be due to SST clean closure activities and requirements for deep soil excavation and disposition. Treated tank waste under Alternative Combination 3 would be managed as HLW and stored on site until disposition decisions are made and implemented.

Table 7–27. Short- and Long-Term Commitments of Land for Alternative Combinations

Alternative Combination	Land Commitment (hectares)		
	Alternative	**Short-Term Use[a]**	**Long-Term Use[b]**
1	Tank Closure Alternative 1	0	17
	FFTF Decommissioning Alternative 1	0	18
	Waste Management Alternative 1	0	0
	Total Combined	**0**	**35**
2	Tank Closure Alternative 2B	16	84
	FFTF Decommissioning Alternative 2	0.2	0.7
	Waste Management Alternative 2, Disposal Group 1	2.7	64
	Total Combined	**19**	**152**
3	Tank Closure Alternative 6B, Base Case	117	25
	FFTF Decommissioning Alternative 3	0.2	0
	Waste Management Alternative 2, Disposal Group 2	2.7	253
	Total Combined	**120**	**278**

[a] Short-term includes the entire life cycle of the construction, operations, deactivation, and closure phases.

[b] Long-term is the period following completion of all alternatives' scheduled activities.

Note: To convert hectares to acres, multiply by 2.471.

Key: FFTF=Fast Flux Test Facility.

Source: SAIC 2007a, 2007b, 2007c, 2008.

Resultant long-term impacts of the Alternative Combinations would be associated with water resources, ecological resources, and human health. Long-term impacts on ecological resources would occur from air emissions and groundwater impacts. Human health impacts would occur for a number of receptors in both offsite and onsite locations, and would also depend on the acuity and duration of groundwater impacts due to linkage of exposure pathways to consumption of surface water or the use of groundwater for drinking water or crop irrigation. Thus, groundwater-related ecological resource and human health

impacts would correlate strongly with the groundwater impacts. Water resources would be impacted the most under Alternative Combination 1, where unmitigated releases from tank inventories would occur and would cause the majority of long-term impacts. Inevitable releases from tank inventories would overcome groundwater impacts of past practices and tank system leaks. Conversely, impacts of air emissions would be least under Alternative Combination 1 because no new facilities would be constructed or operated.

Under Alternative Combination 2, retrieval and treatment of tank waste in the WTP would have short term impacts on air quality. Air emissions would not be sufficient to produce significant long-term impacts on ecological resources. By the time groundwater reaches and is diluted by the Columbia River, impacts on ecological resources would also be negligible. The majority of impacts on groundwater resources would no longer be from tank inventories, as most of this waste would be immobilized through WTP operations, but rather from past discharges to the cribs and trenches (ditches), past leaks from tank systems, and new waste management areas. Ultimately, Alternative Combination 2 is projected to result in a reduction in concentrations of conservative tracers by one or two orders of magnitude at the Core Zone Boundary versus those that would occur under Alternative Combination 1. However, Alternative Combination 2 would require construction of IDF-East and RPPDF in new locations. The receipt and disposal of offsite wastes in IDF-East would also contribute to eventual groundwater impacts in this area, particularly for iodine-129 and technetium-99.

Under Alternative Combination 3, similar air impacts of tank waste treatment would occur; however, to accomplish excavation and clean closure of the tank farms, air impacts would increase significantly. Still, long-term impacts on ecological resources due to air emissions would be minor. Conversely, long-term groundwater impacts on ecological resources would decrease when compared to those impacts under Alternative Combination 2. Under Alternative Combination 3, the SST farms would be clean-closed and any future releases and contributions of residual tank inventories to groundwater impacts eliminated. Similar to Alternative Combination 2, past discharges to the cribs and trenches (ditches) and past leaks from tank systems would still be the major source of impacts on groundwater. Under Alternative Combination 3, all treated tank waste would be managed as HLW and would be stored in onsite storage facilities. As a result, long-term groundwater impacts would be slightly lower under Alternative Combination 3, but generally similar to those under Alternative Combination 2. Treated tank waste requiring disposal in IDF-East would be reduced; however, there would be an increase in need for onsite storage capacity and in disposal requirements for clean-closure waste in IDF-East and tank debris in the RPPDF. As under Alternative Combination 2, receipt and disposal of offsite waste in IDF-East would contribute to eventual groundwater impacts in this area, particularly related to iodine-129 and technetium-99.

All of the alternative combinations would exceed human health dose standards for one or more COPCs within the Core Zone Boundary if groundwater were used as a source of drinking water and crop irrigation. The impacts on the health of human receptors within the Core Zone Boundary is predicated on the receptor's ability to access groundwater; this ability would be delayed or made more difficult under Alternative Combinations 2 and 3, where engineered barriers would be constructed in various locations. These engineered barriers would be constructed over the tank farms, cribs and trenches (ditches), or permanent disposal areas, as applicable under Alternative Combinations 2 or 3.

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10 CFR 835, U.S. Department of Energy, "Occupational Radiation Protection."

10 CFR 1021.331, U.S. Department of Energy, "National Environmental Policy Act Implementing Procedures: Mitigation Action Plans."

10 CFR 1022, U.S. Department of Energy, "Compliance with Floodplain and Wetland Environmental Review Requirements."

40 CFR 1502.16, Council on Environmental Quality, "Environmental Impact Statement: Environmental Consequences."

40 CFR 1508.20, Council on Environmental Quality, "Terminology and Index: Mitigation."

Executive Orders

Executive Order 11988, *Floodplain Management*, May 24, 1977.

Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, January 24, 2007.

Federal Register

62 FR 8693, U.S. Department of Energy, 1997, "Record of Decision for the *Tank Waste Remediation System, Hanford Site, Richland, WA*," February 26.

64 FR 61615, U.S. Department of Energy, 1999, "Record of Decision: *Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)*," November 12.

73 FR 55824, U.S. Department of Energy, 2008, "Amended Record of Decision for the *Hanford Comprehensive Land-Use Plan Environmental Impact Statement*," September 26.

U.S. Department of Energy Orders and Standards

DOE Order 435.1, *Radioactive Waste Management*, Change 1, August 28, 2001.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, Change 2, January 7, 1993.

DOE Standard 1098-99, *Radiological Control*, July 1999.

CHAPTER 8
POTENTIALLY APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

Chapter 8 presents the laws, regulations, and other requirements that apply to the alternatives. Federal, state, and U.S. Department of Energy environmental, safety, and health requirements are summarized in Section 8.1. Permits or licenses that may be required to implement the alternatives are discussed in Section 8.2. Consultations with Federal, state, and local agencies and federally recognized American Indian groups are discussed in Section 8.3.

8.1 ENVIRONMENTAL, SAFETY, AND HEALTH LAWS, REGULATIONS, ORDERS, AND OTHER REQUIREMENTS

Operations at the Hanford Site (Hanford) and Idaho National Laboratory (INL) are affected and, in many cases, regulated by numerous Federal and state legal requirements addressing environmental compliance, remediation, planning, preservation, and waste management. In some cases, the U.S. Department of Energy (DOE) has sole authority to take action, e.g., under the Atomic Energy Act (AEA). In other cases, the U.S. Environmental Protection Agency (EPA) has authority to regulate; in others, EPA has delegated its authority to regulate to the State of Washington, e.g., the Resource Conservation and Recovery Act (RCRA). In still other cases, state laws apply. Under DOE Order 450.1, *Environmental Protection Program*, it is DOE policy to conduct its operations in a manner that ensures the protection of public health, safety, and the environment through compliance with all applicable Federal and state laws, regulations, orders, and other requirements. The major Federal and state laws and regulations, Executive orders, DOE orders, and other requirements that may currently or in the future apply to the various alternatives analyzed in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* are identified in Table 8–1. These compliance requirements are briefly described in Sections 8.1.1 through 8.1.12.

The various action alternatives analyzed in this *TC & WM EIS* involve the construction of new DOE facilities; the operation, deactivation/demobilization, closure/decontamination and decommissioning of new and existing DOE facilities; and the transportation, treatment, and disposal of waste. Chapter 2 provides a discussion of these alternatives.

Table 8–1. Potentially Applicable Environmental, Safety, and Health Laws, Regulations, Orders, and Other Requirements

Law, Regulation, Order, or Other Requirement	Citation/Date
Environmental Quality	
National Environmental Policy Act of 1969	42 U.S.C. 4321 et seq.
Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act	40 CFR 1500 through 1508
"National Environmental Policy Act Implementing Procedures"	10 CFR 1021
National Environmental Policy Act Compliance Program	DOE Order 451.1B (October 26, 2000; Change 1, September 28, 2001); DOE Notice 451.1, Change to DOE Order 451.1B (October 6, 2006)
State Environmental Policy Act	RCW 43.21C
Settlement Agreement in re *State of Washington v. Bodman*	Civil No. 2:03-cv-05018-AAM, January 6, 2006
Protection and Enhancement of Environmental Quality, as amended by Executive Order 11991	Executive Order 11514

Table 8–1. Potentially Applicable Environmental, Safety, and Health Laws, Regulations, Orders, and Other Requirements *(continued)*

Law, Regulation, Order, or Other Requirement	Citation/Date
Environmental Quality (*continued*)	
Environmental Protection Program	DOE Order 450.1 (January 15, 2003; Change 2, December 7, 2005; Administrative Change 1, January 3, 2007)
Air Quality and Noise	
Clean Air Act of 1970, as amended	42 U.S.C. 7401 et seq.
"National Emission Standards for Hazardous Air Pollutants"	40 CFR 61
"National Emission Standards for Hazardous Air Pollutants for Source Categories"	40 CFR 63
Washington Clean Air Act	RCW 70.94
Washington State Air Pollution Control Regulations	WAC 173-400 through 173-495
"Ambient Air Quality Standards and Emission Limits for Radionuclides"	WAC 173-480
"Radiation Protection – Air Emissions"	WAC 246-247
Idaho Environmental Protection and Health Act	IC 39-100
Noise Control Act of 1972, as amended	42 U.S.C. 4901 et seq.
Water Resources	
Clean Water Act of 1972, as amended	33 U.S.C. 1251 et seq.
"EPA Administered Permit Programs: The National Pollutant Discharge Elimination System"	40 CFR 122 et seq.
Washington Water Pollution Control Act of 1945	RCW 90.48
"State Waste Discharge Permit Program"	WAC 173-216
"Underground Injection Control Program"	WAC 173-218
"Water Quality Standards for Ground Waters of the State of Washington"	WAC 173-200
"Water Quality Standards for Surface Waters of the State of Washington"	WAC 173-201A
Idaho Water Pollution Control Act of 1983	IC 39-3600 et seq.
"On-site Sewage Systems"	WAC 246-272
Safe Drinking Water Act of 1974, as amended	42 U.S.C. 300(f) et seq.
National Primary Drinking Water Regulations	40 CFR 141 through 149
Hanford Reach Study Act of 1988	P.L. 100-605
Floodplain Management	Executive Order 11988
"Compliance with Floodplain and Wetland Environmental Review Requirements"	10 CFR 1022
Hazardous Waste and Materials Management	
Resource Conservation and Recovery Act of 1976, as amended	42 U.S.C. 6901 et seq.
Washington State Hazardous Waste Management Act	RCW 70.105
"Dangerous Waste Regulations"	WAC 173-303
Model Toxics Control Act	RCW 70.105D
"Model Toxics Control Act – Cleanup"	WAC 173-340
Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement)	May 15, 1989, as amended
Federal Facility Compliance Act of 1992	P.L. 102-386

Table 8–1. Potentially Applicable Environmental, Safety, and Health Laws, Regulations, Orders, and Other Requirements *(continued)*

Law, Regulation, Order, or Other Requirement	Citation/Date
Hazardous Waste and Materials Management (*continued*)	
Interim Stabilization Consent Decree (No. CT-99-5076-EFS)	September 30, 1999, as amended
Idaho Site Treatment Plan and Consent Order for Federal Facility Compliance Act	November 1, 1995
Idaho Hazardous Waste Management Act of 1983	IC 39-4400 et seq.
Spent Fuel Settlement Agreement (also known as the Governor's Agreement)	October 16, 1995
Toxic Substances Control Act of 1976	15 U.S.C. 2601 et seq.
Framework Agreement for Management of Polychlorinated Biphenyls in Hanford Tank Waste	August 31, 2000
Radioactive Waste and Materials Management	
Atomic Energy Act of 1954	42 U.S.C. 2011 et seq.
Low-Level Radioactive Waste Policy Act of 1980, as amended	42 U.S.C. 2021 et seq.
"Licensing Requirements for Land Disposal of Radioactive Waste"	10 CFR 61
Nuclear Waste Policy Act of 1982, as amended	42 U.S.C. 10101 et seq.
Waste Isolation Pilot Plant Land Withdrawal Act, as amended	P.L. 102-579, as amended by P.L. 104-201
"Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes"	40 CFR 191
Radioactive Waste Management	DOE Order 435.1 (July 9, 1999; Change 1, August 28, 2001)
Real Property Asset Management	DOE Order 430.1B (September 24, 2003; Change 1, February 8, 2008)
Ecological Resources	
Bald and Golden Eagle Protection Act of 1973, as amended	16 U.S.C. 668 through 668d
Endangered Species Act of 1973, as amended	16 U.S.C. 1531 et seq.
Natural Area Preserves Act	RCW 79.70
U.S. Fish and Wildlife Coordination Act	16 U.S.C. 661 et seq.
Migratory Bird Treaty Act of 1918, as amended	16 U.S.C. 703 et seq.
Protection of Wetlands	Executive Order 11990
Cultural and Paleontological Resources	
American Indian Religious Freedom Act of 1978	42 U.S.C. 1996
Antiquities Act of 1906, as amended	16 U.S.C. 431 through 433
Archaeological and Historic Preservation Act of 1960, as amended	16 U.S.C. 469 through 469c-1
Archaeological Resources Protection Act of 1979, as amended	16 U.S.C. 470aa et seq.
National Historic Preservation Act of 1966, as amended	16 U.S.C. 470 et seq.
"Protection of Historic Properties"	36 CFR 800
Programmatic Agreement Among the U.S. Department of Energy Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington	August 21, 1996
Native American Graves Protection and Repatriation Act of 1990	25 U.S.C. 3001 et seq.
Protection and Enhancement of the Cultural Environment	Executive Order 11593

Table 8–1. Potentially Applicable Environmental, Safety and Health Laws, Regulations, Orders, and Other Requirements *(continued)*

Law, Regulation, Order, or Other Requirement	Citation/Date
Cultural and Paleontological Resources (*continued*)	
Indian Sacred Sites	Executive Order 13007
Consultation and Coordination with Indian Tribal Governments	Executive Order 13175
Trails for America in the 21st Century	Executive Order 13195
Preserve America	Executive Order 13287
American Indian Tribal Government Interactions and Policy	DOE Order 144.1 (January 16, 2009)
Worker Safety and Health	
Occupational Safety and Health Act of 1970	29 U.S.C. 651 et seq.
"Occupational Radiation Protection"	10 CFR 835
"Worker Safety and Health Program"	10 CFR 851
Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees	DOE Order 440.1B (May 17, 2007)
Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction, as amended by Executive Order 13286	Executive Order 12699
Radiological Safety Oversight and Radiation Protection	
"Nuclear Safety Management"	10 CFR 830
Facility Safety	DOE Order 420.1B (December 22, 2005)
Startup and Restart of Nuclear Facilities	DOE Order 425.1C (March 13, 2003)
DOE Radiological Health and Safety Policy	DOE Policy 441.1 (April 26, 1996)
Radiation Protection of the Public and the Environment	DOE Order 5400.5 (February 8, 1990; Change 2, January 7, 1993)
Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities	DOE Order 5480.20A (November 15, 1994; Change 1, July 12, 2001)
Transportation	
Hazardous Materials Transportation Act of 1975, as amended	49 U.S.C. 5101 et seq.
"Packaging and Transportation of Radioactive Material"	10 CFR 71
Packaging and Transportation Safety	DOE Order 460.1B (April 4, 2003)
Departmental Materials Transportation and Packaging Management	DOE Order 460.2A (December 22, 2004)
Emergency Planning, Pollution Prevention, and Conservation	
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (also known as Superfund)	42 U.S.C. 9601 et seq.
Emergency Planning and Community Right-to-Know Act of 1986	42 U.S.C. 11001 et seq.
Pollution Prevention Act of 1990	42 U.S.C. 13101 et seq.
Federal Compliance with Pollution Control Standards, as amended by Executive Order 12580, *Superfund Implementation*	Executive Order 12088
Strengthening Federal Environmental, Energy, and Transportation Management	Executive Order 13423

Table 8–1. Potentially Applicable Environmental, Safety and Health Laws, Regulations, Orders, and Other Requirements *(continued)*

Law, Regulation, Order, or Other Requirement	Citation/Date
Environmental Justice and Protection of Children	
Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	Executive Order 12898
Protection of Children from Environmental Health Risks and Safety Risks	Executive Order 13045

Key: CFR=*Code of Federal Regulations*; DOE=U.S. Department of Energy; EPA=U.S. Environmental Protection Agency; IC=*Idaho Code*; P.L.=Public Law; RCW=*Revised Code of Washington*; U.S.C.=*United States Code*; WAC=*Washington Administrative Code*.

8.1.1 Environmental Quality

National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 et seq.). The purposes of NEPA of 1969, as amended, are to (1) declare a national policy that will encourage productive and enjoyable harmony between man and his environment; (2) promote efforts that will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; (3) enrich the understanding of the ecological systems and natural resources important to the Nation; and (4) establish a Council on Environmental Quality (CEQ). NEPA establishes a national policy requiring that Federal agencies consider the environmental impacts of major Federal actions significantly affecting the quality of the human environment before making decisions and taking actions to implement those decisions. Implementation of NEPA requirements in accordance with CEQ regulations (40 CFR 1500–1508) may result in a categorical exclusion, an environmental assessment and Finding of No Significant Impact, or an environmental impact statement (EIS). This *Draft TC & WM EIS* has been prepared in accordance with NEPA requirements, CEQ regulations (40 CFR 1500–1508), and DOE provisions for implementing the procedural requirements of NEPA (10 CFR 1021; DOE Order 451.1B, Change 1). It discusses reasonable alternatives and their potential environmental consequences.

State Environmental Policy Act (SEPA) (RCW 43.21C). The purposes of SEPA are to (1) declare a Washington State policy that will encourage productive and enjoyable harmony between man and his environment; (2) promote efforts that will prevent or eliminate damage to the environment and biosphere; (3) stimulate the health and welfare of man; and (4) enrich the understanding of the ecological systems and natural resources important to the state and Nation.

SEPA also specifies that an EIS shall be prepared on proposals for legislation and other major actions having a probable significant adverse environmental impact. SEPA does not legally apply to Federal agencies. Some states with similar laws generally require state agencies to perform a NEPA-like analysis before issuing permits. *Washington Administrative Code* (WAC) 197-11, which specifies the rules promulgated under SEPA, states that an agency (e.g., Washington State Department of Ecology [Ecology]) may adopt a Federal NEPA EIS as a substitute for preparing a SEPA EIS if (1) the requirements of WAC 197-11-600 and 197-11-630 are met and (2) the Federal NEPA EIS is not found inadequate.

The DOE Office of River Protection and Ecology both signed a Memorandum of Understanding on March 25, 2003 (DOE and Ecology 2003), for the "Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington" ("Tank Closure EIS"). The purpose of this Memorandum of Understanding was to clearly set out the responsibilities of each agency in cooperative preparation of the "Tank Closure EIS," consistent with CEQ cooperating agency requirements (40 CFR 1501.6) and guidance. This Memorandum of Understanding was revised in January 2006 to more effectively carry out their respective responsibilities in complying with the applicable provisions of NEPA and SEPA (DOE and Ecology 2006). Under this revised Memorandum of Understanding, the Office of River Protection will continue as the lead agency, with overall responsibility to produce this *TC & WM EIS*, and Ecology will

continue as the cooperating agency. Ecology will separately review the *Final TC & WM EIS* and determine if the final EIS can be adopted in fulfillment of its own responsibilities under SEPA.

Settlement Agreement in re *State of Washington v. Bodman*, Civil No. 2:03-cv-05018-AAM, January 6, 2006. In March 2003, prior to the issuance of the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington (HSW EIS)* (DOE 2004a) and Record of Decision (69 FR 39449), Ecology initiated litigation on issues related to the importation, treatment, and disposal of radioactive and hazardous waste generated off site as a result of nuclear defense and research activities. The court enjoined shipment of offsite transuranic (TRU) waste to Hanford for processing and storage pending shipment to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

Ecology amended its March 2003 complaint in 2004, challenging the adequacy of the *HSW EIS* analysis of offsite waste importation. In May 2005, the court granted a limited discovery period, continuing the injunction against shipping offsite wastes to Hanford, including low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) (*State of Washington v. Bodman* [Civil No. 2:03-cv-05018-AAM]). In July 2005, while preparing responses to discovery requests from Ecology, Battelle Memorial Institute, DOE's contractor who assisted in preparing the *HSW EIS*, advised DOE of several differences in groundwater analyses between the *HSW EIS* and its underlying data.

DOE promptly notified the court and the state and, in September 2005, convened a team of DOE experts in quality assurance and groundwater analysis, as well as transportation and human health and safety impacts analysis, to conduct a quality assurance review of the *HSW EIS*. In January 2006, the team completed its *Report of the Review of the "Hanford Solid Waste Environmental Impact Statement (EIS)" Data Quality, Control and Management Issues (Quality Review)* (DOE 2006a). Because both Ecology and DOE have a shared interest in the effective cleanup of Hanford, DOE, Ecology, and the Washington State Attorney General's Office signed a Settlement Agreement ending the NEPA litigation on January 6, 2006. The agreement is intended to resolve Ecology's concerns about *HSW EIS* (DOE 2004a) groundwater analyses and to address other concerns about the *HSW EIS*, including those identified in the *Quality Review* (DOE 2006a).

The agreement called for an expansion of the "Tank Closure EIS" to provide a single, integrated set of analyses that will include all waste types analyzed in the *HSW EIS* (LLW, MLLW, and TRU waste); the expanded EIS is now this *Draft TC & WM EIS*. Pending finalization of this *Draft TC & WM EIS*, the *HSW EIS* remains in effect to support ongoing waste management activities at Hanford (including transportation of TRU waste to WIPP) in accordance with applicable regulatory requirements. The agreement also stipulates that when this *TC & WM EIS* has been completed, it will supersede the *HSW EIS*. Until that time, DOE will not rely on *HSW EIS* groundwater analyses for decisionmaking, and DOE will not import offsite waste to Hanford, with certain limited exemptions as specified in the agreement.

Executive Order 11514, *Protection and Enhancement of Environmental Quality* (March 5, 1970), as amended by Executive Order 11991 (May 24, 1977). This Executive order requires Federal agencies to continually monitor and control their activities to (1) protect and enhance the quality of the environment and (2) develop procedures to ensure the fullest practicable provision of timely public information and understanding of Federal plans and programs that may have potential environmental impact so that interested parties can submit their views. DOE has issued regulations (10 CFR 1021) and DOE Order 451.1B, *National Environmental Policy Act Compliance Program*, for compliance with this Executive order.

DOE Order 450.1, *Environmental Protection Program* (January 15, 2003; Change 1, January 24, 2005; Change 2, December 7, 2005; Administrative Change 1, January 3, 2007). Under DOE Order 450.1, it is DOE policy to conduct its operations in a manner that ensures the protection of public health, safety, and the environment through compliance with applicable Federal and state laws,

regulations, orders, and other requirements. The objective of this order is to implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost-effectively meets or exceeds compliance with applicable environmental, public health, and resource protection laws, regulations, and DOE requirements. This objective is to be accomplished by implementing environmental management systems at DOE sites. An environmental management system is a continuing cycle of planning, implementing, evaluating, and improving processes and actions that are undertaken to achieve environmental goals.

8.1.2 Air Quality and Noise

Federal, state, and local agencies enforce the standards and requirements of the Clean Air Act to regulate air emissions and the requirements of the Noise Control Act to regulate noise at facilities such as Hanford's and INL's. DOE must comply with these standards and requirements for any of the activities being considered under this *TC & WM EIS*. These standards and requirements are summarized below.

Clean Air Act of 1970, as amended (42 U.S.C. 7401 et seq.). The Clean Air Act is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Clean Air Act (42 U.S.C. 7418) requires that each Federal agency with jurisdiction over any property or facility engaged in any activity that might result in the discharge of air pollutants comply with "all Federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution.

Section 109 of the Clean Air Act (42 U.S.C. 7409 et seq.) directs EPA to set National Ambient Air Quality Standards (NAAQS) for criteria pollutants. EPA has identified and set national ambient air quality standards under Title 40 of the *Code of Federal Regulations*, Part 50 (40 CFR 50) for the following criteria pollutants: particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. Section 111 of the Clean Air Act (42 U.S.C. 7411) requires establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants. Section 160 of the Clean Air Act (42 U.S.C. 7470 et seq.) requires that specific emission increases be evaluated prior to permit approval to prevent significant deterioration of air quality. Section 112 of the Clean Air Act (42 U.S.C. 7412) requires specific standards for releases of hazardous air pollutants (including radionuclides). These standards are implemented through state implementation plans.

Emissions of air pollutants from DOE facilities are regulated by EPA under 40 CFR 50–99. Emissions of radionuclides from DOE facilities and other hazardous air pollutants, including a release of asbestos during demolition and renovation activities, are regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAPs) program (40 CFR 61 and 40 CFR 63, respectively). EPA initially granted interim delegation of authority to the State of Washington to implement and enforce two NESHAPs for radionuclides, specifically, "Emissions of Radionuclides Other than Radon from DOE Facilities" (40 CFR 61, Subpart H) and "National Emission Standards for Radionuclide Emissions from Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H" (40 CFR 61, Subpart I). Additional delegations to local air agencies in Washington occurred in 1998 (63 FR 66054); delegation to Ecology and four local air pollution control agencies, including the Benton Clean Air Authority, now called the Benton Clean Air Agency, occurred in 2001 (66 FR 48211). Previous delegations of authority were updated in 2002 (67 FR 11417), and partial approval to implement and enforce specific subparts of the NESHAPs for radionuclide air emissions (i.e., Subparts A, B, H, I, K, Q, R, T, and W, as in effect on July 1, 2004, with a few specific exclusions) was granted to the Washington State Department of Health in 2006 (71 FR 32276).

Washington Clean Air Act (RCW 70.94) and Associated Regulations. Most of the provisions of the Washington Clean Air Act mirror the requirements of the Federal Clean Air Act. The Federal Clean Air Act establishes a minimum, or "floor," for Washington air quality programs. The Washington Clean Air Act authorizes Ecology; the Department of Health; and several local agencies, including the Benton County Clean Air Agency (where Hanford is located), to implement provisions and programs consistent

with the Federal Clean Air Act. For example, the Washington Clean Air Act authorizes an operating permit program, enhanced civil penalties, administrative enforcement provisions, motor vehicle inspections, and provisions addressing ozone and acid rain.

Washington State also has an extensive set of regulations governing toxic air pollutants (WAC 173-460 through 173-495). These regulations are similar to the programs for regulating hazardous air pollutants under the Federal Clean Air Act. In contrast to the Federal Clean Air Act program, which applies to new and existing emission sources, the toxic air pollutant rules apply only to new sources and any modification of an existing source where the modification will increase emissions of toxic air pollutants. Ecology's toxic air pollutant rules are implemented under the New Source Review Program. Ecology's Nuclear Waste Program regulates air toxic and criteria pollutant emissions from Hanford. Ecology's implementing requirements (e.g., WAC 173-400, WAC 173-401, WAC 173-460) specify a review of new source emissions, permitting, applicable controls, reporting, notifications, and provisions of compliance with the general standards for applicable sources of Hanford emissions.

The Washington State Department of Health regulations, "Radiation Protection – Air Emissions" (WAC 246-247), contain standards and permit requirements for the emission of radionuclides to the atmosphere from DOE facilities based on Ecology standards, "Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480). Prior to beginning any work that would result in creating a new or modified source of radioactive airborne emissions, a Notice of Construction application must be submitted to the Washington State Department of Health for review and approval. Ensuring adequate emission controls, emissions monitoring/sampling, and/or annual reporting of air emissions are typical requirements for radioactive air emission sources. Hanford operates under state license No. FF-01 for such emissions. This license was incorporated into the Hanford air operating permit renewal, which was reissued by Ecology on December 29, 2006 (Poston et al. 2007:5.9).

The local air authority, Benton Clean Air Agency, enforces state regulations pertaining to detrimental effects, fugitive dust, incineration products, odor, opacity, asbestos, and sulfur oxide emissions. The agency also has been delegated authority to enforce the EPA asbestos regulations.

Compliance with the Clean Air Act requires both facility and sitewide compliance. DOE's *Annual Hanford Site Environmental Permitting Status Report* (DOE 2004b) identifies existing facility-specific and sitewide compliance activities and requirements. The air operating permit for Hanford was renewed and became effective in January 2007 (permit No. 00-05-006 renewal) (Poston et al. 2007:D.2). Activities conducted under all of the alternatives must be in compliance with the Hanford Air Operating Permit and applicable Federal, state, and local regulations. The air quality sections of Chapter 4 of this *TC & WM EIS* provide information on the assessment of compliance with applicable standards and appropriate air quality criteria and standards for each of the alternatives.

Several of the activities under the alternatives would involve construction of a source of air emissions. For new or modified nonradioactive air emissions, DOE would need to obtain a permit to construct from Ecology and would need to conduct a NESHAPs review prior to commencing construction. Prior to construction of any new or modified source of radioactive airborne emissions, DOE would need to submit a Notice of Construction application to the Washington State Department of Health for review and approval. New facilities would also be required to be included in the air operating permit through a permit modification after construction and startup.

