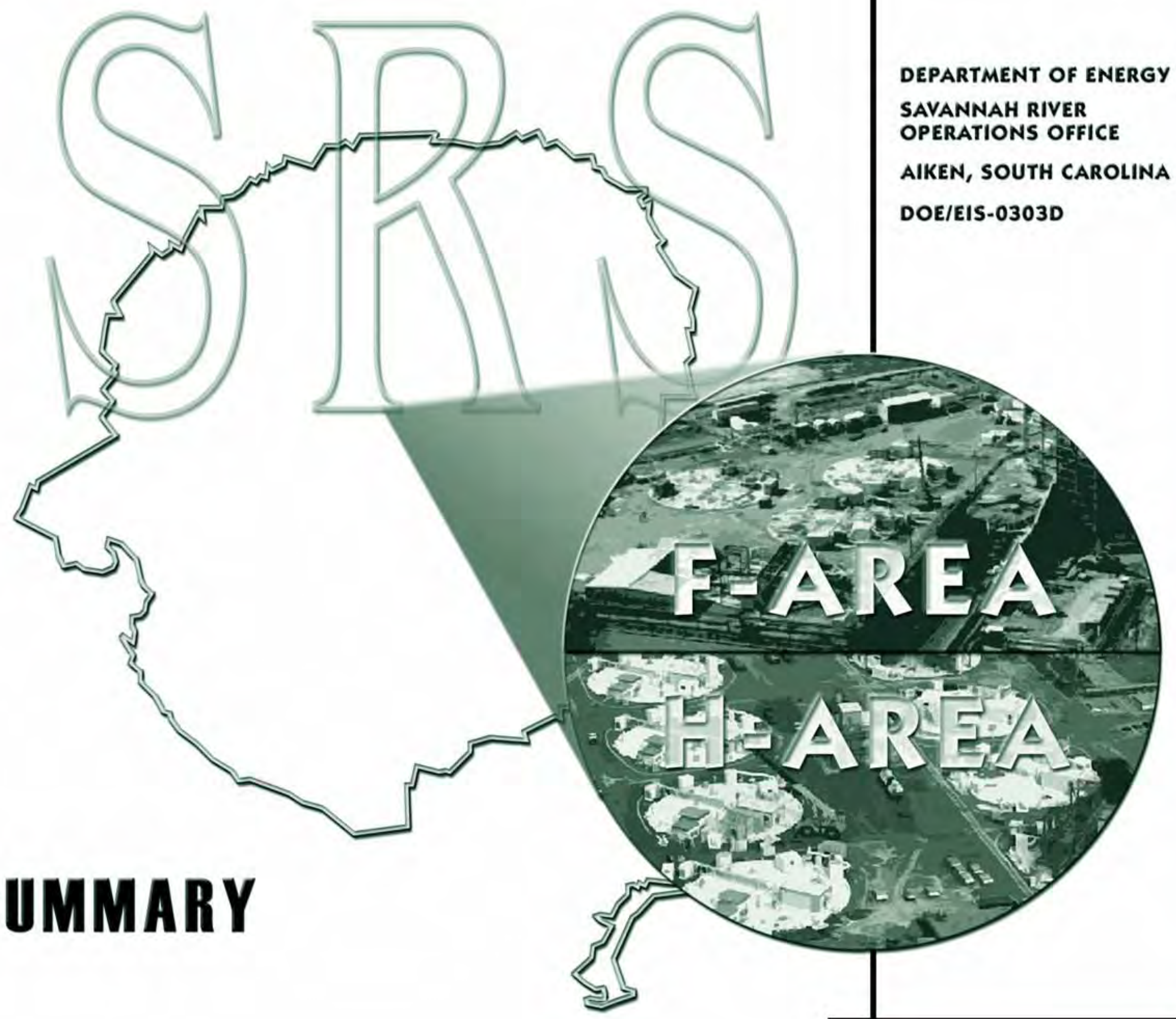
Savannah River Site

HIGH- LEVEL WASTE
TANK CLOSURE
Draft Environmental Impact Statement

DEPARTMENT OF ENERGY
SAVANNAH RIVER
OPERATIONS OFFICE
AIKEN, SOUTH CAROLINA
DOE/EIS-0303D



SUMMARY

November 2000

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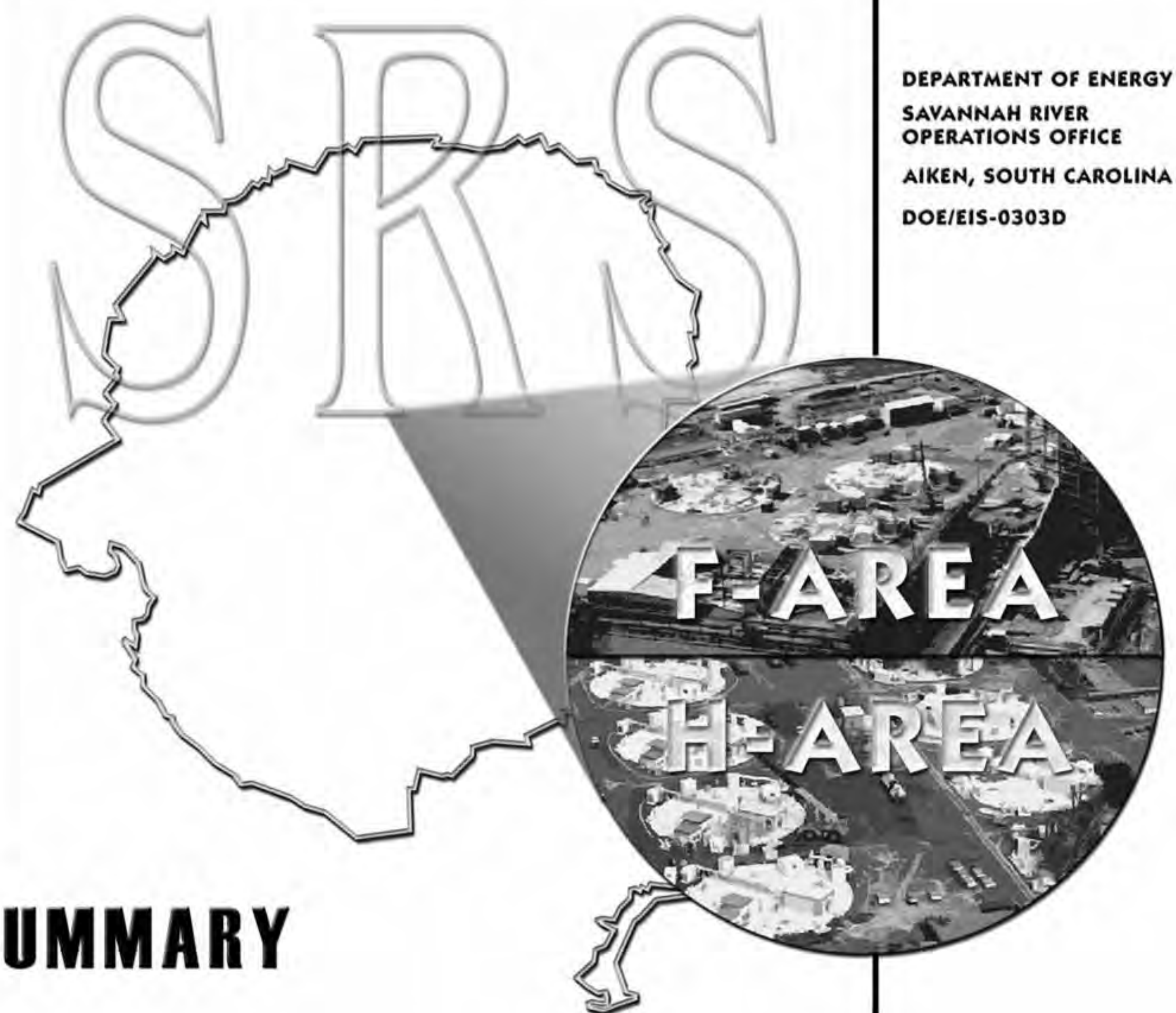

SUMMARY

DEPARTMENT OF ENERGY
SAVANNAH RIVER
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November 2000

COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy (DOE)

TITLE: Savannah River Site, High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE/EIS-0303D), Aiken, SC.

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ABSTRACT: DOE proposes to close the high-level waste (HLW) tanks at the Savannah River Site (SRS) in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (approved by the South Carolina Department of Health and Environmental Control), which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin after bulk waste removal has been completed. This EIS evaluates three alternatives regarding the HLW tanks at the SRS. The three alternatives are the Clean and Stabilize Tanks Alternative, the Clean and Remove Tanks Alternative, and the No Action Alternative. The EIS considers three options for tank stabilization: Fill with Grout (Preferred Alternative); Fill with Sand; and Fill with Saltstone.

Under each alternative (except No Action), DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines. Impacts are assessed primarily in the areas of water resources, air resources, public and worker health, waste management, socioeconomic impacts, and cumulative impacts.

PUBLIC INVOLVEMENT: In preparing this Draft EIS, DOE considered comments received by letter and voice mail and formal statements made at public scoping meetings in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999.

A 45-day comment period on the Draft High-Level Waste Tank Closure EIS begins with the U.S. Environmental Protection Agency's publication of a Notice of Availability in the *Federal Register*. Public meetings to discuss and receive comments on the Draft EIS will be held on December 11, 2000 at the North Augusta Community Center, North Augusta, South Carolina, and on December 12, 2000 at the Adams Mark Hotel, Columbia, South Carolina. Comments may be submitted at the public meeting and by voice mail, e-mail, and regular mail to the first address above. Comments received or postmarked by the end of the comment period will be considered in the preparation of the final EIS. Comments received or postmarked after the close of the comment period will be considered to the extent practicable.

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ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

Acronyms

AAQS	ambient air quality standard
AEA	Atomic Energy Act of 1954
ALARA	as low as reasonably achievable
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLSM	controlled low-strength material
CO	carbon monoxide
D&D	decontamination and decommissioning
DBE	design basis event
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FR	Federal Register
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste
IMNM	Interim Management of Nuclear Material
INEEL	Idaho National Engineering and Environmental Laboratory
ISO	International Organization for Standardization
LCF	latent cancer fatality
LEU	low enriched uranium
LWC	lost workday cases

MCL	maximum contaminant level
MEI	maximally exposed (offsite) individual
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_X	nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
O_3	ozone
OSHA	Occupational Safety and Health Administration
PM_{10}	particulate matter less than 10 microns in diameter
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
ROI	Region of Influence
SCDHEC	South Carolina Department of Health and Environmental Control
SO_2	sulfur dioxide
SRS	Savannah River Site
TRC	total recordable cases
TSP	total suspended particulates
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

cfm	cubic feet per minute
cfs	cubic feet per second = 448.8 gallons per minute = 0.02832 cubic meter per second
cm	centimeter
gpm	gallons per minute
kg	kilogram
L	liter = 0.2642 gallon
lb	pound = 0.4536 kilogram
mg	milligram
µCi	microcurie
µg	microgram
pCi	picocurie
°C	degrees Celsius = 5/9 (degrees Fahrenheit – 32)
°F	degrees Fahrenheit = 32 + 9/5 (degrees Celsius)

Use of Scientific Notation

Very small and very large numbers are sometimes written using "scientific notation" or "E-notation" rather than as decimals or fractions. Both types of notation use exponents to indicate the power of 10 as a multiplier (i.e., 10^n, or the number 10 multiplied by itself "n" times; 10^{-n}, or the reciprocal of the number 10 multiplied by itself "n" times).

For example: $10^3 = 10 \times 10 \times 10 = 1{,}000$

$$10^{-3} = \frac{1}{10 \times 10 \times 10} = 0.001$$

In scientific notation, large numbers are written as a decimal between 1 and 10 multiplied by the appropriate power of 10:

> 4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1{,}000 = 4{,}900$
> 0.049 is written 4.9×10^{-2}
> 1,490,000 or 1.49 million is written 1.49×10^6

A positive exponent indicates a number larger than or equal to one; a negative exponent indicates a number less than one.

In some cases, a slightly different notation ("E-notation") is used, where "× 10" is replaced by "E" and the exponent is not superscripted. Using the above examples

> $4{,}900 = 4.9 \times 10^3 = 4.9\text{E+03}$
> $0.049 = 4.9 \times 10^{-2} = 4.9\text{E-02}$
> $1{,}490{,}000 = 1.49 \times 10^6 = 1.49\text{E+06}$

Metric Conversion Chart

To convert into metric			To convert out of metric		
If you know	**Multiply by**	**To get**	**If you know**	**Multiply by**	**To get**
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
Area					
sq. inches	6.4516	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.092903	sq. meters	sq. meters	10.7639	sq. feet
sq. yards	0.8361	sq. meters	sq. meters	1.196	sq. yards
acres	0.0040469	sq. kilometers	sq. kilometers	247.1	acres
sq. miles	2.58999	sq. kilometers	sq. kilometers	0.3861	sq. miles
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					
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths, then add 32	Fahrenheit

Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa-	E	1 000 000 000 000 000 000 = 10^{18}
peta-	P	1 000 000 000 000 000 = 10^{15}
tera-	T	1 000 000 000 000 = 10^{12}
giga-	G	1 000 000 000 = 10^{9}
mega-	M	1 000 000 = 10^{6}
kilo-	k	1 000 = 10^{3}
centi-	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro-	µ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}
femto-	f	0.000 000 000 000 001 = 10^{-15}
atto-	a	0.000 000 000 000 000 001 = 10^{-18}

S.1 Introduction

The U.S. Atomic Energy Commission, a U.S. Department of Energy (DOE) predecessor agency, established the Savannah River Site (SRS) near Aiken, South Carolina, in the early 1950s. The primary mission of SRS was to produce nuclear materials for national defense. With the end of the Cold War and the reduction in the size of the United States' stockpile of nuclear weapons, the SRS mission has changed. While national defense is still an important facet of the mission, SRS no longer produces nuclear materials and the mission is focused on material stabilization, environmental restoration, waste management, and decontamination and decommissioning of facilities that are no longer needed.

As a result of its nuclear materials production mission, SRS generated large quantities of highly corrosive and radioactive waste known as high-level waste (HLW). The HLW resulted from dissolving spent reactor fuel and nuclear targets to recover the valuable radioactive isotopes. DOE had stored the HLW in 51 large underground storage tanks located in the F- and H-Area Tank Farms at SRS. DOE has emptied and closed two of those tanks. DOE is treating the HLW using a process called vitrification. The highly radioactive portion of the waste is mixed with a glass-like material and stored in stainless steel canisters at SRS, pending shipment to a geologic repository for disposal. This process is currently underway at SRS, in the Defense Waste Processing Facility (DWPF).

The HLW tanks at SRS are of four different types, which provide varying degrees of protection to the environment due to different degrees of containment. The tanks are operated under the authority of the Atomic Energy Act of 1954 (AEA) and DOE Orders issued under the AEA. The tanks are permitted by the South Carolina Department of Environmental Control (SCDHEC) under the South Carolina wastewater regulations, which require permitted facilities to be closed after they are removed from service. DOE has entered into an agreement with the U.S. Environmental Protection Agency (EPA) and SCDHEC to close the HLW tanks after they have been removed from service. Closure of the HLW tanks will comply with DOE's responsibilities under the AEA and the South Carolina closure requirements, and be carried out under a schedule agreed to by DOE, EPA, and SCDHEC.

There are several ways to close the HLW tanks. DOE has prepared this Environmental Impact Statement to ensure that the public and DOE's decisionmakers have a thorough understanding of the potential environmental impacts of alternative means of closing the tanks before one method is chosen. This Summary provides a brief description of the HLW tanks and the closure process, describes the National Environmental Policy Act (NEPA) process that DOE is using to aid in decisionmaking, summarizes the alternatives for closing the HLW tanks and identifies DOE's preferred alternative, and outlines the major conclusions, areas of controversy, and issues that remain to be resolved as DOE proceeds with the HLW tank closure process.

S.2 High-Level Waste Storage and Tank Closure

S.2.1 HIGH-LEVEL WASTE

DOE Manual 435.1-1, which provides direction for implementing DOE Order 435.1, Radioactive Waste Management, defines HLW as "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."

S.2.2 HIGH-LEVEL WASTE MANAGEMENT AT THE SAVANNAH RIVER SITE

Currently, about 34 million gallons of HLW are stored in 49 underground tanks in two tank farms, the F-Area Tank Farm and the H-Area Tank Farm. Two additional tanks have been closed. The tank farms are in the central part of the SRS, about 5.5 miles from the SRS boundaries. Figure S-1 shows the locations of F- and H-Areas and the tank farms.

The HLW in the tanks is in three forms: sludge, salt, and liquid. The sludge is solid material that has precipitated and settled to the bottom of the tank. The salt is comprised of salt compounds[1] that have crystallized as a result of concentrating the liquid by evaporation. The liquid is a highly concentrated solution of salt compounds in water. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks, while others are considered salt tanks, containing both salt and liquid.

HLW management systems at SRS are designed to place the high-radioactivity fraction of the HLW in a form (borosilicate glass) that can be disposed of in a geologic repository, and to dispose of the low-radioactivity fraction in vaults at the SRS. The sludge portion of the HLW is being transferred to the DWPF for vitrification in borosilicate glass. The glass is poured into stainless steel canisters at the DWPF and the filled and sealed canisters are stored nearby, pending shipment to a geologic repository. Almost 1,000 canisters have been filled and stored.

The salt and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before treatment. As described in the *Defense Waste Processing Facility Supplemental Environmental Impact Statement* (DOE/EIS-0082S*)*, any In-Tank Precipitation Process would separate the salt and liquid portions of the HLW into high- and low-radioactivity fractions. The high-radioactivity fraction would be transferred to the DWPF for vitrification along with the sludge portion. The low-radioactivity fraction would be transferred to the Saltstone Manufacturing and Disposal Facility in Z-Area and mixed with grout to make a concrete-like material to be disposed of in vaults at SRS. Since issuance of that EIS, DOE has concluded that the In-Tank Precipitation Process, as currently configured, cannot achieve production goals and meet safety requirements for processing the salt portion of HLW (64 FR 8559, February 22, 1999). DOE is conducting research and development for a new technology for separating the salt and liquid portions of the HLW and is preparing an EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site*, to evaluate the impacts of alternative technologies. Figure S-2 shows the current configuration of the SRS HLW management system.

S.2.3 HIGH-LEVEL WASTE TANKS AND TANK FARMS

The F-Area Tank Farm is a 22-acre site that contains 20 active waste tanks, 2 closed waste tanks (Tanks 17 and 20), 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure S-3 shows the general layout of the F-Area Tank Farm. The H-Area Tank Farm is a 45-acre site with 29 waste tanks, 3 evaporator systems (including the new Replacement High-Level Waste Evaporator), the In-Tank Precipitation Process, the Extended Sludge Processing Facility, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure S-4 shows the general layout of the H-Area Tank Farm.

The HLW tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. The major design features and dimensions of each tank design are shown in Figure S-5.

There are 12 Type I tanks (4 in H-Area and 8 in F-Area) that were built in 1952 and 1953. These tanks have partial height secondary containment and active cooling. The tank tops are 9.5 feet below grade, and the bottoms of Tanks 1 through 8 in F-Area are above the seasonal high water table. The bottoms of Tanks 9 through 12 in H-Area are in the water table. Tanks 1 and 9 through 12 are known to have leak sites where waste has leaked from the primary to the secondary containment. There is no evidence that the waste has leaked from the secondary containment.

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[1] A salt is a chemical compound formed when one or more hydrogen ions of an acid are replaced by metallic ions. Common salt, sodium chloride, is a well-known salt.

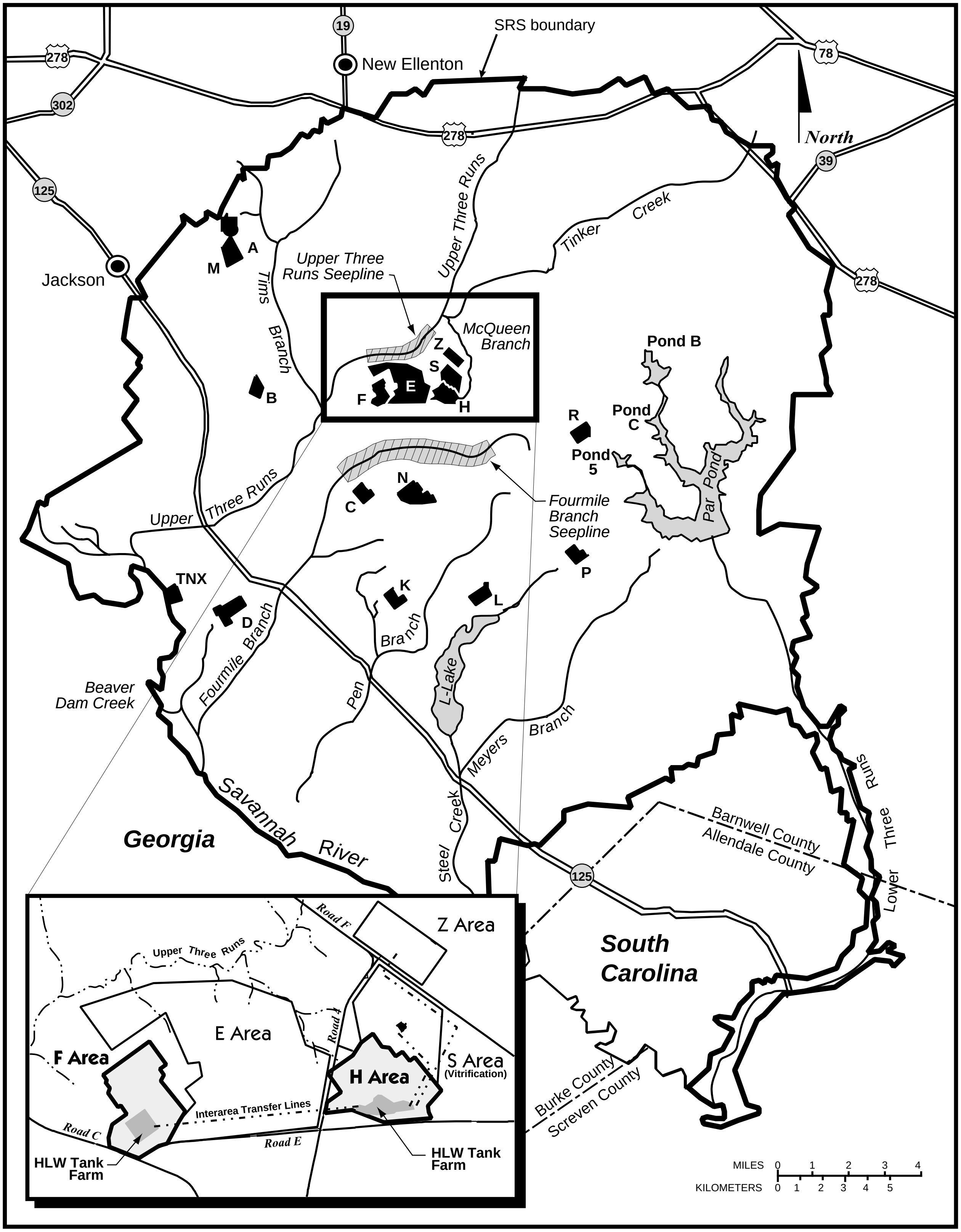
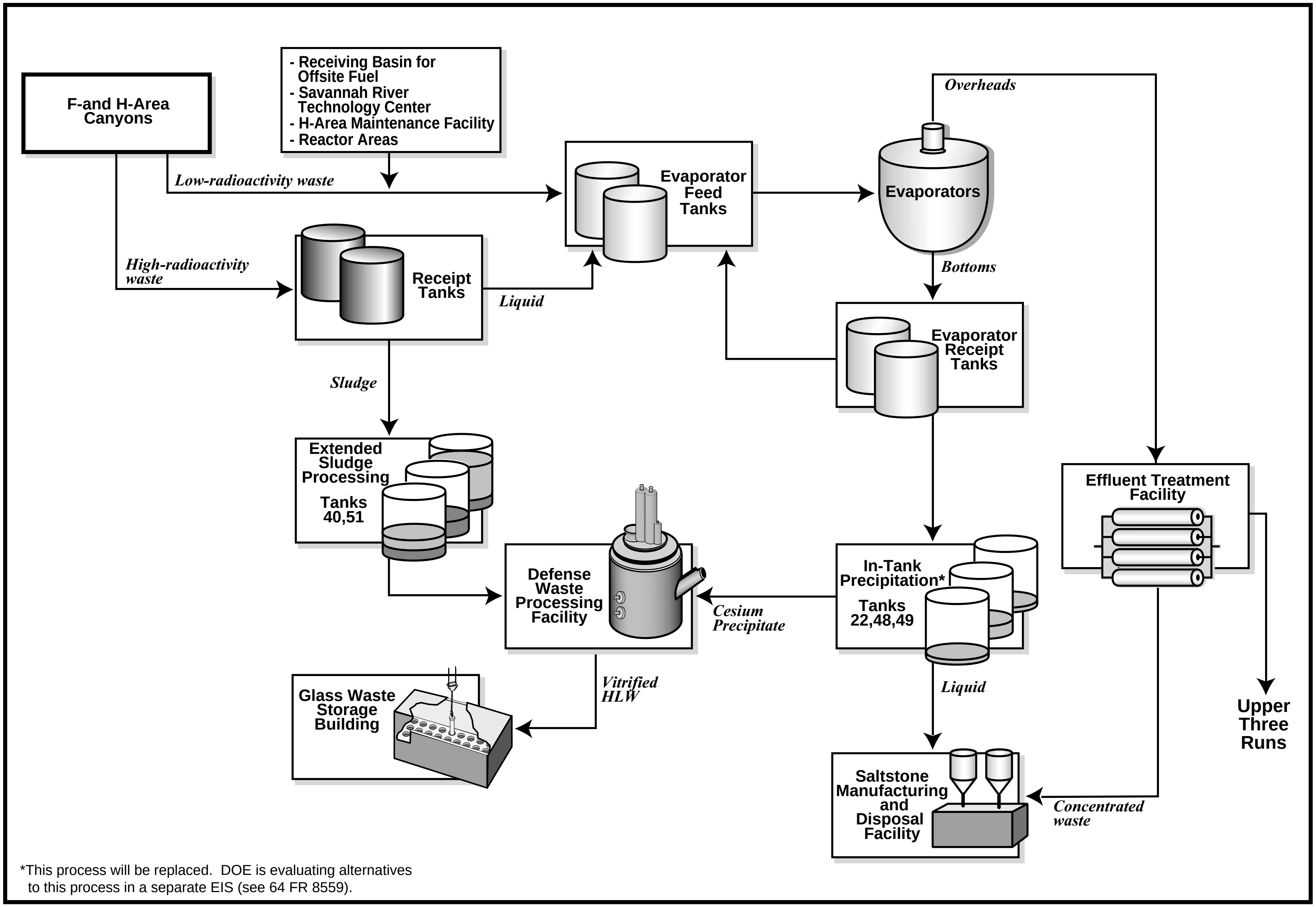


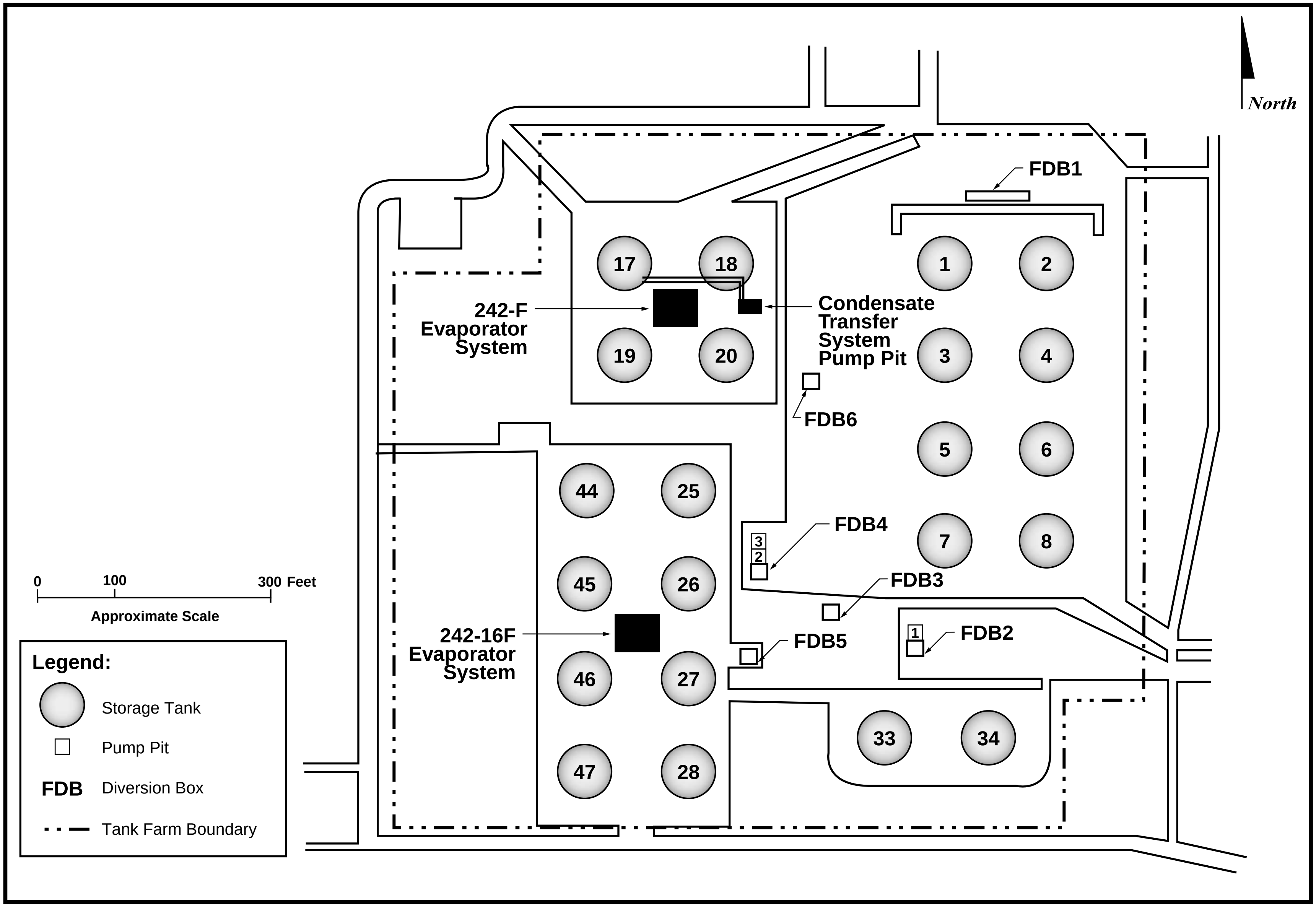
Figure S-1. Savannah River Site map with F- and H-Areas highlighted.



*This process will be replaced. DOE is evaluating alternatives to this process in a separate EIS (see 64 FR 8559).

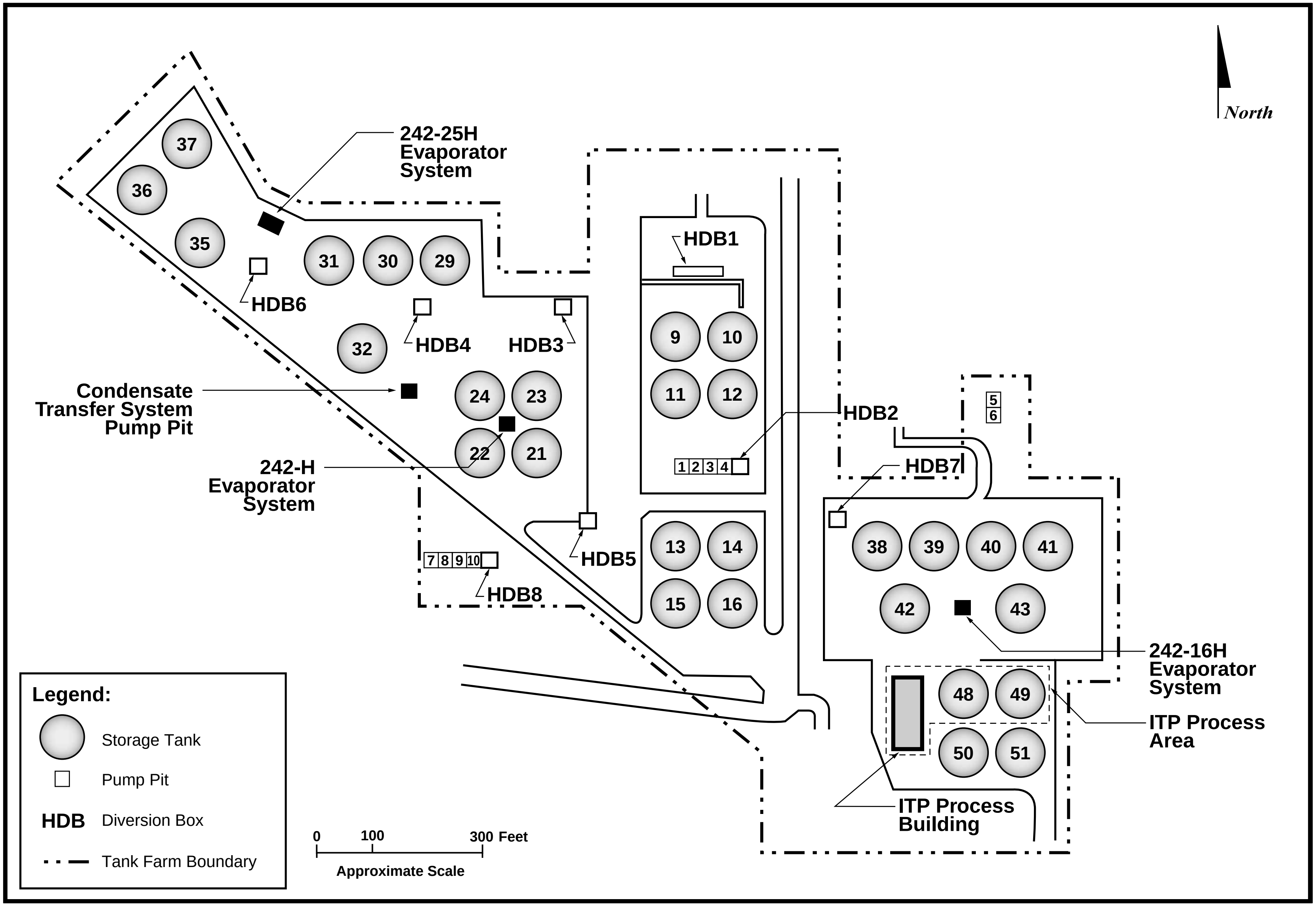
NW TANK/Grfx/Sum/S-2 HLW mgt syst.ai

Figure S-2. Process flows for Savannah River Site High-Level Waste Management System.



NW TANK/Grfx/Sum/S-3 F_Tank.ai

Figure S-3. General layout of F-Area Tank Farm.



NW TANK/Grfx/Sum/S-4 H_Tank.ai

Figure S-4. General layout of H-Area Tank Farm.

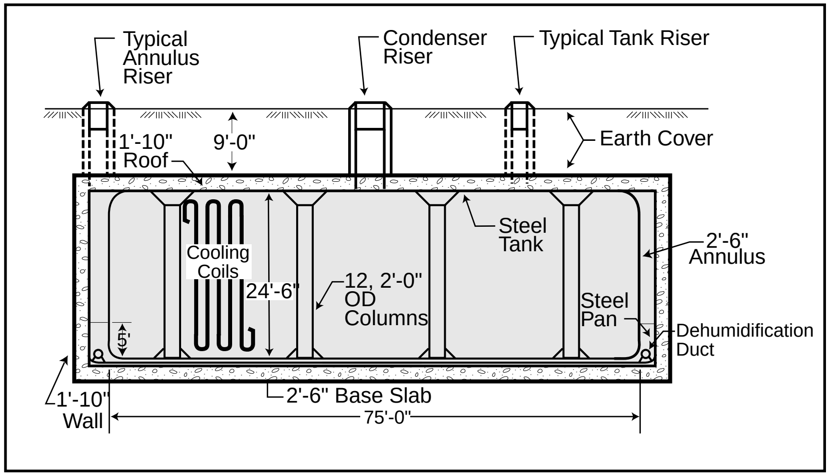


Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

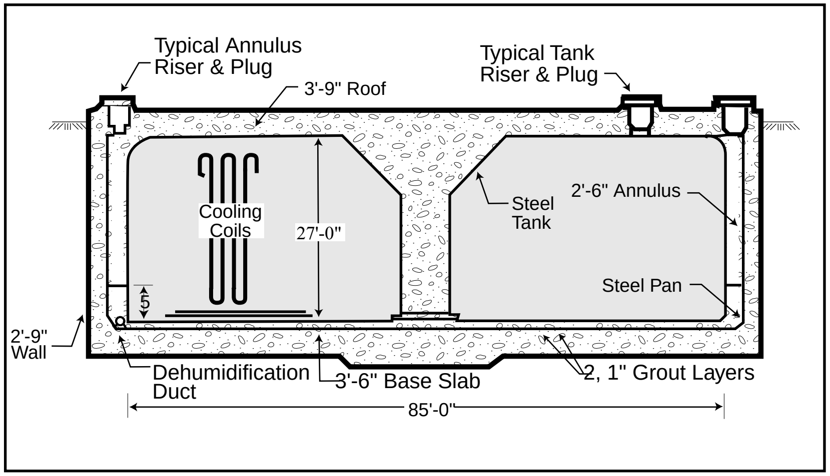


Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

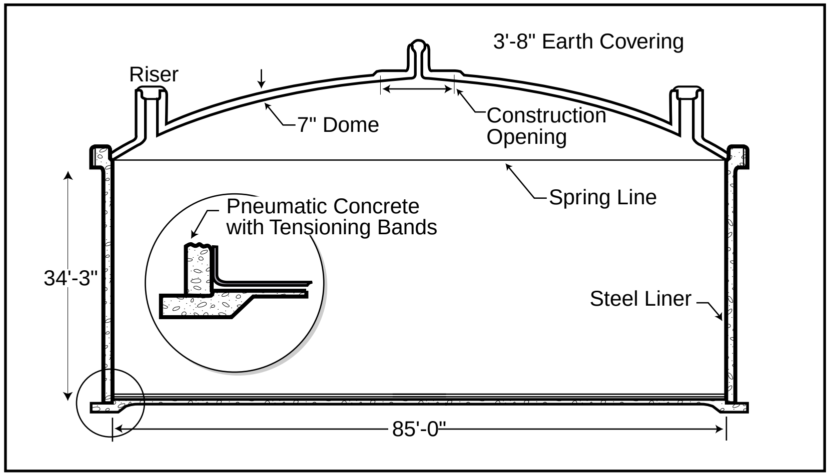


Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

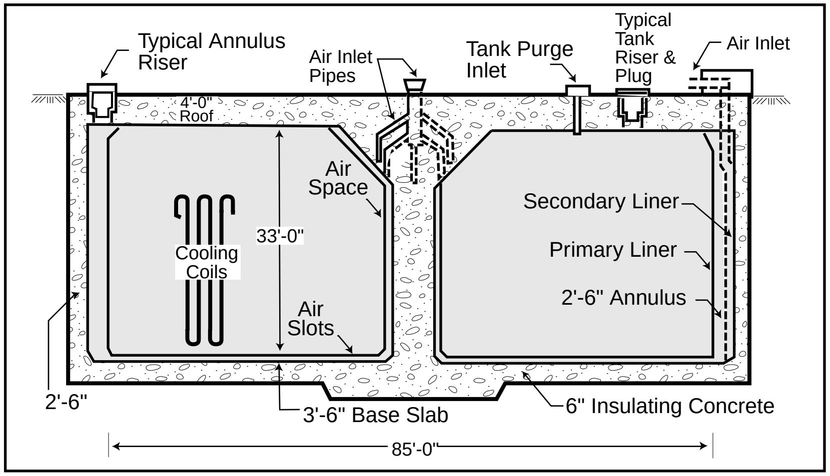


Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

NW TANK/Grfx/Sum/S-5 Tank config.ai

Figure S-5. Tank configuration.

Four Type II tanks, Tanks 13 through 16, were built in 1956 in H-Area. These tanks have partial-height secondary containment and active cooling. These tanks are above the seasonal water table. All four tanks have known leak sites where waste has leaked from the primary to the secondary containment. In Tank 16, waste overflowed the annulus pan (secondary containment) and migrated into the surrounding soil. Waste removal from the Tank 16 primary vessel was completed in 1980, but waste that leaked into the annulus has not been removed.

Eight Type IV tanks, Tanks 17 through 24, were built between 1958 and 1962. These tanks have single steel walls and do not have active cooling. Tanks 17 through 20 in the F-Area Tank Farm are slightly above the water table. Tanks 19 and 20 have known cracks that are believed to have been caused by groundwater corrosion of the tank walls in the past. Small amounts of groundwater have leaked into these tanks, but there is no evidence that waste ever leaked out. Tanks 17 and 20 have been closed in the manner described in the Clean and Fill with Grout Option of the Clean and Stabilize Tanks Alternative evaluated in this EIS. Tanks 21 through 24 in the H-Area Tank Farm are above the groundwater table, but are in a perched water table, caused by the original construction of the tank area.

The newest design, Type III tanks, have a full-height secondary tank and active cooling. These 27 tanks were placed in service between 1969 and 1986, with 10 in the F-Area and 17 in the H-Area Tank Farms. All Type III tanks are above the water table.

S.2.4 HIGH-LEVEL WASTE TANK CLOSURE

Tank closure would begin when bulk waste has been removed from an HLW tank system (a tank and its associated piping and equipment) for treatment and disposal.

DOE has reviewed bulk waste removal of waste from the HLW tanks in the Waste Management Operations, Savannah River Plant EIS (ERDA-1537) and the Long-term Management for Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization) Savannah River Plant EIS (DOE/EIS-0023). In addition, the SRS Waste Management EIS discusses high-level waste management activities as part of the No Action Alternative (continuing the present course of action), and the Defense Waste Processing Facility Savannah River Plant EIS (DOE/EIS-0082) and the Final Supplemental Environmental Impact Statement Defense Waste Processing Facility (DOE/EIS-0082S) discuss management of high-level waste after it is removed from the tanks.

In accordance with the SRS Federal Facility Agreement between DOE, EPA, and SCDHEC, DOE intends to remove the tanks from service as their storage missions are completed. DOE is obligated to close 24 tanks that do not meet the EPA's secondary containment standards under the Resource Conservation and Recovery Act (RCRA) by 2022. The 24 Type I, II, and IV tanks have been or will be removed from service before the 27 Type III tanks. Type III tanks will remain in service until there is no further need for them, which DOE currently anticipates would occur before the year 2030.

The HLW tank systems at SRS are operated in accordance with a permit issued by SCDHEC under the authority of the South Carolina Pollution Control Act as industrial wastewater treatment facilities. DOE is required to close the tank systems in accordance with AEA requirements (i.e., DOE Orders) and South Carolina Regulation R.61-82, "Proper Closeout of Wastewater Treatment Facilities." This regulation requires that closures be carried out according to site-specific guidelines established by SCDHEC to prevent health hazards and to promote safety in and around the tank systems. DOE has adopted a general strategy for HLW tank system closure, set forth in the *Industrial Wastewater Closure Plan for the F- and H-Area High-Level Waste Tank Systems* (DOE 1996), known as the General Closure Plan. The General Closure Plan has been approved by SCDHEC.

The General Closure Plan identifies the resources (e.g., groundwater, air) potentially affected by contaminants remaining in the tanks after waste removal and closure, describes how the tanks would be cleaned and how the tank systems and residual wastes would be stabilized, and identifies Federal and state regulations and guidance that apply to the closures. It describes the use of fate and transport models to calculate potential environmental exposure concentrations or radiological dose rates from the residual waste left in the tank systems. The General Closure Plan describes the method DOE will use to make sure the impacts of closure of individual tank systems do not exceed the environmental standards that apply to the entire F - and H-Area Tank Farms. Chapter 7 of this EIS gives more detail on the development of the General Closure Plan and the environmental standards that apply to closure of the HLW tanks.

Performance Objective

Under the action alternatives, DOE will establish performance objectives for closure of each HLW tank. Each performance objective will correspond to an overall performance standard in the General Closure Plan and will ensure that the overall performance standard can be met. For example, if the performance standard for drinking water in the receiving stream is 4 millirem per year, the contribution from contaminants from all tanks will not exceed the 4-millirem-per-year-limit. DOE will evaluate closure options for specific tanks to determine if use of a specific closure option will allow DOE to meet the performance objectives. Based on this analysis, DOE will develop a Closure Module (a tank-specific closure plan) for each HLW tank such that the performance objectives for the tank can be met. The Closure Module must be approved by SCDHEC before tank closure can begin.

Waste Incidental to Reprocessing

An important issue associated with tank closure, and a subject of controversy, is the determination of the regulatory classification of residual waste in the tanks. Before bulk waste removal, the content of the tanks is HLW. The goal of the bulk waste removal and subsequent cleaning of the tanks is to remove as much waste as can reasonably be removed.

In July 1999, DOE issued Order 435.1, Radioactive Waste Management, and the associated Manual and Implementation Guide. DOE Manual 435.1-1 prescribes two processes, by citation or by evaluation (see text box), for determining that waste resulting from reprocessing spent nuclear fuel can be considered “waste incidental to reprocessing.”

Waste Incidental to Reprocessing Determination

The two processes for determining that waste can be considered incidental to reprocessing are “citation” and “evaluation.” Waste incidental to reprocessing by “citation” includes spent nuclear fuel processing plant wastes that meet the description included in the Nuclear Regulatory Commission’s Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7 that later came to be referred to as “waste incidental to reprocessing.” These radioactive wastes are the result of processing plant operations, such as, but not limited to contaminated job wastes, such as laboratory items (clothing, tools, and equipment).

Waste incidental to reprocessing by “evaluation” includes spent nuclear fuel processing plant wastes that meet the following three criteria: (1) have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical, (2) will be managed to meet safety requirements comparable to the performance standards set forth in Subpart C of 10 CFR 61 (if low-level waste) or will be incorporated in a solid physical form and meet alternative requirements for waste classification and characteristics authorized by DOE (if transuranic waste), and (3) managed as low-level or transuranic waste pursuant to DOE's authority under the Atomic Energy Act in accordance with the applicable provisions of DOE M 435.1-1.

According to Order 435.1, waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not HLW, and shall be managed under DOE’s regulatory authority in accordance with requirements for transuranic waste or low-level waste, as appropriate.[2] Section 7.1.3 of this EIS discusses the waste incidental to reprocessing process in more detail.

HLW Tank Cleaning

Tank cleaning by spray water washing involves washing each tank using hot water in rotary spray jets. The spray nozzles can remove waste near the edges of the tank that is not readily removed by slurry pumps. After spraying, the contents of the tank would be agitated with slurry pumps and pumped out of the tank. This process has been demonstrated on Tanks 16 (which has not been closed) and 17 (which has been closed). The amount of waste left after spray washing was estimated at about 3,500 gallons in Tank 16 and about 4,000 gallons in Tank 17. If modeling evaluations showed that performance objectives could not be met after an initial spray water washing, additional spray water washes would be used prior to employing other cleaning techniques.

After spray water washing is complete, DOE could use oxalic acid cleaning. Hot oxalic acid would be sprayed through the spray nozzles that were used for spray water washing.

Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is about twice as effective as spray water washing for removal of radioactivity (See Table S-1). Use of oxalic acid in an HLW tank would require successfully demonstrating that dissolution of HLW sludge solids by the acid would not create a potential for a nuclear criticality.

On the basis of performance and historical data, DOE believes that waste removal meets the Criteria 2 and 3 requirements of the evaluation process for determining that waste can be considered “waste incidental to reprocessing” (see text box). In addition, waste removal followed by spray water washing, meets the Criterion 1 requirement for removal of key radionuclides to the extent “technically and economically practical” (DOE Order 435.1). If Criteria 2 or 3 could not be met, enhanced cleaning methods such as additional water washes or oxalic acid cleaning could be employed. However, DOE considers that oxalic acid cleaning beyond the extent needed to meet performance objectives is not “technically and economically practical” within the meaning of DOE Order 435.1, for reasons discussed below.

In general, the economic costs of oxalic acid cleaning are quite high. DOE estimates that oxalic acid cleaning (including disposal costs) per tank would cost approximately $1,050,000.

DOE considers that performance of bulk waste removal and spray washing, which together result in removal of 98% to 99% of the total curies and over 99% of the volume of waste, constitutes the limit of what is economically and technically practicable for waste removal (DOE Response to U.S. Nuclear Regulatory Commission Additional Questions on SRS HLW Cover Tank Closure, April 1999). However, DOE recognizes that enhanced waste removal operations may be required for some tanks and is committed to performing the actions necessary to meet “incidental waste” determination and performance objectives. DOE further recognizes that, if it could not clean the tank components sufficiently to meet the waste incidental to reprocessing criteria, it would need to examine alternative disposition strategies. Alternatives could include disposal in place as high-level waste (which is not contemplated in DOE Order 435.1), development of new cleaning technologies, or packaging the cleaned tank pieces and storing them until DOE could ship them to a geologic repository for disposal. A geologic

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[2] The Natural Resources Defense Council (NRDC) has filed a Petition in the Court of Appeals for the Ninth Circuit asking the Court to review DOE Order 435.1 and claiming that the Order is “arbitrary, capricious, and contrary to law.” The Nuclear Regulatory Commission, in responding recently to a separate petition from the NRDC, has concluded that DOE’s commitments to (1) clean up the maximum extent technically and economically practical, and (2) meet performance objectives consistent with those required for disposal of low level waste, if satisfied, should serve to provide adequate protection of public health and safety (65 FR 62377, October 18, 2000).

Table S-1. Tank 16 waste removal process and curies removed with each sequential step.

Sequential Waste Removal Step	Curies Removed	% of Curies Removed	Cumulative Curies Removed	Cumulative Percent Curies Removed
Bulk Waste Removal	2.74×10^{6}	97%	2.74×10^{-6}	97
Spray Water Washing	2.78×10^{4}	0.98%	2.77×10^{-6}	97.98
Oxalic Acid Wash & Rinse	5.82×10^{4}	2%	2.83×10^{-6}	99.98

repository has not yet been approved and waste acceptance criteria have not yet been finalized.

The potential for nuclear criticality is one significant technical constraint on the practicality of oxalic acid cleaning. Also, extensive use of oxalic acid cleaning could affect downstream waste processing activities (DWPF and salt disposition). The presence of oxalates in the waste feed to DWPF that would result from oxalic acid cleaning would adversely affect the quality of the glass, and special batches of the salt disposition process could be required to control the sodium oxalate concentration.

Nine HLW tanks have leaked measurable amounts of waste from primary containment to secondary containment with only one leaking to the soil surrounding the tanks. For these tanks, the waste would be removed from the secondary containment using water and/or steam. Such cleaning has been attempted at SRS on only one tank (Tank 16), and the operation was only about 70 percent completed, because salts mixed with sand (from sandblasting of tank welds) made salt removal more difficult. Cleaning of the secondary containment is not a demonstrated technology and new techniques may need to be developed. The amount of waste in secondary containment is small, so the environmental risk of this waste is minimal compared to the amount of residual waste that would be contained inside the tanks after bulk waste removal and cleaning.

S.3 NEPA Process

NEPA provides Federal decisionmakers with a process to use when considering the potential environmental impacts of proposed actions and alternatives. This process also provides several ways the public can be informed about and influence the selection of an alternative.

In 1995, DOE began preparations for closure of the HLW tanks. DOE prepared the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*. At the same time, DOE prepared the *Environmental Assessment for the Closure of the High-Level Waste Tanks in F- and H-Areas at the Savannah River Site*. In a Finding of No Significant Impact signed on July 31, 1996, DOE concluded that closure of the HLW tanks in accordance with the General Closure Plan would not result in significant environmental impacts. Since that time DOE has closed Tanks 17 and 20.

DOE re-examined the 1996 Tank Closure Environmental Assessment and has decided to prepare an EIS before any additional HLW tanks are closed at SRS. This decision was based on several factors, including a desire to explore the environmental impacts from closure and to open a new round of information sharing and dialogue with stakeholders. In the December 29, 1998, Federal Register, DOE published a Notice of Intent (NOI) to prepare an EIS on closure of the HLW tanks. Publication of the NOI began a 45-day public scoping period. DOE held public scoping meetings on January 14, 1999, in North Augusta, South Carolina, and on January 19, 1999, in Columbia, South Carolina. DOE considered comments received during the scoping period in preparing this Draft EIS. The comments, along with DOE's responses, are given in Appendix D of this EIS and briefly summarized here.

DOE received three comment letters, one E-mail, seven oral comments at the public scoping meetings, and one Recommendation from the

SRS Citizens Advisory Board. DOE identified 36 separate comments in these submittals and presentations.

Several comments related to the alternatives for closing the HLW tanks and suggested additional alternatives. One expressed the opinion that any alternative premised on "reclassification" of the residual waste in the tanks as waste incidental to reprocessing violated the Nuclear Waste Policy Act of 1982. DOE believes that the alternatives suggested by the commentors were substantially the same as the alternatives DOE proposed to evaluate. In regard to the waste incidental to reprocessing comment, it is within the scope of DOE's authority and responsibilities under the AEA to establish and carry out a procedure for determining if residual waste may be managed as transuranic or low-level waste. DOE's procedure is found in DOE Order 435.1 and the accompanying Manual 435.1-1.

Commentors suggested that certain data be included in the EIS, including the total volume of waste and the total amount of each chemical and radionuclide that DOE expected to remain in the tanks as residual waste. DOE has included this information in the EIS.

Several comments suggested evaluations to be performed. DOE has provided reasons for not using certain evaluation methods suggested by commentors (see Appendix D of the EIS).

Commentors were also concerned with the application of certain laws, regulations, and criteria, particularly the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), RCRA, the Nuclear Waste Policy Act, and South Carolina's regulations. DOE has provided responses to each of the comments in Appendix D of the EIS. In addition, Chapter 7 of the EIS provides a review of laws, regulations, and DOE Orders that apply to the closure of the HLW tanks.

Commentors were concerned about the EIS schedule and process as it relates to closure of the HLW tanks. DOE will complete the EIS process before closing any additional waste tanks at SRS. In addition, preparation of the EIS will not interfere with the established schedule for closure of the HLW tanks.

One commentor wanted to know if the tanks being considered for closure were the same tanks that have leaked in the past. All tanks that have leaked are inactive, meaning they do not receive fresh waste, and none of them are continuing to leak. Most of these tanks currently store sludge, salt, or both. In cases where liquid high-level waste is stored, the waste level is below the known leak sites. In accordance with the SRS Federal Facility Agreement, DOE is obligated to close all of these tanks by 2022. One of the tanks that already leaked, Tank 20, has already been closed.

One commentor was concerned about the process for removing sludges from the HLW tanks. The EIS describes the processes that were used for cleaning Tanks 17 and 20 and those that will be used in the future. DOE also acknowledges that new technologies may be useful in the future for removing sludges from the HLW tanks.

One commentor observed that new missions would add to the amount of HLW and prolong the closure process. DOE has recently selected SRS as the site for several new missions. The Pit Disassembly and Conversion Facility, Mixed Oxide Fuel Facility, Immobilization Facility, and the Tritium Extraction Facility will not add HLW to the current SRS inventory. Stabilizing plutonium residues from the Rocky Flats Environmental Technology Site at SRS is expected to result in the equivalent of five DWPF canisters. The melt and dilute facility for management of spent nuclear fuel would add the equivalent of 17 DWPF canisters. These canisters are in addition to the approximately 6,000 canisters DOE expects to produce absent the new missions.

S.4 Purpose and Need

DOE needs to reduce human health and safety risks at and near the HLW tanks, and to reduce the eventual introduction of contaminants into the environment. If DOE does not take action after bulk waste removal, the tanks would fail and contaminants would be released to the environment. Failed tanks would present the risk of accidents to individuals. Release of contaminants to the environment would present human health risks, particularly to individuals who might use contaminated water, in addition to adverse impacts to the environment.

S.5 Decisions to be Based on This EIS

This EIS provides an evaluation of the environmental impacts of several alternatives for closure of the HLW tanks at SRS. The closure process will take place over a period of up to 30 years. The EIS provides the decisionmaker with an assessment of the environmental, health and safety effects of each alternative. The selection of a tank closure alternative, following completion of this EIS, will guide the selection and implementation of a closure method for each HLW tank at SRS. Within the framework of the selected alternative, and the environmental impact of closure described in the EIS, DOE will select and implement a specific closure method for each tank.

In addition to the closure methods and impacts described in this EIS, the tank closure program will operate under a number of laws, regulations, and regulatory agreements described in Chapter 7 of this EIS. In addition to the General Closure Plan (a document prepared by DOE based on responsibilities under the AEA and other laws and regulations and approved by SCDHEC), the closure of individual tanks will be performed in accordance with a tank-specific Closure Module. Each Closure Module will incorporate a specific plan for tank closure and modeling of impacts based on that plan. Through the process of preparing and approving each Closure Module, DOE will select a closure method that is consistent with the closure alternative selected after completion of this EIS. The selected closure method for each tank will result in the closure of all tanks with impact on the environment equal to or less than those described in this EIS. If a tank closure that meets the performance objectives of the closure module cannot be accomplished using the selected alternative, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank.

During the expected 30-year period of tank closure activities, new technologies for tank cleaning or other aspects of the closure process may become available. DOE would conduct the appropriate NEPA review for any proposal to use a new technology.

S.6 Proposed Action and Alternatives

DOE proposes to close the HLW tanks at SRS in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* approved by SCDHEC, which specifies the management of residuals as waste incidental to reprocessing. The proposed action evaluated in this EIS would begin when bulk waste removal has been completed. Under each alternative except No Action, DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines.

DOE is evaluating three alternatives in this EIS.

Tank Closure Alternatives

Implementation of each alternative would start following bulk waste removal and SCDHEC approval of a tank-specific Closure Module that is protective of human health and the environment.

- Clean with water and fill the tanks with grout (Preferred Alternative). If necessary to meet the performance objectives, oxalic acid cleaning could be used. The use of sand or saltstone as fill material would also be considered.
- Clean and remove the tanks for disposal in the SRS waste management facilities
- No Action. Leave the tank systems in place without cleaning or stabilizing, following bulk waste removal.

S.6.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

Following bulk waste removal, DOE would clean the tanks to remove as much additional waste as can reasonably be removed and fill the tanks with a material that would bind up remaining residual waste and prevent future collapse of the tanks. DOE considers three options for tank stabilization under this alternative:

- Fill with Grout (Preferred Alternative)
- Fill with Sand
- Fill with Saltstone

In the evaluation and cleaning phase of tank closure each tank system or group of tank systems would be evaluated to determine the inventory of radiological and nonradiological contaminants remaining after bulk waste removal and spray water washing. This information would be used to conduct a performance evaluation as part of the preparation of a Closure Module. In the evaluation DOE would consider: (1) the types of contamination in the tank and the configuration of the tank system, and (2) the hydrogeologic conditions at and near the tank location, such as distance from the water table and distance to nearby streams. The performance evaluation would include modeling the projected contamination pathways for selected closure methods, and comparing the modeling results with the performance objectives developed in the General Closure Plan. If the modeling shows that performance objectives would be met, the Closure Module would be submitted to SCDHEC for approval.

If the modeling shows that the performance objectives would not be met, additional cleaning steps (such as additional water spray washing, oxalic acid cleaning, or other cleaning techniques) would be taken until enough waste had been removed that the performance objectives could be met. DOE estimates that oxalic acid cleaning could be required on as many as three-quarters of the tanks to meet performance objectives.

Tank Stabilization

After DOE would clean a tank and demonstrate that the performance objectives could be met, SCDHEC would approve a Closure Module. The tank stabilization process would then begin. Each tank system (including the secondary containment, for those that have one) would be filled with a pumpable, self-leveling backfill material. DOE’s preferred option is to use grout, a concrete-like material, as backfill. The grout would be trucked to an area near the tank farm, batched if necessary, and pumped to the tank. The fill material would be high enough in pH to be compatible with the carbon steel walls of the waste tank. The grout would be formulated with chemical properties that would retard the movement of radionuclides in the residual waste in the closed tank. Therefore, the closure configuration for each tank or group of tanks would be determined on a case-by-case basis through development of the Closure Module.

Using the preferred option of grout as fill material, the grout would be poured in three distinct layers as illustrated in Figure S-6. The bottom-most layer would be a specially formulated reducing grout to retard the migration of important contaminants. The middle layer would be a low-strength material designed to fill most of the volume of the tank interior. The final layer would be a high-strength grout to deter inadvertent intrusion from drilling.

If DOE were to choose another fill material (sand or saltstone) for a tank system, all other aspects of the closure process would remain the same, as described above.

Sand is readily available and inexpensive. Its emplacement is more difficult than grout because it does not flow readily into voids. Any equipment or piping left on or inside the tank that might require filling (to eliminate voids inside the device) might not be adequately filled. Over time, the sand would tend to settle in the tank, creating additional void spaces. The dome of the tank would then become unsupported and would sag and crack. The sand would tend to

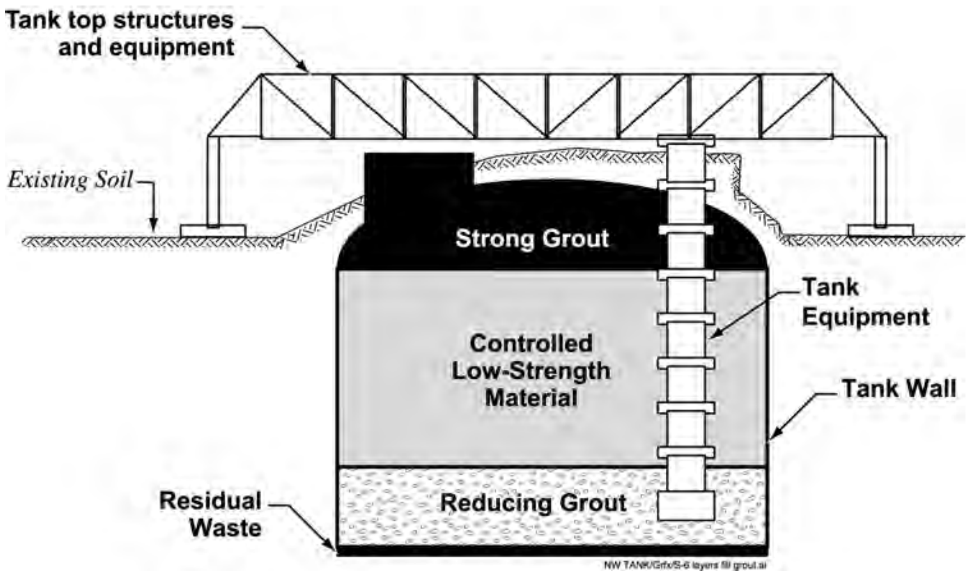

Figure S-6. Typical layers of the fill with grout option.

isolate the contamination from the environment to some extent, limit the amount of settling of the tank top after failure, and prevent wind from spreading the contaminants. Nevertheless, water would flow readily through the sand. Sand is relatively inert and could not be formulated to retard the migration of radionuclides. Thus, expected contamination levels in groundwater and surface water streams resulting from migration of residual contaminants would be higher than the levels for the preferred option.

Saltstone could also be used as fill material. Saltstone is the low-radioactivity fraction of HLW mixed with cement, flyash, and slag to form a concrete-like mixture. Saltstone is normally disposed of as low-level waste in the SRS Saltstone Disposal Facility. This alternative would have the advantage of reducing the amount of Saltstone Disposal Facility area that would be required. Filling the tank with a grout mixture that is contaminated with radionuclides, like saltstone, would considerably complicate the project and increase worker radiation exposure, which would increase risk to workers and add to the cost of closure. In addition, the saltstone would contain large quantities of nitrate that would not be present in the tank residual. Because nitrates are very mobile in the environment, these large quantities of nitrate would adversely impact the groundwater near the tank farms over the long term.

Following the use of any of the stabilization options described above, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting in the surface depressions. This action would prevent ponding conditions over the tanks that could facilitate degradation of the tank structure.

S.6.2 CLEAN AND REMOVE TANKS ALTERNATIVE

The Clean and Remove Tanks Alternative would include cleaning the tanks, cutting them up in situ, removing them from the ground, and transporting tank components for disposal in an engineered disposal facility at another location on SRS. This alternative has not been demonstrated on HLW tanks.

For the Clean and Remove Tanks Alternative, DOE would have to perform enhanced cleaning beyond that contemplated for the other action alternatives, until tanks were clean enough to be safely removed and could meet waste acceptance criteria at SRS Low-Level Waste Disposal Facilities. Worker exposure would have to be As Low As Reasonably Achievable to ensure protection of the individuals required to perform the tank removal operations. This might require the use of cleaning technologies such as oxalic acid cleaning, mechanical cleaning, and additional steps as yet undefined on most of the tanks. DOE considers that these additional actions on so many tanks are not “technically and economically practical” within the meaning of DOE Order 435.1 because of criticality safety concerns associated with acidic cleaning solutions, potential interference with downstream waste processing activities, and high cost.

Following bulk waste removal and cleaning, the steel components of the tank would be cut up, removed, placed in radioactive waste transport containers (approximately 3,900 SRS low-level waste disposal boxes per tank), and transported to SRS radioactive waste disposal facilities for disposal. During cutting and removal operations, steps would be taken and technologies employed to limit both emissions and exposure of workers to radiation. This alternative would require the construction of approximately 16 new low-activity waste vaults at SRS for disposal of the tank components. This alternative has the advantage of allowing disposal of the contaminated tank system in a waste management facility that is already approved for receiving low-level waste.

With removal of the tanks, backfilling of the excavations left after the removal would be required. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

S.6.3 NO ACTION ALTERNATIVE

For HLW tanks, the No Action Alternative would involve leaving the tank systems in place after bulk waste removal has taken place. Even after bulk waste removal, each tank would contain residual waste and, in those tanks that reside in the water table, ballast water. The tanks would not be backfilled.

After some period of time (probably hundreds of years), the reinforcing bar in the roof of the tank would rust and the roof would fail, causing the structural integrity to degrade. Similarly, the floor and walls of the tank would degrade over time. Rainwater would pour into the exposed tank, flushing contaminants from the residual waste in the tanks and eventually carrying these contaminants into the groundwater. Contamination of the groundwater would occur much more quickly than it would if the tank were backfilled and the residual waste bound with the backfill material.

S.7 Alternatives Considered, But Not Analyzed

S.7.1 MANAGEMENT OF TANK RESIDUALS AS HIGH-LEVEL WASTE

The alternative of managing the tank residuals as HLW is not preferred, in light of the requirements embodied in the State-approved General Closure Plan for a regulatory approach based on the designation of the residuals as waste incidental to reprocessing.

The waste incidental to reprocessing designation does not create a new radioactive waste type. The terms "incidental waste" or "waste incidental to reprocessing" refer to a process for identifying waste streams that might otherwise be considered HLW due to their origin, but are actually low-level or transuranic waste, if the waste incidental to reprocessing requirements contained in DOE Manual 435.1-1 are met. The goal of the waste incidental to reprocessing determination process is to safely manage a limited number of reprocessing waste streams that do not warrant geologic repository disposal because of their low threat to human health or the environment. Although the technical alternatives of managing tank residuals under the General Closure Plan would likely be the same as those that would apply to managing residuals as HLW, the application of regulatory requirements would be different.

As described in the General Closure Plan, DOE will meet the waste incidental to reprocessing requirements of DOE Manual 435.1-1, which entail a step for removing key radionuclides to the extent that is technically and economically practical, a step for incorporating the residues into a solid form, and a process for demonstrating that appropriate disposal performance objectives are met. The technical alternatives evaluated in the EIS represent a range of tank cleaning and stabilization techniques. The radionuclides in residual waste would be the same whether the material is HLW, low-level waste, or transuranic waste; however, the regulatory regime would be different.

DOE must demonstrate its ability to meet certain performance objectives before SCDHEC will approve a Closure Module. Appendix C of the General Closure Plan describes the process DOE used to determine the performance objectives (dose limits and concentrations established to be protective of human health) incorporated in the General Closure Plan. As described in Chapter 7 of this EIS, DOE will establish performance standards for the closure of each HLW tank. In the General Closure Plan, DOE considered dose limits and concentrations found in current (40 CFR 191, 10 CFR 60) and proposed (40 CFR 197, 10 CFR 63) HLW management requirements in defining the performance standards. DOE considered the HLW management dose limits and concentrations as performance indicators of the ability to protect human health and the environment, even though the residual would not be considered HLW. That evaluation (described in Appendix C of the General Closure Plan) identified numerical performance standards (concentrations or dose limits for specific radiological or chemical constituents released to the environment) based on the requirements and guidance. Those numerical standards apply to all exposure pathways and to specific media (air, groundwater, and surface water), at different points of compliance, and over various periods during and after closure.

If DOE determines through the waste incidental to reprocessing process that the tank residues cannot be managed as LLW, as expected, or alternatives as TRU waste, the residues would be managed as HLW. The technical alternatives for managing the residues as HLW, however, would be the same as those for managing the residues under the LLW requirements. Thus, DOE expects that the potential environmental impacts that could result from managing the residues under the LLW requirements would be representative of the impacts if the HLW standards were applicable. For these reasons, this EIS does not present the management of tank residues as HLW as a separate alternative.

S.7.2 OTHER ALTERNATIVES CONSIDERED, BUT NOT ANALYZED

DOE considered the alternative of delaying closure of additional tanks, pending the results of research. For the period of delay, the impacts of this approach would be the same as the No Action Alternative. DOE continues to conduct research and development efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of delaying closure.

DOE considered an alternative that would represent grouting of certain tanks and removal of others. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet performance requirements for a given tank, the decisionmakers may elect to remove a tank if it is not possible to meet the performance requirements by using another method. This EIS captures the environmental and health and safety impacts of both options.

S.8 Comparison of Environmental Impacts among Alternatives

Closure of the HLW tanks would affect the environment, as well as human health and safety, during the period of time when work is being done to close the tanks and after the tanks have been closed. For this EIS, DOE has defined the period of short-term impacts to be from the year 2000 through about 2030, or the period during which the HLW tanks would be closed. Long-term impacts would be those resulting from the eventual release of residual waste contaminants from the stabilized tanks to the environment. In this EIS, DOE has estimated these impacts over a period of 10,000 years.

S.8.1 SHORT-TERM IMPACTS

DOE evaluated short-term impacts of the tank closure alternatives (Note – the preferred alternative is one of the options) on a number of environmental media. DOE also characterized the employment required for each alternative and estimated the cost to close an HLW tank using each alternative and option.

DOE compared impacts in the following areas:

- Geologic and Water Resources
- Nonradiological Air Quality
- Radiological Air Quality
- Ecological Resources
- Land use
- Socioeconomics
- Cultural Resources
- Worker and Public Health Impacts
- Environmental Justice
- Transportation
- Waste Generation
- Utilities and Energy Consumption
- Accidents

In general, the No Action alternative has the least impact on the environment over the short term, the Clean and Remove Tanks alternative has the greatest, and the impacts of the Clean and Stabilize Tanks alternative fall in between. Table S-2 shows those areas in which there are notable differences in impacts among the alternatives.