Idaho Environmental Protection Health Act (IC 39-100). This act provides for development of air pollution control permitting regulations in the State of Idaho. Under EPA regulations, the State of Idaho has been delegated authority under the Clean Air Act to maintain the Primary and Secondary NAAQS (40 CFR 52) to issue permits under the Prevention of Significant Deterioration regulations (40 CFR 52.683), to enforce performance standards of new stationary sources, and to issue permits to operate. The Idaho State air pollution control permitting regulations are found under "Rules for the Control of Air Pollution in Idaho," Idaho Administrative Procedures Act (IDAPA) (IDAPA 58.01.01).

The State of Idaho also administers a permit program that regulates sources that are too small to qualify as a major source under Prevention of Significant Deterioration regulations. To date, the State of Idaho does not have authority delegated from EPA to administer the NESHAPs program regulating emissions of radionuclides at DOE facilities, so that authority remains with EPA. The air quality sections of Chapter 4 of this *TC & WM EIS* provide information on the assessment of compliance with applicable standards and appropriate air quality criteria and standards for each of the alternatives.

Noise Control Act of 1972, as amended (42 U.S.C. 4901 et seq.). Section 4 of the Noise Control Act of 1972, as amended, directs all Federal agencies to carry out "to the fullest extent within their authority" programs within their jurisdictions in a manner that furthers a national policy of promoting an environment free from noise jeopardizing health and welfare. Chapter 4 of this EIS addresses the impacts associated with the construction, operations, deactivation, or closure activities analyzed for each of the alternatives.

8.1.3 Water Resources

There are several statutes, orders, and regulations that DOE must comply with to protect the waters at Hanford; these are briefly discussed below, along with potential implication to this *TC & WM EIS*.

Clean Water Act of 1972, as amended (33 U.S.C. 1251 et seq.). The Clean Water Act, which amended the Federal Water Pollution Control Act, was enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." The Clean Water Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the Clean Water Act requires all branches of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with Federal, state, interstate, and local requirements.

Section 404 of the Clean Water Act gives the U.S. Army Corps of Engineers permitting authority over activities that discharge dredge or fill materials into waters of the United States, including wetlands.

The Clean Water Act also provides guidelines and limitations for effluent discharges from point-source discharges and establishes the National Pollutant Discharge Elimination System (NPDES) permit program. The NPDES program is administered by EPA, pursuant to regulations in 40 CFR 122 et seq., and may be delegated to states. Sections 401 through 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act, requiring that EPA establish regulations for permits for stormwater discharges associated with industrial activities, including construction activities disturbing 2 hectares (5 acres) or more. After March 2003, the threshold for obtaining a permit was lowered to 0.4 hectares (1 acre). Stormwater provisions of the NPDES program are set forth at 40 CFR 122.26. This program is administered by EPA in both Washington and Idaho. Permit modifications are required if discharge effluent is altered.

Hanford has one NPDES permit (No. WA-002591-7). This permit covers three active outfalls: outfall 001 for the 300 Area Treated Effluent Disposal Facility and outfalls 003 and 004 in the 100-K Area to the Columbia River. EPA's NPDES Storm Water Multi-Sector General Permit No. WAR05A57F establishes the terms and conditions under which stormwater discharges associated with industrial activity are authorized for Hanford. This permit was issued in 2000 by EPA and expired on October 30, 2005. A new permit to replace it has not been issued. Facilities that obtained coverage under the 2000 Multi-Sector General Permit prior to its expiration are automatically granted an administrative continuance of permit coverage (Poston et al. 2007:5.11). For the construction of new facilities or modifications to existing facilities, DOE would need to develop written stormwater discharge plans that conform to requirements of the existing stormwater discharge permit. Hanford stormwater discharge permits would then need to be appended to include the additional or modified facility.

Washington Water Pollution Control Act of 1945 (RCW 90.48). This act applies to surface waters and groundwaters of the State of Washington and implements, at the state level, provisions of the Federal

Clean Water Act and Federal Safe Drinking Water Act (42 U.S.C. 300(f) et seq.). The Washington Water Pollution Control Act requires the development of state waste discharge permits and onsite sewage disposal system approvals and is administered by Ecology and the Washington State Department of Health. Regulations relating to water pollution and water quality include the following:

- "State Waste Discharge Permit Program" (WAC 173-216)
- "Water Quality Standards for Ground Waters of the State of Washington" (WAC 173-200)
- "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A)
- "On-Site Sewage System" (WAC 246-272)

Discharges from the 200 Area Treated Effluent Disposal Facility and Liquid Effluent Retention Facility, Waste Treatment Plant (WTP), and the Fast Flux Test Facility (FFTF) Ponds in the 400 Area are covered by state wastewater discharge permits issued by Ecology (Poston et al. 2007:5.11, D.2). The state derives its authority to administer the Underground Injection Control Program from *Revised Code of Washington* (RCW) 43.21A.445 whose intent is to satisfy the Federal Safe Drinking Water Act. DOE complies with State of Washington programs and applies for discharge permits or injection control permits as a matter of comity. Activities conducted under all of the alternatives must be in compliance with the applicable standards specified under the requirements listed above. The water resources sections of Chapter 4 provide information on compliance with these standards. If the selected action results in new or modified point-source discharges, DOE would need to modify its current permit.

Idaho Water Pollution Control Act (IC 39-3600). This act establishes a program to enhance and preserve the quality and value of water resources. The "Water Quality Standards" (IDAPA 58.01.02) and "Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater" (IDAPA 58.01.17) require protection of designated water uses and establishment of water quality standards that will protect those uses. The State of Idaho has established groundwater quality standards and enforces them under state authority.

Safe Drinking Water Act of 1974, as amended (42 U.S.C. 300(f) et seq.). The primary objective of the Safe Drinking Water Act is to protect the quality of public drinking water supplies and sources of drinking water. The implementing regulations, administered by EPA unless delegated to states, establish standards applicable to public water systems. These regulations include maximum contaminant levels (including those for radioactivity) in public water systems, which are defined as water systems that have at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. These standards apply to Columbia River water at community water supply intakes downstream of Hanford. The EPA regulations implementing the Safe Drinking Water Act are found in 40 CFR 141–149. For radioactive material, the regulations specify that the average annual concentration of manmade radionuclides in drinking water, as delivered to the user by such a system, shall not produce a dose equivalent to the total body or an internal organ greater than 4 millirem per year beta-gamma activity (40 CFR 141.16(a)). They further specify a concentration limit for gross alpha particle activity (excluding radon and uranium) of 15 picocuries per liter and for uranium of 0.03 milligrams per liter (40 CFR 141.66). Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

The groundwater analysis conducted for this *TC & WM EIS* consists of a comparison of the projected water quality with relevant regulatory standards, including standards established under the Safe Drinking Water Act that apply at the point of delivery. Results of this analysis are summarized in the groundwater resources sections of Chapter 5 and Appendix O of this EIS.

Executive Order 11988, *Floodplain Management* (May 24, 1977). This order (implemented by DOE in 10 CFR 1022) requires Federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken in a floodplain, and that floodplain impacts be avoided to the extent practicable. As discussed in Chapter 3 of this EIS, the areas of Hanford and INL being considered for this EIS are not located in a floodplain.

8.1.4 Hazardous Waste and Materials Management

All the alternatives analyzed for this EIS involve the management of hazardous and mixed wastes. These waste types must be managed in compliance with the applicable requirements. For all alternatives, hazardous waste and nonradioactive hazardous components of mixed waste would be stored at Hanford in accordance with applicable EPA and Ecology regulations. Ultimate treatment and disposal would be conducted in accordance with applicable standards and regulations at Hanford or offsite locations. The waste management sections of Chapter 4 provide information on the generation and management of hazardous and mixed wastes under each of the alternatives. Following are brief summaries of potentially applicable hazardous waste and materials management requirements.

Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6901 et seq.). The transportation and treatment, storage, and disposal (TSD) of solid and hazardous wastes are regulated by EPA under the authority of RCRA of 1976, as amended. The EPA regulations implementing RCRA (40 CFR 260–282) define and identify hazardous waste; establish standards for waste transportation and TSD; and require permits for persons engaged in hazardous waste activities.

EPA defines waste that exhibits the characteristics of ignitability, corrosivity, reactivity, or toxicity as "characteristic" hazardous waste. EPA has also identified certain materials as hazardous waste by listing them in RCRA regulations. These materials are referred to as "listed" hazardous waste. "Mixed waste" is waste that contains both a hazardous waste component regulated under Subtitle C of RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the AEA. The definition of "solid waste" in RCRA specifically excludes the radiological component (i.e., source, special nuclear, or byproduct materials as defined by the AEA). As a result, mixed waste is regulated under multiple authorities: by RCRA, as implemented by EPA or authorized states for the hazardous waste components, and by the AEA, as implemented by either DOE or the U.S. Nuclear Regulatory Commission (NRC) for the radiological components.

RCRA applies mainly to owners and operators of facilities that generate and manage hazardous waste. This act imposed management requirements on generators and transporters of hazardous waste and upon owners and operators of TSD facilities. EPA has established a comprehensive set of regulations governing all aspects of TSD facilities, including location, design, operations, and closure.

Any state that seeks to administer and enforce a hazardous waste program pursuant to RCRA may apply to EPA for authorization to administer its state program in lieu of the Federal program. EPA has authorized the State of Washington to implement the state hazardous waste management program in lieu of the Federal RCRA program, except for delisting authority and variances from the land-disposal-restriction treatment standard, and to the State of Idaho. The following provides additional information on land-disposal-restriction treatment standards specific to the activities addressed by this *TC & WM EIS.*

> ***Land-Disposal-Restriction Requirements.*** The Hazardous and Solid Waste Amendments of 1984 added provisions to RCRA to prohibit the land disposal of hazardous waste that does not meet specific treatment standards. RCRA land disposal restrictions require that hazardous waste be treated to meet applicable standards set forth in 40 CFR 268 prior to disposal. The standards may consist of required treatment technologies or concentration levels that must be achieved for hazardous constituents. Once hazardous waste is treated in accordance with the applicable treatment standards, it may be disposed of under applicable requirements. The tank waste is considered to be mixed waste (i.e., contains both RCRA hazardous waste constituents and radiological constituents regulated under the AEA). Therefore, the tank waste must be treated to meet the applicable treatment standards. Under each of the action alternatives, DOE would need to determine whether the treatment proposed meets the applicable treatment standards for that waste stream. If a specified treatment standard cannot be met, then DOE would need to apply for a treatment variance from that treatment standard or demonstrate equivalent treatment. DOE is preparing a treatability variance for the tank waste to allow vitrification as the treatment method for all the hazardous waste codes that apply to the tank

waste. Currently, vitrification is the treatment standard for high-level radioactive waste (HLW) that exhibits the characteristic of toxicity for metals and corrosivity. Hanford's HLW also exhibits the characteristic of corrosivity and toxicity for organics and contains listed hazardous waste. While HLW would be treated by vitrification, low activity waste and secondary waste would still need to meet the applicable treatment standards.

Washington State Hazardous Waste Management Act (RCW 70.105). The Washington State Hazardous Waste Management Act gives Ecology authority to regulate the disposal of hazardous waste in Washington and to implement waste reduction and prevention programs. Ecology has adopted regulations that are found in "Dangerous Waste Regulations" (WAC 173-303). Except as noted above, Washington State has been authorized to implement the state RCRA program within the state's borders in lieu of the federal program. Ecology's regulations are consistent with, and cover a larger universe of materials than, the Federal hazardous waste program. The waste categories defined in Ecology's regulations (WAC 173-303) are *dangerous waste*, *acutely hazardous waste*, *extremely hazardous waste*, and *special waste*. Following are discussions of two specific areas of compliance with the State of Washington hazardous waste management program (i.e., permits and closure) and their relation to the activities considered in this *TC & WM EIS*.

Hazardous/Dangerous Waste Permit. The owner/operator of a dangerous waste facility that treats, stores, disposes of, or recycles dangerous waste must obtain a permit in accordance with WAC 173-303-800 through 173-303-840 covering the active life, closure period, groundwater protection compliance period, and, for any regulated unit (as defined in WAC 173-303-040) or for any facility that at closure does not meet the removal or decontamination limits of WAC 173-303-610(2)(b), the postclosure care period, unless they demonstrate closure by removal or decontamination as provided under WAC 173-303-800(9) and (10). If a postclosure permit is required, the permit must address applicable groundwater monitoring, unsaturated zone monitoring, corrective action, and postclosure care requirements of WAC 173-303.

Hanford is considered a single facility for purposes of RCRA and the Washington State Hazardous Waste Management Act. Hanford's RCRA permit (No. WA7890008967) was originally issued in two portions, one by EPA Region 10 and the other by Ecology. The EPA portion of the Hanford RCRA permit covered the Hazardous and Solid Waste Amendments. The Ecology portion of the permit covered the dangerous waste provisions and was most recently modified by Ecology in February 2001. The Ecology portion of the permit was issued on September 27, 1994. The permit is the foundation for RCRA permitting on Hanford in accordance with provisions set forth in the Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement [TPA]) (Ecology, EPA, and DOE 1989). The permit expired on September 27, 2004, and DOE continues to operate under the old permit until a revised permit is issued by Ecology. Ecology is now fully authorized to implement the dangerous waste program in lieu of the Federal RCRA program; therefore, there is no need or authority for EPA to separately issue a hazardous solid waste amendment component of the Hanford permit (Bartus 2008). Ecology is working on a draft of the revised permit (Poston et al. 2007). The RCRA permits, along with other environmental permits covering Hanford, are described in the *Annual Hanford Site Environmental Permitting Status Report* (DOE 2004b).

This *TC & WM EIS* analyzes new facilities that will be permitted under RCRA and existing facilities that are operating under interim status requirements. The double-shell tank (DST) farm continues to operate under interim status. The single-shell tanks (SSTs) are expected to be closed in accordance with WAC 173-303 and the TPA. A final RCRA Part B permit is being obtained for the WTP on an incremental basis as the facility design matures. Any new TSD units would require a modification of the Hanford RCRA permit. An RCRA Part B permit application for the 200-East Area Integrated Disposal Facility was submitted to Ecology in 2005.

Treatment or disposal activities at other sites may require RCRA permits or approvals. The State of New Mexico carries out programs similar to the State of Washington's in which the Federal requirements are enforced under state law. Therefore, any hazardous waste management activities taking place in other states as a result of implementing one of the alternatives would be subject to the hazardous waste requirements of that particular state.

RCRA Closure. When hazardous waste management facilities cease operations, they must be closed in a manner that ensures they will not pose a future threat to human health and the environment. RCRA provides for two types of closure for hazardous waste tanks: (1) closure by removal, or decontamination (referred to as "clean closure"), and (2) closure with waste in place, or "landfill closure." The premise of clean closure is that all the hazardous waste has been removed from the RCRA-regulated unit, and any releases at or from the unit have been remediated so that further regulatory control under RCRA Subtitle C is not necessary to protect human health and the environment. The Action Plan (Attachment II to the TPA) (Ecology, EPA, and DOE 1989) presents specific requirements and milestones that are applicable to tank system closure and generally requires that the process to close any unit be carried out in accordance with the applicable requirements of WAC 173-303 and 40 CFR 270.1.

For closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment contaminated with waste and manage them as dangerous waste (WAC 173-303-640).

If the owner or operator demonstrates that all contaminated soils cannot practicably be removed or decontaminated, then the owner or operator must close the tank system and perform postclosure care in accordance with closure and postclosure care requirements that apply to a hazardous waste landfill (WAC 173-303-640(8)(b)). A postclosure care permit covering maintenance, monitoring, and corrective action provisions would be issued.

Ecology's regulations for closure (WAC 173-303-610) state that when the removal or decontamination of dangerous waste, waste residues, or equipment, bases, liners, soils, or other materials containing or contaminated with dangerous waste or waste residue is required, then such removal or decontamination must ensure that the levels of dangerous waste or dangerous waste constituents or residues do not exceed the following:

- For soils, groundwater, surface water, and air, the numeric cleanup levels calculated using residential exposure assumptions according to the Model Toxics Control Act regulations (WAC 173-340) as incorporated by the dangerous waste regulations. Primarily, these will be numeric cleanup levels.

- For all structures, equipment, bases, liners, etc., clean closure standards that will be set by Ecology on a case-by-case basis in accordance with the closure performance standards of WAC 173-303-610(2)(a)(ii) and in a manner that minimizes or eliminates postclosure escape of dangerous waste constituents.

The state has the ability to use alternative closure requirements in WAC 173-303-610(1)(e). The Tank Closure No Action Alternative and Tank Closure Alternative 2A of this *TC & WM EIS* do not address SST system closure, which is not consistent with the commitments for tank closure in the TPA. Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C address SST system closure as landfills. Tank Closure Alternative 4 addresses SST system closure as a combination of a landfill and clean closure of certain tank farms. Tank Closure Alternatives 6A and 6B address SST system closure under the clean closure scenario.

Model Toxics Control Act (RCW 70.105D). The Model Toxics Control Act is implemented through the Hazardous Waste Cleanup – Model Toxics Control Act regulations found under WAC 173-340. The

primary goal of these regulations is to provide a workable process to accomplish effective and expeditious cleanups that are not being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601) in a manner that protects human health and the environment. It is primarily intended to address releases of hazardous substances caused by past activities, although its provisions may be applied to potential and ongoing releases of hazardous substances from current activities. They are also applicable under the state corrective action authority (WAC 173-303-64620). These regulations provide methodologies for calculating numeric cleanup levels for soils, groundwater, surface water, and air.

Washington State Initiative 297, the Cleanup Priority Act. Initiative 297, known as the Cleanup Priority Act, was passed by Washington State voters in November 2004. The Cleanup Priority Act was intended to add a new chapter to the Mixed Radioactive and Hazardous Waste law (RCW 70.105E) and would have, among other things, restricted importing offsite waste to Hanford, set cleanup standards for radioactive releases, and required DOE to pay a new mixed-waste surcharge. The U.S. Department of Justice challenged the initiative, arguing it violated the U.S. Constitution. The Federal District Court agreed and ruled the initiative "invalid in its entirety" because it was preempted by Federal law, violated the Commerce Clause, and violated the principle of sovereign immunity. The State of Washington appealed the ruling, but the Ninth Circuit Court of Appeals affirmed the lower court, declaring the initiative was preempted by the AEA.

Hanford Federal Facility Agreement and Consent Order, May 15, 1989, as amended (Ecology, EPA, and DOE 1989). The TPA is an enforceable agreement among Ecology, EPA, and DOE for achieving compliance at Hanford with RCRA (42 U.S.C. 6901 et seq.); CERCLA (42 U.S.C. 9601 et seq.); and the Washington State Hazardous Waste Management Act (RCW 70.105). This agreement (1) defines RCRA and CERCLA cleanup commitments; (2) establishes responsibilities; (3) provides a basis for budgeting; and (4) reflects a concerted goal to achieve regulatory compliance and remediation with enforceable milestones (Poston et al. 2007:3.1).

The milestones governing the FFTF deactivation activities are defined in the TPA Milestone M-81-00 series and related M-20-29B milestones. A three-phased process is delineated in the TPA for decontamination and decommissioning of key facilities; Phase 1 is Transition or Deactivation, Phase 2 is Surveillance and Maintenance, and Phase 3 is Disposition.

For the SSTs, the TPA (as supplemented by the Interim Stabilization Consent Decree) lays out a process and schedule to remove pumpable liquids, retrieve solids, and close the SST system in lieu of achieving full compliance with RCRA requirements. The TPA milestones applicable to tank farms are provided in the following series: M-20 (immobilized low-activity waste [ILAW] and immobilized HLW [IHLW] facility RCRA permitting); M-23 (SST leak detection and integrity); M-43 (DST upgrades); M-45 (SST retrieval and closure); M-46 (DST space); M-47 (waste feed delivery); M-48 (DST integrity); and M-90 (ILAW and IHLW facility design, construction, and operations). The TPA also lays out the process for submittal, review, and approval of RCRA permit applications and closure plans (CH2M HILL 2003:B-2). In addition, the TPA lays out the process and authority to operate non-RCRA-compliant SSTs pending closure and identifies the process and procedures for SST system closure under RCRA.

It is assumed for each of the technologies evaluated in detail that remediation and closure decisions would be integrated with nearby CERCLA waste sites. Because of the number and location of waste sites surrounding the SST farms, there is a need to integrate decisions on remediation and closure (including surface barrier design). The TPA provides a means to integrate RCRA/CERCLA decisions to prevent conflicting requirements and resolve disputes. This is also a consideration for DST farm closure decisions. However, decisions on disposition of the DST farms are governed by WAC 173-303. This *TC & WM EIS* does not address existing-DST closure decisions nor remediation of contaminated groundwater. Decisions on DST closure would be addressed at a later date, subject to appropriate NEPA review. Groundwater contamination resulting from past leaks is currently being evaluated under the

RCRA Facility Investigation/Corrective Measures Study process (DOE 2003:5-2). Groundwater contamination in the 200 Areas generally is being addressed under CERCLA.

To the extent that the alternatives do not meet all of the commitments of the TPA, the TPA requires DOE to request modification of the agreement prior to proceeding with work that is inconsistent with those commitments. The TPA is involved in legal litigation; the results of this litigation may not match the timeframes laid out in the alternatives, which are included to provide the reader a range of time (e.g., years, decades) in which activities would be executed. In some cases, these timeframes have been modified to specifically examine how infrastructure, design life, and mission duration influence the alternatives and resource areas.

Federal Facility Compliance Act of 1992 (P.L. 102-386). The Federal Facility Compliance Act, enacted on October 6, 1992, amended RCRA Section 6961 and other sections and requires DOE to prepare plans that develop treatment capacity for mixed waste stored or generated at each facility, except for those facilities subject to a permit that establishes a schedule for treatment of such waste or an existing agreement or order governing the treatment of such waste to which the state is a party. The host state and/or EPA must approve each plan.

The State of Washington, EPA, and DOE had an existing plan (i.e., the TPA) addressing compliance with the storage prohibition for mixed waste at the time this law was enacted. Therefore, Hanford was not required to develop a new plan. A violation of the TPA may concurrently be a violation of the Federal Facility Compliance Act (i.e., the State of Washington may seek judicial enforcement under Title 42 of the *United States Code*, Section 6901 et seq. [42 U.S.C. 6901 et seq.]).

DOE and the State of Idaho have an approved plan, known as the "Site Treatment Plan," and associated consent order for INL. The INL Site Treatment Plan, Section 4.5, identifies the process for pretreatment and post-treatment storage at INL of offsite mixed waste. The process identified in the INL Site Treatment Plan, Section 4.5, requires approval of the treatment plan by the State of Idaho Department of Environmental Quality (IDEQ). Approval of the plan would allow for up to 6 months pre- and post-treatment storage of the offsite mixed waste. The process also requires the notification of IDEQ (1) of the proposed schedule subsequent to approval of the treatment plan and addition of the offsite waste stream to the list contained in Section 4.5, Table 4-5, and (2) upon actual receipt of offsite radioactive sodium and remote-handled special components; completion of the primary treatment step; and offsite shipment of product, waste, and treatment residue.

Interim Stabilization Consent Decree (No. CT-99-5076-EFS, September 30, 1999, as amended). This consent decree established a court-enforceable, technically sound schedule for pumping liquid nuclear waste from the remaining 29 unstabilized SSTs. The key elements of the consent decree include:

- Pumping the tanks that pose the greatest environmental risk first, thus providing additional protection for the Columbia River and public health.

- Accelerating the schedule for pumping so that 98 percent of approximately 23.5 million liters (6.2 million gallons) of remaining pumpable liquid is removed by September 30, 2003, with the final 2 percent scheduled to be removed by September 30, 2004 (this was completed).

- Increasing DOE funding to a level that supports successful execution of the new schedule for tank stabilization.

Idaho Hazardous Waste Management Act of 1983 (IC 39-4400 et seq.). The State of Idaho has been given authority by EPA to enact and carry out a hazardous waste program that enables the state to assume primacy over hazardous waste management in the State of Idaho. This includes authority to issue permits for hazardous waste TSD. The Idaho regulations include requirements for hazardous waste generators, transporters, and management facilities, as well as detailed procedures for permitting these activities.

Under the state's law (IC 39-4404), regulations may not be promulgated that impose conditions or requirements more stringent or broader in scope than RCRA or the RCRA regulations of EPA.

Spent Fuel Settlement Agreement (also known as the Governor's Agreement) (October 16, 1995). This agreement allows INL to receive spent nuclear fuel (SNF) and mixed waste from off site and establishes schedules for the treatment of existing HLW, TRU waste, mixed waste, and removal of SNF from the state. This agreement states that any and all treatable waste shipped into the State of Idaho for treatment at INL shall be treated within 6 months of receipt at the facility and shipped off site within 6 months of treatment. DOE may request an exception to the 6-month time period on a case-by-case basis, considering factors at the shipping site such as health and safety concerns, insufficient permitted storage capacity, and base or site closures. This agreement further states that DOE shall continue to use the Federal Facility Compliance Act process, as facilitated by the National Governors Association, to determine what locations are suitable for MLLW treatment and storage.

Toxic Substances Control Act of 1976 (15 U.S.C. 2601 et seq.). The Toxic Substances Control Act provides EPA with the authority to require testing of chemical substances entering the environment and to regulate them as necessary. EPA is also authorized to impose strict limitations on the use and disposal of polychlorinated biphenyls (PCBs), chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium. The EPA regulations that establish prohibitions of and requirements for PCBs and PCB items are found in 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." Removal of the two PCB transformers remaining at FFTF would require disposition in compliance with this act.

Framework Agreement for Management of Polychlorinated Biphenyls in Hanford Tank Waste (August 31, 2000). Some Hanford DSTs contain PCB remediation waste, which is waste containing PCBs as a result of a spill, release, or other unauthorized disposal and is regulated under the Toxic Substances Control Act. Therefore, the waste feed to the vitrification plant will also contain PCB remediation waste. On August 31, 2000, DOE, EPA Region 10, and Ecology signed the Framework Agreement for the Management of Polychlorinated Biphenyls in Hanford Tank Waste (EPA, DOE, and Ecology 2000). The agreement states that, "DOE, EPA and Ecology will pursue a rational path based on a risk-based disposal approval option per Title 40 of the *Code of Federal Regulations* 761.61(c) for the management of PCBs remediation waste." Since that time, DOE has submitted two risk-based disposal applications to EPA Region 10 for their approval. The first application, titled "Transmittal of Toxic Substance Control Act (TSCA) Risk-Based Disposal Application for the Double Shell Tank (DST) System for 2001," was submitted on January 15, 2002. The second application, titled "Application for Risk-Based Disposal Approval for PCBs Hanford 200 Area Liquid Waste Processing Facilities," was submitted on February 28, 2002. The various action alternatives analyzed in this *TC & WM EIS* will require compliance with the Framework Agreement for PCBs and the resulting PCB remediation waste program.

8.1.5 Radioactive Waste and Materials Management

All the alternatives analyzed for this *TC & WM EIS* involve the management of radioactive waste and materials. Radioactive waste and materials must be managed in compliance with the applicable requirements. Under all alternatives, the radioactive waste and the radioactive components of mixed waste would be stored at Hanford in accordance with applicable DOE requirements. Ultimate treatment and disposal would be conducted in accordance with applicable standards and regulations at Hanford or offsite locations. The waste management sections of Chapter 4 of this EIS provide information on the generation and management of radioactive and mixed wastes under each of the alternatives. Following are brief summaries of potentially applicable radioactive waste and materials management requirements.

Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.). The AEA provides fundamental jurisdictional authority to DOE and NRC over governmental and commercial use of nuclear materials. The AEA authorizes DOE to establish standards to protect health and minimize dangers to life or property for

activities under DOE's jurisdiction. DOE has issued a series of departmental orders to establish an extensive system of standards and requirements to ensure safe operation of DOE facilities. DOE regulations are found in Title 10 of the CFR. The DOE regulations that are the most relevant to radioactive waste and materials management include:

- "Nuclear Safety Management" (10 CFR 830)
- "Occupational Radiation Protection" (10 CFR 835)
- "Byproduct Material" (10 CFR 962)

The AEA also gives EPA the authority to develop generally applicable standards for protection of the general environment from radioactive materials. EPA has promulgated several regulations under this authority. The EPA regulation that is the most relevant to radioactive waste and materials management activities addressed by this EIS is "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (40 CFR 191).

Low-Level Radioactive Waste Policy Act of 1980, as amended (42 U.S.C. 2021 et seq.). This act amended the AEA to specify that the Federal Government (i.e., DOE and NRC) is responsible for disposal of LLW. If authorized by NRC under interstate compacts, states may regulate disposal of LLW from commercial sources. DOE remains responsible for the disposition of defense (DOE and U.S. Navy origin) LLW that will require management under any of the alternatives analyzed in this *TC & WM EIS*.

"Licensing Requirements for Land Disposal of Radioactive Waste" (10 CFR 61). The regulations in 10 CFR 61 establish, for land disposal of LLW, the procedures, criteria, and terms and conditions upon which NRC issues licenses for the disposal of radioactive waste containing byproduct, source, and special nuclear material. These regulations do not apply to HLW, or DOE-managed LLW, but do apply to LLW, including waste designated as Class A, B, or C radioactive waste managed in commercial facilities. Disposal facilities for radioactive waste other than DOE-regulated facilities would have to obtain an NRC or agreement state license and comply with these regulations.

Nuclear Waste Policy Act of 1982, as amended (42 U.S.C. 10101, et seq.). The Nuclear Waste Policy Act directed DOE to characterize and evaluate the Yucca Mountain, Nevada, site for suitability as a potential repository for disposal of commercial SNF and HLW. The act also directed the President to evaluate the need for a separate repository for HLW resulting from atomic energy defense activities. On April 30, 1985, President Reagan found "no basis to conclude that a defense only repository is required…" (DOE 1985). As a result of this finding, HLW from atomic energy defense activities may be disposed of in the proposed repository along with SNF. After passage by the U.S. House of Representatives and U.S. Senate, on July 23, 2002, President Bush signed House Joint Resolution 87 approving the site at Yucca Mountain for the development of a repository for the disposal of HLW and SNF, pursuant to the Nuclear Waste Policy Act.

As indicated in the Obama Administration's fiscal year 2010 budget request, the Administration intends to terminate the Yucca Mountain program while developing nuclear waste disposal alternatives. Notwithstanding the decision to terminate the Yucca Mountain program, DOE remains committed to meeting its obligations to manage and ultimately dispose of HLW and SNF. The Administration intends to convene a blue ribbon commission to evaluate alternative approaches for meeting these obligations. The commission will provide the opportunity for a meaningful dialogue on how best to address this challenging issue and will provide recommendations that will form the basis for working with Congress to revise the statutory framework for managing and disposing of HLW and SNF.

Waste Isolation Pilot Plant Land Withdrawal Act, as amended (P.L. 102-579). The Waste Isolation Pilot Plant Land Withdrawal Act withdrew land from the public domain for the purposes of creating and operating WIPP, the geologic repository in New Mexico designated as the national disposal site for defense TRU waste. In addition to establishing the location for the facility, the Land Withdrawal Act also defines the characteristics and amount of waste that will be disposed of at the facility. The amendments

to the Waste Isolation Pilot Plant Land Withdrawal Act exempt waste designated by the Secretary of Energy for disposal at WIPP from the RCRA land disposal restrictions. However, these amendments do not exempt mixed TRU waste from other RCRA requirements. WIPP does have an RCRA permit and can accept mixed TRU waste. On May 15, 2003, EPA Region 6 approved DOE's request to dispose of TRU waste and mixed TRU waste containing PCBs at WIPP subject to certain "conditions of approval." A decision for disposal at WIPP will not be made until the waste meets the (1) WIPP Waste Acceptance Criteria, with special emphasis on the waste determination as delineated in the WIPP recertification decision by EPA in March 2006; and (2) regulatory eligibility requirements for disposal as described in the WIPP hazardous waste facility permit.

"Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (40 CFR 191). The regulations in 40 CFR 191 establish radiation protection standards for the management and storage of SNF, HLW, and TRU waste at (1) facilities regulated by NRC or agreement states and (2) disposal facilities operated by DOE that are not regulated by NRC or agreement states. The regulations also establish limitations on radiation doses, which may occur after closure of the disposal system. These standards include both individual protection requirements and groundwater protection standards.

Under Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C, some portion of the tank waste would remain in the tanks after retrieval and be subjected to closure activities as landfills. If the residual waste in some SSTs is defined as TRU waste, the closure of these tanks as landfills could potentially be considered TRU waste disposal as defined by 40 CFR 191. The options that would be available to DOE include (1) managing the closed tanks as a TRU waste disposal site according to 40 CFR 191 requirements or (2) developing alternative disposal criteria through DOE and EPA rulemaking.

DOE Order 435.1, *Radioactive Waste Management* (July 9, 1999; Change 1, August 28, 2001). This order and its associated manual and guidance establish responsibilities and requirements for the management of DOE HLW, TRU waste, LLW, and the radioactive component of mixed waste. These documents provided detailed radioactive waste management requirements, including waste incidental to reprocessing determinations; waste characterization, certification, and TSD; and radioactive waste facility design and closure.

The terms "incidental waste" and "waste incidental to reprocessing" refer to a process for identifying waste streams that are incidental to SNF reprocessing, and are subsequently managed as LLW or TRU waste, if the waste incidental to reprocessing requirements contained in DOE Manual 435.1-1 are met. Thus, it is a process by which DOE can make a determination that, for example, waste residues remaining in tanks, equipment, or transfer lines can be managed as LLW or TRU waste if the requirements in Section II.B of DOE Manual 435.1-1 have been or will be met. These requirements are divided into two processes, the "citation" process and the "evaluation" process.

Waste resulting from processing SNF that is determined to be incidental to reprocessing is not HLW and shall be managed under DOE's regulatory authority in accordance with the requirements for LLW or TRU waste, as appropriate. When determining whether SNF processing plant wastes are another waste type or HLW, either the citation or evaluation process shall be used. In July 2003, parts of DOE Order 435.1 dealing with the procedures for determining waste incidental to reprocessing were declared invalid by the U.S. District Court for the District of Idaho in *Natural Resources Defense Council v. Abraham*, 271 F. Supp.2d 1260 (D. Id. 2003). On November 5, 2004, the court's decision was reversed on appeal by the U.S. Court of Appeals for the Ninth Circuit and remanded to the District Court with instructions to dismiss the case, *Natural Resources Defense Council v. Abraham*, 388 F.3d 701 (9th Cir. 2004). On March 6, 2006, the District Court dismissed the case. Some alternatives analyzed in this *TC & WM EIS* evaluate SST system closure, as well as the disposal, at Hanford, of ILAW, ancillary equipment, WTP melters, and other supplemental waste streams meeting Hanford Site Solid Waste Acceptance Criteria. DOE would proceed with SST system closure and disposal of these wastes only if closure and disposal activities comply with applicable laws. LLW and MLLW disposal facilities that

would be sited, constructed, and operated under the alternatives analyzed in this EIS would be subject to the appropriate DOE Manual 435.1-1 requirements. Additionally, closure of HLW facilities, including the tank farms, would also be subject to the DOE Manual 435.1-1 requirements.

DOE Order 430.1B, *Real Property Asset Management* (September 24, 2003; Change 1, February 8, 2008). This order establishes a corporate, holistic, and performance-based approach to real property life-cycle asset management that links real property asset planning, programming, budgeting, and evaluation to program mission projections and performance outcomes. This order also identifies requirements and establishes reporting mechanisms and responsibilities for real property asset management. Planning for disposition must be initiated when real property assets are identified as no longer required for current or future programs. Disposition includes stabilizing, preparing for reuse, deactivating, decommissioning, decontaminating, dismantling, demolishing, and/or disposing of real property assets. DOE must ensure compliance with this order during the decontamination and closure phases of the activities being considered under Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, 6A, 6B, and 6C; FFTF Decommissioning Alternatives 2 and 3; and Waste Management Alternatives 2 and 3 (see Chapter 2 of this EIS for discussions of alternatives).

8.1.6 Ecological Resources

The action alternatives analyzed for this EIS require new facilities to be constructed and borrow materials to be excavated, which would result in ground disturbances. As a result of potential ground-disturbing activities, DOE is required by certain statutes and other requirements to ensure that proposed activities will not adversely impact the ecological resources located in those areas. Following are summaries of these legal requirements, which also require consultations with the appropriate agency prior to initiation of such actions. Section 8.3 of this chapter discusses DOE activities regarding consultations with the appropriate agency. The specific results of these consultations are provided in the ecological resources sections of Chapter 4.

Bald and Golden Eagle Protection Act of 1973, as amended (16 U.S.C. 668–668d). The Bald and Golden Eagle Protection Act, as amended, makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States. A permit must be obtained from the U.S Department of Interior (DOI) to relocate a nest that interferes with resource development or recovery operations.

Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). The Endangered Species Act is intended to prevent the further decline of endangered and threatened species and to restore these species and habitats. Section 7 of the act requires Federal agencies having reason to believe that a prospective action may affect an endangered or threatened species or its habitat to consult with the U.S. Fish and Wildlife Service (USFWS) of DOI or the National Marine Fisheries Service of the U.S. Department of Commerce to ensure that the action does not jeopardize the species or destroy its habitat (50 CFR 17). If, despite reasonable and prudent measures to avoid or minimize such impacts, the species or its habitat would be jeopardized by the action, a review process is specified to determine whether the action may proceed as an incidental taking.

U.S. Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.). The U.S. Fish and Wildlife Coordination Act promotes effective planning and cooperation between Federal, state, public, and private agencies for the conservation and rehabilitation of the Nation's fish and wildlife and authorizes DOI to provide assistance. This act requires consultation with USFWS on the possible effects on wildlife if there is construction, modification, or control of bodies of water in excess of 4 hectares (10 acres) in surface area. This act also requires consultation with the head of the state agency that administers wildlife resources in the affected state.

Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703 et seq.). The Migratory Bird Treaty Act, as amended, is intended to protect birds that have common migration patterns between the United

States and Canada, Mexico, Japan, and Russia. It regulates the harvest of migratory birds by specifying conditions such as mode of harvest, hunting seasons, and bag limits. The act stipulates that it is unlawful, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess…any migratory bird…or any part, nest, or egg of any such bird." Although no permit for this project is required under the act, DOE is required to consult with USFWS regarding impacts on migratory birds and to avoid or minimize these effects in accordance with USFWS mitigation policy.

Executive Order 11990, *Protection of Wetlands* (May 24, 1977). This order (implemented by DOE in 10 CFR 1022) requires Federal agencies to avoid any short- or long-term adverse impacts on wetlands wherever there is a practicable alternative. Each agency must also provide opportunity for early public review of any plans or proposals for new construction in wetlands. As discussed in Chapter 4 of this *TC & WM EIS*, because no wetlands exist in the proposed locations, no impact on wetlands is expected under any of the alternatives being considered in this EIS.

8.1.7 Cultural and Paleontological Resources

The action alternatives analyzed for this EIS require new facilities to be constructed and borrow materials to be excavated, which would result in ground disturbances. As a result of potential ground-disturbing activities or the location of these new facilities, DOE is required by certain statutes and other requirements to ensure that proposed activities will not adversely impact the cultural resources located in those areas or to limit access to these culturally important areas. Following are summaries of these legal requirements, some of which require consultations with the appropriate agency and American Indian tribes prior to initiation of such actions. Section 8.3 of this chapter discusses DOE activities regarding consultations with the appropriate agency and American Indian tribes. The specific results of these consultations are provided in the cultural resources sections of Chapter 4.

American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996). This act reaffirms American Indian religious freedom under the First Amendment and sets the United States policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. The act requires that Federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religions.

Antiquities Act of 1906, as amended (16 U.S.C. 431–433). This act protects historic and prehistoric ruins, monuments, and antiquities, including paleontological resources, on federally controlled lands from appropriation, excavation, injury, and destruction without permission. On June 9, 2000 (65 FR 37253), the Hanford Reach was designated as a national monument through Presidential Proclamation No. 7319 under this act. The cultural resources section of Chapter 3 of this EIS provides more information on the Hanford Reach.

Archaeological and Historic Preservation Act of 1960, as amended (16 U.S.C. 469–469c-2). The purpose of this act is to provide for the preservation of historical and archaeological data (including relics and specimens) that might otherwise be irreparably lost or destroyed as a result of Federal actions.

Archaeological Resources Protection Act of 1979, as amended (16 U.S.C. 470aa et seq.). This act requires a permit for any excavation or removal of archaeological resources from Federal or American Indian lands. Excavation must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources that are removed are to remain the property of the United States. The law requires that whenever any Federal agency finds that its activities may cause irreparable loss or destruction of significant scientific, prehistoric, or archaeological data, the agency must notify DOI and may request that DOI undertake the recovery, protection, and preservation of such data. Consent must be obtained from the American Indian tribe or the Federal agency having authority over the land on which a resource is located before issuance of a permit; the permit must contain terms and conditions requested by the tribe or Federal agency.

National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.). This act states that sites with significant national historic value are to be placed on the National Register of Historic Places (National Register), which is maintained by the Secretary of the Interior. The implementing regulations for this act are located in "Protection of Historic and Cultural Properties" (36 CFR 800). The major provisions of the act that affect DOE are Sections 106 and 110. Both sections aim to ensure that historic properties are appropriately considered and preserved in planning Federal initiatives and actions. No permits or certifications are required under the act; however, consultation with the State Historic Preservation Officer, Advisory Council on Historic Preservation, American Indian tribes, and the public is required if a Federal undertaking might impact a historic resource. This consultation might result in a memorandum of agreement that includes stipulations to minimize adverse impacts on the historic resource. Coordination with the State Historic Preservation Office is undertaken to ensure that potentially significant sites are properly identified and appropriate mitigation measures are implemented. DOE has submitted documentation to the State Historic Preservation Officer regarding the determination of eligibility for the portion of the *Laliik* traditional cultural property (including Rattlesnake Mountain) that is under DOE's ownership and management responsibility. In addition, DOE has started consultations under Section 106 with the State Historic Preservation Officer, Advisory Council on Historic Preservation, and American Indian tribes on the possible adverse effects of the use of Borrow Area C for the proposed actions being evaluated in this *TC & WM EIS*. DOE anticipates development of a memorandum of agreement addressing the adverse effects of the proposed actions and alternatives based on the analyses in this *TC & WM EIS.* Copies of the correspondence between DOE and the State Historic Preservation Officer are provided in Appendix C of this EIS.

Programmatic Agreement Among the U.S. Department of Energy Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington (August 21, 1996). Among other things, this agreement identified five buildings (405, 436, 4621-W, 4703, and 4710) inside the 400 Area Property Protected Area, which includes FFTF, as eligible for inclusion in the National Register under criterion A as contributing properties recommended for individual documentation (mitigation) within the Hanford Site Manhattan Project and Cold War Era Historic District. Sixteen other buildings also are eligible for inclusion in the National Register as contributing properties within the Cold War Era Historic District, with no individual documentation required.

As a result of this agreement and the implementing sitewide treatment plan, the DOE Richland Operations Office took numerous actions. For instance, the DOE Richland Operations Office completed walkthroughs of the 5 historic buildings that were required to have individual documentation (mitigation) to locate and identify any artifacts that may have interpretive or educational value as potential exhibits within local, state, or national museums. Because of the potential of locating significant artifacts in these facilities, walkthroughs were also conducted in each of the 16 contributing properties that did not require individual documentation. These walkthroughs were completed, and artifacts were identified and tagged in 8 of the buildings. Tagged artifacts will be documented in place or retrieved for delivery to the Columbia River Exhibition of History, Science, and Technology Museum as appropriate prior to building demolition. By its own terms, the agreement was in effect until September 30, 2000, and has not been renewed. However, some activities undertaken to comply with the agreement are still ongoing. Unless new actions are proposed that would disturb previously undisturbed areas, these activities completed DOE's National Historic Preservation Act responsibilities for the 400 Area Property Protected Area, including FFTF.

Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001 et seq.). The Native American Graves Protection and Repatriation Act directs the Secretary of the Interior to guide Federal agencies in the repatriation of Federal archaeological collections and collections affiliated culturally to American Indian tribes that are currently held by museums receiving Federal funding. This act establishes provisions for the treatment of inadvertent discoveries of American Indian remains and cultural objects. When discoveries are made during ground-disturbing activities, the following steps are

to occur: (1) activity in the area of the discovery is to cease immediately, (2) reasonable efforts are to be made to protect the items discovered, (3) notice of discovery is to be given to the Federal agency and the appropriate tribes, and (4) a period of 30 days is to be set aside following notification for negotiations regarding the appropriate disposition of the discovered item(s).

Executive Order 11593, *Protection and Enhancement of the Cultural Environment* (May 13, 1971). This order directs Federal agencies to locate, inventory, and nominate properties under their jurisdiction or control to the National Register, if those properties qualify. This process requires DOE to provide the Advisory Council on Historic Preservation the opportunity to comment on the possible impacts of the proposed activity on any potential eligible or listed resources.

Executive Order 13007, *Indian Sacred Sites* (May 24, 1996). This order directs Federal agencies, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, to (1) accommodate access to and ceremonial use of American Indian sacred sites by their religious practitioners and (2) avoid adversely affecting the physical integrity of such sacred sites. Where appropriate, agencies are to maintain the confidentiality of sacred sites.

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments* (November 6, 2000). This order supplements the Executive Memorandum (dated April 29, 1994) entitled "Government-to-Government Relations with Native American Tribal Governments" and states that each executive department and agency shall consult, to the greatest extent practicable and to the extent permitted by law, with tribal governments prior to taking actions that affect federally recognized tribal governments. This order also states that each executive department and agency shall assess the impact of Federal Government plans, projects, programs, and activities on tribal trust resources and ensure that tribal government rights and concerns are considered during the development of such plans, projects, programs, and activities.

Executive Order 13195, *Trails for America in the 21st Century* (January 18, 2001). This order states that Federal agencies will, to the extent permitted by law and where practicable—and in cooperation with tribes, states, local governments, and interested citizen groups—protect, connect, promote, and assist trails of all types throughout the United States.

Executive Order 13287, *Preserve America* (March 3, 2003). The goals of the initiative addressed by this order include a greater shared knowledge about the Nation's past, strengthened regional identities and local pride, increased local participation in preserving cultural and natural heritage assets, and support for the economic vitality of our communities. This order establishes Federal policy to provide leadership in preserving America's heritage by actively advancing the protection, enhancement, and contemporary use of the historic properties owned by the Federal Government and by promoting intergovernmental cooperation and partnerships for the preservation and use of historic properties.

DOE Order 1230.2, *American Indian Tribal Government Policy* (April 8, 1992), as revised by DOE Notice 144.1. This order establishes responsibilities and transmits the DOE American Indian policy. The policy outlines the principles to be followed by DOE in its interactions with federally recognized American Indian tribes. It is based on Federal policy treaties, Federal law, and DOE's responsibilities as a Federal agency to ensure that tribal rights and interests are identified and considered during decisionmaking.

Treaties with American Indian Tribes of the Hanford Region. DOE's relationship with American Indians is based on treaties, statutes, and DOE directives. Representatives of the United States negotiated treaties with leaders of various Columbia Plateau American Indian tribes and bands in June 1855 at Camp Stevens in the Walla Walla Valley. The negotiations resulted in three treaties, one with the 14 tribes and bands of the group that would become the Confederated Tribes and Bands of the Yakama Nation, one with the 3 tribes that would become the Confederated Tribes of the Umatilla Indian Reservation, and one

with the Nez Perce Tribe. The U.S. Senate ratified the treaties in 1859. The negotiated treaties are as follows:

- Treaty with the Walla Walla, Cayuse, etc. (June 9, 1855; 12 Stats. 945)
- Treaty with the Yakama Nation (June 9, 1855; 12 Stats. 951)
- Treaty with the Nez Perce (June 11, 1855; 12 Stats. 957)

The Confederated Tribes and Bands of the Yakama Nation of the Yakama Reservation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe of Idaho are federally recognized tribes that are eligible for funding and services from the U.S. Bureau of Indian Affairs by virtue of their status as Indian tribes (68 FR 68180, December 5, 2003).

The terms of the three preceding treaties are similar. Each of the three tribal organizations agreed to cede large blocks of land to the United States. Hanford is within the ceded lands. The treaties reserved to the tribes certain lands for their exclusive use (the three reservations). The treaties also secured to the tribes certain rights and privileges to continue traditional activities outside the reservations. These included (1) the right to fish at usual and accustomed places in common with citizens of the United States and (2) the privileges of hunting, gathering roots and berries, and pasturing horses and cattle on open and unclaimed lands. DOE believes that none of the activities involved in this *TC & WM EIS* would take place on open and unclaimed land.

8.1.8 Worker Safety and Health

DOE emphasizes compliance with requirements to ensure worker safety at DOE facilities, which would include the new and existing facilities being addressed by this *TC & WM EIS*. Through DOE regulations and orders, DOE prescribes that contractors shall meet U.S. Department of Labor Occupational Safety and Health Administration (OSHA) standards applicable to work at Government-owned, contractor-operated facilities and AEA standards to ensure safety of workers from radiation exposure. A summary of worker safety and health requirements is provided below.

Occupational Safety and Health Act of 1970 (29 U.S.C. 651 et seq.). Section 4(b)(1) of the Occupational Safety and Health Act exempts DOE and its contractors from the occupational safety requirements of OSHA. However, 29 U.S.C. 668 requires Federal agencies to establish their own occupational safety and health programs for their places of employment, consistent with OSHA standards. DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*, states that DOE will implement a written worker protection program that (1) provides a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm to their employees and (2) integrates all requirements contained in paragraphs 4a to 4l of DOE Order 440.1A; 29 CFR 1960, "Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters"; and other related site-specific worker protection activities.

"Occupational Radiation Protection" (10 CFR 835). This regulation establishes radiation protection standards, limits, and program requirements for protecting occupational workers and visitors from ionizing radiation resulting from the conduct of DOE activities. These requirements are applicable to general employees involved in activities being considered in this *TC & WM EIS* that have the potential to result in the occupational exposure of an individual to radiation or radioactive materials.

"Worker Safety and Health Program" (10 CFR 851). This regulation establishes requirements for a worker safety and health program that prevents or reduces occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites. This regulation also establishes procedures for investigating whether a violation has occurred, determining the nature and extent of any such violation, and imposing an appropriate remedy.

DOE Order 440.1B, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees* (May 17, 2007). This order establishes the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing safe and healthful DOE Federal and contractor workplaces.

Executive Order 12699, *Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction* (January 5, 1990), as amended by Executive Order 13286 (February 28, 2003). This order requires Federal agencies to (1) reduce risks to occupants of buildings owned, leased, or purchased by the Federal Government or buildings constructed with Federal assistance and to persons who would be affected by failures of Federal buildings in earthquakes; (2) improve the capability of existing Federal buildings to function during or after an earthquake; and (3) reduce earthquake losses of public buildings, all in a cost-effective manner. Each Federal agency responsible for the design and construction of a Federal building shall ensure that the building is designed and constructed in accordance with appropriate seismic design and construction standards.

8.1.9 Radiological Safety Oversight and Radiation Protection

DOE has specific regulations and directives that affect radiological safety during construction, operations, deactivation, and closure of new and existing facilities being addressed by this *TC & WM EIS*. The DOE regulations and directives affecting radiological safety are summarized below.

"Nuclear Safety Management" (10 CFR 830). Specific requirements in these regulations apply to DOE contractors, DOE personnel, and other persons conducting activities (including providing items and services) that affect, or may affect, the safety of DOE nuclear facilities. These regulations include quality assurance (10 CFR 830, Subpart A) and safety-basis (10 CFR 830, Subpart B) requirements. The latter require the contractor responsible for a DOE nuclear facility to analyze the facility, work to be performed and associated hazards, and to identify the conditions, safe boundaries, and hazard controls necessary to protect workers, the public, and the environment from adverse consequences. DOE relies on these analyses and hazard controls to operate facilities safely.

DOE Order 420.1B, *Facility Safety* (December 22, 2005). This order establishes facility safety requirements related to nuclear safety design, criticality safety, fire protection, and the mitigation of hazards related to natural phenomena.

DOE Order 425.1C, *Startup and Restart of Nuclear Facilities* (March 13, 2003). This order establishes DOE requirements for startup of new nuclear facilities and for the restart of existing nuclear facilities that have been shut down. The requirements specify a readiness review process that must demonstrate that it is safe to start (or restart) the applicable facility. The facility must be started (or restarted) only after documented independent reviews of readiness have been conducted and the approvals specified in the order have been received.

DOE Policy 441.1, *DOE Radiological Health and Safety Policy* (April 26, 1996). This document states that it is DOE policy to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. The policy states that in achieving this objective, DOE will ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits, and deliberate efforts are taken to further reduce exposures and releases to as low as is reasonably achievable levels. DOE is committed to implementing a radiological control program of the highest quality that consistently reflects this policy.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (February 8, 1990; Change 2, January 7, 1993). This order establishes standards and requirements for DOE operations for protection of members of the public and the environment against undue risk from radiation. It is DOE policy to implement legally applicable radiation protection standards and to consider and adopt, as appropriate, recommendations by authoritative organizations; for example, the National Council on

Radiation Protection and Measurements and the International Commission on Radiological Protection. It is also DOE policy to adopt and implement standards generally consistent with those of NRC for DOE facilities and activities not subject to NRC licensing authority.

DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities* (November 15, 1994; Change 1, July 12, 2001). This order establishes the selection, qualification, and training requirements for DOE contractor personnel involved in the operation, maintenance, and technical support of DOE nuclear reactors and nonreactor nuclear facilities. DOE objectives under this order are to ensure the development and implementation of contractor-administered training programs that provide consistent and effective training for personnel at DOE nuclear facilities. The order contains minimum requirements that must be included in training and qualification programs.

8.1.10 Transportation

The transportation of all radioactive and other hazardous materials associated with any alternative selected for implementation would need to comply with the applicable DOE directives and EPA, U.S. Department of Transportation (DOT), and Ecology regulations. It is DOE policy (DOE Order 460.2A) that all DOE operations shall be conducted in compliance with all applicable international, Federal, state, local, and tribal laws, rules, and regulations governing materials transportation that are consistent with Federal regulations, unless exemptions or alternatives are approved in accordance with DOE Order 460.2A. Following are summaries of those transportation requirements that are relevant to the transportation of radioactive and other hazardous materials, including mixed TRU waste and TRU waste that would be transported to WIPP under each of the action alternatives and remote-handled special components and bulk sodium that would be transported to the Materials and Fuels Complex for processing or storage under some of the action alternatives.

Hazardous Materials Transportation Act of 1975, as amended (49 U.S.C. 5101 et seq.). The Hazardous Materials Transportation Act of 1975, as amended, requires DOT to prescribe uniform national regulations for transportation of hazardous materials (including radioactive materials). Most state and local regulations regarding such transportation that are not substantively the same as the DOT regulations are preempted (i.e., rendered void) (49 U.S.C. 5125). This, in effect, allows state and local governments only to enforce the Federal regulations, not to change or expand upon them.

This program is administered by the Research and Special Programs Administration of DOT, which, when covering the same activities, coordinates its regulations with NRC (under the AEA) and EPA (under RCRA). DOT regulations, which may be found under 49 CFR 171–178 and 49 CFR 383–397, contain requirements for identifying a material as hazardous or radioactive. These regulations interface with the NRC regulations for identifying material, but DOT hazardous material regulations govern the hazard communication (such as marking, labeling, vehicle placarding, and emergency response information) and shipping requirements. Requirements for transport by rail, air, and public highway are included. EPA regulations (40 CFR 262) govern offsite transportation of hazardous waste. States also have established regulations consistent with DOT regulations. The Ecology regulations applicable to transportation of hazardous waste in Washington State are found in WAC 173-303-240 through 270, for packaging and transporting radioactive materials in WAC 246-231, and for transportation of hazardous materials in WAC 446-50. The State of Idaho regulations for transportation of hazardous materials/waste on highways are found in *Idaho Code* 49-2200 and *Idaho Code* 18-3900.

Transportation of waste products and contaminated equipment that is conducted entirely on DOE property (i.e., on site), to which public access is controlled at all times through the use of gates and guards, is subject to applicable DOE directives and transportation safety requirements set forth in 10 CFR 830, Subpart B, but is not directly subject to the DOT requirements. DOE transport of these materials over highways to which the public has access would be subject to applicable DOT, EPA, and Ecology regulations, as well as to applicable DOE directives.

"Packaging and Transportation of Radioactive Material" (10 CFR 71). These NRC regulations include detailed packaging design requirements and package certification testing requirements. Complete documentation of design and safety analysis and the results of the required testing are submitted to NRC to certify the package for use. This certification testing involves the following components: heat, physical drop onto an unyielding surface, water submersion, puncture by dropping the package onto a steel bar, and gas tightness.

DOE Order 460.1B, *Packaging and Transportation Safety* (April 4, 2003). This order sets forth DOE policy and assigns responsibilities for the proper packaging and transportation of DOE offsite shipments and onsite transfers of hazardous materials and for modal transport.

DOE Order 460.2A, *Departmental Materials Transportation and Packaging Management* (December 22, 2004). This order states that DOE operations shall be conducted in compliance with all applicable international, Federal, state, local, and tribal laws, rules, and regulations governing materials transportation that are consistent with Federal regulations, unless exemptions or alternatives are approved in accordance with DOE Order 460.1B. This order also states that it is DOE policy that shipments will comply with the DOT 49 CFR 100–185 requirements, except those that infringe upon maintenance of classified information.

8.1.11 Emergency Planning, Pollution Prevention, and Conservation

There are several statutes and Executive orders that require Federal agencies to have in place programs or plans to respond to an emergency resulting from the release of hazardous substances and also to have in place programs that allow for conservation and pollution prevention. DOE is required to implement these programs at its facilities and would be required to ensure that these plans and programs are in place to address activities being considered under any of the alternatives. Following are summaries of these statutes and Executive orders related to emergency planning, pollution prevention, and conservation requirements.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601 et seq.) (also known as Superfund). CERCLA provides a statutory framework for the remediation of waste sites, including Federal facilities, containing hazardous substances and, as amended by the Superfund Amendments and Reauthorization Act, an emergency response program in the event a release (or threat of a release) of a hazardous substance to the environment occurs. Releases of hazardous substances exceeding reportable quantities must be reported on a timely basis to the National Response Center. Using a hazard-ranking system, Federal and private contaminated sites are ranked and may be included on the National Priorities List. CERCLA requires Federal facilities with contaminated sites to undertake investigations, remediation, and natural resource restoration, as necessary.

Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 11001 et seq.). Federal facilities are required under Subtitle A of the Emergency Planning and Community-Right-to-Know Act to provide information to EPA and the state and local emergency response offices regarding the inventories of chemicals used or stored at a site and releases from that site. The goal of providing this information is to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. The required information includes inventories of specific chemicals used or stored and descriptions of releases that occur from sites.

Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq.). The Pollution Prevention Act establishes a national policy for waste management and pollution control. Source reduction is given first preference, followed by environmentally safe recycling, with disposal or releases to the environment as a last resort.

Executive Order 12088, *Federal Compliance with Pollution Control Standards* (October 13, 1978), as amended by Executive Order 12580, *Superfund Implementation* (January 23, 1987). This order directs Federal agencies to comply with applicable administrative and procedural pollution control

standards established by, but not limited to, the Clean Air Act, the Noise Control Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act, and RCRA.

Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* (January 24, 2007). This order sets goals for Federal agencies to conduct their environmental, transportation, and energy-related activities under the law in support of their respective missions in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.

8.1.12 Environmental Justice and Protection of Children

There are two Executive orders that require Federal agencies to identify and address environmental risks to certain populations when planning a major Federal action such as those activities being considered in this *TC & WM EIS*. Following are summaries of these two orders.

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (February 11, 1994). This order requires each Federal agency to identify and address disproportionately high and adverse human health and environmental effects of its programs, policies, and activities on minority and low-income populations.