For the short term, No Action means continuing normal tank farm operations, including waste transfers, but not closing any tanks. The impacts, in terms of radiological and nonradiological air and water emissions and human health and safety, are the least of the three alternatives and in all cases are very small.

The primary health effect of radiation is the increased incidence of cancer. Radiation impacts on workers, and public health are expressed in terms of latent cancer fatalities. A radiation dose to a population is estimated to result in cancer fatalities at a certain rate, expressed as a dose-to-risk conversion factor. The EPA has established dose-to-risk conversion factors of 0.0005 per person-rem for the general population and 0.0004 per person-rem for workers. The difference is due to the presence of children, who are believed to be more susceptible to radiation, in the general population.

DOE estimates the doses to the population and uses the conversion factor to estimate the number of cancer fatalities that might result from those doses. In most cases, the result is a small fraction of one. For these cases, DOE concludes that the action would very likely result in no additional cancer in the exposed population.

Over the short term, the Clean and Remove Tanks alternative has significantly greater impacts than the other alternatives. This is particularly notable in worker exposure to radiation and the resultant cancer fatalities, and in the numbers of on-the-job injuries. DOE's analysis estimates that implementation of the Clean and Remove Tanks alternative would result in about five cancer fatalities in the worker population, while the estimate for the Clean and Stabilize Tanks alternative is less than one, and the estimate for No Action is essentially zero. The Clean and Remove Tanks alternative would result in the generation of twice as much liquid radioactive waste and about 15 times as much low-level waste as the Clean and Stabilize Tanks alternative. The waste generation would be the result of the cleaning activities required to clean the tanks so they could be removed from the ground, and from disposal of the tanks as low-level waste at another location on the Savannah River Site.

The labor and waste disposal requirements of the Clean and Remove Tanks alternative would result in a cost of more than $100 million per tank, compared to about $6.3 million for the most costly option (Clean and Fill with Saltstone) of the Clean and Stabilize Tanks alternative. While the Clean and Remove Tanks Alternative would

Table S-2. Comparison of short-term impacts by tank closure alternative.

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Geologic Resources **Soil backfill (m^3)**	None	170,000	170,000	170,000	356,000
Air Resources					
Nonradiological air emissions (tons/yr.):					
Particulate matter	None	4.5	3.1	3.6	None
Carbon monoxide	None	5.6	5.6	16.0	None
Benzene	None	0.02	0.02	0.43	None
Air pollutants at the SRS boundary (maximum concentrations-$\mu g/m^3$)[a]:					
Carbon monoxide – 1 hr.	None	1.2	1.2	3.4	None
Volatile organic compounds – 1 hr.	None	0.5	0.5	2.0	None
Annual radionuclide emissions (curies/year):					
Saltstone mixing facility	Not used	Not used	Not used	0.46	Not used
Socioeconomics (employment – full time equivalents)					
Annual employment	40	85	85	131	284
Life of project employment	980	2,078	2,078	3,210	6,963
Radiological dose and health impacts to involved workers:					
Closure collective dose (total person-rem)	29.4[b]	1,600	1,600	1,800	12,000
Closure latent cancer fatalities	0.012	0.65	0.65	0.72	4.9
Occupational Health and Safety:					
Recordable injuries-closure	110[c]	120	120	190	400
Lost workday cases-closure	60[c]	62	62	96	210

Table S-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Transportation (offsite round-trip truckloads per tank)	0	654	653	19	5
Waste Generation					
Maximum annual waste generation:					
Radioactive liquid waste (gallons)	0	600,000	600,000	600,000	1,200,000
Nonradioactive liquid waste (gallons)	0	20,000	20,000	20,000	0
Low-level waste (m^3)	0	60	60	60	900
Total estimated waste generation					
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Low-level waste (m^3)	0	1,284	1,284	1,284	19,260
Mixed low-level waste (m^3)	0	257	257	257	428
Utility and Energy Usage:					
Water (total gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Steam (total pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (total gallons)	NA	214,000	214,000	214,000	428,000
Utility cost (total)	NA	$4,280,000	$4,280,000	$4,280,000	$12,840,000

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a. No exceedances of air quality standards are expected.

b. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.

c. For the No Action Alternative, recordable injuries and lost workday cases are for the period of closure activities for the other alternatives. These values would continue indefinitely.

NA = Not available.

effectively eliminate the future radiation dose at the seepline, under the Preferred Alternative this seepline dose would be within the 4 millirem per year drinking water standard, which would equate to 0.000002 latent cancer fatality. Thus, DOE would spend $4.9 billion (for all 49 HLW tanks) to reduce a projected dose that already would be less than 4 millirem. This alternative would result in about 12,000 person-rem (4.9 latent cancer fatalities) within the population of SRS workers performing these activities. DOE believes that the incremental benefits of oxalic acid cleaning do not warrant the high costs associated with using this cleaning method on all tanks.

There are some differences in impacts among the three options of the Clean and Stabilize Tanks alternative in the short term, but none are significant. The Clean and Fill with Grout option would use about four times as much water (from groundwater sources) than the other options. The Clean and Fill with Saltstone option would employ the most workers and result in more occupational injuries and a very slightly increased risk of cancer fatalities for workers. It would also be the most costly of the three options.

DOE evaluated the impacts of potential accidents related to each alternative. The highest consequence accidents would be transfer errors (spills) and seismic events during cleaning. Both of these accidents could happen during cleaning under the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative, and there is no difference in the consequences.

S.8.2 LONG-TERM IMPACTS

In the long term, the important impact to consider is the effect on the environment and human health of residual waste contaminants that will eventually find their way to the accessible environment. DOE estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a period of 10,000 years to determine when certain impacts (e.g., radiation dose and the associated health effects) would reach their peak value. Table S-3 shows those areas in which there are notable differences in impacts among the alternatives.

Any waste that migrates through the groundwater and outcrops at a stream location (called a “seepline” in the EIS) would result in radiological doses and possible consequent health effects to individuals exposed to water containing the contaminants. For H-Area, the seepline along Upper Three Runs and Fourmile Branch is about 1,200 meters downgradient from the center of the tank farm while, for F-Area, the seepline is about 1,800 meters downgradient from the tank farm (see Figure S-1). Because of the long travel time from the closed and stabilized tank to the groundwater outcrop, the impacts would be substantially reduced compared to what they might have been if the contaminants came into the accessible environment more quickly. This can be seen clearly by comparing the long-term impacts of the No Action Alternative to the impacts of the Clean and Fill with Grout Option of the Clean and Stabilize Tanks Alternative. Figure S-7 graphically illustrates this.

If the Clean and Remove Tanks Alternative were chosen, residual waste would be removed from the tanks and the tank systems themselves would be removed and transported to SRS radioactive waste disposal facilities. Long-term impacts at these facilities are evaluated in the Savannah River Site Waste Management EIS (DOE/EIS-0217).

The long-term impacts of low-level waste disposal in low-activity vaults presented in the SRS Waste Management EIS are about one-one thousandth of the long-term tank closure impacts presented in this EIS for water resources and public health. Under this alternative, some land in E-Area would be permanently committed to disposal and would therefore be unavailable for other uses or for ecological habitat. After removal of the tanks and subsequent CERCLA actions, some land and habitats could become available for other uses or habitat.

Table S-3. Comparison of long-term impacts by tank closure alternative.[a]

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option
Surface Water	Limited movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters
Maximum dose from beta-gamma emitting radionuclides in surface water (millirem/year)				
Upper Three Runs	0.45	(b)	4.3×10^{-3}	9.6×10^{-3}
Fourmile Branch	2.3	9.8×10^{-3}	0.019	0.130
Groundwater				
Groundwater concentrations from contaminant transport – F-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	35,000	130	420	790
100-meter well	14,000	51	190	510
Seepline, Fourmile Branch (1,800 meters downgradient)	430	1.9	3.5	25
Groundwater concentrations from contaminant transport – H-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	9.3×10^{6}	1×10^{5}	1.3×10^{5}	1×10^{5}
100-meter well	9.0×10^{4}	300	920	870
Seepline (1,200 meters downgradient): North of Groundwater Divide	2,500	2.5	25	46
South of Groundwater Divide	200	0.95	1.4	16
Maximum Groundwater Concentrations of Nitrates[c]				
1-meter well	270	21	22	440,000
100-meter well	69	4.7	4.9	180,000
Seepline	3.4	0.1	0.2	3,300

Table S-3. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative		
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Ecological Resources				
Maximum absorbed dose to aquatic and terrestrial organisms (in millirad per year):				
Sunfish dose	0.89	0.0038	0.0072	0.053
Shrew dose	24,450	24.8	244.5	460.5
Mink dose	2,560	3.3	25.6	265
Public Health				
Radiological contaminant transport from F-Area Tank Farm:				
Adult resident latent cancer fatality risk	2.2×10^{-4}	9.5×10^{-7}	1.8×10^{-6}	1.3×10^{-5}
Child resident latent cancer fatality risk	2.0×10^{-4}	8.5×10^{-7}	1.7×10^{-6}	1.2×10^{-5}
Seepline worker latent cancer fatality risk	2.2×10^{-7}	8.0×10^{-10}	1.6×10^{-9}	1.2×10^{-8}
Intruder latent cancer fatality risk	1.1×10^{-7}	4.0×10^{-10}	8.0×10^{-10}	8.0×10^{-9}
Adult resident maximum lifetime dose (millirem)[d]	430	1.9	3.6	26
Child resident maximum lifetime dose (millirem)[d]	400	1.7	3.3	24
Seepline worker maximum lifetime dose (millirem)[d]	0.54	0.002	0.004	0.03
Intruder maximum lifetime dose (millirem)[d]	0.27	0.001	0.002	0.02
Radiological contaminant transport from H-Area Tank Farm:				
Adult resident latent cancer fatality risk	8.5×10^{-5}	3.9×10^{-7}	5.5×10^{-7}	6.5×10^{-6}
Child resident latent cancer fatality risk	7.5×10^{-5}	3.3×10^{-7}	5.5×10^{-7}	6.5×10^{-7}
Seepline worker latent cancer fatality risk	8.4×10^{-8}	(e)	4.0×10^{-10}	6.8×10^{-9}
Intruder latent cancer fatality risk	4.4×10^{-8}	(e)	(e)	3.2×10^{-9}
Adult resident maximum lifetime dose (millirem)[d]	170	0.7	1.1	13
Child resident maximum lifetime dose (millirem)[d]	150	0.65	1.1	1.3
Seepline worker maximum lifetime dose (millirem)[d]	0.21	(b)	0.001	0.017
Intruder maximum lifetime dose (millirem)[d]	0.11	(b)	(b)	0.008

---

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the tank farm areas and transported to SRS radioactive waste disposal facilities; impacts of this facility are evaluated in the SRS Waste Management EIS (DOE/EIS-0217).

b. The radiation dose for this alternative is less than 1×10^{-3} millirem.

c. Given in percent of EPA Primary Drinking Water Maximum Contaminant Levels (MCL). A value of 100 is equivalent to the MCL concentration.

d. Calculated based on an assumed 70-year lifetime.

e. The risk for this alternative is less than 4.0×10^{-10}.

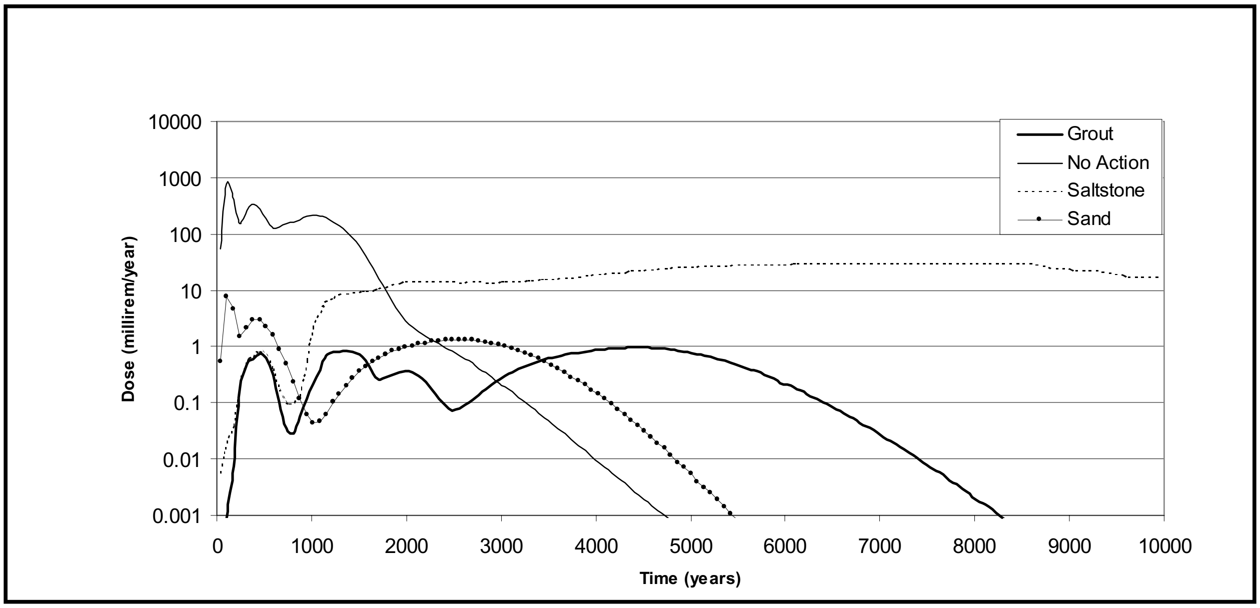


Figure S-7. Predicted Drinking Water Dose Over Time at the H-Area Seepline North of the Groundwater Divide in the Barnwell-McBean and Water Table Aquifers.

There are always uncertainties associated with the results of analyses, especially if the analyses attempt to predict impacts over a long period of time. These uncertainties could result from assumptions used, the complexity and variability of the process(es) being analyzed, the use of incomplete information, or lack of information.

The uncertainties involved in estimating impacts over the 10,000-year period analyzed in this EIS are described in Chapter 4 and Appendix C of the EIS. Over the long term, there would be limited movement of residual contaminants from the closed tanks to surface waters downgradient from the tanks under the No Action Alternative, and almost no such movement under the Clean and Fill with Grout Option under the Clean and Stabilize Tanks Alternative and an intermediate amount under the Clean and Fill with Sand and Clean and Fill with Saltstone Options. The use of a stabilizing agent to retard the movement of residual contaminants under the Clean and Stabilize Alternative results in considerably lower long-term environmental impacts than the No Action Alternative, as described below.

Conservative modeling which exaggerates concentrations at wells close to the tank farms estimates that doses from groundwater at wells 1 meter and 100 meters distant from the tank farms, and at the seepline in Fourmile Branch, would be very large under the No Action Alternative. Under the Clean and Stabilize Tanks Alternative, doses would be much smaller, but incremental doses at the 100 meter well would still exceed the average annual dose a person living in South Carolina receives from natural and man-made sources. The same is true under all three options in the H-Area Tank Farm at the 100-meter well. The doses decrease substantially with distance from the tank farm.

The greatest long-term impacts occur under the No Action Alternative. For this alternative, the Maximum Contaminant Level for beta-gamma radionuclides is exceeded at all points of exposure. On the other hand, the Clean and Fill with Grout Option shows the lowest long-term impacts at all exposure points, and the Maximum Contaminant Level for beta-gamma radionuclides is met at the seepline for this alternative. Impacts for the Clean and Fill with Grout Option would occur later than under the No Action Alternative or the Clean and Fill with Sand Option. The Clean and Fill with Saltstone Option would delay the impacts at the seepline, but would. result in a higher peak dose than either the Clean and Fill with Grout or Clean and Fill with Sand Options

If, in the future, people were unaware of the presence of the closed waste tanks and chose to live in homes built over the tanks, they would have essentially no external radiation exposure under the Clean and Fill with Grout Option or the Clean and Fill with Sand Option. Residents could be exposed to external radiation under the Clean and Fill with Saltstone Option, due to the presence of radioactive saltstone near the ground surface. If it is conservatively assumed that all shielding material over the saltstone would be removed by erosion or excavation, at 1000 years after tank closure a resident living on top of a closed tank would be exposed to an effective dose equivalent of 390 mrem/year, resulting in an estimated 1 percent increase in risk of latent cancer fatality from a 70-year lifetime of exposure. For the No Action Alternative, external exposures to onsite residents would be expected to be unacceptably high, due to the potential for contact with residual waste.

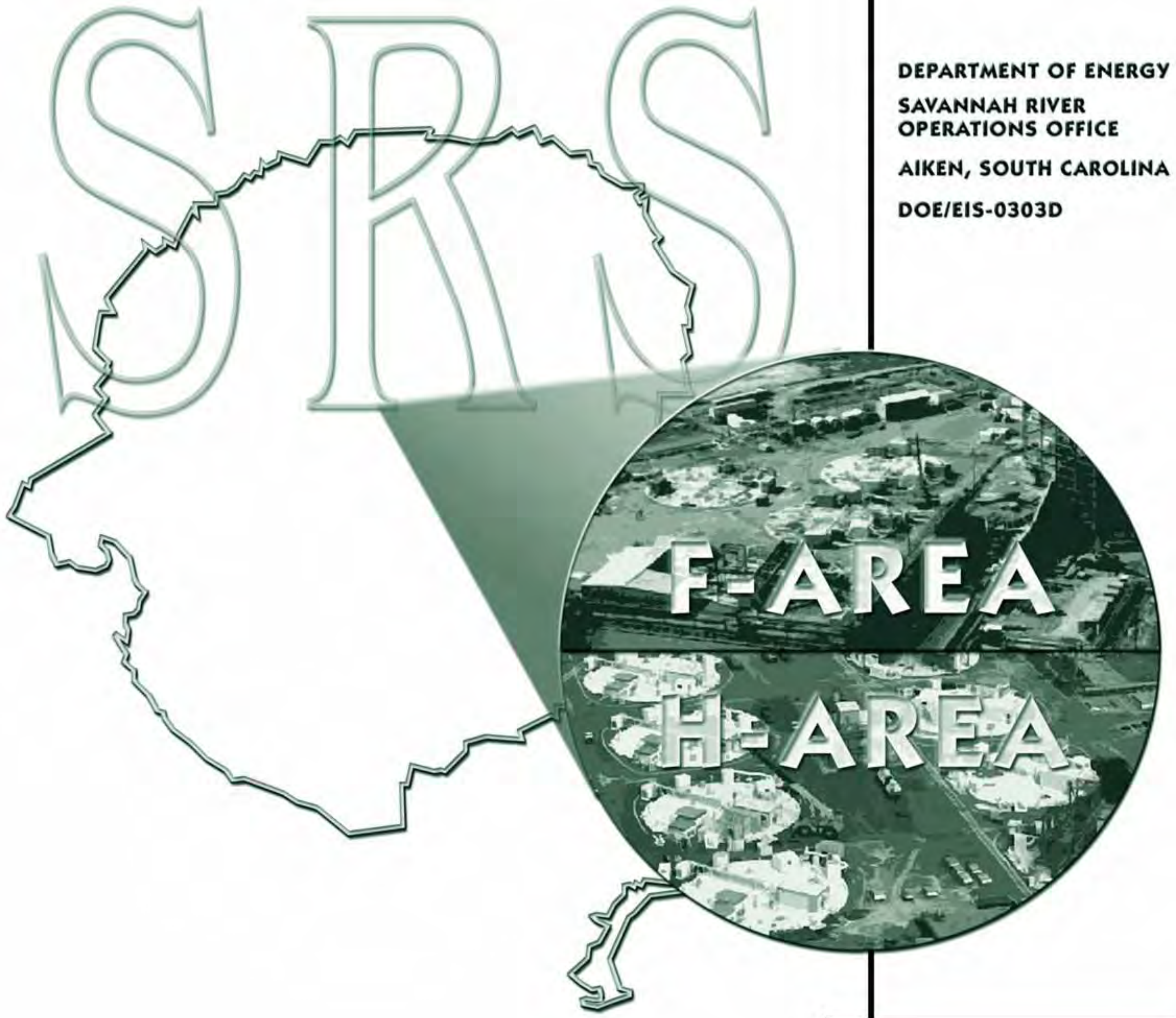
The risk of incurring a fatal cancer as a result of radiation doses is also greater under the No Action Alternative than under any of the Options of the Clean and Stabilize Tanks Alternative. The preferred Option, Clean and Fill with Grout, would result in the least risk of a fatal cancer of all the Options under the Clean and Stabilize Tanks Alternative.

Effects on aquatic and terrestrial organisms are very large under the No Action Alternative, and two or three orders of magnitude less under the options of the Clean and Stabilize Tanks Alternative.

SRS personnel have prepared a report, referred to as the *Composite Analysis*, that calculated the potential cumulative impact to a hypothetical member of the public over a period of 1,000 years from releases to the environment from all sources of residual radioactive material expected to remain in the SRS General Separations Area which contains all of the SRS waste disposal facilities, chemical separations facilities, HLW tank farms, and numerous other sources of radioactive material. The impact of primary concern was the increased probability of fatal cancers. The *Composite Analysis* also included contamination in the soil in and around the HLW tank farms resulting from previous surface spills, pipeline leaks, and Tank 16 leaks as sources of residual radioactive material. The *Composite Analysis* considered 114 potential sources of radioactive material containing 115 radionuclides.

From a land use perspective, the F- and H- Area Tank Farms are zoned Heavy Industrial and are within existing heavily industrialized areas. The alternatives evaluated in this EIS are limited to closure of the tanks and associated equipment. They do not address other potential sources of contamination co-located with the tank systems, such as soil or groundwater contamination from past releases or other facilities. Consequently, future land use of the Tank Farms areas is not solely determined by the alternatives for closure of the tank systems. For example, the Environmental Restoration program may determine that the tank farms areas should be capped to control the spread of contaminants through the groundwater. Such decisions would constrain future use of the tank farms areas. Any of these options under the Clean and Stabilize Tanks Alternative would render the tank farms areas least suitable for other uses, as the closed filled tanks would remain in the ground. The Clean and Remove Tanks Alternative would have somewhat less impact on future land use since the tank systems would be removed. However, DOE does not expect the General Separations Area, which surrounds the F- and H-Area Tank Farms, to be available for other uses.

HIGH-LEVEL WASTE
TANK CLOSURE
Draft Environmental Impact Statement



DEPARTMENT OF ENERGY

SAVANNAH RIVER OPERATIONS OFFICE

AIKEN, SOUTH CAROLINA

DOE/EIS-0303D

November 2000

DOE-SR
AIKEN, SC
DOE/EIS-0303D

Savannah River Site
Savannah River Site

HIGH-LEVEL WASTE
TANK CLOSURE
Draft Environmental
Impact Statement

November 2000

Savannah River Site

HIGH- LEVEL WASTE
TANK CLOSURE
Draft Environmental Impact Statement

DEPARTMENT OF ENERGY
SAVANNAH RIVER
OPERATIONS OFFICE
AIKEN, SOUTH CAROLINA
DOE/EIS-0303D

November 2000

COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy (DOE)

TITLE: Savannah River Site, High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE/EIS-0303D), Aiken, SC.

CONTACT: For additional information or to submit comments on this environmental impact statement (EIS), write or call:

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The EIS is also available on the internet at: http://tis.eh.doe.gov/nepa/docs/docs.htm

For general information on the process that DOE follows in complying with the National Environmental Policy Act, write or call:

Ms. Carol M. Borgstrom, Director
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U.S. Department of Energy
1000 Independence Avenue, S.W.
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ABSTRACT: DOE proposes to close the high-level waste (HLW) tanks at the Savannah River Site (SRS) in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (approved by the South Carolina Department of Health and Environmental Control), which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin after bulk waste removal has been completed. This EIS evaluates three alternatives regarding the HLW tanks at the SRS. The three alternatives are the Clean and Stabilize Tanks Alternative, the Clean and Remove Tanks Alternative, and the No Action Alternative. The EIS considers three options for tank stabilization: Fill with Grout (Preferred Alternative); Fill with Sand; and Fill with Saltstone.

Under each alternative (except No Action), DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines. Impacts are assessed primarily in the areas of water resources, air resources, public and worker health, waste management, socioeconomic impacts, and cumulative impacts.

PUBLIC INVOLVEMENT: In preparing this Draft EIS, DOE considered comments received by letter and voice mail and formal statements made at public scoping meetings in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999.

A 45-day comment period on the Draft High-Level Waste Tank Closure EIS begins with the U.S. Environmental Protection Agency's publication of a Notice of Availability in the *Federal Register*. Public meetings to discuss and receive comments on the Draft EIS will be held on December 11, 2000 at the North Augusta Community Center, North Augusta, South Carolina, and on December 12, 2000 at the Adams Mark Hotel, Columbia, South Carolina. Comments may be submitted at the public meeting and by voice mail, e-mail, and regular mail to the first address above. Comments received or postmarked by the end of the comment period will be considered in the preparation of the final EIS. Comments received or postmarked after the close of the comment period will be considered to the extent practicable.

FOREWORD

The U.S. Department of Energy (DOE) published a Notice of Intent to prepare this environmental impact statement (EIS) on December 29, 1998 (63 FR 71628). As described in the Notice of Intent, DOE's proposed action described in this EIS is to close the high-level waste (HLW) tanks at the Savannah River Site (SRS) in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* approved by the South Carolina Department of Health and Environmental Control. This closure plan specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin after bulk waste removal has been completed and the tank system is turned over to the tank closure program. This EIS assesses the potential environmental impacts associated with alternatives for closing these tanks, as well as the potential environmental impacts of the residual radioactive and non-radioactive material remaining in the closed HLW tanks.

The Notice of Intent requested public comments and suggestions for DOE to consider in its determination of the scope of the EIS, and announced a public scoping period that ended on February 12, 1999. DOE held scoping meetings in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999. During the scoping period, individuals, organizations, and government agencies submitted 36 comments that DOE considered applicable to the SRS HLW tank closure program.

Transcripts of public testimony, written comments received, and reference materials cited in the EIS are available for review in the DOE Public Reading Room, University of South Carolina at Aiken, Gregg-Graniteville Library, University Parkway, Aiken, South Carolina.

DOE has prepared this EIS in accordance with the National Environmental Policy Act (NEPA) regulations of the Council on Environmental Quality (40 CFR Parts 1500-1508) and DOE NEPA Implementing Procedures (10 CFR Part 1021). This EIS identifies the methods used for analyses and the scientific and other sources of information consulted. In addition, it incorporates, directly or by reference, available results of ongoing studies. The organization of the EIS is as follows:

- Chapter 1 provides background information related to SRS HLW tank closures and describes the purpose and need for DOE action regarding HLW tank closure at the SRS.

- Chapter 2 identifies the proposed action and alternatives that DOE is considering for HLW tank closure at the SRS.

- Chapter 3 describes the existing SRS environment as it relates to the alternatives described in Chapter 2.

- Chapter 4 assesses the potential environmental impacts of the alternatives for both the short-term (from the year 2000 through final closure of the existing high-level waste tanks) and long-term (10,000 years post closure) timeframes.

- Chapter 5 discusses the cumulative impacts of HLW tank closure actions in relation to impacts of other past, present, and foreseeable future activities at the SRS.

- Chapter 6 identifies irreversible or irretrievable resource commitments.

- Chapter 7 discusses applicable statutory and regulatory requirements, DOE Orders, and agreements.

- Appendix A provides a description of the SRS HLW Tank Farms and the tank closure process.

- Appendix B provides detailed descriptions of accidents that could occur at SRS during HLW tank closure activities.

- Appendix C provides a detailed description of the fate and transport modeling used to estimate long-term environmental impacts.
- Appendix D describes public comments received during the scoping process and provides DOE responses.

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ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

Acronyms

AAQS	ambient air quality standard
AEA	Atomic Energy Act of 1954
ALARA	as low as reasonably achievable
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLSM	controlled low-strength material
CO	carbon monoxide
D&D	decontamination and decommissioning
DBE	design basis event
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FR	Federal Register
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste
IMNM	Interim Management of Nuclear Material
INEEL	Idaho National Engineering and Environmental Laboratory
ISO	International Organization for Standardization
LCF	latent cancer fatality
LEU	low enriched uranium
LWC	lost workday cases
MCL	maximum contaminant level

MEI	maximally exposed (offsite) individual
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_X	nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
O_3	ozone
OSHA	Occupational Safety and Health Administration
PM_{10}	particulate matter less than 10 microns in diameter
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
ROI	Region of Influence
SCDHEC	South Carolina Department of Health and Environmental Control
SO_2	sulfur dioxide
SRS	Savannah River Site
TRC	total recordable cases
TSP	total suspended particulates
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

cfm	cubic feet per minute
cfs	cubic feet per second = 448.8 gallons per minute = 0.02832 cubic meter per second
cm	centimeter
gpm	gallons per minute
kg	kilogram
L	liter = 0.2642 gallon
lb	pound = 0.4536 kilogram
mg	milligram
µCi	microcurie
µg	microgram
pCi	picocurie
°C	degrees Celsius = 5/9 (degrees Fahrenheit – 32)
°F	degrees Fahrenheit = 32 + 9/5 (degrees Celsius)

Use of Scientific Notation

Very small and very large numbers are sometimes written using “scientific notation” or “E-notation” rather than as decimals or fractions. Both types of notation use exponents to indicate the power of 10 as a multiplier (i.e., 10^n, or the number 10 multiplied by itself “n” times; 10^{-n}, or the reciprocal of the number 10 multiplied by itself “n” times).

For example: $10^3 = 10 \times 10 \times 10 = 1{,}000$

$$10^{-3} = \frac{1}{10 \times 10 \times 10} = 0.001$$

In scientific notation, large numbers are written as a decimal between 1 and 10 multiplied by the appropriate power of 10:

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1{,}000 = 4{,}900$
0.049 is written 4.9×10^{-2}
1,490,000 or 1.49 million is written 1.49×10^6

A positive exponent indicates a number larger than or equal to one; a negative exponent indicates a number less than one.

In some cases, a slightly different notation (“E-notation”) is used, where “× 10” is replaced by “E” and the exponent is not superscripted. Using the above examples

$4{,}900 = 4.9 \times 10^3 =$ 4.9E+03
$0.049 = 4.9 \times 10^{-2} =$ 4.9E-02
$1{,}490{,}000 = 1.49 \times 10^6 =$ 1.49E+06

Metric Conversion Chart

To convert into metric			To convert out of metric		
If you know	**Multiply by**	**To get**	**If you know**	**Multiply by**	**To get**
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
Area					
sq. inches	6.4516	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.092903	sq. meters	sq. meters	10.7639	sq. feet
sq. yards	0.8361	sq. meters	sq. meters	1.196	sq. yards
acres	0.0040469	sq. kilometers	sq. kilometers	247.1	acres
sq. miles	2.58999	sq. kilometers	sq. kilometers	0.3861	sq. miles
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					
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths, then add 32	Fahrenheit

Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa-	E	1 000 000 000 000 000 000 = 10^{18}
peta-	P	1 000 000 000 000 000 = 10^{15}
tera-	T	1 000 000 000 000 = 10^{12}
giga-	G	1 000 000 000 = 10^{9}
mega-	M	1 000 000 = 10^{6}
kilo-	k	1 000 = 10^{3}
centi-	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro-	µ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}
femto-	f	0.000 000 000 000 001 = 10^{-15}
atto-	a	0.000 000 000 000 000 001 = 10^{-18}

CHAPTER 1. BACKGROUND AND PURPOSE AND NEED FOR ACTION

1.1 Background

The Savannah River Site (SRS) occupies approximately 300 square miles adjacent to the Savannah River, primarily in Aiken and Barnwell Counties in South Carolina. It is approximately 25 miles southeast of Augusta, Georgia and 20 miles south of Aiken, South Carolina. The U.S. Atomic Energy Commission, a U.S. Department of Energy (DOE) predecessor agency, established SRS in the early 1950s. Until the early 1990s, the primary SRS mission was the production of special radioactive isotopes to support national programs. More recently, the SRS mission has emphasized waste management, environmental restoration, and decontamination and decommissioning of facilities that are no longer needed for SRS's traditional defense activities.

As a result of its nuclear materials production mission, SRS generated large quantities of highly corrosive and radioactive waste known as high-level waste (HLW). This waste resulted from dissolving spent reactor fuel and nuclear targets to recover the valuable isotopes.

1.1.1 HIGH-LEVEL WASTE DESCRIPTION

DOE Manual 435.1-1, which provides direction for implementing DOE Order 435.1, Radioactive Waste Management, defines HLW as "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." DOE M 435.1-1 also defines two processes for determining that a specific waste resulting from reprocessing spent nuclear fuel can be considered waste incidental to reprocessing (see Section 7.1.3). Waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing does not need to be managed as HLW, and shall be managed under DOE's regulatory authority in accordance with the requirements for transuranic waste or low-level waste, as appropriate.

1.1.2 HLW MANAGEMENT AT SRS

At the present time, approximately 34 million gallons of HLW are stored in 49 underground tanks in two tank farms, the F-Area Tank Farm and the H-Area Tank Farm. These tank farms are in the central portion of SRS. The sites were chosen in the early 1950s because of their proximity to the F- and H-Area Separations Facilities, and the distance (approximately 5.5 miles) from the SRS boundaries. Figure 1-1 shows the setting of the F and H Areas and associated tank farms.

The HLW in the tanks consists primarily of three physical forms: sludge, salt, and liquid. The sludge is solid material that precipitates and settles to the bottom of a tank. The salt is comprised of salt compounds[1] that have crystallized as a result of concentrating the liquid by evaporation. The liquid is highly concentrated salt solution. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks while others are considered salt tanks (containing both salt and salt solution).

The sludge portion of the HLW currently is being transferred to the Defense Waste Processing Facility (DWPF) for vitrification in borosilicate glass to immobilize the radioactive constituents as described in the *Defense Waste Processing Facility Supplemental Environmental Impact Statement* (DOE 1994). [The plan and schedule for managing tank space, mixing waste to create an appropriate feed for the DWPF, and remov-

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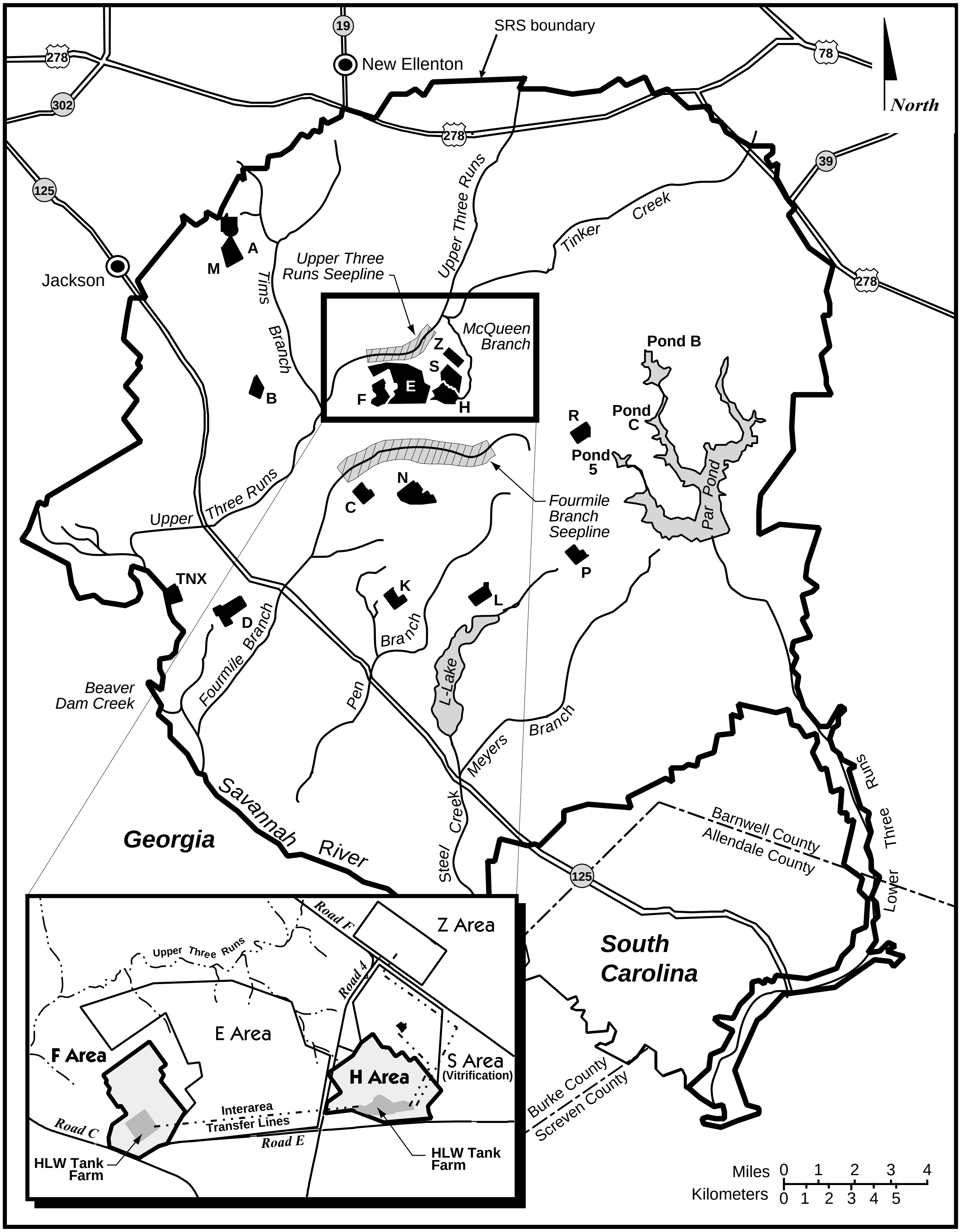
[1] A salt is a chemical compound formed when one or more hydrogen ions of an acid are replaced by metallic ions. Common salt, sodium chloride, is a well-known salt.



NW TANK/Grfx/ch_1/1-1 SRS F&H.ai

Figure 1-1. Savannah River Site map with F- and H-Areas highlighted.

ing bulk waste is contained in the *High Level Waste System Plan* (WSRC 1998 and subsequent revisions)]. The borosilicate glass is poured into stainless steel canisters that are stored in the Glass Waste Storage Building pending shipment to a geologic repository for disposal.

The salt and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before ultimate treatment. As described in DOE (1994), an In-Tank Precipitation process would separate the HLW into high- and low-activity fractions. The high-radioactivity fraction would be transferred to the DWPF for vitrification. The low-radioactivity fraction would be transferred to the Saltstone Manufacturing and Disposal Facility in Z-Area and mixed with grout to make a concrete-like material to be disposed in vaults at SRS. Since issuance of that EIS, DOE has concluded that the In-Tank Precipitation Process, as currently configured, cannot achieve production goals and meet safety requirements for processing the salt portion of HLW (64 FR 8559; February 22, 1999). The process for separating the HLW is the subject of an on-going EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site*. Figure 1-2 shows the SRS HLW management system as currently configured.

1.1.3 DESCRIPTION OF THE TANK FARMS

The F-Area Tank Farm is a 22-acre site that contains 20 active waste tanks, 2 closed waste tanks (Tanks 17 and 20), 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure 1-3 shows the general layout of the F-Area Tank Farm. The H-Area Tank Farm is a 45-acre site that contains 29 waste tanks, 3 evaporator systems (including the new Replacement High-level Waste Evaporator, 242-25H), the In-Tank Precipitation Process, the Extended Sludge Processing facility, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure 1-4 shows the general layout of the H-Area Tank Farm.

The F- and H-Area Tank Farms were constructed to receive high-level radioactive waste generated by various SRS production, processing, and laboratory facilities. The use of the tank farms isolates these wastes from the environment, SRS workers, and the public. In addition, the tank farms enable radioactive decay by aging the waste, clarification of waste by gravity settling, and removal of soluble salts from waste by evaporation. The tank farms also pretreat the accumulated sludge and salt solutions (supernate) to enable the management of these wastes at other SRS treatment facilities (i.e., Defense Waste Processing Facility (DWPF) and Z-Area Saltstone Manufacturing and Disposal Facility (SMDF). These treatment facilities convert the sludge and supernate to more stable forms suitable for permanent disposal.

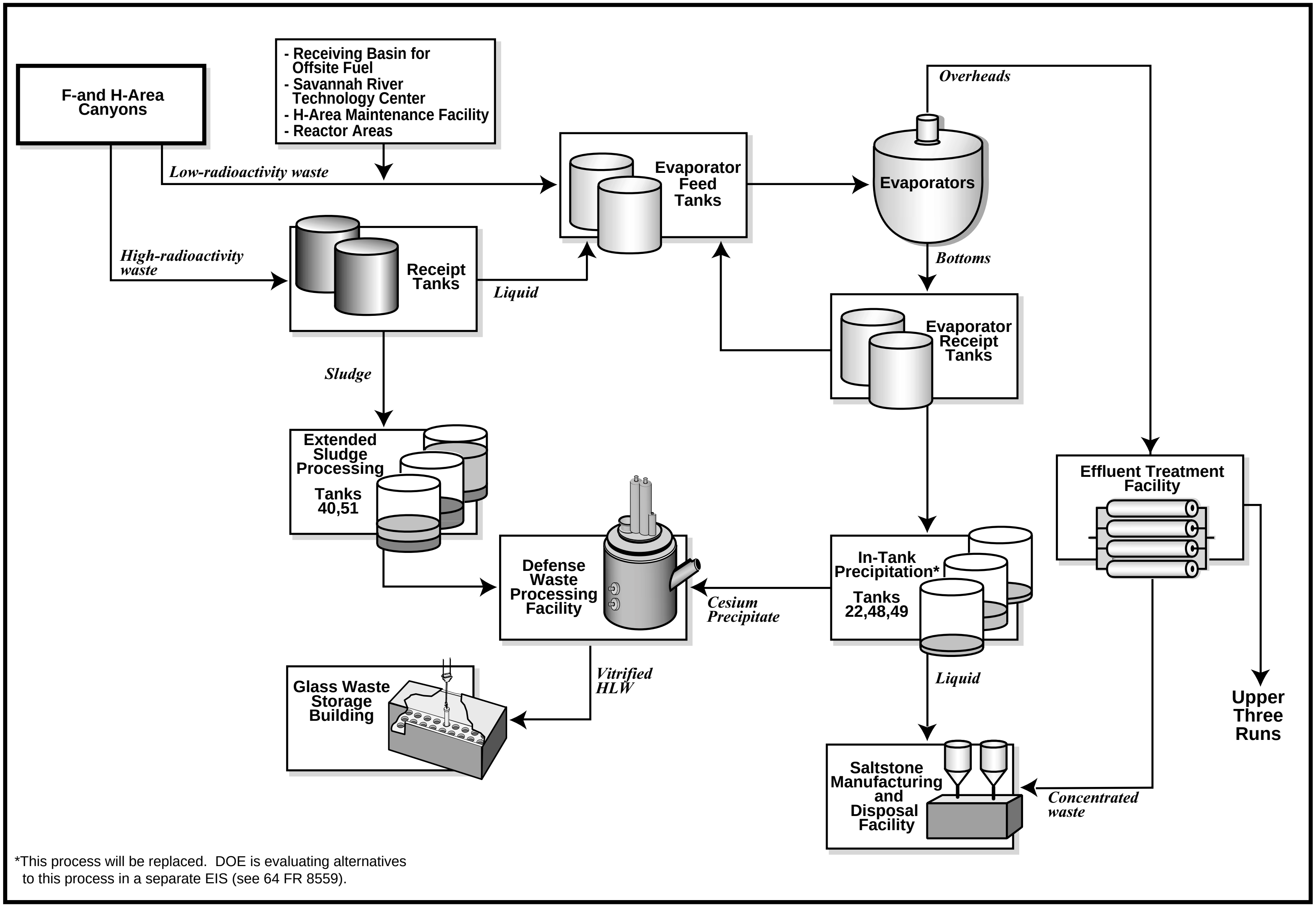
To accomplish the system operational objectives described above, the following units were assembled in the tank farms:

- Fifty-one large underground waste tanks to receive and age the waste, and allow it to settle

- Five existing evaporator systems to concentrate soluble salts and reduce the waste volume

- Transfer system (i.e., transfer lines, diversion boxes, and pump pits) to transfer supernate, sludge and other waste (e.g., evaporator condensate) between tanks and treatment facilities

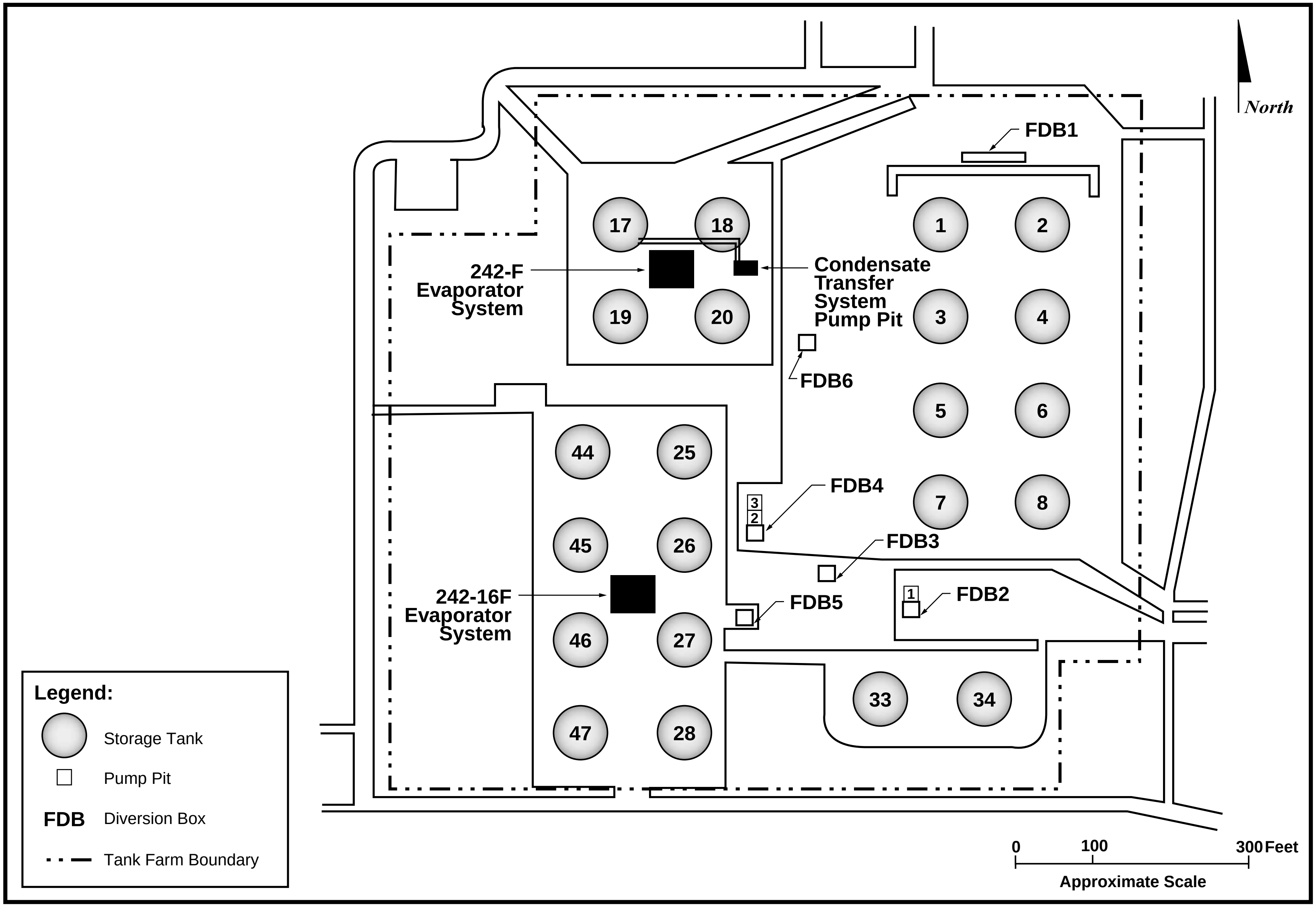
- Precipitation/filtration system (i.e., ITP Facility) to separate the salt solution into high- and low-activity fractions for immobilization at the DWPF Vitrification Facility and Z-Area Saltstone Manufacturing and Disposal Facility, respectively [Operation of the ITP Facility was suspended in early 1998. DOE is currently evaluating alternate salt disposition technologies to replace the ITP process.]



*This process will be replaced. DOE is evaluating alternatives to this process in a separate EIS (see 64 FR 8559).

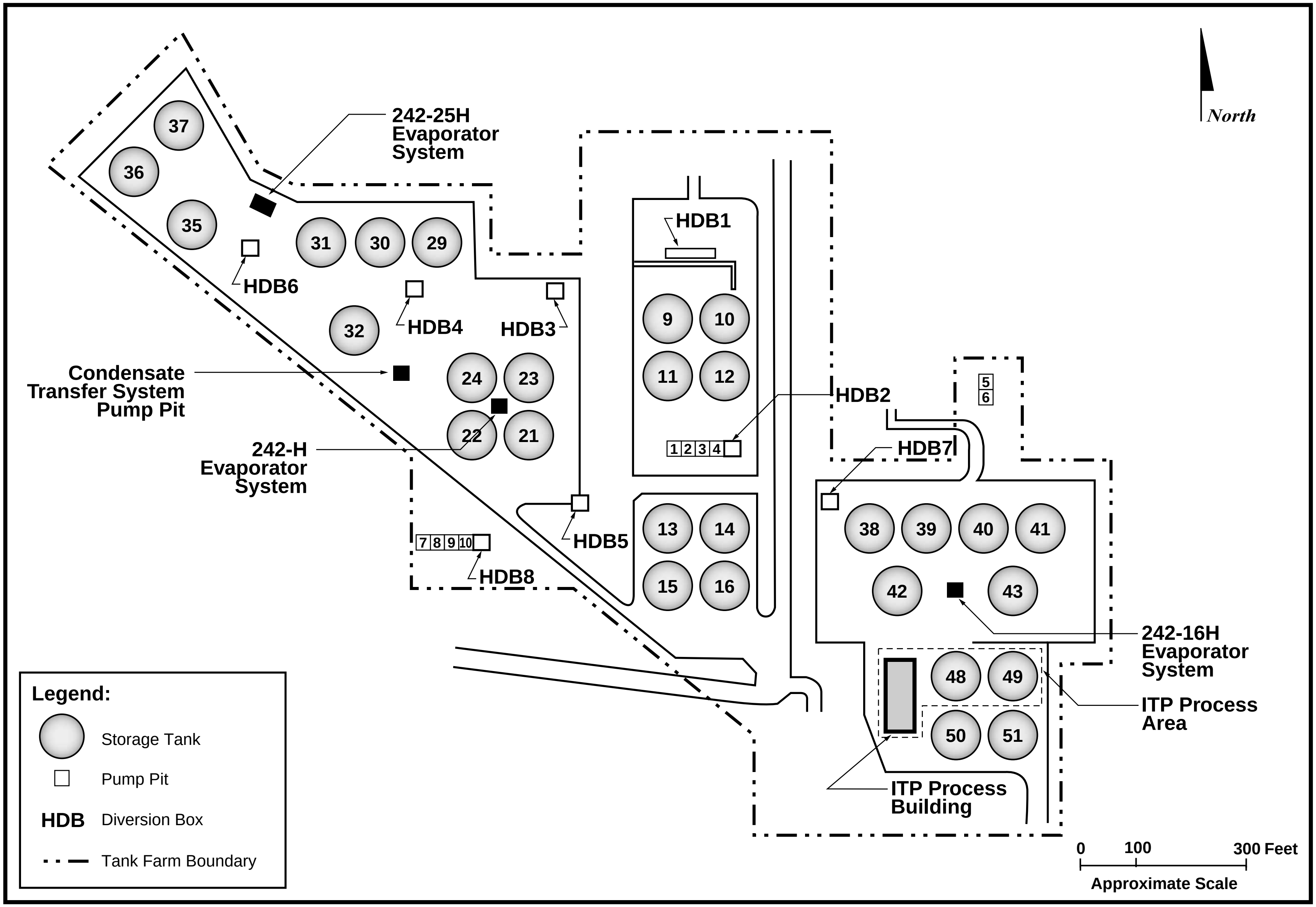
NW TANK/Grfx/1-2 Proc SRS HLW.ai

Figure 1-2. Process flows for Savannah River Site High-Level Waste Management System.



NW TANK/Grfx/1-3 F-Area.ai

Figure 1-3. General layout of F-Area Tank Farm.



NW TANK/Grfx/1-4 H_Tank.ai

Figure 1-4. General layout of H-Area Tank Farm.

- Sludge washing system (i.e., Extended Sludge Processing) to pretreat the accumulated sludge prior to immobilization at the DWPF Vitrification Facility

Tanks

The F- and H-Area tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. Two designs (Types I and II) have 5-foot high secondary annulus "pans" and active cooling (Figure 1-5). (An "annulus" is the space between two walls of a double-walled tank.)

The 12 Type I Tanks (Tanks 1 through 12) were built in 1952 and 1953, five of which (Tanks 1, 9 through 12) have known leak sites in which waste leaked from the primary containment to the secondary containment. The leaked waste is kept dry by air circulation, and there is no evidence that the waste has leaked from the secondary containment. The tank tops are about 9.5 feet below grade. The bottoms of Tanks 1 through 8, in F-Area, are situated above the seasonal high water table. Tanks 9 through 12 in the H-Area Tank Farm are in the water table.

The four Type II tanks (Tanks 13 through 16) were built in 1956 in the H-Area Tank Farm (Figure 1-5). All four have known leak sites in which waste leaked from primary to secondary containment. In Tank 16, the waste overflowed the annulus pan (secondary containment). The waste was still contained in the concrete encasement that surrounds the tank, but surveys indicated that some waste leaked into the soil, presumably through a construction joint on the side of the encasement that is located near the top of the annulus pan, about 25 feet below grade. Based on soil borings around the tank, it is estimated that some tens of gallons of waste leaked into the soil. Much of the leaked waste was removed from the annulus during the period 1976 to 1978; however, several thousand gallons remain in the annulus. Waste removal from the Tank 16 primary vessel was completed in 1980. Assuming that the waste did leak from the construction joint, the leaked waste is in the vicinity of the seasonal water table and is at times below the water table.

The eight Type IV tanks (Tanks 17 through 24) were built between 1958 and 1962. These tanks have a single steel wall and do not have active cooling (Figure 1-5). Tanks 17 through 20 are in the F-Area Tank Farm and Tanks 21 through 24 are in H-Area. Tanks 19 and 20 have known cracks that are believed to have been caused by corrosion of the tank wall from occasional groundwater inundation from fluctuation in the water table. Small amounts of groundwater have leaked into these tanks; there is no evidence that waste ever leaked out. Tanks 17 through 20 are slightly above the water table. Tanks 21 through 24 are above the groundwater table; however, they are in a perched water table caused by the original construction of the tank area. Tanks 17 and 20 have already been closed in a manner described in the Clean and Fill with Grout option of the Clean and Stabilize Tanks Alternative evaluated in this EIS (see Section 2.1.1).

The newest design (Type III) has a full-height secondary tank and active cooling (Figure 1-5). All of the Type III tanks (25 through 51) are above the water table. These 27 tanks were placed in service between 1969 and 1986 with 10 in the F-Area and 17 in the H-Area Tank Farms. None of them has known leak sites.

By 2022, DOE is required to remove from service and close all the remaining tank systems that have experienced leaks or do not have full-height secondary containment. The 24 Type I, II, and IV tanks have been or will be removed from service before the 27 Type III tanks. Type III tanks will remain in service until there is no further need for the tanks, which DOE currently anticipates would occur before the year 2030.

Summary information on the F-and H-Area HLW tanks is presented in Table 1-1.

Evaporator Systems

Each tank farm has two evaporators that concentrate waste following receipt from the canyons. At present, two evaporators are operating, one in each tank farm. Each operating evaporator is made of stainless steel and operates at near

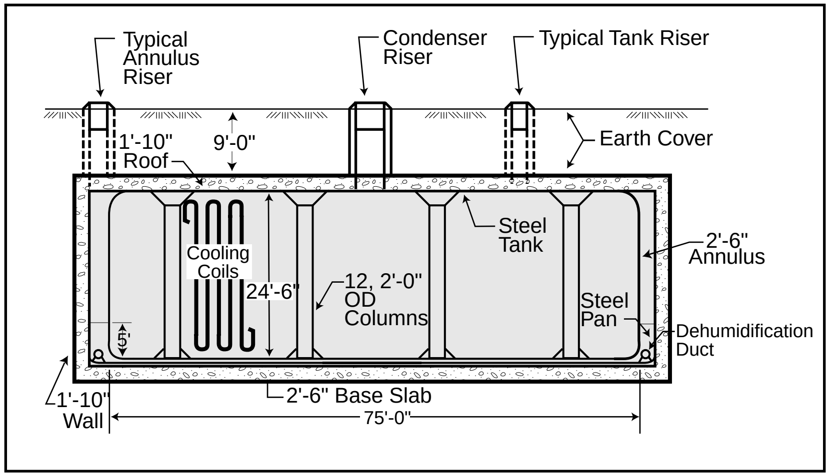


Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

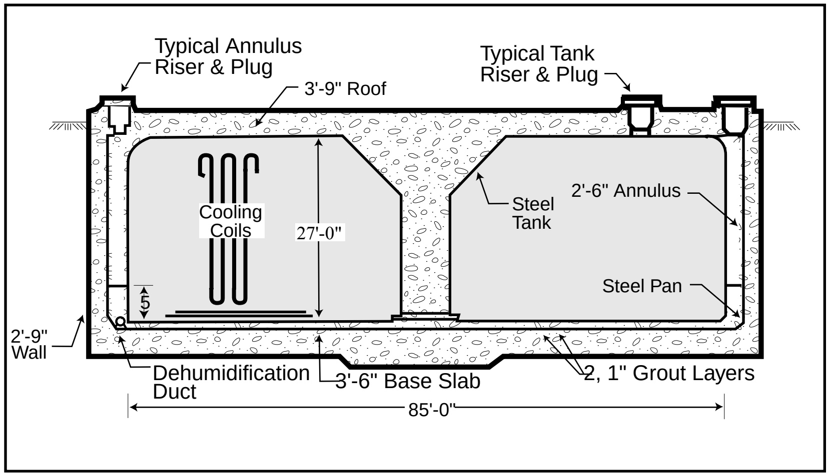


Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

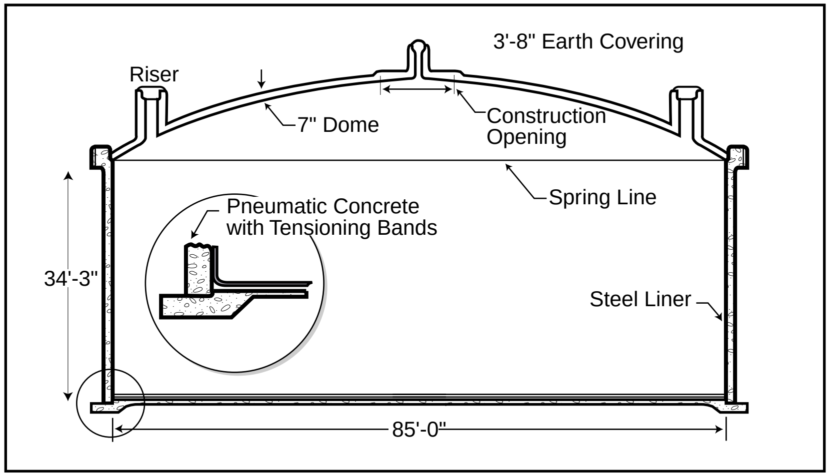


Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

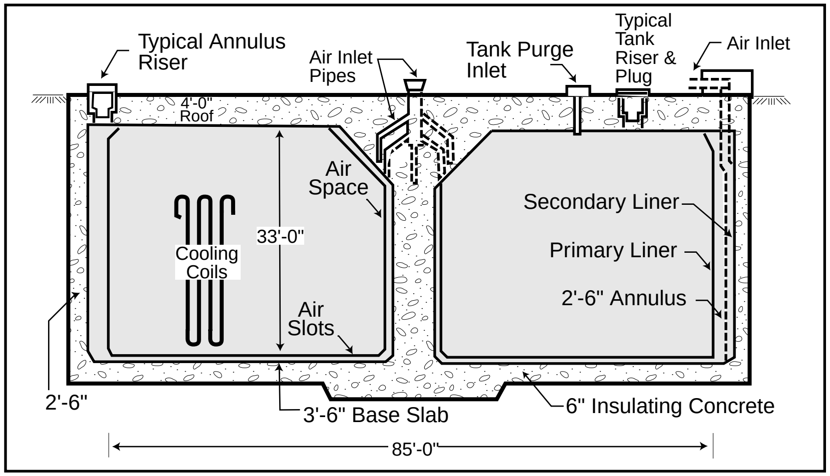


Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

NW TANK/Grfx/1-5 Tank config.ai

Figure 1-5. Tank configuration.

Table 1-1. Summary of high-level waste tanks.

Tank type	Number of tanks	Volume (gallons)	Area	Tank numbers	Year constructed	Year first used
I[a]	12	750,000	F	1 - 8	1952	1954-64
			H	9 - 12	1953	1955-56
II[a]	4	1,030,000	H	13 - 16	1956	1957-60
III	27	1,300,000	F	25 - 28	1978	1980
				33 - 34	1969, 1972	1969, 1972
				44 - 47	1980	1980-82
			H	29 - 32	1970	1971-74
				35 - 43	1976-79	1977-86
				48 - 51	1981	1983-86
IV[a]	8	1,300,000	F	17 - 20[b]	1958	1958-61
			H	21 - 24	1961-62	1961-65

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a. Twenty-four Type I, II, and IV HLW tanks will be removed from service by 2022.
b. Two tanks (Tanks 17 and 20) have been closed.

atmospheric pressure under alkaline conditions. The evaporators are 8 feet in diameter and have an operating capacity of approximately 1,800 gallons. An additional evaporator system, the Replacement High-Level Waste Evaporator, has been built in H-Area. The Replacement High-Level Waste Evaporator has almost twice the operating capacity of the existing evaporators. Because of the radioactivity emitted from the waste, the evaporator systems are either shielded (i.e., lead, steel, or concrete vaults) or placed underground. The process equipment is designed to be operated and maintained remotely.

Waste supernate is transferred from the evaporator feed tanks and heated to the aqueous boiling point in the evaporator vessel. The evaporated liquids (overheads) are condensed and, if required, processed through an ion-exchange column for cesium removal. The overheads are transferred to the F/H Effluent Treatment Facility for final treatment before being discharged to Upper Three Runs. The overheads can be recycled back to a waste tank if evaporator process upsets occur. Supernate can be reduced to about 25 percent of its original volume and immobilized as crystallized salt by successive evaporations of liquid supernate.

Transfer System

A network of transfer lines is used to transfer wastes between the waste tanks, process units, and various SRS areas (i.e., F-Area, H-Area, S-Area, and Z-Area). These transfer lines have diversion boxes that contain removable pipe segments (called jumpers) to complete the desired transfer route. Jumpers of various sizes and shapes can be fabricated and installed to enable the transfer route to be changed. The use of diversion boxes and jumpers allows flexibility in the movement of wastes. The diversion boxes are usually underground, constructed of reinforced concrete, and either sealed with waterproofing compounds or lined with stainless steel.

Pump pits are intermediate pump stations in the F- and H-Area Tank Farm transfer systems. These pits contain pump tanks and hydraulic pumps or jet pumps. Many pump pits are associated with diversion boxes. The pits are constructed of reinforced concrete and have a stainless-steel liner.

1.1.4 HLW TANK CLOSURE

1.1.4.1 Closure Process

After the majority of the waste has been removed from the HLW tanks for treatment and disposal, the tank systems (including the tanks, evaporators, transfer lines, and other ancillary equipment) would become part of the HLW tank closure project, the potential environmental impacts of which are the subject of this EIS. In accordance with the SRS Federal Facility Agreement (EPA 1993), DOE intends to remove the tanks from service as their missions are completed. For 24 tanks that do not meet the U.S. Environmental Protection Agency's (EPA's) secondary containment standards under the Resource Conservation and Recovery Act, DOE is obligated to close the tanks by 2022. The proposed closure process specified by the Federal Facility Agreement is described in Appendix A beginning in Section A.4.

The process of preparing to close tanks began in 1995. DOE prepared the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996a) that describes the general protocol for closing the tanks. This document (referred to as the General Closure Plan) was developed with extensive interaction with the State of South Carolina and EPA. Concurrent with the General Closure Plan, DOE prepared the *Environmental Assessment for the Closure of the High Level Waste Tanks in F- and H-Areas at the Savannah River Site* (DOE 1996b). In a Finding of No Significant Impact published on July 31, 1996, DOE concluded that closure of the HLW tanks in accordance with the General Closure Plan would not result in significant environmental impacts.

Accordingly, DOE began to close Tank 20, from which the bulk waste had already been removed. In accordance with the General Closure Plan, DOE prepared a tank-specific closure plan (DOE 1997a) that outlined the specific steps for Tank 20 closure and presented the long-term environmental impacts of the closure. The State of South Carolina approved the Closure Module, and Tank 20 closure was completed on July 31, 1997. Later in 1997, following preparation and approval of a tank-specific Closure Module, Tank 17 was closed.

DOE has decided to prepare an EIS before any additional HLW tanks are closed at SRS. This decision is based on several factors, including the desire to further explore the environmental impacts from closure and to open a new round of information sharing and dialogue with stakeholders. SRS is committed in the Federal Facility Agreement to close another HLW tank by Fiscal Year 2003. DOE has reviewed bulk waste removal of waste from the HLW tanks in the Waste Management Operations, Savannah River Plant EIS (ERDA-1537) and the Long-term Management for Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization) Savannah River Plant EIS (DOE/EIS-0023). In addition, the SRS Waste Management EIS discusses high-level waste management activities as part of the No Action Alternative (continuing the present course of action), and the Defense Waste Processing Facility Savannah River Plant EIS (DOE/EIS-0082) and the Final Supplemental Environmental Impact Statement Defense Waste Processing Facility (DOE/EIS-0082S) discuss management of high-level waste after it is removed from the tanks.

The National Research Council released a study (National Research Council, 1999) examining the technical options for HLW treatment and tank closure at the Idaho National Engineering and Environmental Laboratory (INEEL). The Council concluded that clean closure is impractical, some residual radioactivity will remain, but with rational judgement and prudent management, that it is reasonable to expect all options will result in very low risks. Recommendations made by the NRC included: 1- establish closure criteria, 2-develop an innovative sampling plan based on risks, and 3-conduct testing to anticipate possible process failure. The SRS General Closure Plan had anticipated and includes points similar to those raised by the Council.

1.1.4.2 Waste Incidental to Reprocessing

An important issue associated with tank closure, and a subject of controversy, is the determination of the regulatory classification of residual waste in the tanks. Before bulk waste removal, the content of the tanks is HLW. The goal of the bulk waste removal and subsequent cleaning of the tanks is to remove as much waste as can reasonably be removed.

In July 1999, DOE issued Order 435.1, Radioactive Waste Management, and the associated Manual and Implementation Guide. DOE Manual 435.1-1 prescribes two processes, by citation or by evaluation (see text box), for determining that waste resulting from reprocessing spent nuclear fuel can be considered “waste incidental to reprocessing.”

Waste Incidental to Reprocessing Determination

The two processes for determining that waste can be considered incidental to reprocessing are “citation” and “evaluation.” Waste incidental to reprocessing by “citation” includes spent nuclear fuel processing plant wastes that meet the description included in the Nuclear Regulatory Commission’s Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7 that later came to be referred to as “waste incidental to reprocessing.” These radioactive wastes are the result of processing plant operations, such as, but not limited to contaminated job wastes, such as laboratory items (clothing, tools, and equipment).

Waste incidental to reprocessing by “evaluation” includes spent nuclear fuel processing plant wastes that meet the following three criteria: (1) have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical, (2) will be managed to meet safety requirements comparable to the performance standards set forth in Subpart C of 10 CFR 61 (if low-level waste) or will be incorporated in a solid physical form and meet alternative requirements for waste classification and characteristics authorized by DOE (if transuranic waste), and (3) managed as low-level or transuranic waste pursuant to DOE's authority under the Atomic Energy Act in accordance with the applicable provisions of DOE M 435.1-1.

According to Order 435.1, waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not HLW, and shall be managed under DOE’s regulatory authority in accordance with requirements for transuranic waste or low-level waste, as appropriate.[2] Section 7.1.3 of this EIS discusses the waste incidental to reprocessing process in more detail.

1.2 Purpose and Need for Action

DOE needs to reduce human health and safety risks at and near the HLW tanks, and to reduce the eventual introduction of contaminants into the environment. If DOE does not take action after bulk waste removal, the tanks would fail, and contaminants would be released to the environment. Failed tanks would present the risk of accidents to individuals. Release of contaminants to the environment would present human health risks, particularly to individuals who might use contaminated water, in addition to adverse impacts to the environment.

1.3 Decisions to be Based on this EIS

This EIS provides an evaluation of the environmental impacts of several alternatives for closure of the high-level waste tanks at the Savannah River Site. The closure process will take place over a period of up to 30 years. The EIS provides the decisionmaker with an assessment of the potential environmental, health and safety effects of each alternative. The selection of a tank closure alternative, following completion of this EIS, will guide the selection and imple-

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[2] The Natural Resources Defense Council (NRDC) has filed a Petition in the Court of Appeals for the Ninth Circuit asking the Court to review DOE Order 435.1 and claiming the Order is “arbitrary, capricious, and contrary to law.” The Nuclear Regulatory Commission, in responding recently to a separate petition from the NRDC, has concluded that DOE’s commitments to (1) clean up the maximum extent technically and economically practical, and (2) meet performance objectives consistent with those required for disposal of low level waste, if satisfied, should serve to provide adequate protection of public health and safety (65 FR 62377, October 18, 2000).

mentation of a closure method for each high-level waste tank at the SRS. Within the framework of the selected alternative, and the environmental impact of closure described in the EIS, DOE will select and implement a closure method for each tank.

In addition to the closure methods and impacts described in this EIS, the tank closure program will operate under a number of laws, regulations, and regulatory agreements described in Chapter 7 of this EIS. In addition to the General Closure Plan (a document prepared by DOE based on responsibilities under the AEA and other laws and regulations and approved by SCDHEC), the closure of individual tanks will be performed in accordance with a tank-specific Closure Module. Each Closure Module will incorporate a specific plan for tank closure and modeling of impacts based on that plan. Through the process of preparing and approving each Closure Module, DOE will select a closure method that is consistent with the closure alternative selected after completion of this EIS. The selected closure method for each tank will result in the closure of all tanks with impact on the environment equal to or less than those described in this EIS. If a tank closure that meets the performance objectives of the closure module cannot be accomplished using the selected alternative, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank.

During the expected 30-year period of tank closure activities, new technologies for tank cleaning or other aspects of the closure process may become available. DOE would conduct the appropriate NEPA review for any proposal to use a new technology.

1.4 EIS Overview

1.4.1 SCOPE

This EIS analyzes the environmental impacts of cleaning, isolating, and stabilizing the HLW tanks and related systems such as evaporators, transfer piping, sumps, pump pits, diversion boxes, filtration systems, sludge washing equipment, valve boxes, and the condensate transfer system. Before tank closure can be accomplished, DOE must remove the waste stored in the tanks, a process called bulk waste removal. Bulk waste removal is discussed as part of the No Action Alternative (i.e., a continuation of the normal course of action) in the Savannah River Site Waste Management EIS (DOE/EIS-0217). In light of proposed changes in the bulk waste removal program, DOE will determine the need to supplement the Waste Management EIS. Bulk waste removal means pumping out all the waste that is possible with existing equipment. Bulk waste removal leaves residual contamination on the tank walls and internal hardware such as cooling coils. A heel of liquid, salt, sludge, or other material remains in the bottom of the tank and cannot be removed without using special means. Removal of this residual material is part of the cleaning stage of the proposed action.

Upon completion of closure activities for a group of tanks (and their related equipment) in a particular section of a tank farm, the tanks and associated equipment in the group would transition to the SRS environmental restoration program. The environmental restoration program would conduct soil assessments and remedial actions to address any contamination in the environment (including previous known leaks) and develop a post-closure strategy. Consideration of alternative remedial actions under the remediation program is outside the scope of this EIS, and would be conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. DOE, however, has established a formal process to ensure that tank closure activities are coordinated with the environmental restoration program. This process is described in the *High-Level Waste Tank Closure Program Plan* (DOE 1996c). This process requires that, once a group of tanks in a particular section of a tank farm is closed, the HLW operations organization and the environmental restoration organization would establish a Co-Occupancy Plan to ensure safe and efficient soils assessment and remediation.

The HLW organization would be responsible for operational control and the environmental restoration organization would be responsible for environmental restoration activities. The primary purpose of the Co-Occupancy Plan is to provide the two organizations with a formal process to plan, control, and coordinate the environmental restoration activities in the tank farm areas. The activities of the environmental restoration program would be governed by the CERCLA, RCRA corrective action, and the Federal Facility Agreement between DOE, SCDHEC, and EPA. As such, it is beyond the scope of this EIS.

1.4.2 ORGANIZATION

This EIS has seven chapters supported by four appendices. Chapter 2 describes the proposed action and alternatives for carrying it out. Chapter 3 discusses the SRS and describes the site and the surrounding environment the alternatives could impact. Chapter 4 presents the estimated impacts from tank closure. Chapter 5 discusses the cumulative impacts of this project plus other existing or planned projects that affect the environment. Chapter 6 presents resource commitments. Chapter 7 discusses applicable laws, regulations, and permit requirements.

This EIS also contains four appendices. Appendix A describes HLW management at SRS with an emphasis on the tank farms and the closure alternatives. Appendix B provides information on accident scenarios. Appendix C describes long-term closure modeling, and Appendix D describes public input received during the scoping period and provides DOE responses.

1.4.3 STAKEHOLDER PARTICIPATION

On December 29, 1998, DOE announced in the *Federal Register* (63 FR 71628) its intent to prepare an EIS on the proposed closure of High-Level Waste Tanks at SRS near Aiken, South Carolina. DOE proposes to close the tanks to protect human health and the environment and to promote safety. With the Notice, DOE established a public comment period that lasted through February 12, 1999.

DOE invited SRS stakeholders and other interested parties to submit comments for consideration in the preparation of the EIS. DOE held scoping meetings on the EIS in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999. Each meeting included presentations on the NEPA process in relation to the proposed action, on the plan for closure of the tanks and on the alternatives presented in this EIS. The meetings also offered opportunities for public comment and general questions and answers.

From the scoping process the Department identified about 25 separate comments. Six comments recommended changes or additions to the alternatives, three comments suggested data to be included, eleven comments suggested evaluations to be used or concerns about analyses, six comments dealt with concerns about criteria used or regulatory compliance, two comments dealt with schedule or EIS process, and four comments dealt with a variety of topics that do not fit in any of the areas given above. DOE considered all of these comments in preparing this EIS.

A summary of the comments received during the pubic scoping period and how they influenced the scope of this Draft EIS is included as Appendix D.

1.4.4 RELATED NEPA DOCUMENTS

This EIS makes use of information contained in other DOE NEPA documents related to HLW management and tank closure. It is also designed to be consistent with DOE's parallel effort to prepare an EIS on HLW Salt Disposition Alternatives, which is related to activities in the H-Area Tank Farm. The NEPA documents related to this HLW Tank Closure EIS are briefly described below.

Environmental Assessment for the Closure of the High-Level Waste Tanks in the F- and H-Areas at the Savannah River Site – DOE prepared an environmental assessment (DOE 1996b) to evaluate the impacts of closing HLW tanks at the SRS after removal of the bulk waste. The proposed action was to remove the residual waste from the tanks and fill them with a material to prevent future collapse and bind up residual waste, to decrease human health risks, and to increase safety in the area of the tank farms. After closure, the tank system would be turned over to the SRS environmental restoration program for environmental assessment and remedial actions as necessary. A Finding of No Significant Impact was determined based on the analyses in the environmental assessment, and DOE subsequently closed Tanks 17 and 20. DOE has now decided to prepare an EIS for proposal to close the remaining HLW tanks.

Final Defense Waste Processing Facility Supplemental Environmental Impact Statement – DOE prepared a Supplemental EIS to examine the impacts of completing construction and operating the DWPF at the SRS. This document (DOE 1994) assisted the Department in deciding whether and how to proceed with the DWPF project, given the changes to processes and facilities that had occurred since 1982, when it issued the original *Defense Waste Processing Facility EIS*.

The Record of Decision (60 FR 18589) announced that DOE would complete the construction and startup testing of DWPF and would operate the facility using the In-Tank Precipitation process after the satisfactory completion of startup tests.

The alternatives evaluated in this EIS could generate radioactive waste that DOE would have to handle or treat at facilities described in the *Defense Waste Processing Facility Supplemental EIS* and the *SRS Waste Management EIS* (see next paragraph). The *Defense Waste Processing Facility Supplemental EIS* is also relevant to the assessment of cumulative impacts (see Chapter 5) that could occur at SRS.

Savannah River Site Waste Management Final Environmental Impact Statement – DOE issued the *SRS Waste Management EIS* (DOE 1995) to provide a basis for the selection of a sitewide approach to managing present and future (through 2024) wastes generated at SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs.

The *SRS Waste Management EI*S includes the treatment of wastewater discharges in the Effluent Treatment Facility, F- and H-Area tank operations and waste removal, and construction and operation of a replacement HLW evaporator in the H-Area Tank Farm. In addition, it evaluates the Consolidated Incineration Facility for the treatment of mixed waste. The Record of Decision (60 FR 55249) stated that DOE will configure its waste management system according to the moderate treatment alternative described in the EIS. The *SRS Waste Management EIS* is relevant to this HLW Tank Closure EIS because it evaluates management alternatives for various types of waste that actions proposed in this EIS could generate. The *Waste Management EIS* is also relevant in the assessment of cumulative impacts that could occur at the SRS (see Chapter 5).

Final Waste Management Programmatic Environmental Impact Statement for Managing, Treatment, Storage, and Disposal of Radioactive and Hazardous Waste – DOE published this EIS as a complex-wide study of the environmental impacts of managing five types of waste generated by past and future nuclear defense and research activities, including HLW at four sites (DOE 1997c). This NEPA analysis was the first time DOE had examined in an integrated fashion the impacts of complex-wide waste management alternatives and the cumulative impacts from all waste management activities at a specific site.

The EIS evaluated four alternatives, including the no action alternative, for managing immobilized HLW until such time as a geologic repository is available to receive it. The preferred alternative was for each site to store its immobilized waste onsite. The Record of Decision to proceed with DOE's preferred alternative of decentralized storage for immobilized HLW was issued August 26, 1999 (64 FR 46661).

Supplemental Environmental Impact Statement for High-Level Waste Salt Disposition Alternatives at the Savannah River Site – On February 22, 1999 DOE published a Notice of Intent to prepare a Supplemental EIS for alternatives to the In-Tank Precipitation process at

SRS (64 FR 8558). The In-Tank Precipitation process was intended to separate soluble, high-activity radionuclides from HLW before vitrifying the high-activity portion of the waste in the DWPF and disposing of the low-activity fraction as saltstone grout in vaults at SRS. However, the In-Tank Precipitation process as presently configured cannot achieve production goals and safety requirements for processing HLW. The Supplemental EIS will evaluate the impacts of alternatives to the In-Tank Precipitation process for separating the high- and low-activity fractions of the HLW currently stored in tanks at SRS. Although the *Salt Disposition Alternatives Supplemental EIS* addresses subject matter and some equipment in common with this EIS, the actions proposed in each EIS are independent and are thus appropriately considered in separate EISs.

References

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082-S, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995, *Final Environmental Impact Statement Waste Management,* DOE/EIS-0217, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996a, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, July 10.

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CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action and Alternatives

DOE proposes to close the HLW tanks at SRS in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996) (the General Closure Plan) approved by SCDHEC, which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin when bulk waste removal has been completed. Under each alternative except No Action, DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines.

DOE is evaluating three alternatives in this EIS. As described above, all of the alternatives would start after bulk waste removal occurs.

- Clean and Stabilize Tanks Alternative. DOE considers three options for tank stabilization:
  - Fill with Grout (Preferred Alternative)
  - Fill with Sand
  - Fill with Saltstone
- Clean and Remove Tanks Alternative
- No Action Alternative (evaluation required by CEQ regulations)

HLW Tank Cleaning

Tank cleaning by spray water washing involves washing each tank using hot water in rotary spray jets. The spray nozzles can remove waste near the edges of the tank that is not readily removed by slurry pumps. After spraying, the contents of the tank would be agitated with slurry pumps and pumped out of the tank. This process has been demonstrated on Tanks 16 (which has not been closed) and 17 (which has been closed). The amount of waste left after spray washing was estimated at about 3,500 gallons in Tank 16 and about 4,000 gallons in Tank 17 (du Pont 1980; WSRC 1995a). If modeling evaluations showed that performance objectives could not be met after an initial spray water washing, additional spray water washes would be used prior to employing other cleaning techniques.

After spray water washing is complete, DOE could use oxalic acid cleaning. Hot oxalic acid would be sprayed through the spray nozzles that were used for spray water washing.

Oxalic acid cleaning – In this process, after the spray washing is complete, hot oxalic acid (80°-90°C) would be sprayed through the spray nozzles that were used for water spray washing. This process has been demonstrated only on Tank 16. A number of potential cleaning agents for sludge removal were studied. Oxalic acid was chosen as the preferred cleaning agent because it dissolves sludge and is only moderately aggressive against carbon steel, the material used in the construction of the waste tanks.

Bradley and Hill (1977) describes the study that led to the selection of oxalic acid as the preferred chemical cleaning agent. The study examined cleaning agents that would not aggressively attack carbon steel and were compatible with high-level waste processes. The studies included tests with waste stimulants and also tests with actual Tank 16 sludge. The agents tested were disodium salt EDTA, glycolic acid, formic acid, sulfamic acid, citric acid, dilute sulfuric acid, alkaline permanganate, and oxalic acid. None of these agents completely dissolved the sludge, but oxalic acid was shown to dissolve about 70% of the sludge in a well-mixed sample at 25% C, which was the highest of any of the cleaning agents tested. (Concentrated mineral acids, such as nitric acid, hydrochloric acid, and concentrated sulfuric acid, will completely dissolve the sludge but also aggressively attack carbon steel.)

Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is about twice as effective as spray water washing for removal of radioactivity (see Table 2-1). Use of oxalic acid in an HLW tank would require a successful demonstration that it would not create a potential for a nuclear criticality. The *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998) specifically states that oxalic acid cleaning of any waste tank is prohibited. This prohibition was established because of concern that oxalic acid could dissolve a sufficient quantity of fissile materials to create the potential for nuclear criticality.

An earlier study (Nomm 1995) had concluded that criticality in the high-level waste tanks is “beyond extremely unlikely” because neutron-absorbing substances present in the sludge would prevent criticality. However, the study assumed the waste would remain alkaline and did not address the possibility that chemicals would be used that would dissolve sludge solids. Therefore, to ensure that no criticality could occur in tank cleaning, DOE would need to prepare a formal Nuclear Criticality Safety Evaluation (i.e., a study of the potential for criticality) before deciding to use oxalic acid in cleaning a tank. If the new evaluation found that oxalic acid could be used safely, the *Liquid Radioactive Waste Facility Safety Analysis Report* would be revised and DOE could permit its use. If not, DOE would need to investigate other cleaning technologies, such as mechanical cleaning.

If oxalic acid cleaning were performed infrequently, there would be minimal impact on the downstream waste processing operations (DWPF and salt disposition). The oxalic acid used to clean a tank would be neutralized with sodium hydroxide, forming sodium oxalate. The sodium oxalate would follow the same treatment path as other salts in the tank farm inventory.

Extensive use of oxalic acid cleaning may result in conditions that, if not addressed by checks within the DWPF feed preparation process, could allow carryover of sodium oxalate to the vitrification process. The presence of oxalates in the waste feed to DWPF that would result from oxalic acid cleaning would adversely affect the quality of the HLW glass produced at DWPF. To prevent that from occurring, special batches of the salt treatment process would be scheduled in which the sodium oxalate concentrations would be controlled to not exceed their solubility limit in the low-radioactivity fraction.

DOE expects that oxalic acid cleaning would be required on tanks that contain first-cycle wastes, the most highly radioactive waste in the tanks. High-level wastes were produced as a byproduct of SRS separations processes. During processing, materials from SRS reactors passed through several cycles of solvent extraction. In these cycles, the plutonium and other products were first separated from the waste and then purified. Most of the radionuclides were removed from the processing streams during the first cycle of solvent extraction, so wastes from this cycle have most of the radionuclides. Wastes from subsequent cycles have radionuclide concentrations that are one to two orders of magnitude lower. DOE anticipates that oxalic acid would be needed to clean tanks that contain the more radioactive first cycle wastes (about three fourths of the tanks).

On the basis of performance and historical data, DOE believes that waste removal meets the Criteria 2 and 3 requirements of the evaluation process for determining that waste can be considered “waste incidental to reprocessing” (see text box). In addition, waste removal followed by spray water washing, meets the Criterion 1 requirement for removal of key radionuclides to the extent “technically and economically practical” (DOE Order 435.1). If Criteria 2 or 3 could not be met, enhanced cleaning methods such as additional water washes or oxalic acid cleaning could be employed. However, DOE considers that oxalic acid cleaning beyond the extent needed to meet performance objectives is not “technically and economically practical” within the meaning of DOE Order 435.1, for reasons discussed below.

In general, the economic costs of oxalic acid cleaning are quite high. DOE estimates that oxalic acid cleaning (including disposal costs) per tank would cost approximately $1,050,000.

Table 2-1. Tank 16 waste removal process and curies removed with each sequential step.

Sequential Waste Removal Step	Curies Removed	% of Curies Removed	Cumulative Curies Removed	Cumulative Percent Curies Removed
Bulk Waste Removal	2.74×10^{6}	97%	2.74×10^{-6}	97
Spray Water Washing	2.78×10^{4}	0.98%	2.77×10^{-6}	97.98
Oxalic Acid Wash & Rinse	5.82×10^{4}	2%	2.83×10^{-6}	99.98

DOE considers that performance of bulk waste removal and spray washing, which together result in removal of 98% to 99% of the total curies and over 99% of the volume of waste, constitutes the limit of what is economically and technically practicable for waste removal (DOE Response to U.S. Nuclear Regulatory Commission Additional Questions on SRS HLW Cover Tank Closure, April 1999). However, DOE recognizes that enhanced waste removal operations may be required for some tanks and is committed to performing the actions necessary to meet "incidental waste" determination and performance objectives. DOE further recognizes that, if it could not clean the tank components sufficiently to meet the waste incidental to reprocessing criteria, it would need to examine alternative disposition strategies. Alternatives could include disposal in place as high-level waste (which is not contemplated in DOE Order 435.1), development of new cleaning technologies, or packaging the cleaned tank pieces and storing them until DOE could ship them to a geologic repository for disposal. A geologic repository has not yet been approved and waste acceptance criteria have not yet been finalized.

Nine HLW tanks have leaked measurable amounts of waste from primary containment to secondary containment with only one leaking to the soil surrounding the tanks. For these tanks, the waste would be removed from the secondary containment using water and/or steam. Such cleaning has been attempted at SRS on only one tank (Tank 16), and the operation was only about 70 percent completed, because salts mixed with sand (from sandblasting of tank welds) made salt removal more difficult. Cleaning of the secondary containment is not a demonstrated technology and new techniques may need to be developed. The amount of waste in secondary containment is small, so the environmental risk of this waste is minimal compared to the amount of residual waste that would be contained inside the tanks after bulk waste removal and cleaning.

2.1.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

Following bulk waste removal, DOE would remove the majority of the waste from the tanks and fill the tanks with a material to prevent future collapse and to bind up residual waste. A detailed description of this alternative can be found in Appendix A.

Tank Closure Alternatives

Implementation of each alternative would start following bulk waste removal and SCDHEC approval of a tank-specific Closure Module that is protective of human health and the environment.

- Clean with water and fill the tanks with grout (Preferred Alternative). If necessary to meet the performance objectives, oxalic acid cleaning could be used. The use of sand or saltstone as fill material would also be considered.
- Clean and remove the tanks for disposal in the SRS waste management facilities.
- No Action. Leave the tank systems in place without cleaning or stabilizing following bulk waste removal.

In the evaluation and cleaning phase, each tank system or group of tank systems, as appropriate, would be evaluated to determine the inventory of radiological and nonradiological contaminants remaining after bulk waste removal, and spray water washing. This information would be used to conduct a performance evaluation as part of the Preparation of a Closure Module. In this evaluation, DOE would consider (1) the types of contamination in the tank and the configuration of the tank system and (2) the hydrogeologic conditions at and near the tank location, such as distance from the water table and distance to nearby streams. The performance evaluation would include modeling the projected contamination pathways for selected closure methods and comparing the modeling results with the performance objectives developed in the General Closure Plan (DOE 1996). These performance objectives are described in Section 7.1.2 of this EIS. If the modeling shows that the performance objectives would be met, the Closure Module would be submitted to SCDHEC for approval.

If the modeling shows that the performance objectives would not be met, additional cleaning steps, such as additional water spray washing, oxalic acid cleaning, or other cleaning techniques, would be taken until enough residual waste had been removed that the performance objectives could be met.

Tank Stabilization

After DOE would clean a tank and demonstrate that the performance objectives could be met, SCDHEC would approve a Closure Module. The tank stabilization process would then begin. Each tank system (including the secondary containment, for those that have one) would be filled with a pumpable, self-leveling backfill material.

DOE's Preferred Alternative is to use grout, a concrete-like material, as backfill. The grout would be trucked to an area near the tank farm, batched if necessary, and pumped to the tank. The grout would be high enough in pH to be compatible with the carbon steel walls of the waste tank. Although the details of each individual closure would vary, any tank system closure under this alternative would have the following characteristics:

- The grout would be pumpable, self-leveling, designed to prevent future subsidence of the tank, and able to fill voids to the extent practical, including equipment and secondary containment.
- The grout would be poured in three distinct layers as illustrated in Figure 2.1-1. The bottom-most layer would be a specially formulated reducing grout to retard the migration of important contaminants. The middle layer would be a low-strength material designed to fill most of the volume of the tank interior. The final layer would be a high strength grout to deter inadvertent intrusion from drilling.
- The final closure configuration would meet performance objectives established by SCDHEC and EPA.

If DOE were to choose another fill material (e.g., sand, saltstone) for a tank system, all other aspects of the closure process would remain the same, as described above.

Sand is readily available and inexpensive. However, its emplacement is more difficult than the grout because it does not flow readily into voids. Any equipment or piping left on or inside the tank that might require filling to eliminate voids inside the device might not be adequately filled. Over time, the sand would tend to settle in the tank, creating additional void spaces. The dome might then become unsupported and would sag and crack. The sand would tend to isolate the contamination from the environment to some extent, limit the amount of settling of the tank top after failure, and prevent winds from spreading the contaminants. Nevertheless, water would flow readily through the sand. Sand is relatively inert and could not be formulated to retard the migration of radionuclides. Thus, the expected contamination levels in groundwater and surface streams resulting from migration of residual contaminants would be higher than the levels for the preferred option.

Saltstone could also be used as fill material. Saltstone is the low-radioactivity fraction of HLW mixed with cement, flyash, and slag to form a concrete-like mixture. Saltstone is normally disposed of as low-level waste in the SRS

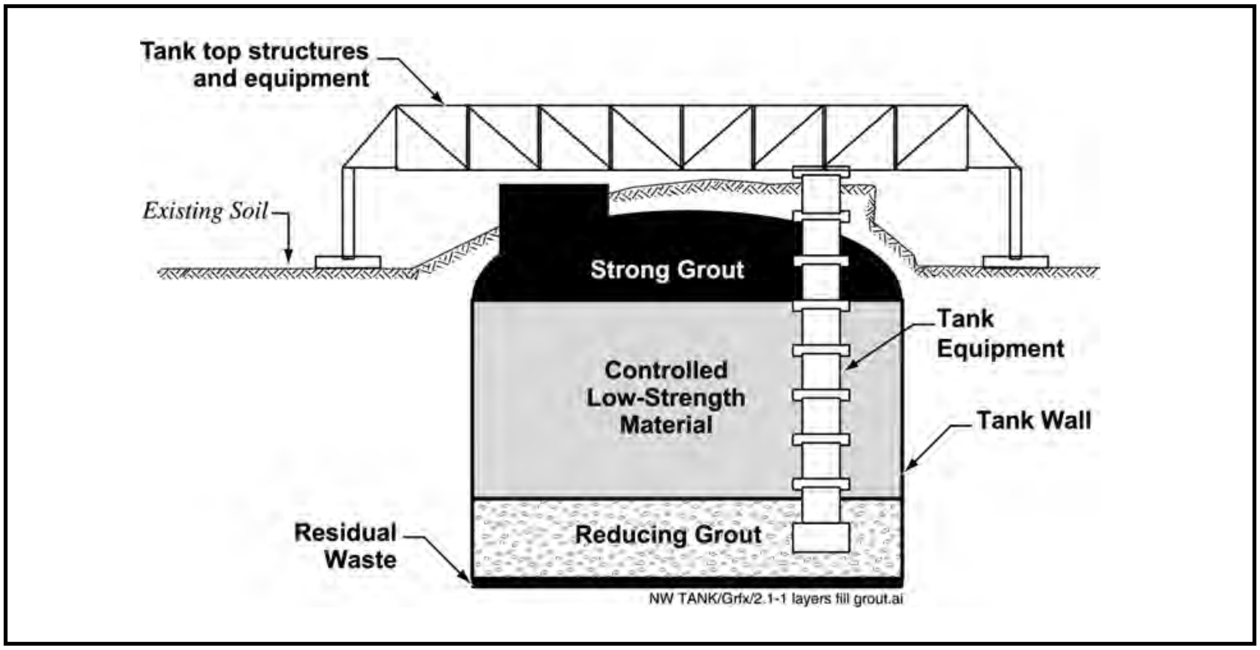

Figure 2.1-1. Typical layers of the fill with grout option.

Saltstone Disposal Facility. See Appendix A for a description of the Saltstone Manufacturing and Disposal Facility and its function within the HLW system.

This alternative would have the advantage of reducing the amount of Saltstone Disposal Facility area that would be required. Any saltstone sent to a waste tank would not require disposal space in the Saltstone Disposal Facility.

The total amount of saltstone required to stabilize the low-activity fraction of HLW would probably be greater than 160 million gallons, which is considerably in excess of the capacity of the HLW tanks. Therefore, disposal of saltstone in the Saltstone Disposal Facility would still be required. Because saltstone sets up quickly and is radioactive, it would be impractical to ship by truck or pump to the tank farms. Thus, a Saltstone Mixing Facility would need to be constructed in F-Area; another facility would be built in H-Area; and the existing Saltstone Manufacturing and Disposal Facility in Z-Area would still be operated.

Filling the tank with saltstone, which is contaminated with radionuclides would considerably complicate the project and increase worker radiation exposure, which would increase risk to workers and add to the cost of closure. In addition, the saltstone would contain large quantities of nitrate that would not be present in the tank residual. Because nitrates are very mobile in the environment, these large quantities of nitrate would adversely impact the groundwater near the tank farms in the long term.

One of the alternatives being evaluated in the Supplemental EIS for high-level waste salt disposition would not involve the manufacture of saltstone (64 FR 8558; February 22, 1999). If this alternative (known as the Direct Disposal in Grout Alternative) is selected, the option of using saltstone as a HLW tank stabilization material would no longer be applicable. The Direct Disposal in Grout Alternative involves the manufacture of a grout with substantially greater radioactive content than saltstone, which would be unsuitable for use as HLW tank stabilization material.

For any of the above options, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting in the surface depressions. This action would prevent ponding conditions over these tanks that could facilitate the degradation of the tank structure.

2.1.2 CLEAN AND REMOVE TANKS ALTERNATIVE

The Clean and Remove Tanks alternative would include cleaning the tanks, cutting them up in situ, removing them from the ground, and transporting tank components for disposal in an engineered disposal facility at another location on the SRS. This alternative has not been demonstrated on HLW tanks.

For the Clean and Remove Tanks Alternative, DOE would have to perform enhanced cleaning beyond that contemplated for the other action alternatives, until tanks were clean enough to be safely removed and could meet waste acceptance criteria at SRS Low-Level Waste Disposal Facilities. Worker exposure would have to be As Low As Reasonably Achievable to ensure protection of the individuals required to perform the tank removal operations. This might require the use of cleaning technologies such as oxalic acid cleaning, mechanical cleaning, and additional steps as yet undefined on most of the tanks.

Following bulk waste removal and cleaning, the steel components of the tank would be cut up, removed, placed in radioactive waste transport containers (approximately 3,900 SRS low-level waste disposal boxes per tank), and transported to SRS radioactive waste disposal facilities for disposal (assuming these components are considered waste incidental to reprocessing). During tank removal activities, the top of the tank would have HEPA-filtered enclosures or airlocks. The tank would remain under negative pressure during cutting operations, and the exhaust would be filtered through HEPA filtration. This alternative would require the construction of approximately 16 new low-activity waste vaults at SRS for disposal of the low-level waste disposal boxes containing the tank components from all 49 tanks. This number of new low-activity waste vaults is within the range DOE previously analyzed in the *Savannah River Site Waste Management Final Environment Impact Statement* (DOE 1995). That EIS analyzed a range of waste treatment alternatives that resulted in the construction of up to 31 new low-activity waste vaults. The long-term impacts presented in that EIS for the low-activity waste vaults are approximately one-one thousandth of the long-term tank closure impacts presented in Section 4.2 of this EIS and are incorporated into this EIS by reference. This alternative has the advantage of allowing disposal of the contaminated tank system in a waste management facility that is already approved for receiving low-level waste.

With removal of all the tanks, backfilling of the excavations left after the removal would be required. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

2.1.3 NO ACTION

For HLW tanks, the No Action Alternative would involve leaving in place the tank systems after bulk waste removal from each tank has taken place and the storage space is no longer needed. Even after bulk waste removal, each tank would contain residual waste and in those tanks that reside in the water table, ballast water, which is required to prevent the tank from "floating" out of the ground. Tanks would not be backfilled.

After some period of time, the reinforcing bar in the roof of the tank would rust and the roof of the tank would fail, causing the structural integrity of the tank to degrade. Similarly, the floor and walls of the tank would degrade over time. Rainwater would readily pour into the exposed tank, flushing contaminants from the residual waste in the tank and eventually carrying these contaminants into the groundwater. Contamination of the groundwater would happen much more quickly than it would if the tank were backfilled and residual wastes were bound with the fill material.

No Action would be the least costly of the alternatives (less than $100,000 per tank), require the fewest worker hours and exposure to radiation (about two person-rem), and would require fewer workers per tank system than the Clean and Stabilize Tanks Alternative. There would be ongoing maintenance and no interruption of operations in the tank farm.

Future inhabitants of the area would be exposed to the contamination in a tank, and injuries or fatalities could occur if an intruder ventured into the area of the tank and the roof were to collapse due to structural failure. Also, movement of the contaminants into the groundwater would be more rapid compared to the other alternatives, and expected contamination levels in groundwater and surface streams would be higher than for the Clean and Stabilize Tanks Alternative because there would be no material to retard movement of the radionuclides. This alternative would be the least protective of human health and safety and of the environment.

2.1.4 ALTERNATIVES CONSIDERED, BUT NOT ANALYZED

2.1.4.1 Management of Tank Residuals as High-Level Waste

The alternative of managing the tank residuals as HLW is not preferred, in light of the requirements embodied in the State-approved General Closure Plan for a regulatory approach based on the designation of the residuals as waste incidental to reprocessing.

The waste incidental to reprocessing designation does not create a new radioactive waste type. The terms "incidental waste" or "waste incidental to reprocessing" refer to a process for identifying waste streams that might otherwise be considered HLW due to their origin, but are actually low-level or transuranic waste, if the waste incidental to reprocessing requirements contained in DOE Manual 435.1-1 are met. The goal of the waste incidental to reprocessing determination process is to safely manage a limited number of reprocessing waste streams that do not warrant geologic repository disposal because of their low threat to human health or the environment. Although the technical alternatives of managing tank residuals under the General Closure Plan would likely be the same as those that would apply to managing residuals as HLW, the application of regulatory requirements would be different.

As described in the General Closure Plan, DOE will meet the waste incidental to reprocessing requirements of DOE Manual 435.1-1, which entail a step for removing key radionuclides to the extent that is technically and economically practical, a step for incorporating the residues into a solid form, and a process for demonstrating that appropriate disposal performance objectives are met. The technical alternatives evaluated in the EIS represent a range of tank cleaning and stabilization techniques. The radionuclides in residual waste would be the same whether the material is HLW, low-level waste, or transuranic waste; however, the regulatory regime would be different.

DOE must demonstrate its ability to meet certain performance objectives before SCDHEC will approve a Closure Module. Appendix C of the General Closure Plan describes the process DOE used to determine the performance objectives (dose limits and concentrations established to be protective of human health) incorporated in the General Closure Plan. As described in Chapter 7 of this EIS, DOE will establish performance standards for the closure of each HLW tank. In the General Closure Plan, DOE considered dose limits and concentrations found in current (40 CFR 191, 10 CFR 60) and proposed (40 CFR 197, 10 CFR 63) HLW management requirements in defining the performance standards. DOE considered the HLW management dose limits and concentrations as performance indicators of the ability to protect human health and the environment, even though the residual would not be considered HLW. That evaluation (described in Appendix C of the General Closure Plan) identified numerical performance standards (concentrations or dose limits for specific radiological or chemical constituents released to the environment) based on the requirements and guidance. Those numerical standards apply to all exposure pathways and to specific media (air, groundwater, and surface water), at different points of compliance, and over various periods during and after closure.

If DOE determines through the waste incidental to reprocessing process that the tank residues cannot be managed as LLW, as expected, or alternatives as TRU waste, the residues would be managed as HLW. The technical alternatives for managing the residues as HLW, however, would be the same as those for managing the residues under the LLW requirements. Thus, DOE expects that the potential environmental impacts that could result from managing the residues under the LLW requirements would be representative of the impacts if the HLW standards were applicable. For these reasons, this EIS does not present the management of tank residues as HLW as a separate alternative.

2.1.4.2 Other Alternatives Considered, but not Analyzed

DOE considered the alternative of delaying closure of additional tanks, pending the results of research. For the period of delay, the impacts of this approach would be the same as the No Action Alternative. DOE continues to conduct research and development efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of delaying closure.

DOE considered an alternative that would represent grouting of certain tanks and removal of others. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet performance requirements for a given tank, the decisionmakers may elect to remove a tank if it is not possible to meet the performance requirements by using another method. This EIS captures the environmental and health and safety impacts of both options.

2.2 Other Cleaning Technologies

The approved General Closure Plan contemplates cleaning the tanks with hot water streams, as described in the Clean and Stabilize Tanks Alternative. Several cleaning technologies have been investigated but are not considered reasonable alternatives to hot water cleaning at this time. However, DOE continues to research cleaning methods and should a particular method prove practical and be required to meet the performance criteria for a specific tank, its use would be proposed in the Closure Module for that tank. DOE would conduct the appropriate NEPA review for any proposal to use such new technology.

Mechanical and chemical cleaning using advanced techniques has not been demonstrated in actual HLW tanks. A number of techniques have been studied involving such technologies as robotic arms, wet-dry vacuum cleaners, and remote cutters. However, none of these techniques have been demonstrated for this application. For example, no robotic arms have been demonstrated that could navigate through the cooling coils that are found in most SRS waste tanks. These techniques could be applied for specific tank closures based on the waste characteristics (e.g., presence of zeolite or insoluble materials) and other circumstances (e.g., cooling coils or other obstructions) for specific SRS tank closures.

There are more aggressive cleaning agents than oxalic acid (e.g., nitric acid). However, in addition to the same safety questions involving the use of oxalic acid (see Section 2.2.1), these cleaning agents have an unacceptable environmental risk because they attack the carbon steel wall of the waste tank, causing deterioration of the metal, and reducing the intact containment life of the tank. This would result in much more rapid release of contaminants to the environment.

2.3 Considerations in the Decision Process

This environmental impact statement evaluates the environmental impacts of several alternatives for closure of the high-level waste tanks at the Savannah River Site. The closure process would take place over a period of up to 30 years. The selection of a tank closure alternative following completion of this EIS would guide the selection and implementation of a closure method for each high-level waste tank at the SRS. Within the framework of the selected alternative, and the environmental impacts of closure described in the EIS, DOE will select and implement a closure method for each tank.

The tank closure program will operate under a number of laws, regulations and regulatory agreements, described in Chapter 7 of this EIS. In addition to the General Closure Plan, a document prepared by DOE based on responsibilities under the Atomic Energy Act and other laws and regulations, the closure of individual tanks will be performed in accordance with a tank-specific Closure Module. The Closure Module incorporates a specific plan for tank closure and modeling of impacts based on that plan. Through the process of preparing and approving the Closure Module, DOE will select a closure method that is consistent with the closure alternative selected following completion of this EIS. The selected closure method will result in a closure that has impacts on the environment equal to or less than those described in this EIS. If a tank closure that meets the performance objectives of the closure module cannot be accomplished using the selected alternative, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank.

During the expected 30-year period of tank closure activities, new technologies for tank cleaning or other aspects of the closure process may become available. If DOE elects to use such a technology, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank using the new technology.

During scoping for this EIS, a commentor suggested that DOE should consider the alternative of delaying closure of additional tanks pending the results of research. For the period of delay, the impacts of this approach would be the same as the No-Action Alternative. DOE continues to conduct research and development (R&D) efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of the alternative suggested by the commentor.

A comment was made that tank removal and grouting should be combined as an alternative. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet the performance requirements for a given tank, the decisionmaker may elect to remove a tank if it is not possible to meet the performance requirements by another method. This EIS captures the environmental and health and safety impacts of both options. Additional discussion on these and other comments made during scoping is included in Appendix D.

As stewards of the Nation's financial resources, DOE decision-makers must also consider cost of the alternatives. DOE has prepared rough order-of-magnitude estimates of cost for each of the alternatives (DOE 1997). These costs, which are presented on a per tank basis, are as follows:

No Action Alternative – <$100,000

Clean and Stabilize Tanks Alternative

- Clean and Fill with Grout Option - $3.8-4.6 million
- Clean and Fill with Sand Option - $3.8 million
- Clean and Fill with Saltstone Option - $6.3 million
- Clean and Remove Tanks Alternative - >$100 million

2.4 Comparison of Environmental Impacts Among Alternatives

Closure of the HLW tanks would affect the environment, and human health and safety, during the period of time when work is being done to close the tanks and after the tanks have been closed. For purposes of analysis in this EIS, DOE has defined the period of short-term impacts to be from the year 2000 through about 2030, when all of the existing HLW tanks are proposed to be closed. Long-term impacts would be those resulting from the eventual release of residual waste contaminants from the stabilized tanks to the environment. In this EIS, DOE has estimated these impacts over a period of 10,000 years.

Chapter 4 presents estimates of the potential short-term and long-term environmental impacts associated with each tank closure alternative, as well as the No Action Alternative. Section 2.4.1 summarizes the short-term impacts and accident scenarios, while Section 2.4.2 summarizes the long-term impacts.

2.4.1 SHORT-TERM IMPACTS

Section 4.1 presents the potential short-term impacts (approximately the years 2000 to 2030) for each of the alternatives. These potential impacts are summarized in Table 2-2 and discussed in more detail in the sections that follow.

Geologic and water resources – Each of the tank stabilization options under the Clean and Stabilize Tanks Alternative would require an estimated 170,000 cubic meters of soil for backfill. The Clean and Remove Tank Alternative would require more, approximately 356,000 cubic meters. Short-term impacts to surface water and groundwater are expected to be negligible for any of the alternatives.

Nonradiological air quality – Tank closure activities would result in the release of regulated nonradiological pollutants to the surrounding air. The primary source of air pollutants for the Clean and Fill with Grout Option would be a portable concrete batch plant and three diesel generators. For the Clean and Fill with Sand Option, pollutants would be emitted from operation of a portable sand feed plant and three diesel generators. The Clean and Fill with Saltstone Option would require saltstone batching facilities in F- and H- Areas. Regulated nonradiological air pollutants released as a result of activities associated with the No Action Alternative and Clean and Remove Tanks Alternative would consist largely of emissions from vehicular traffic. All alternatives except the No Action Alternative include the cleaning of interior tank walls with oxalic acid. The acid would be transferred to the HLW tanks through a sealed pipeline. No releases are expected during this procedure. The cleaning process would consist of spraying hot (80-90°C) acid using remotely operated water sprayers. The tanks would be ventilated with 300-400 cfm of air which would pass thorough a HEPA filter; acid releases from the ventilated air are expected to be minimal. Under all alternatives, the expected emission rate for each source would be less than the Prevention of Significant Deterioration Standards.

The maximum air concentrations at the SRS boundary associated with the release of regulated pollutants would be highest for the Clean and Fill with Saltstone Option. However, ambient concentrations for all the pollutants and alternatives would be less then 1 percent of the regulatory limits. The concentrations at the location of the hypothetical noninvolved worker would be highest for the Clean and Fill with Saltstone Option. All concentrations, however, would be below the Occupational Safety and Health Administration (OSHA) limits; all concentrations with the exception of nitrogen oxide (as NO_x) would be less than 1 percent of the regulatory limit. Nitrogen dioxide (NO_x) could reach 8 percent of the regulatory limit for the Clean and Fill with Grout and Clean and Fill with Sand Options, while NO_x levels under the Clean and Fill with Saltstone Option could reach about 16 percent of the OSHA limit. These emissions would be attributable to the diesel generators.

Radiological air quality – Radiation dose to the maximally-exposed offsite individual from air emissions during tank closure would be essentially the same for all alternatives and options, 2.5×10^{-5} to 2.6×10^{-5} millirem per year. Estimated dose to the offsite population would also be similar for all alternatives and options, from 1.4×10^{-3} to 1.5×10^{-3} person-rem per year.

Ecological resources – Construction-related disturbance under the Clean and Stabilize Tanks Alternative and Clean and Remove Tank Alternative would result in impacts to wildlife that are small, intermittent, and localized. Some individual animals could be displaced by construction noise and activity, but populations would not be affected.

Table 2-2. Summary comparison of short-term impacts by tank closure alternative.

		Clean and Stabilize Tanks Alternative			
Parameter	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Geologic Resources **Soil backfill (m^3)**	None	170,000	170,000	170,000	356,000
Water Resources Surface Water	None	None	None	None	None
Groundwater		<0.6% of F-Area well production required	<0.6% of F-Area well production required	<0.6% of F-Area well production required	<0.6% of F-Area well production required
Air Resources					
Nonradiological air emissions (tons/yr.):					
Sulfur dioxide (as SO_x)	None	2.2	2.2	3.3	None
Total suspended particulates	None	(a)	(a)	3.0	None
Particulate matter	None	4.5	3.1	1.7	None
Carbon monoxide	None	5.6	5.6	8.0	None
Volatile organic compounds	None	2.3	2.3	3.3	None
Nitrogen dioxide (as NO_x)	None	33	33	38	None
Lead	None	9.0×10^{-4}	9.0×10^{-4}	1.5×10^{-3}	None
Beryllium	None	1.7×10^{-4}	1.7×10^{-4}	2.8×10^{-4}	None
Mercury	None	2.2×10^{-4}	2.2×10^{-4}	4.3×10^{-4}	None
Benzene	None	0.02	0.02	0.43	None
Air pollutants at the SRS boundary (maximum concentrations-$\mu g/m^3$):[b]					
Sulfur dioxide (as SO_x) – 3 hr.	None	0.2	0.0	0.6	None
Total suspended particulates – annual	None	(a)	(a)	0.005	None
Particulate matter – 24 hr.	None	0.08	0.06	0.06	None
Carbon monoxide – 1 hr.	None	1.2	1.2	3.4	None
Volatile organic compounds – 1 hr.	None	0.5	0.5	2.0	None
Nitrogen dioxide (as NO_x) - annual	None	0.03	0.03	0.07	None
Lead – max. quarterly	None	1.2×10^{-6}	1.2×10^{-6}	4.1×10^{-6}	None
Beryllium – 24 hr.	None	3.2×10^{-6}	3.2×10^{-6}	1.1×10^{-5}	None

Table 2-2. (Continued).

		Clean and Stabilize Tanks Alternative			
Parameter	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Mercury – 24 hr.	None	4.0×10^{-6}	4.0×10^{-6}	1.6×10^{-5}	None
Benzene	None	3.8×10^{-4}	3.8×10^{-4}	2.0×10^{-2}	None
Annual radionuclide emissions (curies/year):					
F-Area	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}
H-Area	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Saltstone mixing facility	Not used	Not used	Not used	0.46	Not used
Annual dose from radiological air emissions:					
Noninvolved worker dose (mrem/yr.)	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}
Maximally Exposed Offsite Individual dose (mrem/yr.)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}
Offsite population dose (person-rem)	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.5×10^{-3}	1.4×10^{-3}
Ecological Resources	No change	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife
Land Use	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns
Socioeconomics (employment – full time equivalents)					
Annual employment	40	85	85	131	284
Life of project employment	980	2,078	2,078	3,210	6,963
Cultural Resources	None	None	None	None	None

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Worker and Public Health					
Radiological dose and health impacts to the public and non-involved workers:					
Maximally-exposed offsite individual (mrem/yr.)	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}
Maximally exposed offsite individual estimated latent cancer fatality risk	6.1×10^{-10}	6.1×10^{-10}	6.1×10^{-10}	6.4×10^{-10}	6.1×10^{-10}
Noninvolved worker estimated latent cancer fatality risk	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}
Estimated increase in number of latent cancer fatalities in population within 50 miles of SRS	3.4×10^{-5}	3.4×10^{-5}	3.4×10^{-5}	3.7×10^{-5}	3.4×10^{-5}
Radiological dose and health impacts to involved workers:					
Closure collective dose (total person-rem)	29.4[c]	1,600	1,600	1,800	12,000
Closure latent cancer fatalities	0.012	0.65	0.65	0.72	4.9
Nonradiological air pollutants at noninvolved worker location (max conc.):					
Sulfur dioxide (as SO_x) – 8 hr.	None	5.0×10^{-3}	5.0×10^{-3}	0.02	None
Total suspended particulates – 8 hr.	None	ND	ND	0.01	None
Particulate matter – 8 hr.	None	9.0×10^{-3}	6.0×10^{-3}	8.0×10^{-3}	None
Carbon monoxide – 8 hr.	None	0.01	0.01	0.04	None
Oxides of nitrogen (as NO_x) - ceiling	None	0.70	0.70	1.40	None
Lead – 8 hr.	None	2.1×10^{-6}	2.1×10^{-6}	6.5×10^{-6}	None

Table 2-2. (Continued).

		Clean and Stabilize Tanks Alternative			
Parameter	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Beryllium – 8 hr.	None	4.1×10^{-7}	4.1×10^{-7}	1.3×10^{-6}	None
Mercury - ceiling	None	4.2×10^{-6}	4.2×10^{-6}	1.4×10^{-5}	None
Benzene – 8 hr.	None	4.8×10^{-5}	4.8×10^{-5}	1.0×10^{-3}	None
Occupational Health and Safety:					
Recordable injuries-closure	110[d]	120	120	190	400
Lost workday cases-closure	60[d]	62	62	96	210
Environmental Justice	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations
Transportation (offsite round-trip truckloads)	0	654	653	19	5
Waste Generation					
Maximum annual waste generation:					
Radioactive liquid waste (gallons)	0	600,000	600,000	600,000	1,200,000
Nonradioactive liquid waste (gallons)	0	20,000	20,000	20,000	0
Transuranic waste (m^3)	0	0	0	0	0
Low-level waste (m^3)	0	60	60	60	900
Hazardous waste (m^3)	0	2	2	2	2
Mixed low-level waste (m^3)	0	12	12	12	20
Industrial waste (m^3)	0	20	20	20	20
Sanitary waste (m^3)	0	0	0	0	0

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Total estimated waste generation					
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Transuranic waste (m^3)	0	0	0	0	0
Low-level waste (m^3)	0	1,284	1,284	1,284	19,260
Hazardous waste (m^3)	0	42.8	42.8	42.8	42.8
Mixed low-level waste (m^3)	0	257	257	257	428
Industrial waste (m^3)	0	428	428	428	428
Sanitary waste (m^3)	0	0	0	0	0
Utility and Energy Usage:					
Water (total gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Electricity	NA	NA	NA	NA	NA
Steam (total pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (total gallons)	NA	214,000	214,000	214,000	428,000
Utility cost (total)	NA	$4,280,000	$4,280,000	$4,280,000	$12,840,000

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a. No data on TSP emissions for these sources is readily available and therefore is not reflected in the analysis.

b. No exceedences of air quality standards are expected.

c. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.

d. For the No Action Alternative, recordable injuries and lost work day cases are for the period of closure activities for the other alternatives. These values would continue indefinitely.

NA = Not applicable; ND = Below detection limit.

Land use – From a land use perspective, the F- and H- Area Tank Farms are zoned Heavy Industrial and are within existing heavily industrialized areas. SRS land use patterns are not expected to change over the short term due to closure activities.

Socioeconomics – An annual average of 284 workers would be required for tank closure activities under the Clean and Remove Tanks Alternative. Fewer workers (85 to 131) would be required by the three tank stabilization options under the Clean and Stabilize Tanks Alternative. None of the alternatives or options is expected to measurably affect regional employment or population trends.

Cultural resources – There would be no impacts on cultural resources under any of the alternatives. The Tank Farms lie in a previously-disturbed, highly-industrialized area of the SRS.

Worker and public health impacts – All alternatives are expected to result in similar airborne radiological release levels. Public radiation doses and potential adverse health effects could occur from airborne releases only. Latent cancer fatality risk to the maximally-exposed offsite individual from air emissions during tank closure would be highest (6.4×10^{-10}) under the Clean and Fill with Saltstone Option due to the operation of the saltstone batch plant. Latent cancer fatality risk to the maximally-exposed offsite individual from other alternatives and options would be slightly lower, 6.1×10^{-10}. Estimated latent cancer fatalities to the offsite population of 620,000 people would also be highest under the Clean and Fill with Saltstone Option (3.7×10^{-5}), with other alternatives and options expected to result in a nominally-lower number of latent cancer fatalities of 3.4×10^{-5}.

Collective involved worker dose for closure of all 49 tanks would be highest under the Clean and Remove Tanks Alternative (12,000 person-rem), with the three stabilization options under the Clean and Stabilize Tanks Alternative ranging from 1,600 (Clean and Fill with Grout and Clean and Fill with Sand options) to 1,800 person-rem (Clean and Fill with Saltstone Option). Increased latent cancer fatalities attributable to these collective doses would be 4.9 (Clean and Remove Tanks Alternative), 0.72 (Clean and Fill with Saltstone Option), and 0.65 (Clean and Fill with Grout and Clean and Fill with Sand Options), respectively. The higher dose associated with the Clean and Remove Tanks Alternative relates to larger numbers of personnel required to implement the alternative.

The primary health effect of radiation is the incidence of cancer. Radiation impacts on workers and public health are expressed in terms of latent cancer fatalities. A radiation dose to a population is estimated to result in cancer fatalities at a certain rate, expressed as a dose-to-risk conversion factor. The EPA has established dose-to-risk conversion factors of 0.0005 per person-rem for the general population and 0.0004 per person-rem for workers. The difference is due to the presence of children, who are believed to be more susceptible to radiation, in the general population.

DOE estimates the doses to the population and uses the conversion factor to estimate the number of cancer fatalities that might result from those doses. In most cases the result is a small fraction of one. For these cases, DOE concludes that the action would very likely result in no additional cancer in the exposed population.

Occupational Health and Safety – Recordable injuries and lost workday cases would be the lowest for the No Action Alternative and highest for the Clean and Remove Tanks Alternative. Of the three options under the Clean and Stabilize Tanks Alternative, the Fill with Saltstone option would have about 50% more recordable injuries and lost workday cases than the Fill with Grout and Fill with Sand options.

Environmental Justice – Because short-term impacts from tank closure activities would not significantly affect the surrounding population, and no means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the tank closure alternatives.

Transportation – Offsite transportation of material by truck to clean and fill tanks would require from zero round-trips per tank for the No Action Alternative to 654 round trips per tank for the Clean and Fill with Grout Option. The amount of increased traffic expected under the proposed action and alternatives would be minimal. There would be no transportation of material under the No Action Alternative.

Waste generation – Tank cleaning activities under the Clean and Remove Tank Alternative would generate as much as 1.2 million gallons of radioactive liquid waste annually, while tank cleaning activities under the Clean and Stabilize Tanks Alternative (regardless of tank stabilization option) would generate as much as 600,000 gallons annually. This radioactive liquid waste would be managed as HLW. Small amounts of mixed low-level waste, hazardous waste, and industrial waste would be produced under both the Preferred Alternative and Clean and Remove Tanks Alternative. The amount of low-level radioactive waste generated by the Clean and Remove Tanks Alternative would be much higher than that generated by any of the other alternatives. No radioactive or hazardous wastes would be generated under the No Action Alternative.

Utilities and energy consumption – None of the alternatives would require electricity usage beyond that associated with current tank farm operations. Electrical power for field activities would be supplied by portable diesel generators. The Clean and Remove Tanks Alternative would require twice the fossil fuel use of the three options under the Clean and Stabilize Tanks Alternative. Total utility costs under the Clean and Remove Tanks Alternative would be approximately three times the costs of the options under the Clean and Stabilize Tanks Alternative. The increased costs are primarily associated with fossil fuel consumption and steam generation. Water consumption is not a substantial contributor to overall utility costs. The highest water usage would be expected for the Clean and Fill with Grout Option. The Clean and Remove Tanks Alternative would require the next highest water usage. The water required to clean tanks, mix tank fill material, or to be used as tank ballast would require less than 0.6 percent (or 0.006) of the annual production from F-Area wells.

Accidents – DOE evaluated the impacts of potential accidents related to each of the alternatives (Table 2-3). For the tank stabilization options, DOE considered transfers during cleaning, a design basis seismic event during cleaning, and failures of the salt solution hold tank. For the Clean and Remove Tanks Alternative, DOE considered transfer errors during cleaning and a seismic event.

For each accident, the impacts were evaluated as radiation dose and latent cancer fatalities (or increased risk of a latent cancer fatality) to the noninvolved workers, to the offsite maximally-exposed individual, and to the offsite population. For the Clean and Stabilize Tanks Alternative and the Clean and Remove Tank Alternative option, a design basis earthquake would result in the highest potential dose and the highest potential increase in latent cancer fatalities or increased risk of latent cancer for each of the receptor groups. The Clean and Fill with Saltstone Option was reviewed to identify potential accidents resulting from producing saltstone and using it to fill tanks. The highest consequence accident identified for saltstone production and use was the failure of the Salt Solution Hold Tank. This accident would result in lower dose and cancer impacts than the bounding accidents for other phases of the alternative.

2.4.2 LONG-TERM IMPACTS

Section 4.2 presents a discussion of impacts associated with residual radioactive and nonradioactive material remaining in the closed HLW tanks. DOE estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a long time span (10,000 years) to determine when certain measures of impacts (e.g., radiation dose) reach their peak value.

There is always uncertainty associated with the results of analyses, especially if the analyses attempt to predict impacts over a long period of

Table 2-3. Estimated accident consequences by alternative.

		Consequences					
Alternative	Accident frequency	Noninvolved worker (rem)	Latent cancer fatalities	Maximally exposed offsite individual (rem)	Latent cancer fatalities	Offsite population (person-rem)	Latent cancer fatalities
Clean and Stabilize Tanks Alternative							
Transfer errors during cleaning	0.1% per year (once in 1,000 years)	7.3	2.9×10^{-3}	0.12	4.8×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	0.0019% per year (once in 53,000 years)	15	6.0×10^{-3}	0.24	9.6×10^{-5}	11,000	5.5
Failure of Salt Solution Hold Tank (Saltstone option only)	0.005% per year (once in 20,000 years)	0.02	8.0×10^{-6}	4.2×10^{-4}	1.7×10^{-7}	17	8.4×10^{-3}
Clean and Remove Tank Alternative							
Transfer errors during cleaning	0.1% per year (once in 1,000 years)	7.3	2.9×10^{-3}	0.12	4.8×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	0.0019% per year (once in 53,000 years)	15	6.0×10^{-3}	0.24	9.6×10^{-5}	11,000	5.5

time. The uncertainty could be the result of assumptions used, the complexity and variability of the process being analyzed, the use of incomplete information, or the unavailability of information. The uncertainties involved in estimating impacts over the 10,000 year period analyzed in this EIS are described in Section 4.2 and in Appendix C.

Because long-term impacts to certain resources were not anticipated, detailed analyses of impacts to these resources were not conducted. These included air resources, socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, utilities and energy, and accidents. Therefore Section 4.2 (as summarized in Table 2-4) focuses on the following discipline areas: geologic resources, water resources, ecological resources, land use, and public health. Tables 2-5 through 2-7 present the long-term transport of nonradiological constituents in groundwater.

Geologic resources – Filling the closed-in-place tanks with ballast water (No Action), grout, sand, or saltstone (the three tank stabilization options under the Clean and Stabilize Tanks Alternative) could increase the infiltration of rainwater at some point in the future, allowing more percolation of water into the underlying geologic deposits. No detrimental effect on surface soils, topography, or to the structural or load-bearing properties of the geologic deposits would occur from these actions. With tank failure, the underlying soil could become contaminated for either the No Action Alternative or any of the options under the Clean and Stabilize Tanks Alternative. No long-term impacts to geologic resources are anticipated from the Clean and Remove Tanks Alternative.

Water resources/surface water – Based on modeling results, any of the three tank stabilization options under the Clean and Stabilize Tanks Alternative would be effective in limiting the long-term movement of residual contaminants in closed tanks to nearby streams via groundwater. Concentrations of non-radiological contaminants moving to Upper Three Runs via the Upper Three Runs seepline would be minuscule, in most cases several times below applicable standards. Concentrations of non-radiological contaminants reaching Upper Three Runs and Fourmile Branch would be low under the No Action Alternative as well, but somewhat higher than those expected under the Clean and Stabilize Tanks Alternative. In all instances, predicted long-term concentrations of nonradiological contaminants would be well below applicable water quality standards.

The fate and transport modeling indicates that movement of residual radiological contaminants from closed HLW tanks to nearby surface waters via groundwater would also be limited by the three stabilization options under the Clean and Stabilize Tanks Alternative. Based on the modeling results, all three stabilization options under the Clean and Stabilize Tanks Alternative would be more effective than the No Action Alternative. The Clean and Fill with Grout Option would be the most effective of the three tank stabilization options as far as minimizing long-term movement of residual radiological contaminants.

Water resources/groundwater – The highest concentrations of radionuclides in groundwater would occur under the No Action Alternative. For this alternative, the EPA primary drinking water maximum contaminant level of 4.0 millirem per year for beta-gamma emitting radionuclides would be exceeded at all points of exposure since essentially all of the drinking water dose is due to beta-gamma emitting radionuclides. The Clean and Fill with Grout Option shows the lowest groundwater concentrations of radionuclides at all exposure points. Only this option and the Clean and Fill with Sand Option would meet the maximum contaminant level at the seepline. The beta-gamma maximum contaminant level would be substantially exceeded at the 1-meter and 100-meter wells under all alternatives.

The results for alpha-emitting radionuclides also show that the highest concentrations would occur for the No Action Alternative. For this alternative, the maximum contaminant level of 15 picocuries per liter would be exceeded at the 1-meter and 100-meter wells for both tank farms

Table 2-4. Summary comparison of long-term impacts by tank closure alternative.[a]

		Clean and Stabilize Tanks Alternative		
Parameter	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Geologic Resources	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated
Surface Water	Limited movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters
Nonradiological constituents in Upper Three Runs at point of compliance (mg/L)				
Aluminum	(b)	(b)	(b)	(b)
Chromium IV	(b)	(b)	(b)	(b)
Copper	(b)	(b)	(b)	(b)
Iron	3.7×10^{-5}	(b)	(b)	(b)
Lead	(b)	(b)	(b)	(b)
Mercury	(b)	(b)	(b)	(b)
Nickel	(b)	(b)	(b)	(b)
Silver	1.2×10^{-6}	(b)	(b)	(b)
Nonradiological constituents in Fourmile Branch at point of compliance (mg/L)				
Aluminum	(b)	(b)	(b)	(b)
Chromium IV	(b)	(b)	(b)	(b)
Copper	(b)	(b)	(b)	(b)
Iron	4.9×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Lead	(b)	(b)	(b)	(b)
Mercury	(b)	(b)	(b)	(b)
Nickel	(b)	(b)	(b)	(b)
Silver	1.1×10^{-4}	8.8×10^{-5}	6.5×10^{-6}	8.8×10^{-6}

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative		
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Maximum dose from beta-gamma emitting radionuclides in surface water (millirem/year)				
Upper Three Runs	0.45	(b)	4.3×10^{-3}	9.6×10^{-3}
Fourmile Branch	2.3	9.8×10^{-3}	0.019	0.130
Groundwater				
Groundwater concentrations from contaminant transport – F-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	35,000	130	420	790
100-meter well	14,000	51	190	510
Seepline, Fourmile Branch (1,800 meters downgradient)	430	1.9	3.5	25
Alpha concentration (pCi/L)				
1-meter well	1,700	13	13	13
100-meter well	530	4.8	4.7	4.8
Seepline, Fourmile Branch (1,800 meters downgradient)	9.2	0.04	0.039	0.04
Groundwater concentrations from contaminant transport – H-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	9.3×10^{6}	1×10^{5}	1.3×10^{5}	1×10^{5}
100-meter well	9.0×10^{4}	300	920	870
Seepline (1,200 meters downgradient)				
North of Groundwater Divide	2,500	2.5	25	46
South of Groundwater Divide	200	0.95	1.4	16
Alpha concentration (pCi/L)				
1-meter well	13,000	24	290	24

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative		
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
100-meter well	3,800	7.0	38	7.0
Seepline, North of Groundwater Divide	34	0.15	0.33	0.15
Seepline, South of Groundwater Divide	4.9	0.02	0.19	0.02
Ecological Resources				
Maximum hazard indices for aquatic environments	2.0	1.42	0.18	0.16
Maximum hazard quotients for terrestrial environments				
Aluminum	(c)	(c)	(c)	(c)
Barium	(c)	(c)	(c)	(c)
Chromium	0.04	0.02	(c)	(c)
Copper	(c)	(c)	(c)	(c)
Fluoride	0.19	0.08	0.01	0.01
Lead	(c)	(c)	(c)	(c)
Manganese	(c)	(c)	(c)	(c)
Mercury	(c)	(c)	(c)	(c)
Nickel	(c)	(c)	(c)	(c)
Silver	1.55	0.81	0.09	0.13
Uranium	(c)	(c)	(c)	(c)
Zinc	(c)	(c)	(c)	(c)
Maximum absorbed dose to aquatic and terrestrial organisms (in millirad per year):				
Sunfish dose	0.89	0.0038	0.0072	0.053
Shrew dose	24,450	24.8	244.5	460.5
Mink dose	2,560	3.3	25.6	265

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option
Land Use	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS
Public Health				
Radiological contaminant transport from F-Tank Farm:				
Adult resident latent cancer fatality risk	2.2×10^{-4}	9.5×10^{-7}	1.8×10^{-6}	1.3×10^{-5}
Child resident latent cancer fatality risk	2.0×10^{-4}	8.5×10^{-7}	1.7×10^{-6}	1.2×10^{-5}
Seepline worker latent cancer fatality risk	2.2×10^{-7}	8.0×10^{-10}	1.6×10^{-9}	1.2×10^{-8}
Intruder latent cancer fatality risk	1.1×10^{-7}	4.0×10^{-10}	8.0×10^{-10}	8.0×10^{-9}
Adult resident maximum lifetime dose (millirem)[f]	430	1.9	3.6	26
Child resident maximum lifetime dose (millirem)[f]	400	1.7	3.3	24
Seepline worker maximum lifetime dose (millirem)[f]	0.54	0.002	0.004	0.03
Intruder maximum lifetime dose (millirem)[f]	0.27	0.001	0.002	0.02
1-meter well drinking water dose (millirem per year)	3.6×10^{5}	130	420	790
1-meter well alpha concentration (picocuries per liter)	1,700	13	13	13
100-meter well drinking water dose (mrem/yr)	1.4×10^{4}	51	190	510
100-meter well alpha concentration (picocuries per liter)	530	4.8	4.7	4.8
Seepline drinking water dose (millirem per year)	430	1.9	3.5	25
Seepline alpha concentration (picocuries per liter)	9.2	0.04	0.039	0.04
Radiological contaminant transport from H-Tank Farm:				
Adult resident latent cancer fatality risk	8.5×10^{-5}	2.0×10^{-6}	5.5×10^{-7}	6.5×10^{-6}
Child resident latent cancer fatality risk	7.5×10^{-5}	3.3×10^{-7}	5.5×10^{-7}	6.5×10^{-7}
Seepline worker latent cancer fatality risk	8.4×10^{-8}	(e)	4.0×10^{-10}	6.8×10^{-9}
Intruder latent cancer fatality risk	4.4×10^{-8}	(e)	(e)	3.2×10^{-9}

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative		
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Adult resident maximum lifetime dose (millirem)[f]	170	4	1.1	13
Child resident maximum lifetime dose (millirem)[f]	150	0.65	1.1	1.3
Seepline worker maximum lifetime dose (millirem)[f]	0.21	(d)	0.001	0.017
Intruder maximum lifetime dose (millirem) [f]	0.11	(d)	(d)	0.008
1-meter well drinking water dose (millirem per year)	9.3×10^6	1×10^5	1.3×10^5	1.0×10^5
1-meter well alpha concentration (picocuries per liter)	13,000	24	290	24
100-meter well drinking water dose (millirem per year)	9.0×10^4	300	920	870
100-meter well alpha concentration (picocuries per liter)	3,800	7.0	38	7.0
Seepline drinking water dose (millirem per year)	2.5×10^3	2.5	25	46
Seepline alpha concentration (picocuries per liter)	34	0.15	0.33	0.15

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a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities; impacts of this facility are evaluated in the SRS Waste Management EIS (DOE/EIS-0217).

b. Radiation dose less than 1.0×10^{-6} or non-radiological concentration less than 1.0×10^{-6} mg/L.

c. Hazard quotient is less than ~ 1×10^{-2}.

d. The radiation dose for this alternative is less than 1×10^{-3} millirem.

e. The risk for this alternative is less than 4.0×10^{-10}.

f. Calculated based on an assumed 70-year lifetime.

Table 2-5. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, 1-meter well.[a]

	Maximum concentration (percent of MCL)				
1-Meter well	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	18.5	320	6,500	150
Barnwell McBean	0.0	47.5	380	0.0	270
Congaree	0.0	6.8	0.0	0.0	62
Grout Fill Option					
Water Table	0.0	0.3	21	70	2.3
Barnwell McBean	0.0	5	23	0.0	21
Congaree	0.0	0.1	0.0	0.0	0.5
Saltstone Fill Option					
Water Table	0.0	0.3	21	70	240,000
Barnwell McBean	0.0	5	23	0.0	440,000
Congaree	0.0	0.1	0.0	0.0	160,000
Sand Fill Option					
Water Table	0.0	1.6	8.5	37	6.7
Barnwell McBean	0.0	5.3	19	0.0	22
Congaree	0.0	0.1	0.0	0.0	0.7

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

Table 2-6. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, 100-meter well.[a]

	Maximum concentration (percent of MCL)				
100-Meter well	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	8.3	74	265	69
Barnwell McBean	0.0	12.5	81	0.0	58
Congaree	0.0	1.2	0.0	0.0	11
Grout Fill Option					
Water Table	0.0	0.1	2.7	1.5	0.7
Barnwell McBean	0.0	1.1	4.4	0.0	4.7
Congaree	0.0	0.0	0.0	0.0	0.1
Saltstone Fill Option					
Water Table	0.0	0.1	2.7	1.5	68,000
Barnwell McBean	0.0	1.1	4.4	0.0	180,000
Congaree	0.0	0.0	0.0	0.0	21,000
Sand Fill Option					
Water Table	0.0	0.3	1.5	2.7	1.3
Barnwell McBean	0.0	1.2	3.7	0.0	4.9
Congaree	0.0	0.0	0.0	0.0	0.1

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

Table 2-7. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, seepline.[a]

	Maximum concentration (percent of MCL)				
Fourmile Branch seepline	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	0.4	1.0	0.0	3.4
Barnwell McBean	0.0	0.5	0.8	0.0	2.4
Congaree	0.0	0.0	0.0	0.0	0.1
Grout Fill Option					
Water Table	0.0	0.0	0.0	0.0	0.0
Barnwell McBean	0.0	0.0	0.0	0.0	0.1
Congaree	0.0	0.0	0.0	0.0	0.0
Saltstone Fill Option					
Water Table	0.0	0.0	0.0	0.0	3,000
Barnwell McBean	0.0	0.0	0.0	0.0	3,300
Congaree	0.0	0.0	0.0	0.0	300
Sand Fill Option					
Water Table	0.0	0.0	0.0	0.0	0.1
Barnwell McBean	0.0	0.0	0.0	0.0	0.2
Congaree	0.0	0.0	0.0	0.0	0.0

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of “100” for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

[a] The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

and the seepline north of the groundwater divide for H-Tank Farm. The Grout, Sand, and Saltstone Options show similar concentrations at most locations. For these three options, the maximum contaminant level for alpha-emitting radionuclides would be exceeded only in H-Area at the 1-meter well (all three options) and at the 100-meter well (Sand Option).

If the Clean and Remove Tanks Alternative were chosen, residual waste would be removed from the tanks and the tank systems themselves would be removed and transported to SRS radioactive waste disposal facilities. Long-term impacts at these facilities are evaluated in the Savannah River Site Waste Management EIS (DOE/EIS-0217). The long-term impacts of low-level waste disposal in low-activity vaults presented in the SRS Waste Management EIS are about one-one thousandth of the long-term tank closure impacts presented in this EIS for water resources and public health.

For nonradiological constituents, the EPA primary drinking water maximum contaminant levels would be exceeded only for the No Action Alternative and Clean and Fill with Saltstone Option. The impacts would be greatest in terms of the variety of contaminants that exceed the maximum contaminant level for the No Action Alternative, but exceedances of the maximum contaminant levels only occur primarily at the 1-meter well, with mercury exceeding the MCL also at the 100-meter well. Impacts from the Clean and Fill with Saltstone Option would occur at all exposure points, including the seepline; however, nitrate is the only contaminant that would exceed its maximum contaminant level. The maximum contaminant levels would not be exceeded for any contaminant in any aquifer layer, at any point of exposure, for either the Grout or the Sand Options.

Ecological resources – Risks to aquatic organisms in Fourmile Branch and Upper Three Runs for non-radiological contaminants would be negligible under the Clean and Fill with Sand and Clean and Fill with Saltstone Options. For the Clean and Fill with Grout Option and the No Action Alternative, there would be relatively low risk to aquatic organisms.

Risks to terrestrial organisms such as the shrew and mink (and other small mammalian carnivores with limited home range sites) from non-radiological contaminants would be negligible for all options under the Clean and Stabilize Tanks Alternative. For the No Action Alternative, there would be generally low risk to terrestrial organisms.

All calculated radiological doses to terrestrial and aquatic animal organisms were well below the limit of 365,000 millirad per year (1.0 rad per day) established in DOE Order 5400.5, including the No Action Alternative.

Land use – Long-term land use impacts at the tank farm areas are not expected because of DOE's established land use policy for the SRS. In the *Savannah River Site Future Use Plan*, DOE established a future use policy for the SRS. Several key elements of that policy would maintain the lands that are now part of the tank farm areas for heavy industrial use and exclude use from non-conforming land uses. Most notable are:

- Protection and safety of SRS workers and the public shall be a priority.
- The integrity of site security shall be maintained.
- A "restricted use" program shall be developed and followed for special areas (e.g., CERCLA and RCRA regulated units).
- SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government.
- Residential uses of all SRS land shall be prohibited in any area of the site.

As mentioned above, the tank farm areas will remain in an industrialized zone. In principle, industrial zones are ones in which the facilities pose either a potentially significant nuclear or non-nuclear hazard to employees or the general public. In the case of the Industrial-Heavy Nuclear zone, facilities included (1) produce, process, store and/or dispose of radioactive liquid or solid waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; or (4) conduct fuel enrichment operations.

Public health – DOE evaluated the impacts over a 10,000-year period. Structural collapse of the tanks would pose a safety hazard under the No Action Alternative, creating unstable ground conditions and forming holes into which workers or other site users could fall. Neither the Clean and Stabilize Tanks Alternative nor the Clean and Remove Tanks Alternative would have this safety hazard, although there could be some moderate ground instability with the Clean and Fill with Sand Option. Airborne releases from the tanks are considered to be possible only under the No Action Alternative, and their likelihood is considered to be minimal for that alternative because the presence of moisture and the considerable depth of the tanks below grade would tend to discourage resuspension of tank contents. Therefore, the principal source of potential impacts to public health is leaching and groundwater transport of contaminants. DOE calculated risks to public health based on postulated release and transport scenarios.

The maximum calculated dose to the adult resident for either tank farm, as presented in Table 2-3, would be 430 mrem for a 70-year lifetime for the No Action Alternative. This dose is less than the 100 mrem per year public dose limit and represents only a marginal increase in the annual average exposure of individuals in the United States of approximately 360 mrem due to natural and manmade sources of radiation exposure. Based on this low dose, DOE would not expect any health effects if an individual were to receive this hypothetical dose.