The CEQ, which oversees the Federal Government's compliance with Executive Order 12898 and NEPA, has developed guidelines to assist Federal agencies in incorporating the goals of Executive Order 12898 in the NEPA process. This guidance, published in 1997, was intended to "…assist Federal agencies with their NEPA procedures so that environmental justice concerns are effectively identified and addressed." As part of this process, DOE has performed an analysis to determine whether implementing any of the proposed alternatives would result in disproportionately high or adverse impacts on minority or low-income populations. The results of this analysis are discussed in the environmental justice sections of Chapter 4 for each of the alternatives under consideration.

Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks* (April 21, 1997), as amended by Executive Order 13229 (October 9, 2001). This order requires each Federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and to ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

8.2 PERMITS

Information on the status of existing environmental permits at Hanford is discussed in the *Annual Hanford Site Environmental Permitting Status Report* (DOE 2004b). Included is information on current and anticipated environmental permitting required by RCRA; the Toxic Substances Control Act, Clean Air Act, and Clean Water Act; the State Waste Discharge, Hydraulic Permit, and Underground Injection Control Programs; the Onsite Sewage System Program; and the Petroleum Underground Storage Tank Program.

Hanford is considered a single facility for purposes of RCRA and the Washington State Hazardous Waste Management Act. The site has been issued EPA/state identification No. WA7890008967. The Hanford RCRA permit governs all final-status TSD activities at Hanford (Duncan 2007). The Hanford RCRA permit was originally issued in two portions, one issued by EPA Region 10 and the other by Ecology. The EPA portion of the Hanford RCRA permit covered the Hazardous and Solid Waste Amendments. The Ecology portion of the permit covered compliance with Ecology's dangerous waste regulations, as well as standard conditions, general facility conditions, and specific conditions for the individual TSD units and TSD units undergoing corrective action or closure (Duncan 2007). The 10-year period for the permit, as specified by the regulations, ended on September 27, 2004, and DOE continues to operate

under the old permit until a revised permit is issued by Ecology. Ecology is now fully authorized to implement the dangerous waste program in lieu of the Federal RCRA program; therefore, there is no need or authority for EPA to separately issue a hazardous solid waste amendment component of the Hanford permit (Bartus 2008).

The DST farms continue to operate under interim status requirements. A Part B permit application for the DSTs was submitted to Ecology in 2005. The TPA lays out the process and authority to operate non-RCRA-compliant SSTs pending closure and identifies the process and procedures for SST system closure. A final RCRA Part B permit is being obtained for the WTP on an incremental basis as the design matures. A Part B permit application for the 200-East Area Integrated Disposal Facility was submitted to Ecology in 2005. Any new or modified TSD units would require a modification of the Hanford RCRA permit. An RCRA Part B permit application for the 200-East Area Integrated Disposal Facility was submitted to Ecology in 2005.

DOE has submitted two risk-based disposal applications to EPA Region 10 for their approval. The first application, titled "Transmittal of Toxic Substance Control Act (TSCA) Risk-Based Disposal Application for the Double Shell Tank (DST) System for 2001," was submitted on January 15, 2002. The second application, titled "Application for Risk-Based Disposal Approval for PCBs Hanford 200 Area Liquid Waste Processing Facilities," was submitted on February 28, 2002.

The 400 Area waste management unit is currently permitted under the Hanford RCRA permit. The 400 Area waste management unit stores mixed waste (i.e., sodium residuals-contaminated waste) generated from FFTF deactivation activities in the FFTF Fuel Storage Facility and the 400 Area Interim Storage Area. Once this waste is treated, removed, and disposed of, appropriate closure of the 400 Area waste management unit facilities would be done under applicable regulations.

IDEQ administers the requirements of RCRA through the Idaho Hazardous Waste Management Act. The Idaho hazardous waste regulations are found in IDAPA 58.01.05 (ANL-W and Fluor Hanford 2002).

The Sodium Processing Facility (SPF) at Idaho obtained an Idaho Hazardous Waste Management Act/RCRA hazardous waste treatment and storage permit in January 1997. The SPF is permitted in accordance with IDAPA 58.01.05.008/40 CFR 264 for tank and container treatment and storage. This hazardous waste operating permit allows for the treatment and storage of sodium, sodium potassium, and caustic (sodium and potassium hydroxide). No SPF Idaho Hazardous Waste Management Act/RCRA permit modifications are anticipated that would be required for treatment and storage of FFTF sodium in the SPF whether the sodium is classified as product or hazardous waste (ANL-W and Fluor Hanford 2002).

Hanford Site Air Operating Permit No. 00-05-006, Renewal, covers operations at Hanford having a potential to emit airborne emissions. This permit became effective on January 1, 2007, and expires January 1, 2012. The permit is intended to provide a compilation of applicable Clean Air Act requirements for both radioactive and nonradioactive emissions at Hanford. It is implemented through Federal and state programs (Poston et al. 2007:D.2).

DOE holds a license (No. FF-01), issued by the Washington State Department of Health, covering airborne radioactive effluents from Hanford operations. The license is incorporated as Attachment 2 in the Hanford Site Air Operating Permit (Poston et al. 2007:D.2).

The State of Idaho issued to INL a Tier I operating permit under Title V of the Clean Air Act, with an effective date of June 28, 2005 (DOE 2006b:2.1). A Notice of Construction was prepared according to requirements of WAC 246-247, "Radiation Protection – Air Emissions," and 40 CFR 61 Subpart H, for the Sodium Storage Facility and submitted to EPA and the Washington State Department of Health. The final Notice of Construction was approved on February 24, 1995. A Notice of Construction would be

required for the Sodium Reaction Facility, if it is constructed at Hanford (ANL-W and Fluor Hanford 2002).

A NESHAPs application (40 CFR 61) for the SPF was submitted to EPA Region 10 on December 19, 1995; approval for construction was granted in February 1996. EPA Region 10 granted approval for construction on February 5, 1996 (ANL-W and Fluor Hanford 2002). DOE-Chicago received an approved permit from IDEQ to construct the SPF on September 29, 1995, with subsequent amendments and approval on September 26, 2000. IDEQ found the SPF treatment and storage operations met the provisions of IDAPA 58.01.01 "Rules for the Control of Air Pollution in Idaho" (ANL-W and Fluor Hanford 2002).

Assuming that the radionuclide concentrations for Hanford sodium would not exceed the permitted radionuclide emissions from the SPF, no modification for the NESHAPs application would be necessary. Additionally, no modification is expected for the SPF permit to construct, as no other air contaminants, other than those currently specified in the permit to construct, are identified in FFTF sodium.

There is one NPDES permit (No. WA-002591-7) issued by EPA for Hanford. The permit covers three active outfalls: outfall 001 for the 300 Area Treated Effluent Disposal Facility and outfalls 003 and 004 in the 100-K Area. Fluor Hanford, Inc. is the holder of this permit (Poston et al. 2007:5.11).

EPA's NPDES Storm Water Multi-Sector General Permit No. WAR05A57F establishes the terms and conditions under which stormwater discharges associated with industrial activity are authorized. The permit was issued in 2000 and expired on October 30, 2005. A new permit to replace it has not been issued. Facilities that obtained coverage under the 2000 Multi-Sector General Permit prior to its expiration are automatically granted an administrative continuance of permit coverage. Fluor Hanford, Inc. is the holder of this permit (Poston et al. 2007:5.11).

Hanford has five state wastewater discharge permits for the discharge or disposal of wastewater to groundwater (Permit Nos. ST 4500, ST 4501, ST 4502, ST 4507, and ST 4511), issued by Ecology (Poston et al. 2007:5.11).

DOE has asserted a federally reserved water withdrawal right with respect to its Hanford operations. Current Hanford activities use water withdrawn under DOE's federally reserved water rights (Duncan 2007).

The INL site complies with four Clean Water Act permits through implementation of procedures, policies, and best management practices. These four permits are: Section 404 Permit for dredge and fill activities; discharges from Idaho Falls facilities to the City of Idaho Falls publicly owned treatment works; NPDES General Permit for Storm Water Discharges from Industrial Activities; and NPDES General Permit for Storm Water Discharges from Construction Activities (DOE 2006b:2.12).

DOE would obtain the required permits or permit modifications for any new or modified facility. In particular, DOE would need to obtain permits and approvals for (1) construction and operation of new treatment facilities (i.e., supplemental treatment facilities); (2) modifications to currently planned or existing treatment facilities (e.g., the WTP, 200 Area Effluent Treatment Facility, Liquid Effluent Retention Facility, T Plant complex, Waste Receiving and Processing Facility); (3) construction and operation of new or modified waste storage facilities (e.g., canister storage modules, WTP melter pads, the Central Waste Complex); (4) construction, operation, and closure of disposal facilities (i.e., one or two Integrated Disposal Facilities and the River Protection Project Disposal Facility); and (5) closure of storage facilities (i.e., the SST system, including ancillary equipment). Table 8–2 provides a list of future permits, permit modifications, or approvals that may be required at Hanford as a result of activities discussed under the action alternatives.

Table 8–2. Potential Permits and Approvals Needed for *TC & WM EIS* Activities

Activity	Regulatory Action	Requirement	Regulatory Agency
Air emissions (nonradioactive)	Notice of Construction (approval) and sitewide air operating permit (permit modification)	40 CFR 61 WAC 173-400 WAC 173-460 IDAPA 58.01.01	Ecology and EPA; Idaho Department of Environmental Quality
Air emissions (radioactive)	Notice of Construction (approval) and sitewide air operating permit (permit modification)	40 CFR 61 WAC 173-400 WAC 246-247	Washington State Department of Health, Ecology, and EPA; Idaho Department of Environmental Quality
Dangerous (including mixed) waste generation, treatment, storage and disposal	Dangerous waste and RCRA permit (permit modification)	40 CFR 260–280 WAC 173-303 IDAPA 58.01.05	Ecology; Idaho Department of Environmental Quality
Dangerous (including mixed) waste facility closure	Dangerous waste permit, RCRA permit (permit modification) and closure plan/postclosure plan (approvals)	40 CFR 260–280 WAC 173-303 IDAPA 58.01.05	Ecology; Idaho Department of Environmental Quality
Radiological	Disposal authorization statement, waste incidental to reprocessing determination, and authorization to proceed with closure activities statement (approvals)	DOE Manual 435.1-1	DOE
Water effluents	NPDES (permit modification) and stormwater discharge (permit modification)	40 CFR 122	EPA

Key: CFR=*Code of Federal Regulations*; DOE=U.S. Department of Energy; Ecology=Washington State Department of Ecology; EPA=U.S. Environmental Protection Agency; IDAPA=Idaho Administrative Procedures Act; NPDES=National Pollutant Discharge Elimination System; RCRA=Resource Conservation and Recovery Act; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; WAC=*Washington Administrative Code*.

8.3 CONSULTATIONS

Certain laws, such as the Endangered Species Act, U.S. Fish and Wildlife Coordination Act, and National Historic Preservation Act, require consultation and coordination by DOE with other governmental entities, including other Federal agencies, state and local agencies, and federally recognized American Indian governments. In addition, the DOE *American Indian Tribal Government Policy* (DOE Order 1230.2) requires DOE to consult with any American Indian or Alaska Native tribal government with regard to any property to which the tribe attaches religious or cultural importance that might be affected by a DOE action. Most of these consultations are related to biotic resources, cultural resources, and American Indian rights.

The biotic resource consultations generally pertain to the potential for activities to disturb sensitive species or habitats. Cultural resource consultations relate to the potential for disruption of important cultural resources and archaeological sites. American Indian consultations are concerned with the potential for impacts on any rights and interests, including disturbance of ancestral American Indian sites, traditional practices of American Indians, and natural resources of importance to American Indians.

DOE has performed consultations with the appropriate State Historic Preservation Officers, as required by NEPA and Section 106 of the National Historic Preservation Act; USFWS, as required by the Endangered Species Act of 1973, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act; the

National Oceanic and Atmospheric Administration, as required by the Endangered Species Act; and the appropriate state regulators, as required by Washington State laws or regulations. These consultations began in 2002 during the initial preparation of the "Tank Closure EIS" and continued with the newly scoped *TC & WM EIS*. A list of those organizations consulted for the "Tank Closure EIS" consultation process is provided in Table 8–3 and for this *TC & WM EIS* in Table 8–4. The specific results of the consultation process are presented in Chapter 4 of this EIS. Copies of the correspondence to these agencies and responses received are provided in Appendix C of this EIS. DOE also initiated consultations with the appropriate American Indian tribal governments for the "Tank Closure EIS," which continued with the newly scoped *TC & WM EIS*, as required by the Executive Memorandum (dated September 23, 2004) entitled "Government-to-Government Relationship with Tribal Governments" (White House 2004) and DOE Order 144.1, *American Indian Tribal Government Interaction and Policy*.

Table 8–3. Organizations Contacted During the Consultation Process for the "Tank Closure EIS"

Subject	Addressee (Date of Letter)
Ecological resources	Mr. Mark Miller U.S. Fish and Wildlife Service (June 16, 2003)
	Mr. Dennis Carlson National Oceanic and Atmospheric Administration (June 16, 2003)
	Mr. Jeff Tayer Washington State Department of Fish and Wildlife (June 16, 2003)
	Ms. Sandy Swope Moody Washington State Department of Natural Resources (June 16, 2003)
Cultural resources	Dr. Allyson Brooks Washington State Department of Archaeology and Historic Preservation (August 12, 2003, and September 3, 2003)

Key: "Tank Closure EIS"="Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington."

In addition to the formal consultation process, DOE initiated many staff-to-staff discussions during the development of this EIS. A chronology of the consultation process and communications with the American Indian tribal governments for the "Tank Closure EIS" and for this *TC & WM EIS* is provided in Appendix C.

In addition to tribal consultation and communication, DOE used other forums to reach out during the development of this *TC & WM EIS*. A summary of the interactions with the Hanford Advisory Board and Oregon Hanford Cleanup Board are provided in Appendix C.

Table 8–4. Organizations Contacted During the Consultation Process for This *TC & WM EIS*

Subject	Addressee (Date of Letter)
Ecological resources	Mr. Mark Miller U.S. Fish and Wildlife Service (June 12, 2008)
	Mr. Dennis Carlson National Oceanic and Atmospheric Administration (June 12, 2008)
	Mr. Jeff Tayer Washington State Department of Fish and Wildlife (June 12, 2008)
	Ms. Sandy Swope Moody Washington State Department of Natural Resources (June 12, 2008)
Cultural resources	Dr. Allyson Brooks Washington State Department of Archaeology and Historic Preservation (April 6, 2007)
	Mr. John M. Fowler Advisory Council on Historic Preservation (April 10, 2007)
	Dr. Allyson Brooks Washington State Department of Archaeology and Historic Preservation (July 30, 2007)
	Mr. John M. Fowler Advisory Council on Historic Preservation (September 5, 2007)
	Dr. Allyson Brooks Washington State Department of Archaeology and Historic Preservation (September 25, 2007)
	Mr. John M. Fowler Advisory Council on Historic Preservation (November 2, 2007)

Key: *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

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CHAPTER 9
GLOSSARY

absorbed dose – The energy imparted to matter by ionizing radiation per unit mass of the irradiated material (e.g., biological tissue). The units of absorbed dose are the rad and the gray. (One rad equals 0.01 grays, which equals 100 ergs per gram of material.) (See *gray*, *ionizing radiation*, and *radiation absorbed dose [rad]*.)

accelerator (particle) – An apparatus for imparting high velocities by electromagnetic or electrostatic means to charged particles (as electrons) that are generated in the apparatus, accelerated in controlled paths to a state of high energy, and focused continuously until they emerge as a stream of high-speed projectiles. (See *electron*.)

accident – In the context of this environmental impact statement, a specific, identifiable, unexpected, unusual, and unintended event or sequence of events that results in undesirable consequences.

accident sequence – In regard to nuclear facilities, an initiating event followed by system failures or operator errors that could result in significant core damage, confinement system failure, and/or radionuclide releases.

acid – A chemical compound with a pH value lower than 7.0. (See *pH*.)

actinide – Any member of the group of elements with atomic numbers 89 (actinium) to 103 (lawrencium), including uranium and plutonium. All members of this group are radioactive. (See *radioactivity*.)

activation energy – The minimum amount of energy required to initiate a chemical reaction.

activation product – An element that is formed by absorption of neutrons, protons, or other nuclear particles and thus may be radioactive. (See *neutron* and *proton*.)

active fault – A fault where another earthquake is likely sometime in the future. Faults are commonly considered to be active if they have moved one or more times in the last 10,000 years. (See *fault*.)

activity – (1) A measure of the amount of radiation emitted from a radioactive material, expressed in either curies or becquerels. (See *becquerel* and *curie*.) (2) An action, operation, or effort.

Acute Exposure Guideline Levels (AEGLs) – Threshold values published by the National Research Council and National Academy of Sciences for use in chemical emergency planning, prevention, and response programs. AEGLs represent threshold exposure limits for the general population, including susceptible individuals, and are developed for exposure periods of 10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours. AEGL values are defined for varying degrees of severity of toxic effects, as follows:

AEGL-1: The airborne level of concentration of a substance above which the exposed population could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects would not be disabling and would be transient and reversible upon cessation of exposure.

AEGL-2: The airborne level of concentration of a substance above which the exposed population could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3: The airborne level of concentration of a substance above which the exposed population could experience life-threatening health effects or death.

additive – The property whereby the total effect of multiple agents is the sum of effects of the agents acting separately under the same conditions.

administrative control – Provisions related to organization and management, procedures, record-keeping, assessment, and reporting that are necessary to ensure safe operation of a facility.

adsorption – A "taking up" by physical or chemical forces of the molecules of gases, dissolved substances, or liquids by the surfaces of solids or liquids with which they are in contact.

AEGL-1, -2, and -3 – See *Acute Exposure Guideline Levels.*

affected environment – The existing biological, physical, social, and economic conditions of an area that are subject to direct and/or indirect changes as a result of a proposed human action.

air pollutant – Generally, an airborne substance that, in sufficiently high concentrations, could harm living things or cause damage to materials. From a regulatory perspective, air pollutants are substances for which emissions or atmospheric concentrations are regulated or for which maximum guideline levels have been established to enable assessment of their potential for harmful effects on human health and welfare.

air quality – The cleanliness of the air as measured by the levels of pollutants relative to the standards or guideline levels established to protect human health and welfare.

air quality control region – Geographic subdivisions of the United States that were established to deal with pollution on a regional or local level. Some regions span more than one state.

ALARA – See *as low as is reasonably achievable*.

alkaline – Having the properties of a soluble mineral salt capable of neutralizing acids.

alluvium (alluvial) – Unconsolidated, poorly sorted detrital sediments deposited by streams and ranging in size from clay to gravel.

alpha activity – The emission of alpha particles by radioactive materials.

alpha particle – A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). (See *alpha radiation*.)

alpha radiation – A strongly ionizing, but weakly penetrating, form of radiation consisting of positively charged alpha particles emitted spontaneously from the nuclei of certain elements during radioactive decay. Alpha radiation is the least penetrating of the three common types of ionizing radiation (alpha, beta, and gamma). Even the most energetic alpha particle generally fails to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. Alpha radiation is most hazardous when an alpha-emitting source resides inside an organism. (See *alpha particle*.)

alternative – One of two or more actions, processes, or propositions from which a decisionmaker will determine the course to be followed. The National Environmental Policy Act of 1969 (NEPA), as amended, states that in preparing an environmental impact statement (EIS), an agency "shall ... study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" (Title 42 of the *United States Code*, Section 4322(2)(E)). Council on Environmental Quality NEPA-implementing regulations indicate that the alternatives section in an EIS is "the heart of the environmental impact statement" (Title 40 of the *Code of Federal Regulations*, Section 1502.14) and include rules for presenting the alternatives, including no action, and their estimated impacts.

ambient – Surrounding.

ambient air – The atmosphere surrounding people, plants, and structures.

ambient air quality standards – As prescribed by regulations, the level of pollutants in the air that may not be exceeded during a specified time in a defined area. Air quality standards are used to provide a measure of the health-related and visual characteristics of the air.

amphibian – Class of cold-blooded, scaleless vertebrates that usually begin life with gills and then develop lungs.

anadromous – Fish (such as salmon) that ascend freshwater streams from saltwater bodies of water to spawn.

ancillary equipment – Structures associated with tank operations, including miscellaneous underground storage tanks; the waste transfer system (diversion boxes, valve pits, and transfer piping); tank pits; tank risers; in-tank equipment; and miscellaneous facilities used in the treatment, transfer, or storage of tank waste.

anion – A negatively charged ion. (See *ion*.)

annulus – The space between the inner and outer shells of a double-shell tank.

antagonistic – Opposing or counteracting the effects of something else.

aquatic – Living or growing in, on, or near water.

aquatic biota – The sum total of living organisms within any designated aquatic area.

aquifer – An underground geologic formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to wells or springs.

aquitard – A semipermeable geologic unit that inhibits the flow of water.

archaeological sites – Any location where humans have discarded artifacts or otherwise altered the terrain during prehistoric or historic times.

area use factor – The ratio of the size of an organism's home, breeding, or feeding/foraging range to the size of a contamination area; if the home range is larger than the contamination area, then the area use factor is unity.

aromatic – Of, related to, or containing the six-carbon ring typical of the benzene series and related organic groups; also, "having an aroma."

artifact – An object produced or shaped by human workmanship that is of archaeological or historical interest.

as low as is reasonably achievable (ALARA) – An approach to radiation protection used to manage and control worker and public exposures (individual and collective) and releases of radioactive material to the environment to as far below applicable limits as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit; it is instead a process for minimizing doses to as far below limits as is practicable.

atmospheric dispersion – The distribution of pollutants from their source into the atmosphere by wind, turbulent air motion attributable to solar heating of Earth's surface, or air movement over rough terrain and variable land and water surfaces.

Atomic Energy Act – A law enacted in 1946 and amended in 1954 that placed nuclear production and control of nuclear materials under the oversight of a civilian agency, originally the Atomic Energy Commission.

Atomic Energy Commission (AEC) – A five-member commission established by the Atomic Energy Act of 1946 to supervise nuclear weapons design, development, manufacturing, maintenance, modification, and dismantlement. In 1974 AEC was abolished, and all its functions were transferred to the U.S. Nuclear Regulatory Commission and the Administrator of the Energy Research and Development Administration (ERDA). ERDA was later terminated, and functions vested by

law in the Administrator were transferred to the Secretary of Energy.

atomic number – The number of positively charged protons in the nucleus of an atom or the number of electrons on an electrically neutral atom.

attainment area – An area that the U.S. Environmental Protection Agency has designated as in compliance with one or more of the National Ambient Air Quality Standards for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others. (See *National Ambient Air Quality Standards, nonattainment area*, and *particulate matter*.)

attenuate – In the context of this environmental impact statement: (1) To reduce the concentration over time of a chemical (usually through adsorption, degradation, dilution, and/or transformation) or radionuclide (through radioactive decay). (See *adsorption* and *radioactive decay*.) (2) To dissipate, e.g., certain geologic strata tend to dissipate (attenuate) seismic energy.

backfill – Excavated earth or other material transferred into an open trench, cavity, or other opening in the earth.

background radiation – Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material); and atmospheric fallout (e.g., from the testing of nuclear explosive devices).

barrier – Any material or structure that prevents or substantially delays movement of constituents toward the accessible environment, especially an engineered structure used to isolate contaminants from the environment in accordance with appropriate regulations. (See *cap, Hanford barrier,* and *modified RCRA Subtitle C barrier*.)

basalt – The most common volcanic rock, dark gray to black in color, high in iron and magnesium, low in silica, and typically found in lava flows.

base – A chemical compound with a pH value higher than 7.0. (See *pH*.)

baseline – The existing environmental conditions against which the impacts of the proposed actions and their alternatives can be compared.

basin – Geologically, a circular or elliptical downwarp or depression in Earth's surface that collects sediment. Younger sedimentary beds occur in the center of basins. Topographically, a depression into which water from the surrounding area drains.

becquerel – A unit of radioactivity equal to one disintegration per second. Thirty-seven billion becquerels equal 1 curie. (See *curie*.)

bedrock – The solid rock that lies beneath soil and other loose surface materials.

BEIR V – The fifth in a series of committee reports from the National Research Council on the biological effects of ionizing radiation, published in 1990. (See *BEIR VII*.)

BEIR VII – The seventh in a series of committee reports from the National Research Council on the biological effects of ionizing radiation, published in 2006. BEIR VII updates BEIR V, using epidemiologic and experimental research information accumulated since the BEIR V report to develop the best possible risk estimate for exposure experienced by radiation workers and members of the general public. (See *BEIR V*.)

benchmark – Dose or concentration known or accepted to be associated with a specific level of effect.

benthic – Relating to plants and animals dwelling at the bottom of oceans, lakes, rivers, and other surface waters.

beryllium – An extremely lightweight element with the atomic number 4. It is metallic and is used in nuclear reactors as a neutron reflector. (See *neutron* and *nuclear reactor*.)

best available technology (BAT) – (1) Economically achievable pollution control methods that allow point sources to comply with the effluent limitations required by the Clean Water Act. Taken into account in identifying the BAT are the age of the equipment and facilities involved; process employed; engineering aspects of various control techniques; process changes; cost of achieving such effluent reduction; non-water-quality environmental impacts (including energy requirements); and other factors deemed appropriate by the U.S. Environmental Protection Agency (EPA) Administrator. (2) Available techniques, processes, or knowledge the EPA Administrator finds are available to comply with the provisions of the Safe Drinking Water Act after examining their efficacy under field and laboratory conditions and considering the costs. For the purpose of setting maximum contaminant levels for synthetic organic chemicals, any BAT must be at least as effective as granular activated carbon. (See *maximum contaminant level*.)

best management practices (BMPs) – Structural, nonstructural, and managerial techniques, other than techniques for effluent limitations, used to prevent or reduce pollution of surface water. They are the most effective and practical means to control pollutants that are compatible with the productive use of the resource to which they are applied. BMPs are used in both urban and agricultural areas. BMPs can include activity schedules; practice prohibitions; maintenance procedures; treatment requirements; operating procedures; and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

beta emitter – A radioactive substance that decays by releasing a beta particle.

beta particle – A particle emitted in the radioactive decay of many radionuclides. A beta particle is identical to an electron. It has a short range in air and a limited ability to penetrate other materials; it can be stopped by clothing or a thin sheet of metal.

beyond-design-basis accident – An accident postulated for the purpose of generating large consequences by exceeding the functional and performance requirements for safety structures, systems, and components. (See *design-basis accident*.)

beyond-design-basis events – Postulated disturbances in process variables resulting from external events or multiple component or system failures that can potentially lead to beyond-design-basis accidents. (See *design-basis events*.)

bioaccumulation factor – The ratio of the concentration of a chemical in an organism to its concentration in a medium to which the organism is exposed.

bioconcentration factor – The ratio of the concentration of a chemical in an aquatic organism to the concentration of the chemical in the surface water, sediment, or soil to which that organism is exposed.

biodiversity – The diversity of life forms and their levels of organization.

biomagnification – The process by which the concentration of some chemicals increases with the increasing trophic level; thus, the concentration in a predator exceeds the concentration in its prey. (See *trophic level*.)

biota (biotic) – The plant and animal life of a region.

biotransfer factor – The ratio of the concentration of a substance in an organism to the concentration of that substance in food that is ingested per unit time.

blanket assembly – The material in an accelerator wherein the generated neutrons are moderated to permit their absorption (capture) in the target material to produce a new isotope.

block – U.S. Census Bureau term for small areas bounded on all sides by visible features or political boundaries; used in tabulation of census data.

body burden – The total amount of a substance in the cells and tissues of an organism.

boron-10 – An isotope of the element boron that has a high-capture cross section for neutrons. It is used in nuclear reactor absorber rods for reactor control. (See *isotope* and *nuclear reactor*.)

borrow – Excavated material that has been taken from one area to be used as raw material or fill at another location.

borrow area (pit, site) – An area designated as the excavation site for geologic resources such as rock/basalt, sand, gravel, or soil to be used elsewhere for fill.

bound – To use simplifying assumptions and analytical methods in an analysis of impacts or risks such that the result overestimates or describes an upper limit on (i.e., "bounds") potential impacts or risks.

A *bounding analysis* is an analysis designed to overestimate, or determine the upper limit to, potential impacts or risks.

A *bounding accident* is a hypothetical accident, the calculated consequences of which equal or exceed the consequences of all other potential accidents for a particular activity or facility.

bounded – Having the greatest consequences of any assessment of impacts associated with normal or abnormal operations.

buffering capacity – The ability of chemicals in solution (usually a weak acid or base and its salt) to minimize changes in the hydrogen ion concentration upon addition of an acid or base. (See *ion*.)

bulk vitrification – A supplemental thermal treatment process that converts low-activity waste into a solid glass form by drying that waste, mixing it with soil, and applying electrical current to the mix within a large steel container. (See *low-activity waste*.)

burial ground – A place for burying low-level radioactive waste and mixed low-level radioactive waste so as to prevent the escape of hazardous chemicals radiation, and the dispersion thereof, into the environment. (See *hazardous chemical, low-level radioactive waste,* and *mixed low-level radioactive waste*.)

byproduct material – Any radioactive material (except special nuclear material [SNM]) yielded in, or made radioactive by exposure to radiation during, the process of producing or utilizing SNM; also, the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore that is processed primarily for its source material content.

Byproduct material is exempt from regulation under the Resource Conservation and Recovery Act (RCRA). However, the exemption applies only to the actual radionuclides dispersed or suspended in the waste substance. Any nonradioactive hazardous waste component of the waste is subject to regulation under RCRA. (See *radioisotope or radionuclide*.)

caisson – Any of the cylindrical, steel-reinforced concrete underground vaults that are designed to store remote-handled waste in the low-level radioactive waste burial grounds. (See *burial ground* and *remote-handled waste*.)

calcination – A process that uses heat to evaporate water from radioactive waste and de-nitrate fission products to assist in stabilizing the waste form produced. (See *fission* and *radioactive waste*.)

cancer – The name given to a group of diseases characterized by uncontrolled cellular growth where the cells have invasive characteristics that enable the disease to transfer from one organ to another.

candidate species – *Federal:* Species native to the United States for which the U.S. Fish and Wildlife Service or the National Marine Fisheries Service has sufficient information on biological vulnerability and threats to justify proposing to add them to the threatened or endangered species list, but cannot do so immediately because other species have a higher priority for listing. The Services determine the listing priority of candidate taxa

in accordance with general guidelines published in the *Federal Register*.