At the one-meter well, the highest calculated peak drinking water dose under the No Action Alternative is 9,300,000 millirem per year (9,300 rem per year), which would lead to acute radiation health effects, including death. Peak doses at this well for the Clean and Stabilize Tanks Alternative are calculated to be in the range of 100,000 to 130,000 millirem per year (100 to 130 rem per year), which substantially exceeds all criteria for acceptable exposure, could result in acute health effects, and would give a significantly increased probability of a latent cancer fatality. Peak doses calculated at the 100-meter well range from 300 millirem (0.3 rem per year) per year for the Clean and Fill with Grout Option to 90,000 millirem per year (90 rem per year) for the No Action Alternative. Individuals exposed to 300 millirem per year would experience a lifetime increased risk of latent cancer fatality of less that 0.02 percent per year of exposure. The estimated doses at the 1- and 100-meter wells are extremely conservative (high) estimates because the analysis treated all of the tanks in a given group as being at the same physical location. Realistic doses at these close-in locations would be substantially smaller.

DOE considered the potential exposures to people who live in a home built over the tanks at some time in the future when they are unaware that the residence was built over closed waste tanks. DOE previously modeled this type of exposure for the saltstone disposal vaults in the Z Area. That analysis found that external radiation exposure was the only potentially significant pathway of potential radiological exposure other than groundwater use (WSRC 1992). For the Clean and Fill with Grout and Clean and Fill with Sand Options of the Clean and Stabilize Tanks Alternative, external radiation doses to onsite residents would be negligible because the thick layers of nonradioactive material between the waste (near the bottom of the tanks) and the ground surface would shield residents from any direct radiation emanating from the waste. External radiation exposures could occur under the Clean and Fill with Saltstone Option which would place radioactive saltstone near the ground surface. If it is conservatively assumed that all of the backfill soil is eroded or excavated away and there is no other cap over the saltstone, so that a home is built directly on the saltstone, analysis presented in WSRC (1992) indicates that 1000 years after tank closure a resident would be exposed to an effective dose equivalent of 390 mrem/year, resulting in an estimated 1 percent increase in risk of latent cancer fatality from a 70-year lifetime of exposure. Backfill soils or caps would eliminate or substantially reduce the potential external exposure. For example, with a 30-inch-thick intact concrete cap, the dose would be reduced to 0.1 mrem/year. For the No Action Alternative external exposures to onsite residents would be expected to be unacceptably high due to the potential for contact with the residual waste.

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CHAPTER 3. AFFECTED ENVIRONMENT

Chapter 3 describes the existing SRS environment as it relates to the alternatives described in Chapter 2.

3.1 Geologic Setting and Seismicity

The SRS is in west-central South Carolina, approximately 100 miles from the Atlantic coast (Figure 3.1-1). It is on the Aiken Plateau of the Upper Atlantic Coastal Plain about 25 miles southeast of the Fall Line that separates the Atlantic Coastal Plain from the Piedmont.

3.1.1 GENERAL GEOLOGY

In South Carolina, the Atlantic Coastal Plain Province consists of a wedge of seaward-dipping and thickening unconsolidated and semiconsolidated sediments that extend from the Fall Line to the Continental Shelf. The Aiken Plateau is the subdivision of the Coastal Plain that includes the location of the SRS. The plateau extends from the Fall Line to the oldest of several scarps incised in the Coastal Plain sediment. The Plateau surface is highly dissected and characterized by broad interfluvial areas with narrow steep-sided valleys. Although it is generally well drained, poorly drained depressions (called Carolina bays) do occur (DOE 1995). At the Site, the plateau is underlain by 600 to 1,400 feet of sands, clays, and limestones of Tertiary and Cretaceous age. These sediments are underlain, in turn, by sandstones of Triassic age and older metamorphic and igneous rocks (Arnett and Mamatey 1996). Because of the proximity of the SRS to the Piedmont Province, it has more relief than areas that are nearer the coast, with onsite elevations ranging from 89 to 420 feet above mean sea level.

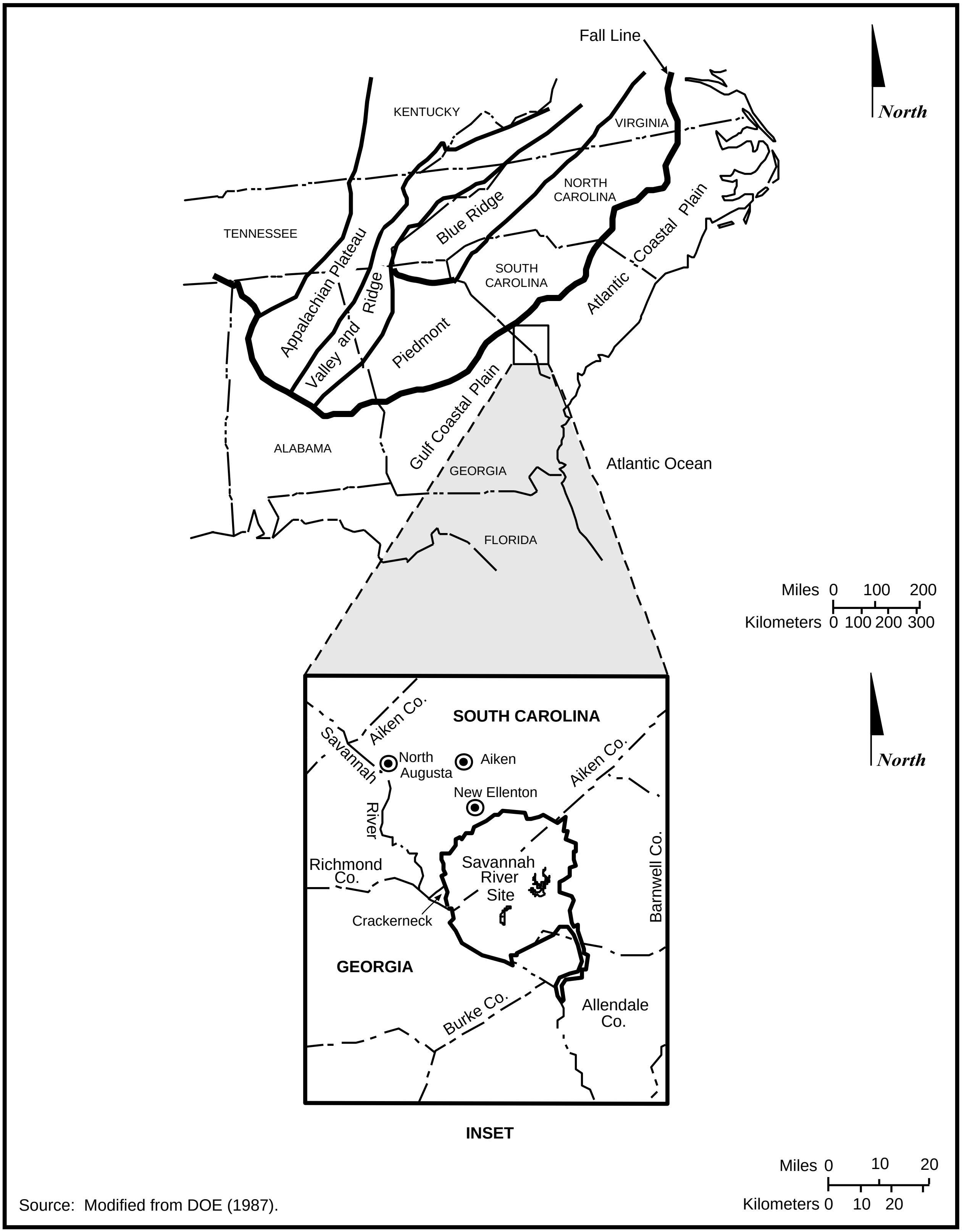
The sediments of the Atlantic Coastal Plain (Figure 3.1-2) dip gently seaward from the Fall Line and range in age from Late Cretaceous to Recent. The sedimentary sequence thickens from essentially 0 feet at the Fall Line to more than 4,000 feet at the coast. Regional dip is to the southeast. Coastal Plain sediments underlying the SRS consist of sandy clays and clayey sands, although occasional beds of clean sand, gravel, clay, or carbonate occur (DOE 1995). The formations of interest in F- and H-Areas (General Separations Area) are part of the shallow (Floridan) aquifer system (Figure 3.1-2 and Table 3.1-1). Contaminants released to these formations could be transported by groundwater to local SRS streams.

3.1.2 LOCAL GEOLOGY AND SOILS

The principal surface and near-surface soils in F- and H- Areas consist of cross-bedded, poorly sorted sands and pebbly sands with lenses and layers of silts and clays. The surface and near surface soils contain a grater percentage of clay which has demonstrated a good retention capacity for most radionuclides. A significant portion of the surface soils around the F- and H- Area Tank Farms are composed of backfill material resulting from previous excavation and construction activities.

The vadose zone is comprised of the middle to late Miocene-age “Upland Unit,” which extends over much of SRS. The term “Upland Unit” is an informal name used to describe sediments at higher elevations located in the Upper Coastal Plain in southwestern South Carolina. This area has also been referred to as the Aiken Plateau which is bounded by the Savannah and Congaree Rivers and extends from the Fall Line to the Orangeburg escarpment. This unit is highly dissected and is characterized by broad interfluvial areas with narrow, steep-sided valleys (SCDNR, 1995). Erosion in these dissected, steep-sided valley areas expose older, underlying deposits.

The occurrence of cross-bedded, poorly sorted sands with clay lenses indicate fluvial deposition (high-energy channel deposits to channel-fill deposits) with occasional transitional marine influence. This depositional environment results in wide differences in lithology and presents a very complex system of transmissive and confining beds or zones (SCDNR, 1995). The lower surface of the “Upland Unit” is very irregular due to erosion of the underlying



Source: Modified from DOE (1987).

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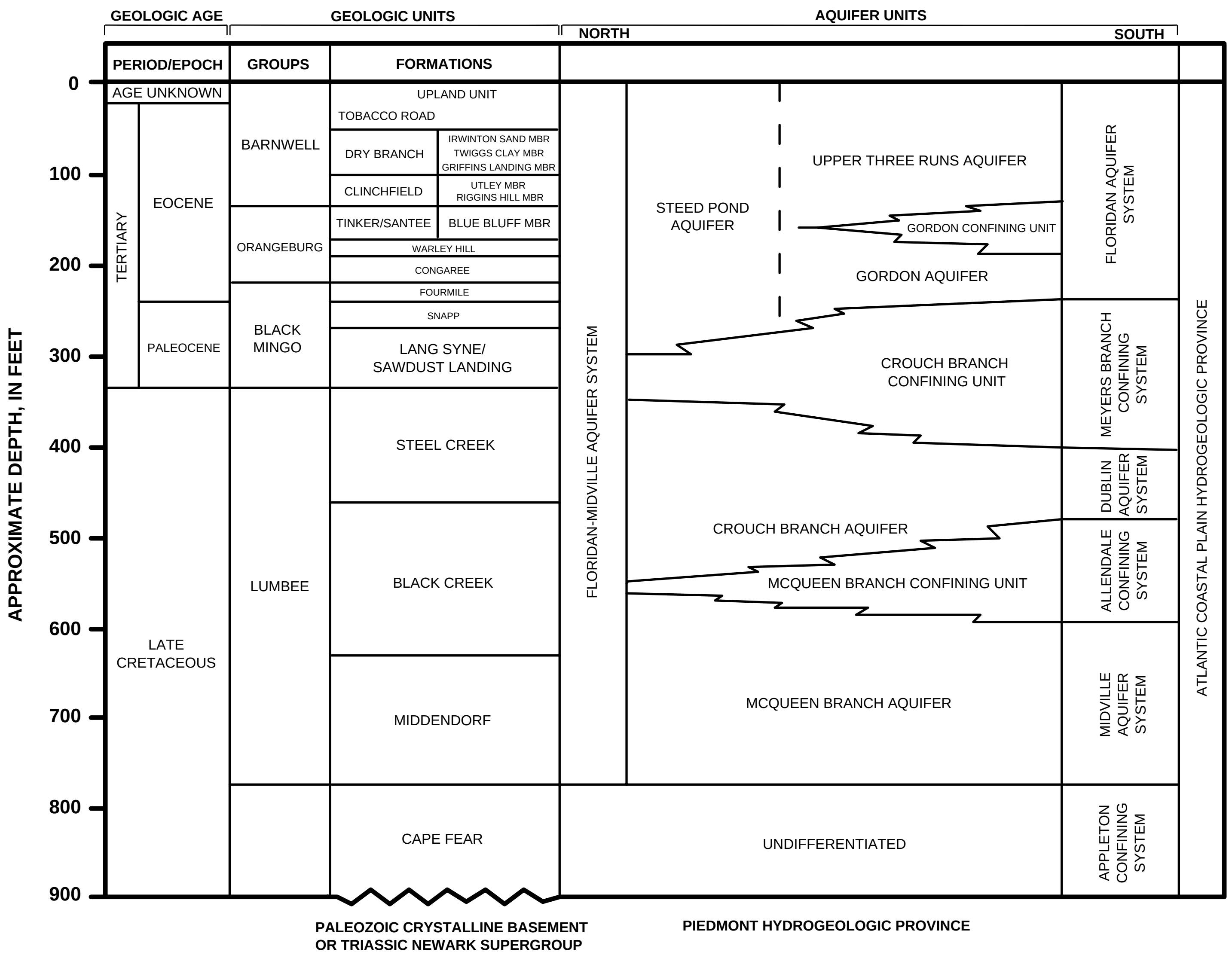
Figure 3.1-1. Generalized location of Savannah River Site and its relationship to physiographic provinces of southeastern United States.



Source: Aadland, Gellici, and Thayer (1995).

NW TANK/Grfx/3.1-2 Geo_Aqu Units.ai

Figure 3.1-2. Generalized geologic and aquifer units in SRS region.

Table 3.1-1. Formations of the Floridan aquifer system in F- and H-Areas.[a]

Aquifer unit	Formation	Description
Upper Three Runs Aquifer -upper zone [Water Table]	"Upland Unit"	Poorly sorted, clayey-to-silty sands, with lenses and layers of conglomerates, pebbly sands, and clays. Clay clasts are abundant, and cross-bedding and flecks of weathered feldspar are locally common.
	Tobacco Road Formation	Moderately to poorly sorted, variably colored, fine-to-coarse grained sand, pebbly sand, and minor clay beds.
"Tan Clay" Confining Zone Upper Three Runs Aquifer -lower zone [Barnwell/McBean]	Dry Branch Formation -Twiggs Clay Member -Griffins Landing Member -Irwinton Sand Member	Variably colored, poorly sorted to well sorted sand with the interbedded tan to gray clay ("Tan Clay") of the Twiggs Clay Member. The Tan Clay where present divides the Upper Three Runs Aquifer into an upper and lower zone.
	Clinchfield Formation	Light colored basal quartz sand and glauconitic, biomoldic limestone, calcareous sand and clay. Sand beds of the formation constitute Riggins Mill Member and consist of medium to coarse, poorly to well sorted, loose and slightly indurated, tan, gray, and green quartz. The carbonate sequence of the Clinchfield consists of Utley Member -- sandy, glauconitic limestone and calcareous sand with indurated biomoldic facies.
	Tinker/Santee Formation	Unconsolidated, moderately sorted, subangular, lower coarse-to-medium grained, slightly gravely, immature yellow and tan quartz sand and clayey sand; calcareous sands and clays and limestone also occur in F- and H-Areas.
Gordon Confining Unit [Green Clay]	Blue Bluff Member of Santee Limestone	Micritic limestone
	Warley Hill Formation	Fine grained, glauconitic, clayey sand, and clay that thicken, thin, and pinch out abruptly.
Gordon Aquifer [Congaree]	Congaree Formation	Yellow, orange, tan, gray, and greenish gray, well-sorted, fine-to-coarse-grained quartz sands. Thin clay laminae occur throughout the section, with pebbly layers, clay clasts, and glauconite in places. In some places on SRS, upper part of Congaree Formation is cemented with silica; in other places it is slightly calcareous. Glauconitic clay, encountered in some borings on SRS near the base of this formation, indicates that basal contact is unconformable.
	Fourmile Formation	Tan, yellow-orange, brown, and white, moderately to well-sorted sand, with clay beds near middle and top of unit. The sand is very coarse to fine-grained, with pebbly zones common. Glauconite and dinoflagellate fossils occur.
	Snapp Formation	Silty, medium- to course-grained quartz sand interbedded with clay. Dark, micaceous, lignitic sand also occurs. In northwestern part of SRS, this Formation is less silty and better sorted, with thinner clay interbeds.

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a. Source: Aadland, Gellici, and Thayer (1995).

formations (Fallow and Price, 1992). The thickness of the "Upland Unit" ranges from 16 feet to 40 feet in the vicinity of the F-and H- Area Seepline Basins (WSRC, 1991), but may be as thick as 70 feet in the Central Savannah River Area (Fallow and Price, 1992). The F- and H- Area Seepage Basins are located southwest and west of the F- and H- Area Tank farms, respectively.

A notable feature of the "Upland Unit" is its compositional variability (Figure 3.1.2). This formation predominantly consists of red-brown to yellow-orange, gray, and tan colored, coarse to fine grained sand, pebbly and with lenses and beds of sandy clay and clay. Generally vertically upward through the unit, sorting of grains becomes poorer, clay beds become more abundant and thicker, and sands become more argilaceous and indurated (Fallow and Price, 1992). In some areas, small-scale joints and fractures, both of which are commonly filled with sand or silt, traverse the unit. The mineralogy of the sands and pebbles primarily consists of quarts, with some feldspars. In areas to the east-southeast, sediments may become more phosphatic and dolomitic. The mineralogy of the clays consists of kaolinite, resulting from highly weathered feldspars, and muscovite (Nystrom et al., 1991). The soils at F- and H- Areas may contain as much as 20 to 40 percent clay (WSRC, 1991).

3.1.3 SEISMICITY

There are several fault systems off the Site northwest of the Fall Line (DOE 1990). A recent study of geophysical evidence (Wike et al. 1996) and an earlier study (Stephenson and Stieve 1992) also identified the onsite faults indicated on Figure 3.1-3. The earlier study identified the following faults – Pen Branch, Steel Creek, Advanced Tactical Training Area, Crackerneck, Ellenton, and Upper Three Runs – under SRS. The more recent study (Wike et al. 1996) identifies a previously unknown fault that passes through the southeastern corner of H-Area and passes approximately one-half mile south of F-Area between F-Area and Fourmile Branch. The Upper Three Runs Fault, which is a Paleozoic fault that does not cut Coastal Plain sediments, passes approximately 1 mile north and west of F Area. The lines shown on Figure 3.1-3 represent the projection of faults to the ground surface. The actual faults do not reach the surface but stop several hundred feet below.

Based on available information, none of the faults discussed in this section is capable, which means that none of the faults has moved at or near the ground surface within the past 35,000 years or is associated with another fault that has moved in the past 35,000 years. The regulation 10 CFR 100 contains a more detailed definition of a capable fault. Two major earthquakes have occurred within 186 miles of SRS.

- According to URS/Blume (1982), the Charleston, South Carolina earthquake of 1886 had an estimated Richter scale magnitude of 6.8; it occurred approximately 90 miles from the SRS area, which experienced an estimated peak horizontal acceleration of 10 percent of gravity (0.10*g*). Lee et al. (1997) reevaluated the data determined the magnitude to have been 7.5.

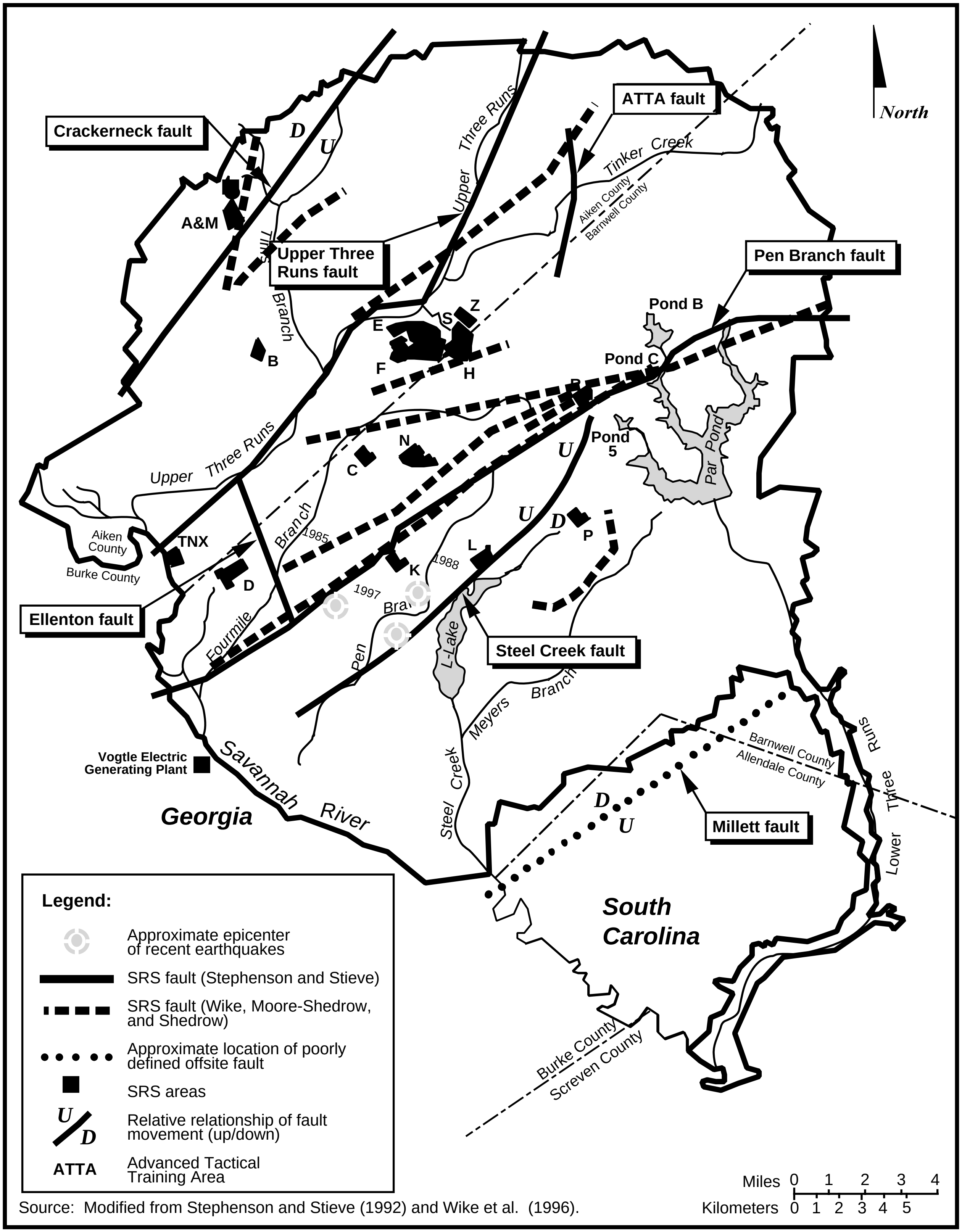
- The Union County, South Carolina earthquake of 1913 had, according to Bollinger (1973), an estimated Richter scale magnitude of 6.0 and occurred about 99 miles from the Site. The magnitude has since been revised downward to 4.5 based on a reevaluation of the duration data (Geomatrix 1991).

These earthquakes are not associated conclusively with a specific fault.

In recent years, three earthquakes occurred inside the SRS boundary.

- On May 17, 1997, with a duration magnitude of 2.3 and a focal depth of 3.38 miles; its epicenter was southeast of K Area.

- On August 5, 1988, with a duration magnitude of 2.0 and a focal depth of 1.66 miles; its epicenter was northeast of K Area.



Source: Modified from Stephenson and Stieve (1992) and Wike et al. (1996).

NW TANK/Grfx/3.1-3 Fault lines.ai

Figure 3.1-3. Savannah River Site, showing seismic fault lines and locations of onsite earthquakes and their year of occurrence.

- On June 8, 1985, with a duration magnitude of 2.6 and a focal depth of 0.59 mile; its epicenter was south of C Area and west of K Area.

Existing information does not relate these earthquakes conclusively with known faults under the Site. In addition, the focal depth of these earthquakes is currently being evaluated. Figure 3.1-3 shows the locations of the epicenters of these earthquakes.

Outside the SRS boundary, an earthquake with a Richter scale magnitude of 3.2 occurred on August 8, 1993, approximately 10 miles east of the City of Aiken near Couchton, South Carolina. People reported feeling this earthquake in Aiken, New Ellenton (immediately north of SRS), North Augusta (approximately 25 miles northwest of the SRS), and on the Site.

3.2 Water Resources

3.2.1 SURFACE WATER

The Savannah River bounds SRS on its southwestern border for about 20 miles, approximately 160 river miles from the Atlantic Ocean. Five upstream reservoirs -- Jocassee, Keowee, Hartwell, Richard B. Russell, and Strom Thurmond – reduce the variability of flow downstream, in the area of SRS. River flow averages about 10,000 cubic feet per second at SRS (DOE 1995).

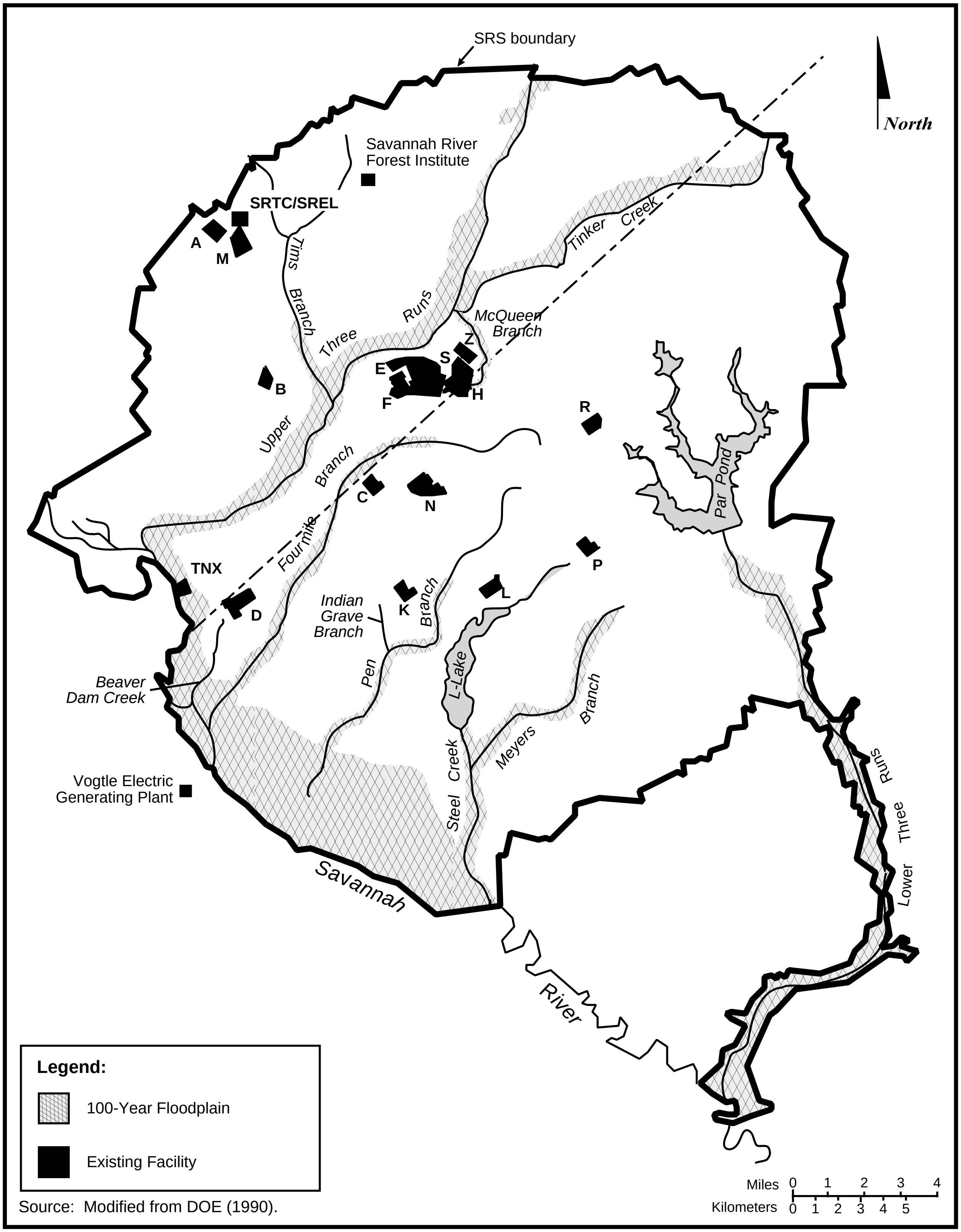
Upstream of SRS, the river supplies domestic and industrial water for Augusta, Georgia, and North Augusta, South Carolina. Approximately 130 river miles downstream of SRS, the river supplies domestic and industrial water for Savannah, Georgia, and Beaufort and Jasper Counties in South Carolina through intakes at about River Mile 29 and River Mile 39, respectively (DOE 1995).

Five tributaries discharge directly to the Savannah River from SRS: Upper Three Runs, Beaver Dam Creek, Fourmile Branch, Steel Creek, and Lower Three Runs (Figure 3.2-1). A sixth stream, Pen Branch, which does not flow directly into the river, joins Steel Creek in the Savannah River floodplain swamp. Each of these six streams originates on the Aiken Plateau in the Coastal Plain and descends 50 to 200 feet before discharging into the river (DOE 1995). The streams, which historically have received varying amounts of effluent from SRS operations, are not commercial sources of water.

F- and H-Areas are situated on the divide that separates the drainage into Upper Three Runs (including McQueen Branch and Crouch Branch) and Fourmile Branch; approximately half of each area drains into each stream (DOE 1997b). F- and H-Areas are relatively elevated areas of SRS and are centrally located inside the SRS boundary. Surface elevations range from approximately 270 to 320 feet above mean sea level for both F- and H-Areas. The F- and H-Areas are drained by Upper Three Runs to the north and west and by Fourmile Branch to the south. In addition, the Water Table Aquifer for both F- and H-Areas outcrops at the seeplines along both Fourmile Branch and Upper Three Runs.

Upper Three Runs, the longest of the SRS streams, is a large blackwater stream in the northern part of SRS that discharges to the Savannah River. It drains an area of over 195 square miles and is approximately 25 miles long, with its lower 17 miles within SRS boundaries. This creek receives more water from underground sources than other SRS streams and is the only stream with headwaters arising outside the site. It is the only major tributary on SRS that has not received thermal discharges (Halverson et al. 1997).

Fourmile Branch is a blackwater stream that originates near the center of SRS and flows southwest for 15 miles before emptying into the Savannah River (Halverson et al. 1997). It drains an area of about 22 square miles inside SRS, including much of F-, H-, and C-Areas. Fourmile Branch flows parallel to the Savannah River behind natural levees and enters the river through a breach downriver from Beaver Dam Creek. In its lower reaches, Fourmile Branch broadens and flows via braided channels through a delta formed by the deposition of sediments eroded from upstream during high flows.



Source: Modified from DOE (1990).

NW Tank/Grfx/3.2-1 Floodplain.ai

Figure 3.2-1. Savannah River Site, showing 100-year floodplain and major stream systems.

Downstream from the delta, the channels rejoin into one main channel. Most of the flow discharges into the Savannah River while a small portion flows west and enters Beaver Dam Creek (DOE 1995).

The natural flow of SRS streams ranges from about 10 cubic feet per second in smaller streams to 245 cubic feet per second in Upper Three Runs. From 1974 to 1995, the mean flow of Upper Three Runs at Road A was 245 cubic feet per second, and the 7Q10 (minimum 7-day average flow rate that occurs with an average frequency of once in 10 years) was 100 cubic feet per second (Halverson et al. 1997). The mean flow of Fourmile Branch southwest of SC Highway 125 from 1976 to 1995 was 113 cubic feet per second, and the 7Q10 was 7.6 cubic feet per second (Halverson et al. 1997). The *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a) contain detailed information on flow rates and water quality of the Savannah River and SRS streams.

There are various potential sources of contamination to the Upper Three Runs and Fourmile Branch watersheds in and around the F- and H-Areas. These potential sources have been identified in the SRS Federal Facility Agreement, Appendix C, RCRA/CERCLA Units (WSRC 1993) and are listed in Table 3.2-1. These potential sources could contribute contaminants to the surface waters of Upper Three Runs and Fourmile Branch in the same manner as the F- and H-Area Tank Farms.

SCDHEC regulates the physical properties and concentrations of chemicals and metals in SRS effluents under the National Pollutant Discharge Elimination System (NPDES) program. SCDHEC, which also regulates biological water quality standards for SRS waters, has classified the Savannah River and SRS streams as “Freshwaters.” In 1998, 99.3 percent of the NPDES water quality analyses on SRS effluents were in compliance with the SRS NPDES permit; only 42 of 5,790 analyses exceeded permit limits (Arnett and Mamatey 1999a). The 1998 exceedances were higher than in previous years. Repeat exceedances at 4 outfalls accounted for a majority of the exceedances; some of which can be attributed to ongoing heavy rainfall. In particular, heavy rainfall caused groundwater levels to rise significantly at outfall D-1A which had a total of 18 exceedances. A comparison of 1998 Savannah River water quality analyses showed no significant differences between up- and downstream SRS stations (Arnett and Mamatey 1999a). Table 3.2-2 summarizes the water quality of Fourmile Branch and Upper Three Runs for 1998.

3.2.2 GROUNDWATER RESOURCES

3.2.2.1 Groundwater Features

In the SRS region, the subsurface contains two hydrogeologic provinces. The uppermost, consisting of a wedge of unconsolidated Coastal Plain sediments of Late Cretaceous and Tertiary age, is the Atlantic Coastal Plain Hydrogeologic Province. Beneath the sediments of the Atlantic Coastal Plain Hydrogeologic Province are rocks of the Piedmont Hydrogeologic Province. These rocks consist of Paleozoic igneous and metamorphic basement rocks and lithified mudstone, sandstone, and conglomerates of the Dunbarton basin of the Upper Triassic. Sediments of the Atlantic Coastal Plain Hydrogeologic Province are divided into three main aquifer systems, the Floridan Aquifer System, the Dublin Aquifer System, and the Midville Aquifer System as shown in Figure 3.1-2 (Aadland et al. 1995). The Meyers Branch Confining System and/or the Allendale Confining System, as shown in Figure 3.1-2, separate the aquifer systems of interest.

Groundwater within the Floridan System (the shallow aquifer beneath the Site) flows slowly toward SRS streams and swamps and into the Savannah River at rates ranging from inches to several hundred feet per year. The depth to which onsite streams cut into sediments, the lithology of the sediments, and the orientation of the sediment formations control the horizontal and vertical movement of the groundwater. The valleys of smaller perennial streams allow dis-

Table 3.2-1. Potential F- and H-Area contributors of contamination to Upper Three Runs and Fourmile Branch.[a]

Fourmile Branch Watershed	Upper Three Runs Watershed
Burial Ground Complex Groundwater[b]	Burial Ground Complex Groundwater[a]
Burial Ground Complex [the Old Radioactive Waste Burial Ground (643-E) and Solvent Tanks S01-S22 portions]	Burial Ground Complex [the Low-Level Radioactive Waste Disposal Facility (643-7E) portion]
F-Area Coal Pile Runoff Basin, 289-F	Burma Road Rubble Pit, 231-4F
F-Area Hazardous Waste Management Facility, 904-41G, -42G, -43G	F-Area Burning/Rubble Pits, 231-F, -1F, -2F
F-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-1F	F-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-1F
F-Area Retention Basin, 281-3F	
F-Area Seepage Basin Groundwater Operable Unit	H-Area Coal Pile Runoff Basin, 289-H
H-Area Hazardous Waste Management Facility, 904-44G, -45G, -46G, -56G	H-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-H
H-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-H	
H-Area Retention Basin, 281-3H	Old F-Area Seepage Basin, 904-49G
H-Area Seepage Basin Groundwater Operable Unit	211-FB Plutonium-239 Release, 081-F
H-Area Tank Farm Groundwater	
Mixed Waste Management Facility, 643-28E	
Warner's Pond, 685-23G	

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a. Source: WSRC (1993).
Units located in more than one watershed.

charge from the shallow saturated geologic formations. The valleys of major tributaries of the Savannah River (e.g., Upper Three Runs) drain formations of intermediate depth, and the river valley drains deep formations. With the release of water to the streams, the hydraulic head of the aquifer unit releasing the water can become less than that of the underlying unit. If this occurs, groundwater has the potential to migrate upward from the lower unit to the overlying unit.

Groundwater flow in the shallow aquifer (Floridan) system is generally horizontal but may have a vertically downward component. In the divide areas between surface water drainages the vertical component of groundwater flow is downward due to the decreasing hydraulic head with increasing depth. In areas along the lower reaches of most of the Site streams, groundwater moves generally in a horizontal direction and has vertically upward potential from deeper aquifers to the shallow aquifers. In these areas, hydraulic heads increase with depth. In the vicinity of these streams, the potential for vertically upward flow occurs across a confining unit where the underlying aquifer has not been incised by an overlying stream (Aadland et al. 1995). For example, in the area south of H-Area where Fourmile Branch cuts into the Upper Three Runs Aquifer but does not cut into the Gordon Aquifer, the hydraulic head is greater in the Gordon Aquifer than the overlying Upper Three Runs Aquifer that discharges to Fourmile Branch. At these locations any contaminants in the overlying aquifer system are prevented from migrating into deeper aquifers by the prevailing hydraulic gradient and the low permeability of the confining unit. Groundwater flow in the General Separations Area, which includes F- and H-Areas, is toward Upper Three Runs and its tributaries to the north and Fourmile Branch to the south.

Table 3.2-2. SRS stream water quality (onsite downstream locations).[a]

Parameter[b]	Units	Fourmile Branch (FM-6) average	Upper Three Runs (U3R-4) average	Water Quality Criterion[c], MCL[d], or DCG[e]
Aluminum	mg/L	0.285[f]	0.294[f]	0.087
Cadmium	mg/L	NR[g]	NR	0.00066
Calcium	mg/L	NR	NR	NA[h]
Cesium-137	pCi/L	4.74	0.67	120[e]
Chromium	mg/L	ND[i]	ND	0.011
Copper	mg/L	0.006	ND	0.0065
Dissolved oxygen	mg/L	8.31	6.3	≥5
Iron	mg/L	0.717	0.547	1
Lead	mg/L	0.18	0.011	0.0013
Magnesium	mg/L	NR	NR	0.3
Manganese	mg/L	0.045	0.026	1
Mercury	mg/L	0.0002	ND	0.000012
Nickel	mg/L	ND	ND	0.088
Nitrate (as nitrogen)	mg/L	1.29	0.26	10[d1]
pH	pH	6.4	5.8	6-8.5
Plutonium-238	pCi/L	0.003	ND	1.6[e]
Plutonium-239	pCi/L	0.001	0.005	1.2[e]
Strontium-89,90	pCi/L	6.79	0.04	8[d2]
Suspended solids	mg/L	3.9	5.9	NA
Temperature[j]	°C	20.2	18.8	32.2
Tritium	pCi/L	1.9×10^5	4.2×10^3	20,000[d2]
Uranium-234	pCi/L	0.69	0.093	20[e]
Uranium-235	pCi/L	0.053	0.046	24[e]
Uranium-238	pCi/L	0.84	0.11	24[e]
Zinc	mg/L	0.019	0.02	0.059

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a. Source: Arnett and Mamatey (1999b).

b. Parameters DOE routinely measures as a regulatory requirement or as part of ongoing monitoring programs.

c. Water Quality Criterion (WQC) is Aquatic Chronic Toxicity unless otherwise indicated.

d. MCL = Maximum Contaminant Level; State Primary Drinking Water Regulations [d1 = Chapter 61-58.5 (b)(2)h; d2= Chapter 61-585(h(2)b].

e. DCG = DOE Derived Concentration Guides for Water (DOE Order 5400.5). DCG values are based on committed effective dose of 100 millirem per year; however, because drinking water MCL is based on 4 millirem per year, value listed is 4 percent of DCG.

f. Concentration exceeded WQC; however, these criteria are for comparison only. WQCs are not legally enforceable.

g. ND = Not detected.

h. NA = Not applicable.

i. Shall not be increased more than 2.8°C (5°F) above natural temperature conditions or exceed a maximum of 32.2°C (90°F) as a result of the discharge of heated liquids unless appropriate temperature criterion mixing zone has been established.

3.2.2.2 Groundwater Use

Groundwater is a domestic, municipal, and industrial water source throughout the Upper Coastal Plain. Regional domestic water supplies come primarily from the shallow aquifers including the Gordon Aquifer and the Upper Three Runs Aquifer (water-table aquifer). Most municipal and industrial water supplies in Aiken County are from the Crouch Branch and McQueen Branch Aquifers, formerly the Black Creek and Middendorf, respectively. In Barnwell and Allendale Counties some municipal water supplies are from the Gordon Aquifer and overlying units that thicken to the southeast. At SRS, most groundwater production for domestic and process water comes from the Crouch Branch and McQueen Branch, with a few lower-capacity domestic waterwells pumping from the shallower Gordon (Congaree) Aquifer and the lower zone of the Upper Three Runs (McBean) Aquifer. These wells are located away from the main operations areas in outlying areas including guard barricades and operations offices/ laboratories (DOE 1998).

The domestic water requirements for the General Separations Area are supplied from groundwater wells located in A Area (Arnett and Mamatey 1997). From January to December 1998, the total groundwater withdrawal rate in the General Separations Area for industrial use, including groundwater from process production wells and former domestic wells, now used as process wells in F-, H-, and S-Areas, was approximately 2.1 million gallons per day. These wells are installed in the deeper Crouch Branch and McQueen Branch Aquifers. Groundwater in F-Area is pumped from four process production and two former domestic wells currently being used for process production. The total F-Area groundwater production rate in 1998 was approximately 1.01 million gallons per day. During the same period, wells in H- and S-Areas produced approximately 1.02 million gallons per day and 49,000 gallons per day, respectively. H-Area has two former domestic wells and three process production wells (Wells 1997; WSRC 1999). S-Area's groundwater production is from three process/former domestic wells (WSRC 1995).

3.2.2.3 Hydrogeology

The aquifers of interest for F- and H-Areas within the General Separations Area are the Upper Three Runs and Gordon Aquifers. The Upper Three Runs Aquifer (formerly Water Table and Barnwell-McBean Aquifers) is defined by the hydrogeologic properties of the Tinker/Santee Formation, the Dry Branch Formation, and the Tobacco Road Formation (DOE 1997a). Table 3.1-1 provides descriptions of these formations. The Twiggs Clay Member of the Dry Branch Formation acts as a confining unit (Tan Clay) that separates the Upper Three Runs Aquifer into an upper and lower zone. The horizontal hydraulic conductivity for the upper zone of the Upper Three Runs Aquifer ranges between 5 to 13 feet per day with localized areas as high as 40 feet per day (Aadland et al. 1995). The horizontal hydraulic conductivity for the lower zone of the Upper Three Runs Aquifer is approximately 2.5 to 10 feet per day (Aadland et al. 1995). The vertical conductivity of the Upper Three Runs Aquifer (upper and lower zones) is generally assumed to be about 1/10th to 1/100th of the horizontal conductivity based on its lithology and stratified nature. The vertical hydraulic conductivity of the Tan Clay unit is generally taken to be on the order of 5×10^{-3} to 8×10^{-4} feet per day to support groundwater flow modeling calibration (Flach 1994).

Groundwater flow in the Upper Three Runs Aquifer is generally horizontal but may have a vertically downward component. In the groundwater divide areas generally located between surface water drainages a component of groundwater flow is downward due to the decreasing hydraulic head with increasing depth. Because the F- and H- Area Tank Farms lie near the groundwater divide the groundwater flow direction may be toward either Upper Three Runs and its tributaries to the north or Fourmile Branch to the south. In areas along Fourmile Branch shallow groundwater moves generally in a horizontal direction and deeper groundwater has vertically upward potential to the shallow aquifers. In these areas, hydraulic heads increase with depth. Therefore, along Fourmile Branch any contaminants in the Upper Three Runs Aquifer are prevented from migrating into deeper aquifers by the prevailing hydraulic gradient and the low permeability of the Tan and Green Clay confining units. To the north of the tank farms, however the rising elevation of the Upper Three Runs Aquifer and the deep incision of Upper Three Runs Creek result in truncation of the entire aquifer. In these areas shallow groundwater may seep out along the major tributaries to Upper Three Runs Creek above the valley floor or may seep downward to the next underlying aquifer zone and discharge along the stream valley.

The Gordon Confining Unit (green clay), which separates the Upper Three Runs and Gordon Aquifers, consists of the Warley Hill Formation and the Blue Bluff Member of the Santee Limestone (Table 3.1-1). It is not a continuous clay unit but consists of several superimposed lenses of green and gray clay that thicken, thin, and pinch out abruptly. Locally, beds of calcareous mud add to the thickness of the unit with minor interbeds of clayey sand or sand (Aadland et al. 1995). The vertical hydraulic conductivity is generally taken to be on the order of 1×10^{-4} to 1×10^{-5} foot per day to support groundwater flow modeling calibration (Flach 1994).

The Gordon Aquifer consists of the Congaree, Fourmile, and Snapp Formations. Table 3.1-1 provides soil descriptions for these formations. The Gordon Aquifer is partially eroded near the Savannah River and along Upper Three Runs. This aquifer is recharged directly by precipitation in the outcrop area, at interstream drainage divides in and near the outcrop area, and by leakage from overlying and underlying aquifers. The southeast-to-northwest hydraulic gradient across SRS is consistent and averages 4.8 feet per mile. The horizontal hydraulic conductivity ranges between approximately 30 to 40 feet per day (Aadland et al. 1995). The vertical hydraulic conductivity is generally assumed to be about 1/10th to 1/100th of the horizontal conductivity based on its lithology and stratified nature (Flach 1994).

Figures 3.2-2 through 3.2-4 show the approximate groundwater flow paths for F- and H-Area Tank Farms for the Water Table, Barnwell-McBean, and Congaree aquifers.

3.2.2.4 Groundwater Quality

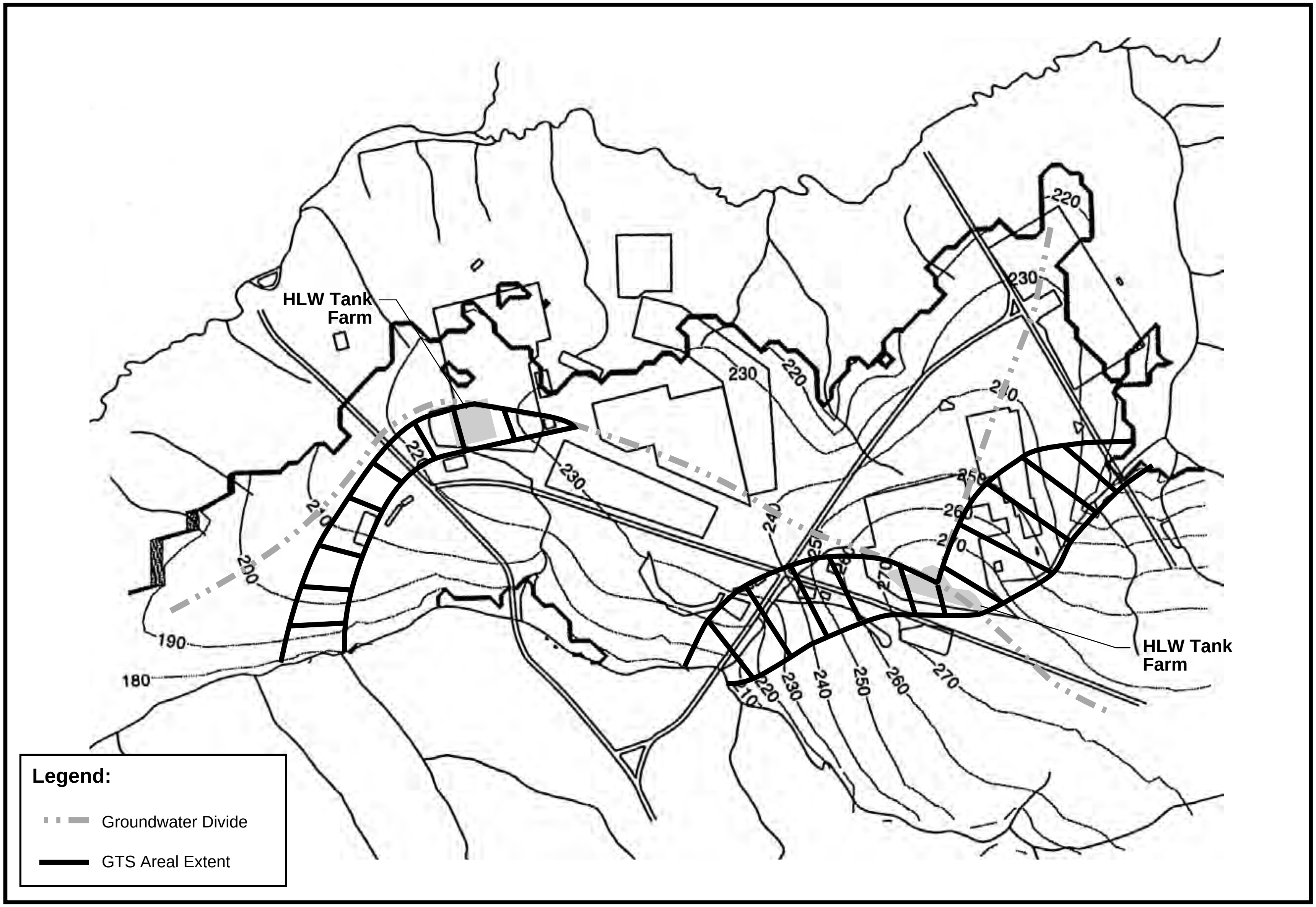
Industrial solvents, metals, tritium, and other constituents used or generated on SRS have contaminated the shallow aquifers beneath the industrial areas that make up 5 to 10 percent of the Site. In general, DOE does not use these aquifers for SRS process operations or drinking water, although there are a few low-yield wells in the Gordon Aquifer and in the lower zone of the Upper Three Runs Aquifer (formerly known as the McBean and Barnwell-McBean) in remote locations. The shallow aquifer units of the Floridan System discharge to SRS streams and eventually the Savannah River (Arnett and Mamatey 1997).

Most contaminated groundwater at SRS occurs beneath the industrial facilities; the contaminants reflect the operations and chemical processes performed at those facilities. In the General Separations Area, contaminants above regulatory and DOE guidelines include tritium and other radionuclides, metals, nitrates, sulfates, and chlorinated and volatile organics. Tables 3.2-3 through 3.2-7 list concentrations of individual analytes above regulatory or SRS guidelines for the period from fourth quarter 1997 through third quarter 1998 for the General Separations Area that includes E-, F-, H-, S-, and Z-Areas, respectively (WSRC 1997; WSRC 1998a,b,c). Figure 3.2-5 shows generalized groundwater contamination maximum values for analytes at or above regulatory or established SRS guidelines for the areas of concern.

3.3 Air Resources

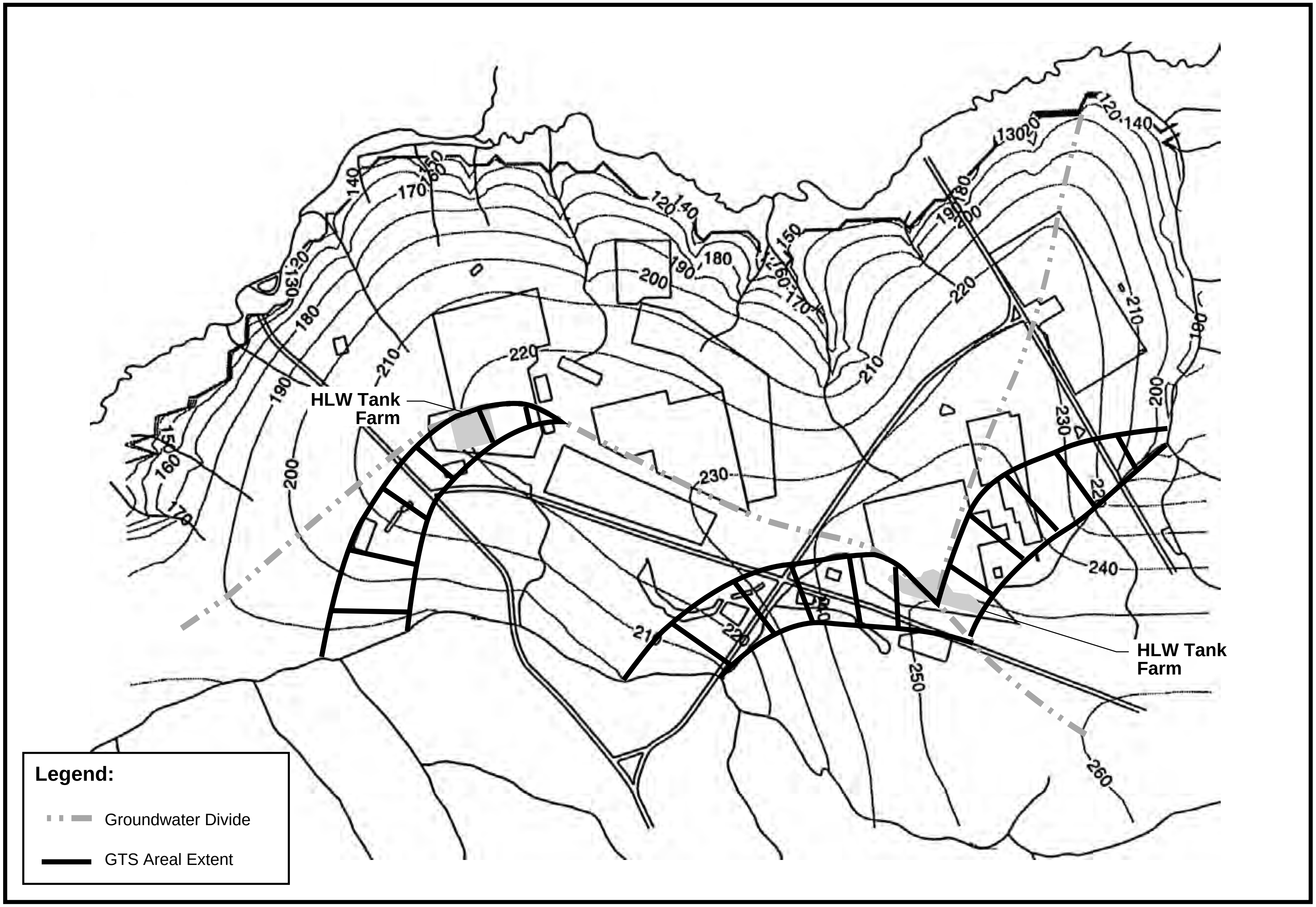
3.3.1 METEOROLOGY

The southeastern U.S. has a humid subtropical climate characterized by relatively short, mild winters and long, warm, and humid summers. Summer-like weather typically lasts from May through September, when the area is subject to the persistent presence of the Atlantic subtropical anticyclone (i.e., the “Bermuda” high). The humid conditions often result in scattered afternoon thunderstorms. Average seasonal rainfall is usually lowest during the fall.



NW TANK/Grfx/3.2-2 Water table.ai

Figure 3.2-2. Calibrated potentiometric surface (ft) for the Water Table aquifer.



NW TANK/Grfx/3.2-3 Barnw-McB.ai

Figure 3.2-3. Calibrated potentiometric surface (ft) for the Barnwell/McBean aquifer.

NW TANK/Grfx/3.2-4 Congaree.ai

Figure 3.2-4. Calibrated potentiometric surface (ft) for the Congaree aquifer.

Table 3.2-3. E-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Aluminum[b]	3,670 µg/L	50 µg/L[c]
Antimony[b]	10.2 µg/L	6.0 µg/L[d]
Bromomethane	20.0 µ/L	20 µg/L[e]
Cadmium[b]	9.48 µg/L	5.0 µg/L[d]
Carbon-14	5.29×10^{-5} µCi/mL	2.0×10^{-6} µCi/mL[f]
Carbon tetrachloride	11.4 µg/L	5.0 µg/L[d]
Chloroethene (vinyl chloride)	24.9 µg/L	2.0 µg/L[d]
Chloroform	163 µg/L	100 µg/L[d]
Chromium[b]	117 µg/L	100 µg/L[d]
1,1-Dichloroethane	60.8 µg/L	5.0 µg/L[e]
1,1-Dichloroethylene	25.6 µg/L	7.0 µg/L[d]
Dichloromethane	150 µg/L	5.0 µg/L[d]
Gross alpha	3.27×10^{-8} µCi/mL	1.5×10^{-8} µCi/mL[d]
Iron[b]	13,500 µg/L	300 µg/L[c]
Lead[b]	116.0 µg/L	50 µg/L[g]
Lithium[b]	1,510 µg/L	250 µg/L[e]
Manganese[b]	309 µg/L	50 µg/L[c]
Mercury[b]	6.67 µg/L	2.0 µg/L[d]
Nickel[b]	134 µg/L	100 µg/L[d]
Nonvolatile beta	1.05×10^{-7} µCi/mL	5.0×10^{-8} µCi/mL[f]
Radium, total alpha emitting	6.90×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[f]
Strontium-90	6.44×10^{-8} µCi/mL	8.0×10^{-9} µCi/mL[d]
Tetrachloroethylene	50.2 µg/L	5 µg/L[d]
Thallium[b]	8.30 µg/L	2 µg/L[d]
Total organic halogens	559 µg/L	50 µg/L[e]
Trichloroethylene	1,160 µg/L	5 µg/L[d]
Trichlorofluoromethane	35.1 µg/L	20 µg/L[e]
Tritium	2.96×10^{-1} µCi/mL	2.0×10^{-5} µCi/mL[d]

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a. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.
b. Total recoverable.
c. EPA National Secondary Drinking Water Standards (WSRC 1997; 1998a,b,c). EPA Final Primary Drinking Water Standards (WSRC 1997; 1998a,b,c).
d. Drinking Water Standards do not apply. Criterion 10 times a recently published 90th percentile detection limit was used (WSRC 1997; 1998a,b,c).
e. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
g. SCDHEC Final Primary Drinking Water Standards (WSRC 1997; 1998a,b,c), Chapter 61-58.6E(7)(d).

Measurable snowfall is rare. Spring is characterized by mild temperatures, relatively low humidity, and a higher frequency of tornadoes and severe thunderstorms.

3.3.1.1 Local Climatology

Sources of data used to characterize the climatology of SRS consist of a standard instrument shelter in A-Area (temperature, humidity, and precipitation for 1961 to 1994), the Central Climatology Meteorological Facility near N-Area (temperature, humidity, and precipitation for 1995 to 1996), and seven meteorological towers (winds and atmospheric stability). The average annual temperature at SRS is 64.7°F. July is the warmest month of the year with an average daily maximum of 92°F and an average daily minimum near 72°F; January is the coldest month with an average daily high around 56°F and an average daily low of 36°F. Temperature extremes recorded at SRS since 1961 range from a

Table 3.2-4. F-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Aluminum[b]	37,100 µg/L	50 µg/L[c]
Americium-241	5.27×10^{-8} µCi/mL	6.34×10^{-9} µCi/mL[d]
Antimony[b]	27.0 µg/L	6.0 µg/L[e]
Beryllium[b]	16.6 µg/L	4.0 µg/L[e]
Bis (2-ethylhexyl) phthalate	160 µg/L	6 µg/L[e]
Cadmium[b]	36.3 µg/L	5.0 µg/L[e]
Carbon-14	1.97×10^{-5} µCi/mL	2.0×10^{-6} µCi/mL[f]
Cesium-137	2.58×10^{-7} µCi/mL	2.0×10^{-7} µCi/mL[f]
Cobalt[b]	863 µg/L	100 µg/L[g]
Copper[b]	1,530 µg/L	1,000 µg/L[h1]
Curium-243/244	1.08×10^{-7} µCi/mL	8.30×10^{-9} µCi/mL[d]
Dichloromethane	11.3 µg/L	5 µg/L[e]
Gross alpha	2.32×10^{-6} µCi/mL	1.5×10^{-8} µCi/mL[e]
Iodine-129	8.14×10^{-7} µCi/mL	1.0×10^{-9} µCi/mL[f]
Iron[b]	15,200 µg/L	300 µg/L[c]
Lead[b]	548 µg/L	50 µg/L[h2]
Manganese[b]	63.5 µg/L	50 µg/L[c]
Mercury[b]	8.38 µg/L	2.0 µg/L[e]
Nickel[b]	156 µg/L	100 µg/L[e]
Nickel-63	5.58×10^{-8} µCi/mL	5.0×10^{-8} µCi/mL[f]
Nitrate-nitrite as nitrogen	324,000 µg/L	10,000 µg/L[e]
Nonvolatile beta	3.06×10^{-6} µCi/mL	5.0×10^{-8} µCi/mL[f]
Radium-226	1.31×10^{-7} µCi/mL	5.0×10^{-9} µCi/mL[f,i]
Radium-228	6.19×10^{-7} µCi/mL	5.0×10^{-9} µCi/mL[f,i]
Ruthenium-106	5.41×10^{-8} µCi/mL	3.0×10^{-8} µCi/mL[f]
Strontium-89/90	2.46×10^{-5} µCi/mL	8.0×10^{-9} µCi/mL[e]
Strontium-90	9.07×10^{-7} µCi/mL	8.0×10^{-9} µCi/mL[e]
Technicium-99	1.32×10^{-6} µCi/mL	9.0×10^{-7} µCi/mL[f]
Tetrachloroethylene	15.7 µg/L	5 µg/L[e]
Thallium[b]	145 µg/L	2 µg/L[e]
Trichloroethylene	88.3 µg/L	5 µg/L[e]
Trichlorofluoromethane	55.8 µg/L	20µg/L[g]
Tritium	1.55×10^{-2} µCi/mL	2.0×10^{-5} µCi/mL[e]
Uranium-233/234	4.48×10^{-7} µCi/mL	1.38×10^{-8} µCi/mL[d]
Uranium-234	4.71×10^{-7} µCi/mL	1.39×10^{-8} µCi/mL[d]
Uranium-235	3.48×10^{-8} µCi/mL	1.45×10^{-8} µCi/mL[d]
Uranium-238	8.79×10^{-7} µCi/mL	1.46×10^{-8} µCi/mL[d]
Zinc[b]	8,430 µg/L	5,000 µg/L[c]

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a. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.
b. Total recoverable.
c. EPA National Secondary Drinking Water Standards (WSRC 1997, 1998a,b,c).
d. EPA Proposed Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
e. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).
f. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
g. Drinking Water Standards do not apply. Criterion 10 times a recently published 90th percentile detection limit was used (WSRC 1997, 1998a,b,c).
h. SCDHEC Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c) [h1 = Chapter 61-58.5 0(2); h2 = Chapter 61-58.6 F(7)(d)].
i. Radium 226/228 Combined Proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.

Table 3.2-5. H-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Aluminum[b]	13,000 µg/L	50 µg/L[c]
Bis (2-ethylhexyl) phthalate	142 µg/L	6 µg/L[d]
Dichloromethane	8.45 µg/L	5 µg/L[d]
Gross alpha	9.74×10^{-8} µCi/mL	1.5×10^{-8} µCi/mL[d]
Iodine-129	1.09×10^{-7} µCi/mL	1.0×10^{-9} µCi/mL[e]
Iron[b]	17,100 µg/L	300 µg/L[c]
Lead[b]	417 µg/L	50 µg/L[f]
Manganese[b]	1,650 µg/L	50 µg/L[c]
Mercury[b]	18.5 µg/L	2.0 µg/L[d]
Nickel-63	4.79×10^{-7} µCi/mL	5.0×10^{-8} µCi/mL[e]
Nitrate-nitrite as nitrogen	52,800 µg/L	10,000 µg/L[d]
Nonvolatile beta	3.37×10^{-6} µCi/mL	5.0×10^{-8} µCi/mL[e]
Phorate	2.28 µg/L	1.7 µg/L[g]
Radium-226	6.52×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[e, h]
Radium-228	6.98×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[e,h]
Radium, total alpha emitting	6.70×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[e]
Ruthenium-106	3.81×10^{-8} µCi/mL	3.0×10^{-8} µCi/mL[e]
Strontium-89/90	1.01×10^{-8} µCi/mL	8.0×10^{-9} µCi/mL[d]
Strontium-90	1.24×10^{-6} µCi/mL	8.0×10^{-9} µCi/mL[d]
Thallium[b]	1,060 µg/L	2 µg/L[d]
Trichloroethylene	14.7 µg/L	5 µg/L[d]
Tetrachloroethylene	12.6 µg/L	5 µg/L[d]
Tritium	1.02×10^{-2} µCi/mL	2.0×10^{-5} µCi/mL[d]
Uranium-233/234	4.28×10^{-8} µCi/mL	1.38×10^{-8} µCi/mL[i]
Uranium-238	4.20×10^{-8} µCi/mL	1.46×10^{-8} µCi/mL[i]
Vanadium[b]	139 µg/L	133 µg/L[g]

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a. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.
b. Total recoverable.
c. EPA National Secondary Drinking Water Standards (WSRC 1997, 1998a,b,c).
d. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).
e. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
f. SCDHEC Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c) [Chapter 61-58.6 F(7)(d).
g. Drinking Water Standards do not apply. Criterion 10 times a recently published 90th percentile detection limit was used (WSRC 1997, 1998a,b,c).
h. Radium 226/228 Combined Proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.
i. EPA Proposed Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).

maximum of 107°F in July 1986 to -3°F in January 1985.

Annual precipitation averages 49.5 inches. Summer is the wettest season of the year with an average monthly rainfall of 5.2 inches. Fall is the driest season with a monthly average rainfall of 3.3 inches. Relative humidity averages 70 percent annually with an average daily maximum of 91 percent and an average daily minimum of 45 percent.

Wind directions frequently observed at SRS show that there is no prevailing wind at SRS, which is typical for the lower Midlands of South Carolina. According to wind data collected from 1992 through 1996, winds are most fre-

Table 3.2-6. S-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Trichloroethylene	49.2 µg/L	5 µg/L[b]

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a. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.
b. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).

Table 3.2-7. Z-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Gross alpha	9.77×10^{-8} µCi/mL	1.5×10^{-8} µCi/mL[b]
Nonvolatile beta	5.26×10^{-8} µCi/mL	5.0×10^{-8} µCi/mL[c]
Radium-226	7.78×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[c, d]
Radium-228	8.09×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[c, d]
Radium, total alpha emitting	5.55×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[c]
Ruthenium-106	3.08×10^{-8} µCi/mL	3.0×10^{-8} µCi/mL[c]

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a. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.
b. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).
c. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
d. Radium 226/228 Combined Proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.

quently from the southwest sector (9.7 percent) (Arnett and Mamatey 1998a). Measurements of turbulence are used to determine whether the atmosphere has relatively high, moderate, or low potential to disperse airborne pollutants (commonly identified as unstable, neutral, or stable atmospheric conditions, respectively). Generally, SRS atmospheric conditions were categorized as unstable 56 percent of the time (DOE 1997).

The average wind speed for a measured 5-year period was 8.5 miles per hour. Average hourly wind speeds of less than 4.5 miles per hour occur approximately 10 percent of the time (NOAA 1994).

3.3.1.2 <u>Severe Weather</u>

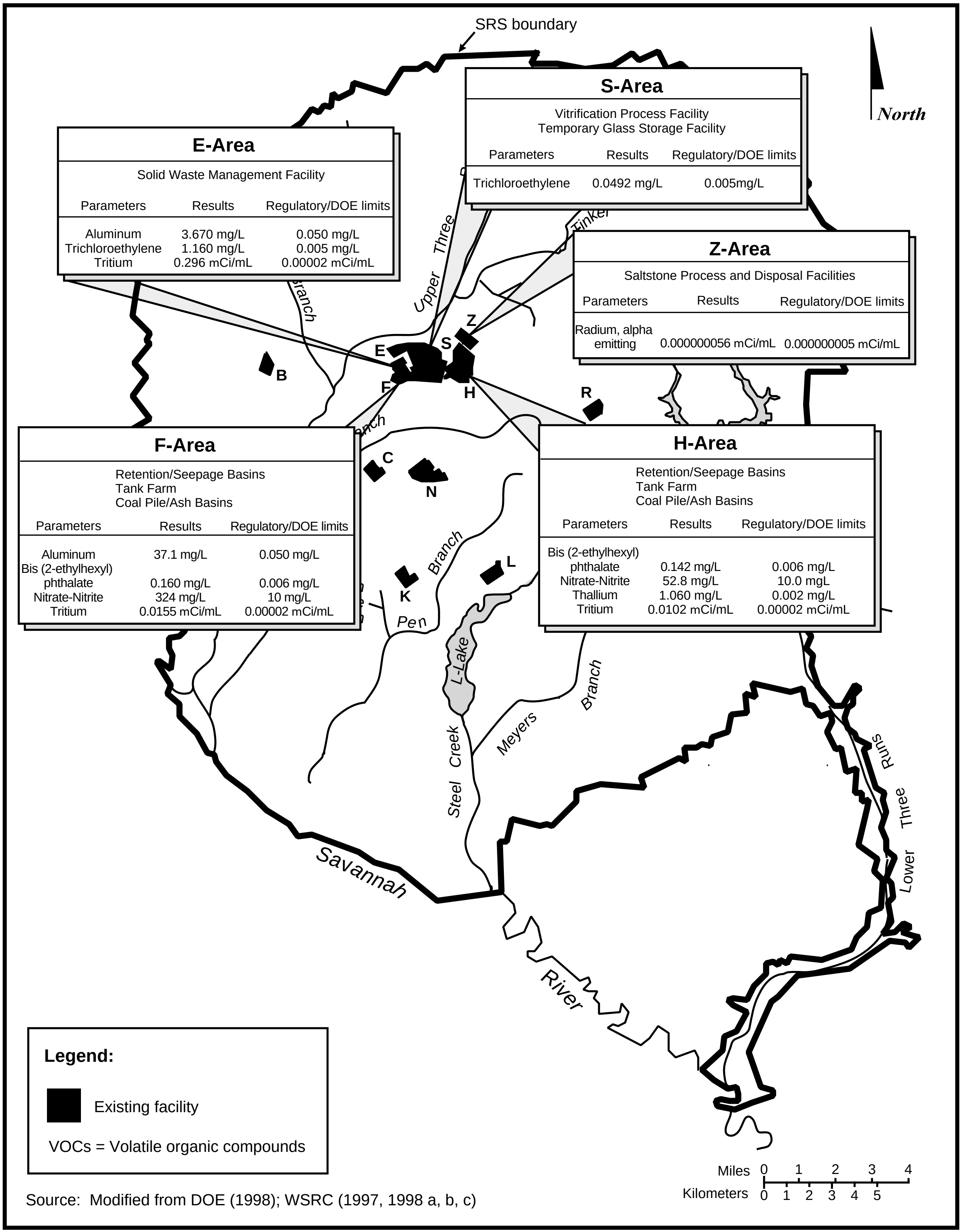
An average of 54 thunderstorm days per year were observed at the National Weather Service in Augusta, Georgia office during the period 1951 to 1995. About half of the thunderstorms occurred during the summer. Since operations began at SRS, 10 confirmed tornadoes have occurred on or in close proximity to the Site. Several of these tornadoes, which were estimated to have winds up to 150 miles per hour, did considerable damage to forested areas of SRS. None caused damage to structures. Tornado statistics indicate that the average frequency of a tornado striking any single point on the Site is 2×10^{-4} per year or about once every 5,000 years (Weber 1998).