Washington State: Current information indicates the probable appropriateness of listing as endangered or threatened (*Washington Administrative Code* 232-12-297). (See *endangered species* and *threatened species*.)

canister – A general term for a container, usually cylindrical, used in the handling, storage, transportation, or disposal of waste.

canyon – In the nuclear industry, a large, heavily shielded concrete building that contains a remotely operated nuclear materials processing facility.

cap – A cap used to cover a radioactive burial ground with soil, rock, vegetation, or other materials as part of the facility closure process. The cap is designed to reduce migration of radioactive and hazardous materials in the waste by infiltration of water or intrusion of humans, plants, or animals from the surface. In this environmental impact statement, the modified Resource Conservation and Recovery Act Subtitle C barrier was selected as a cap for low-level radioactive waste and mixed low-level radioactive waste disposal grounds. Also called a cover cap or barrier. (See *barrier, burial ground, low-level radioactive waste,* and *mixed low-level radioactive waste*.)

capable fault – A fault that has exhibited one or more of the following characteristics: (1) movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years; (2) macroseismicity as determined instrumentally and as reflected in records of sufficient precision to demonstrate a direct relationship with the fault; and (3) a structural relationship with another capable fault according to characteristic 1 or 2 above such that movement on one could reasonably be expected to be accompanied by movement on the other. (See *fault* and *macroseismicity*.)

capacity (electric) – An electric power plant's maximum power output.

capacity factor – The ratio of the annual average power production of a power plant to its rated capacity.

capping – As applied to radioactive and mixed-waste disposal facilities, the process of covering a burial ground with soil, rock, vegetation, or other materials as part of the facility closure process.

carbonate – A salt or ester of carbonic acid.

carbon dioxide – A colorless, odorless gas that is a normal component of ambient air and a product of fossil fuel combustion, animal expiration, and the decay or combustion of animal or vegetable matter.

carbon monoxide – A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

carcinogen – A substance or agent that produces or incites cancerous growth.

cask – A heavily shielded container used to store or ship radioactive materials.

cast stone – A nonthermal waste stabilization process that may be performed at ambient temperatures and pressures and involves mixing the waste with grout formers (e.g., Portland cement, fly ash, and slag) and conditioners to produce a solid waste form.

Category 1 low-level radioactive waste (LLW) – LLW containing radionuclide concentrations within the maximum limits defined for this waste type in the *Hanford Site Solid Waste Acceptance Criteria*. These limits are site-specific and define the lowest activity category of LLW. Category 1 waste typically does not require special packaging or treatment for disposal by shallow land burial. (See *low-level radioactive waste*.)

Category 3 low-level radioactive waste (LLW) – LLW containing radionuclide concentrations greater than those defined for Category 1 waste, but within the maximum limits defined for Category 3 waste in the *Hanford Site Solid Waste Acceptance Criteria*.

These limits are site-specific and are established using the performance assessment for a particular disposal facility. Category 3 waste typically requires special packaging or treatment for disposal by shallow land burial. (See *low-level radioactive waste*.)

cation – A positively charged ion. (See *ion*.)

cell – See *hot cell*.

Central Plateau – The elevated area in the center of the Hanford Site where the 200-East and 200-West Areas are located.

chain reaction – A reaction that initiates its own repetition. In nuclear fission, a chain reaction occurs when a neutron induces a nucleus to fission and the fissioning nucleus releases one or more neutrons, which induce other nuclei to fission. (See *fission*, *neutron*, and *nucleus*.)

Chalfont container 9975 – A shielded Type B container with primary and secondary containment features that is used to store or ship radioactive materials. (See *cask* and *Type B packaging*.)

characteristic waste – Solid waste that is classified as hazardous waste because it exhibits any of the following properties or characteristics: ignitability, corrosivity, reactivity, or toxicity, as described in Title 40 of the *Code of Federal Regulations*, Sections 261.20 through 261.24. (See *hazardous waste*, *solid waste*, and *waste characterization.*)

characterization – See *waste characterization.*

chemical oxidation – A chemical reaction in which a molecule or atom loses electrons, thereby increasing its oxidation state, often by adding oxygen. Typical oxidizing agents include ozone, peroxides, persulfates, and permanganates and are commonly used for oxidation of organic constituents. (See *oxidation*.)

chemical reduction – A chemical reaction in which a molecule or atom gains electrons, thereby decreasing its oxidation state. Typical reducing agents include chemicals such as sulfites, polyethylene glycol, hydrosulfide, or ferrous salts. When used for reduction of hexavalent chromium to the trivalent state, the reduced forms of this contaminant are much less mobile in the environment because of their low solubility and high adsorption to soils. Microbiological reduction of these waste constituents also has been found to occur naturally in sediment and aquifer environments; with the addition of chemical food sources to enhance microbe growth rates, reductive biological remediation is becoming more economical. (See *hexavalent, hexavalent chromium, trivalent,* and *valence*.)

chronic exposure – A continuous or intermittent exposure of an organism to a stressor (e.g., a toxic substance or ionizing radiation) over an extended period of time or significant fraction (often 10 percent or more) of the organism's lifespan. Generally, chronic exposure is considered to produce effects that can be observed only after a time following initial exposure. These may include impaired reproduction or growth, genetic effects, congenital defects, cancer, precancerous lesions, benign tumors, cataracts, and skin changes.

cladding – The outer metal jacket of a nuclear fuel element or target. It prevents fuel corrosion and retains fission products during nuclear reactor operation and subsequent storage, as well as providing structural support. Zirconium alloys, stainless steel, and aluminum are common cladding materials. In general, a metal coating bonded onto another metal. (See *fission products* and *target*.)

Class I area – A specifically designated area where the degradation of air quality is stringently restricted (e.g., many national parks, wilderness areas). (See *nuclear reactor* and *Prevention of Significant Deterioration.*)

Class II area – Most of the country that is not designated as Class I is designated as Class II. Class II areas are generally cleaner than air quality standards require, and moderate increases in new pollution are allowed after a regulatory-mandated impacts review.

clastic – Refers to rock or sediment made up primarily of broken fragments of preexisting rocks or minerals.

clay – The name for a family of finely crystalline sheet silicate minerals that commonly form as a product of rock weathering. Also, any particle smaller than or equal to about 0.002 millimeters (0.00008 inches) in diameter.

Clean Air Act – This act mandates and provides for enforcement of regulations to control air pollution from various sources.

Clean Air Act Amendments of 1990 – Amendments expanding the U.S. Environmental Protection Agency's enforcement powers and adding restrictions on air toxics, ozone-depleting chemicals, stationary and mobile emission sources, and emissions implicated in acid rain and global warming.

clean closure – The premise of clean closure is that all hazardous waste has been removed from a given Resource Conservation and Recovery Act (RCRA)-regulated unit and any releases at or from the unit have been remediated so that further regulatory control under RCRA Subtitle C is not necessary to protect human health and the environment. Under State of Washington requirements (*Washington Administrative Code* 173-303-64) for closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (e.g., liners), contaminated soils, and structures and equipment contaminated with waste and must manage them as dangerous waste as required.

cleanup – Refers to the full range of projects and activities undertaken to address environmental and legacy waste issues associated with the Hanford Site.

Clean Water Act of 1972, 1987 – This act regulates the discharge of pollutants from a point source into navigable waters of the United States in compliance with a National Pollutant Discharge Elimination System permit and regulates discharges to or dredging of wetlands.

closure – Refers to the deactivation and stabilization of a waste treatment, storage, or disposal unit (such as a waste treatment tank, waste storage building, or landfill) or hazardous materials storage unit (such as an underground storage tank). For storage units, closure typically includes removal of all residues, contaminated system components, and contaminated soil. For radioactive and hazardous waste disposal units (i.e., where waste is left in place), closure typically includes site stabilization and emplacement of surface barriers. Specific requirements for the closure process are found in the regulations applicable to many types of waste management units and hazardous material storage facilities. For the State of Washington, hazardous waste disposal unit closure regulations are found at *Washington Administrative Code* 173-303-610.

***Code of Federal Regulations* (CFR)** – All Federal regulations that are in effect are published in codified form in the CFR.

collective dose – The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation. Collective dose is expressed in units of person-rem or person-sieverts. (See *dose, ionizing radiation, person-rem,* and *person-sievert*.)

commercial light-water reactor – The term used to describe commercially operated power-producing U.S. nuclear reactors that use "light" (as opposed to heavy) water for cooling and neutron moderation. (See *neutron* and *nuclear reactor*.)

committed dose equivalent – The dose equivalent received by an individual's organs or tissues during the 50 years following an intake of radioactive material. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem or sieverts. (See *ionizing radiation, roentgen equivalent man [rem],* and *sievert*.)

committed effective dose equivalent – The dose value obtained by multiplying the committed dose equivalents for the organs or tissues that are irradiated and the weighting factors applicable to those organs or tissues and summing all the resulting products. Committed effective dose equivalent is expressed in units of rem or sieverts. (See *committed dose equivalent, roentgen equivalent man [rem], sievert,* and *weighting factor*.)

community – *(biotic definition)* All plants and animals occupying a specific area under relatively similar conditions.

(environmental justice definition) A group of people or a site within a spatial scope exposed to risks that potentially threaten health, ecology, or land values or exposed to industry that stimulates unwanted noise, smell, industrial traffic, particulate matter, or other nonaesthetic impacts.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) – A Federal law (also known as Superfund) enacted in 1980 and reauthorized in 1986 (Title 42 of the *United States Code*, Section 9601 et seq.) that provides the legal authority for emergency response and cleanup of hazardous substances released into the environment and for the cleanup of inactive waste sites.

conformity – Conformity is defined in the Clean Air Act as the action's compliance with an implementation plan's purpose of eliminating or reducing the severity and number of violations of the National Ambient Air Quality Standards and achieving expeditious attainment of such standards. Such activities will not cause or contribute to any new violation of any standard in any area; increase the frequency or severity of any existing violation of any standard in any area; or delay timely attainment of any standard, any required interim emission reduction, or other milestones in any area.

contact-handled waste – Radioactive waste or waste packages whose external dose rate is low enough to permit contact-handling by humans during normal waste management activities (e.g., waste with a surface dose rate not exceeding 200 millirem per hour). (See *remote-handled waste*.)

container – In regard to radioactive waste, the outside envelope in the waste package that provides the primary containment function of the waste package, which is designed to meet the containment requirements of Title 10 of the *Code of Federal Regulations*, Part 60.

containment design basis – For a nuclear reactor, those bounding conditions for the design of the containment, including temperature, pressure, and leakage rate. Because the containment is provided as an additional barrier to mitigate the consequences of accidents involving the release of radioactive materials, the containment design basis may include an additional specified margin above those conditions expected to result from the plant design-basis accidents to ensure that the containment design can mitigate unlikely or unforeseen events. (See *bound, design basis, nuclear reactor,* and *reactor containment*.)

contamination – The deposition of undesirable material in air, soils, water, or ecological resources or on the surfaces of structures, areas, objects, or personnel.

control rod – A rod containing material such as boron that is used to control the power of a nuclear reactor. By absorbing excess neutrons, a control rod prevents the neutrons from causing further fissions, i.e., increasing power. (See *boron-10, fission, neutron,* and *nuclear reactor*.)

coolant – A substance, either gas or liquid, circulated through a nuclear reactor or processing plant to remove heat.

cooperating agency – "Any Federal agency (other than a lead agency) that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment. A state or local agency of similar qualification

or, when the effects are on a reservation, an Indian tribe, may, by agreement with the lead agency, become a cooperating agency" (Title 40 of the *Code of Federal Regulations*, Section 1508.5).

core zone – A portion of the Central Plateau within the Hanford Site, encompassing the 200-East and 200-West Areas, that lies within the Industrial-Exclusive land use designation established under the 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*.

Core Zone Boundary – The perimeter of the core zone that is used as a line of analysis for groundwater transport calculations.

credible accident – An accident with a probability of occurrence greater than or equal to once in 1 million years.

crib – An underground structure designed to distribute liquid waste, usually through a perforated pipe, to the soil directly or to a connected tile field. Cribs use the filtration and ion exchange properties of the soil to contain radionuclides. A crib is operated only if radionuclide contamination observed in the groundwater beneath the crib is below a prescribed limit. (See *ion* and *radioisotope or radionuclide*.)

criteria pollutant – An air pollutant that is regulated by National Ambient Air Quality Standards. The U.S. Environmental Protection Agency must describe the characteristics and potential health and welfare effects that form the basis for setting or revising the standard for each regulated pollutant. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: less than or equal to 2.5 and 10 micrometers (0.0001 and 0.0004 inches) in diameter. New pollutants may be added to or removed from the list of criteria pollutants as more information becomes available. (See *National Ambient Air Quality Standards*.)

critical habitat – Habitat essential to the conservation of an endangered or threatened species that has been designated as critical by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures outlined in the Endangered Species Act (Title 16 of the *United States Code*, Parts 1551 through 1599) and its implementing regulations (Title 50 of the *Code of Federal Regulations* [CFR], Part 424). The lists of critical habitats can be found in 50 CFR, Section 17.95 (fish and wildlife); 50 CFR, Section 17.96 (plants); and 50 CFR, Part 226 (marine species). (See *endangered species* and *threatened species*.)

criticality – The condition in which a system is capable of sustaining a nuclear chain reaction (a reaction that initiates its own repetition). In nuclear fission, a chain reaction occurs when a neutron induces a nucleus to fission and the fissioning nucleus releases one or more neutrons, which induce other nuclei to fission.

critical mass – The smallest mass of fissionable material that will support a self-sustaining nuclear chain reaction. (See *criticality* and *fission*.)

critical organ – The body organ receiving a radionuclide or radiation dose that would result in the greatest overall damage to the body. Specifically, that organ in which the dose equivalent would be most significant due to a combination of the organ's radiological sensitivity and the dose distribution throughout the body. (See *dose, dose equivalent, ionizing radiation,* and *radioisotope or radionuclide*.)

cryptogamic (microbiotic) crusts – Earth crusts that generally occur in the top 1 to 4 millimeters (0.039 to 0.157 inches) of soil and are formed by living organisms and their byproducts, creating a crust of soil particles bound together by organic materials.

cullet – Small (pea-sized) pieces of glass formed when hot molten glass is quenched in a water bath.

cultural resources – Archaeological sites, historical sites, architectural features, traditional use areas, and American Indian sacred sites. (See *archaeological sites* and *historic resources*.)

cumulative impacts – Impacts on the environment that result from incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions, regardless of the agency or person undertaking such other actions. Cumulative impacts can result from individually minor, but collectively significant, actions that take place over a period of time (Title 40 of the *Code of Federal Regulations*, Section 1508.7).

curie – A unit of radioactivity equal to 37 billion disintegrations per second (i.e., 37 billion becquerels); also, a quantity of any radionuclide or mixture of radionuclides having 1 curie of radioactivity.

dangerous waste – Solid waste designated in *Washington Administrative Code* 173-303-070 through 173-303-100 as dangerous, extremely hazardous, or mixed waste. (See *mixed waste*.)

daphnid – A group of simple animals related to insects, nearly microscopic in size and found in freshwater habitats.

day-night average sound level – The 24-hour, A-weighted equivalent sound level expressed in decibels. A 10-decibel penalty is added to sound levels between 10:00 P.M. and 7:00 A.M. to account for increased annoyance due to noise during night hours. (See *decibel, A-weighted*.)

deactivation – Placing a facility in a stable and known condition, including removal of hazardous and radioactive materials, to ensure adequate protection of workers, public health and safety, and the environment, thereby limiting the long-term cost of surveillance and maintenance. Actions include the removal of fuel, draining and/or de-energizing nonessential systems, removal of stored radioactive and hazardous materials, and related actions. Deactivation does not include all decontamination necessary for the dismantlement and demolition phase of decommissioning (e.g., removing contamination remaining in fixed structures and equipment after deactivation).

As applied to waste treatment, removal of the hazardous characteristics of a waste due to its ignitability, corrosivity, and/or reactivity. (See *decontamination* and *reactivity*.)

decay (radioactive) – See *radioactive decay.*

decay heat (radioactivity) – The heat produced by the decay of radionuclides. (See *radioisotope or radionuclide*.)

decibel (dB) – A unit for expressing the relative intensity of sounds on a logarithmic scale where zero is below human perception and 130 is above the threshold of pain to humans. For traffic and industrial noise measurements, the A-weighted decibel, a frequency-weighted noise unit, is widely used.

decibel, A-weighted (dBA) – A unit of frequency-weighted sound pressure level, measured by the use of a metering characteristic and the "A" weighting specified by the American National Standards Institute in ANSI S1.4-1983 (R1594), which accounts for the frequency of the human ear.

deciduous – Trees that shed leaves at a certain season.

decommissioning – The process of closing and securing a nuclear facility or nuclear material storage facility to provide adequate protection from radiation exposure and to isolate radioactive contamination from the human environment. It takes place after deactivation and includes surveillance, maintenance, decontamination, and/or dismantlement. These actions are taken at the end of the facility's life to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment. The ultimate goal of decommissioning is unrestricted release or restricted use of the site. (See *deactivation, decontamination,* and *ionizing radiation*.)

decontamination – The removal or reduction of residual chemical, biological, or radiological contaminants and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

depleted uranium – Uranium whose content of the fissile isotope uranium-235 is less than the 0.7 percent (by weight) found in natural uranium, so that it contains more uranium-238 than natural uranium.

deposition – In geology, the laying down of potential rock-forming materials; sedimentation. In atmospheric transport, the settling out on ground and building surfaces of atmospheric aerosols and particles ("dry deposition") or their removal from the air to the ground by precipitation ("wet deposition" or "rainout").

derived concentration guide – The concentration of a radionuclide in air or water that, under conditions of continuous exposure for 1 year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 millirem. (See *dose equivalent, millirem,* and *radioisotope or radionuclide*.)

dermal – Of or pertaining to the skin or other external body covering.

design basis – For nuclear facilities, information that identifies the specific functions to be performed by a structure, system, or component and the specific values (or ranges of values) chosen for controlling parameters for reference bounds for design. These values may be (1) restraints derived from generally accepted state-of-the-art practices for achieving functional goals; (2) requirements derived from analysis (based on calculation and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals; or (3) requirements derived from Federal safety objectives, principles, goals, or requirements. (See *bound*.)

design-basis accident – An accident postulated for the purpose of establishing functional and performance requirements for safety structures, systems, and components. (See *beyond-design-basis accident*.)

design-basis events – Postulated disturbances in process variables that can potentially lead to design-basis accidents. (See *beyond-design-basis events*.)

detector – A device used to convert the energy of incident radiation into another form (such as light, an electrical signal, or a trace in a chemical emulsion) to observe or measure radiation.

A *particle detector* is any device used to sense the passage of atomic or subatomic particles or to measure their properties. For many particle detectors, this involves observing and measuring the electromagnetic or ionizing radiation released as particles interact with a gaseous, liquid, or solid medium or an electromagnetic field. The term also may refer to a collection of particle detection devices designed to allow physicists to reconstruct particle events. (See *ionizing radiation*.)

deterministic analysis – A single calculation using only a single value for each of the model parameters. A deterministic system is governed by definite rules of system behavior leading to cause-and-effect relationships and predictability. Deterministic calculations do not account for uncertainty in the physical relationships or parameter values. Typically, deterministic calculations are based on best estimates of the involved parameters. (See *stochastic analysis.*)

dewatering – The removal of water. Saturated soils are "dewatered" to make construction of building foundations easier.

dip – A measure of the angle between the flat horizon and the slope of a sedimentary layer, fault plane, metamorphic foliation, or other geologic structure.

direct jobs – The number of workers required at a site to implement an alternative.

disassociation – The action of becoming separated.

discharge – In surface-water hydrology, the amount of water issuing from a spring or in a stream that passes a specific point in a given period of time.

disintegration – Any transformation of a nucleus, whether spontaneous or induced by irradiation, in which the nucleus emits one or more particles or photons. (See *nucleus* and *photon*.)

disposal – As generally used in this environmental impact statement, the placement of waste with no intent to retrieve. Statutory or regulatory definitions of disposal may differ.

disposal groups – Specific combinations of waste capacities allocated to the River Protection Project Disposal Facility and 200-East (or both 200-East and 200-West) Area Integrated Disposal Facility(ies) over varying operational timeframes, based on the different types and amounts of waste generated under the three sets of alternatives analyzed in this environmental impact statement.

disposition – The ultimate "fate" or end use of a surplus U.S. Department of Energy facility following transfer of the facility to the Office of the Assistant Secretary for Environmental Management.

DOE orders – Requirements internal to the U.S. Department of Energy that establish policy and procedures, including those for compliance with applicable laws.

dose – The accumulated radiation or hazardous substance delivered to the whole body or a specified tissue or organ within a specified time and originating from an external or internal source. (See *absorbed dose, dose [chemical], dose [radiological], exposure,* and *ionizing radiation*.)

dose (chemical) – The amount of a substance administered to, taken up by, or assimilated by an organism. It is often expressed in terms of the amount of substance per unit mass of the organism, tissue, or organ of concern.

dose (radiological) – A generic term that means absorbed dose, effective dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

dose commitment – The total dose equivalent a body, organ, or tissue would receive during a specified period of time (e.g., 50 years) as a result of intake (as by ingestion or inhalation) of one or more radionuclides from a defined release. (See *dose equivalent* and *radioisotope or radionuclide*.)

dose equivalent – A measure of radiological dose that correlates with biological effect on a common scale for all types of ionizing radiation. Defined as a quantity equal to the absorbed dose in tissue multiplied by a quality factor (the biological effectiveness of a given type of radiation) and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and the sievert. (See *dose, ionizing radiation, roentgen equivalent man [rem],* and *sievert*.)

dose rate – The radiation dose delivered per unit of time (e.g., rem per year). (See *dose, ionizing radiation,* and *roentgen equivalent man [rem]*.)

double-shell tank – A large reinforced concrete underground container with two steel liners to provide containment and backup containment of liquid waste. The space between the liners has instruments that detect leaks from the inner liner.

drinking water standards – The maximum permissible levels of constituents or characteristics in a drinking water supply as specified by the Safe Drinking Water Act (Title 42 of the *United States Code*, Section 300(f) et seq.).

dynamic time-varying model – A representation of a system with state variables that change in value over time due to changes in parameters or inputs.

easting – The difference in longitude between two positions as a result of movement to the east.

ecological risk assessment – Evaluation of the likelihood of adverse effects on animals and plants as a result of actual or potential stressors in the environment.

ecology – A branch of science dealing with the interrelationships of living organisms with one another and with their nonliving environment.

ecosystem – A community of organisms and their physical environment that interact as an ecological unit.

edaphic – Of or relating to the soil.

effective dose equivalent – The dose value obtained by multiplying the dose equivalents received by specified tissues or organs of the body by the appropriate weighting factors applicable to the tissues or organs irradiated, and then summing all of the resulting products. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of rem or sieverts. (See *committed dose equivalent, committed effective dose equivalent, dose, ionizing radiation, roentgen equivalent man [rem],* and *sievert*.)

effervescent – Giving off gas bubbles.

efficacy – A measure of the probability and intensity of beneficial effects.

effluent – A waste stream flowing into the atmosphere, surface water, groundwater, or soil; frequently applied to waste discharged to surface water.

electrometallurgical treatment – A technique for collecting, concentrating, and immobilizing fission products and transuranic elements from metallic spent nuclear fuel by removing the uranium in the spent fuel with an electrochemical cell. The treatment alters the chemical and physical nature of spent nuclear fuel to reduce its toxicity, volume, and mobility and render it suitable for transport, storage, or disposal. (See *hot cell* and *spent nuclear fuel*.)

electron – An elementary particle with a mass of 9.107×10^{-28} grams (or 1/1,837 of a proton) and a negative charge. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

element occurrence – An element occurrence of a plant community is one that meets minimum standards set by the Washington State Natural Heritage Program, established by the Natural Area Preserves Act (*Revised Code of Washington*, Chapter 79.70), for ecological condition, size, and surrounding landscape. Element occurrences are generally considered to be of significant conservation value from a state and/or regional perspective.

eluate – An adsorbed substance that has been removed from an adsorbent solution. (See *adsorption*.)

Emergency Response Planning Guidelines (ERPGs) – Values developed by the American Industrial Hygiene Association to assist emergency response personnel in planning for catastrophic releases to the community. ERPG values are defined for varying degrees of severity of toxic effects, as follows:

> **ERPG-1:** The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
>
> **ERPG-2:** The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.
>
> **ERPG-3:** The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

emission – A material discharged into the atmosphere from a source operation or activity.

emission standard – A requirement established by the state or the U.S. Environmental Protection Agency that limits the quantity, rate, or concentration of air

pollutant emissions on a continuous basis, including any requirement relating to (1) operation or maintenance of a source to ensure continuous emission reduction and (2) any design, equipment, work practice, or operational standard.

endangered species – *Federal:* Species that are in danger of extinction throughout all or a significant portion of their ranges and that have been listed as endangered by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following procedures outlined in the Endangered Species Act (Title 16 of the *United States Code*, Parts 1551 through 1599) and its implementing regulations (Title 50 of the *Code of Federal Regulations* [CFR], Part 424). The lists of endangered species can be found in 50 CFR, Section 17.11 (wildlife); 50 CFR, Section 17.12 (plants); and 50 CFR, Section 222.23(a) (marine organisms).

Washington State: Any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state within the foreseeable future if factors contributing to its decline continue (*Washington Administrative Code* 232-12-297; Washington State Natural Heritage Program, established by the Natural Area Preserves Act [*Revised Code of Washington*, Chapter 79.70]). (See *candidate species* and *threatened species*.)

engineered safety features – For a nuclear facility, features that prevent, limit, or mitigate the release of radioactive material from its primary containment. (See *radioactivity* and *reactor containment*.)

enriched uranium – Uranium with a content of the fissile isotope uranium-235 greater than the 0.7 percent (by weight) found in natural uranium. (See *highly enriched uranium*, *natural uranium*, and *uranium*.)

entombment – A process whereby aboveground structures are decontaminated and dismantled, belowground structures are grouted and left in place, and an infiltration barrier is placed over the contaminated material.

entrainment – The involuntary capture and inclusion of organisms in streams of flowing water; a term often applied to the cooling water systems of power plants and nuclear reactors. The organisms involved may include phyto- and zooplankton, fish eggs and larvae (ichthyoplankton), shellfish larvae, and other forms of aquatic life. (See *nuclear reactor*.)

Environment, Safety, and Health Program – In the context of the U.S. Department of Energy (DOE), encompasses those requirements, activities, and functions in the conduct of all DOE and DOE-controlled operations that are concerned with: impacts on the biosphere; compliance with environmental laws, regulations, and standards controlling air, water, and soil pollution; limiting the risks to the well-being of both the operating personnel and the general public; and protecting property against accidental loss and damage. Typical activities and functions related to this program include, but are not limited to, environmental protection, occupational safety, fire protection, industrial hygiene, health physics, occupational medicine, process and facility safety, nuclear safety, emergency preparedness, quality assurance, and radioactive and hazardous waste management.

environmental assessment (EA) – A concise public document that a Federal agency prepares under the National Environmental Policy Act (NEPA) to provide sufficient evidence and analysis to determine whether a proposed agency action would require preparation of an environmental impact statement (EIS) or a Finding of No Significant Impact. A Federal agency may also prepare an EA to aid its compliance with NEPA when no EIS is necessary or to facilitate its preparation of an EIS when one is necessary.

An EA must include brief discussions of the (1) need for the proposal, (2) alternatives, (3) environmental impacts of the proposed actions and alternatives, and (4) a list of agencies and persons consulted. (See *environmental impact statement, Finding of No Significant Impact*, and *National Environmental Policy Act of 1969*.)

environmental impact statement (EIS) – The detailed written statement that is required by Section 102(2)(C) of the National Environmental Policy Act (NEPA) for a proposed major Federal action that could significantly affect the quality of the human environment. A U.S. Department of Energy (DOE) EIS is prepared in accordance with applicable requirements of the Council on Environmental Quality's NEPA regulations (Title 40 of the *Code of Federal Regulations* [CFR], Parts 1500–1508) and the DOE NEPA regulations found in 10 CFR, Part 1021. The statement includes, among other information, discussions of the environmental impacts of the proposed actions and the range of reasonable alternatives; the adverse environmental effects that cannot be avoided should the proposal be implemented; the relationship between short-term use of the environment and long-term productivity; and any irreversible and irretrievable commitments of resources.

environmental justice – The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, and socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, or commercial operations or the execution of Federal, state, local, or tribal programs or policies. Executive Order 12898 directs Federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects of agency programs, policies, and activities on minority and low-income populations. (See *low-income population* and *minority population*.)

eolian – Pertaining to, caused by, or carried by the wind.

ephemeral stream – A stream that flows only after a period of heavy precipitation.

epicenter – The point on Earth's surface directly above the focus of an earthquake.

epidemiology – Study of the occurrence, causes, and distribution of disease or other health-related states and events in human populations, often as related to age, sex, occupation, ethnic, and economic status, to identify and alleviate health problems and promote better health.

equilibrium partitioning – Process of achieving a steady state between the activity of chemicals (usually approximated as concentration) in the various component phases—water, sediment, and organisms.

equivalent sound (pressure) level – The equivalent, steady sound level that, if continuous during a specified time period, would contain the same total energy as the actual time-varying sound. L_{eq} (1-h) and L_{eq} (24-h) are the 1-hour and 24-hour equivalent sound levels, respectively.

erg – An absolute unit of work representing the work done by a force of 1 dyne acting through a displacement of 1 centimeter in the direction of the force. (A dyne is a unit of force equal to the force that would accelerate a free mass of 1 gram 1 centimeter per second per second.)

erosion – Removal of material by water, wind, or ice.