The highest sustained wind (fastest-mile) recorded at the Augusta National Weather Service Office is 82 miles per hour. Hurricanes struck South Carolina 36 times during the period 1700 to 1992, which equates to an average recurrence frequency of once every 8 years. A hurricane force wind of 75 miles per hour has been observed at SRS only once, during Hurricane Gracie in 1959.

3.3.2 AIR QUALITY

3.3.2.1 <u>Nonradiological Air Quality</u>

The SRS is located in the Augusta-Aiken Interstate Air Quality Control Region (AQCR). All areas within this region are classified as achieving attainment with the National Ambient Air Quality Standards (NAAQS) (40 CFR 50). Ambient air is defined as that portion of the atmos-



Legend:

■ Existing facility

VOCs = Volatile organic compounds

E-Area

Solid Waste Management Facility

Parameters	Results	Regulatory/DOE limits
Aluminum	3.670 mg/L	0.050 mg/L
Trichloroethylene	1.160 mg/L	0.005 mg/L
Tritium	0.296 mCi/mL	0.00002 mCi/mL

S-Area

Vitrification Process Facility
Temporary Glass Storage Facility

Parameters	Results	Regulatory/DOE limits
Trichloroethylene	0.0492 mg/L	0.005mg/L

Z-Area

Saltstone Process and Disposal Facilities

Parameters	Results	Regulatory/DOE limits
Radium, alpha emitting	0.000000056 mCi/mL	0.000000005 mCi/mL

F-Area

Retention/Seepage Basins
Tank Farm
Coal Pile/Ash Basins

Parameters	Results	Regulatory/DOE limits
Aluminum	37.1 mg/L	0.050 mg/L
Bis (2-ethylhexyl) phthalate	0.160 mg/L	0.006 mg/L
Nitrate-Nitrite	324 mg/L	10 mg/L
Tritium	0.0155 mCi/mL	0.00002 mCi/mL

H-Area

Retention/Seepage Basins
Tank Farm
Coal Pile/Ash Basins

Parameters	Results	Regulatory/DOE limits
Bis (2-ethylhexyl) phthalate	0.142 mg/L	0.006 mg/L
Nitrate-Nitrite	52.8 mg/L	10.0 mgL
Thallium	1.060 mg/L	0.002 mg/L
Tritium	0.0102 mCi/mL	0.00002 mCi/mL

Source: Modified from DOE (1998); WSRC (1997, 1998 a, b, c)

NW Tank/Grfx/f3.2-5 Groundwater.ai

Figure 3.2-5. Maximum reported groundwater contamination in excess of regulatory/DOE limits at Savannah River Site.

phere, external to buildings, to which the general public has access. The NAAQS define ambient concentration criteria or limits for sulfur dioxide (SO_2), particulate matter equal to or less than 10 microns in aerodynamic diameter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb). These pollutants are generally referred to as "criteria pollutants." The nearest area not in attainment with the NAAQS is Atlanta, Georgia, which is approximately 150 miles west of SRS.

All of the Aiken-Augusta AQCR is designated a Class II area with respect to the Clean Air Act's Prevention of Significant Deterioration (PSD) regulations (40 CFR 51.166). The PSD regulations provide a framework for managing the existing clean air resources in areas that meet the NAAQS. Areas designated PSD Class II have sufficient air resources available to support moderate industrial growth. A Class I PSD designation is assigned to areas that are to remain pristine, such as national parks and wildlife refuges. Little additional impact to the existing air quality is allowed with a Class I PSD designation. Industries located within 100 kilometers (62 miles) of Class I Areas are subject to very strict Federal air pollution control standards. There are no Class I areas within 62 miles of SRS. The only Class 1 Area in South Carolina is the Cape Romain National Wildlife Refuge located in Charleston County.

The EPA approved more restrictive ambient standards for ground-level ozone and particulate matter that became effective on September 16, 1997 (62 FR 138). The new primary standard for ground-level ozone is based on an 8-hour averaging interval with a limit of 0.08 parts-per-million (ppm). Monitoring data from 1993 to 1997 indicate that ozone concentrations in the urban areas of Greenville-Spartanburg-Anderson, Columbia-Lexington, Rock Hill, Aiken, and Florence may approach or exceed the new standard. Monitoring data from 1997, 1998, and 1999 will be used to determine compliance with the new ozone standard (SCDHEC 1998).

Based on review of available scientific data on all particulate matter, the EPA determined that fine particulate matter less than 2.5 microns in diameter or $PM_{2.5}$ present greater health concerns than larger sized particulates. As a result, in addition to keeping the current PM_{10} regulations, EPA issued a daily (24-hour) $PM_{2.5}$ standard of 65 $\mu g/m^3$ and an annual limit of 15.0 $\mu g/m^3$. Limited data collected in several rural and urban areas in South Carolina, along with estimates derived from PM_{10} and TSP sampling around the State, indicate that many areas of South Carolina may exceed or have the potential to exceed the new annual standard for $PM_{2.5}$. SCDHEC expects that Aiken County will likely comply with the new standards. States will collect 3 years of monitoring data beginning in 1998 and will make attainment demonstrations beginning in 2002 (SCDHEC 1998).

On May 14, 1999, in response to challenges filed by industry and others, a 3-judge panel of the U.S. Court of Appeals for the District of Columbia Circuit issued a split opinion (2 to 1) on the new clean air standards. The Court vacated the new particulate standard and directed EPA to develop a new standard meanwhile reverting back to the previous PM_{10} standard. The revised ozone standard was not nullified, however, the judges ruled that the standard "cannot be enforced" (EPA 1999). On June 28, 1999, the EPA filed a petition for rehearing key aspects of the case in the U.S. Court of Appeals for the D.C. Circuit. The EPA has asked the U.S. Department of Justice to appeal this decision and take all judicial steps necessary to overturn the decision.

SCDHEC has been delegated authority to implement and enforce requirements of the Clean Air Act for the State of South Carolina. SCDHEC Air Pollution Regulation 62.5, Standard 2, enforces the NAAQS and sets ambient limits for two additional pollutants: total suspended particulates (TSP) and gaseous fluorides (as hydrogen fluoride, HF). The latter is not expected to be emitted as result of tank closure activities and is not included in subsequent discussions. In addition, SCDHEC Standard 8, Section II, Paragraph E) establishes ambient standards for 256 toxic air pollutants.

Significant sources of regulated air pollutants at SRS include coal-fired boilers for steam production, diesel generators, chemical storage tanks, the DWPF, groundwater air strippers, and various other process facilities. Another source of criteria pollutant emissions at SRS is the prescribed burning of forested areas across the Site by the U.S. Forest Service (Arnett and Mamatey 1998a). Table 3.3-1 shows the actual atmospheric emissions from all SRS sources in 1997.

Prior to 1991, ambient monitoring of SO_2, NO_2, TSP, CO, and O_3 was conducted at five sites across SRS. Because there is no regulatory requirement to conduct air quality monitoring at SRS, all of these stations have been decommissioned. Ambient air quality data collected during 1997 from monitoring stations operated by SCDHEC in Aiken County and Barnwell County, South Carolina, are summarized in Table 3.3-2. These data indicate that ambient concentrations of the measured criteria pollutants are generally much less than the standards.

SCDHEC also requires dispersion modeling as a means of evaluating local air quality. Periodically, all permitted sources of regulated air emissions at SRS must be modeled to determine estimates of ambient air pollution concentrations at the SRS boundary. (The ambient limits found under Standards 2 and 8 are enforceable at or beyond the Site boundary.) The results are used to demonstrate compliance with ambient standards and to define a baseline from which to assess the impacts of any new or modified sources. Additionally, a site-wide inventory of air emissions is developed every year as part of an annual emissions inventory required by SCDHEC regulation 61-62.1, Section III, "Emissions Inventory." Table 3.3-3 provides a summary of the most recent regulatory compliance modeling for SRS emissions. These calculations were performed with EPA's Industrial Source Complex (ISC3) air dispersion model (EPA 1995) and site-wide maximum potential emissions data from the annual air emissions inventory for 1998. Site boundary concentrations for the eight South Carolina ambient air pollutants include background concentrations of these pollutants, as observed at SCDHEC monitoring stations. Background concentrations of toxic/hazardous air pollutants are assumed to be zero. As Table 3.3-3 shows, estimated ambient SRS boundary concentrations are within the ambient standards for all regulated air pollutants emitted at SRS.

3.3.2.2 Radiological Air Quality

In the SRS region, airborne radionuclides originate from natural (i.e., terrestrial and cosmic) sources, worldwide fallout, and SRS operations. DOE maintains a network of 23 air sampling stations on and around SRS to determine concentrations of radioactive particulates and aerosols in the air (Arnett and Mamatey 1999a). Table 3.3-4 lists average and maximum atmospheric concentrations of radioactivity at the SRS boundary and at 25-mile radius monitoring locations during 1998.

DOE provides detailed summaries of radiological releases to the atmosphere from SRS operations, along with resulting concentrations and doses, in a series of annual environmental data reports. Table 3.3-5 lists 1998 radionuclide releases from each major operational group of SRS facilities.

Atmospheric emissions of radionuclides from DOE facilities are limited under the EPA regulation "National Emission Standards for Hazardous Air Pollutants (NESHAP)," 40 CFR Part 61, Subpart H. The EPA annual effective dose equivalent limit of 10 millirem per year to members of the public for the atmospheric pathway is also incorporated in DOE Order 5400.5, "Radiation Protection of the Public and the Environment." To demonstrate compliance with the NESHAP regulations, DOE annually calculates maximally exposed offsite individual (MEI) and collective doses and a percentage of dose contribution from each radionuclide using the CAP88 computer code. The dose to the maximally exposed individual (MEI) from 1998 SRS emissions (Table 3.3-5) was estimated at 0.08 millirem which is 0.8 percent of the 10 millirem per year EPA standard. The population dose was calculated, by pathway and radionuclide, using the POPGASP computer code which is discussed later in this section. The POPGASP

Table 3.3-1. Criteria and toxic/hazardous air pollutant emissions from SRS (1997).[a]

Pollutant	Actual tons/year
Criteria pollutants[b]	
Sulfur dioxide (as SO_x)	490
Total suspended particulates	2,000
Particulate matter (≤10 µm)	1,500
Carbon monoxide	5,200
Ozone (as Volatile Organic Components)	290
Nitrogen dioxide (as NO_x)	430
Lead	0.019
Toxic/Hazardous Air Pollutants [c]	
Benzene	13
Beryllium	0.0013
Mercury	0.039

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a. Sources: Mamatey (1999). Based on 1997 annual air emissions inventory from all SRS sources (permitted and unpermitted).

b. Includes an additional pollutant, PM-10, regulated under SCDHEC Regulation 61-62.5, Standard 2. Note: gaseous fluoride is also regulated under this standard but is not expected to be emitted as a result of tank closure activities.

c. Pollutants listed only include air toxics of interest to tank closure activities. A complete list of 1997 toxic air pollutant emissions for SRS can be found in Mamatey (1999).

Table 3.3-2. SCDHEC ambient air monitoring data for 1997.[a]

Pollutant	Averaging time	SC Standard (µg/m^3)	Aiken Co. (µg/m^3)	Barnwell Co. (µg/m^3)
Sulfur dioxide (as SO_x)	3-hr[d]	1,300	60	44
	24[d]	365	21	10
	Annual[e]	80	5	3
Total suspended particulates[c]	Annual geometric mean	75	36	--
Particulate matter (≤10 µm)	24-hr[d]	150	45	44
	Annual[e]	50	21	19
Carbon monoxide	1-hr[d]	40,000	5,100 [b]	--
	8-hr[d]	10,000	3,300 [b]	--
Ozone[c]	1-hr	235	200	210
Nitrogen dioxide (as NO_x)	Annual[c]	100	9	8
Lead	Calendar quarterly mean	1.5	0.01	--

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a. Source: SCDHEC (1998).

b. Richland County in Columbia, South Carolina (nearest monitoring station to SRS).

c. New standards may be applicable in the future; see discussion in text.

d. Second highest maximum concentration observed.

e. Arthmetric mean of observed concentrations.

Table 3.3-3. SRS baseline air quality for maximum potential emissions and observed ambient concentrations.

Pollutant	Averaging time	SCDHEC ambient standard $(\mu g/m^3)$[a]	Estimated SRS baseline concentration $(\mu g/m^3)$[b]
Criteria pollutants			
Sulfur dioxide (as SO_x) [c]	3-hr	1,300	1,200
	24-hr	365	350
	Annual	80	34
Total suspended particulates	Annual geometric mean	75	67
Particulate matter (≤ 10 µm)[d]	24-hr	150	130
	Annual	50	25
Carbon monoxide	1-hr	40,000	10,000
	8-hr	10,000	6,900
Nitrogen Dioxides (as NO_x) [e]	Annual	100	26
Lead	Calendar quarterly mean	1.5	0.03
Ozone	1-hr	235	200[f]
Toxic/hazardous air pollutants			
Benzene	24-hr	150	4.6
Beryllium	24-hr	0.01	0.009
Mercury	24-hr	0.25	0.03

Source: SCDHEC Regulation 61-62.5, Standard 2, "Ambient Air Quality Standards," and Regulation 61-62.5, Standard 8, Section II, Paragraph E, "Toxic Air Pollutants" (SCDHEC 1976).

a. Source: Hunter (1999). Concentration is the sum of Industrial Source Complex (ISC3) modeled air concentrations using the maximum potential emissions from the 1998 air emissions inventory for all SRS sources not exempted by Clean Air Act Title V requirements and observed concentrations from nearby ambient air monitoring stations.

b. Based on emissions for all oxides of sulfur (SO_x).

c. New NAAQS for particulate matter ≤ 2.5 microns (24-hour limit of 65 $\mu g/m^3$ and an annual average limit of 15 $\mu g/m^3$) may become enforceable during the life of this project.

d. Based on emissions for all oxides of nitrogen (NO_x).

e. Source: SCDHEC (1998). Observed concentration of ozone at SCDHEC ambient monitoring station for Aiken County. Ambient concentration of ozone from SRS emissions is not available.

g. New NAAQS for ozone (8-hour limit of 0.08 parts per million) may become enforceable during the life of this project.

collective (population) dose was estimated at 3.5 person-rem. Tritium oxide accounts for 94 and 77 percent of the MEI and the population dose, respectively. Plutonium-239 is the second highest contributor to dose with 3 percent of both the collective and MEI doses (Arnett and Mamatey 1999b). The contributions to dose from other radionuclides can be found in *SRS Environmental Data for 1998* (Arnett and Mamatey 1999a).

SRS-specific computer dispersion models such as MAXIGASP and POPGASP (see discussion of these models in Section 4.1.3.2) are also used to calculate radiological doses to members of the public from SRS annual releases. Whereas the CAP88 code assumes that all releases occur from one point (for SRS, at the center of the site), MAXIGASP can model multiple release locations which is truer to actual conditions.

Table 3.3-4. Radioactivity in air at the SRS boundary and at a 25-mile radius during 1998 (picocuries per cubic meter).[a]

Location	Tritium	Gross alpha	Gross beta	Cobalt-60	Cesium-137	Strontium-89,90	Plutonium-238	Plutonium-239
Site boundary								
Average[b]	11.3	1.4×10^{-3}	0.017	1.3×10^{-3}	2.6×10^{-4}	1.1×10^{-5}	7×10^{-7}	(c)
Maximum[d]	79.6	5.91×10^{-3}	0.061	0.021	0.011	1.1×10^{-4}	4.1×10^{-6}	7.4×10^{-7}
Background (25-mile radius)								
Average	6.7	0.0015	0.019	1.48	2.8×10^{-4}	(c)	(c)	(c)
Maximum	54	0.0036	0.003	0.011	0.0079	5.1×10^{-4}	8.6×10^{-6}	2.9×10^{-6}

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a. Source: Arnett and Mamatey (1999b).
b. The average value is the average of the arithmetic means reported for the site perimeter sampling locations.
c. Below background levels.
d. The maximum value is the highest value of the maximum reported for the site perimeter sampling locations.

3.4 Ecological Resources

3.4.1 NATURAL COMMUNITIES OF THE SAVANNAH RIVER SITE

The SRS comprises a variety of diverse habitat types that support terrestrial and semi-aquatic wildlife species. These habitat types include upland pine forests, mixed hardwood forests, bottomland hardwood forests, swamp forests, and Carolina bays. Since the early 1950s, the site has changed from 60 percent forest and 40 percent agriculture to 90 percent forest, with the remainder in aquatic habitats and developed (facility) areas (Halverson et al. 1997). The wildlife correspondingly shifted from forest-farm edge species to a predominance of forest-dwelling species. The SRS now supports 44 species of amphibians, 59 species of reptiles, 255 species of birds, and 54 species of mammals (Halverson et al. 1997). Comprehensive descriptions of the SRS's ecological resources and wildlife can be found in documents such as *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a).

SRS has extensive, widely distributed wetlands, most of which are associated with floodplains, creeks, or impoundments. In addition, approximately 200 Carolina bays occur on SRS (DOE 1995). Carolina bays are unique wetland features of the southeastern United States. They are isolated wetland habitats dispersed throughout the uplands of SRS. The approximately 200 Carolina bays on SRS exhibit extremely variable hydrology and a range of plant communities from herbaceous marsh to forested wetland (DOE 1995).

The Savannah River bounds SRS to the southwest for approximately 20 miles. The river floodplain supports an extensive swamp, covering about 15 square miles of SRS; a natural levee separates the swamp from the river (Halverson et al. 1997).

Timber was cut in the swamp from the turn of the century until 1951, when the Atomic Energy Commission assumed control of the area. At present, the swamp forest is comprised of two kinds of forested wetland communities (Halverson et al. 1997). Areas that are slightly elevated and well drained are characterized by a mixture of oak species (*Quercus nigra, Q, laurifolia, Q. michauxii,* and *Q. lyrata*) as well as red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), and other hardwood species. Low-lying areas that are continuously flooded are dominated by second-growth bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*).

Table 3.3-5. 1998 Radioactive atmospheric releases by source.[a]

	Curies[b]						
Radionuclide	Reactors	Separations[c]	Reactor materials	Heavy water	SRTC[d]	Diffuse and fugitive[e]	Total
			Gases and vapors				
H-3(oxide)	2.28×10^{4}	3.45×10^{4}		4.04×10^{2}		9.31×10^{2}	5.86×10^{4}
H-3(elem.)		2.41×10^{4}					2.41×10^{4}
H-3 Total	2.28×10^{4}	5.86×10^{4}		4.04×10^{2}		9.31×10^{2}	8.27×10^{4}
C-14		7.01×10^{-2}				9.68×10^{-5}	7.02×10^{-2}
Kr-85		1.70×10^{4}					1.70×10^{4}
Xe-135		4.95×10^{-2}					4.95×10^{-2}
I-129		1.25×10^{-2}				1.29×10^{-5}	1.25×10^{-2}
I-131		5.92×10^{-5}			8.29×10^{-6}		6.75×10^{-5}
I-133					1.59×10^{-4}		1.59×10^{-4}
			Particulates				
Na-22						7.76×10^{-11}	7.76×10^{-11}
Cr-51						1.21×10^{-4}	1.21×10^{-4}
Fe-55						3.90×10^{-4}	3.90×10^{-4}
Co-57						9.40×10^{-11}	9.40×10^{-11}
Co-58						1.27×10^{-4}	1.27×10^{-4}
Co-60					2.65×10^{-7}	1.38×10^{-4}	1.38×10^{-4}
Ni-59						8.33×10^{-13}	8.33×10^{-13}
Ni-63						8.21×10^{-6}	8.21×10^{-6}
Zn-65						2.23×10^{-5}	2.23×10^{-5}
Se-79						1.85×10^{-11}	1.85×10^{-11}
Sr-89,90[F,6]	1.62×10^{-3}	3.22×10^{-4}	5.50×10^{-4}	2.61×10^{-4}	2.66×10^{-5}	2.58×10^{-2}	2.85×10^{-2}
Zr-95						1.71×10^{-5}	1.71×10^{-5}
Nb-95						1.13×10^{-4}	1.13×10^{-4}
Tc-99						2.82×10^{-5}	2.82×10^{-5}
Ru-103						2.26×10^{-5}	2.26×10^{-5}
Ru-106		1.80×10^{-5}				2.26×10^{-5}	3.34×10^{-5}
Sn-126						1.29×10^{-13}	1.29×10^{-13}
Sb-125		1.79×10^{-7}				5.27×10^{-5}	5.29×10^{-5}
Cs-134		2.32×10^{-7}				1.31×10^{-4}	1.31×10^{-4}
Cs-137	3.50×10^{-5}	3.77×10^{-4}			2.30×10^{-6}	4.89×10^{-3}	5.30×10^{-3}
Ce-141						4.16×10^{-5}	4.16×10^{-5}
Ce-144						1.45×10^{-4}	1.45×10^{-4}
Pm-147						9.79×10^{-10}	9.79×10^{-10}
Eu-152						4.19×10^{-8}	4.19×10^{-8}
Eu-154						5.74×10^{-6}	5.74×10^{-6}

Table 3.3-5. (Continued).

Radionuclide	Reactors	Separations[c]	Reactor materials	Heavy water	SRTC[d]	Diffuse and fugitive[e]	Total
Eu-155						1.10×10^{-6}	1.10×10^{-6}
Ra-226						8.64×10^{-6}	8.64×10^{-6}
Ra-228						2.13×10^{-5}	2.13×10^{-5}
Th-228						9.44×10^{-6}	9.44×10^{-6}
Th-230						1.02×10^{-5}	1.02×10^{-5}
Th-232						7.51×10^{-7}	7.51×10^{-7}
Pa-231						1.00×10^{-9}	1.00×10^{-9}
U-232			1.20×10^{-6}				1.20×10^{-6}
U-233						2.35×10^{-6}	2.35×10^{-6}
U-234		2.62×10^{-5}	3.39×10^{-5}			1.83×10^{-5}	7.84×10^{-5}
U-235		1.57×10^{-6}	6.21×10^{-6}			2.10×10^{-6}	9.88×10^{-6}
U-236						2.39×10^{-9}	2.39×10^{-9}
U-238		6.92×10^{-5}	6.32×10^{-5}			5.12×10^{-5}	1.84×10^{-4}
Np-237						1.01×10^{-9}	1.01×10^{-9}
Pu-238		1.15×10^{-4}	4.76×10^{-8}			3.28×10^{-4}	4.43×10^{-4}
Pu-239[h]	2.19×10^{-4}	1.12×10^{-4}	5.09×10^{-5}	2.98×10^{-5}	6.71×10^{-6}	1.41×10^{-3}	1.83×10^{-3}
Pu-240						1.12×10^{-6}	1.12×10^{-6}
Pu-241						6.02×10^{-5}	6.02×10^{-5}
Pu-242						1.59×10^{-7}	1.59×10^{-7}
Am-241		3.31×10^{-5}	2.17×10^{-8}			5.75×10^{-6}	3.89×10^{-5}
Am-243						1.89×10^{-5}	1.89×10^{-5}
Cm-242						1.58×10^{-7}	1.58×10^{-7}
Cm-244		3.67×10^{-6}	4.90×10^{-9}			1.30×10^{-4}	1.34×10^{-4}
Cm-245						2.08×10^{-13}	2.08×10^{-13}
Cm-246						9.37×10^{-7}	9.37×10^{-7}
Cf-249						5.27×10^{-16}	5.27×10^{-16}
Cf-251						2.17×10^{-14}	2.17×10^{-14}

Note: Blank spaces indicate no quantifiable activity.

a. Source: Arnett and Mamatey (1999b).
b. One curie equals 3.7×10^{10} Becquerels.
c. Includes separations, waste management, and tritium facilities.
d. Savannah River Technology Center.
e. Estimated releases from minor unmonitored diffuse and fugitive sources.
f. Includes unidentified beta emissions.
g. Includes SR-89.
h. Includes unidentified alpha emissions.

The aquatic resources of SRS have been the subject of intensive study for more than 30 years. Research has focused on the flora and fauna of the Savannah River, the tributaries of the river that drain SRS, and the artificial impoundments (Par Pond and L-Lake) on two of the tributary systems. Several monographs (Britton and Fuller 1979; Bennett and McFarlane 1983), the eight-volume comprehensive cooling water study (du Pont 1987), and a number of EISs (DOE 1987, 1990, 1997a) describe the aquatic biota (fish and macroinvertebrates) and aquatic systems of SRS. The *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a) review ecological research and monitoring studies conducted in SRS streams and impoundments over several decades.

The Savannah River site was designated as the first National Environmental Research Park (NERP) by the Atomic Energy Commission in 1972. Especially significant components of the NERP are DOE Research Set-Aside Areas, representative habitats that DOE has preserved for ecological research and that are protected from public intrusion and most site-related activities. Set-Aside Areas protect major plant communities and habitats indigenous to the SRS, preserve habitats for endangered species, and also serve as controls against which to measure potential environmental impacts of SRS operations. These ecological Set-Aside Areas total 14,005 acres, approximately 7 percent of the Site's total area. Descriptions of the 30 tracts that have been set aside to date can be found in Davis and Janacek (1997).

Under the Endangered Species Act of 1973, the Federal government provides protection to six species that occur on the SRS: American alligator (*Alligator mississippiensis*; threatened due to similarity of appearance to the endangered American crocodile), shortnose sturgeon (*Acipenser brevirostrum*; endangered), bald eagle (*Haliaeetus leucocephalus*; threatened), wood stork (*Mycteria americana*; endangered), red-cockaded woodpecker (*Picoides borealis*; endangered), and smooth purple coneflower (*Echinacea laevigata*; endangered) (SRFS 1994; Halverson et al. 1997). None of these species is known to occur on or near the F- and H-Area Tank Farms, which are intensively developed industrial areas surrounded by roads, parking lots, construction shops, and construction lay-down areas and are continually exposed to high levels of human disturbance.

3.4.2 ECOLOGICAL COMMUNITIES POTENTIALLY AFFECTED BY TANK FARM CLOSURE ACTIVITIES

<u>F- and H-Area Biota</u>

The F- and H-Area Tank Farms are located within a densely developed, industrialized area of SRS. The immediate area provides habitat for only those animal species typically classified as urban wildlife (Mayer and Wike 1997). Species commonly encountered in this type of urban landscape include the Southern toad, green anole, rat snake, rock dove, European starling, house mouse, opossum, and feral cats and dogs (Mayer and Wike 1997). Lawns and landscaped areas within F- and H-Area also provide some marginal terrestrial wildlife habitat. A number of ground-foraging bird species (e.g., American robin, killdeer, and mourning dove) and small mammals (e.g., cotton mouse, cotton rat, and Eastern cottontail) that use lawns and landscaped areas around buildings may be present at certain times of the year, depending on the level of human activity (e.g., frequency of mowing) (Mayer and Wike 1997). Pine plantations managed for timber production by the U.S. Forest Service (under an interagency agreement with DOE) occupy surrounding areas (DOE 1994).

Wildlife characteristically found in SRS pine plantations include toads (i.e., the southern toad), lizards (e.g., the eastern fence lizard), snakes (e.g., the black racer), songbirds (e.g., the brown-headed nuthatch, and the pine warbler), birds of prey (e.g., the sharp-shinned hawk), and a number of mammal species (e.g., the cotton mouse), the gray squirrel, the opossum, and the white-tailed deer) (Sprunt and Chamberlain 1970; Cothran et al. 1991; Gibbons and Semlitsch 1991; Halverson et al. 1997).

Several populations of rare plants have been found in undeveloped areas adjacent to F- and H-Areas. One population of Nestronia *(Nestronia umbellula)* and three populations of Oconee azalea (*Rhododendron flammeum*) were located on the steep slopes adjacent to the Upper Three Runs floodplain approximately one mile north of the F-Area Tank Farm (DOE 1995: SRFS 1999). Populations of two additional rare plants, Elliott's croton (*Croton elliotti*) and spathulate seedbox (*Ludwigia spathulata*) were found in the pine forest southeast of H-Area, approximately one-half mile from the H-Area Tank Farm (SRFS 1999).

Seeplines and Associated Riparian Communities

As mentioned in Section 3.2, F- and H-Areas are on a near-surface groundwater divide, and groundwater from these areas discharges at seeplines adjacent to Upper Three Runs and Fourmile Branch. The biota associated with the seepage areas are discussed in the following paragraphs.

The Fourmile Branch seepline area is located in a bottomland hardwood forest community (DOE 1997b). The canopy layer of this bottomland forest is dominated by sweetgum (*Liquidambar styraciflua)*, red maple (*Acer rubrum*), and red bay (*Persea borbonia*). Sweet bay (*Magnolia virginiana)* is also common. The understory consists largely of saplings of these same species, as well as a herbaceous layer of greenbrier (*Smilax* sp), dog hobble (*Leucothoe axillaris*), giant cane (*Arundinaria gigantea*), poison ivy (*Rhus radicans*), chain fern (*Woodwardia virginica*), and hepatica (*Hepatica americana*). At the seepline's upland edge, scattered American holly and white oak occur. Upslope of the seepline area is an upland pine/hardwood forest. Tag alder (*Alnus serrulata*), willow (*Salix nigra)*, sweetgum, and wax myrtle (*Myrica cerifera)* are found along the margins of the Fourmile Branch in this area. The Upper Three Runs seepline is located in a similar bottom land hardwood forest community (DOE 1997b).

The floodplains of both streams in the general vicinity of the seeplines provide habitat for a variety of aquatic, semi-aquatic, and terrestrial animals including amphibians (e.g., leopard frogs), reptiles (e.g., box turtles), songbirds (e.g., wood warblers), birds of prey (e.g., barred owls), semi-aquatic mammals (e.g., beaver), and terrestrial mammals (white-tailed deer). For detailed lists of species known or expected to occur in the riparian forests and wetlands of SRS, see Gibbons et al. (1986), duPont (1987), Cothran et al. (1991), DOE (1997a), and Halverson et al. (1997).

No endangered or threatened fish or wildlife species have been recorded near the Upper Three Runs and Fourmile Branch seeplines. The seeplines and associated bottomland community do not provide habitat favored by endangered or threatened fish and wildlife species known to occur at SRS. The American alligator is the only Federally-protected species that could potentially occur in the area of the seeplines. Fourmile Branch does support a small population of American alligator in its lower reaches, where the stream enters the Savannah River swamp (Halverson et al. 1997). Alligators have been infrequently observed in man-made waterbodies (e.g., stormwater retention basins) in the vicinity of H-Area (Mayer and Wike 1997).

Aquatic Communities Downstream of F- and H-Areas

Upper Three Runs

According to summaries of studies on Upper Three Runs documented in the *SRS Ecology Environmental Information Document* (Halverson et al. 1997), the macroinvertebrate communities of Upper Three Runs are characterized by unusually high measures of taxa richness and diversity. Upper Three Runs is a spring-fed stream and is colder and generally clearer than most streams in the upper Coastal Plain. As a result, species normally found in the Northern U.S. and southern Appalachians are found here along with endemic lowland (Atlantic Coastal Plain) species (Halverson et al. 1997).

A study conducted from 1976 to 1977 identified 551 species of aquatic insects within this stream system, including a number of species and genera new to science (Halverson et al. 1997). A 1993 study found more than 650 species in Upper Three Runs, including more than 100 caddisfly species. Although no threatened or endangered species have been found in Upper Three Runs, there are several environmentally sensitive species. Davis and Mulvey (Halverson et al. 1997) identified a rare clam species (*Elliptio hepatica*) in this drainage. Also, in 1997 the U.S. Fish and Wildlife Service listed the American sand-burrowing mayfly (*Dolania americana*), a mayfly relatively common in Upper Three Runs, as a species of special concern. Between 1987 and 1991, the density and variety of insects collected from Upper Three Runs decreased for unknown reasons. More recent data, however, indicate that insect communities are recovering (Halverson et al. 1997).

The fish community of Upper Three Runs is typical of third- and higher-order streams on SRS that have not been greatly affected by industrial operations, with shiners and sunfish dominating collections. The smaller tributaries to Upper Three Runs are dominated by shiners and other small-bodied species (i.e., pirate perch, madtoms, and darters) indicative of unimpacted streams in the Atlantic Coastal Plain (Halverson et al. 1997). In the 1970s, the U.S. Geological Service designated Upper Three Runs as a National Hydrological Benchmark Stream due to its high water quality and rich fauna. However, this designation was rescinded in 1992 due to increased development of the Upper Three Runs watershed north of the SRS (Halverson et al. 1997).

Fourmile Branch

Until C-Reactor was shut down in 1985, the distribution and abundance of aquatic biota in Fourmile Branch were strongly influenced by reactor operations (high water temperatures and flows downstream of the reactor discharge). Following the shutdown of C-Reactor, macroinvertebrate communities began to recover, and in some reaches of the stream began to resemble those in nonthermal and unimpacted streams of the SRS (Halverson et al. 1997). Surveys of macroinvertebrates in more recent years showed that some reaches of Fourmile Branch had healthy macroinvertebrate communities (high measures of taxa richness) while others had depauperate macroinvertebrate communities (low measures of diversity or communities dominated by pollution-tolerant forms). Differences appeared to be related to variations in dissolved oxygen levels in different portions of the stream. In general, macroinvertebrate communities of Fourmile Branch show more diversity (taxa richness) in downstream reaches than upstream reaches (Halverson et al. 1997).

Studies of fish populations in Fourmile Branch conducted in the 1980s, when C-Reactor was operating, revealed that very few fish were present downstream of the reactor outfall (Halverson et al. 1997). Water temperatures exceeded 140°F at the point where the discharge entered Fourmile Branch and were as high as 100°F where the stream flowed into the Savannah River Swamp, approximately 10 miles downstream. Following the shutdown of C-Reactor in 1985, Fourmile Branch was rapidly recolonized by fish from the Savannah River swamp system. Centrarchids (sunfish) and cyprinids (minnows) were the most common taxa.

To assess potential impacts of groundwater outcropping to Fourmile Branch, WSRC in 1990 surveyed fish populations in Fourmile Branch up- and downstream of F- and H-Area seepage basins (Halverson et al. 1997). Upstream stations were dominated by pirate perch, creek chubsucker, yellow bullhead, and several sunfish species (redbreast sunfish, dollar sunfish, spotted sunfish). Downstream stations were dominated by shiners (yellowfin shiner, dusky shiner, and taillight shiner) and sunfish (redbreast sunfish and spotted sunfish), with pirate perch and creek chubsucker present but in lower numbers. Differences in species composition were believed to be due to habitat differences rather than the effect of contaminants in groundwater.

Savannah River

An extensive information base is available regarding the aquatic ecology of the Savannah River in the vicinity of SRS. The most recent water quality data available from environmental monitoring conducted on the river in the vicinity of SRS and its downstream reaches can be found in *Savannah River Site Environmental Data for 1998* (Arnett and Mamatey 1999b). These data demonstrate that the Savannah River is not adversely impacted by SRS wastewater discharges to its tributary streams. A full description of the ecology of the Savannah River in the vicinity of SRS can be found in the *SRS Ecology Environmental Information Document* (Halverson et al. 1997), the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a), and the EIS for *Accelerator Production of Tritium at the Savannah River Site* (DOE 1997c).

3.5 Land Use

The SRS is in south central South Carolina (Figure 3.1-1) approximately 100 miles from the Atlantic Coast. The major physical feature at SRS is the Savannah River, about 20 miles of which serve as the southwestern boundary of the Site and the South Carolina-Georgia border. The SRS includes portions of Aiken, Barnwell, and Allendale counties in South Carolina.

The SRS occupies an almost circular area of approximately 300 square miles or 192,000 acres and contains production, service, and research and development areas (Figure 3.2-1). The production facilities occupy less than 10 percent of the SRS; the remainder of the site is undeveloped forest or wetlands (DOE 1997).

The site is a significant large-scale facility available for wildlife management and research activities. SRS is a desirable location for landscape scale studies and externally funded studies conducted as a part of DOE's National Environmental Research Park. Public use of the site's natural resources is presently limited to controlled hunts and to various science literacy programs encompassing elementary through graduate school levels.

The F- and H-Areas, of which the tank farms are a part, are in the north-central portion of the SRS, bounded by Upper Three Runs to the north and Fourmile Branch to the South. The F-Area occupies about 364 acres while the H-Area occupies 395 acres (DOE 1997). Land within a 5-mile radius of these areas lies entirely within the SRS boundaries and is used for either industrial purposes or as forested land (DOE 1997).

Figures 3.5-1 and 3.5-2 are aerial photographs of the tank farm areas and give an indication of the industrial character of each location.

In March of 1998, the *Savannah River Future Use Plan* was formally issued. It was developed in partnership with all major site contractors, support agencies, and Headquarters counterparts with the input of stakeholders, and defines the future use for the site. The plan states as policy the following important points: (1) SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government, consistent with the site's designation as a National Environmental Research Park; (2) residential uses of all SRS land shall be prohibited; and (3) an Integral Site Model that incorporates three planning zones (industrial, industrial support, and restricted public uses) will be utilized. The land around the F- and H-Areas (i.e., between Upper Three Runs and Fourmile Branch) will be considered in the industrial use category (DOE 1998). Consequently, DOE's plan is to continue active institutional control for those areas as long as necessary to protect the public and the environment (DOE 1998). For purposes of analysis, however, DOE assumes institutional control for the next 100 years. After that, the area would be zoned as industrial for an indefinite period with deed restrictions on the use of groundwater. This was the basis for the analysis in the *Industrial Wastewater Closure Plan for F- and H- Area High-Level Waste Tank Systems* (DOE 1997).

3.6 Socioeconomics and Environmental Justice

This section describes the economic and demographic baseline for the area around SRS. The purpose of this information is to assist in understanding the potential impacts HLW tank closure could have on population and employment income and to identify any potential disproportionately high and adverse impacts the actions could have on minority and low-income populations.

NW TANK/Grfx/3.5-1 F_Tank.ai

Figure 3.5-1. F-Area Tank Farm (view toward the north, with 21 of the 22 F-Area liquid high-level waste tanks).

NW TANK/Grfx/3.5-2 H Tank.ai

Figure 3.5-2. H-Area Tank Farm (view toward the south, with 11 of the 29 H-Area liquid high-level waste tanks).

3.6.1 SOCIOECONOMICS

The socioeconomic region of influence for the proposed action is a six-county area around the SRS where the majority of Site workers reside and where socioeconomic impacts are most likely to occur. The six counties are Aiken, Allendale, Barnwell, and Bamberg in South Carolina, and Columbia and Richmond in Georgia. *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site* (HNUS 1997) contains details on the region of influence, as well as most of the information discussed in this section. The study includes full discussions of regional fiscal conditions, housing, community services and infrastructure, social services and institutions, and educational services. This section will, however, focus on population and employment estimates that have been updated to reflect the most recently available data.

Population

Based on state and Federal agency surveys and trends, the estimated 1998 population that live in the region of influence was 466,222. About 90 percent lived in the following counties: Aiken (29 percent), Columbia (20 percent), and Richmond (41 percent). The population in the region grew at an annual growth rate of about 6.5 percent between 1990 and 1998 (Bureau of the Census 1999). Columbia County, and to a lesser extent Aiken County, contributed to most of the growth due to inmigration from other region of influence counties and states. Over the same period Bamberg and Barnwell counties experienced net outmigration.

Population projections indicate that the overall population in the region should continue to grow less than 1 percent until about 2040, except Columbia County, which could experience 2 percent to 3 percent annual growth. Table 3.6-1 presents projections by county through 2040.

Based on the most recent information available (1992), the estimated median age of the population in the region was 31.8 years, somewhat higher than 1980, when the estimated median age was 28. Median ages in the region are generally lower than those of the nation and the two states. The region had slightly higher percentages of persons in younger age groups (under 5 and 5 to 19) than the U.S., while for all other age groups, the region was comparable to U.S. percentages. The only exception to this was Columbia County, with only 6 percent of its population 65 years or older while the other counties and the U.S. were 10 percent or greater in this age group. The proportion of persons younger than 20 is expected to decrease, while the proportion of persons older than 64 is expected to increase (DOE 1997).

Employment

In 1994, the latest year consistently developed information is available for all counties in the region of influence, the total civilian labor force for the region of influence was 206,518, with 6.9 percent unemployment. The unemployment rate for the U.S. for the same period was 6.1 percent. For the Augusta-Aiken Metropolitan Statistical Area which does not exactly coincide with the counties in the region of influence, the 1996 labor force totaled 202,400 with an unemployment rate of 6.7 percent. The most recent unemployment rate for the Augusta-Aiken Metropolitan Statistical Area issued for February 1999 was 5.0 percent.

In 1994, total employment according to Standard Industrial Code sectors ranged from 479 workers in the mining sector (e.g., clay and gravel pits) to 58,415 workers in the services sector (e.g., health care and education). Average per capita personal income in 1993 (adjusted to 1995 dollars) was $18,867, in comparison to the U.S. figure of $21,937.

Based on a detailed workforce survey completed in the fall of 1995, the SRS had 16,625 workers (including contractors, permanent and temporary workers, and persons affiliated with Federal agencies and universities who work on the Site) with a total payroll of slightly over $634 million. In September 1997, DOE had reduced the total workforce to 15,112 (DOE 1998).

Table 3.6-1. Population projections and percent of region of influence.[a]

	2000		2010		2020	
Jurisdiction	Population	% ROI	Population	% ROI	Population	% ROI
South Carolina						
Aiken County	135,126	28.7	143,774	27.9	152,975	26.9
Allendale County	11,255	2.4	11,514	2.2	11,778	2.1
Bamberg County	16,366	3.5	17,528	3.4	18,773	3.3
Barnwell County	21,897	4.6	23,517	4.6	25,257	4.5
Georgia						
Columbia County	97,608	20.7	120,448	23.3	148,633	26.9
Richmond County	189,040	40.1	199,059	38.6	209,609	37.0
Six-county total	471,292	100	515,840	100	567,025	100

	2030		2040	
Jurisdiction	Population	% ROI	Population	% ROI
South Carolina				
Aiken County	162,766	26.0	173,182	24.9
Allendale County	12,049	1.9	12,326	1.8
Bamberg County	20,106	3.2	21,533	3.1
Barnwell County	27,126	4.5	29,134	4.2
Georgia				
Columbia County	184,413	29.4	226,332	32.6
Richmond County	220,718	35.2	232,417	33.4
Six-county total	627,178	100	694,924	100

a. Source: Scaled from HNUS (1997) and Bureau of the Census (1999).
ROI = region of influence.

3.6.2 ENVIRONMENTAL JUSTICE

DOE completed an analysis of the economic and racial characteristics of the population in areas affected by SRS operations for the *Interim Management of Nuclear Materials Environmental Impact Statement* (DOE 1995). That EIS evaluated whether minority communities or low-income communities could receive disproportionately high and adverse human health and environmental impacts from the alternatives included in that EIS. Geographically, it examined the population within a 50-mile radius of the SRS plus areas downstream of the Site that withdraw drinking water from the Savannah River. The area encompasses a total of 147 census tracts, resulting in a total potentially affected population of 993,667. Of that population, 618,000 (62 percent) are white. In the minority population, approximately 94 percent are African American; the remainder consists of small percentages of Asian, Hispanic, and Native American persons (see Table 3.6-2).

It should be noted that the Interim Management of Nuclear Materials EIS used data on minority and low-income populations from the 1990 census. Although the Bureau of Census publishes county- and state-level population estimates and projections in odd (inter-census) years, census-tract-level statistics on minority and low-income populations are only collected for decennnial censuses. Updated census tract information is expected to be published by the Bureau of Census in 2001.

The analysis determined that, of the 147 census tracts in the combined region, 80 contain populations of 50 percent or more minorities. An additional 50 tracts contain between 35 and 50 percent minorities. These tracts are well dis-

Table 3.6-2. General racial characteristics of population in the Savannah River Site region of influence.[a]

State	Total population	Total White	Total Minority	African American	Hispanic	Asian	Native American	Other	Percent minorities
South Carolina ROI	418,685	267,639	151,046	144,147	3,899	1,734	911	355	36.1%
Georgia ROI	574,982	350,233	224,749	208,017	7,245	7,463	1,546	478	39.1%
Total	993,667	617,872	375,795	352,164	11,144	9,197	2,457	833	37.8%

a. Source: DOE (1995).
ROI = region of influence.

tributed throughout the region, although there are more toward the south and in the immediate vicinities of Augusta and Savannah (see Figure 3.6-1).

Low-income communities [25 percent or more of the population living in poverty (i.e., income of $8,076 for a family of two)] occur in 72 census tracts distributed throughout the region of influence but primarily to the south and west of SRS (see Figure 3.6-2.). This represents more than 169,000 persons or about 17 percent of the total population (see Table 3.6-3).

3.7 Cultural Resources

Through a cooperative agreement, DOE and the South Carolina Institute of Archaeology and Anthropology of the University of South Carolina conduct the Savannah River Archaeological Research Program to provide the services required by Federal law for the protection and management of archaeological resources. Ongoing research programs work in conjunction with the South Carolina State Historic Preservation Office. They provide theoretical, methodological, and empirical bases for assessing site significance using the compliance process specified by law. Archaeological investigations usually begin through the Site Use Program, which requires a permit for clearing land on SRS.

The archaeological research has provided considerable information about the distribution and content of archaeological and historic sites on SRS. Savannah River archaeologists have examined SRS land since 1974. To date they have examined 60 percent of the 300-square-mile area and recorded more than 1,200 archaeological sites (HNUS 1997). Most (approximately 75 percent) of these sites are prehistoric. To facilitate the management of these resources, SRS is divided into three archaeological zones based upon an area's potential for containing sites of historical or archaeological significance (DOE 1995). Zone 1 represents areas with the greatest potential for having significant resources; Zone 2 areas possess sites with moderate potential; Zone 3 has areas of low archaeological significance.

Studies of F- and H-Areas in a previous EIS (DOE 1994) noted that activities associated with the construction of F- and H-Areas during the 1950s could have destroyed historic and archaeological resources present in this area. As mentioned in Chapter 2, F- and H-Areas are heavily industrialized sites. They are surrounded by Zone 2 and Zone 3 lands outside of the facilities' secure parameters.

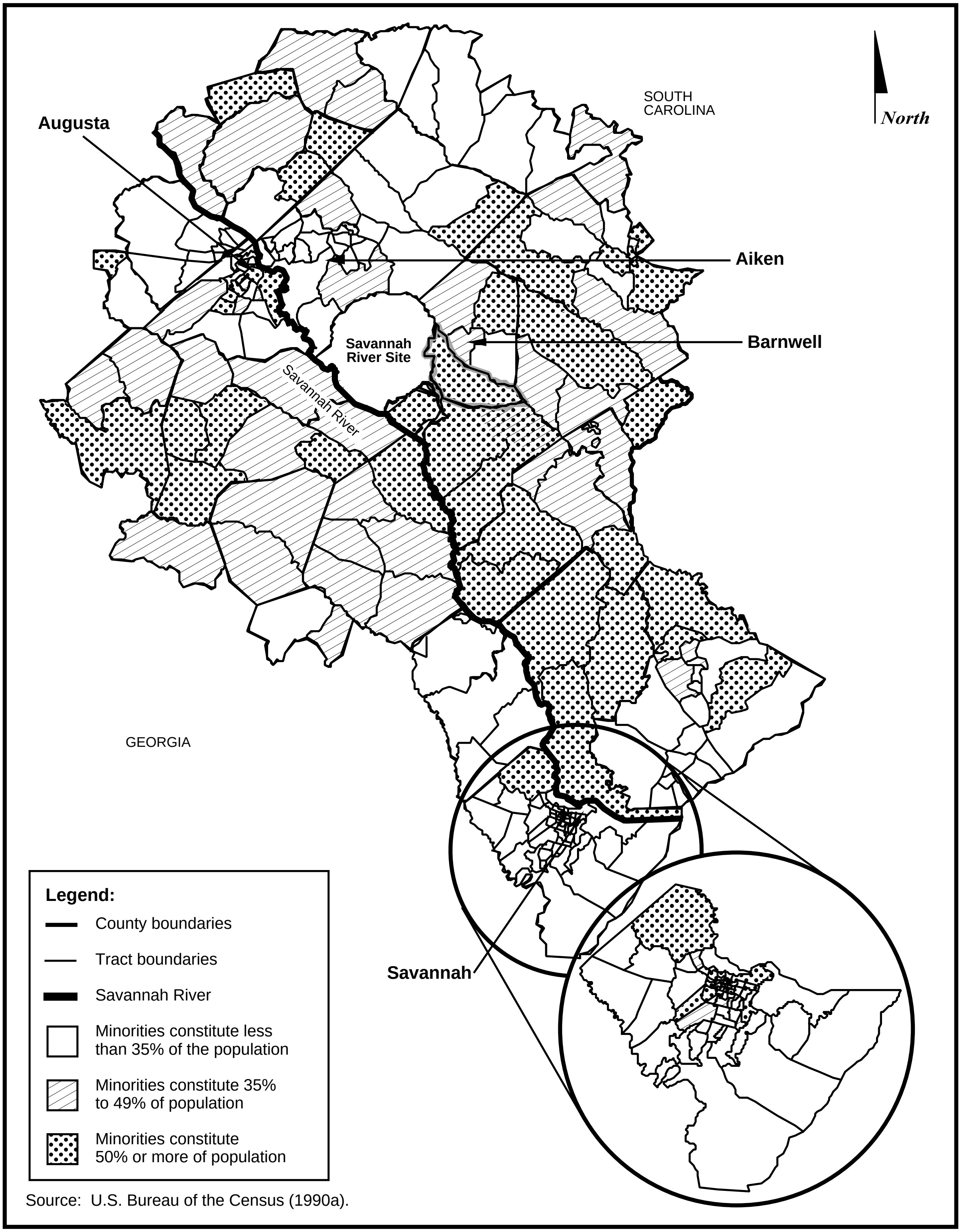
3.8 Public and Worker Health

3.8.1 PUBLIC RADIOLOGICAL HEALTH

Because there are many sources of radiation in the human environment, evaluations of radioactive releases from nuclear facilities must consider all ionizing radiation to which people are routinely exposed.

Doses of radiation are expressed as millirem, rem (1,000 millirem), and person-rem (sum of dose to all individual in population).

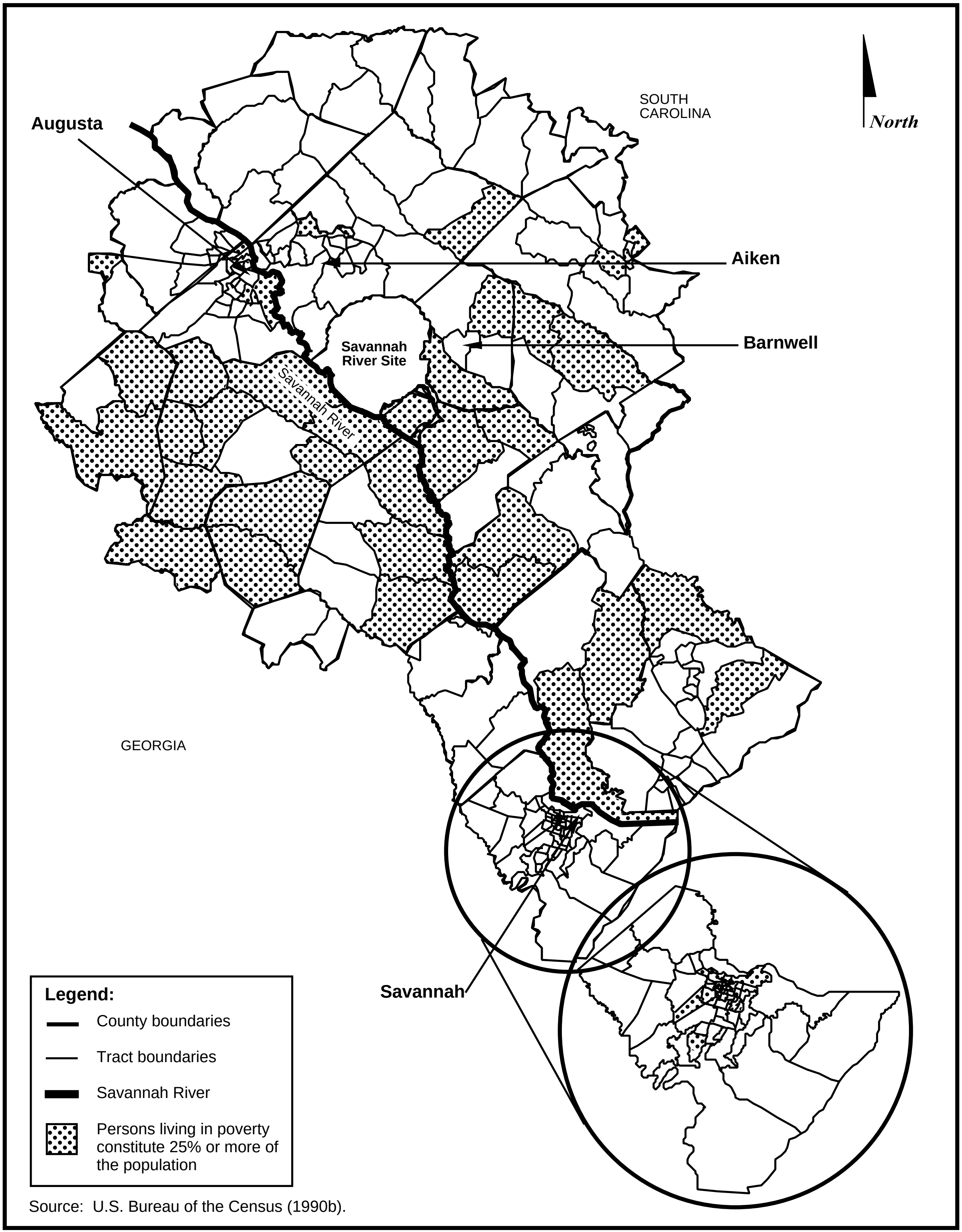
An individual's radiation exposure in the vicinity of SRS amounts to approximately



Source: U.S. Bureau of the Census (1990a).

NW TANK/Grfx/F3-6-1 Pop.ai

Figure 3.6-1. Distribution of minority population by census tracts in the SRS region of analysis.



Source: U.S. Bureau of the Census (1990b).

NW Tank/Grfx/3-6-2 Income.ai

Figure 3.6-2. Low income census tracts in the SRS region of analysis.

Table 3.6-3. General poverty characteristics of population in the Savannah River Site region of interest.

Area	Total population	Persons living in poverty[a]	Percent living in poverty
South Carolina	418,685	72,345	17.3%
Georgia	574,982	96,672	16.8%
Total	993,667	169,017	17.0%

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a. Families with income less than the statistical poverty threshold, which in 1990 was 1989 income of $8,076 for a family of two [U.S Bureau of the Census (1990b)].

357 millirem per year, which is comprised of natural background radiation from cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; weapons test fallout; consumer and industrial products, and nuclear facilities. Figure 3.8-1 shows the relative contribution of each of these sources to the dose an individual living near SRS would receive. All radiation doses mentioned in this EIS are effective dose equivalents. Effective dose equivalents include the dose from internal deposition of radionuclides and the dose attributable to sources external to the body.

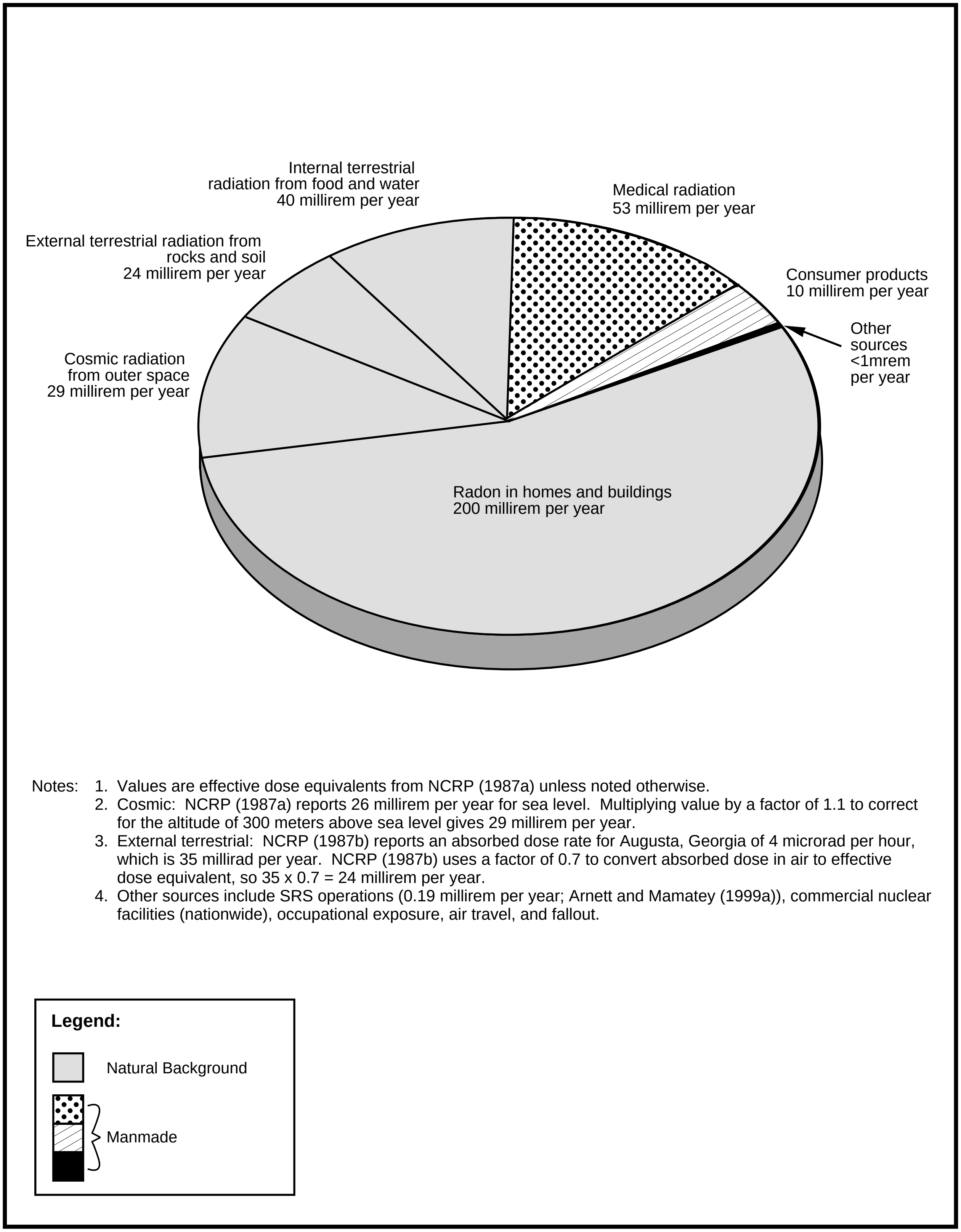
Releases of radioactivity to the environment from SRS account for less than 0.1 percent of the total annual average environmental radiation dose to individuals within 50 miles of the Site. Natural background radiation contributes about 293 millirem per year, or 82 percent of the annual dose of 357 millirem received by an average member of the population within 50 miles of the Site. Based on national averages, medical exposure accounts for an additional 15 percent of the annual dose, and combined doses from weapons test fallout, consumer and industrial products, and air travel account for about 3 percent (NCRP 1987a).

Other nuclear facilities within 50 miles of SRS include a low-level waste disposal site operated by Chem-Nuclear Systems, Inc., near the eastern Site boundary and Georgia Power Company's Vogtle Electric Generating Plant, directly across the Savannah River from SRS. In addition, Starmet CMI (formerly Carolina Metals), Inc., which is northwest of Boiling Springs in Barnwell County, processes depleted uranium.

The *South Carolina Department of Health and Environmental Control Annual Report* (SCDHEC 1995) indicates that the Chem-Nuclear and Starmet CMI facilities do not influence radioactivity levels in the air, precipitation, groundwater, soil, or vegetation. Plant Vogtle began commercial operation in 1987: 1992 re leases produced an annual dose of 0.054 millirem to the maximally exposed individual at the plant boundary and a total population dose within a 50-mile radius of 0.045 person-rem (NRC 1996).

In 1997, releases of radioactive material to the environment from SRS operations resulted in a maximum individual dose of 0.07 millirem in the west-southwest sector of the Site boundary from atmospheric releases, and a maximum dose from liquid releases of 0.12 millirem for a maximum total annual dose at the boundary of 0.19 millirem. The maximum dose to downstream consumers of Savannah River water – 0.05 millirem – occurred to users of the Port Wentworth and the Beaufort-Jasper public water supplies (Arnett and Mamatey 1999a).

In 1990 the population within 50 miles of the Site was approximately 620,100. The collective effective dose equivalent to that population in 1998 was 3.5 person-rem from atmospheric releases. The 1998 population of 10,000 people using water from the Cherokee Hill Water Treatment Plant near Port Wentworth, Georgia, and 60,000 people using water from the Beaufort-Jasper Water Treatment Plant near Beaufort, South Carolina, received a collective dose equivalent of 1.8 person-rem in 1998 (Arnett and Mamatey 1999a). Population statistics indicate that cancer caused 23.2 percent of the



Notes:
1. Values are effective dose equivalents from NCRP (1987a) unless noted otherwise.
2. Cosmic: NCRP (1987a) reports 26 millirem per year for sea level. Multiplying value by a factor of 1.1 to correct for the altitude of 300 meters above sea level gives 29 millirem per year.
3. External terrestrial: NCRP (1987b) reports an absorbed dose rate for Augusta, Georgia of 4 microrad per hour, which is 35 millirad per year. NCRP (1987b) uses a factor of 0.7 to convert absorbed dose in air to effective dose equivalent, so 35 x 0.7 = 24 millirem per year.
4. Other sources include SRS operations (0.19 millirem per year; Arnett and Mamatey (1999a)), commercial nuclear facilities (nationwide), occupational exposure, air travel, and fallout.

NW TANK/Grfx/3.8-1 Radiation.ai

Figure 3.8-1. Major sources of radiation exposure in the vicinity of the Savannah River Site.

deaths in the United States in 1997 (CDC 1998). If this percentage of deaths from cancer continues, 23.2 percent of the U.S. population would contract a fatal cancer from all causes. Thus, in the population of 620,100 within 50 miles of SRS, 143,863 persons would be likely to contract fatal cancers from all causes. The total population dose from SRS of 5.3 person-rem (3.5 person-rem from atmospheric pathways plus 1.8 person-rem from water pathways) could result in 0.0027 additional latent cancer death in the same population [based on 0.0005 cancer death per person-rem (NCRP 1993)].

3.8.2 PUBLIC NONRADIOLOGICAL HEALTH

The hazards associated with the alternatives described in this EIS include exposure to nonradiological chemicals in the form of water and air pollution (see Sections 3.2 and 3.3). Table 3.3-2 lists ambient air quality standards and concentrations for selected pollutants. The purpose of these standards is to protect the public health and welfare. The concentrations of pollutants from SRS sources, listed in Table 3.3-3, are lower than the standards. Section 3.2 discusses water quality in the SRS vicinity.

3.8.3 WORKER RADIOLOGICAL HEALTH

One of the major goals of the SRS Health Protection Program is to keep worker exposures to radiation and radioactive material as low as reasonably achievable. Such a program must evaluate both external and internal exposures with the goal to minimize the total effective dose equivalent. An effective as low as reasonably achievable program to keep doses as low as reasonably achievable must also balance minimizing individual worker doses with minimizing the collective dose of workers in a group. For example, using many workers to perform small portions of a task would reduce the individual worker dose to low levels. However, frequent worker changes would make the work inefficient, resulting in a significantly higher collective dose to all the workers than if fewer had received slightly higher individual doses.

SRS worker doses have typically been well below DOE worker exposure limits. DOE set administrative exposure guidelines at a fraction of the exposure limits to help enforce doses that are as low as reasonably achievable. For example, the current DOE worker exposure limit is 5,000 millirem per year, and the 1998 SRS as low as reasonably achievable administrative control level for the whole body is 500 millirem per year. Every year DOE evaluates the SRS as low as reasonably achievable administrative control levels and adjusts them as needed.

Table 3.8-1 lists average individual doses and SRS collective doses from 1988 to 1998.

3.8.4 WORKER NONRADIOLOGICAL HEALTH

Industrial hygiene and occupational health programs at the SRS deal with all aspects of worker health and relationship of the worker to the work environment. The objective of an effective occupational health program is to protect employees from hazards in their work environment. To evaluate these hazards, DOE uses routine monitoring to determine employee exposure levels to hazardous chemicals.

Exposure limit values are the basis of most occupational health codes and standards. If an overexposure to a harmful agent does not exist, that agent generally does not create a health problem.

OSHA has established Permissible Exposure Limits to regulate worker exposure to hazardous chemicals. These limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could receive repeated exposures day after day without adverse health effects.

Table 3.8-2 lists OSHA-regulated workplace pollutants likely to be generated by HLW tank closure activities and the applicable OSHA limit.

Table 3.8-1. SRS annual individual and collective radiation doses.[a]

Year	Average individual worker dose (rem)[b]	Site worker collective dose (person-rem)
1988	0.070	864
1989	0.056	754
1990	0.056	661
1991	0.038	392
1992	0.049	316
1993	0.051	263
1994	0.022	311
1995	0.018	247
1996	0.019	237
1997	0.013	164
1998	0.015	163

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a. Sources: DuPont (1989), Petty (1993), WSRC (1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999).
b. The average dose includes only workers who received a measurable dose during the year.

Table 3.8-2. Potential occupational safety and health hazards and associated exposure limits.

Pollutant	OSHA PEL[a] (mg/m^3)	Time period
Carbon monoxide	55	8 hours
Oxides of nitrogen	9	Ceiling limit
Total particulates	15	8 hours
Particulate matter (<10 microns)	150 50	24 hours Annual
Oxides of sulfur	13	8 hours

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a. PEL = Permissible Exposure Limits. The OSHA PEL listed in Table Z-1-A or Z-2 of the OSHA General Industry Air Contaminants Standard (29 CFR 1910.1000) provided if appropriate. These limits, unless otherwise noted (e.g., ceiling), must not be exceeded during any 8-hour work shift of a 40-hour work week.

A well-defined worker protection program is in place at the SRS to protect the occupational health of DOE and contractor employees. To prevent occupational illnesses and injuries and to preserve the health of the SRS workforce, contractors involved in the construction and operations programs have implemented DOE-approved health and safety programs. Tables 3.8-3 and 3.8-4 indicated that these health and safety programs have resulted in lower incidences of injury and illness than those that occur in the general industry construction and manufacturing workforces.

3.9 Waste and Materials

3.9.1 WASTE MANAGEMENT

This section describes the waste generation baseline that DOE uses in Chapter 4 to gauge the relative impact of each tank closure alternative on the overall waste generation at SRS and on DOE's capability to manage such waste. In 1995 DOE prepared an EIS on the management of wastes projected to be generated by SRS for the next 40 years (DOE 1995).

Table 3.8-3. Comparison of 1997 rates for SRS construction to general industry construction.

Incident rate	SRS construction department[a]	Construction industry[b]
Total recordable cases	4.6	8.70
Total lost workday cases	2.3	4.09

a. Source: Hill (1999).
b. Source: Bureau of Labor Statistics (1998).

Table 3.8-4. Comparison of 1997 rates for SRS operations to private industry and manufacturing.

Incident rate	SRS operations[a]	Private industry[b]	Manufacturing[b]
Total recordable cases	1.08	6.05	10.30
Total lost workday cases	0.44	2.82	4.83

a. Source: Hill (1999).
b. Source: Bureau of Labor Statistics (1998).

DOE generates six basic types of waste – HLW, low-level radioactive, hazardous, mixed (low-level radioactive and hazardous), transuranic (including alpha-contaminated), and sanitary (nonhazardous, nonradioactive) – which this EIS considers because they are possible by products of the SRS tank closure activities. The following sections describe the waste types. Table 3.9-1 lists projected total waste generation volumes for fiscal years 1999 through 2029 (a time period that encompasses the expected duration of the tank closure activities addressed in this EIS). The assumptions and uncertainties applicable to SRS waste management plans and waste generation estimates are described in Halverson (1999). These estimates do not include wastes that would be generated as a result of closure of the SRS HLW tank systems.

Tables 3.9-2 through 3.9-4 provide an overview of the existing and planned facilities that DOE expects to use in the storage, treatment, and disposal of the various waste classes.

3.9.1.1 Low-Level Radioactive Waste

DOE (1999) defines low-level radioactive waste as radioactive waste that cannot be classified as HLW, spent nuclear fuel, transuranic waste, by-product material, or naturally occurring radioactive material.

At present, DOE uses a number of methods for treating and disposing of low-level waste at SRS, depending on the waste form and activity. Approximately 41 percent of this waste is low in radioactivity and can be treated at the Consolidated Incineration Facility. In addition, DOE could volume-reduce these wastes by compaction, supercompaction, smelting, or repackaging (DOE 1995). After volume reduction, DOE would package the remaining low-activity waste and place it in either shallow land disposal or vault disposal in E-Area.

DOE places low-level wastes of intermediate activity and some tritiated low-level wastes in E Area intermediate activity vaults and will store long-lived low-level waste (e.g., spent deionizer resins) in the long-lived waste storage buildings in E-Area, where they will remain until DOE determines their final disposition.

3.9.1.2 Mixed Low-Level Waste

Mixed low-level waste is radioactive waste that contains material that is listed as hazardous waste under RCRA or that exhibits one or more of the following hazardous waste characteristics: ignitability, corrosivity, reactivity, or toxicity. It includes such materials as tritiated mercury, tritiated oil contaminated with mercury, other mer-

Table 3.9-1. Total waste generation forecast for SRS (cubic meters).[a]

	Waste class				
Inclusive dates	Low-level	HLW	Hazardous	Mixed low-level	Transuranic and alpha
1999 to 2029	180,299	14,129	6,315	3,720	6,012

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a. Source: Halverson (1999).

cury-contaminated compounds, radioactively contaminated lead shielding, equipment from the tritium facilities in H-Area, and filter paper takeup rolls from the M-Area Liquid Effluent Treatment Facility.

As described in the *Approved Site Treatment Plan* (WSRC 1999a), storage facilities for mixed low-level waste are in several different SRS areas. These facilities are dedicated to solid, containerized, or bulk liquid waste and all are approved for this storage under RCRA as interim status or permitted facilities or as Clean Water Act-permitted tank systems. Several treatment processes described in WSRC (1999a) exist or are planned for mixed low-level waste. These facilities, which are listed in Table 3.9-3, include the Consolidated Incineration Facility, the M-Area Vendor Treatment Facility, and the Hazardous Waste/Mixed Waste Containment Building.

Depending on the nature of the waste residues remaining after treatment, DOE plans to use either shallow land disposal or RCRA-permitted hazardous waste/mixed waste vaults for disposal.

3.9.1.3 High-Level Waste

HLW is highly radioactive material, resulting from the reprocessing of spent nuclear fuel, that contains a combination of transuranic waste and fission products in concentrations that require permanent isolation. It includes both liquid waste produced by reprocessing and any solid waste derived from that liquid (DOE 1999).