ERPG-1, -2, and -3 – See *Emergency Response Planning Guideline.*

ester – Any of a class of chemical compounds that, when hydrolyzed, yield an organic or inorganic acid and an alcohol or phenol and hence may be classified by either their acid constituent or their alcohol or phenol constituent.

Evolutionarily Significant Unit – A distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

excavation – A cavity in the earth formed by cutting, digging, or scooping using heavy construction equipment.

experimental, nonessential population (Federal) – The term "experimental population" means any population (including any offspring arising solely therefrom) authorized, per procedures outlined in the Endangered Species Act (Title 16 of the *United States Code*, Parts 1551 through 1599), for release outside the current range of such species, but only when, and at such times as, the population is wholly separate geographically from nonexperimental populations of the same species. An experimental population determined to be not essential to the continued existence of a species shall be treated, except when it occurs in an area within the National Wildlife Refuge System or the National Park System, as a species proposed to be listed as an endangered species or a threatened species.

exposure – The condition of being subject to the effects of, or acquiring a dose of, a potential stressor such as a hazardous chemical agent or ionizing radiation; also, the process by which an organism acquires a dose of a chemical such as mercury or a physical agent such as ionizing radiation. Exposure can be quantified as the amount of the agent available at various boundaries of the organism (e.g., skin, lungs, gut) and available for absorption. (See *ionizing radiation*.)

exposure limit – The level of exposure to a hazardous chemical (set by law or a standard) at which or below which adverse human health effects are not expected to occur. (See *reference concentration* and *reference dose*.)

exposure pathway – The course a chemical or physical agent takes from the source to the exposed organism. An exposure pathway describes a mechanism by which chemicals or physical agents at or originating from a release site reach an individual or population. Each exposure pathway includes a source or release from a source, an exposure route, and an exposure point. If the exposure point differs from the source, a transport/exposure medium such as air or water is also included. (See *exposure*.)

external dose or exposure – The portion of the dose equivalent received from radiation sources outside the body (i.e., "external sources"). (See *dose equivalent* and *ionizing radiation*.)

extrusion – A type of process in which a material (e.g., metal or plastic) is forced through a die, or very small hole, to give it a certain shape.

Fast Flux Test Facility (FFTF) – A liquid-metal (sodium)-cooled and -moderated nuclear test reactor at the Hanford Site. It was fueled with a mixture of plutonium-uranium dioxide and had a 400-megawatt power level. It is presently being deactivated. (See *nuclear reactor*.)

fault – A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage has occurred. A normal fault occurs when the hanging wall has been depressed in relation to the footwall. A reverse fault occurs when the hanging wall has been raised in relation to the footwall.

fill material – Soil, rock, gravel, or other matter that is placed at a specified location to bring the ground surface up to a desired elevation.

Finding of No Significant Impact (FONSI) – A Federal agency, having prepared an environmental assessment of an action, issues this public document that briefly presents the reasons the action has no potential to have a significant effect on the human environment and, thus, will not require preparation of an environmental impact statement. (See *environmental assessment* and *environmental impact statement*.)

fissile material – Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning, namely, any material fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239. (See *fission* and *neutron*.)

fission – A nuclear transformation that is typically characterized by the splitting of a

heavy atomic nucleus into at least two other nuclei, the emission of one or more neutrons, and the release of a relatively large amount of energy. Fission of heavy atomic nuclei can occur spontaneously or be induced by neutron bombardment. (See *neutron*.)

fission products – Radioactive elements or compounds formed by the fission of heavy elements, plus the nuclides formed by the radioactive decay of those elements or compounds. (See *fission* and *nuclide*.)

fissionable material – Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238. (See *neutron*.)

floodplain – The lowlands and relatively flat areas adjoining inland and coastal waters and the flood-prone areas of offshore islands. Floodplains include, at minimum, that area with at least a 1 percent chance of being inundated by a flood in any given year.

The *probable maximum flood* is the hypothetical flood considered to be the most severe reasonably possible flood, based on comprehensive hydrometeorological application of maximum precipitation and other hydrological factors favorable for maximum flood runoff (e.g., sequential storms and snowmelts). It is usually several times larger than the maximum recorded flood.

fluvial – Produced by the action of flowing water.

flux – Rate of flow through a unit area; in nuclear reactor operation, the apparent flow of neutrons in a defined energy range. (See *neutron flux* and *nuclear reactor*.)

food chain multiplier – A numerical factor quantifying the increase in concentration of a substance in an organism resulting from the accumulation and biomagnification of the substance through the food web.

food web – The network of feeding relationships in an ecosystem. (See *ecosystem*.)

formation – In geology, the primary unit of formal stratigraphic mapping or description. Most formations possess certain distinctive features.

French drain – A rock-filled encasement with an open bottom to allow seepage of liquid waste into the ground.

fuel assembly – A cluster of fuel rods or plates; also called a fuel element. Approximately 200 fuel assemblies make up a nuclear reactor core. (See *nuclear reactor*.)

fuel rod – A nuclear reactor component that includes the fissile material. (See *fissile material*.)

fugitive emissions – (1) Emissions that do not pass through a stack, vent, chimney, or similar opening where they could be captured by a control device. (2) Any air pollutant emitted to the atmosphere other than from a stack. Sources of fugitive emissions include pumps; valves; flanges; seals; area sources such as ponds, lagoons, landfills, and piles of stored material (e.g., coal); and road construction areas or other areas where earthwork occurs.

fusion – The combining of two light atomic nuclei (such as hydrogen isotopes or lithium) to form a heavier atomic nucleus. Fusion is accompanied by the release of large amounts of energy. (See *nucleus*.)

g – In measuring earthquake ground motion, the acceleration (the rate of change in velocity) experienced relative to that due to Earth's gravity (i.e., approximately equal to 980 centimeters per second squared).

gamma radiation – High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an atom during radioactive decay. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium. Gamma rays are similar to x-rays, but are usually more energetic. (See

alpha radiation, beta particle, ionizing radiation, nucleus, and *radioactive decay*.)

generator – Within the context of this environmental impact statement, generators refer to organizations within the U.S. Department of Energy (DOE) or managed by DOE whose act or process produces low-level radioactive waste (LLW), mixed LLW, or transuranic waste.

genetic effects – Inheritable changes (chiefly mutations), produced by exposure to ionizing radiation or other chemical or physical agents, of the parts of cells that control biological reproduction and inheritance. (See *ionizing radiation*.)

GENII – A computer code used to predict the radiological impacts on individuals and populations associated with the release of radioactive material into the environment during normal operations and postulated accidents.

geologic repository – A place to dispose of radioactive waste deep beneath Earth's surface.

geology – The science that studies the materials, processes, environments, and history of Earth, including rocks and their formation and structure.

gigaelectron volts – One thousand million electron volts (MeV). (See *MeV*.)

glovebox – A large enclosure that separates workers from equipment used to process hazardous material while allowing the workers to be in physical contact with the equipment. Gloveboxes are normally constructed of stainless steel, with large acrylic/lead glass windows. Workers access equipment using heavy-duty, lead-impregnated rubber gloves, the cuffs of which are sealed in portholes in the glovebox windows.

graded approach – A process by which the level of analysis, documentation, and actions necessary to comply with a requirement are commensurate with (1) the relative importance to safety, safeguards, and security; (2) the magnitude of any hazard involved; (3) the life-cycle stage of a facility; (4) the programmatic mission of a facility; (5) the particular characteristics of a facility; and (6) any other relevant factor.

grading – Any stripping, cutting, filling, stockpiling, or combination thereof that modifies the land surface.

gravel pit No. 30 – This gravel pit, located between the 200-East and 200-West Areas, is an approximately 54-hectare (134-acre) borrow site containing a large quantity of aggregate (sand and gravel) suitable for multiple uses. Gravel pit No. 30 provides aggregate for onsite concrete batch plants in support of the construction of new facilities, including those at the Waste Treatment Plant adjacent to the 200-East Area.

gray – The International System of Units (SI) unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (1 gray is equal to 100 rad). The joule is the SI unit of energy and is equivalent to 10 million ergs. (See *absorbed dose*, *erg, joule,* and *radiation absorbed dose [rad]*.)

greater-than-Category 3 (GTC3) low-level radioactive waste (LLW) – LLW that exceeds the maximum radionuclide concentration limits as defined for Category 3 LLW. (See *Category 3 low-level radioactive waste*.)

greater-than-Class C (GTCC) low-level radioactive waste (LLW) – LLW generated by the commercial sector that exceeds U.S. Nuclear Regulatory Commission (NRC) concentration limits for Class C LLW, as specified in "Licensing Requirements for Land Disposal of Radioactive Waste" (Title 10 of the *Code of Federal Regulations*, Part 61).

In addition to the GTCC LLW generated as a result of NRC- or agreement-state-licensed activities, the U.S. Department of Energy (DOE) generates waste containing concentrations of radionuclides that are similar to GTCC LLW. This waste is referred to as "DOE GTCC-like waste."

ground shine – The radiation dose received from an area on the ground where radioactivity has been deposited by a radioactive plume or cloud. (See *dose* and *ionizing radiation*.)

groundwater – Water below the ground surface in a zone of saturation.

grout – A fluid mixture of cement-like materials and liquid waste that sets up as a solid mass and is used for waste fixation, immobilization, and stabilization.

habitat – The environment occupied by individuals of a particular species, population, or community.

half-life (radiological) – The time in which one-half of the atoms of a particular radioactive isotope disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years. (See *radioisotope or radionuclide*.)

Hanford barrier – A horizontal, multilayered, above-grade soil structure used as a representative surface barrier (cap) for closure at a Hanford Site landfill. The barrier's function is to isolate the waste site from the environment by preventing or reducing the likelihood of wind erosion; water infiltration; or plant, animal, or human intrusion.

Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) – An agreement signed in 1989 by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology that identifies milestones for key environmental restoration and waste management actions.

Hazard Index – *(ecological definition)* The sum of the individual Hazard Quotients of constituents within a class that exert effects with the same toxicological mechanism or endpoint and are additive in effect.

(human health definition) A summation of the Hazard Quotients for all chemicals now being used at a site, as well as those proposed to be added, to yield the cumulative levels for the site. A Hazard Index value of 1.0 or less means that no adverse human health effects (noncancer) are expected to occur. (See *Hazard Quotient*.)

Hazard Quotient – The value used as an assessment of non-cancer-associated toxic effects of chemicals, e.g., kidney or liver dysfunction. It is a ratio of the estimated exposure to that level of exposure at which it is expected that adverse health effects would begin to be produced. It is independent of a cancer risk, which is calculated for only those chemicals identified as carcinogens.

hazardous air pollutants – Air pollutants that are not covered by ambient air quality standards, but may present a threat of adverse human health or environmental effects. Those specifically listed in Title 40 of the *Code of Federal Regulations*, Section 61.01, are asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. More broadly, hazardous air pollutants include any of the 189 pollutants listed in or pursuant to Section 112(b) of the Clean Air Act.

hazardous chemical – Under Title 29 of the *Code of Federal Regulations*, Part 1910, Subpart Z, hazardous chemicals are defined as "any chemical that is a physical hazard or a health hazard." Physical hazards include combustible liquids, compressed gases, explosives, flammables, organic peroxides, oxidizers, pyrophorics, and reactives. A health hazard is any chemical for which there is good evidence that acute or chronic health effects occur in exposed employees. Hazardous chemicals include carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, agents that act on the hematopoietic system, and agents that damage the lungs, skin, eyes, or mucous membranes.

hazardous material – A material, including a hazardous substance, as defined by Title 49 of the *Code of Federal Regulations*, Section 171.8, that poses a risk to health, safety, or property when transported or handled.

hazardous substance – Any substance subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act.

hazardous waste – A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in Title 40 of the *Code of Federal Regulations* (CFR), Sections 261.20 through 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity), or it must be specifically listed by the U.S. Environmental Protection Agency in 40 CFR, Sections 261.31 through 261.33. Hazardous waste may also include solid waste designated by Washington State in *Washington Administrative Code* 173-303-070 through 173-303-100 as dangerous or extremely hazardous waste.

heavy-haul truck – A truck that exceeds normally applicable vehicle weight limits for highway travel. State authorities may issue special permits allowing trucks to exceed weight limits to carry "nondivisible loads," such as spent nuclear fuel casks, on public highways. Roadways and bridges may need to be upgraded to carry such vehicles. (See *legal-weight truck* and *spent nuclear fuel*.)

As used in this environmental impact statement, "heavy-haul truck" means a truck with a gross vehicle weight (truck and cargo weight) of more than 58,500 kilograms (129,000 pounds).

heavy metal – In the context of nuclear technology, "heavy metal" means all uranium, plutonium, or thorium placed into a nuclear reactor. (See *nuclear reactor*.)

heavy metals – Metallic and semimetallic elements that are generally highly toxic to plants and animals and tend to accumulate in food chains are referred to collectively as "heavy metals." Heavy metals include lead, mercury, cadmium, chromium, and arsenic.

hexavalent – Having a valence of six. (See *hexavalent chromium* and *valence*.)

hexavalent chromium – Hexavalent chromium compounds are a group of chemical substances that contain the metallic element chromium in its positive-6 valence (hexavalent) state. (See *hexavalent* and *valence*.)

high-efficiency particulate air filter – An air filter capable of removing at least 99.97 percent of particles 0.3 micrometers (about 0.00001 inches) in diameter. These filters include a pleated fibrous medium (typically fiberglass) that is capable of capturing very small particles.

high-integrity container – A container that provides additional confinement for remote-handled Category 3 low-level radioactive waste (LLW) and some contact-handled Category 3 LLW and is typically constructed of concrete or other durable material.

high-level radioactive waste – As defined in the *Radioactive Waste Management Manual* (U.S. Department of Energy Manual 435.1-1), highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation. (See *fission products*, *radioactive waste*, and *spent nuclear fuel*.)

highly enriched uranium – Uranium whose content of the fissile isotope uranium-235 has been increased through enrichment to 20 percent or more (by weight). (See *depleted uranium*, *enriched uranium*, and *natural uranium*.)

HIGHWAY – A computer code used for predicting routes for transporting radioactive material in the United States and calculating route-specific population density statistics.

historic resources – (1) Archaeological sites, architectural structures, and objects produced

after the advent of written history or dating to the time of the first European-American contact in an area. (See *archaeological sites*.)

(2) As defined by the National Historic Preservation Act of 1966, as amended (Title 16 of the *United States Code*, Part 470 et seq.), any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on, the National Register of Historic Places, including artifacts, records, and material remains related to such a property or resource.

Holocene – An epoch of the Quaternary period that began at the end of the Pleistocene, or the "Ice Age," about 10,000 years ago and continues to the present. It is named from the Greek words "holos" (entire) and "ceno" (new).

hot cell – A shielded facility that requires the use of remote manipulators for handling radioactive materials.

hydraulic head – A specific measurement of the potential for water to flow, expressed in units of length relative to a vertical datum. For an unconfined aquifer (as modeled in this environmental impact statement [EIS]), the hydraulic head is nearly equivalent to the water table elevation. In this EIS, hydraulic head is expressed in meters relative to the North American Vertical Datum of 1988 (NAVD88).

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

hydrophobic – Lacking an affinity for water.

immobilization – Placing waste within a material such as concrete or glass to reduce (immobilize) the dispensability and leachability of the radioactive or hazardous components within the waste.

immobilized high-level radioactive waste (IHLW) – High-level radioactive waste as defined in the *Radioactive Waste Management Manual* (U.S. Department of Energy Manual 435.1-1) that has been immobilized (vitrified) by processing it through the Waste Treatment Plant. (See *vitrification*.)

immobilized low-activity waste (ILAW) – (1) Waste immobilized by the Waste Treatment Plant or processed by supplemental treatment (i.e., bulk vitrification, cast stone, steam reforming). After receiving the necessary approvals, ILAW could be managed as low-level radioactive waste incidental to reprocessing, as defined in U.S. Department of Energy Manual 435.1-1. Because it is produced from treatment of Hanford Site tank waste, it also could be managed as a mixed waste. (See *cast stone, low-activity waste,* and *vitrification*.) (2) Waste that contains mostly nonradioactive chemical constituents.

incident-free risk – The radiological or chemical impacts resulting from emissions during normal operations and normal transportation of packages aboard vehicles. This includes the radiation or hazardous chemical exposure of specific population groups and workers. (See *exposure, hazardous chemical*, and *ionizing radiation*.)

indirect jobs – Within a regional economic area, jobs generated or lost in related industries as a result of a change in direct employment.

infrastructure – The basic facilities, services, and utilities needed for the functioning of an industrial facility. Transportation and electrical systems are part of the infrastructure.

ingestion – The action of taking solids or liquids into the digestive system.

inhalation – The action of taking airborne material into the respiratory system.

injection well – A well that takes water from the surface into the ground, either through gravity or by mechanical means.

injector – A device that provides protons for an accelerator by heating hydrogen gas to a plasma state in which the hydrogen atoms lose their electrons, thereby giving the hydrogen nuclei a positive charge. An electric voltage removes the protons from the injector. (See *proton*.)

inorganic – Of or pertaining to chemical substances that do not contain carbon except for compounds such as carbonates, carbides, cyanides, carbon dioxide, and carbon monoxide.

institutional control – The period of time when a site is under active governmental controls. Institutional controls may include administrative or legal controls, physical barriers or markers, and methods to preserve information and data and to inform current and future generations of hazards and risks.

Integrated Disposal Facility – A permitted landfill on the Hanford Site with two separate, expandable cells—one for the disposal of low-level radioactive waste and another for the disposal of mixed low-level radioactive waste.

intensity (of an earthquake) – A measure of the effects (due to ground shaking) of an earthquake at a particular location, based on observed damage to structures built by humans, changes in Earth's surface, and reports of how people felt the earthquake. Earthquake intensity is measured in numerical units on the Modified Mercalli Intensity Scale. (See *magnitude [of an earthquake]* and *Modified Mercalli Intensity Scale*.)

interbedded (geological) – Occurring between beds (layers) or lying in a bed parallel to other beds of a different material.

interim status facility (under the Resource Conservation and Recovery Act [RCRA]) – A hazardous waste management (treatment, storage, or disposal) facility that is subject to RCRA permit requirements and was in existence on the effective date of the law or its implementing regulations. Such facilities are considered to have been issued a permit on an interim basis if they met the requirements for notification and submitted a permit application. Such facilities are required to meet the interim status standards described in Title 40 of the *Code of Federal Regulations*, Part 265, until they have been issued a final permit or until their interim status is withdrawn.

internal dose – That portion of the dose equivalent received from radioactive material taken into the body (i.e., "internal sources"). (See *dose equivalent*.)

in-trench grouting – Involves placing the waste on a cement pad or on spacers, installing reinforcement steel and forms around the waste, and covering the waste with fresh concrete to encapsulate the waste within a concrete barrier.

invertebrate – Of or pertaining to animals that do not have a backbone.

involved worker – A worker participating in a proposed action. (See *noninvolved worker*.)

ion – An atom that has too many or too few electrons, causing it to be electrically charged. (See *electron*.)

ion exchange – A unit physiochemical process that removes anions and cations, including radionuclides, from liquid streams (usually water) for the purpose of purification or decontamination. (See *anion, cation,* and *radioisotope or radionuclide*.)

ion exchange resin – An organic polymer that functions as an acid or base. These resins are used to remove ionic material from a solution. Cation exchange resins are used to remove positively charged particles (cations); anion exchange resins are used to remove negatively charged particles (anions). (See *acid, base,* and *polymer*.)

ionizing radiation – Alpha particles, beta particles, gamma rays, high-speed electrons, high-speed protons, and other particles or electromagnetic radiation that can displace electrons from atoms or molecules, thereby producing ions. (See *alpha radiation, beta particle, electron, gamma radiation, ion,* and *proton*.)

irradiated – Exposed to ionizing radiation. The condition of nuclear reactor fuel elements and other materials in which atoms bombarded with nuclear particles have undergone nuclear changes. (See *ionizing radiation*.)

isotope – Any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number) but different numbers of neutrons so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties (e.g., carbon-12 and -13 are stable; carbon-14 is radioactive). (See *neutron*, *nucleus*, and *proton*.)

joule – A metric unit of energy, work, or heat, equivalent to 1 watt-second, 0.737 foot-pounds, or 0.239 calories.

joule-heated melter – See *melter*.

lacustrine – Of or pertaining to lakes.

land disposal restrictions – The restrictions and requirements for land disposal of hazardous or dangerous waste as specified in Title 40 of the *Code of Federal Regulations*, Part 268 (Resource Conservation and Recovery Act), and *Washington Administrative Code* 173-303-140 (Washington State Dangerous Waste Regulations).

landfill closure – Landfill closure typically includes site stabilization and emplacement of a surface barrier, followed by a postclosure care period.

landscape character – The arrangement of a particular landscape as formed by the variety and intensity of the landscape features (land, water, vegetation, and structures) and the four basic elements (form, line, color, and texture). These factors give an area a distinctive quality that distinguishes it from its immediate surroundings.

land use designations – Land use designations at the Hanford Site were established by the U.S. Department of Energy under the 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* Record of Decision, amended in September 2008. Changes to land use are subject to procedures identified in that environmental impact statement.

Industrial: An area that is suitable and desirable for activities such as reactor operations; rail and barge transport facilities; mining; manufacturing; food processing; assembly, warehouse, and distribution operations; and other industrial uses.

Industrial-Exclusive: An area that is suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes and related activities.

Conservation (Mining): An area reserved for management and protection of archaeological, cultural, ecological, and natural resources. Limited and managed mining (e.g., quarrying for sand, gravel, basalt, and topsoil for governmental purposes only) could occur as a special use within appropriate areas (a permit would be required). Limited public access would be consistent with resource conservation. This designation includes related activities.

larval – Of or pertaining to the juvenile form of certain kinds of animals.

latent cancer fatality – Death from cancer occurring sometime after, and postulated to be due to, exposure to ionizing radiation or other carcinogens.

leachate – As applied to mixed low-level radioactive waste trenches, any liquid, including any suspended components in the liquid, that has percolated through, or drained from, hazardous waste. (See *mixed low-level radioactive waste*.)

legal-weight truck – A truck that meets vehicle weight limits for U.S. interstate highways. Under Federal regulations (Title 23 of the *Code of Federal Regulations*, Section 658.17), the total loaded weight of a tractor-trailer combination is limited to 34,874 kilograms (80,000 pounds). Some states allow heavier vehicles on highways within the state.

license amendment – Changes to an existing reactor's operating license that are approved by the U.S. Nuclear Regulatory Commission.

light water – The common form of water (a molecule with two hydrogen atoms and one oxygen atom, H_2O), in which the hydrogen atoms consist completely of the normal hydrogen isotope (one proton), with no additional neutrons. (See *isotope* and *proton*.)

light-water reactor – A nuclear reactor in which circulating light water is used to cool the reactor core and to moderate (reduce the energy of) the neutrons created in the core by the fission reactions. (See *fission, neutron,* and *nuclear reactor*.)

loam – Soil material that is composed of 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

lobe – A lobe is a section of a barrier that covers a contiguous area of tank farms. Three barrier lobes are anticipated in the 200-West Area, and two much larger lobes are anticipated in the 200-East Area.

long-lived radionuclide – A radioactive isotope with a half-life of generally greater than 30 years. (See *half-life [radiological], isotope,* and *radioisotope or radionuclide*.)

loss-of-coolant accident – An accident that results from a loss of reactor coolant because of a break in the reactor coolant system. (See *nuclear reactor*.)

lost workdays – The total number of workdays (consecutive or not) during which employees were away from work or limited to restricted work activity because of an occupational injury or illness.

low-activity waste (LAW) – Waste that remains after as much radioactivity as technically and economically practical has been separated from high-level radioactive waste that, when solidified, may be disposed of as low-level radioactive waste in a near-surface facility. In its final form, such solid LAW would not exceed Title 10 of the *Code of Federal Regulations* (CFR), Section 61.55, Class C radioisotope limits and would meet performance objectives comparable to those in 10 CFR, Part 61, Subpart C.

low-enriched uranium – Uranium whose content of the fissile isotope uranium-235 has been increased through enrichment to more than 0.7 percent, but less than 20 percent, by weight. Most nuclear-power reactor fuel contains low-enriched uranium containing 3 to 5 percent uranium-235.

low-income person – A person living in a household that reports an annual income less than the United States official poverty level, as reported by the U.S. Census Bureau.

low-income population – Low-income populations, as defined in terms of U.S. Census Bureau annual statistical poverty levels (Current Population Reports, Series P60 on Consumer Income), may consist of groups or individuals who either live in geographic proximity to one another or are geographically dispersed or transient (such as migrant workers or American Indians), where either type of group experiences common conditions of environmental exposure or effect. (See *environmental justice* and *minority population*.)

low-level radioactive waste – Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in Section 11e(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

macroencapsulation – Treatment method applicable to debris waste as defined by the Resource Conservation and Recovery Act. Refers to application of surface-coating materials such as polymeric organics (e.g., resins and plastics) or of a jacket of inert material to reduce surface exposure to potential leaching media.

macroseismicity – Seismicity at a level that implies significant, coherent, sustained tectonic activity, as defined by the International Atomic Energy Agency. Associated earthquakes are generally of magnitude 3.5 or greater and instrumentally determined with records of

sufficient precision to demonstrate a direct relationship with the causative fault.

magnitude (of an earthquake) – A term used to quantify the total energy released by an earthquake, in contrast to "intensity," which describes its effects at a particular place. Magnitude is determined by taking the common logarithm (base 10) of the largest ground motion recorded on a seismograph during the arrival of a seismic wave and applying a standard correction factor for distance to the epicenter. The three common types of magnitude are Richter (or local) (M_L), P body wave (m_b), and surface wave (M_s). Additional magnitude scales, notably the moment magnitude (M_w), have been introduced to increase uniformity in the representation of an earthquake's size.

Moment magnitude is defined as the rigidity of the rock multiplied by the area of faulting, multiplied by the amount of slip. A one-unit increase in magnitude (for example, from magnitude 6 to magnitude 7) represents a 30-fold increase in the amount of energy released. (See *intensity [of an earthquake]*.)

mammal – Warm-blooded, hairy vertebrates whose offspring are fed by milk secreted by the female.

maximally exposed individual (MEI) – A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure). As used in this environmental impact statement, the MEI refers to an individual located off site, unless characterized otherwise in terms of time or location.

maximum contaminant level (MCL) – The U.S. Environmental Protection Agency (EPA) standards for drinking water quality under the Safe Drinking Water Act. The MCL for a given substance is the maximum permissible concentration of that substance in water delivered by a public water system. The primary MCLs (Title 40 of the *Code of Federal Regulations* [CFR], Part 141) are intended to protect public health and are federally enforceable. They are based on health factors, but are also required by law to reflect the technological and economic feasibility of removing the contaminant from the water supply. Secondary MCLs (40 CFR, Part 143) are set by EPA to protect the public welfare. These secondary drinking water regulations control substances in drinking water that primarily affect aesthetic qualities (such as taste, odor, and color), which are related to public acceptance of water. These regulations are not federally enforceable, but are intended as guidelines for the states.

mayflies – An insect that spends its larval stage on the bottom of a lake or stream and emerges into the terrestrial environment as a flying adult.

megawatt – A unit of power equal to 1 million watts. *Megawatt-thermal* is commonly used to describe heat produced, while *megawatt-electric* describes electricity produced.

melter – The type of melters used in the Waste Treatment Plant (WTP) to treat tank waste are joule-heated melters. Joule heating involves placing electrodes into a material (a slurry of tank waste mixed with glass-forming materials) and applying electrical potential. This results in an electrical current and resistance heating. WTP melters include (1) high-level radioactive waste (HLW) melters used to treat the HLW stream, with a theoretical maximum capacity (TMC) of producing 3 metric tons of glass (MTG) per day, and (2) low-activity waste (LAW) melters used to treat the LAW stream, with a TMC of producing 15 MTG per day.

meteorology – The science dealing with the atmosphere and its phenomena, especially as related to weather.

MeV (million electron volts) – A unit used to quantify energy. In this environmental impact statement, it describes a particle's kinetic energy, which is an indicator of particle speed.

microbial crust – A surface layer of microbes that becomes harder than the underlying soil horizon.

microbiotic crusts – See *cryptogamic (microbiotic) crusts*.

microencapsulation – Encapsulation of waste components in the atomic structure of compounds or materials such as glass, cement, or polymer waste forms.

migration – The natural movement of a material through the air, soil, or groundwater; also, seasonal movement of animals from one area to another.

Migratory Bird Treaty Act – This act states that it is unlawful to pursue, take, attempt to take, capture, possess, or kill any migratory bird or any part, nest, or egg of any such bird other than permitted activities.

millirem – One-thousandth of 1 rem. (See *roentgen equivalent man [rem]*.)

minority – Individuals who are members of the following population groups: American Indian or Alaska Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

minority population – Minority populations exist where either (1) the minority population of the affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than that in the general population or in some other appropriate unit of geographic analysis (such as a governing body's jurisdiction, a neighborhood, census tract, or other similar unit). "Minority populations" include either a single minority group or the total of all minority persons in the affected area. They may consist of groups of individuals living in geographic proximity to one another or a geographically dispersed/transient set of individuals (such as migrant workers or American Indians), where either type of group experiences common conditions of environmental exposure or effect. (See *environmental justice, low-income population,* and *minority*.)

Miocene – A geologic epoch of the upper Tertiary period, spanning between about 24 million and 5 million years ago.

miscellaneous underground storage tanks – These tanks were used for waste storage in the past, and some are currently being used for a variety of purposes. The tanks vary in capacity from 3,407 to 189,270 liters (900 to 50,000 gallons) and are considered part of the Hanford Site tank waste system.

mitigation – Mitigation includes (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

mixed low-level radioactive waste – Low-level radioactive waste determined to contain source, special nuclear, or byproduct material that is subject to the Atomic Energy Act of 1954, as amended, as well as a hazardous component subject to the Resource Conservation and Recovery Act, as amended, or *Washington Administrative Code* 173-303-140. (See *dangerous waste* and *hazardous waste*.)

mixed oxide fuel – Nuclear reactor fuel made with a physical blend of different fissionable materials, such as uranium dioxide and plutonium dioxide. (See *nuclear reactor*.)

mixed waste – Waste that contains source, special nuclear, or byproduct material that is subject to the Atomic Energy Act of 1954, as amended, as well as a hazardous component subject to the Resource Conservation and Recovery Act.

moderator – A material used to decelerate neutrons in a nuclear reactor from high energies to low energies. (See *neutron* and *nuclear reactor*.)