At present, DOE stores HLW in carbon steel and reinforced concrete underground tanks in the F- and H-Area Tank Farms. The HLW in the tanks consists of three physical forms: sludge, saltcake, and liquid. The sludge is solid material that precipitates or settles to the bottom of a tank. The saltcake is comprised of salt compounds that have crystallized as a result of concentrating the liquid by evaporation. The liquid is highly concentrated salt solution. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks while others are considered salt tanks (containing both saltcake and liquid salt solution).

The sludge portion of the HLW is currently being transferred to the DWPF for immobilization in borosilicate glass. The saltcake and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before ultimate treatment. The process for separating HLW is the subject of an ongoing supplemental EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site*. The high-radioactivity fraction would be transferred to the DWPF for vitrification. The low-radioactivity fraction would be treated and disposed at the Saltstone Manufacturing and Disposal Facility. Both treatment processes are described in the *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility* (DOE 1994).

DOE has committed to complete closure by 2022 of the 24 high-level waste tank systems that do not meet the secondary containment requirements in the Federal Facility Agreement (WSRC 1998). During waste removal, DOE will retrieve as much of the stored HLW as can be removed using the existing waste transfer equipment. The retrieved waste will be processed through the remaining tank systems and treated at either the DWPF Vitrification Facility or the Saltstone Manufacturing and Disposal

Table 3.9-2. Planned and existing waste storage facilities.[a]

Storage facility	Location	Capacity	Original waste stream[b]						Status
			Low-level	HLW	Transuranic	Alpha[c]	Hazardous	Mixed Low-level	
Long-lived waste storage buildings	E-Area	140 m^3/ bldg	X						One exists; DOE plans to construct additional buildings, as necessary.
Containerized mixed waste storage	Buildings 645-2N, 643-29E, 643-43E, 316-M, and Pad 315-4M	4,237 m^3						X	DOE plans to construct additional storage buildings, similar to 643-43E, as necessary.
Liquid mixed waste storage	DWPF Organic Waste Storage Tank (S-Area) SRTC Mixed Waste Tanks Liquid Waste Solvent Tanks (H-Area) Process Waste Interim Treatment/Storage Facility Tanks (M-Area)	9,586 m^3						X	The Process Waste Interim Treatment/Storage Facility ceased operation under RCRA in March 1996 and now operates under the Clean Water Act.
HLW Tank Farms	F- and H-Areas	(d)		X					51 underground tanks; one (16H) has been removed from service and two (17F, 20F) have been closed.[e]
Failed equipment storage vaults	Defense Waste Processing Facility (S-Area)	300 m^3		X					Two exist; DOE plans approximately 12 additional vaults.
Glass waste storage buildings	Defense Waste Processing Facility (S-Area)	2,286 canisters[f]		X					One exists and is expected to reach capacity in 2005; a second is planned to accommodate canister production from 2005 to 2015.
Hazardous waste storage facility	Building 710-B Building 645-N Building 645-4N Waste Pad 1 (between 645-2N and 645-4N) Waste Pad 2 (between 645-4N and 645-N) Waste Pad 3 (east of 645-N)	4,557 m^3					X		Currently in use. No additional facilities are planned, as existing space is expected to adequately support the short-term storage of hazardous wastes awaiting treatment and disposal.
Transuranic waste storage pads	E-Area	(g)			X	X		X	19 pads exists; additional pads will be constructed as necessary.

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m^3 = cubic meters, SRTC = Savannah River Technology Center.

a. Sources: DOE (1994; 1995), WSRC (1998; 1999a).

b. Sanitary waste is not stored at SRS, thus it is not addressed in this table.

c. Currently, alpha waste is handled and stored as transuranic waste.

d. As of April 1998, there were approximately 660,00 gallons of space available in each of the HLW Tank Farms.

e. Twenty-four of these tanks do not meet secondary containment requirements and have been scheduled for closure.

f. Usable storage capacity of 2,159 canisters due to floor plug problems.

g. Transuranic waste storage capacities depend on the packaging of the waste and the configuration of packages on the pads.

Table 3.9-3. Planned and existing waste treatment processes and facilities.[a]

		Waste type							
Waste Treatment Facility	Waste Treatment Process	Low-level	High-level	Transuranic	Alpha[b]	Hazardous	Mixed Low-level	Sanitary	Status
Consolidated Incineration Facility	Incineration	X				X	X		Began treating waste in 1997.
Offsite facility[c]	Incineration	X				X	X		Currently operational.
Offsite facility	Compaction	X							Currently operational.
Offsite facility	Supercompaction	X							Currently operational.
Offsite facility	Smelting	X							Currently operational.
Offsite facility	Repackaging	X							Currently operational.
Defense Waste Processing Facility	Vitrification		X						Currently operational.
Saltstone Manufacturing and Disposal Facility	Stabilization						X		Currently operational.
Replacement High-Level Waste Evaporator[d]	Volume Reduction		X						Planned to replace existing evaporators in December 1999.
M-Area Vendor Treatment Facility	Vitrification						X		Treatment of design basis wastes completed in February 1999.
Hazardous Waste/Mixed Waste Containment Building	Macroencapsulation					X	X		Plan to begin operations in 2006.
Treatment at point of waste stream origin	Decontamination Macroencapsulation						X		As feasible based on waste and location.
Non-Alpha Vitrification Facility	Vitrification	X				X	X		Under evaluation as a potential process.
DOE Broad Spectrum Contractor	Amalgamation/ Stabilization/ Macroencapsulation						X		DOE is considering use of the Broad Spectrum Contract.
Offsite facility	Offsite Treatment and Disposal					X			Currently operational.
Offsite facility	Decontamination						X		Begin treating waste onsite in December 1998. Plan to pursue treatment offsite in 2000, if necessary.
Various onsite and offsite facilities[e]	Recycle/Reuse	X				X	X	X	Currently operational.
High-activity mixed transuranic waste facility	Repackaging/size reduction			X	X				Planned to begin operations in 2012.
Low-activity mixed transuranic waste facility	Repackaging/size reduction/ supercompaction			X	X				Planned to begin operations in 2002.
Existing DOE facilities	Repackaging/ Treatment			X					Transuranic waste strategies are still being finalized.
F- and H-Area Effluent Treatment Facility	Wastewater Treatment	X					X		Currently operational.

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a. Sources: DOE (1994, 1995); Sessions (1999); WSRC (1998; 1999a).
b. Currently, alpha waste is handled as transuranic waste. After it is surveyed and separated, most will be treated and disposed of as low-level or mixed low-level waste.
c. An offsite incinerator may be used as a back-up to the Consolidated Incineration Facility.
d. Evaporation precedes treatment at the DWPF and is used to maximize HLW storage capacity.
e. Various waste streams have components (e.g., silver, lead, freon, paper) that might be recycled or reused. Some recycling activities might occur onsite, while other waste streams are directed offsite for recycling. Some of the recycled products are released for public sale, while others are reused onsite.

Table 3.9-4. Planned and existing waste disposal facilities.[a]

			Original waste stream[b]						
Disposal facility	Location	Capacity (m^3)	Low-level	High-level	Transuranic	Hazardous	Mixed Low-level	Sanitary	Status
Shallow land disposal trenches	E-Area	(c)	X						Four have been filled; up to 58 more may be constructed.
Low-activity vaults	E-Area	30,500/vault	X						One vault exists and one additional is planned.
Intermediate-activity vaults	E-Area	5,300/vault	X						Two vaults exist and five more may be constructed.
Hazardous waste/mixed waste vaults	NE of F-Area	2,300/vault				X	X		RCRA permit application submitted for 10 vaults. At least 11 additional vaults may be needed.
Saltstone Manufacturing and Disposal Facility	Z-Area	80,000/vault[d]	X						Two vaults exist and approximately 13 more are planned.
Three Rivers Landfill	SRS Intersection of SC 125 and Rd. 2	NA						X	Current destination for SRS sanitary waste.
Burma Road Cellulosic and Construction Waste Landfill	SRS Intersection of C Rd. and Burma Rd	NA						X	Current destination for demolition/construction debris. DOE expects to reach permit capacity in 2008.
Waste Isolation Pilot Plant	New Mexico	175,600			X				EPA certification of WIPP completed in April 1998. RCRA permit expected to be finalized in fall of 1999.[e]
Federal repository	See Status	NA		X					Proposed Yucca Mountain, Nevada site is currently under investigation.

NA = Not Available, WIPP = Waste Isolation Pilot Plant.

[a] Sources: DOE (1994, 1995, 1997); WSRC (1998; 1999a,b).

[b] After alpha waste is assayed and separated from the transuranic waste, DOE plans to dispose of it as low-level or mixed low-level waste so it is not addressed separately here.

[c] Various types of trenches exist including engineered low-level trenches, greater confinement disposal boreholes and engineered trenches, and slit trenches. The different trenches are designed for different waste types, are constructed differently, and have different capacities.

[d] This is the approximate capacity of a double vault. One single vault and one double vault have been constructed. Future vaults are currently planned as double vaults.

[e] SRS is scheduled for WIPP certification audit in summer 1999, after which WIPP could begin receiving SRS waste.

Facility. The tank closure activities described in this EIS would occur after waste removal is completed.

3.9.1.4 Sanitary Waste

Sanitary waste is solid waste that is neither hazardous, as defined by the Resource Conservation and Recovery Act (RCRA) nor radioactive. It consists of salvageable material and material that is suitable for disposition in a municipal sanitary landfill. Sanitary waste streams include such items as paper, glass, discarded office material, and construction debris (DOE 1994).

Sanitary waste volumes have declined due to recycling and the decreasing SRS workforce. DOE sends sanitary waste that is not recycled or reused to the Three Rivers Landfill on SRS. The SRS also continues to operate the Burma Road Cellulosic and Construction Waste Landfill to dispose of demolition and construction debris.

3.9.1.5 Hazardous Waste

Hazardous waste is nonradioactive waste that SCDHEC regulates under RCRA and corresponding state regulations. Waste is hazardous if the EPA lists it is as such or if it exhibits the characteristic(s) of ignitability, corrosivity, reactivity, or toxicity. SRS hazardous waste streams consist of a variety of materials, including mercury, chromate, lead, paint solvents, and various laboratory chemicals.

At present, DOE stores hazardous wastes in three buildings and on three solid waste storage pads that have RCRA permits. Hazardous waste is sent to offsite treatment and disposal facilities and is also treated at the Consolidated Incineration Facility. DOE also plans to continue to recycle, reuse, or recover certain hazardous wastes, including metals, excess chemicals, solvents, and chlorofluorocarbons. Wastes remaining after treatment might be suitable for either shallow land disposal or disposal in the Hazardous/Mixed Waste Disposal Vaults (DOE 1995).

3.9.1.6 Transuranic and Alpha Waste

Transuranic waste contains alpha-emitting transuranic radionuclides (those with atomic weights greater than 92) that have half-lives greater than 20 years at activities exceeding 100 nanocuries per gram (DOE 1999). At present, DOE manages low-level alpha-emitting waste with activities between 10 and 100 nanocuries per gram, referred to as alpha waste, as transuranic waste at SRS.

WSRC (1999a) defines the future handling, treatment, and disposal of the SRS transuranic and alpha waste stream. Current SRS efforts consist primarily of providing continued safe storage until treatment and disposal facilities are available. Eventually, DOE plans to ship the SRS retrievably stored transuranic and mixed transuranic waste to the Waste Isolation Pilot Plant in New Mexico for disposal.

Before disposition, DOE plans to measure the radioactivity levels of the wastes stored on the transuranic waste storage pads and segregate the alpha waste. A high-activity mixed transuranic waste facility could be constructed to process the higher activity SRS waste in preparation for shipment to the Waste Isolation Pilot Plant. This facility would use repackaging, sorting, and size reduction technologies. A low-activity mixed transuranic waste facility could also be constructed to process the lower activity SRS waste. The technology to process low-activity SRS waste is currently under development. A compactor could also be used to process lower activity mixed transuranic waste in preparation for shipment to the Waste Isolation Pilot Plant. After segregation and repackaging, DOE could dispose of much of the alpha waste as either mixed low-level or low-level waste.

3.9.2 HAZARDOUS MATERIALS

The *Savannah River Site Tier II Emergency and Hazardous Chemical Inventory Report* for 1998 (WSRC 1999c) lists more than 79 hazardous chemicals that were present at SRS at some time during the year in amounts that exceeded the minimum reporting thresholds [generally 10,000 pounds for hazardous chemicals and 500 pounds for extremely hazardous substances]. Four of the 79 hazardous chemicals are considered extremely hazardous substances under the Emergency Planning and Community Right-to-Know Act of 1986. The actual number and quantity of hazardous chemicals present on the Site and at individual facilities changes daily as a function of use and demand.

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CHAPTER 4. ENVIRONMENTAL IMPACTS

Chapter 4 describes the potential environmental consequences to the SRS and the surrounding region of implementing each of the alternatives described in Chapter 2. As discussed in Chapter 2, DOE has identified three alternatives and three tank stabilization options:

- No Action Alternative
- Clean and Stabilize Tanks Alternative
  - Clean and Fill with Grout Option (Preferred Alternative)
  - Clean and Fill with Sand Option
  - Clean and Fill with Saltstone Option
- Clean and Remove Tanks Alternative

Environmental consequences of actions could include direct physical disturbance of resources, consumption of affected resources, and degradation of resources caused by effluents and emissions. Resources include air, water, soils, plants, animals, cultural artifacts, and people, including SRS workers and people in nearby communities. Consequences may be detrimental (e.g., increased airborne emissions of hazardous chemicals) or beneficial (e.g., jobs created by new construction).

Section 4.1 describes the short-term impacts associated with each alternative within the scope of this EIS. For purposes of the analyses in the EIS, the short-term impacts span from the year 2000 through final closure of the existing HLW tanks associated with operation of the DWPF (approximately 2030). Section 4.2 describes the long-term impacts of the residual radioactive and non-radioactive material in the closed HLW tanks. Long-term assessment involves a 10,000-year performance evaluation beginning with a 100-year period of institutional control and continuing through an extended period during which it is assumed that residents and intruders could be present.

The impact assessments in this EIS have generally been performed in such a way that the magnitude and intensity of estimated impacts are unlikely to be exceeded during either normal operations or in the event of an accident. For routine operations, the results of monitoring the impacts from actual operations provide realistic predictions of impacts. For accidents there is more uncertainty because the impacts are based on events that have not occurred. In this EIS, DOE selected hypothetical accidents that would produce impacts as severe or more severe than any reasonably foreseeable accidents, which bounds the impacts of all reasonably foreseeable accidents for each alternative. The use of this methodology ensures that all of the alternatives have been evaluated using the same methods and data, allowing a non-biased comparison of impacts.

To ensure that small potential impacts are not over-analyzed and large potential impacts are not under-analyzed, analysts have assessed potential impacts based on their significance. This methodology follows the recommendation for the use of a "sliding scale" approach to analysis described in *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993). The sliding scale approach uses a determination of significance by the analyst (and, in some cases, peer reviewers) for each potential impact. Potential impacts determined to be insignificant are not analyzed further, while potential impacts that may be significant are analyzed at a level of detail commensurate with the magnitude of the impacts.

4.1 Short-Term Impacts

Section 4.1 describes the short-term impacts associated with each alternative. For purposes of the analyses in the EIS, the short-term impacts span from year 2000 through final closure of the existing HLW tanks associated with operation of the DWPF (approximately 2030). The structure of Section 4.1 closely parallels that of Chapter 3, Affected Environment, with the addition of sections on utilities and energy consumption and accidents. The sections discuss methodology and present the potential impacts of each alternative evaluated. More details on the methodology for accident analysis are provided in Appendix B.

4.1.1 GEOLOGIC RESOURCES

No geologic deposits within F- and H-Areas have been economically or industrially developed, and none are known to have significant potential for development. There are, however, four tanks in F-Area and four tanks in H-Area that would require backfill soil to be placed over the top of the tanks for the Clean and Stabilize Tanks Alternative. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent surface water from collecting in the surface depressions. This action would prevent ponded conditions over these tanks that could facilitate the degradation of the tank structure. DOE currently estimates that 170,000 cubic meters of soil would be required to fill the depressions to grade.

Under the Clean and Remove Tanks Alternative, the tanks would be cleaned as appropriate and removed from the subsurface. This would require the backfilling of the excavations left by the removal of the tanks. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks. DOE currently estimates that 356,000 cubic meters of soil would be required to backfill the voids left by the removal of the tanks.

The backfill soils would be excavated from an onsite borrow area(s) as determined by DOE. The excavation of borrow soils would be performed under Best Management Practices to limit impact to geologic resources that may be present. As a result, there would be no short-term impacts at the individual tank locations to geologic resources from any of the proposed alternatives discussed in Chapter 2.

4.1.2 WATER RESOURCES

4.1.2.1 Surface Water

Surface runoff in F- and H-Area Tank Farms flows to established storm sewer systems that may be used to block, divert, re-route, or hold up flow as necessary. During periods of earth moving or soil excavating, surface water runoff can be routed to area stormwater basins to prevent sediment from moving into down-gradient streams. During phases of the operation when the potential for a contaminant spill exists, specific storm sewer zones (or “flowpaths”) can be secured, ensuring that contaminated water or cleaning chemicals inadvertently spilled would be routed to a lined retention basin via paved ditches and underground drainage lines.

The retention basins are flat-bottomed, slope-walled, earthen basins lined with rubber (H-Area Retention Basin) or polyethylene (F-Area Retention Basin). Both basins have a capacity of 6,000,000 gallons. Stormwater in the retention basins may be sent to Fourmile Branch (if uncontaminated rainwater), to the Effluent Treatment Facility for removal of contaminants, or rerouted to the tank farms for temporary storage prior to treatment. Because any construction site runoff or spills would be controlled by the tank farm storm sewer system, DOE does not anticipate impacts to down-gradient surface waters. Activities would be confined to developed areas and discharges would be in compliance with existing stormwater permits.

Small (approximately one acre) lay-down areas would be established just outside of the F- and H-Area Tank Farms to serve as equipment storage and staging areas. Development of these lay-down areas would require little or no construction or land disturbance; therefore, the potential for erosion and sedimentation under any of the alternatives would be negligible.

Prior to construction, DOE would review and augment (if necessary) its existing erosion and sedimentation plans, ensuring that they were in compliance with State regulations on stormwater discharges and approved by SCDHEC.

4.1.2.2 Groundwater

The only direct impact to groundwater resources during the short-term activities associated with tank closure would be the use of groundwater for cleaning, for tank ballast, and for mixing grout, saltstone, or sand fill. Of the alternatives described in Chapter 2, only the No Action Alternative involves using water as ballast; however, this alternative does not use water for tank cleaning. The Grout and Saltstone Options under the Clean and Stabilize Tanks Alternative include water use for tank cleaning and for mixing with the grout and saltstone backfill. The Clean and Fill with Sand Option uses water for tank cleaning and a relatively small amount of water to prepare the sand slurry for tank filling. The Clean and Remove Tanks Alternative only uses water for cleaning, although the higher degree of cleaning required for tank removal would use more water than cleaning for in-place tank closure alternatives.

An accounting of the volumes of water required for each of the closure alternatives (as described in Section 4.1.11) shows that the largest volume of water would be used during the Clean and Stabilize Tanks Alternative (Grout Option). The largest volume on a per tank basis would be consumed during closure of Type III tanks. Based on the anticipated closure schedule, closure of two Type III tanks in any given year would consume approximately 2.3 million gallons of water. This water would come from the groundwater production wells located at various operating areas at SRS. As a comparison, the total groundwater production from the F-Area industrial wells from January through December 1998 was approximately 1.01 million gallons per day (370 millions gallons per year) (Johnson 1999). This water was pumped from the intermediate and deep aquifers that have been widely used as an industrial and municipal groundwater source for many years across Aiken County. The tank closure water requirements represent less than 0.6 percent of the F-Area annual production alone. Based on these projections, there would be no significant impact to groundwater resources for any of the tank closure alternatives.

The tank farms are situated in highly developed industrial areas. Some of the tank groups were constructed in pits substantially lower in elevation than the surrounding terrain. The existing tank farm sites include facilities and structures designed to prevent surface ponding and to manage precipitation runoff in a controlled manner. Reclamation of the tank farms after closure would require backfilling and grading to provide a suitable site for future industrial/commercial development, to prevent future ponding of water at the surface, and to promote non-erosional surface water runoff. Backfilling and grading would be performed using borrow material derived from local areas at the SRS; borrow material is assumed to be physically similar to the in-place materials. Therefore, there should be little or no impact to short-term groundwater recharge as a result of the surface reclamation activities.

The in-place tank closure alternatives would result in residual waste being left in the tanks. The residual waste has the potential to contaminate groundwater at some point in the future due to leaching and water-borne transport of contaminants. This is not expected to occur, however, until several hundred years after tank closure when the tank, tank contents, and underlying basemat are anticipated to fail due to deterioration. Under all closure alternatives, construction and/or demolition activities have the potential to result in soil, wastewater, or direct groundwater contamination through spills of fuels or chemicals or construction by-products and wastes. By following safe work practices and implementing good engineering methodologies, concentrations in soil, wastewater, and groundwater should be kept well within applicable standards and guidelines to protect groundwater resources.

4.1.3 AIR RESOURCES

This section discusses nonradiological and radiological air quality impacts that would result from actions related to tank closure activities. To determine the impacts on air quality, DOE estimated the emission rates associated with processes used in each alternative. This included an identification of potential emission sources and any methods by which air would be filtered before being released to the environment. These emissions were entered into air dispersion models to determine potential maximum concentrations at onsite and offsite locations. The estimated emissions and air concentrations of nonradiological and radiological pollutants are discussed and compared to the pertinent SCDHEC and Federal regulatory limits in the following two sections. Any human health effects resulting from increased air concentrations are discussed in the Worker and Public Health Section (4.1.8).

4.1.3.1 Nonradiological Air Quality

Tank closure activities would result in the release of regulated nonradiological pollutants to the surrounding air. The estimated emission rates (tons per year) for each emitted regulated pollutant and each alternative/option are presented in Table 4.1.3-1. These emission rates can be compared against emission rates defined in SCDHEC Standard 7, "Prevention of Significant Deterioration (PSD)." The PSD limits are included in Table 4.1.3-1 and are discussed in this section.

The primary sources of nonradiological air pollutants for the Grout Option under the Clean and Stabilize Tanks Alternative would be a concrete batch plant located next to each of the F- and H-Area Tank Farms and three diesel generators that would provide electrical power for each of these batch plants. The batch plants and generators were assumed to be identical to those used during the two previous tank closures and were conservatively assumed to run continuously. The diesel generators account for a majority of the pollutants emitted; however, the batch plants' emissions would account for 77 percent of the total PM_{10} (particulate matter with an aerodynamic diameter $\leq 10\ \mu m$) emitted. Additional nonradiological pollutants would be expected from the exhaust from trucks delivering raw materials to the batch plant every few days. Since these emissions would only occur occasionally, they were considered very small relative to batch plant emission and were not included in the emissions calculations for this option or any other option under the Clean and Stabilize Tanks Alternative.

For the Sand Option of the Clean and Stabilize Tanks Alternative, nonradiological pollutants would be emitted from operation of the sand conveyance (feed) plants, one at H-Area and a second at F-Area, and three diesel generators providing electric power for each of the sand conveyance plants. The sand feed plants would emit 67 percent of the total PM_{10} that would be emitted under this option. The diesel generators and sand conveyance plants were assumed to operate continuously.

The option of filling the cleaned tanks with saltstone would require saltstone batching facilities to be located at F- and H-Areas. The total amount of saltstone that would be made from the stabilization of all the low-activity fraction of HLW would probably be greater than the capacity of the waste tanks (DOE 1996). Therefore, each of the two new facilities for producing the saltstone necessary to fill the tanks was assumed to be one-half the size of the existing facility and was assumed to have identical sources of air pollution (Hunter 1999). The diesel generator emissions were based on the permitted emissions for the three generators at the Saltstone Manufacturing and Disposal Facility.

Regulated nonradiological air pollutants released as a result of activities associated with the No Action Alternative would consist primarily of emissions from vehicular traffic operating during waste removal. Relatively few vehicles would be required and would not run continuously; therefore, the emissions would be very small.

Regulated nonradiological air pollutants released as a result of activities associated with the Clean and Remove Tanks Alternative would consist of emissions from cutting the carbon steel tanks and emissions from vehicular traffic operating during cleaning and removal. The tank cutting would produce particulates, but not air toxics, and these particulates would be heavier and deposited to the ground much quicker than for welding. The cutting operations would be intermittent and short term (a day or two every few weeks). Also, a hut would be erected around the cutting operation to control the particulates; therefore the emissions would be very

Table 4.1.3-1. Nonradiological air emissions (tons per year) for tank closure alternatives.[a]

			Diesel Generators			Batch/Feed Plant			
Air pollutant	PSD significant emissions rate[b]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tank Alternative
Sulfur dioxide (as SO_x)	40	-[c]	2.2	2.2	6.6				-[c]
Total suspended particulates	25	-[c]	-[d]	-[d]	5.2				-[c]
Particulate matter (≤10 µm)	15	-[c]	1.0	1.0	3.3	3.5	2.1	0.3	-[c]
Carbon monoxide	100	-[c]	5.6	5.6	16.0				-[c]
VOCs	40	-[c]	2.3	2.3	4.9			0.8	-[c]
Nitrogen dioxide (as NO_x)	40	-[c]	33	33	77				-[c]
Lead	0.6	-[c]	9.0×10^{-4}	9.0×10^{-4}	2.9×10^{-3}				-[c]
Beryllium	4.0×10^{-4}	-[c]	1.7×10^{-4}	1.7×10^{-4}	5.6×10^{-4}				-[c]
Mercury	0.1	-[c]	2.2×10^{-4}	2.2×10^{-4}	7.0×10^{-4}			8.4×10^{-5}	-[c]
Benzene	NA	-[c]	0.02	0.02	0.04			0.84	-[c]

NA = Not applicable; no regulatory limit for this pollutant.
Source: Hunter (1999).
b. SCDHEC, Regulation 61-62.5, Standard 7, "Prevention of Significant Deterioration (PSD), Part V(1)."
c. Emissions from these alternatives have not been quantified, but would be small in relation to the clean and Stabilize Tanks Alternative.
d. No data on TSP emissions for these sources are readily available and therefore are not reflected in this analysis.
e. VOCs = volatile organic compounds, includes benzene.

small. Relatively few vehicles would be required and would not run continuously.

Additionally, all but one alternative includes the possibility of cleaning the interior tank walls with oxalic acid, a toxic air pollutant regulated under SCDHEC Standard 8. Oxalic acid would likely be stored in aboveground storage tanks. Tank ventilation would result in the release of small amounts of vapor to the atmosphere. A review of emissions data from two oxalic acid tanks currently used at SRS shows that the emissions from these sources are less than 3.5×10^{-9} tons per year. This resulting concentration in the vented air would be much less than any ambient air limit and would therefore be considered to be very small for purposes of assessing impacts to air quality (Hunter 1999).

The oxalic acid would be stored as a 4-8% (by weight) solution in tank trucks and driven to the tank to be cleaned. The acid would be transferred to the HLW tanks through a sealed pipeline. No releases are expected during this procedure. The cleaning process would consist of spraying hot (80-90°C) acid using remotely operated water sprayers. The tanks would be ventilated with 300-400 cfm of air, which would pass through a HEPA filter. The acid has a very low vapor pressure (as demonstrated by the very low tank emissions), releases from the ventilated air will be minimal. After its use in the tank, the acid is pumped and neutralized. Although no specific monitoring for oxalic acid fumes was performed during the cleaning of Tank 16 (see Sect. 2.1.1), no deleterious effects of using the acid were noted at the time.

The expected emission rates from the identified sources for each alternative/option were compared to the emission rates listed in SCDHEC Standard 7, "Prevention of Significant Deterioration (PSD)," to determine if the emission would result in an exceedance of this standard or a significant emission increase. Facilities such as SRS that are located in attainment areas and are classified as major facilities may trigger a PSD permit review under the new source review requirements of the Clean Air Act when they construct a major stationary source or make a major modification to a major source. A major source is defined as a source with the potential to emit any air pollutant regulated under the Clean Air Act in amounts equal to or exceeding specified thresholds. A PSD permit review is required if that modification or addition to the major facility results in a significant net emissions increase of any regulated pollutant. However, as can be seen in Table 4.1.3-1, the expected nonradiological emissions would be below the PSD significant emission rates listed in Standard 7 for most pollutants. The estimated emission rate for oxides of nitrogen under each alternative (33, 33, and 77 tons per year) are close to or exceed the PSD limit of 40 tons per year. However, the estimated emission rates were based on the assumption that batch operations at both F-Area and H-Area are running at the same time and continuously throughout the year. In all likelihood, tanks would be closed one at a time and there would be time between each closure when equipment is not in operation. Therefore, the estimated emission rates in Table 4.1.3-1 are conservative and none would be expected to exceed the PSD limits in Standard 7. In addition, the estimated emission rate for beryllium from diesel generators for the Clean and Fill with Saltstone Option would slightly exceed the PSD significant emissions rate.

Using the emission rates from Table 4.1.3-1, maximum concentrations of released regulated pollutants were determined using the EPA's Industrial Source Complex – Short Term (ISC3) air dispersion model (EPA 1995). The one-year meteorological data set collected onsite at SRS for 1996 was used as input into the model. Maximum concentrations were estimated at: (1) the SRS boundary where members of the public potentially could receive the highest exposure, and (2) at the location of a hypothetical noninvolved site worker. For the location of the noninvolved worker, the analysis used a generic location 2,100 feet from the release point in the direction of the greatest concentration. This location is the standard distance for assessing consequences from facility accidents and is used here for normal operations for consistency. Concentrations at the receptor locations were calculated at an elevation of 2 meters above ground to approximate the breathing height of a typical adult. The maximum air concentrations (micrograms per cubic meter) at the SRS boundary associated with the release of regulated nonradiological pollutants are listed in Tables 4.1.3 2 and 4.1.3-3. As can be expected, the Clean and Fill with Saltstone Option, which has slightly higher emissions, results in higher concentrations at the site boundary. However, ambient concentrations for all the pollutants and alternatives/options would increase by less than 1 percent of the regulatory limits. Therefore, no proposed tank closure activities would result in an exceedance of standards.

The air quality impacts at the location of a hypothetical noninvolved worker in the vicinity of F- and H-Areas are presented in Table 4.1.3-4. As with the modeled concentrations at the Site boundary, ambient concentrations of the OSHA-regulated pollutants (milligrams per cubic meter) at the location of the noninvolved worker would be highest for the Clean and Fill with Saltstone Option. All concentrations would be below OSHA limits; all concentrations with the exception of nitrogen dioxide (as NO_x) would be less than 1 percent of the regulatory limit. Nitrogen dioxide (as NO_x) could reach 8 percent of the regulatory limit for the Clean and Fill with Grout and Clean and Fill with Sand Options while nitrogen dioxide levels under the Clean and Fill with Saltstone Option could reach approximately 16 percent of the OSHA limit. All emissions of nitrogen dioxide are attributable to the operation of the diesel generators.

Emissions of regulated nonradiological air pollutants resulting from tank closure activities would not exceed PSD limits enforced under SCDHEC Standard 7. Likewise, air concentrations at the SRS boundary of the emitted pollutants under all options would not exceed SCDHEC or Clean Air Act regulatory limits. Any impacts to human health from these pollutants are discussed in Section 4.1.8.2 – Nonradiological Health Effects.

Table 4.1.3-2. Estimated maximum concentrations (in micrograms per cubic meter) at the SRS boundary for SCDHEC Standard 2 Air Pollutants.[a]

				Maximum concentration increment				
					Clean and Stabilize Tanks Alternative			
Air pollutant	Averaging time	South Carolina Standard[b]	SRS baseline[c]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Sulfur dioxide (as SO_x)	3-hr	1,300	1,200	(d)	0.2	0.2	0.6	(d)
	24-hr	365	350	(d)	0.04	0.04	0.12	(d)
	Annual	80	34	(d)	0.002	0.002	0.006	(d)
Total suspended particulates	Annual Geometric Mean	75	67	(d)	ND	ND	0.005	(d)
Particulate matter (≤10 μm)	24-hr	150 (65)[e]	130	(d)	0.08	0.06	0.06	(d)
	Annual	50 (15)[e]	25	(d)	0.004	0.003	0.003	(d)
Carbon monoxide	1-hr	40,000	10,000	(d)	1.2	1.2	3.4	(d)
	8-hr	10,000	6,900	(d)	0.3	0.3	0.8	(d)
VOCs	1-hr	(f)	(f)	(d)	0.5	0.5	2.0	(d)
Ozone	1-hr	235	NA	(d)	(g)	(g)	(g)	(d)
Nitrogen dioxide (as NO_x)	Annual	100	26	(d)	0.03	0.03	0.07	(d)
Lead	Calendar Quarter Mean	1.5	0.03	(d)	1.2×10^{-6}	1.2×10^{-6}	4.1×10^{-6}	(d)

NA = Not applicable; ND = Not detectable; maximum concentration below detectable limit; VOC = volatile organic compounds.

a. Source: Hunter (1999).

b. Source: SCDHEC Air Pollution Regulation 61-62.5, Standard 2, "Ambient Air Quality Standards."

c. Sum of (1) an estimated maximum site boundary concentration from modeling all sources of the indicated pollutant at SRS not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory data base) and (2) observed concentrations from nearby ambient air monitoring stations.

d. No emissions of this pollutant are expected.

e. New NAAQS for particulate matter ≤2.5 microns (24-hour limit of 65 $\mu g/m^3$ and an annual average limit of 15 $\mu g/m^3$) may become enforceable during the life of this project.

f. There is no standard for ambient concentrations of volatile organic compounds, but their concentrations are relevant to estimating ozone concentrations.

g. Ozone is a regional pollutant resulting from complex photochemical reactions involving oxides of nitrogen (NO_x) and volatile organic compounds (VOCs). Because estimated NO_x and VOCs emissions are below Prevention of Significant Deterioration (PSD) significant emissions rates, corresponding ozone increases are expected to be insignificant.

Table 4.1.3-3. Estimated maximum concentrations (in micrograms per cubic meter) at the SRS boundary for SCDHEC Standard 8 Toxic Air Pollutants.

				Maximum concentration increment				
					Clean and Stabilize Tanks Alternative			
Air pollutant	Averaging time	South Carolina Standard[a]	SRS baseline[b]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Beryllium	24-hr	0.01	0.009	(c)	3.2×10^{-6}	3.2×10^{-6}	1.1×10^{-5}	(c)
Mercury	24-hr	0.25	0.03	(c)	4.0×10^{-6}	4.0×10^{-6}	1.6×10^{-5}	(c)
Benzene	24-hr	150	4.6	(c)	3.8×10^{-4}	3.8×10^{-4}	2.0×10^{-2}	(c)

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a. From SCDHEC Air Pollution Regulation 61-62.5, Standard 8, Part II, Paragraph E, “Toxic Air Pollutants.”

b. Estimated maximum site boundary concentrations from modeling all sources of the indicated pollutant at SRS not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory database).

c. No emissions of this pollutant are expected.

Table 4.1.3-4. Estimated maximum concentrations (in milligrams/cubic meter) of OSHA-regulated nonradiological air pollutants at hypothetical noninvolved worker location.

			Maximum concentration[b]				
			Clean and Stabilize Tanks Alternative				
Air pollutant	Averaging time	OSHA Standard[a]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Sulfur dioxide (as SO_x)	8-hr TWA	13	-	5.0×10^{-3}	5.0×10^{-3}	0.02	-
Total suspended particulates	8-hr TWA	15	-	ND	ND	0.01	-
Particulate matter (≤10 μm)	8-hr TWA	5	-	9.0×10^{-3}	6.0×10^{-3}	8.0×10^{-3}	-
Carbon monoxide	8-hr TWA	55	-	0.01	0.01	0.04	-
Oxides of nitrogen (as NO_x)	Ceiling	9	-	0.7	0.7	1.4	-
Lead	8-hr TWA	0.05	-	2.1×10^{-6}	2.1×10^{-6}	6.5×10^{-6}	-
Beryllium	8-hr TWA	2.0×10^{-3}	-	4.1×10^{-7}	4.1×10^{-7}	1.3×10^{-6}	-
	Ceiling	5.0×10^{-3}	-	3.4×10^{-6}	3.4×10^{-6}	1.1×10^{-5}	-
Mercury	Ceiling	1.0		4.2×10^{-6}	4.2×10^{-6}	1.4×10^{-5}	-
Benzene	8-hr TWA	3.1	-	4.8×10^{-5}	4.8×10^{-5}	1.0×10^{-3}	-
	Ceiling	15.5	-	3.9×10^{-4}	3.9×10^{-4}	3.3×10^{-3}	-

ND = Not detectable; maximum concentration below detectable limit.

[a] Air pollutants regulated under 29 CFR 1910.1000. Averaging values listed are 8-hour time-weighted averages (TWA) except for oxides of nitrogen, mercury, benzene, and beryllium which also include not-to-be exceeded ceiling (29 CFR 1910.1000 values).

[b] Hunter (1999). Maximum estimated concentrations for a noninvolved worker at a distance of 2,100 feet from source and a breathing height of 2 meters.

4.1.3.2 Radiological Air Quality

Routine radiological air emissions that would be associated with tank closure activities were assumed to be equivalent to the current level of releases from the F- and H-Area Tank Farms. Annual emissions were based on the previous 5 years measured data for the tank farms (predominantly Cs-137). For No Action and each of the fill alternatives, all the air exiting the tanks would be filtered through high efficiency particulate air (HEPA) filters. For the Clean and Remove Tanks Alternative, the top of the tank would have HEPA-filtered enclosures or airlocks during removal of the metal from the tank. The tank would remain under negative pressure during cutting operations, and the exhaust would be filtered through HEPA filtration (Johnson 1999). Therefore, emissions from the tanks in F-Area and H-Area would not vary substantially among alternatives. The Saltstone Option under the Clean and Stabilize Tanks Alternative would require two new saltstone mixing facilities that would result in additional radionuclide emissions. The estimated Saltstone Manufacturing and Disposal Facility radionuclide emission rates presented in the *DWPF Supplemental EIS* (DOE 1994) were assumed to bound the emissions from both saltstone mixing facilities. The total estimated radiological air emissions for each alternative are shown in Table 4.1.3-5. The relevance to human health of these emissions are presented in Section 4.1.8 – Worker and Public Health.

After determining routine emission rates, DOE used the MAXIGASP and POPGASP computer codes to estimate radiological doses to the maximally exposed individual, the hypothetical noninvolved worker, and the offsite population surrounding SRS. Both codes utilize the GASPAR (Eckerman et al. 1980) and XOQDOQ (Sagendorf et al. 1982) modules that have been adapted and verified for use at SRS (Hamby 1992 and Bauer 1991, respectively). MAXIGASP and POPGASP are both site-specific computer programs that have SRS-specific meteorological parameters (e.g., wind speeds and directions) and population distribution parameters (e.g., number of people in sectors around the Site). The 1990 census population database was used to represent the population living within a 50-mile radius of the center of SRS.

Table 4.1.3-6 presents the calculated maximum radiological doses associated with tank closure activities for all the analyzed alternatives and options. Based on the dispersion modeling, the maximally exposed individual was identified as being located in the northern sector at the SRS boundary (Simpkins 1996). The maximum committed effective dose equivalent for the maximally exposed individual would be 2.6×10^{-5} millirem per year for the Clean and Fill with Saltstone Option, which is slightly higher than the other alternatives due to the additional emissions from operation of the saltstone batch plants. A majority of the dose to the maximally exposed individual, 70 percent, is associated with emissions from the tanks in H-Area. The annual maximally exposed individual dose under all the alternatives is well below the established annual dose limit of 10 millirem for SRS atmospheric releases (40 CFR 61.92). The maximum estimated dose to the offsite population residing within a 50-mile radius is calculated as 1.5×10^{-3} person-rem per year for the Clean and Fill with Saltstone Option. As with the maximally exposed individual dose, the tank farm emissions from H-Area comprise a majority (71 percent) of the total dose.

Table 4.1.3-6 also reports a dose to the hypothetical onsite worker from the estimated annual radiological emissions. The Clean and Fill with Saltstone Option is slightly higher than the other alternatives, 2.64×10^{-3} versus 2.57×10^{-3} millirem per year, with 74 percent of the total dose due to emissions from the H-Area Tank Farm.

Radionuclide doses from tank closure activities for all alternatives and options considered would not exceed any regulatory limit. Potential human health impacts from these doses are presented in Section 4.1.8.

Table 4.1.3-5. Annual radionuclide emissions (curies/year) resulting from tank closure activities.

	Annual emission rate				
		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
F-Area [a]	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}
H-Area [a]	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Saltstone Facility[b]	NA	NA	NA	0.46	NA
Total	1.5×10^{-4}	1.5×10^{-4}	1.5×10^{-4}	0.46	1.5×10^{-4}

a. Source: Arnett and Mamatey (1997 and 1998), Arnett (1994, 1995, and 1996).
b. Source: DOE (1994).

Table 4.1.3-6. Annual doses from radiological air emissions from tank closure activities.[a]

	Maximum dose				
		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Noninvolved worker dose (millirem/year)	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}
Maximally exposed individual dose (millirem/year)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}
Offsite population dose (person-rem/year)	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.5×10^{-3}	1.4×10^{-3}

a. Source: Based on emissions values listed in Table 4.1.3-5 and Simpkins (1996).

4.1.4 ECOLOGICAL RESOURCES

Most of the closure activities described in Chapter 2 (e.g., excavation and removal of transfer lines) would take place within the fenced boundaries of the F- and H-Area Tank Farms, heavily industrialized areas that provide limited wildlife habitat (see Figures 3.5-1 and 3.5-2). However, wildlife in undeveloped woodland areas adjacent to the F- and H-Area Tank Farms could be intermittently disturbed by construction activity and noise over the approximately 30-year period when 49 HLW tanks would be emptied (under all alternatives, including No Action), cleaned and stabilized (under the Clean and Stabilize Tanks Alternative), or cleaned and removed (under the Clean and Remove Tanks Alternative).

Construction would involve the movement of workers and construction equipment and would be associated with relatively loud noises from earth-moving equipment, portable generators, cutting tools, drills, hammers, and the like. Although noise levels in construction areas could be as high as 110 dBA, these high local noise levels would not extend far beyond the boundaries of the project sites.

Table 4.1.4-1 shows the attenuation of construction noise over relatively short distances. At

Table 4.1.4-1. Peak and attenuated noise (in dBA) levels expected from operation of construction equipment.[a]

Source	Noise level (peak)	Distance from source			
		50 feet	100 feet	200 feet	400 feet
Heavy trucks	95	84-89	78-83	72-77	66-71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Generator	96	76	70	64	58
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Dragline	105	85	79	73	67
Pile driver	105	95	89	83	77
Fork lift	100	95	89	83	77

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a. Source: Golden et al. (1980).

400 feet from the construction sites, construction noises would range from approximately 60 to 80 dBA. Golden et al. (1980) suggest that noise levels higher than 80 to 85 dBA are sufficient to startle or frighten birds and small mammals. Thus, there would be minimal potential for disturbing birds and small mammals outside a 400-foot radius of the construction sites.

Although noise levels would be relatively low outside the immediate areas of construction, the combination of construction noise and human activity probably would displace small numbers of animals (e.g., songbirds and small mammals) that forage, feed, nest, rest, or den in the woodlands to the south and west of the F-Area Tank Farm and to the south of the H-Area Tank Farm. Construction-related disturbances are likely to create impacts to wildlife that would be small, intermittent, and localized. Some animals could be driven from the area permanently, while others could become accustomed to the increased noise and activity and return to the area. Species likely to be affected (e.g., gray squirrel, opossum, white-tailed deer) are common to ubiquitous in these areas.

Lay-down areas (approximately one to three acres in size) would be established in previously-disturbed areas immediately adjacent to the F- and H-Area Tank Farms to support construction activities under the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative. These lay-down areas would serve as staging and equipment storage areas. The specialized equipment required for handling and conveying fill material under the Clean and Stabilize Tanks Alternative (e.g., the batch plants and diesel generators) would also be placed in these lay-down areas. Creating these lay-down areas would have the effect of extending the zone of potential noise impact several hundred feet, but noise-related impacts would still be limited to a relatively small area (less than 20 acres) adjacent to the F- and H-Area Tank Farms.

As noted in Section 3.4.1, no threatened or endangered species, or critical habitat occurs in or near the F- and H-Area Tank Farms, which are heavy-industrial sites surrounded by roads, parking lots, construction shops, and construction laydown areas and are continually exposed to high levels of human disturbance. DOE will continue to monitor the tank farm area, and all of the SRS, for the presence of threatened or endangered species. If a listed species is found, DOE will determine if tank closure activities would affect that species. If DOE were to determine that adverse impacts may occur, DOE would initiate consultation with the U.S. Fish and Wildlife Service under Section 7 of the ESA.

DOE has not selected a location for the onsite borrow area, but suitability of a potential sites would be based on proximity to F- and H-Area, topography, characteristics of soil in an area, accessibility (whether or not access roads are present), and the presence/absence of sensitive resources such as wetlands and archaeological sites. DOE would attempt to locate a source of soil in a previously-developed area (or adjacent to a previously-developed area) in order to minimize disturbance to plant and animal communities. Representative impacts from borrow pit development would include the physical alteration of 7 to 14 acres of land (and attendant loss of potential wildlife habitat) and noise disturbances to nearby wildlife.

DOE would require approximately 51 acres of land in E-Area for use as low-activity waste storage vaults under the Clean and Remove Tanks Alternative. A total of 70 acres of developed land in E-Area was identified as available for waste management activities in the SRS Waste Management EIS. Currently only one low-activity waste storage vault has been constructed. The analysis in SRS Waste Management EIS found that the construction and operation of storage and disposal facilities within the previously cleared and graded portions of E-Area (i.e., developed) would have little effect on terrestrial wildlife. Wildlife habitat in these areas is poor and characterized by mowed grassy areas with few animals. Birds and mammals that use these areas, mostly for feeding, would be displaced by construction activities, but it is unlikely that they would be physically harmed or killed.

4.1.5 LAND USE

As can be see from Figures 3.5-1 and 3.5-2, the tank farms are in a highly industrialized portion of the SRS. Since bulk material removal would continue until completed, the transition of tanks to the HLW tank closure project would be phased over an approximately 30-year period. Consequently, closure activities would not result in short-term changes to the land use patterns of the SRS or alter the use or character of the tank farm areas.

As noted in Section 4.1.1, a substantial volume of soil (6 to 12.5 million cubic feet) could be required for backfill under the Clean and Stabilize Tanks Alternative or the Clean and Remove Tanks Alternative. DOE would obtain this soil from an onsite borrow area. Assuming an average depth of 20 feet for the borrow pit, the borrow area would be approximately 7 to 14 acres in surface area.

DOE has not selected a location for the onsite borrow area, but suitability of potential sites would be based on proximity to F- and H-Area, topography (ridges and hilltops would be avoided to limit erosion), characteristics of soil in an area, accessibility (whether or not access roads are present), and the presence/absence of sensitive resources such as wetlands and archaeological sites. DOE would attempt to locate a source of soil in a previously-developed area (or adjacent to a previously-developed area) in order to minimize the amount of undeveloped land converted to industrial use. Consistent with SRS long-term land use plans, any site selected would be within the central developed core of the SRS, which is dedicated to industrial facilities (DOE 1998). There would be no change in overall land use patterns on the SRS.

As discussed in Section 2.1.2, this amount of solid low-level waste generated under the Clean and Remove Tanks Alternative would require about 16 new low-activity waste vaults (650 feet by 150 feet). The land use impacts of constructing and operating the required low-activity-waste vaults were described and presented in the SRS Waste Management EIS (DOE/EIS-0217) and was based on constructing up to 31 low-activity waste vaults. Based on design information presented in the Waste Management EIS, the 16 vaults under the Clean and Remove Tanks Alternative would require just over 51 acres of land. In the SRS Waste Management EIS, DOE identified 70 acres of previously developed land in E-Area that is available for waste storage use. Since completion of the

SRS Waste Management EIS in July 1995, DOE has not identified the remaining land as a potential site for other activities therefore, there are no conflicting land uses and the analysis presented in the SRS Waste Management EIS is still valid. However, should future land uses change these changes would be made by DOE through the site development, land-use, and future-use planning processes, including public input through various avenues such as the Citizens Advisory Board. Finally any land use changes would be in accordance with the current Future Use Plan (DOE 1998).

4.1.6 SOCIOECONOMIC IMPACTS

Table 4.1.6-1 presents the estimated employment levels associated with each tank closure alternative.

For the No Action Alternative, operators, supervisors, technical staff and maintenance personnel would be required to monitor the tanks and maintain equipment and instruments. These activities are estimated to require about 40 personnel from the existing work force to cover shift and day operations (Johnson 1999).

As seen in Table 4.1.6-1, approximately 85 employees, on average, would be required to perform closure activities for the Clean and Fill with Grout and Sand Options under the Clean and Stabilize Tanks Alternative. The Clean and Fill with Saltstone Option would require approximately 130 employees (Caldwell 1999). The Clean and Remove Tanks Alternative would require, on average, over 280 employees. In each case, it is assumed two tanks will be closed per year. The employment estimates includes all employee classifications: operations, engineering, design, construction, support, and project management.

The maximum peak annual employment would occur under the Clean and Remove Tanks Alternative. This alternative would require less than 2 percent of the existing SRS workforce. All options under the Clean and Stabilize Tanks Alternative would require less than 1 percent of the existing SRS workforce.

Given the size of the economy in the six-county region of influence (described in Section 3.6), the estimated SRS workforce, and the size of the regional population and workforce, tank closure activities are not expected to result in any measurable socioeconomic impacts for any of the alternatives. Likewise, impacts to low-income or minority areas (as described in Section 3.6) are also not expected.

4.1.7 CULTURAL RESOURCES

As discussed in Chapter 2, activities associated with the tank closure alternatives at SRS would occur within the current F- and H-Area Tank Farms. Although there may have been prior human occupation at or near the F- and H-Area

Table 4.1.6-1. Estimated HLW tank closure employment.

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Annual employment (Full-time equivalent employees)[a,b]	40	85	85	131	284
Life of project employment (Full-time equivalent employees – years)[c]	980	2,078	2,078	3,210	6,963

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a. Source: Caldwell (1999).
b. Assumes two tanks closed per year.
c. Total for all 49 tanks.

Tank Farms, the likelihood of historic resources surviving the construction of the tank farms in the early 1950s, before the enactment of regulations to protect such resources, would be small. The potential for the presence of prehistoric site in the candidate locations also is limited. As with any historic sites, tank farm construction activities probably destroyed or severely damaged prehistoric deposits. Therefore, tank closure activities would not be expected to further impact historic or prehistoric resources.

Under the Clean and Remove Tanks Alternative, 16 new low-activity waste vaults would be constructed in E-Area. As with the Tank Farm areas, previous DOE activities in E-Area probably destroyed or severely damaged any historic or prehistoric resources. Therefore, construction of these low-activity waste vaults would not be expected to further impact historic or prehistoric resources.

If any historic or archaeological resources should become threatened, however, DOE would take appropriate steps to identify the resources and contact the Savannah River Archaeological Research Program, the South Carolina Institute of Archaeology and Anthropology at the University of South Carolina and the State Historic Preservation Officer to comply with Section 106 of the National Historic Preservation Act.

4.1.8 WORKER AND PUBLIC HEALTH

This section discusses potential radiological and nonradiological health effects to SRS workers and the surrounding public from the HLW tank closure alternatives; it does not include impacts of potential accidents, which are discussed in Section 4.1.12. DOE based its calculations of health effects from the airborne radiological releases on (1) the dose to the hypothetical maximally exposed offsite individual; (2) the dose to the maximally exposed noninvolved worker (i.e., SRS employees who may work in the vicinity of the HLW tank closure facilities but are not directly involved in tank closure work); (3) the collective dose to the population within a 50-mile radius around the SRS (approximately 620,000 people); and (4) the collective dose to workers involved in implementing a given alternative (i.e., the workers involved in tank closure activities). All radiation doses mentioned in this EIS are effective dose equivalents; internal exposures are committed effective dose equivalents. This discussion characterizes health effects as additional lifetime latent cancer fatalities likely to occur in the general population around SRS and in the population of workers who would be associated with the alternatives.

Nonradiological health effects discussed in this section include health effects from nonradiological air emissions. In addition, occupational health impacts are presented in terms of estimated work-related illness and injury rates associated with each of the tank closure alternatives.

4.1.8.1 Radiological Health Effects

Radiation can cause a variety of health effects in people. The major effects that environmental and occupational radiation exposures could cause are delayed cancer fatalities, which are called latent cancer fatalities because the cancer can take many years to develop and cause death.

To relate a dose to its effect, DOE has adopted a dose-to-risk conversion factor of 0.0004 latent cancer fatality per person-rem for workers and 0.0005 latent cancer fatality per person-rem for the general population (NCRP 1993). The factor for the population is slightly higher due to the presence of infants and children who are believed to be more sensitive to radiation than the adult worker population.

DOE uses these conversion factors to estimate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to background radiation (0.3 rem per year), DOE would calculate 15 latent cancer fatalities per year caused by radiation (100,000 persons × 0.3 rem per year × 0.0005 latent cancer fatality per person-rem).

Calculations of the number of latent cancer fatalities associated with radiation exposure might not yield whole numbers and, especially in environmental applications, might yield values less than 1. For example, if a population of 100,000 were exposed to a dose of 0.001 rem per person, the collective dose would be 100 person-rem, and the corresponding number of latent cancer fatalities would be 0.05 (100,000 persons × 0.001 rem × 0.0005 latent cancer fatality per person-rem).

Vital statistics on mortality rates for 1997 (CDC 1998) indicate that the overall lifetime fatality rate in the United States from all forms of cancer is about 23.4 percent (23,400 fatal cancers per 100,000 deaths).

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation; these include nonfatal cancers among the exposed population and genetic effects in subsequent generations. Previous studies have concluded that these effects are less probable than fatal cancers as consequences of radiation exposure (NCRP 1993). Dose-to-risk conversion factors for nonfatal cancers and hereditary genetic effects (0.0001 per person-rem and 0.00013 per person-rem, respectively) are substantially lower than those for fatal cancers. This EIS presents estimated effects of radiation only in terms of latent cancer fatalities because that is the major potential health effect from exposure to radiation. Estimates of nonfatal cancers and hereditary genetic effects can be estimated by multiplying the radiation doses by the appropriate dose-to-risk conversion factors for these effects.

DOE expects minimal worker and public health impacts from the radiological consequences of tank closure activities under any of the closure alternatives. All closure alternatives are expected to result in similar radiological release levels in the near-term. Public radiation doses would likely occur from airborne releases only (Section 4.1.3). Table 4.1.8-1 lists incremental radiation doses estimated for the noninvolved worker [a worker not directly involved with implementing the option but located 2,100 feet (a standard distance used for consistency with other SRS for NEPA evaluations) from the HLW tank farm] and the public (maximally exposed offsite individual and collective population dose) and corresponding incremental latent cancer fatalities, for each closure alternative.

DOE based estimated worker doses on past HLW tank operating experience and the projected number of employees associated with each action (Newman 1999a; Johnson 1999). For the maximally exposed worker, DOE assumed that no worker would receive an annual dose greater than 500 millirem from any alternative because SRS uses the 500 millirem value as an administrative limit for normal operations: that is, an employee who receives an annual dose approaching the administrative limit normally is reassigned to duties in a nonradiation area. Table 4.1.8-2 estimates radiation doses for the collective population of workers who would be directly involved in implementing the options. This estimation was derived by assigning a specific number of workers for each tank closure task and then combining the tasks for each option/alternative. An average collective dose was then assigned for the closure of all 49 HLW tanks. Latent cancer fatalities likely attributable to the doses are also listed in this table. Individual worker doses were not calculated or assigned by this method. Total dose to the involved worker population was not evaluated by DOE due to the speculative nature of worker locations at the site. As expected, the Clean and Remove Tanks Alternative would result in larger radiological dose and health impacts due to larger manpower needs. However, impacts are well within the administrative control limit for SRS workers.

As shown in Table 4.1.8-2, post-closure activities would result in minimal radiological worker impacts. The Clean and Stabilize Tanks Alternative as well as the Clean and Remove Tanks Alternative would result in a smaller collective worker dose than the No Action Alternative. The lower dose is due to the reduced number of employees that would be needed once the tank closure activities are completed.

The estimated number of latent cancer fatalities in the public listed in Table 4.1.8-1 from airborne emissions for each alternative and/or options can be compared to the projected number of fatal cancers (143,863) in the public around the SRS from all causes (as discussed in Section 3.8.1). In all cases, the incremental impacts from the options would be small.

Table 4.1.8-1. Estimated radiological dose and health impacts to the public and noninvolved worker from SRS airborne emissions.

	F-Tank[a]					H-Tank[a]				
		Clean and Stabilize Tanks Alternative					Clean and Stabilize Tanks Alternative			
Receptor	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Maximally exposed offsite individual dose (millirem/year)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}
Maximally exposed offsite individual dose over entire period of analysis (millirem)	6.1×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.4×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.4×10^{-4}	6.1×10^{-4}
Maximally exposed offsite individual estimated latent cancer fatality risk	3.1×10^{-10}	3.1×10^{-10}	3.1×10^{10}	3.2×10^{10}	3.1×10^{10}	3.1×10^{10}	3.1×10^{10}	3.1×10^{10}	3.2×10^{10}	3.1×10^{10}
Noninvolved worker dose (millirem/year)	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.7×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.7×10^{-3}	2.6×10^{-3}
Noninvolved worker individual dose over entire period of analysis (millirem)	6.4×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.6×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.6×10^{-2}	6.4×10^{-2}
Noninvolved worker estimated latent cancer fatality risk	2.5×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.6×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.6×10^{-8}	2.5×10^{-8}
Dose to population within 50 miles of SRS (person-rem/year)	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.5×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.40×10^{-3}	1.5×10^{-3}	1.4×10^{-3}
Dose to population within 50 miles of SRS over entire period of analysis (person-rem)	3.4×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.7×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.7×10^{-2}	3.4×10^{-2}
Estimated increase in number of latent cancer fatalities in population within 50 miles of SRS	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.8×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.8×10^{-5}	1.7×10^{-5}

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a. Estimated annual dose levels based on tank emissions in F-Area and H-Area.

Table 4.1.8-2. Estimated radiological dose and health impacts to involved workers by alternative.

		Clean and Stabilize Tanks Alternative			
	No Action Alternative[a]	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Total workload per tank closure (person-year)[b]	NA	2.8	2.8	3.1	11.0
Collective involved worker dose (person-rem)[c]	29.4[d]	1,600	1,600	1,800	12,000
Estimated increase in number of latent cancer fatalities	0.012	0.65	0.65	0.72	4.9

NA = Not applicable.

a. For the No Action Alternative, a work level of 40 persons would be required per year for both tank farms. Source: Newman (1999a).

b. Source: Caldwell (1999).

c. Collective dose is for closure of all 49 tanks.

d. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.

4.1.8.2 Nonradiological Health Effects

DOE evaluated the range of chemicals to which the public and workers would be exposed due to HLW tank closure activities and expects minimal health impacts from nonradiological exposures. The onsite and offsite chemical concentrations from air emissions were discussed in Section 4.1.3. DOE estimated noninvolved worker impacts and site boundary concentrations to which a maximally exposed member of the public could be exposed.

OSHA limits (29 CFR Part 1910.1000) are time-weighted average concentrations that a facility cannot exceed in any 8-hour work shift of a 40-hour week. In addition, there are OSHA ceiling concentrations that may not be exceeded during any part of the workday. These exposure limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could be exposed day after day without adverse health effects. However, because of the wide variation in individual susceptibility, a small percentage of workers could experience discomfort from concentrations of some substances at or below the permissible limit.

After analysis of expected activities during tank closure, DOE expects little possibility of involved workers in the tank farms and associated facilities being exposed to anything other than incidental concentrations of airborne nonradiological materials. Transfer of oxalic acid to and from the HLW tanks will be by sealed pipeline. Tank cleaning will be performed remotely. Normal industrial practices (e.g., wearing acid aprons and goggles) will be followed for all workers involved in acid handling. For routine operations, no exposure of personnel to oxalic acid would be expected. Therefore, health effects from exposure to nonradiological material inside the facilities or directly around the waste tanks would be small for all options.

The noninvolved worker concentrations were compared to OSHA permissible exposure limits or ceiling limits for protecting worker health, and DOE concluded that all pollutant concentrations were negligible compared to the OSHA standards except for oxides of nitrogen (NO_X).

The NO_X emissions result in ambient concentrations that are about 10 to 15 percent of the standard for all three options within the Clean and Stabilize Tanks Alternative.

Estimated pollutant releases for beryllium, benzene, and mercury are also expected to be within OSHA guidelines. The maximum excess lifetime cancer risk to the noninvolved worker from exposure to beryllium emissions was estimated to be 3.1×10^{-9}, based on the EPA's Integrated Risk Information System (IRIS) database unit risk factor for beryllium of 2.4×10^{-3} excess cancer risk per microgram per cubic meter. The maximum excess lifetime cancer risk to the noninvolved worker from benzene was estimated to be 8.3×10^{-9}, based on a unit risk factor for benzene of 8.3×10^{-6} excess cancer risk per microgram per cubic meter. These values are less than 1% of the 1.0×10^{-6} risk value that EPA typically uses as the threshold of concern. For mercury, there are inconclusive data relating to cancer studies. Therefore, EPA does not report unit risk factors for mercury. However, the mercury concentrations for the noninvolved worker and at the site boundary are less than 1% of their respective OSHA and SCDHEC standards respectively, for all options. The pollutant values are for the maximum option presented, which is Clean and Fill with Saltstone. All other options are expected to have lower impact values. See Table 4.1.3-4 for nonradiological pollutant concentrations discussed above.

Exposure to nonradiological contaminants such as beryllium and mercury could also result in adverse health effects other than cancer. For example, exposure to beryllium could result in the development of a scarring lung disease, chronic beryllium disease (also known as berylliosis). However, the beryllium and mercury concentrations at the noninvolved worker locations would be so low that adverse health effects would not be expected.

Likewise, site boundary concentrations were compared to the SCDHEC standards for ambient concentrations, and DOE concluded that all air emission concentrations were below the applicable standard. See Section 4.1.3 for comparison of estimated concentrations at the site boundary with SCDHEC standards.

4.1.8.3 Occupational Health and Safety

Table 4.1.8-3 provides estimates of the number of total recordable cases (TRCs) and lost workday cases (LWCs) that could occur during the entire tank closure process. The projected injury rates are based on historic SRS injury rates over a 5-year period from 1994 through 1998 multiplied by the employment levels for each alternative.

The TRC value includes work-related death, illness, or injury that resulted in loss of consciousness, restriction from work or motion, transfer to another job, or required medical treatment beyond first aid. The data for LWCs represent the number of workdays beyond the day of injury or onset of illness that the employee was away from work or limited to restricted work activity because of an occupational injury or illness.

The results that are presented in Table 4.1.8-3 show that the Clean and Remove Tanks Alternative has the highest number of total TRCs and LWCs (400 and 200, respectively because it would require the largest number of workers). The injury rate for the No Action Alternative is caused by the number of workers that are needed to continue to conduct operations if no action is taken in regard to tank closure activities.

4.1.8.4 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directs each Federal agency to "make…achieving environmental justice part of its mission" and to identify and address "…disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations." The Presidential Memorandum that accompanied Executive Order 12898 emphasized the importance of using existing laws, including the National Environmental Policy Act, to identify and address environmental justice concerns, "including human health, economic, and social effects, of Federal actions."

The Council on Environmental Quality, which oversees the Federal government's compliance with Executive Order 12898 and the National Environmental Policy Act, subsequently developed guidelines to assist Federal agencies in incorporating the goals of Executive Order 12898

Table 4.1.8-3. Estimated Occupational Safety impacts to involved workers by alternative.

		Clean and Stabilize Tanks Alternative			
	No Action Alternative[a]	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Total workload per tank closure (person-years)[b]	40	42	42	66	140
Total recordable cases of accident or injury[c]	110	120	120	190	400
Lost workday cases[c]	60	62	62	96	210

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a. For the No Action Alternative, workload, TRC, and LWC estimates are for the period of closure activities for the other alternatives. These would continue indefinitely. Workload source: Johnson (1999).

b. Total manpower estimates are per tank. Source: Caldwell (1999).

c. TRC and LWC rates basis source: Newman (1999b).

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 identified (in Section 3.6.2) minority and low-income populations within a 50-mile radius of the SRS (plus areas downstream of the Site that withdraw drinking water from the Savannah River), which was defined as the region of influence for the environmental justice analysis. The section that follows discusses whether implementing the alternatives described in Chapter 2 would result in disproportionately high or adverse impacts to minority and low-income populations.

Methodology

The Council Environmental Quality guidance (CEQ 1997) does not provide a standard approach or formula for identifying and addressing environmental justice issues. Instead, it offers Federal agencies general principles for conducting and environmental analysis under NEPA:

- Federal agencies should consider the population structure in the region of influence to determine whether minority populations, low-income populations, or Indian tribes are present, and if so, whether there may be disproportionately high and adverse human health or environmental effects on any of these groups.
- Federal agencies should consider relevant public health and industry data concerning the potential for multiple or cumulative exposure to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards, to the extent such information is available.
- Federal agencies should recognize the interrelated cultural social, occupational, historical, or economic factors that may amplify the effects of the proposed agency action. These would include the physical sensitivity of the community or population to particular impacts.
- Federal agencies should develop effective public participation strategies that seek to overcome linguistic, cultural, institutional, and geographic barriers to meaningful participation, and should incorporate active outreach to affected groups.

- Federal agencies should assure meaningful community representation in the process, recognizing that diverse constituencies may be present.

- Federal agencies should seek tribal representation in the process in a manner that is consistent with the government-to-government relationship between the United States and trial governments, the Federal government's trust responsibility to Federally-recognized tribes, and any treaty rights.

First, DOE assessed the impacts of the proposed action and alternatives to the general population, which near the Savannah River Site includes minority and low-income populations. No special considerations, such as unique exposure pathways or cultural practices, contribute to any discernible disproportionate impacts. The only identified cultural practice (or unusual pathway) potentially associated with minority and low-income populations is use of the Savannah River for subsistence fishing. For the Draft and Final Accelerator Production of Tritium EIS (issued in 1999) DOE reviewed the limited body of literature available on subsistence activities in the region. DOE concluded that because the identified communities downstream from the SRS are widely distributed, and the potential impact to the general population is not discernible, there would be no potential for disproportionate impacts among minority or low-income populations. Second, having concluded that the potential off-site consequences to the general public of the proposed action and the alternatives would be small, DOE concluded there would be no disproportionately high and adverse impacts to minority or low-income populations.

The above stated conclusions are based on the comparison of HLW actions to past actions for which environmental justice issues were evaluated in detail. In 1995, DOE conducted an analysis of economic and racial characteristics of the population potentially affected by SRS operations within a 50-mile radius of the site Reference Interim Management EIS (DOE 1995). In addition, DOE examined the population downstream of the site that withdraws drinking water from the Savannah River. The economic and racial characterization was based on 1990 census tract data from the U.S. Census Bureau. More recent census tract data are not available. The nearest minority and low-income populations to SRS are to the south of Augusta, Georgia, northwest of the site.

This environmental justice analysis was based on the assessment of potential impacts associated with the various tank closure alternatives to determine if there would be high and adverse human health or environmental impacts. In this assessment, DOE reviewed potential impacts arising under the major disciplines and resource areas including socioeconomics, cultural resources, air resources, water resources, ecological resources, and public and worker health over the short term (approximately the years 2000 to 2030) and long term (approximately 10,000 years after HLW tanks are closed). Regarding health effects, both normal facility operations and postulated accident conditions were analyzed, with accident scenarios evaluated in terms of risk to workers and the public.

Although no high and adverse impacts were predicted for the activities analyzed in this EIS, DOE nevertheless considered whether there were any means for minority or low-income populations to experience disproportionately high and adverse impacts. The basis for making this determination would be a comparison of areas predicted to experience human health or environmental impacts with areas in the region of influence known to contain high percentages of minority or low-income populations.

The environmental justice analysis for the tank closure alternatives was assessed for a 50-mile area surrounding SRS (plus downstream areas) as discussed in Section 3.6.2.

<u>Short-Term Impacts</u>

For environmental justice concerns to be implicated, high and adverse human health or environmental impacts must disproportionately affect minority populations or low-income populations.

None of the proposed tank closure alternatives would produce significant short-term impacts to surface water (see Section 4.1.2.1) or groundwater (see Section 4.1.2.2). Emissions of nonradiological and radiological air pollutants from tank closure activities would be below regulatory limits (see Section 4.1.3) and would result in minimal impacts to workers (see Section 4.1.8.1) and the public (see Section 4.1.8.2). The estimated radiological doses and health impacts to the noninvolved worker and the public are very small (highest dose is 0.0026 millirem per year to the noninvolved worker, under the Saltstone Option of the Clean and Stabilize Tanks Alternative).

Because all tank closure activities would take place in an area that has been dedicated to industrial use for more than 40 years, no short-term impacts to ecological resources (see Section 4.1.4), existing land uses (see Section 4.1.5) or cultural resources (see Section 4.1.7) are expected.

Relatively small numbers of workers would be required to carry out tank closure activities regardless of the alternative selected (see Section 4.1.6); as a result, none of the tank closure alternatives would affect socioeconomic trends (i.e., unemployment, wages, housing) in the region of influence.

As noted in Section 4.2, no long-term environmental justice impacts are anticipated.

Because short-term impacts would not significantly impact the surrounding population, and no means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the alternatives.

<u>Subsistence Consumption of Fish, Wildlife, and Game</u>

Section 4-4 of Executive Order 12898 directs Federal agencies "whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence and that Federal governments communicate to the public the risks of these consumption patterns." There is no evidence to suggest that minority or low-income populations in the SRS region of influence are dependent on subsistence fishing, hunting, or gathering. DOE nevertheless considered whether there were any means for minority or low-income populations to be disproportionately affected by examining levels for contaminants in vegetables, fruit, livestock, and game animals collected from the SRS and from adjacent lands. In addition, DOE assessed concentrations of contaminants in fish collected from SRS waterbodies and from the Savannah River up- and downstream of the Site.

Based on recent monitoring results, concentrations of radiological and nonradiological contaminants in vegetables, fruit, livestock, game animals, and fish from the SRS and surrounding areas are generally low, in virtually all instances below applicable DOE standards (Arnett and Mamatey 1999). Consequently, no disproportionately high and adverse human health impacts would be expected in minority or low-income populations in the region that rely on subsistence consumption of fish, wildlife, or native plants.

It should be noted that mercury, which is present in relatively high concentrations in fish collected from SRS and the middle reaches of the Savannah River, could pose a potential threat to individuals and populations that rely on subsistence fishing. This mercury in fish has been attributed to upstream (non-DOE) industrial sources and natural sources (DOE 1997). The tank closure alternatives under consideration would not affect mercury concentrations in SRS waterbodies or the Savannah River.

4.1.9 TRANSPORTATION

SRS is served by more than 199 miles of primary roads and more than 995 miles of unpaved secondary roads. The primary highways used by SRS commuters are State Routes 19, 64, and 125; 40, 10, and 50 percent of the workers use these routes, respectively. Significant congestion can occur during peak traffic periods onsite on SRS Road 1-A, State Routes 19 and 125, and

U.S. Route 278 at SRS access points. Construction vehicles associated with this action would use these same routes and access points.

Cement (grout), saltstone, and sand are the different materials that could be used to fill the tanks. The trucks could come to the site with premixed fill material batched at the vendor's facility. If the Grout Option under the Clean and Stabilize Tanks Alternative were used, approximately 654 truckloads would be required to fill each waste tank, which would result in 654 round trips. The total trips for all 49 tanks would be 32,046. The Clean and Fill with Sand Option would require approximately 653 truckloads; therefore, 653 round trips would be necessary. The total trips for all 49 tanks would be 31,997. The Clean and Fill with Saltstone Option would result in approximately 19 truck loads and 19 round trips leading to 931 total trips for all the tanks. The No Action Alternative would not require any truckloads of material. Lastly, the Clean and Remove Tanks Alternative would require 5 truckloads of material, which would result in 5 round trips and 245 trips for all the tanks because only oxalic acid would be transported from offsite. See Table 4.1.9-1 for summary of data used to obtain the above information.

Assuming that the material is supplied by vendor facilities in Jackson and New Ellenton (i.e., a round-trip distance of 18 miles), closure of the tanks using each alternative would result in approximately 576,828 miles traveled for the grout fill option under the Clean and Stabilize Tanks Alternative, 575,946 miles for the sand fill option, 16,758 miles for the saltstone fill option, 0 miles for the No Action Alternative, and 4,410 miles for the Clean and Remove Tanks Alternative. Using Federal Aid Primary Highway System statistics for South Carolina for the 1986 to 1988 DOE calculated the impacts of potential transportation accidents for each alternative, which are presented in Table 4.1.9-2.

Regardless of the alternative chosen, it is anticipated that one tank would be closed at a time; therefore, the existing transportation structure would be adequate to accommodate this projected traffic volume. None of the routes associated with this transportation would require additional traffic controls and/or highway modifications. The surrounding area already has a certain volume of truck and car traffic associated with SRS logging, agriculture, and industrial activity. The amount of traffic associated with the proposed action would increase traffic volume by 0.025 percent based on traffic counts from the South Carolina Highway Department.

Table 4.1.9-1. Estimated maximum volumes of materials consumed and round trips per tank during tank closure.

		Clean and Stabilize Tanks Alternative			
Materials	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Oxalic acid (4 weight percent) (gallons)	-	225,000	225,000	225,000	500,000
Soil (cubic meters)[a]	-	170,000	170,000	170,000	356,000
Sand (gallons)	-	-	2,640,000	-	-
Cement (gallons)	-	2,640,000	-	52,800	-
Fly ash (gallons)	-	-	-	Included in saltstone	-
Boiler slag (gallons)	-	-	-		-
Additives (grout) (gallons)	-	500	-	-	-
Saltstone (gallons)	-	-	-	2,640,000	-
Round trips/tank	-	654	653	19	5

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a. Soil values represent the total volume needed for the eight tanks requiring backfill under the Clean and Stabilize Tanks Alternative and the voids for all 49 tanks under the Clean and Remove Tanks Alternative.

- = not used in that option/alternative.

Table 4.1.9-2. Estimated transportation accidents, fatalities, and injuries during tank closure.

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Accidents	NA	0.6	0.6	0.02	0.005
Fatalities	NA	0.08	0.08	0.002	0.0006
Injuries	NA	0.6	0.6	0.02	0.005

NA = Not applicable.

4.1.10 WASTE GENERATION AND DISPOSAL CAPACITY

This section describes impacts to the existing or planned SRS waste management systems resulting from closure of the HLW tank systems. Waste generation estimates are provided for each tank closure alternative that DOE considered in this EIS. Impacts are described in terms of increases in waste generation beyond that expected from other SRS activities during the same period and the potential requirements for new waste management facilities or expanded capacity at existing or planned facilities.

The SRS HLW tank systems include four tank designs (Types I, II, III, and IV). Estimates were developed for the volume of waste generated from closure of a single Type III tank system. Closure of a Type III tank system represents the maximum waste generation relative to the other tank designs. Waste generation estimates for closure of the other tank designs are assumed to be: Type I – 60 percent of Type III estimate, Type II – 80 percent of Type III estimates, and Type IV – 90 percent of Type III estimate. Table 4.1.10-1 provides estimates of the maximum annual waste generation. These annual values assume that two Type III tanks would be closed in one year. Table 4.1.10-2 provides the total waste volumes that would be generated from closure of the 49 remaining SRS HLW tank systems for each of the alternatives.

4.1.10.1 Liquid Waste

Radioactive liquid wastes would be generated as a result of tank cleaning activities under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternative. The waste consists of the spent oxalic acid cleaning solutions and water rinses. This material would be managed as part of ongoing operations in the SRS HLW management system (e.g., evaporation and treatment of the evaporator overheads in the Effluent Treatment Facility). The projected volume of radioactive liquid waste under the Clean and Stabilize Tanks Alternative is 3.4 times the forecasted SRS HLW generation through 2029 (see Section 3.9, Table 3.9-1). The projected volume under the Clean and Remove Tanks Alternative is 6.9 times the forecasted SRS HLW generation for that period. This liquid waste would contain substantially less radioactivity than HLW and would not affect the environmental impacts of tank farm operations (i.e., there would be no increase in airborne emissions or worker radiation exposure).

DOE would need to evaluate the current schedule for closure of the HLW tank systems to ensure that adequate capacity remained in the Tank Farms to manage the amount of radioactive liquid waste generated from tank cleaning activities. A *High Level Waste System Plan* (WSRC 1998) has been developed to present the integrated operating strategy for the various components (Tank Farms, DWPF, salt disposition) comprising the HLW system. The *High Level Waste System Plan* integrates budgetary information, regulatory considerations (including waste removal and closure schedules), and production planning data (e.g., projected Tank Farm influents and effluents, evaporator operations, DWPF canister production). DOE uses computer simulations to model the operation of the HLW system. The amount of available Tank Farm storage space is an important parameter in those simulations. Other elements in the HLW

Table 4.1.10-1. Maximum annual generation for the HLW tank closure alternatives.[a]

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Radioactive liquid waste (gallons)	0	600,000	600,000	600,000	1,200,000
Nonradioactive liquid waste (gallons)	0	20,000	20,000	20,000	0
Transuranic waste (cubic meters)	0	0	0	0	0
Low-level waste (cubic meters)	0	60	60	60	900
Hazardous waste (cubic meters)	0	2	2	2	2
Mixed low-level waste (cubic meters)	0	12	12	12	20
Industrial waste (cubic meters)	0	20	20	20	20
Sanitary waste (cubic meters)	0	0	0	0	0

a. Source: Johnson (1999a,b).

Table 4.1.10-2. Total estimated waste generation for the HLW tank closure alternatives.[a]

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Transuranic waste (cubic meters)	0	0	0	0	0
Low-level waste (cubic meters)	0	1,284	1,284	1,284	19,260
Hazardous waste (cubic meters)	0	42.8	42.8	42.8	42.8
Mixed low-level waste (cubic meters)	0	257	257	257	428
Industrial waste (cubic meters)	0	428	428	428	428
Sanitary waste (cubic meters)	0	0	0	0	0

a. Source: Johnson (1999a,b).

system are adjusted to ensure the Tank Farms will have adequate waste storage capacity to support operations. The *High Level Waste System Plan* assumes that a salt disposition process will be operational by the year 2010. However, if the salt disposition process startup is delayed, the tank closure schedule may need to be extended because there would not be sufficient space in the tank farms to manage the large amounts of dilute liquid wastes generated by waste removal activities. The volume of this dilute waste can readily be reduced using the tank farm evaporators. The salt disposition process should be adequate to handle the additional radioactive liquid waste volume for the most water-intensive of the HLW tank closure alternatives (Clean and Remove Tanks) without schedule delays. The bulk of this wastewater would be generated at a time when other contributors to the tank farm inventory have stopped producing waste or dramatically reduced their generation rates. Delaying startup of the salt disposition process would result in about a year-for-year slip in the current waste removal schedule with a corresponding delay in tank closures. The need for any schedule modification would be identified through the *High Level Waste System Plan.*

Nonradioactive liquid wastes would be generated under the Clean and Stabilize Tanks Alternative as a result of flushing activities associated with the preparation and transport of all the fill material. This wastewater would be managed in existing SRS treatment facilities.

4.1.10.2 Transuranic Waste

DOE does not expect to generate transuranic wastes as a result of the proposed HLW tank system closure activities.

4.1.10.3 Low-Level Waste

Under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternatives, approximately 30 cubic meters of solid low-level waste would be generated per Type III tank closure. This would consists of job control wastes (e.g., personnel protective equipment) generated from activities performed in the area of the tank top. Under the Clean and Remove Tanks Alternative, an additional 420 cubic meters of solid low-level waste would be generated as a result of each Type III tank removal. DOE assumed that any steel in direct contact with the waste would be removed (e.g., primary tank walls, cooling coils). The concrete shell and secondary containment liner would be left in place and the void space filled with soil. The steel components that are removed would be cut to a size that would fit into standard SRS low-level waste disposal boxes. The low-level waste would be disposed at existing SRS disposal facilities. The projected volume of low-level waste under the Clean and Stabilize Tanks Alternative is less than 1 percent of the forecasted SRS low-level waste generation through 2035. The projected volume under the Clean and Remove Tanks Alternative is about 11 percent of the forecasted SRS low-level waste generation for that period.

4.1.10.4 Hazardous Waste

Under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternatives, a small amount (about 1 cubic meter) of nonradioactive lead waste would be generated from each Type III tank closure. The projected volume represents less than 1 percent of the forecasted SRS hazardous waste generation through 2035.

4.1.10.5 Mixed Low-Level Waste

Under the Clean and Stabilize Tanks Alternative, about 6 cubic meters of radioactive lead waste would be generated for each Type III tank closure. A slightly larger volume (10 cubic meters) would be generated from each Type III tank closure under the Clean and Remove Tanks Alternative. These projected volumes represent 7 and 12 percent, respectively, of the forecasted SRS mixed low-level waste generation through 2035.

4.1.10.6 Industrial Waste

DOE estimates that about 10 cubic meters of industrial (nonhazardous, nonradioactive) waste would be generated for each Type III tank closure under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternatives.

4.1.10.7 Sanitary Waste

DOE does not expect to generate sanitary wastes as a result of the proposed HLW tank system closure activities.

4.1.11 UTILITIES AND ENERGY

This section describes the estimated utility and energy impacts associated with each of the HLW tank system closure alternatives that DOE considered in this EIS. Water, steam, and diesel fuel would be required to support many of the alternatives. Estimates of water use include preparation of cleaning solutions and rinsing of the tank systems. Steam is used primarily to operate the ventilation systems and to heat the cleaning solutions prior to use. Fuel consumption is based on use of diesel-powered equipment during tank closure activities. Total utility costs are also provided. The utility costs are primarily associated with fossil fuel consumption and steam generation. Water consumption is not a substantial contributor to the overall utility costs.

Table 4.1.11-1 lists the total estimated utility and energy requirements for each tank closure alternative. DOE used applicable past SRS operations or engineering judgements to estimate the utility consumption for new closure methods. The following paragraphs describe estimated utility requirements for the alternatives.

4.1.11.1 Water Use

Under the Clean and Stabilize Tanks Alternative, the estimated quantities of water are based on an assumption that three oxalic acid flushes (75,000 gallons each) and one water rinse (75,000 gallons) would be required to clean the tanks to the extent technically and economically feasible. Oxalic acid would be purchased in bulk and diluted with water to the desired strength (about 4 weight percent) prior to use in the tank farms. Under the Clean and Remove Tanks Alternative, DOE assumed that the quantities of cleaning solutions required to clean the HLW tank systems sufficiently to allow removal would be twice that required under the Clean and Stabilize Tanks Alternative. No water usage would be required under the No Action Alternative except for ballast water in those tanks that reside in the water table.

Additional water would be required for the Grout Option under the Clean and Stabilize Tanks Alternative. Water would be used to produce the reducing grout, controlled low-strength material (known as CLSM), and strong (high compressive strength) grout used to backfill the tank after cleaning is completed. Assuming a closure configuration of 5 percent reducing grout, 80 percent CLSM, and 15 percent strong grout, about 840,000 gallons of water would be required per Type III tank system (Johnson 1999c).

The largest annual water consumption, approximately 2.3 million gallons, would occur for closure of two Type III tanks in a given year. This volume represents less than 1 percent of current SRS groundwater production from industrial wells in the Tank Farms area (see Section 4.1.2.2).

Table 4.1.11-1. Total estimated utility and energy usage for the HLW tank closure alternatives.[a]

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Water (gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Electricity	NA[b]	NA	NA	NA	NA
Steam (pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (gallons)	NA	214,000	214,000	214,000	428,000
Total utility cost	NA	$4,280,000	$4,280,000	$4,280,000	$12,840,000

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a. Source: Johnson (1999a,b,c,d).

b. NA = Not applicable to this alternative. Utility and energy usage for these alternatives would not differ significantly from baseline consumption.

4.1.11.2 Electricity Use

DOE assumed that there would be no significant additional electrical usage beyond that associated with current tank farm operations. This assumption is supported by DOE's closure of Tanks 17 and 20. Major power requirements associated with the HLW tank closure activities would be met by the use of diesel-powered equipment. Fuel consumption to power the equipment is addressed in Section 4.1.11.4.

4.1.11.3 Steam Use

The two main uses for steam are operation of the ventilation systems on the waste tanks during closure operations and heating of the cleaning solutions prior to use. Operation of the ventilation system uses about 100,000 pounds of 15 psig (pounds per square inch above atmospheric pressure) steam per year. The ventilation system operates as part of current tank farm operations. Thus, steam usage by the ventilation system was not included in this evaluation of tank closure alternatives.

Under the Clean and Stabilize Tanks Alternative, heating of the oxalic acid cleaning solution would use about 200,000 pounds of 150 psig steam per Type III tank system. The Clean and Remove Tanks Alternative would require twice as much oxalic acid cleaning solution and therefore would use twice (400,000 pounds per Type III tank system) as much steam as the Clean and Stabilize Tanks Alternative. There would be no additional steam requirements for the No Action Alternative (Johnson 1999c).

4.1.11.4 Diesel Fuel Use

Major power requirements would be covered by the use of diesel-powered equipment. Approximately 5,000 gallons of diesel fuel would be required for each Type III tank system closure under the Clean and Stabilize Tanks Alternative. The Clean and Remove Tanks Alternative would have twice the number of equipment operating hours as the Clean and Stabilize Tanks Alternative and would use 10,000 gallons of diesel fuel per Type III tank system closure. There would be no additional diesel fuel requirements for the No Action Alternative (Johnson 1999c,d).

4.1.12 ACCIDENT ANALYSIS

This section summarizes risks to the public and workers from potential accidents associated with the various alternatives for HLW tank closure at the SRS.

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as a human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of materials released. Initiating events fall into three categories:

- *Internal initiators* normally originate in and around the facility but are always a result of facility operations. Examples include equipment or structural failures and human errors.

- *External initiators* are independent of facility operations and normally originate from outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.

- *Natural phenomena initiators* are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, lightning, and snow. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

Table 4.1.12-1 summarizes the estimated impacts to workers and the public from potential accidents for each HLW tank closure alternative. Appendix B contains details of each accident, including the scenario description, probability, source term, and consequence. Table 4.1.12-1 lists potential accident consequences as latent cancer fatalities, without consideration of the accident's probability. Accidents involving nonradiological, hazardous materials were evaluated in Appendix B; however, these other accidents were shown to result in no significant impacts to the onsite or offsite receptors. Therefore, the accidents contained in Table 4.1.12-1 are limited to those involving the release of radiological materials.

DOE estimated impacts to three receptors: (1) a noninvolved worker 2,100 feet from the accident location, (2) the maximally exposed individual at the SRS boundary, and (3) the offsite population within 50 miles. DOE did not evaluate total dose to noninvolved worker population due the speculative nature of worker locations at the site.

DOE identified potential accidents in Yeung (1999) and estimated impacts using the AXAIRQ computer model (Simpkins 1995a,b), as discussed in Appendix B.

For all of the accidents, there is a potential for injury or death to involved workers in the vicinity of the accident. In some cases, the impacts to the involved worker would be greater than to the noninvolved worker. However, prediction of latent potential health effects becomes increasingly difficult to quantify as the distance between the accident location and the receptor decreases because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The worker also may be acutely injured or killed by physical effects of the accident itself.

Table 4.1.12-1. Estimated accident consequences by alternative.

		Consequences					
Alternative	Accident frequency	Noninvolved worker (rem)	Latent cancer fatalities	Maximally exposed offsite individual (rem)	Latent cancer fatalities	Offsite population (person-rem)	Latent cancer fatalities
Clean and Stabilize Tanks Alternative							
Transfer errors during cleaning	Once in 1,000 years	7.3	2.9×10^{-3}	0.12	6.0×10^{-5}	5,500	2.8
Seismic event (DBE)[a] during cleaning	Once in 53,000 years	15	6.0×10^{-3}	0.24	1.2×10^{-4}	11,000	5.5
Failure of Salt Solution Hold Tank (Clean and Fill with Saltstone Option only)	Once in 20,000 years	0.02	8.0×10^{-6}	2.1	2.1×10^{-7}	17	8.4×10^{-3}
Clean and Remove Tanks Alternative							
Transfer errors during cleaning	Once in 1,000 years	7.3	2.9×10^{-3}	0.12	6.0×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	Once in 53,000 years	15	6.0×10^{-3}	0.24	1.2×10^{-4}	11,000	5.5

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a. DBE = Design basis earthquake.

4.2 Long-Term Impacts

Section 4.2 presents a discussion of impacts associated with residual radioactive and non-radioactive material remaining in the closed HLW tanks. DOE has estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a long time span (10,000 years) to determine when certain measures of impacts (e.g., radiation dose) reach their peak value. More details on the methodology for long-term closure modeling analysis, and the uncertainties associated with this long-term modeling, are provided in Appendix C. The overall methodology for this long-term closure modeling is the same as the modeling used in the closure modules for Tanks 17 and 20 (DOE 1997a,b), which have been approved by SCDHEC and EPA Region IV. DOE intends to restrict the area around the tank farms from residential use for the entire 10,000-year period of analysis but has also assessed the potential impacts if institutional controls are lost and residents move into or intruders enter the tank farm areas.

Certain resources involve no long-term impacts and therefore are not included in the long-term analysis. These include air resources, socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, and utilities and energy. Therefore, Section 4.2 presents impacts only for the following discipline areas: geologic resources, water resources, ecological resources, land use, and public health.

If the Clean and Remove Tanks Alternative were chosen, residual waste would be removed from the tanks and the tanks systems themselves would be removed and transported to SRS waste disposal facilities. Long-term impacts at these facilities are evaluated in the Savannah River Site Waste Management EIS (DOE/EIS-0217) (DOE 1995). The long-term impacts of low-level waste disposal in low-activity vaults presented in the SRS Waste Management EIS are approximately one-one thousandth of the long-term tank closure impacts presented in this EIS for water resources and public health and are incorporated into Section 4.2 of this EIS by reference.

4.2.1 GEOLOGIC RESOURCES

No geologic deposits within F- and H-Areas have been economically or industrially developed, and none are known to have significant potential for development. The Clean and Remove Tanks Alternative would result in backfilling the tank excavations. Because the backfill material would be locally derived from borrow pits at SRS (see Section 4.1.1), it is assumed to be similar to the natural soils and sediments encountered in the excavations; therefore, no long-term impacts to geologic deposits would occur.

The other tank closure alternatives include closing the tanks in place, which would result in residual waste remaining in the tanks. Upon failure of the tanks as determined by each of the alternatives described in Appendix C, the waste in the tanks would have the potential to contaminate the surrounding soils. The inventory and concentration of the residual waste is expected to be less than that listed in Appendix C, Tables C.3.1-1 and C.3.1-2, which are based on conservative assumptions for the waste that would remain in the tanks after waste removal and washing. The residual waste has the potential to contaminate percolating groundwater at some point in the future due to leaching. The water-borne transport of contaminants would contaminate geologic deposits that lie below the tanks. The contamination would not result in any significant physical alteration of the geologic deposits. Filling the closed-in-place tanks with ballast water, sand, saltstone, or grout may also increase the infiltration of precipitation at some point in the future, allowing a greater percolation of water into the underlying geologic deposits. No detrimental effect on surface soils, topography, or to the structural or load-bearing properties of geologic deposits would occur from these actions. There are no anticipated long-term impacts to geologic resources from the Clean and Remove Tanks Alternative. The No Action Alternative and all options under the Clean and Stabilize Tanks Alternative would allow the soils in the vicinity of the tanks to be impacted.

4.2.2 WATER RESOURCES

4.2.2.1 Surface Water

Because the No Action Alternative and Clean and Stabilize Tanks Alternative would leave some residual radioactive and non-radioactive material in waste tanks, the potential would exist for long-term impacts to groundwater. Contaminants in groundwater could then be transported through the Water Table, Barnwell-McBean, or Congaree Aquifers to the seeplines along Fourmile Branch and Upper Three Runs, respectively (see Section 4.2.2.2 for a more detailed discussion). The factors governing the movement of contaminants through groundwater (i.e., the hydraulic conductivity, hydraulic gradient, and effective porosity of aquifers in the area) and the processes resulting in attenuation of radiological and non-radiological contaminants (i.e., radioactive decay, ion exchange in the soil, and adsorption to soil particles) would be expected to mitigate subsequent impacts to surface water resources.

DOE used the Multimedia Environmental Pollution Assessment System (MEPAS) computer code (Buck et at. 1995) to model the fate and transport of contaminants in groundwater and subsequent flux to surface waters. Maximum annual concentrations of contaminants at various locations) were estimated and compared to appropriate water quality criteria for the protection of aquatic life.

EPA periodically publishes water quality criteria, which are concentrations of substances that are known to affect "diversity, productivity, and stability" of aquatic communities including "plankton, fish, shellfish, and wildlife" (EPA 1986, 1999). These recommended criteria provide guidance for state regulatory agencies in the development of location-specific water quality standards to protect aquatic life (SCDHEC 1999). Such standards are used in implementing a number of environmental programs, including setting discharge limits in NPDES permits. Water quality criteria and standards are generally not legally enforceable; however, NPDES discharge limits based on these criteria and standards are legally binding and are enforced by SCDHEC.

The results of the fate and transport modeling of non-radiological contaminants are presented in Tables 4.2.2-1 (Upper Three Runs) and 4.2.2-2 (Fourmile Branch). Based on the modeling, any of the three tank stabilization options under the Clean and Stabilize Tanks Alternative would be effective in limiting the movement of residual contaminants in closed tanks to nearby streams via groundwater. Concentrations of non-radiological contaminants moving to Upper Three Runs via the Upper Three Runs seepline would be minuscule, in all cases several times lower than applicable standards. Concentrations of non-radiological contaminants reaching Fourmile Branch via the Fourmile Branch seepline would also be low under the Clean and Stabilize Tanks Alternative. Concentrations of contaminants reaching Upper Three Runs and Fourmile Branch would be low under the No Action Alternative as well, but somewhat higher than those expected under the Clean and Stabilize Tanks Alternative. In all instances, predicted concentrations of non-radiological contaminants were well below applicable water quality standards.

Based on the modeling results, all three stabilization options under the Clean and Stabilize Tanks Alternative would be more effective than the No Action Alternative. The Clean and Fill with Grout Option would be most effective of the three tank stabilization options under the Clean and Stabilize Tanks Alternative for reducing contaminant migration to surface water.

Table 4.2.2-3 shows maximum radiation doses to humans in surface (drinking) water at the points of compliance for Upper Three Runs and Fourmile Branch. Doses are low under all three tank stabilization options, and are well below the drinking water standard of 4 millirem per year (40 CFR 141.16). The 4 millirem per year standard applies only to beta- and gamma-emitting radionuclides, but since the total dose is less than 4 millirem per year, then the standard is met. The DOE dose limit for native aquatic animals is 1 rad per day from exposure to radio-

Table 4.2.2-1. Maximum concentrations of non-radiological constituents of concern in Upper Three Runs (milligrams/liter).

	Clean and Stabilize Tanks Alternative					
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Water Quality Criteria[a] Acute	Water Quality Criteria[a] Chronic
Aluminum	(b)	(b)	(b)	(b)	0.750	0.087
Chromium IV	(b)	(b)	(b)	(b)	0.016	0.011
Copper	(b)	(b)	(b)	(b)	0.0092	0.0065
Iron	(b)	(b)	(b)	3.7×10^{-5}	2.000	1.000
Lead	(b)	(b)	(b)	(b)	0.034	0.0013
Mercury	(b)	(b)	(b)	(b)	0.0024	1.2×10^{-5}
Nickel	(b)	(b)	(b)	(b)	0.790	0.088
Silver	(b)	(b)	(b)	1.2×10^{-6}	0.0012	-----

a. Criteria to Protect Aquatic Life (SCR. 61-68, Appendix 1).
b. Concentration less than 1.0×10^{-6} milligrams/liter.

Table 4.2.2-2. Maximum concentrations of non-radiological constituents of concern in Fourmile Branch (milligram/liter).

	Clean and Stabilize Tanks Alternative					
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Water Quality Criteria[a] Acute	Water Quality Criteria[a] Chronic
Aluminum	(b)	(b)	(b)	(b)	0.750	0.087
Chromium IV	(b)	(b)	(b)	(b)	0.016	0.011
Copper	(b)	(b)	(b)	(b)	0.0092	0.0065
Iron	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	4.9×10^{-4}	2.000	1.000
Lead	(b)	(b)	(b)	(b)	0.034	0.0013
Mercury	(b)	(b)	(b)	(b)	0.0024	1.2×10^{-5}
Nickel	(b)	(b)	(b)	(b)	0.790	0.088
Silver	8.8×10^{-6}	6.5×10^{-6}	8.8×10^{-6}	1.1×10^{-4}	0.0012	-----

a. Criteria to Protect Aquatic Life (SC R. 61-68, Appendix 1).
b. Concentration less than 1.0×10^{-6} milligram/liter.

Table 4.2.2-3. Maximum drinking water dose from radionuclides in surface water (millirem/year).

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Upper Three Runs	(a)	4.3×10^{-3}	9.6×10^{-3}	0.45
Fourmile Branch	9.8×10^{-3}	0.019	0.130	2.3

Radiation dose for this alternative is less than 1×10^{-3} millirem.

active materials in liquid wastes discharged to natural waterways (DOE Order 5400.5). The absorbed dose (see Table 4.2.3-3) from surface water would be a small fraction of the DOE dose limit under any of the alternatives, including No Action.

4.2.2.2 Groundwater

Contamination Source

Waste remaining in tanks as a result of the closure alternatives has been identified as the primary source for long-term impacts to groundwater quality. The physical configurations of the waste after closure and the chemical parameters associated with the resulting contamination source zone would, however, vary between the closure alternatives. The in-place closure alternatives consist of the following:

- No Action Alternative (bulk waste removal and fill with ballast water)
- Clean and Stabilize Tanks Alternative
  - Clean and Fill with Grout Option (Preferred Alternative)
  - Clean and Fill with Sand Option
  - Clean and Fill with Saltstone Option

For the No Action Alternative, the contaminant inventory would be the highest because this alternative would not provide for tank cleaning following bulk waste removal. In addition, filling the tanks with ballast water would allow for the immediate generation of a large volume of contaminated leachate. For the three tank stabilization options under the Clean and Stabilize Tanks Alternative, cleaning of the tanks would result in lower initial volume and inventory of contaminants in the residual waste prior to filling. The Clean and Fill with Grout Option would produce a source zone that consists of the residual waste covered by a low-permeability reducing grout. The grout fill would lower the water infiltration until failure and would reduce the leach rate of chemicals compared to the other options. The source zone for this option, therefore, would have more time to undergo radioactive decay prior to tank failure compared to the other alternatives. The Clean and Fill with Sand Option would result in little physical alteration of the residual waste in the tanks other than some mixing and an overall increase in the volume of contaminated material. This option also would result in a higher leaching rate than the Clean and Fill with Grout or Saltstone Options. The Clean and Fill with Saltstone Option would bind the residual waste and create a low-permeability zone compared to natural soils; however, the overall magnitude of the source term would be increased due to the presence of background contamination in the saltstone medium.

The evaluation and comparison of the in-place closure alternatives uses the results of long-term groundwater fate and transport modeling to interpret the potential impacts to groundwater resources beneath the F- and H-Area Tank Farms for each of the alternatives. Areas within the groundwater migration pathway to the downgradient point of compliance (the seepline along Upper Three Runs and Fourmile Branch, located approximately 1,200 meters downgradient of F-Area Tank Farm and approximately 1,800 meters downgradient of H-Area Tank Farm) are also included in the evaluation. The analysis also presents the impacts to groundwater at 1 meter and 100 meters downgradient of the tank farm. Impacts are presented in tables in the following sections that compare the predicted (i.e., modeled) groundwater concentrations to regulatory limits or established SRS guidelines for the various contaminants of interest.

The tank farms were modeled assuming conditions that would exist after tank closure for each of the alternatives that included closure of the tanks in place. The identity and level of residual contaminants in each tank were derived from data provided by Johnson (1999).

Each of the closure alternatives proposed in Chapter 2 except for tank removal includes actions that may result in potential long-term impacts to groundwater beneath the tank farms. Because groundwater is in a state of constant flux, impacts that occur directly above or below the tank farms may propagate to areas hydraulically downgradient of the tank farms. The primary action that would result in long-term impacts to groundwater is in-place tank closure that would result in some quantity of residual waste material remaining in the tanks. The residual waste has the potential to contaminate groundwater at some point in the future due to leaching and water-borne transport of contaminants.

The tank farms are situated in highly developed industrial areas. Some of the tank groups were constructed in pits substantially lower in elevation than the surrounding terrain. The existing tank farm sites, therefore, include facilities and structures designed to prevent surface ponding and to manage precipitation runoff in a controlled manner. Reclamation of the tank farms after closure would require backfilling and grading to provide a suitable site for future industrial/commercial development, to prevent future ponding of water at the surface, and to promote non-erosional surface water runoff. Backfilling and grading would be performed using borrow material derived from local areas at the SRS (see Section 4.1.1). The material is assumed to be physically similar to the in-place materials. Therefore, there should be little or no impact to long-term groundwater recharge or quality as a result of the surface reclamation activities. Because the tanks would be completely removed from service at closure, there are no other long-term operations at the tank farms that could potentially impact groundwater resources.

Modeling Methodology

The modeling results are used to predict whether each closure alternative and option would meet the identified regulatory and SRS water quality criteria at the point of compliance. This process addresses the cumulative effect of all the tanks in a tank farm whose plumes may intersect. Because of the physical separation of the F- and H-Area Tank Farms and the hydrogeologic setting, no overlapping of plumes from the two tank farms is anticipated. The presence of a groundwater divide that runs through the H-Area Tank Farm required a separation of the tank groups in the H-Area. This separation was necessary to identify impacts at various locations that are separated in both space and time as a result of the various groundwater flow directions and paths that leave different areas of the H-Area Tank Farm. Therefore the analysis and presentation of results are provided on a tank-farm or tank-grouping basis for each alternative.

Modeling the fate and transport of contaminants was performed using the Multimedia Environmental Pollutant Assessment System (MEPAS) computer model (Buck et al. 1995). The program is EPA-recognized and uses analytical methods to model the transport of contaminants from a source unit to any point at which the user desires to calculate the concentration. The modeling effort requires certain assumptions about the contaminant source term, source configuration, and hydrogeologic structure of the area between each of the tank farms, or tank groups, and the point where impacts are evaluated. Appendix C presents the major assumptions and inputs used in modeling concentrations of contaminants.

To account for overlapping of the contaminant plumes from separate tank groups that discharge to the same location, the modeled groundwater concentrations were summed as if the various tank groups were at the same initial physical location. Because of the size of the tank groups and the length of the groundwater flow paths, sensitivity analyses showed that the actual location of the contaminant source within the tank group had little impact at the point of analysis at the seepline. The impact analysis also summed the centerline concentrations from each tank-group plume at the point of analysis to ensure that the highest concentration was reported. Therefore, although the plumes from different tank groups may not overlap entirely, the calculation methodology provides an upper estimate for the predicted groundwater impacts. The simplification of treating all the tanks in a group as if they are at the same physical location has the effect of greatly exaggerating estimated groundwater concentrations and doses at close-in locations, including 1-meter and 100-meter wells.

For all of the tank groups in F-Area and for several groups in H-Area, the historical water level data showed that the tank bottoms are elevated above the zone of groundwater saturation. For these tanks, the modeling simulated leaching of contaminants from the waste zone and vertical migration to the water table. It was observed that some tank groups in the H-Area tank farm, due to their installation depth and the presence of a local high in the water table, lie partially or nearly entirely in the zone of groundwater saturation. The modeling simulation was adjusted for these sites to account for submergence of the contamination source zone.

Groundwater Quality Impacts

As described in detail in Appendix C, groundwater flowing beneath the tank farms flows in different directions and includes vertical flow components. In the analyzed alternatives, the mobile contaminants in the tanks would gradually migrate downward through unsaturated soil to the hydrogeologic units comprising the shallow aquifers underlying the tank farms. As identified above, because some tank groups in the H-Area lie beneath the water table, the contaminants from these tanks would be released directly into the groundwater.

The first hydrogeologic unit impacted would be the Water Table Aquifer formally known as the upper zone of the Upper Three Runs Aquifer (Aadland et al. 1995). Some contaminants from each tank farm would be transported by groundwater through the Water Table Aquifer to the seepline along Fourmile Branch. For tanks situated north of the groundwater divide in the H-Area Tank Farm, contaminants released to the Water Table Aquifer may discharge to unnamed tributaries of Upper Three Runs or migrate downward to underlying aquifers. Previous DOE modeling results for this portion of H-Area, (GeoTrans 1993), from which the model inputs were based, showed that approximately 73 percent of the contaminant mass released from these tanks would remain in the Water Table and Barnwell-McBean Aquifers and 27 percent would migrate to the Congaree Aquifer (i.e., Gordon Aquifer) to a point of discharge along Upper Three Runs.

For tank groups located in the F-Area and for tank groups located south of the groundwater divide in H-Area, the contaminant mass released was simulated to migrate both laterally and vertically based on the hydrogeologic setting. Previous DOE modeling results for F-Area (GeoTrans 1993), from which the model inputs were derived, showed that approximately 96 percent of the contaminant mass released from the F-Area tanks would remain in the Water Table and Barnwell-McBean Aquifers and would discharge at the seepline along lower Fourmile Branch. Previous DOE modeling results for H-Area (GeoTrans 1993) showed that approximately 78 percent of the released contaminant mass would remain in the Water Table and Barnwell-McBean Aquifers and would discharge at the seepline along upper Fourmile Branch. The remaining 22 percent of contaminant mass released from the H-Area tanks was simulated as migrating downward and laterally through the Congaree Aquifer to a point of discharge at the seepline along Upper Three Runs.

Summary of Estimated Concentrations

The results of the groundwater fate and transport modeling for radiological and non-radiological contaminants for each tank farm are presented in Tables 4.2.2-4 through 4.2.2-8. The modeling calculated impacts for each aquifer layer. Because the concentrations in groundwater from the various aquifers are not additive, only the maximum value is presented in the tables. The results are presented for each alternative for the 1-meter and 100-meter wells, and for the seepline. Figure 4.2.2-1 illustrates some of the same results graphically. This figure shows the predicted concentrations over time at the Three Runs seepline (north of the groundwater divide) resulting from contamination transported from the H-Area Tank Farm through the Water Table and Barnwell-McBean Aquifers. Results at the other modeled exposure locations show similar patterns over time. The pattern of the peaks in the graph results from the simplified and conservative approach used in modeling, such as the simplifying assumption that the tanks would release their entire inventories simultaneously and completely. The specific concentrations for each radiological and nonradiological contami-

Table 4.2.2-4. Maximum radiological groundwater concentrations from contaminant transport from F-Area Tank Farm.[a]

		Clean and Stabilize Tanks Alternative		
Radiological emitter - exposure point	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Drinking water dose (millirem/yr)				
1-meter well	35,000	130	420	790
100-meter well	14,000	51	190	510
Seepline	430	1.9	3.5	25
Maximum Contaminant Level (millirem/yr)	4	4	4	4
Alpha concentration (picocuries per liter)				
1-meter well	1,700	13	13	13
100-meter well	530	4.8	4.7	4.8
Seepline	9.2	0.04	0.039	0.04
Maximum Contaminant Level (pCi/liter)	15	15	15	15

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a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

Table 4.2.2-5. Maximum radiological groundwater concentrations from contaminant transport from H-Area Tank Farm.[a]

		Clean and Stabilize Tanks Alternative		
Radiological emitter - exposure point	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Drinking water dose (millirem/yr)				
1-meter well	9.3×10^6	1×10^5	1.3×10^5	1×10^5
100-meter well	9.0×10^4	300	920	870
Seepline, North of Groundwater Divide	2,500	2.5	25	46
Seepline, South of Groundwater Divide	200	0.95	1.4	16
Maximum Contaminant Level (millirem/yr)	4	4	4	4
Alpha Concentration (picocuries per liter)				
1-meter well	13,000	24	290	24
100-meter well	3,800	7.0	38	7.0
Seepline, North of Groundwater Divide	34	0.15	0.33	0.15
Seepline, South of Groundwater Divide	4.9	0.02	0.019	0.02
Maximum Contaminant Level (pCi/liter)	15	15	15	15

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a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Management EIS (DOE 1995).

Table 4.2.2-6. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Area Tank Farm, 1-meter well.[a]

	Maximum concentration (percent of MCL)				
	Barium	Fluoride	Chromium	Mercury	Nitrate
No Action Alternative					
Water Table	0.0	18.5	320	6,500	150
Barnwell McBean	0.0	47.5	380	0.0	270
Congaree	0.0	6.8	0.0	0.0	62
Clean and Fill with Grout Option					
Water Table	0.0	0.3	21	70	2.3
Barnwell McBean	0.0	5	23	0.0	21
Congaree	0.0	0.1	0.0	0.0	0.5
Clean and Fill with Sand Option					
Water Table	0.0	1.6	8.5	37	6.7
Barnwell McBean	0.0	5.3	19	0.0	22
Congaree	0.0	0.1	0.0	0.0	0.7
Clean and Fill with Saltstone Option					
Water Table	0.0	0.3	21	70	240,000
Barnwell McBean	0.0	5	23	0.0	440,000
Congaree	0.0	0.1	0.0	0.0	160,000

Notes: MCL = Maximum Contaminant Level. Only those contaminants with current EPA Primary Drinking Water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

Table 4.2.2-7. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Area Tank Farm, 100-meter well.[a]

	Maximum concentration (percent of MCL)				
100-Meter well	Barium	Fluoride	Chromium	Mercury	Nitrate
No Action Alternative					
Water Table	0.0	8.3	74	265	69
Barnwell McBean	0.0	12.5	81	0.0	58
Congaree	0.0	1.2	0.0	0.0	11
Clean and Fill with Grout Option					
Water Table	0.0	0.1	2.7	1.5	0.7
Barnwell McBean	0.0	1.1	4.4	0.0	4.7
Congaree	0.0	0.0	0.0	0.0	0.1
Clean and Fill with Sand Option					
Water Table	0.0	0.3	1.5	2.7	1.3
Barnwell McBean	0.0	1.2	3.7	0.0	4.9
Congaree	0.0	0.0	0.0	0.0	0.1
Clean and Fill with Saltstone Option					
Water Table	0.0	0.1	2.7	1.5	68,000
Barnwell McBean	0.0	1.1	4.4	0.0	180,000
Congaree	0.0	0.0	0.0	0.0	21,000

Notes: MCL = Maximum Contaminant Level. Only those contaminants with current EPA Primary Drinking Water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

Table 4.2.2-8. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Area Tank Farm, seepline.[a]

Fourmile Branch seepline	Maximum concentration (percent of MCL)				
	Barium	Fluoride	Chromium	Mercury	Nitrate
No Action Alternative					
Water Table	0.0	0.4	1.0	0.0	3.4
Barnwell McBean	0.0	0.5	0.8	0.0	2.4
Congaree	0.0	0.0	0.0	0.0	0.1
Clean and Fill with Grout Option					
Water Table	0.0	0.0	0.0	0.0	0.0
Barnwell McBean	0.0	0.0	0.0	0.0	0.1
Congaree	0.0	0.0	0.0	0.0	0.0
Clean and Fill with Sand Option					
Water Table	0.0	0.0	0.0	0.0	0.1
Barnwell McBean	0.0	0.0	0.0	0.0	0.2
Congaree	0.0	0.0	0.0	0.0	0.0
Clean and Fill with Saltstone Option					
Water Table	0.0	0.0	0.0	0.0	3,000
Barnwell McBean	0.0	0.0	0.0	0.0	3,300
Congaree	0.0	0.0	0.0	0.0	300

Notes: Only those contaminants with current EPA Primary Drinking Water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration.

[a] The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

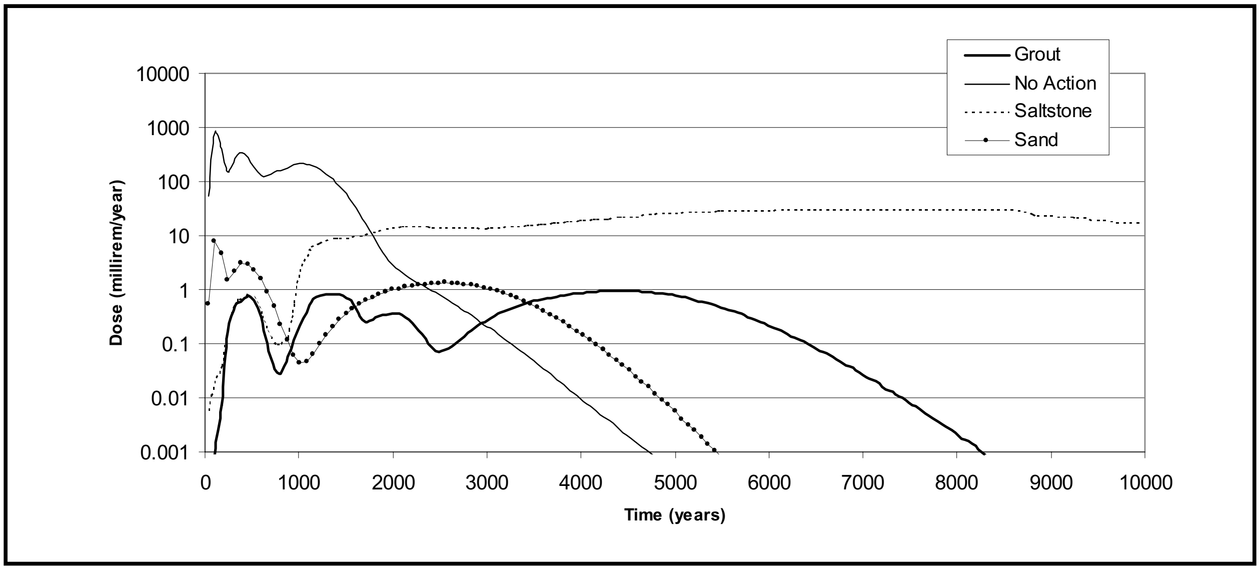

Figure 4.2.2-1 Predicted Drinking Water Dose Over Time at the H-Area Seepline North of the Groundwater Divide in the Barnwell-McBean and Water Table Aquifers.

nant for each aquifer layer and each exposure point are presented in Appendix C. For radiological contaminants, the dose in millirem per year from all radionuclides or the concentration of all alpha-emitting radionuclides are considered additive for any given aquifer layer at any exposure point. The maximum radiation dose (millirem per year) and maximum alpha concentration (picocuries per liter) regardless of the aquifer layer, therefore, are presented in the tables for each exposure point. This data represents the increment in time when the sum of all beta-gamma or alpha emitters is greatest but not necessarily when each species is at its maximum concentration. This method of data presentation shows the overall maximum dose or concentration that occurs at each exposure point.

For nonradiological contaminants the effects of the contaminants are not considered to be additive. The maximum concentration of each nonradiological contaminant, regardless of time, was determined for each aquifer layer and for each exposure point. Only those contaminants with current EPA Drinking Water Standard Maximum Contaminant Levels are shown on the tables. For comparison between the different alternatives the maximum value for each nonradiological contaminant was converted to its percentage of the Maximum Contaminant Level. This value provides a streamlined, quantitative method of comparing the impacts of the maximum concentrations for each alternative.

Comparison of Alternatives

The radiological results provided in Tables 4.2.2-4 through 4.2.2-5 and illustrated in Figure 4.2.2-1 consistently show that the greatest long-term impacts occur under the No Action Alternative. For this alternative, the Maximum Contaminant Level for beta-gamma radionuclides is exceeded at all points of exposure. On the other hand, the Clean and Fill with Grout Option shows the lowest-long term impacts at all exposure points, and the Maximum Contaminant Level for beta-gamma radionuclides is met at the seepline for this alternative. Also, Figure 4.2.2-1 shows that impacts would occur later than under the No-Action Alternative or the Clean and Fill with Sand Option. Peak dose under the Clean and Fill with Sand Alternative would be less than under the No-Action Alternative and the Maximum Contaminant Level would be met at the seepline, but doses would be greater than under the Clean and Fill with Grout Option and would occur sooner. Like the Clean and Fill with Sand Option, the Clean and Fill with Saltstone Option would delay the impacts at the seepline, but it would result in a higher peak dose than either the Clean and Fill with Grout or Clean and Fill with Sand Options (the peak dose under this alternative would exceed the Maximum Contaminant Level at the seepline) and the peak doses would persist for a very long time due to the release of other radiological constituents from the saltstone.

The results for alpha-emitting radionuclides shown in Tables 4.2.2-4 through 4.2.2-5 also show that the greatest long-term impacts would occur for the No Action Alternative. For this alternative, the Maximum Contaminant Level is exceeded at the 1-meter and 100-meter wells. The grout, sand, and saltstone fill options show similar impacts at all most locations. For these three options, the Maximum Contaminant Level for alpha-emitting radionuclides would be exceeded only at the 1-meter well (all three options) and at the 100-meter well (Clean and Fill with Sand Option).

The non-radiological results presented in Tables 4.2.2-6 through 4.2.2-8 show a consistent trend for all points of exposure. Unlike the radiological results, however, the data show exceedances of the Maximum Contaminant Levels only for the No Action Alternative and Clean and Fill with Saltstone Option. The impacts are greatest in terms of the variety of contaminants that exceed the Maximum Contaminant Level for the No Action Alternative, but exceedances of the Maximum Contaminant Levels primarily occur at the 1-meter well. Impacts from the Clean and Fill with Saltstone Option occur at all exposure points, including the seepline; however, nitrate is the only contaminant that exceeds the Maximum Contaminant Level. This occurs because the saltstone would contain large quantities of nitrate that would not be present in the tank residual. The Maximum Contaminant Levels are not exceeded for any contaminant in any aquifer layer, at any point of exposure, for either the Clean and Fill with Grout or the Clean and Fill with Sand Options.

4.2.3 ECOLOGICAL RESOURCES

This section presents an evaluation of the potential long-term impacts of F- and H-Area Tank Farm closure to ecological receptors. DOE assessed the potential risks to ecological receptors at groundwater points of discharge (seeplines) to Upper Three Runs and Fourmile Branch, and the risks to ecological receptors in these streams downstream of the seeplines. This section presents a summary of this analysis; the detailed assessment is provided in Appendix C.

Groundwater-to-surface water discharge of tank farm-related contaminants was the only migration pathway evaluated because the closed tanks would be 4 to 7 meters underground, precluding overland runoff of contaminants and associated terrestrial risks. As a result, only aquatic and semi-aquatic receptors and associated risks were evaluated.

The habitat in the vicinity of the seeplines is bottomland hardwood forest. On the upslope side of the bottomland, the forest becomes a mixture of pine and hardwood.

The estimated 1.24 acre seepage areas are small, (DOE 1997a), so risk to plant populations would be negligible even if individual plants were harmed. The only case in which harm to individual plants might be a concern in such a small area would be if protected plant species are present. Because no protected plant species are known to occur in these areas, risks to terrestrial plants are not treated further in the risk assessment.

4.2.3.1 Non-radiological Contaminants

Exposure for aquatic receptors (e.g., fish, aquatic invertebrates) is expressed as the concentration of contaminants in the water surrounding them. Sediment can become contaminated from the influence of the surface water or from seepage that enters sediment directly. However, this exposure medium was not evaluated because estimating sediment contamination from surface water inputs would be highly speculative and seepage into sediment is not considered in the groundwater model; all of the transported material is assumed to come out at the seeplines. For aquatic receptors, risks were evaluated by comparing concentrations of contaminants in surface water downgradient of seeps with ecological screening guidelines indicative of potential risks to aquatic receptors. Guidelines used are presented in Appendix C. If the ratio of the surface water concentration to the guideline (called the “hazard quotient”) exceeded 1.0, risks to aquatic receptors were considered possible.

Exposure for terrestrial (semi-aquatic) receptors is based on dose, expressed as milligrams of contaminant absorbed per kilogram of body mass per day. For this evaluation, the southern short-tailed shrew and mink were selected as representative receptors (see Appendix C). The exposure routes used for estimating dose were ingestion of food and water. The food of shrews is mainly soil invertebrates, and the mink eats small mammals, fish, and a variety of other small animals. Contaminants in seepage water were considered to be directly ingested as drinking water (shrew); ingested as drinking water after dilution in Fourmile Branch and Upper Three Runs (mink); ingested in aquatic prey (mink); and transferred to soil, soil invertebrates, shrews, and to mink through a simple terrestrial food chain. The short-tailed shrew was assumed to receive exposure at the seepline only, and the mink was modeled as obtaining half of its diet from shrews at the seep area and the other half from aquatic prey downstream of the seepline. The bioaccumulation factor for soil and soil invertebrates is 1.0 for all inorganics, as is the factor for accumulation in shrew tissue. Literature-based bioconcentration factors were used to estimate chemical concentrations in aquatic prey for the mink (see Appendix C).

For the short-tailed shrew and the mink, toxicity thresholds are based on the lowest oral doses found in the literature that are no-observed-adverse-effect-levels (NOAELs) or lowest-observed-adverse-effect-levels (LOAELs) for chronic endpoints that could affect population viability or fitness (Appendix C). Usually the endpoints are adverse effects on reproduction or development. The exposure calculation is a ratio of total contaminant intake to body mass, on a daily basis. This dose is divided by the toxicity threshold value to obtain a hazard quotient. Similar to the ratio used for the aquatic receptors, risks were considered possible when the ratio of the estimated dose to the toxicity threshold (hazard quotient) exceeded 1.0.

Potential risks were evaluated for all of the analyzed scenarios, which are described in Appendix C. Each of the scenarios was evaluated using four methods for tank stabilization, which include the Clean and Fill with Grout Option, the Clean and Fill with Sand Option, the Clean and Fill with Saltstone Option, and the No Action Alternative (no stabilization). Comprehensive lists of all hazard quotients for each analyzed scenario are presented in Appendix C. Table 4.2.3-1 presents a summary of the maximum hazard indices (HIs) for aquatic receptors by tank stabilization method. Hazard quotients for individual aquatic contaminants were summed to obtain HIs. All HI values for the Clean and Fill with Sand and Saltstone Options were less than 1.0, indicating negligible risks to aquatic receptors in Fourmile Branch and Upper Three Runs. The maximum HIs for the Clean and Fill with Grout Option and No Action Alternative were slightly greater than 1.0. As a result, risks to aquatic receptors are possible. However, the relatively low HI values indicate that although risks are present, they are somewhat low. Although no guidance exists regarding the interpretation of the magnitude of HI values, given the conservation inherent in all aspects of the assessment single-digit HI values are most likely associated with low risks.

Table 4.2.3-2 presents a summary of the hazard quotients for the short-tailed shrew and mink by tank stabilization method. All terrestrial HQs were less than 1.0 for the grout, sand, and saltstone options, suggesting negligible risks to the shrew and mink (and similar species). The maximum HQ for silver for the No Action Alternative was slightly greater than 1.0. Hence, some risks are possible. Nevertheless, the relatively low maximum HQ suggests generally low risks.

As noted in Section 3.4, no Federally – listed species are known to occur in the vicinity of the F- and H-Area Tank Farms, and none have been recorded near the Upper Three Runs and Fourmile Branch seeplines. The American alligator (threatened due to similarity of appearance to the American crocodile) is the only Federally – protected species that could potentially occur in the area of the seeplines. Given that no Federally – listed species are believed to be present and ecological risks to terrestrial and aquatic receptors are low, DOE does not expect any long-term impacts as a result of the proposed actions and alternatives.

4.2.3.2 <u>Radionuclides</u>

DOE calculated peak radiation dose to aquatic and terrestrial receptors at the seepline and receiving surface water from the tank closure alternatives. These radiation doses are compared to the limit of 1,000 millirad per day (365,000 millirad per year).

The following exposure pathways were chosen for calculating absorbed radiation dose to the terrestrial mammals of interest (shrew and mink) located on or near the seepline: ingestion of food (earthworms, slugs, insects and similar organisms for the shrew, and shrews for the mink); ingestion of soil; and ingestion of water. The following exposure pathways were chosen for calculating absorbed dose to aquatic animals of interest (sunfish) living in Fourmile Branch and Upper Three Runs: uptake of contaminants from water and direct irradiation from submersion in water. Standard values for parameters such as mass, food ingestion rate, water ingestion rate, soil ingestion rate, and bioaccumulation factors were used. Appendix C provides more details on the methodology and parameters used in this analysis.

Table 4.2.3-1. Summary of maximum hazard indices for the aquatic assessment by tank closure alternative.

No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Max. HI	Max. HI	Max. HI	Max. HI
2.0	1.42	0.18	0.16

Calculated absorbed doses to the referenced organisms are listed in Table 4.2.3-3. All calculated doses are below the regulatory limit of 365,000 millirad per year.

4.2.4 LAND USE

DOE's primary planning document for land use at SRS is the *Savannah River Site Future Land Use Plan* (DOE 1998). This plan (DOE 1998) analyzed several future use options, including residential future use. The residential use option would call for all of SRS, except for existing waste units with clean up decisions under RCRA or CERCLA that preclude residential use, to be cleaned up to levels consistent with residential land use. Clean up of SRS to levels required for residential use would result in enormous costs and considerable time commitment. Many areas at the site are contaminated at low levels with various contaminants and it is probably not feasible with current technology to remediate these areas to standards acceptable for residential development. An integral site future-use model that assumes no residential uses would be permitted in any area of the site was identified as the basis for SRS future-use planning.

The General Separations Area includes several nuclear material processing and waste management areas. In addition to the Tank Farms, this area includes the F- and H-Area canyon buildings, radioactive waste storage and disposal facilities, and the DWPF vitrification and salt processing facilities. This area also contains numerous as yet unremediated waste sites (basins, pits, piles, tanks, contaminated groundwater plumes). Soils and groundwater within the General Separations Area are contaminated with radionuclides and hazardous chemicals as a result of 40 years of site operations. As described in Section 3.2.2.4, several contaminants in groundwater (tritium and other radionuclides, metals, nitrates, sulfates, and chlorinated and volatile organics) currently exceed the applicable regulatory or DOE guidelines. This area of the SRS is least amenable to remediation to the levels that would enable future residential use.

Section 4.2.5 discusses impacts to humans using the land in or near the Tank Farms. DOE does not envision relinquishing control of this area. However, DOE recognizes that there is uncertainty in projecting future land use and effectiveness of institutional controls considered in this EIS. For purposes of analysis, DOE assumes direct physical control in the General Separations Area only for the next 100 years. In accordance with agreements with the State of South Carolina and as reflected in the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996), DOE has calculated human health impacts based on doses that would be received over time at a point of compliance that is at the seepline, about a mile from the tank farms. However, recognizing the potential for exposure to groundwater and the fact that DOE's land use assumptions may be incorrect, DOE has also provided estimates of human health implications of doses that would be received directly adjacent to the boundary of the tank farm. This location is much closer to the tank farm than the point of compliance and the projected doses and consequent health effects are greater.

With respect to the 100-years of physical control, the land use plan establishes a future use policy for the SRS. Several key elements of that policy would maintain the tank farm area and exclude its future use from non-conforming land uses (see Figure 4.2.4-1). The most notable elements are the following:

- Protection and safety of SRS workers and the public shall be a priority.

Table 4.2.3-2. Summary of maximum hazard quotients for the terrestrial assessment by tank closure alternative.

			Clean and Stabilize Tanks Alternative					
	No Action Alternative		Clean and Fill with Grout Option		Clean Fill with Sand Option		Clean Fill with Saltstone Option	
	Max. HQ	Time of maximum exposure[a]	Max. HQ	Time of maximum exposure[a]	Max. HQ	Time of maximum exposure[a]	Max. HQ	Time of maximum exposure[a]
Aluminum	b	NA	b	NA	b	NA	b	NA
Barium	b	NA	b	NA	b	NA	b	NA
Chromium	0.04	4,235	0.02	3,955	b	NA	b	NA
Copper	b	NA	b	NA	b	NA	b	NA
Fluoride	0.20	105	0.08	105	0.01	105	0.01	1,015
Lead	b	NA	b	NA	b	NA	b	NA
Manganese	b	NA	b	NA	b	NA	b	NA
Mercury	b	NA	b	NA	b	NA	b	NA
Nickel	b	NA	b	NA	b	NA	b	NA
Silver	1.55	455	0.81	245	0.09	525	0.13	1,365
Uranium	b	NA	b	NA	b	NA	b	NA
Zinc	b	NA	b	NA	b	NA	b	NA

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a. Years after closure.
b. HQ is less than 0.01
NA = Not applicable.

Table 4.2.3-3. Calculated maximum absorbed radiation dose to aquatic and terrestrial organisms by tank stabilization method (millirad/year).[a]

		Clean and Stabilize Tanks Alternative		
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Sunfish dose	0.89	0.0038	0.0072	0.053
Shrew dose	24,450	24.8	244.5	460.5
Mink dose	2,560	3.3	25.6	265

a. DOE limit is 365,000 millirad per year.

- The integrity of site security shall be maintained.
- A "restricted use" program shall be developed and followed for special areas (e.g., CERCLA and RCRA regulated units).
- SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government.
- Residential uses of all SRS land shall be prohibited in any area of the site.

In principle, industrial zones are ones in which the facilities pose either a potentially significant nuclear or non-nuclear hazard to employees or the general public. In the case of the Industrial-Heavy Nuclear zone, the facilities included (1) produce, process, store and/or dispose of radioactive liquid or solid waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; or (4) conduct fuel enrichment operations (DOE 1998).

The future condition of the F- and H-Area Tank Farms would vary among the alternatives. Under the No Action Alternative, structural collapse of the tanks would create unstable ground conditions and form holes into which workers or other site users could fall. Neither the Clean and Stabilize Tanks Alternative nor the Clean and Remove Tanks Alternative would have this safety hazard, although there could be some moderate ground instability with the Clean and Fill with Sand Option. For the Clean and Stabilize Tanks Alternative, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting in the surface depressions. This action would prevent ponding conditions over these tanks that could facilitate the degradation of the tank structure. For the Clean and Remove Tanks Alternative, the tank voids remaining after excavation would be filled in. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

4.2.5 PUBLIC HEALTH

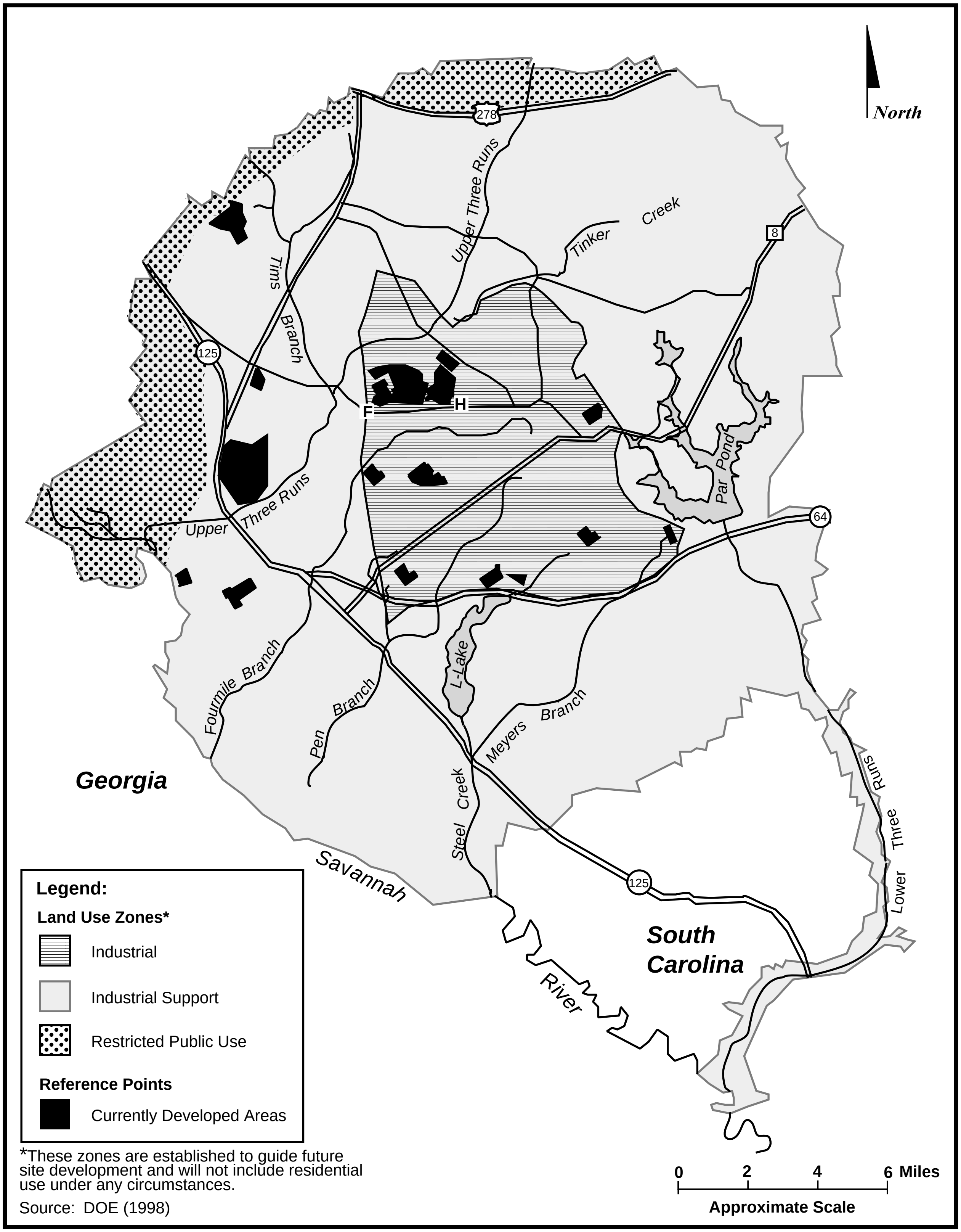
This section presents the potential impacts on human health from residual contaminants remaining in the HLW tanks after closure following the period of institutional control of the H-Area and F-Area Tank Farms.

To determine the long-term impacts, DOE has reviewed data for both tank farms, including the following:

- Expected source inventory that would remain in the tanks
- Existing technical information on geological and hydrogeological parameters in the vicinity of the tank farms

Use of the land around the tank farms

- Arrangement of the tanks within the stratigraphy
- Actions to be completed under each of the alternatives



*These zones are established to guide future site development and will not include residential use under any circumstances.

Source: DOE (1998)

NW TANK/Grfx/4.2.4-1Land Use.ai

Figure 4.2.4-1. Savannah River Site land use zones.

In its evaluation, DOE has reviewed the human populations who could be exposed to contaminants from the tank farms and has identified the following hypothetical individuals:

- *Worker*: an adult who has authorized access to, and works at, the tank farm and surrounding areas. This analysis assumes that the worker remains on the shores of Fourmile Branch or Upper Three Runs during working hours. This assumption maximizes the hypothetical worker's exposure to contaminants that might emerge at the seepline.

- *Intruder*: a person who gains unauthorized access to the tank farm and is potentially exposed to contaminants.

- *Nearby adult resident*: an adult who lives in a dwelling across either Fourmile Branch or Upper Three Runs downgradient of the tank farms, near the stream.

- *Nearby child resident*: a child who lives in a dwelling across either Fourmile Branch or Upper Three Runs downgradient of the tank farms, near the stream.

- *Downstream resident*: a person who lives in a downstream community where residents get their household water from the Savannah River. Effects are estimated for an average individual in the downstream communities and for the entire population in these communities.

DOE has based the assessment of population health effects on present-day populations because estimation of future populations is very speculative. The analysis based on present-day populations is useful for the purpose of understanding the potential impacts of the proposed action on future residents of the region.

DOE evaluated the impacts over a 10,000-year period, which is consistent with the time period used previously in the *Industrial Wastewater Closure Plan for F- and H-Area High Level Waste Tank System*. Because the tanks are located below the grade of the surrounding topography, DOE does not expect any long-term airborne releases to occur from the tanks. Therefore, DOE based its calculations on postulated release scenarios whereby contaminants in the tanks would be leached from the tank structures and transported to the groundwater. However, the holes formed by the collapsed tanks under the No Action Alternative would pose a long-term safety hazard.

As discussed in Section 4.2.2, the aquifers in the vicinity of F-Area Tank Farm and H-Area Tank Farm outcrop along both Fourmile Branch and Upper Three Runs. Because the locations where these aquifers outcrop from the tank farms do not overlap, DOE has chosen to calculate and present the impacts for these hypothetical individuals separately for F-Area Tank Farm and H-Area Tank Farm.

In addition to the hypothetical individuals and population listed above, DOE also calculated the concentration of contaminants in groundwater at the location where the groundwater outcrops into the environment (i.e., the seepline) and at 1 meter and 100 meters downgradient from each of the tank farms. Discussion of these results is provided in Section 4.2.2, along with an estimate of the impacts from pathways at these locations.

For non-radiological constituents, DOE compared the water concentrations directly to the concentrations listed as Maximum Contaminant Levels in 40 CFR 141. Appendix C lists concentrations for all the nonradiological constituents. As discussed in Section 4.2.2, DOE has chosen to present the fractions of Maximum Contaminant Level for non-radiological constituents to enable quantitative comparison among the alternatives.

As discussed in Appendix C, DOE performed its calculations for the three uppermost aquifers underneath the General Separations Area; however, in this section, DOE presents only the maximum results for the two tank farms. In addition, the maximum results for H-Area Tank Farm are reported, independent of which seepline (Upper Three Runs or Fourmile Branch) receives the highest level of contaminants. Downstream Savannah River users are assumed to be exposed to contemporaneous releases from all aquifers and seeplines. Further details on aquifer-specific results can be found in Appendix C.

Tables 4.2.5-1, 4.2.5-2, and 4.2.5-3 show the radiological results for the F- and H-Area Tank Farms. The maximum annual dose to the adult resident for either tank farm is 6.2 millirem per year for the No Action Alternative. This dose is less than the annual 100 millirem public dose limit and represents only a marginal increase in the annual average exposure of individuals in the United States of approximately 360 mrem due to natural sources of radiation exposure, as discussed in Section 3.8. Based on this low dose, DOE would not expect any health effects if an individual were to receive the dose calculated for the hypothetical adult.

DOE considered, but did not model, the potential exposures to people who live in a home built over the tanks at some time in the future when they are unaware that the residence was built over closed waste tanks. DOE previously modeled this type of exposure for the saltstone disposal vaults in the Z Area. That analysis found that external radiation exposure was the only potentially significant pathway of potential radiological exposure other than groundwater use (WSRC 1992). Tables 4.2.2-4 and 4.2.2-5 present estimates of the radiological doses from drinking water from the close-in wells where onsite residents might obtain their water. DOE also projected the contribution of other water-related environmental pathways to one set of model output and concluded that the dose to a future resident from these other pathways would not exceed the drinking water dose by more than 20 percent. For the Clean and Fill with Grout and Clean and Fill with Sand Options of the Clean and Stabilize Tanks Alternative, external radiation doses to onsite residents would be negligible because the thick layers of nonradioactive material between the waste (near the bottom of the tanks) and the ground surface would shield residents from any direct radiation emanating from the waste. External radiation exposures could occur under the Clean and Fill with Saltstone Option which would place radioactive saltstone near the ground surface. If it is conservatively assumed that all of the backfill soil is eroded or excavated away and there is no other cap over the saltstone, so that a home is built directly on the saltstone, analysis presented in WSRC (1992) indicates that 1000 years after tank closure a resident would be exposed to an effective dose equivalent of 390 mrem/year, resulting in an estimated 1 percent increase in risk of latent cancer fatality from a 70-year lifetime of exposure. Backfill soils or caps would eliminate or substantially reduce the potential external exposure. For example, with a 30-inch-thick intact concrete cap, the dose would be reduced to 0.1 mrem/year. For the No Action Alternative external exposures to onsite residents would be expected to be unacceptably high due to the potential for contact with the residual waste.

At the one-meter well, the highest calculate peak drinking water dose under the No Action Alternative is 9,300,000 millirem per year (9,300 rem per year), which would lead to acute radiation health effects, including death. Peak doses at this well for the Clean and Stabilize Tanks Alternative are calculated to be in the range of 100,000 to 130,000 millirem per year (100 to 130 rem per year), which substantially exceeds all criteria for acceptable exposure, could result in acute health effects, and would give a significantly increased probability of a latent cancer fatality. Peak doses calculated at the 100-meter well range from 300 millirem (0.3 rem per year) per year for the Clean and Fill with Grout Option to 90,000 millirem per year (90 rem per year) for the No Action Alternative. Individuals exposed to 300 millirem per year would experience a lifetime increased risk of latent cancer fatality of less that 0.02 percent per year of exposure. The estimated doses at the 1- and 100-meter wells are extremely conservative (high) estimates because the analysis treated all of the tanks in a given group as being at the same physical location. Realistic doses at these close-in locations would be substantially smaller. As noted above, land-use controls and other institutional control measures would be employed to prevent exposure at these locations.