Modified Mercalli Intensity – A level on the Modified Mercalli Intensity Scale. A measure of the perceived intensity of earthquake ground

shaking, with 12 divisions from I (not felt except by a very few people) to XII (damage total). It is a unitless expression of observed effects. (See *Modified Mercalli Intensity Scale*.)

Modified Mercalli Intensity Scale – A standard of relative measurement of earthquake intensity, developed to fit construction conditions in most of the United States. It is a 12-step scale, with values from I (not felt except by a very few people) to XII (damage total). A *Modified Mercalli Intensity* is a numerical value on the Modified Mercalli Intensity Scale.

modified RCRA Subtitle C barrier – Landfill cover described by Resource Conservation and Recovery Act regulations that also accounts for the unique climatic conditions at the Hanford Site. The design includes layers for foundation and slope, gas collection, low-permeability barrier, drainage, and cover soil.

modular facility – As used in this environmental impact statement, a modular disposal facility would consist of a number of expandable segments or areas within an overall master facility. Each module would be designed to handle certain waste types or forms. For example, remote-handled waste might be in a different area or "module" than standard packages of contact-handled low-level radioactive waste (LLW) or mixed LLW.

molar – A chemical term relating to the mole, or gram-molecular weight. A 1-molar solution would have 1 mole of solute per liter of solution.

mole ratio (molar ratio) – The mole ratio is the fraction created when a mole of one element is measured against a molar gram of carbon (e.g., 1 mole of nitrogen/1 mole of carbon). A mole is the amount of a substance that contains as many atoms, molecules, ions, or other elementary units as the number of atoms in 0.012 kilograms of carbon-12. The number is 6.0225×10^{23}, or Avogadro's number. Also called *gram molecule***.**

monitor species – *Idaho State:* Plant taxa that are common within a limited range or taxa that are uncommon but have no identifiable threats.

Washington State: Animal species that are not considered species of concern, but are monitored for status and distribution. They require management, survey, or data emphasis because they (1) were classified as endangered, threatened, or sensitive within the last 5 years; (2) require habitat that is of limited availability during some of their life cycle; (3) are indicators of environmental quality; or (4) have unresolved taxonomic questions. They are managed by the Washington Department of Fish and Wildlife, as needed, to prevent them from becoming endangered, threatened, or sensitive (*Washington Administrative Code* 232-12-297).

National Ambient Air Quality Standards – Standards defining the highest allowable levels of certain pollutants in the ambient air (outdoor air to which the public has access). Because the U.S. Environmental Protection Agency must establish the criteria for setting these standards, the regulated pollutants are called criteria pollutants. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: less than or equal to 2.5 and 10 micrometers (0.0001 and 0.0004 inches, respectively) in diameter. Primary standards are established to protect public health; secondary standards are established to protect public welfare (e.g., visibility, crops, animals, buildings). (See *criteria pollutant*.)

National Emission Standards for Hazardous Air Pollutants (NESHAPs) – Emission standards set by the U.S. Environmental Protection Agency for air pollutants that are not covered by National Ambient Air Quality Standards and may, at sufficiently high levels, cause increased fatalities, irreversible health effects, or incapacitating illness. These standards are given in Title 40 of the *Code of Federal Regulations*, Parts 61 and 63. NESHAPs are given for many specific categories of sources (e.g., equipment leaks, industrial process cooling towers, drycleaning

facilities, petroleum refineries). (See *hazardous air pollutants*.)

National Environmental Policy Act of 1969 (NEPA) – This act is the basic national charter for protection of the environment. It establishes policy, sets goals (Section 101), and provides means for carrying out policy (Section 102). Section 102(2) contains "action-forcing" provisions to ensure that Federal agencies follow the letter and spirit of the act. For major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA requires Federal agencies to prepare a detailed statement that analyzes the environmental impacts of the proposed actions and other specified information.

National Historic Preservation Act – This act provides for placement of property resources with significant national historic value on the National Register of Historic Places. It does not require any permits; however, pursuant to Federal code, if a proposed action might impact a historic property resource, it mandates consultation with the proper agencies.

National Pollutant Discharge Elimination System (NPDES) – A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency; a state; or, where delegated, a tribal government on an American Indian reservation. The NPDES permit lists either permissible discharges, the level of cleanup technology required for wastewater, or both.

National Priorities List (NPL) – The U.S. Environmental Protection Agency's (EPA's) list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under the Comprehensive Environmental Response, Compensation, and Liability Act. The list is based primarily on the score a site receives from the Hazard Ranking System described in Title 40 of the *Code of Federal Regulations*, Part 300, Appendix A. EPA must update the NPL at least once a year. (See *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.)

National Register of Historic Places – The official list of the Nation's historic resources that are worthy of preservation. The National Park Service maintains the list under direction of the Secretary of the Interior. Buildings, structures, objects, sites, and districts are included in the National Register for their importance in American history, architecture, archaeology, culture, or engineering. Properties included in the National Register range from large-scale, monumentally proportioned buildings to smaller-scale, regionally distinctive buildings. Listed properties are not just of nationwide importance; most are primarily significant at the state or local level. Procedures for listing properties in the National Register are found in Title 36 of the *Code of Federal Regulations*, Part 60.

natural uranium – Uranium with the naturally occurring distribution of uranium isotopes (about 0.7 weight-percent uranium-235, with the remainder essentially uranium-238). (See *depleted uranium, enriched uranium, highly enriched uranium, low-enriched uranium,* and *uranium.*)

neptunium – A mostly manmade element with the atomic number 93. Pure neptunium is a silvery metal. The neptunium-237 isotope has a half-life of 2.14 million years. When neptunium-237 is bombarded by neutrons, it is transformed to neptunium-238, which in turn undergoes radioactive decay to become plutonium-238. When neptunium-237 undergoes radioactive decay, it emits alpha particles and gamma rays. (See *alpha particle, beta particle, gamma radiation, neutron,* and *radioactive decay*.)

neutralization – Changing the pH of a solution to near 7 by adding an acidic or basic material.

neutron – An uncharged elementary particle with a mass slightly greater than that of the proton. Neutrons are found in the nucleus of every atom heavier than hydrogen-1. (See *nucleus* and *proton*.)

neutron flux – The product of neutron number density and velocity (energy), giving an apparent number of neutrons flowing through a unit area per unit time. (See *neutron*.)

nitrate – A compound containing nitrogen, typically seen as a negative anion composed of one nitrogen and three oxygen atoms.

nitrogen – A natural element with the atomic number 7. It is a diatomic, colorless, odorless gas that constitutes about four-fifths of the volume of the atmosphere.

nitrogen oxides – The oxides of nitrogen, primarily nitrogen oxide and nitrogen dioxide. These are produced by the combustion of fossil fuels and can constitute an air pollution problem. Nitrogen dioxide emissions contribute to acid deposition and formation of atmospheric ozone. (See *acid, oxide,* and *ozone*.)

noise – Any sound that is undesirable because it interferes with speech and hearing, is intense enough to damage hearing, or is otherwise annoying or undesirable.

nonattainment area – An area that the U.S. Environmental Protection Agency has determined does not meet one or more of the National Ambient Air Quality Standards for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may meet the standards for some pollutants, but not for others. (See *National Ambient Air Quality Standards* and *particulate matter*.)

noninvolved worker – A worker on the site of an action, but not participating in the action. (See *involved worker*.)

nonstandard (waste packaging) – Specially designed waste containers or packages used for large or odd-shaped low-level radioactive waste (LLW), mixed LLW, transuranic waste, or items with high dose rates or other unique conditions. (See *standard [waste packaging]*.)

normal operations – All normal (incident-free) conditions, as well as those abnormal conditions that frequency estimation techniques indicate typically occur with a frequency greater than 0.1 events per year. As used in this environmental impact statement, normal operations refers to routine waste management activities, e.g., waste treatment activities (including processing), packaging and repackaging, storage, and final disposal of waste, excluding accident conditions (except minor process upsets).

northing – The difference in latitude between two positions as a result of movement to the north.

Notice of Intent – An announcement of the initiation of an environmental impact scoping process. The Notice of Intent is usually published in both the *Federal Register* and a local newspaper. The scoping process includes holding at least one public meeting and requesting written comments on issues and environmental concerns that an environmental impact statement should address.

nuclear criticality – See *criticality*.

nuclear facility – A facility that is subject to requirements intended to control potential nuclear hazards. Defined in U.S. Department of Energy directives as "any nuclear reactor or any other facility whose operations involve radioactive materials in such form and quantity that a significant nuclear hazard potentially exists to the employees or the general public."

nuclear fuel cycle – The path followed by nuclear fuel in its various states from mined ore to waste disposal. The basic fuel materials for the generation of nuclear power are the elements uranium and thorium.

nuclear grade – Material of a quality that is adequate for use in a nuclear application.

nuclear material – Composite term applied to (1) special nuclear material; (2) source material such as uranium or thorium or ores containing uranium or thorium; and (3) byproduct material, which is any radioactive material that is made radioactive by exposure to the radiation

incident to the process of producing or using special nuclear material.

nuclear radiation – Particles (alpha, beta, neutrons) or photons (gamma) emitted from the nucleus of unstable radioactive atoms as a result of radioactive decay. (See *alpha particle, beta particle, gamma radiation, neutron, nucleus,* and *radioactive decay*.)

nuclear reactor – A device that sustains a controlled nuclear-fission chain reaction that releases energy in the form of heat. (See *chain reaction*.)

nucleus – The positively charged central portion of an atom that composes nearly all of the atomic mass and consists of protons and neutrons, except in hydrogen, in which it consists of one proton only. (See *neutron* and *proton*.)

nuclide – A species of atom characterized by the constitution of its nucleus (the number of protons and neutrons and the energy content). (See *neutron, nucleus,* and *proton*.)

occlusion – A blocking or obstruction of something.

Occupational Safety and Health Administration – Oversees and regulates workplace health and safety; created by the Occupational Safety and Health Act of 1970.

offsite/off site – Outside of the site boundary.

omnivore – An animal that eats both plant and animal matter.

onsite/on site – Within the site boundary.

operable unit – A term for each of a number of separate activities undertaken as part of a Superfund site cleanup. A typical operable unit would be removal of drums and tanks from the surface of a site. (See *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.)

operational waste – Solid waste that is generated to support cleanup activities, including contaminated personnel protective clothing, disposable laboratory supplies, and failed tools and equipment.

order of magnitude – As used in this environmental impact statement, an order of magnitude is taken as a power (or factor) of 10.

outfall – The discharge point of a drain, sewer, or pipe as it empties into a body of water.

overpack – Any container into which another container (usually a waste container) is placed. An overpack might be used to provide shielding and structural support (e.g., during transportation), provide additional physical containment for the contents of the inner container, or enclose a damaged container.

oxidation – The combination of a substance with oxygen or the loss of electrons by an oxidized species in a reaction.

oxide – A compound of oxygen and another element.

ozone – The triatomic form of oxygen. In the stratosphere, ozone protects Earth from the Sun's ultraviolet rays, but in lower levels of the atmosphere, ozone is considered an air pollutant.

package – For radioactive materials, the packaging and its radioactive contents.

packaging – In regard to hazardous or radionuclide materials, the assembly of components necessary to ensure compliance with Federal regulations for storage and transport. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle tie-down system and auxiliary equipment may be designated part of the packaging.

parameter – A term in a model or equation representing a measurable property or quantity of fixed or variable value.

particulate matter (PM) – Any finely divided solid or liquid material other than uncombined (i.e., pure) water. A subscript denotes the

upper limit of the diameter of the particles included. Thus, $PM_{2.5}$ includes only particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers (0.0001 inches); PM_{10}, less than or equal to 10 micrometers (0.0004 inches).

partitioning or distribution coefficient – A quantity relating the amount or concentration of a substance in a unit of soil or sediment to the amount or concentration in the overlying or pore water in contact with the solid medium.

past-practice unit – The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) defines past-practice unit as a waste management unit where wastes or substances have been disposed of (intentionally or unintentionally) that is not subject to regulation as a treatment, storage, or disposal unit. Due to the relatively large number of past-practice units at the Hanford Site, these units have been organized into groups called operable units for investigation and response action to prioritize the cleanup work to be done at the site.

pathways (exposure) – The means by which a substance moves from an environmental source to an organism.

Peak ground acceleration – A measure of the maximum horizontal acceleration (as a percentage of the acceleration due to Earth's gravity) experienced by a particle on the surface of Earth during the course of earthquake motion.

perched aquifer/groundwater – A body of groundwater of small lateral dimensions separated from an underlying body of groundwater by an unsaturated zone.

performance assessment – A systematic analysis of the potential risks posed by waste management systems to the public and the environment and a comparison of those risks to established performance objectives.

periphyton – Total assemblage of attached (sessile) organisms on any substrate that are capable of fixing carbon by photosynthesis or chemosynthesis.

permeability – In geology, the ability of rock or soil to transmit a fluid.

person-rem – A unit of collective radiation dose applied to populations or groups of individuals; that is, a unit for expressing the dose when summed across all persons in a specified population or group. One person-rem equals 0.01 person-sieverts. (See *collective dose, dose, person-sievert,* and *ionizing radiation*.)

person-sievert – A unit of collective radiation dose applied to populations or groups of individuals; that is, a unit for expressing the dose when summed across all persons in specified population or group. One person-sievert equals 100 person-rem.

pH – A measure of the relative acidity or alkalinity of a solution, expressed on a scale from 0 to 14, with the neutral point at 7.0. Acid solutions have pH values lower than 7.0, and basic (alkaline) solutions have pH values higher than 7.0.

Because pH is the negative logarithm of the hydrogen ion (H+) concentration, each unit increase in pH value expresses a change of state of 10 times the preceding state. Thus, pH 5 is 10 times more acidic than pH 6, and pH 9 is 10 times more alkaline than pH 8.

phenolic protective coating – A coating material made from the chemical phenol.

photon – A unit of electromagnetic energy exhibiting behavior like that of a particle.

physical extraction – Separation or removal of materials or components based on size or material characteristic.

phytoplankton – Microscopic plants floating in a body of water that are incapable of countering water movements.

picocurie – One trillionth (10^{-12}) of a curie. (See *curie*.)

Pleistocene – The geologic period of the earliest epoch of the Quaternary period, spanning between about 1.6 million years ago and the beginning of the Holocene epoch at 10,000 years ago. It is characterized by the succession of northern glaciations; also called the "Ice Age."

Pliocene – The latest geologic epoch of the Tertiary period, beginning about 5.3 million years ago and ending 1.6 million years ago.

plume – The elongated volume of contaminated water or air originating at a pollutant source, such as an outlet pipe or a smokestack. A plume eventually diffuses into a larger volume of less-contaminated material as it is transported away from the source.

plutonium – A heavy, radioactive metallic element with the atomic number 94. It is produced artificially by neutron bombardment of uranium. Plutonium has 15 isotopes, with atomic masses ranging from 232 to 246 and half-lives ranging from 20 minutes to 76 million years. (See *half-life [radiological]*, *isotope*, and *neutron*.)

plutonium-238 – An isotope with a half-life of 87.74 years, used as the heat source for radioisotope power systems. When plutonium-238 undergoes radioactive decay, it emits alpha particles and gamma rays. (See *alpha particle, beta particle, gamma radiation, half-life [radiological], isotope,* and *radioactive decay*.)

plutonium-239 – An isotope with a half-life of 24,110 years, it is the primary radionuclide in weapons-grade plutonium. When plutonium-239 decays, it emits alpha particles. (See *alpha particle, half-life [radiological], isotope, radioactive decay,* and *radioisotope or radionuclide*.)

$PM_{2.5}$ and **PM_{10}** – See *particulate matter.*

pollution prevention – The use of materials, processes, and practices that reduce or eliminate the generation and release of pollutants, contaminants, hazardous substances, and waste into land, water, and air. For the U.S. Department of Energy, this includes recycling activities. (See *waste minimization and pollution prevention*.)

polychlorinated biphenyl (PCB) – Any compound or mixture of compounds of a family of chlorinated organic chemicals that were formerly manufactured for use as coolants and lubricants in transformers, capacitors, and other electrical equipment. The manufacture of PCBs stopped in the United States in 1977 because of evidence that they build up in the environment and cause harmful effects. PCBs in water, for example, build up in fish and marine mammals and can reach levels thousands of times higher than the levels in water. It is not known whether PCBs cause cancer in people, but the U.S. Department of Health and Human Services has determined that PCBs may reasonably be anticipated to be carcinogens. The U.S. Environmental Protection Agency has classified all PCBs as Group B2, possible human carcinogens.

polymer – A natural or synthetic chemical compound or mixture of compounds formed by a chemical reaction in which two or more small molecules combine to form larger molecules that contain repeating structural units of the original molecules.

population dose – See *collective dose*.

pore water – The water present between particles of soil or sediment.

pounds per square inch – A measure of pressure; atmospheric pressure is about 14.7 pounds per square inch.

predator – An animal that eats another animal.

Prevention of Significant Deterioration (PSD) (of air quality) – Regulations established to prevent significant deterioration of air quality in areas that already meet National Ambient Air Quality Standards. Specific details of PSD are found in Title 40 of the *Code of Federal Regulations* (CFR), Section 51.166. Among other provisions, cumulative increases in sulfur dioxide, nitrogen dioxide, and PM_{10} (particulate matter with an

aerodynamic diameter less than or equal to 10 micrometers) levels after specified baseline dates must not exceed specified maximum allowable amounts. These allowable increases, also known as increments, are especially stringent in areas designated as Class I areas (e.g., national parks, wilderness areas), where the preservation of clean air is particularly important. All areas not designated as Class I are currently designated as Class II. Maximum increments in pollutant levels are also given in 40 CFR, Section 51.166, for Class III areas, if any such areas should be so designated by the U.S. Environmental Protection Agency. Class III increments are less stringent than those for Class I or II areas. (See *National Ambient Air Quality Standards*.)

prey – An animal that is eaten by another animal.

primary system – In regard to nuclear reactors, the system that circulates a coolant (e.g., water) through the reactor core to remove the heat of reaction. (See *nuclear reactor*.)

prime farmland – Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor and without intolerable soil erosion, as determined by the Secretary of Agriculture (Farmland Protection Policy Act of 1981; Title 7 of the *Code of Federal Regulations*, Part 658).

Priority 1 species (Idaho State) – A taxon in danger of becoming extinct in Idaho in the foreseeable future if identifiable factors contributing to its decline continue to operate; these are taxa whose populations are present only at a critically low level or whose habitats have been degraded or depleted to a significant degree.

Priority 2 species (Idaho State) – A taxon likely to be classified as Priority 1 within the foreseeable future in Idaho if factors contributing to its population decline or habitat degradation or loss continue.

priority habitat – A habitat type with unique or significant value to many species that may be described by a (1) unique vegetation type or dominant plant species of primary importance to fish and wildlife (e.g., oak woodlands, eelgrass meadows) or (2) successional stage (e.g., old growth and mature forests). Alternatively, a priority habitat may consist of a specific habitat element (e.g., consolidated marine/estuarine shorelines, talus slopes, caves, snags) of key value to fish and wildlife.

probabilistic risk assessment – A comprehensive, logical, and structured methodology that accounts for population dynamics and human activity patterns at various levels of sophistication, considering time-space distributions and sensitive subpopulations. The probabilistic method results in a more-complete characterization of the exposure information available, which is defined by probability distribution functions. This approach offers the possibility of an associated quantitative measure of the uncertainty around the value of interest.

process – Any method or technique designed to change the physical or chemical character of a product.

processing – As used in this environmental impact statement, any activity necessary to prepare waste for disposal. Processing waste may consist of repackaging, removal, or stabilization of nonconforming waste or treatment of physically or chemically hazardous constituents in compliance with state or Federal regulations.

protactinium – An element produced by the radioactive decay of neptunium-237. This pure metal has a bright metallic luster. The protactinium-233 isotope has a half-life of 27 days and emits beta particles and gamma rays during radioactive decay. (See *beta particle, gamma radiation, half-life [radiological], isotope,* and *radioactive decay*.)

proton – An elementary nuclear particle with a positive charge equal in magnitude to the negative charge of the electron; it is a constituent of all atomic nuclei. The atomic

number of an element indicates the number of protons in the nucleus of each atom of that element. (See *electron* and *nucleus*.)

PUREX – An acronym for plutonium-uranium extraction, the name of the chemical process usually used to remove plutonium and uranium from spent nuclear fuel, irradiated targets, and other nuclear materials.

purpose-built vessel – A vessel specifically designed to carry nuclear fuel casks.

pyrolysis – Chemical decomposition or other chemical change brought about by the action of heat, regardless of the temperature involved.

quality factor – A multiplying factor applied to an absorbed dose to express the biological effectiveness of the radiation producing it. The numerical values of the quality factor are given as a function of the linear energy transfer in water for the radiation producing the absorbed dose. (See *absorbed dose*.)

Quaternary – The second geologic time period of the Cenozoic era, dating from about 1.6 million years ago to the present. It contains two epochs: the Pleistocene and the Holocene, and is characterized by the first appearance of human beings on Earth.

rad – See *radiation absorbed dose*.

radiation absorbed dose (rad) – The basic unit of absorbed dose equal to the absorption of 0.01 joules per kilogram (100 ergs per gram) of absorbing material (such as body tissue). One rad equals 0.01 grays. (See *erg*, *gray*, and *joule*.)

radiation (ionizing) – See *ionizing radiation*.

radioactive decay – The decrease in the amount of any radioactive material with the passage of time due to spontaneous nuclear disintegration (i.e., emission from atomic nuclei of charged particles, photons, or both). (See *nucleus*.)

radioactive waste – In general, waste that is managed for its radioactive content. Waste material that contains source, special nuclear, or byproduct material is subject to regulation as radioactive waste under the Atomic Energy Act. Also, waste material that contains accelerator-produced radioactive material or a high concentration of naturally occurring radioactive material may be considered radioactive waste.

radioactivity – *(process definition)* The spontaneous transformation of unstable atomic nuclei, usually accompanied by the emission of ionizing radiation.

(property definition) The property of unstable nuclei in certain atoms to spontaneously emit ionizing radiation during nuclear transformations. (See *neutron* and *ionizing radiation.*)

radioisotope or radionuclide – An unstable isotope that undergoes spontaneous transformation, emitting radiation. (See *isotope*.)

radiological risk – In general, a measure of potential harm to populations or individuals due to the presence or occurrence of an environmental or manmade radiological hazard. In terms of human health, risk comprises three components: a sequence of events leading to an adverse impact, the probability of occurrence of that sequence of events, and the severity of the impact. For the release of radionuclides affecting a population, the impact is occurrence of a fatal cancer; risk is expressed as the expected number of latent cancer fatalities (i.e., the product of probability of occurrence and the magnitude of impact). For the release of radionuclides affecting individuals, the impact is incidence of cancer; risk is expressed as the probability over a lifetime of developing cancer.

radon – A gaseous, radioactive element with the atomic number 86 resulting from the radioactive decay of radium. Radon occurs naturally in the environment and can collect in unventilated enclosed areas, such as basements. Large concentrations of radon can cause lung cancer in humans.

RADTRAN – A computer code combining user-determined meteorological, demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences and accident risk of transporting radioactive material.

reactivity – The rate of nuclear disintegration in a nuclear reactor. (See *nuclear reactor*.)

reactor accident – See *design-basis accident* and *severe accident*.

reactor containment – A steel-reinforced concrete dome built over a nuclear reactor to trap radioactive vapors that might otherwise be released into the environment during a nuclear accident. (See *nuclear reactor*.)

reactor coolant system – The system used to transfer energy from the reactor core either directly or indirectly to the heat rejection system. (See *nuclear reactor*.)

reactor core – The fuel assemblies, fuel and target rods, control rods, blanket assemblies, and coolant/moderator. Fissioning takes place in this part of the reactor.

reactor facility – Unless it is modified by words such as *containment*, *vessel*, or *core*, this term includes the housing, equipment, and associated areas devoted to the operation and maintenance of one or more reactor cores. Any apparatus that is designed or used to sustain nuclear chain reactions in a controlled manner, including critical and pulsed assemblies and research, tests, and power reactors, is defined as a reactor. All assemblies designed to perform subcritical experiments that could potentially reach criticality are also considered reactors.

receptor – An organism that is exposed to chemicals or radionuclides in the environment. (See *radioisotope or radionuclide*.)

Record of Decision (ROD) – *(National Environmental Policy Act [NEPA] definition)* A concise public document that records a Federal agency's decision(s) concerning proposed actions for which the agency has prepared an environmental impact statement. The ROD is prepared in accordance with Council on Environmental Quality NEPA regulations (Title 40 of the *Code of Federal Regulations*, Section 1505.2). A ROD identifies the alternatives considered in reaching the decision, the environmentally preferred alternative(s), the factors balanced by the agency in making the decision, and whether all practicable means to avoid or minimize environmental harm were adopted, and if not, why they were not. (See *environmental impact statement*.)

(Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] definition) A document that records the selection of remedial actions, facts, analyses, public participation, and site-specific policy determinations considered in the course of carrying out CERCLA cleanup activities.

redd – The nest of gravel or small cobble that a fish makes in a river to lay its eggs.

reductant – A chemical used to reduce the oxidation state (ionic charge) of another chemical.

reference concentration – The chronic-exposure concentration (milligrams per cubic meter) for a given hazardous chemical at which or below which adverse human noncancer health effects are not expected to occur. (See *exposure limit* and *reference dose*.)

reference dose – The chronic-exposure dose (milligrams or kilograms per day) for a given hazardous chemical at which or below which adverse human noncancer health effects are not expected to occur. (See *exposure limit* and *reference concentration*.)

refractory block – A solid object composed of a nonmetallic material that maintains its strength and integrity when exposed to extreme heat. Refractory blocks are used in the construction of structures or system components that are exposed to extremely high temperatures.

refueling outage – The period of time that a reactor is shut down for refueling operations.

region of influence – A site-specific geographic area in which the principal direct and indirect effects of actions are likely to occur and are expected to be of consequence for local jurisdictions.

regional economic area – A geographic area consisting of an economic node, including surrounding counties that are economically related because they include the locations of the places of work and residences of the labor force. Each regional economic area is defined by the U.S. Bureau of Economic Analysis.

regulated substances – A general term used to refer to materials other than radionuclides that may be regulated by other applicable Federal, state, or local requirements.

release – Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a material into the environment. Statutory or regulatory definitions of release may differ.

rem – See *roentgen equivalent man*.

remedial action – Activities conducted to reduce potential risks to people and/or harm to the environment from radioactive and/or hazardous substance contamination. (See *cleanup*.)

remediation – The process, or a phase in the process, of rendering radioactive, hazardous, or mixed waste environmentally safe, whether through processing, entombment, or other methods.

remote-handled waste – In general, refers to radioactive waste that must be handled at a distance (remotely) to protect workers from unnecessary exposure (e.g., waste with a dose rate of 200 millirem per hour or more at the surface of the waste package). (See *contact-handled waste*.)

resin – See *ion exchange resin*.

resource – Valued attribute of a system.

Resource Conservation and Recovery Act (RCRA), as amended – This law gives the U.S. Environmental Protection Agency the authority to control hazardous waste from "cradle to grave" (i.e., from the point of generation to the point of ultimate disposal), including its minimization, generation, transportation, treatment, storage, and disposal. RCRA also sets forth a framework for management of nonhazardous solid waste. (See *hazardous waste*.)

respiration – Processes by which a living organism takes in oxygen from the air or water, distributes and utilizes it in oxidation, and gives off products of oxidation.

retrievably stored waste – Waste stored in a manner intended to permit retrieval at a future time.

Review Group 1 species (Washington State) – A plant taxon of potential concern for which additional fieldwork is needed before a status can be assigned (Washington State Natural Heritage Program, established by the Natural Area Preserves Act [*Revised Code of Washington*, Chapter 79.70]).

Review Group 2 species (Washington State) – A plant taxon of potential concern for which taxonomic questions are unresolved (Washington State Natural Heritage Program, established by the Natural Area Preserves Act [*Revised Code of Washington*, Chapter 79.70]).

***Revised Code of Washington* (RCW)** – The compilation of all permanent laws now in force in the State of Washington; a collection of session laws (enacted by the legislature and signed by the governor or enacted via the initiative process), arranged by topic, with amendments added and repealed laws removed. Temporary laws such as appropriation acts are not included.

riparian – Of or pertaining to the banks of a river or stream.

risk – In general, a measure of potential harm to populations or individuals due to the presence or occurrence of an environmental or manmade hazard. Risk is calculated as the product of the probability of an occurrence of an impact and the magnitude of the impact. The probability can be interpreted as a relative frequency of occurrence, a quantity with no assigned units.

In terms of human health, risk comprises three components: a sequence of events leading to an adverse impact, the probability of occurrence of that sequence of events, and the severity of the impact. For the release of radionuclides affecting a population, the impact is occurrence of a fatal cancer; risk is expressed as the expected number of latent cancer fatalities (i.e., the product of probability of occurrence and the magnitude of impact). For the release of radionuclides affecting individuals, the impact is incidence of cancer; risk is expressed as the probability over a lifetime of developing cancer.

risk assessment (chemical or radiological) – The qualitative and quantitative evaluation performed to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific chemical or radiological materials.

River Protection Project (RPP) – The Hanford Site's U.S. Department of Energy RPP mission is to retrieve and treat the site's tank waste and to close the tank farms to protect the Columbia River.

roentgen – A unit of exposure to ionizing x or gamma radiation equal to or producing one electrostatic unit of charge per cubic centimeter of air. (See *gamma radiation* and *x-rays*.)

roentgen equivalent man (rem) – A unit of dose equivalent. The dose equivalent in rem equals the absorbed dose in rad in tissue multiplied by the appropriate quality factor and possibly other modifying factors. Rem refers to the dosage of ionizing radiation that will cause the same biological effect as 1 roentgen of x-ray or gamma-ray exposure. One rem equals 0.01 sieverts. (See *absorbed dose, dose equivalent, radiation absorbed dose [rad],* and *roentgen*.)

runoff – The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually enters streams.

Safe Drinking Water Act – This act protects the quality of public water supplies, water supply and distribution systems, and all sources of drinking water.

safe, secure trailer (also "safeguarded trailer") – A specially modified semitrailer pulled by an armored tractor truck and used by the U.S. Department of Energy to transport nuclear weapons, nuclear weapon components, or special nuclear material over public highways.

safeguarded trailer – See *safe, secure trailer*.

safeguards – An integrated system of physical protection, material accounting, and material control measures designed to deter, prevent, detect, and respond to unauthorized access, possession, use, or sabotage of nuclear materials.

safety analysis report (SAR) – A report that systematically identifies potential hazards within a nuclear facility, describes and analyzes the adequacy of measures to eliminate or control identified hazards, and analyzes potential accidents and their associated risks. SARs are used to ensure that a nuclear facility can be constructed, operated, maintained, shut down, and decommissioned safely and in compliance with applicable laws and regulations. SARs are required for U.S. Department of Energy (DOE) nuclear facilities and as a part of applications for U.S. Nuclear Regulatory Commission (NRC) licenses. NRC regulations or DOE orders and technical standards that apply to the facility type provide specific requirements for the content of SARs. (See *nuclear facility*.)

safety evaluation report – A document prepared by the U.S. Nuclear Regulatory Commission that evaluates documentation (technical specifications, safety analysis

reports, and special safety reviews and studies) submitted by a reactor licensee for approval. This ensures that all of the safety aspects of part or all of the activities conducted at a reactor are formally and thoroughly analyzed, evaluated, and recorded.

saline – Of or pertaining to salt.

sand – Loose grains of rock or mineral sediment formed by weathering that range in size from 0.0625 to 2.0 millimeters (0.0025 to 0.08 inches) in diameter and often consist of quartz particles.

sanitary waste – Liquid or solid waste generated by normal housekeeping activities (includes sludge) that is not hazardous or radioactive.

scope – The range of actions, alternatives, and impacts to be considered in a document prepared pursuant to the National Environmental Policy Act of 1969.

scoping – An early and open process for determining the scope of issues to be addressed in an environmental impact statement (EIS) and for identifying significant issues related to proposed actions. The scoping period begins upon publication in the *Federal Register* of a Notice of Intent to prepare an EIS. The public scoping process is that portion of the process where the public is invited to participate. The U.S. Department of Energy (DOE) also conducts an early internal scoping process for environmental assessments and EISs. For EISs, this internal scoping process precedes the public scoping process. DOE's scoping procedures are found in Title 10 of the *Code of Federal Regulations*, Section 1021.311.

screening – Type of assessment that allows some receptors, pathways, or stressors to be removed from further consideration with a high degree of confidence by using conservative assumptions.

secondary waste – Waste generated as a result of other activities, e.g., waste retrieval or waste treatment, that is not further treated by the Waste Treatment Plant or supplemental treatment facilities, and includes liquid and solid wastes. Liquid waste sources could include process condensates, scrubber wastes, spent reagents from resins, offgas and vessel vent wastes, vessel washes, floor drain and sump wastes, and decontamination solutions. Solid waste sources could include worn filter membranes, spent ion exchange resins, failed or worn equipment, debris, analytical laboratory waste, high-efficiency particulate air filters, spent carbon adsorbent, and other process-related wastes. Secondary waste can be characterized as low-level radioactive waste, mixed low-level radioactive waste, transuranic waste, or hazardous waste.

security – An integrated system of activities, systems, programs, facilities, and policies for the protection of restricted data and other classified information or matter; nuclear materials, weapons and components; and/or U.S. Department of Energy contractor facilities, property, and equipment.

sediment – Soil, sand, and minerals washed from land into water and deposited on the bottom of a water body.

sediment-dwelling biota – Animals and plants that live in or on the soft substrate in aquatic environments.

seep – A spot where water contained in the ground oozes slowly to the surface and often forms a pool; a small spring. On the Columbia River, seepage occurs below the river surface and exposed riverbank, and is particularly noticeable at the low-river stage. The seeps flow intermittently, apparently influenced primarily by changes in the river level.

seismic – Pertaining to any Earth vibration, especially an earthquake.

seismicity – The frequency and distribution of earthquakes.

sensitive species – *Idaho State:* A taxon with small populations or localized distributions within Idaho that presently do not meet the criteria for classification as Priority 1 or 2, but whose populations and habitats may be

jeopardized without active management or removal of threats.

Washington State: A taxon that is vulnerable or declining and could become endangered or threatened without active management or removal of threats (*Washington Administrative Code* 232-12-297; Washington State Natural Heritage Program, established by the Natural Area Preserves Act [*Revised Code of Washington*, Chapter 79.70]).

severe accident – An accident with a frequency rate of less than 10^{-6} per year that would have more-severe consequences than a design-basis accident in terms of damage to the facility, offsite consequences, or both. Also called "beyond-design-basis reactor accidents" in this environmental impact statement.

sewage – The total organic waste and wastewater generated by an industrial establishment or a community's municipal wastewater.

shielding – In regard to radiation, any material of obstruction (bulkheads, walls, or other construction) that absorbs radiation to protect personnel or equipment.

short-lived activation product – An element formed from neutron interaction that has a relatively short half-life and is not produced from a fission reaction (e.g., a cobalt isotope formed from impurities in the metal of the reactor piping). (See *fission, half-life [radiological], neutron,* and *nuclear reactor*.)

shrub steppe – Plant community consisting of short-statured, widely spaced, small-leaved shrubs, sometimes aromatic, with brittle stems and an understory dominated by perennial bunch grasses.

shutdown – Facility condition where operations and/or construction activities have ceased.

sievert – The International System of Units (SI) unit of radiation dose equivalent. The dose equivalent in sieverts equals the absorbed dose in grays multiplied by the appropriate quality factor (1 sievert equals 100 rem). (See *dose equivalent, gray,* and *roentgen equivalent man [rem]*.)

silica gel – An amorphous, highly adsorbent form of silicon dioxide.

silt – Loose particles of rock or mineral sediment ranging in size from about 0.002 to 0.0625 millimeters (0.00008 to 0.0025 inches) in diameter. Silt is finer than sand, but coarser than clay.

single-shell tank (SST) – Underground reinforced concrete containers with one carbon steel liner that are covered with 2 to 3 meters (6.6 to 9.8 feet) of earth. Capacity ranges from 208,175 to 3.79 million liters (55,000 to 1 million gallons). SSTs have been used to store radioactive and mixed waste.

single-shell tank (SST) system – An area of the Hanford Site high-level radioactive waste tank farm system that includes 149 SSTs, ancillary equipment, and soils (from surface soils to the interface with groundwater) within SST farms and/or waste management area boundaries used to support Hanford Site waste retrieval and storage activities. (See *high-level radioactive waste*.)

sinter – A process in which particles are bonded together by pressure and heating them below the melting point.

site – A geographic entity comprising leased or owned land, buildings, and other structures required to perform program activities.

soil profile – A two-dimensional cross section extending vertically from Earth's surface and exposing all the soil horizons and a part of the relatively unaltered underlying material.

soils – All unconsolidated materials above bedrock; natural earthy materials on Earth's surface, in places modified or even made by human activity, that contain living matter and either support or are capable of supporting plants out of doors.

solid waste – In general, nonliquid, nonsoluble discarded materials, ranging from municipal garbage to industrial waste, that contains complex and sometimes hazardous substances, including sewage sludge, agricultural refuse, demolition waste, and mining residues. For purposes of regulation under the Resource Conservation and Recovery Act, solid waste is "any garbage; refuse; sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility; and other discarded material." Solid waste includes solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. Solid waste does not include solid or dissolved material in domestic sewage or irrigation return flows or industrial discharges, which are point sources subject to permits under Section 402 of the Clean Water Act. Finally, solid waste does not include source, special nuclear, or byproduct material as defined by the Atomic Energy Act. A more-detailed regulatory definition of solid waste can be found in Title 40 of the *Code of Federal Regulations*, Section 261.2. (See *hazardous waste* and *Resource Conservation and Recovery Act*.)

source material – In general, material from which special nuclear material can be derived. Under the Atomic Energy Act and U.S. Nuclear Regulatory Commission regulations, "source material" is uranium and thorium in any physical or chemical form, including ores, containing one-twentieth of 1 percent (0.05 percent) or more by weight of uranium or thorium. (See *special nuclear material*.)

source term – The amount of a specific pollutant (e.g., chemical, radionuclide) emitted or discharged to a particular environmental medium (e.g., air, water) from a source or group of sources. It is usually expressed as a rate (i.e., amount per unit time).

spallation – A nuclear reaction in which light particles are ejected as the result of bombardment (as by high-energy protons). (See *proton*.)

special nuclear material – As defined in Section 11 of the Atomic Energy Act of 1954, special nuclear material includes (1) plutonium, uranium enriched in the isotope 233 or 235, and any other material that the U.S. Nuclear Regulatory Commission determines to be special nuclear material; or (2) any material artificially enriched by any of the above. Hydrogen-3 (tritium) is not a special nuclear material. (See *isotope*.)

species of concern (Federal) – Species whose conservation standing is of concern to the U.S. Fish and Wildlife Service, but for which status information is still needed.

spectral (response) acceleration – An approximate measure of the acceleration (as a percentage of the acceleration due to Earth's gravity) experienced by a building, as modeled by a particle on a massless vertical rod that has the same natural period of vibration as the building.

spent nuclear fuel – Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.

stability class – A category characterizing the degree of stability (absence of turbulence) in the atmosphere. The classification used for regulatory models and methods for estimating the appropriate stability category from other meteorological data are given by the U.S. Environmental Protection Agency.

stabilization – Mixing an agent such as Portland cement with waste to increase the mechanical strength of the resulting waste form and decrease its leachability.

stable isotope – Variation of an element that has the same atomic number but a different weight (because of the number of neutrons in its nucleus) and that does not undergo radioactive decay. (See *neutron*, *nucleus*, and *radioactive decay*.)

standard (waste packaging) – The common forms of waste packages (such as drums and boxes) used for low-level radioactive waste

(LLW) and mixed LLW. (See *nonstandard [waste packaging]*.)

State Environmental Policy Act (SEPA) – The State of Washington's environmental law enacted in 1971 as Chapter 43.12C of the *Revised Code of Washington*. The purposes of this law are to (1) declare a state policy that will encourage productive and enjoyable harmony between man and his environment, (2) promote efforts that will prevent or eliminate damage to the environment and biosphere, (3) stimulate the health and welfare of man, and (4) enrich the understanding of the ecological systems and natural resources important to the state and Nation.

steady state model – A representation of a system with state variables that do not change in value over time; the parameters and inputs are constant.

steam reforming – A thermal process that immobilizes waste by converting (1) low-activity waste solutions (tank waste) to granular minerals and volatilizing water and (2) the decomposing organic compounds, nitrate, and nitrite present in the tank waste to carbon dioxide, water, and nitrogen. (See *low-activity waste*.)

stochastic analysis – A set of calculations performed using values randomly selected from a range of reasonable values for one or more parameters. In this environmental impact statement, the median value is reported (in contrast, see *deterministic analysis*).

stochastic variability – Natural variation of a measured quantity. For example, in a room full of people, there is an average height, with some being taller and some shorter; the stochastic variability of that group is described by the differences between the individuals' heights and the average.

storage – Holding waste for a temporary period, at the end of which the waste is treated, disposed of, or stored elsewhere.

stratigraphy – The science of the description, correlation, and classification of strata in sedimentary rocks, including interpretation of the depositional environments of those strata.

sulfate removal – Sulfate, a significant component in the supernatant fractions of tank waste at the Hanford Site, poses serious economic impacts (creating more glass) and risks for the low-activity waste (LAW) vitrification process. Sulfate tends to phase-separate in the melter, forming a corrosive molten sulfate salt layer on top of the glass melt that will damage the melter if allowed to accumulate. Removal of the sulfate from the LAW before vitrifying can mitigate these problems. The sulfate removal approach comprises sulfate precipitation using strontium nitrate addition, filtration, and solidification with grout-forming additives for immobilized waste. (See *immobilization*, *low-activity waste*, *melter*, and *vitrification*.)

sulfur oxides – Common air pollutants, primarily sulfur dioxide, a heavy, pungent, colorless gas formed in the combustion of fossil fuels and considered a major air pollutant, and sulfur trioxide. Sulfur dioxide is involved in the formation of acid rain. It can also irritate the upper respiratory tract and cause lung damage.

supernatant – The liquid that stands over a precipitated material.

supplemental treatment – As used in this environmental impact statement, a waste treatment process used to solidify or immobilize the low-activity waste fraction of tank waste in addition to the Waste Treatment Plant vitrification process. (See *immobilization*, *low-activity waste*, and *vitrification*.)

surface water – All bodies of water on the surface of Earth that are open to the atmosphere, such as rivers, lakes, reservoirs, ponds, seas, and estuaries.

surficial material (deposit) – Any loose, unconsolidated sedimentary deposit lying on or above bedrock.

suspect transuranic (TRU) waste – Suspect TRU waste is radioactive waste that is thought to be TRU waste, but for which adequate characterization data are not yet available to confirm the classification.

tank systems – *Single-shell tank (SST) system:* All 149 SSTs, ancillary equipment (e.g., pipes and pits), and soils (from surface to interface with groundwater) within SST farms and/or waste management area boundaries. (See *single-shell tank*.)

Double-shell tank (DST) system: Existing and new DSTs, as well as the ancillary equipment and soils within the DST farms. (See *double-shell tank*.)

target – A tube, rod, or other form containing material that, on being irradiated in a nuclear reactor or an accelerator, would produce a desired end product. (See *nuclear reactor*.)

taxa – Plural of taxon. (See *taxon*.)

taxon – A group of organisms sharing common characteristics in varying degrees of distinction that constitute one of the categories of taxonomic classification, such as a phylum, class, order, family, genus, or species.

technical specifications – In regard to U.S. Nuclear Regulatory Commission (NRC) regulations, part of an NRC license authorizing the operation of a nuclear reactor facility. A technical specification establishes requirements for items such as safety limits and limits on safety system settings, control settings, and conditions for operation, as well as surveillance requirements, design features, and administrative controls.

tectonic – Of or relating to motion in Earth's crust and occurring along geologic faults.

TEEL-0, -1, -2, and -3 – See *Temporary Emergency Exposure Limits.*

teleost fish – Of or belonging to the Teleostei or Teleostomi, a large group of fish with bony skeletons, including most common fish. The teleosts are distinct from cartilaginous fish such as sharks, rays, and skates.

temporal use factor – The ratio of the amount of time that an organism uses an area of contamination per unit time.

Temporary Emergency Exposure Limits (TEELs) – Values developed by the U.S. Department of Energy (DOE) for use in DOE facility hazard analyses and emergency planning and response for chemicals lacking Acute Exposure Guideline Levels or Emergency Response Planning Guidelines. TEEL values are applied to the peak 15-minute time-weighted average concentration at the point of interest and are defined for varying degrees of severity of toxic effects, as follows:

TEEL-0: The threshold concentration below which most people will experience no appreciable risk of health effects.

TEEL-1: The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

TEEL-2: The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

TEEL-3: The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

terrestrial – Of or pertaining to life on land.

Tertiary – The first geologic time period of the Cenozoic era (after the Mesozoic era and before the Quaternary period), spanning between about 66 million and 1.6 million years ago. During this period, mammals became the dominant life form on Earth.

thermal treatment – Treatment of waste in a device that uses elevated temperature to change

the chemical, physical, or biological character of the waste. Examples include, but are not limited to, vitrification, pyrolysis, steam reforming, and calcination.

threatened species – *Federal:* Species that are likely to become endangered species within the foreseeable future throughout all or a significant portion of their ranges and have been listed as threatened by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures set out in the Endangered Species Act (Title 16 of the *United States Code*, Parts 1551 through 1599) and its implementing regulations (Title 50 of the *Code of Federal Regulations* [CFR], Part 424).

The lists of threatened species can be found at 50 CFR, Sections 17.11 (wildlife), 17.12 (plants), and 227.4 (marine organisms).

Idaho State: Any wildlife species native to the state that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state if factors contributing to its decline continue. (See *candidate species* and *endangered species*.)

Washington State: Any wildlife species native to the state that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state if factors contributing to its decline continue (*Washington Administrative Code* 232-12-297; Washington State Natural Heritage Program, established by the Natural Area Preserves Act [*Revised Code of Washington*, Chapter 79.70]). (See *candidate species* and *endangered species*.)

threshold limit values – The recommended highest concentrations of contaminants to which workers may be exposed according to the American Conference of Governmental Industrial Hygienists.

total effective dose equivalent (TEDE) – The sum of the effective dose equivalent from external exposures and the committed effective dose equivalent from internal exposures. TEDE is expressed in units of rem (or sieverts). (See *dose equivalent* and *roentgen equivalent man [rem]*.)

total recordable cases – The total number of cases recorded of work-related (1) deaths or (2) illnesses or injuries resulting in loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid.

total uranium – As used in this environmental impact statement, the total concentration of all of the 14 isotopes of uranium used for calculating *nonradiological* human health and ecological risk. (See *uranium* and *uranium-238*.)

Toxic Substances Control Act of 1976 – This law requires that the health and environmental effects of all new chemicals be reviewed by the U.S. Environmental Protection Agency before they are manufactured for commercial purposes. This act also imposes strict limitations on the use and disposal of polychlorinated biphenyls, chlorofluoro-carbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium.

Toxic Substances Control Act (TSCA) waste – Any waste, including polychlorinated biphenyl–commingled waste, regulated under TSCA requirements as codified in Title 40 of the *Code of Federal Regulations*, Part 761.

toxicity reference value – An exposure level from a valid scientific study that represents a threshold for some level of ecological effect.

toxicity test – An experiment to measure the adverse physiological effect in living organisms resulting from exposure to a chemical substance.

toxicological – Of or pertaining to a poison.

toxicological impact – Impact on human health, due to exposure to, or intake of, chemical materials. These impacts are typically described in terms of damage to affected organs.

traditional cultural property – A property or place that is eligible for inclusion on the National Register of Historic Places because of its association with cultural practices and beliefs that are (1) rooted in the history of a community and (2) important to maintaining the continuity of that community's traditional beliefs and practices.

transients – Events that could cause a change or disruption of plant thermal, hydraulic, or neutronic behavior.

transportation index (of the package or packages) – Defined as the highest package dose rate (millirem per hour) that would be received by an individual located at a distance of 1 meter (3.3 feet) from the external surface of the package. (See *dose*.)

transuranic – Refers to any element with an atomic number higher than uranium (atomic number 92), including neptunium, plutonium, americium, and curium. All transuranic elements are produced artificially and are radioactive.

transuranic isotope – Isotopes of any element having an atomic number greater than 92 (the atomic number of uranium). (See *isotope*.)

transuranic (TRU) waste – Radioactive waste containing more than 100 nanocuries (3,700 becquerels) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by Title 40 of the *Code of Federal Regulations* (CFR), Part 191, disposal regulations; or (3) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR, Part 61. (See *alpha particle*, *half-life [radiological]*, and *high-level radioactive waste*.)

treatment – The physical, chemical, or biological processing of dangerous waste to make such waste nondangerous or less dangerous, safer for transport, amenable for energy or material resource recovery, amenable for storage, or lesser in volume, with the exception of compacting, repackaging, and sorting, as allowed under *Washington Administrative Code* 173-303-400(b) and 173-303-600. For radioactive waste, treatment is any method, technique, or process designed to change the physical or chemical character of waste to render it less hazardous; safer to transport, store, or dispose of; or lesser in volume.

treatment, storage, and disposal facility – A facility engaged in the treatment, storage, and/or disposal of hazardous waste. These facilities are the last link in the cradle-to-grave hazardous waste management system.

trench (ditch) – A depression dug in the ground, open to the atmosphere, and designed for disposal of low-level or intermediate-level radioactive waste. It uses the moisture retention capability of the relatively dry soils above the groundwater.

Tri-Party Agreement (TPA) – See *Hanford Federal Facility Agreement and Consent Order*.

tritiated – Containing hydrogen-3 (tritium).

trivalent – Having a valence of three. (See *valence*.)

trophic level – The number of feeding relations between an organism and an abiotic energy source.

Type A packaging – A regulatory category of packaging for transportation of radioactive materials. Type A packaging must be designed and demonstrated to retain its containment and shielding integrity under normal conditions of transport. Examples of Type A packaging include 0.21-cubic-meter (55-gallon) drums and standard waste boxes. Type A packaging is used to transport materials with low radioactivity levels and usually does not require special handling, packaging, or transportation equipment. (See *Type B packaging*.)

Type B packaging – A regulatory category of packaging for transportation of radioactive material. The U.S. Department of Transportation and U.S. Nuclear Regulatory Commission (NRC) require Type B packaging for shipping highly radioactive material. Type B packages must be designed and demonstrated to retain their containment and shielding integrity under severe accident conditions, as well as under the normal conditions of transport. The current NRC testing criteria for Type B package designs (Title 10 of the *Code of Federal Regulations*, Part 71) are intended to simulate severe accident conditions, including impact, puncture, fire, and immersion in water. The most widely recognized Type B packages are the massive casks used for transporting spent nuclear fuel. Large-capacity cranes and mechanical lifting equipment are usually needed to handle Type B packages.

Type B shipping cask – A U.S. Nuclear Regulatory Commission–certified cask with a protective covering that contains and shields radioactive materials, dissipates heat, prevents damage to the contents, and prevents criticality during normal shipment and accident conditions. It is used for transport of highly radioactive materials and is tested under severe, hypothetical accident conditions that demonstrate resistance to impact, puncture, fire, and submersion in water.

unit cancer risk – A quantitative measure of the likelihood that a substance is a human carcinogen that estimates risk from oral or inhalation exposure. This estimate can be in terms of either risk per microgram per liter of drinking water or risk per microgram per cubic meter of inhaled air.

untilled – Not plowed for cultivation.

uptake mechanisms (routes) – Means by which a chemical enters an organism from the environment (e.g., ingestion, inhalation, dermal absorption).

uranium – A radioactive, metallic element with the atomic number 92; one of the heaviest naturally occurring elements. Uranium has 14 known isotopes, of which uranium-238 is the most abundant in nature. Uranium-235 is commonly used as a fuel for nuclear fission. (See *depleted uranium, enriched uranium, highly enriched uranium, isotope,* and *natural uranium*.)

uranium-238 – As used in this environmental impact statement, the total concentration of all of the 14 isotopes of uranium used for calculating *radiological* human health and ecological risk. (See *uranium* and *total uranium*.)

U.S. Nuclear Regulatory Commission (NRC) – The Federal agency that regulates the civilian nuclear power industry in the United States.

vadose zone – The region of soil and rock between the ground surface and the top of the water table in which pore spaces are only partially filled with water. Over time, contaminants in the vadose zone often migrate downward to the underlying aquifer. (See *aquifer*.)

valence – The combining capacity of an atom or radical determined by the number of electrons that it will lose, add, or share when it reacts with other atoms. (See *hexavalent, hexavalent chromium,* and *trivalent*.)

viewshed – The extent of an area that may be viewed from a particular location. Viewsheds are generally bounded by topographic features such as hills or mountains.

Visual Resource Management class – Any of the classifications of visual resources established through application of the Visual Resources Management process of the U.S. Bureau of Land Management. Four classifications are employed to describe different degrees of modification to landscape elements: Class I, areas where the natural landscape is preserved, including national wilderness areas and the wild sections of national wild and scenic rivers; Class II, areas with very limited land development activity, resulting in visual contrasts that are seen, but do not attract attention; Class III, areas in which development may attract attention, but

the natural landscape still dominates; and Class IV, areas in which development activities may dominate the view and may be the major focus in the landscape.

vitrification – A method used to immobilize waste (radioactive, hazardous, and mixed). This involves adding glass formers and waste to a vessel and melting the mixture into a glass. The purpose of this process is to permanently immobilize the waste and isolate it from the environment. (See *immobilization*.)

volatile organic compound – Any of a broad range of organic compounds, often halogenated, that vaporize at ambient or relatively low temperatures, such as benzene, chloroform, and methyl alcohol. In regard to air pollution, any organic compound that participates in atmospheric photochemical reaction, except for those determined by the U.S. Environmental Protection Agency Administrator to have negligible photochemical reactivity.

***Washington Administrative Code* (WAC)** – Regulations of the executive branch agencies in the State of Washington as issued by the authority of statutes. The WAC codifies the regulations of the State of Washington and arranges them by subject or responsible agency. The WAC, which is a source of primary law, also states how agencies shall organize and adopt rules and regulations.

waste acceptance criteria – The technical and administrative requirements that a waste must meet for it to be accepted at a treatment, storage, or disposal facility.

waste certification – A process by which a waste generator certifies that a given waste or waste stream meets the waste acceptance criteria of the facility to which the generator intends to transfer waste for treatment, storage, or disposal.

waste characterization – Identification of waste composition and properties to determine appropriate storage, treatment, handling, transportation, and disposal requirements by (1) reviewing process knowledge, (2) nondestructive examination, (3) nondestructive assay, or (4) sampling and analysis.

waste classification – Wastes are classified according to U.S. Department of Energy Manual 435.1-1, *Radioactive Waste Management Manual*, and include high-level radioactive, transuranic, and low-level radioactive wastes.

waste container – Any portable device in which a material is stored, transported, treated, disposed of, or otherwise handled (*Washington Administrative Code* 173-303-400). A waste container may include any liner or shielding material that is intended to accompany the waste in disposal. At the Hanford Site, waste containers typically consist of 208- or 320-liter (55- or 85-gallon) drums and standard waste boxes. Other sizes and styles of containers may also be employed, depending on the physical, radiological, and chemical characteristics of the waste.

waste disposal – See *disposal*.

Waste Isolation Pilot Plant (WIPP) – A U.S. Department of Energy facility designed and authorized to permanently dispose of transuranic radioactive waste in a mined underground facility in deep geologic salt beds. WIPP is located in southeastern New Mexico, 42 kilometers (26 miles) east of the city of Carlsbad.

waste life cycle – The life of a waste from generation through storage, treatment, transportation, and disposal.

waste management – The planning, coordination, and direction of those functions related to the generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated surveillance and maintenance activities.

waste minimization and pollution prevention – An action that economically avoids or reduces the generation of waste and pollution by source reduction, reducing the toxicity of hazardous waste and pollution, improving

energy use, or recycling. These actions will be consistent with the general goal of minimizing present and future threats to human health, safety, and the environment.

waste stream – A waste or group of wastes from a process or a facility with similar physical, chemical, or radiological properties. In the context of this environmental impact statement, a waste stream is defined as a collection of wastes with physical and chemical characteristics that will generally require the same management approach (use of the same treatment, storage, and disposal capabilities).

waste treatment facilities – Includes existing and new facilities required to complete waste treatment.

Waste Treatment Plant (WTP) – Facility designed and built to thermally treat and immobilize tank waste at the U.S. Department of Energy's Hanford Site.

watch list species (Washington State) – A category of plant species, as identified by the Washington State Natural Heritage Program, established by the Natural Area Preserves Act (*Revised Code of Washington*, Chapter 79.70). Watch list species consist of those plant taxa of concern that are more abundant and/or less threatened than previously assumed.

water table – The boundary between the unsaturated zone and the deeper, saturated zone. The upper surface of an unconfined aquifer.

weighting factor – Generally, a method of attaching different importance values to different items or characteristics. In the context of radiation protection, the proportion of the risk of effects resulting from irradiation of a particular organ or tissue to the total risk of effects when the whole body is irradiated uniformly (e.g., the organ dose weighting factor for the lung is 0.12, compared to 1.0 for the whole body). Weighting factors are used to calculate the effective dose equivalent. (See *dose equivalent*.)

wetlands – Those areas that are inundated by surface water or groundwater with a frequency that is sufficient to support, and under normal circumstances do or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas (e.g., sloughs, potholes, wet meadows, river overflow areas, mudflats, natural ponds).

Jurisdictional wetlands are those wetlands protected by the Clean Water Act. They must have a minimum of one positive wetland indicator from each parameter (i.e., vegetation, soil, and hydrology). The U.S. Army Corps of Engineers requires a permit to fill or dredge jurisdictional wetlands.

whole-body dose – In regard to radiation, a dose of radiation resulting from the uniform exposure of all organs and tissues in a human body. (See *effective dose equivalent*.)

wind rose – A circular diagram showing, for a specific location, the percentage of time the wind is from each compass direction. A wind rose for use in assessing consequences of airborne releases also shows the frequency of different windspeeds for each compass direction.

x-rays – Penetrating electromagnetic radiation with a wavelength much shorter than that of visible light. X-rays are identical to gamma rays, but originate outside the nucleus, either when the inner orbital electrons of an excited atom return to their normal state or when a metal target is bombarded with high-speed electrons. (See *electron*, *gamma radiation*, and *nucleus*.)

zircaloy – An alloy of zirconium containing tin, iron, chromium, and nickel.

zooplankton – Microscopic animals floating in a body of water that are incapable of countering water movements.

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Education: B.S., Biology, Eastern Washington University
Experience: 9 years

Stengle, Ryan
EIS Responsibilities: *Computer Support, Vadose Zone and Groundwater Flow and Transport Modeling and Analysis*
Education: B.S., Biology, Central Washington State University
B.S., Anthropology, Central Washington State University
Experience: 6 years

Yates, Ryan
EIS Responsibilities: *Vadose Zone and Groundwater Flow and Transport Modeling and Analysis*
Education: B.S., Environmental Science, Washington State University
Experience: 4 years

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