Table 4.2.5-1. Radiological results from contaminant transport from F-Area Tank Farm.[a]

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident maximum annual dose (millirem per year)	0.027	0.051	0.37	6.2
Child resident maximum annual dose (millirem per year)	0.024	0.047	0.34	5.7
Seepline worker maximum annual dose (millirem per year)	(c)	(c)	0.001	0.018
Intruder maximum annual dose (millirem per year)	(c)	(c)	(c)	9.0×10^{-3}
Adult resident maximum lifetime dose (millirem)[b]	1.9	3.6	26	430
Child resident maximum lifetime dose (millirem)[b]	1.7	3.3	24	400
Seepline worker maximum lifetime dose (millirem)[d]	0.002	0.004	0.03	0.54
Intruder maximum lifetime dose (millirem)[d]	0.001	0.002	0.02	0.27
Adult resident latent cancer fatality risk	9.5×10^{-7}	1.8×10^{-6}	1.3×10^{-5}	2.2×10^{-4}
Child resident latent cancer fatality risk	8.5×10^{-7}	1.7×10^{-6}	1.2×10^{-5}	2.0×10^{-4}
Seepline worker latent cancer fatality risk	8.0×10^{-10}	1.6×10^{-9}	1.2×10^{-8}	2.2×10^{-7}
Intruder latent cancer fatality risk	4.0×10^{-10}	8.0×10^{-10}	8.0×10^{-9}	1.1×10^{-7}
1-meter well drinking water dose (millirem per year)	130	420	790	3.6×10^{5}
1-meter well alpha concentration (picocuries per liter)	13	13	13	1,700
100-meter well drinking water dose (millirem per year)	51	190	510	1.4×10^{4}
100-meter well alpha concentration (picocuries per liter)	4.8	4.7	4.8	530
Seepline drinking water dose (millirem per year)	1.9	3.5	25	430
Seepline alpha concentration (picocuries per liter)	0.04	0.039	0.04	9.2
Surface water drinking water dose (millirem per year)	9.8×10^{-3}	0.019	0.13	2.3

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[a] The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995), Section 4.2.3.

[b] Lifetime of 70 years assumed for this individual.

[c] The radiation dose for this alternative is less than 1×10^{-3} millirem.

[d] Lifetime of 30 years assumed for this individual.

Table 4.2.5-2. Radiological results from contaminant transport from H-Area Tank Farm.[a]

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident maximum annual dose (millirem per year)	0.010	0.016	0.19	2.4
Child resident maximum annual dose (millirem per year)	9.3×10^{-3}	0.015	0.18	2.2
Seepline worker maximum annual dose (millirem per year)	(c)	(c)	(c)	7×10^{-3}
Intruder maximum annual dose (millirem per year)	(c)	(c)	(c)	3.5×10^{-3}
Adult resident maximum lifetime dose (millirem)[b]	0.7	1.1	13	170
Child resident maximum lifetime dose (millirem)[b]	0.65	1.1	1.3	150
Seepline worker maximum lifetime dose (millirem)[d]	(c)	0.001	0.017	0.21
Intruder maximum lifetime dose (millirem)[d]	(c)	(c)	0.008	0.11
Adult resident latent cancer fatality risk	3.9×10^{-7}	5.5×10^{-7}	6.5×10^{-6}	8.5×10^{-5}
Child resident latent cancer fatality risk	3.3×10^{-7}	5.5×10^{-7}	6.5×10^{-7}	7.5×10^{-5}
Seepline worker latent cancer fatality risk	(e)	4.0×10^{-10}	6.8×10^{-9}	8.4×10^{-8}
Intruder latent cancer fatality risk	(e)	(e)	3.2×10^{-9}	4.4×10^{-8}
1-meter well drinking water dose (millirem per year)	1×10^{5}	1.3×10^{5}	1.0×10^{5}	9.3×10^{6}
1-meter well alpha concentration (picocuries per liter)	24	290	24	13,000
100-meter well drinking water dose (millirem per year)	300	920	870	9.0×10^{4}
100-meter well alpha concentration (picocuries per liter)	7.0	38	7.0	3,800
Seepline drinking water dose (millirem per year)	2.5	25	46	2.5×10^{3}
Seepline alpha concentration (picocuries per liter)	0.15	0.33	0.15	34
Surface water drinking water dose (millirem per year)	3.7×10^{-3}	6.0×10^{-3}	0.071	0.90

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a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995), Section 4.2.3.

b. Lifetime of 70 years assumed for this individual.

c. The radiation dose for this alternative is less than 1×10^{-3} millirem.

d. Lifetime of 30 years assumed for this individual.

Table 4.2.5-3. Radiological results to downstream resident from contaminant transport from F- and H-Area Tank Farms.[a]

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Downstream maximum individual annual dose (millirem per year)	(b)	(b)	(b)	(b)
Downstream maximum individual lifetime dose (millirem)	(b)	(b)	3.4×10^{-3}	4.1×10^{-2}
Downstream maximum individual latent cancer fatality risk	(c)	(c)	1.8×10^{-9}	2.1×10^{-8}
Population dose (person-rem per year)	8.6×10^{-5}	3.3×10^{-4}	3.4×10^{-3}	4.1×10^{-2}
Population latent cancer fatality risk (incidents per year)	4.3×10^{-8}	1.7×10^{-7}	1.8×10^{-6}	2.1×10^{-5}

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a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995), Section 4.2.3.

b. The radiation dose for this alternative is less than 1×10^{-3} millirem.

c. The risk for this alternative is very low, less than 10^{-9}.

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CHAPTER 5. CUMULATIVE IMPACTS

In its regulations for implementing the procedural provisions of NEPA, the Council on Environmental Quality (CEQ) defines cumulative impacts as follows: the impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR 1508.7). The cumulative impacts analysis presented in this chapter is based on the incremental actions associated with the highest potential impact for each resource area considered for all alternatives for HLW tank closure at the SRS, other actions associated with onsite activities, and offsite activities with the potential for related environmental impacts. The highest impact alternative varied based on the resource area being evaluated as shown in the data tables within this chapter.

DOE has examined impacts of the construction and operation of SRS over its 50-year history. It has analyzed trends in the environmental characteristics of the site and nearby resources to establish a baseline for measurement of the incremental impact of tank closure activities and other reasonably foreseeable onsite and offsite activities with the potential for related environmental impact.

SRS History

In 1950, the U.S. Government selected a large rural area of nearly 400 square miles in southwest South Carolina for construction and operation of facilities required to produce nuclear fuels (primarily defense-grade plutonium and tritium) for the nation's defense. Then called the Savannah River Plant, the facility would have full production capability, including fuel and target fabrication, irradiation of the fuel in five production reactors, product recovery in two chemical separations plants, and waste management facilities, including the high-level waste tank farms (DOE 1980).

Construction impacts included land clearing, excavation, air emissions from construction vehicles, relocation of about 6,000 persons, and the formation of mobile home communities to house workers and families during construction; peak construction employment totaled 38,500 in 1952 (DOE 1980).

Socioeconomic effects stabilized quickly. The largest community on the Site, Ellenton, was relocated immediately north of the Site boundary and was renamed New Ellenton.

Aftereffects of construction are minimal. The site, later reduced to approximately 300 square miles, is predominately (73 percent) open fields and pine and hardwood forests. Twenty-two (22) percent is wetlands, streams, and reservoirs, and only five percent is dedicated to production and support areas, roads, and utility corridors (DOE 1997). The Savannah River Natural Resource Management and Research Institute (SRI) (formerly the Savannah River Forest Station) manages the natural resources at SRS. The SRI supports forest research, erosion control projects, and native plants and animals (through maintenance and improvements to their habitats). SRI sells timber, manages controlled-burns, plants new seedlings, and maintains secondary roads and exterior boundaries (Arnett and Mamatey 1997a).

Normal operations included non-radioactive and radioactive emissions of pollutants to the surrounding air and discharges of pollutants to onsite streams. Impacts to these releases to the environment were minimal. In addition, large withdrawals of cooling water from the Savannah River caused minimal entrainment and impingement of aquatic biota and severe thermal impacts due to the subsequent discharge of the cooling water to onsite streams. The thermal discharges stripped the vegetation along stream channels and adjacent banks and destroyed cypress-tupelo forests in the Savannah River Swamp. Thermal effects did not extend beyond the site boundary. In 1991, DOE committed to reforest the Pen Branch delta in the Savannah River Swamp using appropriate wetland species and to manage it until successful reforestation had been achieved (56 FR 5584-5587; February 11, 1991).

Groundwater contamination also occurred in areas of hazardous, radioactive, and mixed waste sites and seepage basins. Due to the large buffer area from the center of operations to the site boundary (approximately five miles), offsite effects were minimal. Groundwater contamination plumes did not move offsite, and onsite surface water contamination had minimal effect offsite because they are discharged to the Savannah River and diluted to concentrations that are well below concentrations of concern.

SRS has had a beneficial socioeconomic effect on employment in the region. The operations workforce varied from 7,500 (DOE 1980) to almost 26,000 (Halliburton NUS 1992), and presently numbers approximately 14,000 by February 2000 (DOE 2000a).

Over the years of operation, mitigation measures have substantially reduced onsite environmental stresses. DOE installed a Liquid Effluent Treatment Facility that minimized liquid releases of pollutants except tritium before discharge through a National Pollutant Discharge Elimination System outfall. Direct discharge of highly tritiated disassembly basin purge water to surface streams was replaced by discharge to seepage basins that enabled substantial decay during transport in the groundwater before their eventual outcrop to onsite streams. In addition, DOE eliminated thermal discharges with construction of a cooling lake for L-Reactor operation and a cooling tower intended to support K-Reactor operation.

Other agencies contributed to this trend by improving the quality and regulation of flows in the Savannah River. Five large reservoirs upriver of SRS were constructed in the 1950s through early 1980s. They have reduced peak flows in the Savannah River, moderated flood cycles in the Savannah River Swamp and, with the exception of a severe drought in 1985 through 1988, maintained flows sufficient for water quality and managing fish and wildlife resources downstream (DOE 1990). In 1975, the city of Augusta installed a secondary sewage treatment plant to eliminate the discharge of untreated or inadequately treated domestic and industrial waste into the Savannah River and its tributaries. Similarly, treatment facilities for Aiken County began operation in 1979 (DOE 1987).

In 1988, DOE placed the active site reactors on standby, and the end of the cold war resulted in permanent shutdown. DOE planted wetland hardwood species in 300-400 acres of the Pen Branch delta. Successful reforestation has begun and is ongoing.

Once operations ceased, key indicators of environmental impact decreased rapidly. For example, one discriminator for measuring impacts to human health is the dose to the *maximally exposed offsite individual* (MEI). The impact that it measures is the estimated probability of a latent cancer fatality, which is assumed to be directly proportional to dose. The estimate of latent cancers is, at best, an order of magnitude approximation. Thus an estimate of 10^{-5} latent cancer fatalities is likely between 10^{-6} and 10^{-4}. By 1996, the dose to the MEI (and the associated probability of a latent cancer fatality) decreased to about 1/8th of its 1987 value (Arnett and Mamatey 1997b). Further detail on the MEI is discussed later under public and worker health.

In general, the combination of mitigation measures and post-cold war cleanup efforts demonstrates an environmental trend of protecting and improving the quality of the SRS environment with minimal impact on the offsite environment. Although groundwater modeling indicates that most contaminants in the groundwater have reached their peak concentrations, several slow moving constituents would peak in this millennium at the 100-meter well (DOE 1987). Long-Term Cumulative Impacts are discussed further in Section 5.7 of this chapter.

CEQ Cumulative Effects Guidance

A handbook prepared by CEQ (1997) guides this chapter. In accordance with the handbook, DOE identified the resource areas in which tank closure could add to the impacts of past, present, and reasonably foreseeable actions within the project impact zones as defined by CEQ (1997).

Based on an examination of the environmental impacts of actions resulting from tank closure coupled with DOE and other agency actions, and some private actions it was determined that cumulative impacts for the following areas need to be presented: (1) air resources; (2) water resources; (3) public and worker health; (4) waste generation; (5) utilities and energy consumption; and (6) land use (long-term only). Discussion of cumulative impacts for the following resources is omitted because impacts from the proposed tank closure activities would be so small that their potential contribution to cumulative impacts would be very small: geologic resources, ecological resources, aesthetic and scenic resources, cultural resources, traffic, socioeconomics, and environmental justice.

In accordance with the CEQ guidance, DOE defined the geographic (spatial) and time (temporal) boundaries to encompass cumulative impacts on the five identified resources of concern.

Spacial and Temporal Boundaries

For determining the human health impact from airborne emissions the population within the 50-mile radius surrounding SRS was selected as the project impact zone. Although the doses are almost undetectable at the 50-mile boundary, this is the customary definition of the offsite public. For aqueous releases, onsite streams and the downstream population that uses the Savannah River as its source of drinking water was selected. Analyses revealed that other potential incremental impacts from tank closure, including air quality, waste management, and utilities and energy diminish within or quite near the site boundaries. The effective project impact zone for each of these is identified in the discussions that follow.

Nuclear facilities in the vicinity of SRS include Georgia Power's Plant Vogtle Electric Generating Plant across the river from SRS; Chem-Nuclear Inc., a commercial low-level waste burial site just east of SRS; and Starmet CMI, Inc. (formerly Carolina Metals), located southeast of SRS, which processes uranium-contaminated metals. Plant Vogtle, Chem-Nuclear, and Carolina Metals are approximately 11, 8, and 15 miles, respectively, from the SRS HLW Tank Farms. Other nuclear facilities are clearly too far (greater than 50 miles) to have a cumulative effect. Therefore, the project impact zone for cumulative impacts on air quality from radioactive emissions is 15 miles. Radiological impacts from the operation of the Vogtle Electric Generating Plant, a two-unit commercial nuclear power plant are minimal, but DOE has factored them into the analysis. *The SCDHEC Annual Report* (SCDHEC 1995) indicates that operation of the Chem-Nuclear Services facility and the Starmet CMI facility does not noticeably impact radiation levels in air or water in the vicinity of SRS. Therefore, they are not included in this assessment.

The counties surrounding SRS have numerous existing (e.g., Bridgestone Tire, textile mills, paper product mills, and manufacturing facilities) and planned industrial facilities with permitted air emissions and discharges to surface waters. Because of the distances between SRS and the private industrial facilities, there is little opportunity for interactions of plant emissions and no major cumulative impact on air or water quality. As indicated in results from the SRS Environmental Surveillance program report, ambient levels of pollutants in air and water have remained below regulatory levels in and around the SRS region (Arnett and Mamatey 1998).

An additional offsite facility with the potential to affect the nonradiological environment is South Carolina Electric and Gas Company's Urquhart Station. Urquhart Station is a three-unit, 250-megawatt, coal- and natural-gas-fired steam electric plant in Beech Island, South Carolina, located about 20 river miles and about 18 aerial miles north of SRS. Because of the distance between SRS and the Urquhart Station and the regional wind direction frequencies, there is little opportunity for any interaction of plant emissions, and no significant cumulative impact on air quality. Thus, the project impact zone for nonradiological atmospheric releases is less than 18 miles.

Finally, utility and energy capacity is available onsite and is too small to affect the offsite region. Similarly, onsite waste disposal capacity can satisfy the quantities generated by tank closure. Thus the extent of the project impact zone (from utilities, energy, and waste generation) is best described as the SRS boundary.

Temporal limits were defined by examining the period of influence from both the proposed action and other Federal and non-Federal actions that have the potential for cumulative impacts. Actions for tank closure are expected to begin in 2001.

With the exception of the long-term cumulative impacts described in Section 5.7, the period of interest for the cumulative impacts analysis for this EIS includes 2000 to 2030.

Reasonably Foreseeable DOE Actions

DOE also evaluated the impacts from its own proposed future actions by examining impacts to resources and the human environment as shown in NEPA documentation related to SRS (see Section 1.6). Additional NEPA documents related to SRS that are considered in the cumulative impacts section include the following:

- *Final Environmental Impact Statement - Interim Management of Nuclear Materials* (DOE/EIS-0220) (DOE 1995a). DOE is in the process of implementing the preferred alternatives for the nuclear materials discussed in the Interim Management of Nuclear Materials EIS. SRS baseline data in this chapter reflect projected impacts from implementation.

- *Final Environmental Impact Statement for the Accelerator Production of Tritium at the Savannah River Site* (DOE/EIS-0270) (DOE 1999a). DOE has proposed an accelerator design (using helium-3 target blanket material) and an alternate accelerator design (using lithium-6 target blanket material). If an accelerator were to be built, it would have been located at SRS. However, since the record of decision (64 FR 26369; May 14, 1999) states the preferred alternative as use of an existing commercial light-water reactor, data from this EIS are not used.

- *Environmental Assessment for the Tritium Facility Modernization and Consolidation Project at the Savannah River Site* (DOE/EA-1222) (DOE 1997). This environmental assessment addresses the impacts of consolidating the tritium activities currently performed in Building 232-H into the new Building 233-H and Building 234-H. Tritium extraction functions will be transferred to the Tritium Extraction Facility. The overall impact will be to reduce the tritium facility complex net tritium emissions by up to 50 percent. Another positive effect of this planned action will be to reduce the amount of low-level radioactive job-control waste. Effects on other resources will be negligible. Therefore, impacts from the environmental assessment have not been included in this cumulative impacts analysis.

- *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement* (DOE/EIS-0240) (DOE 1996). This cumulative impacts analysis incorporates blending highly enriched uranium at SRS to 4 percent low-enriched uranium as uranyl nitrate hexahydrate, as decided in the Record of Decision (61 FR 40619, August 5, 1996).

- *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site* (DOE/EIS-0277F) (DOE 1998a). As stated in the record of decision (64 FR 8068; February 18, 1999), DOE will process certain plutonium-bearing materials being stored at the Rocky Flats Environmental Technology Site. These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at Rocky Flats. DOE has decided to ship certain residues from the Rocky Flats Environmental Technology Site to SRS for plutonium separation and stabilization. The separated plutonium will be stored at SRS pending disposition decisions. Environmental impacts from using F Canyon to chemically separate the plutonium from the remaining materials at SRS are included in this section.

- *Draft and Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site* DOE/EIS-0271) (DOE 1998b, 1999b). As stated in the record of decision (64 FR 26369; May 14, 1999), DOE will construct and operate a Tritium Extraction Facility on SRS to provide the capability to extract tritium from commercial light water reactor targets and targets of similar design. The purpose of the proposed action and alternatives evaluated in the EIS is to provide tritium extraction capability to support either accelerator or reactor tritium production. Environmental impacts from the maximum processing option in both the draft and final EISs are included in this section. The final EIS presents responses to public comments and a record of changes to the draft EIS.

- *Surplus Plutonium Disposition Final Environmental Impact Statement* (DOE/EIS-0283) (DOE 1999d). This EIS analyzed the activities necessary to implement DOE's disposition strategy for surplus plutonium. As announced in the Record of Decision (65 FR 1608; January 11, 2000), SRS was selected for three disposition facilities, pit (a nuclear weapon component) disassembly and conversion, plutonium conversion and immobilization, and mixed oxide fuel fabrication. The DOE decision allows the immobilization of approximately 17 metric tons of surplus plutonium and the use of up to 33 metric tons of surplus plutonium as mixed oxide fuel. Both methods in this hybrid approach ensure that surplus plutonium produced for nuclear weapons is never again used for nuclear weapons. Impacts from this EIS are included in this section.

- *Defense Waste Processing Facility (DWPF) Supplemental Environmental Impact Statement* (DOE/EIS-0082-S) (DOE 1994). The selected alternative in the Record of Decision (60 FR 18589, April 12, 1995) was the completion and operation of the DWPF to immobilize HLW at the SRS. The facility is currently processing sludge from SRS HLW tanks. However, SRS baseline data are not representative of full DWPF operational impacts, including processing of salt and supernate from these tanks. Therefore, the DWPF data are listed separately.

- *Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (DOE/EIS-0306) (DOE 2000b). DOE has prepared a Final EIS for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel (65 FR 47987, August 4, 2000). One of the alternatives evaluated in the EIS would involve processing INEEL's sodium-bonded fuel inventory at SRS using the Plutonium-Uranium Extraction process. Because processing at SRS is a reasonable alternative to processing of INEEL, it has been included in this cumulative impact analysis. This method of stabilization of spent nuclear fuel could be used for the sodium-bonded spent nuclear fuel, most of which is currently in storage at INEEL. There are approximately 22.4 metric tons of heavy metal (MTHM) of Experimental Breeder Reactor-II (EBR-II) fuel and 34.2 MTHM of Fermi-1 fuel to be processed. This fuel would be declad before shipment to SRS. Because the decladding activities would occur at INEEL, the impacts of these decladding activities are not included in this chapter.

In the Record of Decision (65 FR 56565; September 19, 2000), DOE decided to electrometallurgically treat the EBR-II fuel at Argonne National Laboratory-West. However, due to the different characteristics of the Fermi-1 fuel, DOE decided to continue to store this material while alternative treatments are evaluated.

- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (DOE/EIS-0279)* (DOE 2000c). The proposed DOE action described in this EIS is to implement appropriate processes for the safe and efficient management of spent nuclear fuel and targets at SRS, including placing these materials in forms suitable for ultimate disposition. Options to treat, package, and store this material are discussed. The material included in this EIS consists of approximately 68 MTHM of spent nuclear fuel (20 MTHM of aluminum-based spent nuclear fuel at SRS, as much as 28 MTHM of aluminum-clad spent nuclear fuel from foreign and domestic research reactors to be shipped to SRS through 2035, and 20 MTHM of stainless-steel or zirconium-clad spent nuclear fuel and some programmatic material stored at SRS for repackaging and dry storage pending shipment offsite).

  In the Record of Decision (65 FR 48224; August 7, 2000), DOE decided to implement the Preferred Alternative. As part of the Preferred Alternative, DOE will develop and demonstrate the Melt and Dilute technology. Following development and demonstration of the technology, DOE will begin detailed design, construction, testing, and startup of a Treatment and Storage Facility (TSF). The SNF will remain in wet storage until treated and placed in dry storage in the TSF.

  DOE also decided to use conventional processing to stabilize about 3 percent by volume and 40 percent by mass of the aluminum-based SNF. DOE also decided to continue to store small quantities of higher actinide materials until DOE determines their final disposition. Finally, DOE decided to ship non-aluminum-based SNF from the SRS to the Idaho National Engineering and Environmental Laboratory.

Other materials under consideration for processing at SRS canyons include various components currently located at other DOE sites, including Oak Ridge, Rocky Flats, Los Alamos, and Hanford. These materials, which were identified during the processing needs assessment, consist of various plutonium and uranium components. If DOE were to propose to process these materials in the SRS chemical separations facilities, additional NEPA reviews would need to be performed. In this chapter, estimates of the impacts of processing these materials (DOE 2000b) have been included in the cumulative analysis. These estimates are qualitative because DOE has not yet proposed to process the materials. When considering cumulative impacts, the reader should be aware of the indeterminate nature of some of the actions for which impacts have been estimated.

In addition, the cumulative impacts analysis includes the impacts from actions proposed in this EIS. Risks to members of the public and site workers from radiological and nonradiological releases are based on operational impacts from the alternatives described in Section Chapter 4.

The cumulative impacts analysis also accounts for other SRS operations. Most of the SRS baseline data are based on 1998 environmental report information (Arnett and Mamatey 1999), which are the most recent published data available.

5.1 Air Resources

Table 5-1 compares the cumulative concentrations of nonradiological air pollutants from the SRS, including the tank closure alternative with the largest impact (the Saltstone Option under the Clean and Stabilize Tanks Alternative) to Federal and State regulatory standards. The listed values are the maximum modeled concentrations that could occur at ground level at the site boundary. The data demonstrate that total estimated concentrations of nonradiological air pollutants from SRS would in all cases be below the regulatory standards at the site boundary.

The highest percentages of the regulatory standards are for sulfur dioxide concentrations for the shorter time interval (approximately

Table 5-1. Estimated maximum cumulative ground-level concentrations of nonradiological pollutants (micrograms per cubic meter) at SRS boundary.[a]

Pollutant[b]	Averaging time	SCDHEC ambient standard (µg/m^3)[c]	SRS baseline[d] (µg/m^3)	Tank closure[e] (µg/m^3)	Other foreseeable planned SRS activities[f] (µg/m^3)	Maximum cumulative concentration[g] (µg/m^3)	Percent of standard
Carbon monoxide	1 hour	40,000	10,000	3.4	46.4	10,050	25
	8 hours	10,000	6,900	0.8	6.5	6,907	69
Oxides of nitrogen	Annual	100	26	0.07	7.7	33.8	34
Sulfur dioxide	3 hours	1,300	1,200	0.6	9.7	1,210	93
	24 hours	365	350	0.12	2.6	352.7	97
	Annual	80	34	0.006	0.19	34.2	43
Ozone[h]	1 hour	235	NA[i]	2.0	1.51	3.5	1.5
Lead	Max. quarter	1.5	0.03	4.1×10^{-6}	<0.00001	0.03	2
Particulate matter (≤10 microns aerodynamic diameter)[h]	24 hours	150	130	0.06	3.37	133.43	89
	Annual	50	25	0.03	0.15	25.2	50
Total suspended particulates (µg/m^3)	Annual	75	67	0.005	0.08	67.1	90

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a. DOE (1994, 1996, 1997, 1998a,b, 1999c,d; 2000b,c).
b. Hydrochloric acid, formaldehyde, hexane, and nickel are not listed in Table 5-1 because tank closure or other foreseeable, planned SRS activities would not result in any change to the SRS baseline concentrations of these toxic pollutants.
c. SCDHEC (1976).
d. Source: Table 3.3-3.
e. Data based on the Saltstone Option under the Clean and Stabilize Tanks Alternative (Table 4.1.3-2).
f. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility, Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.
g. Includes tank closure concentrations.
h. New NAAQS for ozone (1 hr replaced by 8 hr standard = 0.08 ppm) and particulate matter ≤ 2.5 microns (24 hr standard = 65 µg/m^3 and annual standard of 15 µg/m^3) may become enforceable during the stated temporal range of the cumulative impacts analyses.
NA = Not available.
µg/m^3 = micrograms per cubic meter.

97 percent of standard for the 24-hour averaging time and 93 percent of the standard for the 3-hour average time), for particulate matter of less than 10 microns (approximately 89 percent of standard for the 24-hour averaging time), and total suspended particulates (approximately 90 percent of standard). The remaining pollutant concentrations would range from under 2 to 69 percent of the applicable standards. The majority of the concentration comes from estimated SRS baseline concentrations and not tank closure and other foreseeable actions. The incremental impact from tank closure would not be noticeable. Also, it is unlikely that actual concentrations at ambient monitoring stations would be as high as that shown for the SRS baseline values. The SRS baseline values are based on the maximum potential emissions from the 1998 air emissions inventory and for all SRS sources, and observed concentrations from nearby ambient air monitoring stations.

DOE also evaluated the cumulative impacts of airborne radioactive releases in terms of dose to a maximally exposed individual at the SRS boundary and dose to the 50-mile population (see Table 5-2). Although comparable results for Plant Vogtle were not available for the nonradiological analysis (Table 5-1), DOE included the impacts of Plant Vogtle (NRC 1996) in this cumulative radioactive release total. The South Carolina Department of Health and Environmental Control Annual Report (SCDHEC 1995)

Table 5-2. Estimated average annual cumulative radiological doses and resulting health effects to the maximally exposed offsite individual and population in the 50-mile radius from airborne releases.

	Offsite Population			
	Maximally exposed individual		50-mile population	
Activity	Dose (rem)	Probability of fatal cancer risk	Collective dose (person-rem)	Excess latent cancer fatalities
SRS Baseline[b]	7.0×10^{-5}	3.5×10^{-8}	3.5	1.8×10^{-3}
Tank Closure[a]	5.2×10^{-8}	2.6×10^{-11}	3.0×10^{-3}	1.5×10^{-6}
Other foreseeable SRS activities[c]	5.1×10^{-5}	2.5×10^{-8}	3.4	1.7×10^{-3}
Plant Vogtle[d]	5.4×10^{-7}	2.7×10^{-10}	0.042	2.1×10^{-5}
Total	1.2×10^{-4}	6.1×10^{-8}	6.9	3.5×10^{-3}

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a. Data is based on the Saltstone Option under the Clean and Stabilize Tanks Alternative (Table 4.1.8-1).
b. Arnett and Mamatey (1999) for 1998 data for maximally exposed individual and population.
c. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.
d. NRC (1996).

indicates that operation of the Chem-Nuclear low-level waste disposal facility just east of SRS does not noticeably impact radiation levels in air or water in the vicinity of SRS and thus are not included.

Table 5-2 lists the results of this analysis using 1998 emissions (1992 for Plant Vogtle) which are the latest available data for the SRS baseline. The cumulative dose to the maximally exposed member of the public would be 0.0001 rem (or 0.10 millirem) per year, well below the regulatory standard of 10 millirem per year (40 CFR 61). Summing the doses to the maximally exposed individual for the actions and baseline SRS operations listed in Table 5-2 is an extremely conservative approach because in order to get the calculated dose, the maximally exposed individual would have to occupy different physical locations at the same time, which is impossible.

Adding the population doses from current and projected activities at SRS, Plant Vogtle, and tank closure activities could yield a total annual cumulative dose of 6.9 person-rem from airborne sources. The total annual cumulative dose translates into 0.0035 excess latent cancer fatality for each year of exposure for the population living within a 50-mile radius of the SRS.

5.2 Water Resources

At present, a number of SRS facilities discharge treated wastewater to Upper Three Runs and its tributaries and Fourmile Branch via NPDES-permitted outfalls. These include the F- and H-Area Effluent Treatment Facility (ETF) and the M-Area Liquid Effluent Treatment Facility. As stated in Section 4.1.2, the SRS storm drainage system is designed to enable operators to secure specific storm sewer zones and divert potentially contaminated water to lined retention basins. Therefore, during the short term, tank closure activities are not expected to result in any radiological or nonradiological discharges to groundwater. Discharges to surface water would be treated to remove contaminants prior to release into SRS streams. Other potential sources of contaminants into Upper Three Runs during the tank closure activities period include the accelerator production of tritium, the tritium extraction facility, environmental restoration, and decontamination and decommissioning activities, as well as modifications to existing SRS facilities. Discharges associated with the accelerator production of tritium and tritium extraction facility activities would not add significant amounts of nonradiological contaminants to Upper Three Runs. The amount of discharge associated with environmental restoration and decontamination and decommissioning activities would vary based on the level of activity. All the potential activities that could result in wastewater discharges would be required to comply with the NPDES permit limits that ensure protection of the water quality needed to support state-designated uses for the receiving stream. Studies of water quality and biota in Upper Three Runs suggest that discharges from facilities outfalls have not degraded the stream (Halverson et al. 1997).

5.3 Public and Worker Health

Table 5-3 summarizes the cumulative radiological health effects of routine SRS operations, proposed DOE actions, and non-Federal nuclear facility operations (Plant Vogtle Electric Generating Facility). In addition to estimated radiological doses to the hypothetical maximally exposed offsite individual, the offsite population, and the involved workers population. Table 5-3 also lists the potential number of excess latent cancer fatalities for the public and workers due to exposure to radiation and the involved workers population and the risk of a latent cancer fatality to the maximally exposed offsite individual. The radiation dose to the maximally exposed offsite individual from air and liquid pathways would be 0.00035 rem (0.35 mrem) per year, which is well below the applicable DOE regulatory limits (10 mrem per year from the air pathway, 4 mrem per year from the liquid pathway, and 100 mrem per year for all pathways). The total annual population dose for current and projected activities of 8.9 person-rem translates into 0.0045 latent cancer fatality for each year of exposure for the population living within a 50-mile radius of the SRS. As stated in Section 5.1, for comparison, 144,000 deaths from cancer due to all causes would be likely in the same population over their lifetimes.

The annual radiation dose to the involved worker population would be 1,344 person-rem, which could result in 0.54 latent cancer fatalities. Closure actions under the Clean and Remove Tanks Alternative would result in 0.2 latent cancer fatalities per year. In addition, doses to individual workers would be kept below the regulatory limit of 5,000 mrem per year (10 CFR 835). Furthermore, as low as reasonably achievable principles would be exercised to maintain individual worker doses below the SRS Administrative Control Level of 500 mrem per year. Tank closure activities would add minimal amounts to the overall radiological health effects of the workers and general public.

5.4 Waste Generation and Disposal Capacity

As stated in Section 4.1.10, HLW, low-level waste, and hazardous/mixed waste would be generated from tank closure activities.

Table 5-4 lists cumulative volumes of HLW, low-level, transuranic, and hazardous and mixed wastes that SRS would generate. The table includes data from the SRS 30-year expected waste forecast. The 30-year expected waste forecast is based on operations, environmental restoration, and decontamination and decommissioning waste forecasts from existing generators and the following assumptions: secondary waste from the DWPF, a form of HLW salt processing (In-Tank Precipitation), and Extended Sludge Processing operations are addressed in the DWPF EIS; HLW volumes are based on the selected option for the F-Canyon Plutonium Solutions EIS and the Interim Management of Nuclear Materials at SRS EIS; some investigation-derived wastes are handled as hazardous waste per RCRA regulations; purge water from well samplings is handled as hazardous waste; and the continued receipt of small amounts of low-level waste from other DOE facilities and nuclear naval operations would occur. The estimated quantity of radioactive/hazardous waste from operations in this forecast during the next 30 years would be approximately 143,000 cubic meters. In addition, radioactive/hazardous waste associated with environmental restoration and decontamination and decommission activities would have a 30-year expected forecast of approximately 68,000 cubic meters. Waste generated from the Clean and Remove Tanks Alternative would add a total of 117,000 cubic meters. During this same time period, other reasonably foreseeable activities that were not included in the 30-year forecast would add an

Table 5-3. Estimated average annual cumulative radiological doses and resulting health effects to offsite population and facility workers.

	Maximally exposed individual				Offsite population[a]				Workers	
Activity	Dose from airborne releases (rem)	Dose from water releases (rem)	Total dose (rem)	Probability of fatal cancer risk	Collective dose from airborne releases (person-rem)	Collective dose from water releases (person-rem)	Total collective dose (person-rem)	Excess latent cancer fatalities	Collective dose (person-rem)	Excess latent cancer fatalities
SRS Baseline[b]	7.0×10^{-5}	1.2×10^{-4}	1.9×10^{-4}	9.5×10^{-8}	3.5	1.8	5.3	2.7×10^{-3}	160	0.066
Tank Closure[c]	5.2×10^{-8}	(f)	5.2×10^{-8}	2.6×10^{-11}	3.0×10^{-3}	(f)	3.0×10^{-3}	1.5×10^{-6}	490	0.20
Other foreseeable SRS activities[d]	5.1×10^{-5}	5.7×10^{-5}	1.1×10^{-4}	5.4×10^{-8}	3.4	0.19	3.6	1.8×10^{-3}.	694	0.28
Plant Vogtle[e]	5.4×10^{-7}	5.4×10^{-5}	5.5×10^{-5}	2.7×10^{-8}	0.042	2.5×10^{-3}	0.045	2.1×10^{-5}	NA	NA
Total	1.2×10^{-4}	2.3×10^{-4}	3.5×10^{-4}	1.8×10^{-7}	6.9	2.0	8.9	4.5×10^{-3}	1,344	0.54

N/A = not available

a. A collective dose to the 50-mile population for atmospheric releases and to the downstream users of the Savannah River for aqueous releases.

b. Arnett and Mamatey (1999) for 1998 data for MEI and population. Worker dose is based on 1997 data (WSRC 1998).

c. Collective worker dose of 490 person-rem is based on closure of two tanks per year for the Clean and Remove Tanks Alternative (Table 4.1.8-2).

d. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility, Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.

e. NRC (1996).

f. Less than minimum reportable levels.

Table 5-4. Estimated cumulative waste generation from SRS concurrent activities (cubic meters).

Waste type	SRS baseline[a,b]	Tank closure[c]	ER/D&D[b,d]	Other waste volume[e]	Total
HLW	14,000	97,000	0	80,000	191,000
Low-level	119,000	19,260	61,600	251,000	450,000
Hazardous/mixed	3,900	470	6,200	4,700	15,200
Transuranic	6,000	0	0	12,500	18,500
Total[f]	143,000	117,000	67,800	348,000	675,000

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a. Source: Halverson 1999.
b. Based on a total 30-year expected waste generation forecast, which includes previously generated waste.
c. Waste volume estimates based on the Clean and Remove Tanks Alternative (Table 4.1.10-2).
d. ER/D&D = environmental restoration/decontamination & decommissioning; based on a total 30-year expected waste forecast.
e. Sources: DOE (1996, 1997, 1998a,b, 1999b,c, 2000b,c). Life-cycle waste associated with reasonably foreseeable future activities such as spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly-enriched uranium, commercial light water reactor waste, sodium-bonded spent nuclear fuel, and weapons components that could be processed in SRS canyons. Impacts for the last two groups are based on conventional processing impacts of spent nuclear fuel "Group A"; DOE (2000c).
f. Totals have been rounded.

additional 348,000 cubic meters. The major contributor to the other waste volumes would be from weapons components from various DOE sites that could be processed in SRS canyons and from SNF management activities. Therefore, the potential cumulative amount of waste generated from SRS activities during the period of interest would be 675,000 cubic meters.

This large quantity of radioactive and hazardous waste must be managed safely and effectively to avoid severe impacts to human health and the environment. Such management is a major component of new missions for DOE. DOE has facilities in place and is developing new ways to better contain radioactive and hazardous substances. It is important to note that the quantities of waste generated are not equivalent to the amounts that will require disposal. For example, HLW is evaporated and concentrated to a smaller volume for final disposal.

The Three Rivers Solid Waste Authority Regional Waste Management Center at SRS accepts non-hazardous and non-radioactive solid wastes from SRS and eight surrounding South Carolina counties. This municipal solid waste landfill provides state-of-the-art Subtitle D (non-hazardous) facilities for landfilling solid wastes while reducing the environmental consequences associated with construction and operation of multiple county-level facilities (DOE 1995b). It was designed to accommodate combined SRS and county solid waste disposal needs for at least 20 years, with a projected maximum operational life of 45 to 60 years (DOE 1995b). The landfill is designed to handle an average of 1,000 tons per day and a maximum of 2,000 tons per day of municipal solid wastes. SRS and eight cooperating counties had a combined generation rate of 900 tons per day in 1995. The Three Rivers Solid Waste Authority Regional Waste Management Center opened in mid-1998.

Tank closure activities and other planned SRS activities would not generate larger volumes of radioactive, hazardous, or solid wastes beyond current and projected capacities of SRS waste storage and/or management facilities.

5.5 Utilities and Energy

Table 5-5 lists the cumulative total of water consumption from activities at SRS. The values are based on annual consumption estimates. DOE has also evaluated the SRS water needs during tank closure. At present, the SRS rate of groundwater withdrawal is estimated to be a maximum of 1.7×10^{10} liters per year. The maximum estimated amount of water needed annually for the Grout Option under the Clean

Table 5-5. Estimated average annual cumulative water consumption.

Activity	Water usage[a] (liters)
SRS Baseline	1.70×10^{10}
SRS HLW Tank Closure[b]	8.65×10^{6}
Other foreseeable SRS activities[c]	8.84×10^{8}
Total	1.79×10^{10}

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a. Includes groundwater and surface-water usage.

b. Based on the Grout Option under the Clean and Stabilize Tanks Alternative (Table 4.1.11-1).

c. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility, Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.

and Stabilize Tanks Alternative would increase this demand by less that 0.1 percent (Table 5-5) when added to present groundwater withdrawals and that for other foreseeable SRS activities. This level of water withdrawal is not expected to exceed SRS capacities.

Overall SRS electricity consumption would not be impacted by tank closure activities. Electricity usage for tank closure would be similar to current consumption levels in F- and H-Tank Farms Area.

5.6 Closure – Near-Term Cumulative Impacts

The above analysis demonstrates minimal cumulative impacts due to the increment of near-term (2000-2030) tank-closure activities for the five resource areas that required evaluation. Table 5-6 summarizes the near-term cumulative impact of past, present, proposed, and other reasonably foreseeable actions for the resource areas presented in this chapter.

5.7 Long-Term Cumulative Impacts

SRS personnel have prepared a report, referred to as the *Composite Analysis* (WSRC 1997), that calculated the potential cumulative impact to a hypothetical member of the public over a period of 1,000 years from releases to the environment from all sources of residual radioactive material expected to remain in the SRS General Separations Area which contains all of the SRS waste disposal facilities, chemical separations facilities, HLW tank farms, and numerous other sources of radioactive material. The impact of primary concern was the increased probability of fatal cancers. The *Composite Analysis* also included contamination in the soil in and around the HLW tank farms resulting from previous surface spills, pipeline leaks, and Tank 16 leaks as sources of residual radioactive material. The *Composite Analysis* considered 114 potential sources of radioactive material containing 115 radionuclides.

The *Composite Analysis* calculated maximum radiation doses to hypothetical members of the public at the mouth of Fourmile Branch, at the mouth of Upper Three Runs, and on the Savannah River at the Highway 301 bridge. The estimated peak all-pathway dose (excluding the drinking water pathway) from all radionuclides was 14 mrem/year (7×10^{-7} fatal cancer risk to a hypothetical member of the public at the mouth of Fourmile Branch), 1.8 mrem/year (mouth of Upper Three Runs), and 0.1 mrem/year (Savannah River). The major contributors to dose were tritium, carbon-14, neptunium-237, and isotopes of uranium (WSRC 1997). These impacts are small because they are substantially below the NRC (and DOE) exposure limit of 100 mrem/yr for offsite individuals.

The analysis also calculated radiation doses from drinking water in Fourmile Branch and Upper Three Runs. The estimated peak drinking water doses from all radionuclides for these

Table 5-6. Summary of short-term cumulative effects on resources from HLW tank closure alternatives.

Resource	Key Indicator of Environmental Impacts	Past Actions	Present Actions	HLW Tank Closure Alternatives	Other Future Actions	Cumulative Effect
Air	24-hour sulfur dioxide concentration	No residual impacts remain from past emissions.	Conservatively estimated to be 96 percent of applicable standard	Incremental increase from the Saltstone Option under the Clean and Stabilize Tanks Alternative is about 0.03 percent of present condition.	Increment about 0.33 percent of present condition.	Unchanged by proposed and other future actions.
Water	Tritium to onsite streams	No residual impacts of past direct discharges. Tritium in the Savannah River was a small fraction of federally mandated limit.	Largest contributor to dose from drinking water dramatically reduced from past operations.	No addition of tritium to Upper Three Runs under any tank closure alternative.	Very small addition of tritium to Upper Three Runs.	No meaningful increment from present, satisfactory conditions.
Health	Annual radiological dose to offsite maximally exposed individual	All-pathway dose of 1.6 mrem is small fraction of 100 mrem limit	All-pathway dose of 0.07 mrem is very small fraction of 100 mrem limit	All pathway dose from the Saltstone Option under the Clean and Stabilize Tanks Alternative is less than 0.1 percent of current dose of 0.07 mrem (which is a small fraction of the 100 mrem limit).	Approximately 60 percent of current dose of 0.07 mrem (which is a small fraction of the 100 mrem limit).	All pathway dose of 0.12 mrem is small fraction of 100 mrem limit.
Waste management	High-level waste (HLW) generation	Large, continual quantities of HLW generated.	Less annual generation, minimal additional tank space needed, 34 million gallons in storage	About 50 percent of cumulative total from the Clean and Remove Tanks Alternative	Highly radioactive fraction immobilized in DWPF. Separated, low activity waste disposed in onsite vaults	Actions initiated to handle this substantial quantity (191,000 cubic meters) of HLW with minimal impact to human health and the environment.
Utility and Energy	Annual withdrawal of groundwater	No cumulative impact to aquifer from past high withdrawals	Aquifer is not stressed by annual withdrawals of 1.7×10^{10} liters.	Very small fraction (0.05 percent) of current withdrawals from the Grout Option under the Clean and Stabilize Tanks Alternative.	Moderate increase (13 percent) in groundwater withdrawals	Potential cumulative impacts are not added to by the proposed action.

creeks were 23 mrem/year (1.2×10^{-5} fatal cancer risk to a hypothetical member of the public at Fourmile Branch) and 3 mrem/year for Upper Three Runs (WSRC 1997).

In this EIS, DOE estimated peak doses over a 10,000 year period of analysis. The highest estimated radiation dose in these creeks from the No Action Alternative, the first location where it could interact with contaminants from these other facilities, is 2.3 mrem/year. The location for which this value is calculated is upstream of the location presented in the Composite Analysis. DOE expects additional dilution to occur as the contaminants from HLW tank closure activities move downstream. Therefore, the dose and the associated impact (1.2×10^{-6} fatal cancer risk to a hypothetical member of the public) from HLW tank closure activities would be a small fraction of the doses due to the other activities analyzed in the Composite Analysis.

In addition, the peak radiation doses from HLW tank closure activities would occur substantially later in time than the impacts of the other activities evaluated in the *Composite Analysis*. For example, because the radioactive contamination in the soil in and around the HLW tanks farms does not have the benefit of a concrete layer below or above it (as would the residual activity remaining in the closed HLW tanks under the fill with grout option), these contaminants would reach the groundwater (and thus the seepline and the surface water) long before the contaminants in the in the closed HLW tanks. Therefore there would be no overlap in time of these contaminants.

As described in Section 4.2.4, DOE has developed a future use policy for the SRS. A key component of this policy is that residential uses of all SRS land would be prohibited in any area of the site. This policy also states that SRS boundaries would remain unchanged, and the land would remain under the ownership of the Federal government. The area around the General Separations Area would remain an industrial use zone. Residential uses of the General Separations Area would be prohibited under any circumstances.

The future condition of the F- and H-Area Tank Farms would vary among the alternatives. Under the No Action Alternative, structural collapse of the tanks would create unstable ground conditions and form holes into which workers or other site users could fall. Neither the Clean and Stabilize Tanks Alternative nor the Clean and Remove Tanks Alternative would have this safety hazard, although there could be some moderate ground instability with the Clean and Fill with Sand Option. For the Clean and Stabilize Tanks Alternative, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting in the surface depressions. This action would prevent ponding conditions over these tanks that could facilitate the degradation of the tank structure. For the Clean and Remove Tanks Alternative, the tank voids remaining after excavation would be filled in. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

From a land use perspective, the F- and H- Area Tank Farms are zoned Heavy Industrial and are within existing heavily industrialized areas. The alternatives evaluated in this EIS are limited to closure of the tanks and associated equipment. They do not address other potential sources of contamination co-located with the tank systems such as soil or groundwater contamination from past releases or other facilities. Consequently, future land use of the Tank Farms areas is not solely determined by the alternatives for closure of the tank systems. For example, the Environmental Restoration program may determine that the Tank Farms areas should be capped to control the spread of contaminants through the groundwater. Such decisions would constrain future use of the Tank Farms areas. The Clean and Stabilize Tanks Alternative would render the Tank Farms areas least suitable for other uses, as the closed grout-filled tanks would remain in the ground. The Clean and Remove Tanks Alternative would have somewhat less impact on future land use since the tank systems would be removed. However, DOE does not expect the General Separations Area, which surrounds the F and H-Area Tank Farms, to be available for other uses making future uses of the Tank Farms areas a moot point.

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CHAPTER 6. RESOURCE COMMITMENTS

This chapter describes the unavoidable adverse impacts, short-term uses of environmental resources versus long-term productivity, and irreversible or irretrievable commitments of resources associated with cleaning, isolating, and stabilizing the HLW tanks and related systems at the SRS. This chapter also includes discussions about DOE waste minimization, pollution prevention, and energy conservation programs in relation to implementation of the proposed action.

6.1 Unavoidable Adverse Impacts

Implementing any of the alternatives considered in this EIS for the closure of the HLW tanks at SRS would result in unavoidable adverse impacts to the human environment. The construction and operation of a saltstone mixing facility in F- and H-Areas (combined with the continued operation of the current Saltstone Manufacturing and Disposal Facility in Z-Area) under the Clean and Fill with Saltstone Option, or the construction and operation of temporary batch plants for grout production in F- and H-Areas under the Clean and Fill with Grout Option, would result in minimal short-term adverse impacts to geologic resources, traffic, and cultural resources as described in Chapter 4. Short-term impacts span from year 2000 through final closure of the existing HLW tanks in approximately 2030. Generally all construction activities would occur within the boundary of the tank farms (67 acres total) in an already-developed industrial complex. An additional 1 to 3 acres would be required outside the fenced areas as a lay-down area to support construction activities under the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative.

Excavation of backfill material from an onsite borrow area could result in potential adverse impacts to geologic and surface water resources. Under the Clean and Stabilize Tanks Alternative, the soil elevation configurations surrounding four tanks in F-Area and four tanks in H-Area would require backfill soil to bring the ground surface at these tanks up to the surrounding surface elevation to prevent surface water from collecting in the surface depressions. An estimated 170,000 cubic meters of soil would be required to fill the depressions to grade. Under the Clean and Remove Tanks Alternative, 356,000 cubic meters of soil would be required to backfill the voids left by the removal of the tanks. As part of the required sediment and erosion control plan (using Best Management Practices), storm water management and sediment control measures (i.e., retention basins) would minimize runoff from these areas and any potential discharges of silts, solids, and other contaminants to surface-water streams. Any stormwater collected in the lined retention basins would be sent to Fourmile Branch (if uncontaminated rainwater), to the Effluent Treatment Facility for removal of contaminants, or rerouted to the tank farms for temporary storage prior to treatment. In addition, use of Best Management Practices would minimize any short-term adverse impacts to geologic resources.

Impacts from the borrow site development would include the physical alteration of 7-14 acres of land (and attended loss of potential wildlife habitat) and noise disturbances to wildlife in nearby woodlands, assuming woodlands are present. Any site selected for the borrow area would be within the central developed core of the SRS, which is dedicated to industrial facilities. There would be no change in overall land use patterns on the SRS.

Adverse impacts to ecological resources would be minimal and short-term because most activities would occur within the previously disturbed and fenced areas. Although noise levels would be relatively low outside the immediate areas of construction, the combination of construction noise and human activity probably would displace small numbers of animals associated with an approximate 20-acre area surrounding the F- and H-Areas.

6.2 Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

The proposed locations for any new facilities would all be within developed industrial landscapes. Each of the options for the Clean and Stabilize Tanks Alternative would require approximately 1 to 3 additional acres for lay-down areas. The existing infrastructure (roads and utilities, etc.) within the F- and H-Areas is sufficient to support the proposed facilities.

For both F- and H-Area saltstone mixing facilities, after the operational life (i.e., all tanks are filled and closed) DOE could decontaminate and decommission the facilities in accordance with applicable regulatory requirements and restore the area to a brown-field site that would be available for other industrial use. Appropriate NEPA review would be conducted prior to the initiation of any decontamination and decommissioning action. In all likelihood, none of the sites would be restored to a natural terrestrial habitat (DOE 1998).

The project-related uses of environmental resources for the implementation of any of the proposed alternatives are characterized in the following paragraphs:

- Groundwater would be used in tank washing and cleaning and to meet process and sanitary water needs over the short-term impact period (i.e., 2000 to 2030). Long-term groundwater use would be limited to amounts necessary to support sanitary and drinking water needs during monitoring of the institutional area. After use and treatment (in the F- and H-Area Effluent Treatment Facility), this water would be released through permitted discharges into surface water streams. Therefore, the withdrawal, use, and treatment of groundwater would not affect the long-term productivity of this resource.

- Air emissions associated with implementation of any of the alternatives would add small amounts of radiological and nonradiological constituents to the air of the region. During the short-term impacts period (i.e., 2000 to 2030), these emissions would result in an additional loading and exposure but would not impact SRS compliance with air quality or radiation exposure standards. During the long-term impacts period, air emissions associated with the proposed action would be negligible. Therefore, there would be no significant residual environmental affects to long-term environmental productivity.

- Radiological contamination of the groundwater below and adjacent to the F- and H-Areas would occur over time. Because some tank groups in the H-Area lie beneath the water table, the contaminants from these tanks would be released directly into the groundwater. In addition, some contaminants from each tank farm would be transported by groundwater through the Water Table and Barnwell-McBean Aquifers to the seepline along Fourmile Branch. For tanks situated north of the groundwater divide in the H-Area Tank Farm, contaminants released to the Water Table or Barnwell-McBean Aquifers may discharge to unnamed tributaries to Upper Three Runs or migrate downward to underlying aquifers. Beta-gamma dose and alpha concentrations would be below Maximum Contaminant Levels at the seepline in both F- and H-Areas for two of the three preferred options (i.e., Clean and Fill with Grout, Clean and Fill with Sand). In addition, the No Action Alternative would exceed the Maximum Contaminant Levels at the seepline. DOE calculated peak radiation dose to aquatic and terrestrial receptors at the seepline and receiving surface water and compared the dose to the limit of 1.0 rad per day. Results indicated that all calculated absorbed doses to the referenced organisms are below the regulatory limit and therefore would have no impact on the long-term productivity of the ecosystem at the seepline.

- Residual contaminants remaining in the HLW tanks after closure following the period of institutional control could result in long-term impacts to the public health. DOE evaluated the impacts over a 10,000-year period in which the contaminants would be leached from the tank structures to the groundwater. The seepline was determined to be the area of greatest concern (i.e., area of maximum dose). Results indicated that the maximum dose to an adult receptor at the seepline for either tank farm is 6.2 mrem for the No Action Alternative. This dose is less than the 100 mrem public dose limit. Based on this low dose, DOE would not expect any long-term productivity health effects to an adult receptor.

- The management and disposal of waste (low-level, hazardous, mixed, industrial, and sanitary) and non-recyclable radiological waste over the project's life would require energy and space at SRS treatment, storage, or disposal facilities (e.g., Z-Area Saltstone, E-Area Vaults, Consolidated Incineration Facility, Three Rivers Sanitary Landfill). The land required to meet the solid waste needs would require a long-term commitment of terrestrial resources. DOE established a future use policy for the SRS for the next 50 years in the 1998 *Savannah River Site Future Use Plan* (DOE 1998). This report sets forth guidance that would exclude the tank farm and associated waste disposal areas from non-conforming land uses. Therefore, this policy ensures that the areas would be removed from long-term productivity.

6.3 Irreversible and Irretrievable Resource Commitments

Resources that would be irreversibly and irretrievably committed during the implementation of HLW tank closure alternatives include those that cannot be recovered or recycled and those that are consumed or reduced to unrecoverable forms. The commitment of capital, energy, labor, and material during the implementation of HLW tank closure alternatives would generally be irreversible.

Energy expended would be in the form of fuel for equipment and vehicles, electricity for facility operations [e.g., bulk waste removal and production of grout at batch plant(s)], production of steam (i.e., for operation of ventilation systems on the waste tanks and heating of the cleaning solutions), and human labor. Construction (e.g., new saltstone mixing facilities) would generate nonrecyclable materials such as sanitary solid waste and construction debris. Implementation of any of the options for the Clean and Stabilize Tanks Alternative would generate nonrecyclable waste streams such as radiological and nonradiological wastes including liquids, low-level, hazardous, mixed low-level, and industrial. For example, oxalic acid cleaning would require between 225,000 and 500,000 gallons of oxalic acid for washing of each Type III tank (see Section 4.1.10 for greater detail). However, certain materials (e.g., copper, stainless steel) used during construction and operation of any proposed facility or facilities could be recycled when the facility is decontaminated and decommissioned. Some construction materials, particularly those associated with existing F- and H-Area Tank Farm facilities would not be salvageable due to radioactive contamination. Table 6-1 lists estimated requirements for materials consumed during the closure of a single Type III tank.

The implementation of the any of the HLW tank closure alternatives considered in this EIS, including the No Action Alternative, would require water, electricity, and diesel fuel. Table 6-2 lists the utilities and energy that would be consumed as a result of implementing each of the proposed alternatives.

Water would be obtained from onsite groundwater sources. Electricity, oxalic acid, sand, and diesel fuel would be purchased from commercial sources. These commodities are readily available, and the amounts required would not

Table 6-1. Estimated maximum quantities of materials consumed for each Type III tank closed.[a]

	Clean and Stabilize Tanks Alternative				
Materials	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tank Alternative	No Action Alternative
Oxalic acid[b] (4 percent) (gal)	225,000	225,000	225,000	500,000	-
Sand (gal)	-	2,640,000	-	-	-
Cement (gal)	2,640,000	-	52,800	-	-
Fly Ash	-	-	Included in	-	-
Boiler slag	-	-	saltstone	-	-
Additives (grout) (gal)	500	-	-	-	-
Saltstone (gal)	-	-	2,640,000	-	-

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a. The SRS HLW tank systems includes four tank designs (Types I, II, III, and IV). Estimates were developed for closure of a single Type III tank system. Closure of a Type III tank system represents the maximum material consumption relative to the other tank designs. Waste generation estimates for closure of the other tank designs are assumed to be: Type I – 60 percent of Type III estimate, Type II – 80 percent of Type III estimates, and Type IV – 90 percent of Type III estimate (Johnson 1999a).

b. At the present time, potential safety considerations restrict the use of oxalic acid in the HLW tanks (see Section 2.2.1).

Table 6-2. Total estimated utility and energy usage for the HLW tank closure alternatives.[a]

	Clean and Stabilize Tanks Alternative				
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative	No Action Alternative
Water (gallons)	48,930,000	12,840,000	12,840,000	25,680,000	NA[b]
Electricity	NA	NA	NA	NA	NA
Steam (pounds)	8,560,000	8,560,000	8,560,000	17,120,000	NA
Fossil fuel (gallons)	214,000	214,000	214,000	428,000	NA
Total utility cost	$4,280,000	$4,280,000	$4,280,000	$12,840,000	NA

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a. Source: Johnson (1999a,b,c,d).

b. NA = Not applicable to this alternative. Utility and energy usage for these alternatives would not differ significantly from baseline consumption.

have an appreciable impact on available supplies or capacities.

6.4 Waste Minimization, Pollution Prevention, and Energy Conservation

6.4.1 WASTE MINIMIZATION AND POLLUTION PREVENTION

DOE has implemented an aggressive waste minimization and pollution prevention program at SRS at the sitewide level and for individual organizations and projects. As a result, significant reductions have been achieved in the amounts of wastes discharged into the environment and sent to landfills, resulting in significant cost savings.

To implement a waste minimization and pollution prevention program for the closure of the HLW tanks, DOE would characterize waste streams and identify opportunities for reducing or eliminating them. Emphasis would be placed on minimizing the largest waste stream, radioactive liquid waste, through source reductions, efficiencies, and recycling (if possible). Selected waste minimization practices could include:

- Process design changes to eliminate the potential for spills and to minimize contamination areas

- Decontamination of equipment to facilitate reuse

- Recycling metals and other usable materials, especially during the construction phase of the project

- Preventive maintenance to extend process equipment life

- Modular equipment designs to isolate potential failure elements to avoid changing out entire units

- Use of non-toxic or less toxic materials to prevent pollution and minimize hazardous and mixed waste streams

- Gloveboxes to eliminate the need for plastic suits and air hoses during maintenance activities and line breaks

- Incineration at the Consolidated Incineration Facility and other volume reduction techniques (i.e., compaction, cutting) to reduce waste volumes

During construction, DOE would implement actions to control surface water runoff and construction debris and to prevent infiltration of contaminants into groundwater. The construction contractor would be selected, in part, based on prior pollution prevention practices.

6.4.2 ENERGY CONSERVATION

SRS has an active energy conservation and management program. Since the mid-1990s more than 40 onsite administrative buildings have undergone energy efficiency upgrades. Representative actions include the installation of energy-efficient light fixtures, the use of occupancy sensors in rooms, use of diode light sticks in exit signs, and the installation of insulating blankets around hot water heaters. Regardless of location, the incorporation of these types of energy-efficient technologies into facility design, along with the implementation of process efficiencies and waste minimization concepts, would facilitate energy conservation by any of the tank closure alternatives.

Reference

DOE (U.S. Department of Energy), 1998, *Savannah River Site Future Plan*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, January.

Hunter, C. H., 1999, "Non-Radiological Air Quality Modeling for the High-Level Waste Tank Closure Environmental Impact Statement (EIS)," SRT-NTS-990067, interoffice memorandum to C. B. Shedrow, Westinghouse Savannah River Company, Aiken, South Carolina, March 26.

Johnson G., 1999a, Westinghouse Savannah River Company, "Draft Input to Tank Closure EIS," e-mail to P. Young, Tetra Tech NUS, Aiken, South Carolina, April 8.

Johnson G., 1999b, Westinghouse Savannah River Company, "Re: FW: Draft Input to Tank Closure EIS," e-mail to P. Young, Tetra Tech NUS, Aiken, South Carolina, April 13.

Johnson G., 1999c, Westinghouse Savannah River Company, "Responses to 4/20/99 Questions for Tank Closure EIS," e-mail to P. Young, Tetra Tech NUS, Aiken, South Carolina, April 21.

Johnson G., 1999d, Westinghouse Savannah River Company, "Re: Tank Closure EIS," e-mail to L. Matis, Tetra Tech NUS, Aiken, South Carolina, May 20.

CHAPTER 7. APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

This chapter identifies and summarizes the major laws, regulations, Executive Orders, and DOE Orders that could apply to the closure of the HLW tank systems at the SRS. Permits or licenses could be required under some of these laws and regulations.

Section 7.1 describes the process DOE used to develop the methodology and performance standards for closure of the SRS HLW tank systems. Section 7.2 discusses the major Federal and State of South Carolina statutes and regulations that impose environmental protection requirements on DOE and that require DOE to obtain approval prior to closing the HLW tank systems. Each of the applicable regulations establishes how potential releases of pollutants and radioactive materials are to be controlled or monitored and include requirements for the issuance of permits for new operations or new emission sources. In addition to environmental permit requirements, the statutes may require consultations with various authorities to determine if an action requires a permit or the implementation of protective or mitigative measures. Sections 7.2.1 and 7.2.2 discuss the environmental permitting process and list the environmental permits and consultations (see Table 7-1) applicable to closure of the SRS HLW tank systems.

Sections 7.3 and 7.4 address the major Federal statutes, regulations, and Executive Orders, respectively, which address issues such as protection of public health and the environment, worker safety, and emergency planning. The Executive Orders clarify issues of national policy and set guidelines under which Federal agencies must act.

DOE implements its responsibilities for protection of public health, safety, and the environment through a series of departmental regulations and orders (see Section 7.5) that are typically mandatory for operating contractors of DOE-owned facilities.

7.1 Closure Methodology

7.1.1 CLOSURE STANDARDS

The SRS HLW tank systems are permitted by SCDHEC under authority of the South Carolina Pollution Control Act (SC Code Ann., Section 48-1-10, et seq.) (see Section 7.2.1) as industrial wastewater treatment facilities. DOE is required to close the HLW tank systems in accordance with Atomic Energy Act requirements (e.g., DOE Orders) and SC Regulation R.61-82 "Proper Closeout of Wastewater Treatment Facilities." This regulation requires the performance of such closures to be carried out in accordance with site-specific guidelines established by SCDHEC to prevent health hazards and to promote safety in and around the tank systems. To facilitate compliance with this requirement and recognize the need for consistency with overall remediation of SRS under the Federal Facility Agreement (see Section 7.3.2), DOE has adopted a general strategy for HLW tank system closure that includes evaluation of an appropriate range of closure alternatives with respect to pertinent, substantive environmental requirements and guidance and other appropriate criteria (e.g., technical feasibility, cost). The general strategy for HLW tank system closure is set forth in the *Industrial Wastewater Closure Plan for the F- and H-Area High-Level Waste Tank Systems* (DOE 1996a). The general strategy is consistent with comparative analyses performed as part of a corrective measures study/feasibility study under the Federal Facility Agreement.

DOE will close all of the HLW tank systems in the F- and H-Area Tank Farms in accordance with the general strategy, including Tank 16, which is no longer operational and hence was not permitted as part of the industrial wastewater treatment facility. With respect to closure,

Table 7-1. Environmental permits and consultations required by law (if needed).

Activity/Topic	Law	Requirements	Agency
Site Preparation	Federal Clean Water Act (Section 404)	Stormwater Pollution Prevention Plan for Industrial Activity	SCDHEC[a]
Wastewater Discharges	Federal Clean Water Act S.C. Pollution Control Act	Stormwater Pollution Prevention/Erosion Control Plan for construction activity	SCDHEC
		NPDES Permit(s) for Process Wastewater Discharges	SCDHEC
		Process Wastewater Treatment Systems Construction and Operation Permits (if applicable)	SCDHEC
		Sanitary Waste Water Pumping Station Tie-in Construction Permit; Permit to Operate	SCDHEC
Air	Clean Air Act – NESHAP[b]	Rad Emissions - Approval to construct new emission source (if needed)	EPA[c]
		Air Construction and Operation permits - as required (e.g., Fire Water Pumps; Diesel Generators)	SCDHEC
		General source - Stacks, Vents, Concrete batch plant	SCDHEC
		Air Permit - Prevention of Significant Deterioration (PSD)	SCDHEC
Domestic Water	Safe Drinking Water Act	Construction and operation permits for line to domestic water system	SCDHEC
Endangered Species	Endangered Species Act	Consultation	U.S. Fish and Wildlife Service; National Marine Fisheries Service
Migratory Birds	Migratory Bird Treaty Act	Consultation	U.S. Fish and Wildlife Service
Historical/Cultural Resources	National Historic Preservation Act	Consultation	State Historic Preservation Officer

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a. South Carolina Department of Health and Environmental Control.
b. National Emissions Standards for Hazardous Air Pollutants.
c. Environmental Protection Agency.

Tank 16 is subject to the same considerations that determine acceptable closure alternatives for the other 50 HLW tank systems. The past release from Tank 16 that resulted in its removal from service will be addressed along with the releases from the Tank 37 condensate transfer system as part of the H-Area Tank Farm Groundwater Operable Unit in accordance with the Federal Facility Agreement.

The General Closure Plan identifies the resources potentially affected by contaminants remaining in the tanks after waste removal and closure, describes how the tanks would be cleaned and how the tank systems and residual wastes would be stabilized, and identifies Federal and state environmental regulations and guidance that apply to the tank closures. It also describes the methodology using fate and transport models to calculate potential environmental exposure concentrations or radiological dose rates from the residual waste left in the tank systems and provides a methodology to account for closure impacts of individual tank systems such that all closures would comply with environmental standards. This closure plan specifies the management of residual waste as waste incidental to reprocessing.

In developing its general closure strategy that includes extensive consultation with environmental regulators, DOE identified the substantive environmental requirements and guidance documents most pertinent to the selection and implementation of HLW tank system closure options. These requirements and guidance are comparable to those established as applicable or relevant and appropriate requirements (known as “ARARs”) and to-be-considered materials (known as “TBCs”) in the context of a corrective measures study/feasibility study under the Federal Facility Agreement. A compilation of the ARARs and TBCs can be found in Appendix C of DOE (1996a).

DOE reviewed the requirements and guidance to identify (1) standards for environmental protection that are invoked by more than one regulatory program or authority, and (2) conflicting requirements. This process resulted in a list of requirements and guidance, including DOE Orders (435.1, 5400.1, 5400.5) and state and Federal regulations, that DOE used to identify specific regulatory standards for protection of human health and the environment. Overlapping requirements and guidance were reduced to a single list representing only the most stringent or most specific standards. This listing became the closure performance standards. The performance standards are generally numerical, such as concentrations or dose limits for specific radiological or chemical constituents in releases to the environment, which are set forth in the requirements and standards guidance. The numerical standards apply at different points of compliance and at varying times during or after closure. The performance standards apply to the entire tank farm area. Performance standards are established for environmental media. For example, the performance standard for groundwater will be the groundwater protection standard applied at the point where groundwater discharges to the surface (known as the seepline). For surface water, the performance standard will be the surface water quality standard applied in the receiving stream. Tables 7-2 and 7-3 present the radiological and nonradiological water quality criteria identified as performance standards for the SRS HLW tank closures.

7.1.2 PERFORMANCE OBJECTIVE

DOE will establish performance objectives for closure of each HLW tank. Each performance objective will correspond to a performance standard in the Closure Plan. Performance objectives will normally be more stringent than the performance standard. For example, if the performance standard for drinking water in the receiving stream is 4 millirem per year, the contribution of contaminants from all tanks (and other facilities) will not exceed the 4 millirem per year limit. DOE will evaluate closure options for specific tank systems to determine if use of a specific closure option will allow DOE to meet the performance objectives. Based on this analysis, DOE will develop a closure module for each HLW tank system such that the performance objectives for the tank system can be met.

Table 7-2. Nonradiological groundwater and surface water performance standards applicable to SRS HLW tank closure.

Constituents of concern[a]	Maximum contaminant level (40 CFR §141.62) (mg/l)	Maximum contaminant level goal (40 CFR §141.51) (mg/l)	Maximum contaminant levels (SC R.61-58.5.B(2)) (mg/l)	Water quality criteria for protection of human health (SC R.61-68, Appendix 2) (mg/l)	Criteria to protect aquatic life (SC R.61-68, Appendix 1) (mg/l)	
					Average	Maximum
Aluminum					0.087	0.750
Chromium III				637.077	0.120	0.980
Chromium VI				0.050	0.011	0.016
Total chromium	0.1	0.1	0.1		0.011	0.016
Copper		1.3			0.0065	0.0092
Fluoride	4.0	4.0	4.0			
Iron					1.000	2.000
Lead		zero[b]		0.050	0.0013	0.034
Mercury	0.002	0.002	0.002	1.53×10^{-4}	1.2×10^{-5}	0.0024
Nickel			0.1	4.584	0.088	0.790
Nitrate	10 (as N)	10 (as N)	10 (as N)			
Nitrite	1 (as N)	1 (as N)	1 (as N)			
Total nitrate and nitrite	10 (as N)	10 (as N)	10 (as N)			
Selenium	0.05	0.05	0.05	0.010	0.0050	0.020
Silver				0.050		0.0012

Source: DOE (1996a)

a. Includes SRS HLW constituents for which water quality performance standards were identified.

b. Action level for lead is 0.015 mg/l.

Table 7-3. Radiological groundwater and surface water performance standards applicable to SRS HLW tank closure.

Constituent of concern	Standard
Beta particle and photon radioactivity	4 mrem/yr
Combined radium-226 and radium-228	5 pCi/l
Gross alpha	15 pCi/l (including radium-226 but excluding radon and uranium)
Tritium	20,000 pCi/l
Strontium	8 pCi/l
Radiation dose to native aquatic organisms	1 rad/day from liquid discharges to natural waterways

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Source: DOE (1996a).

The performance evaluation will focus on the exposure pathways and contaminants of most concern for a specific HLW tank system. DOE anticipates that the exposure pathway of most concern will be the contaminant release to groundwater and migration to onsite streams. The contaminants of most concern will be those subject to the most stringent performance standards for points of compliance within the exposure pathway. The lowest concentration limit for a specific constituent would become the performance objective for that constituent.

An example of comparison to performance objectives is provided in Table 7-4.

7.1.3 INCIDENTAL WASTE

The terms “incidental waste” or “waste incidental to reprocessing” refer to a process for identifying wastes that might otherwise be considered HLW due to their origin, but are actually managed as low-level or transuranic waste, as appropriate, if the waste incidental to reprocessing requirements contained in DOE Radioactive Waste Management Manual (DOE M 435.1-1) are met. This is a process by which DOE can make a determination that, for example, wastes residues remaining in HLW tanks, equipment, or transfer lines, are managed as low-level or transuranic waste if the requirements in Section II.B of DOE M 435.1-1 have been or will be met.

The requirements contained in DOE M 435.1-1 are divided into two processes: the “citation” process and the “evaluation” process. When determining whether spent nuclear fuel reprocessing plant wastes are another waste type or HLW, either the citation or evaluation process described in DOE M 435.1-1 shall be used.

- Citation – Waste incidental to reprocessing by “citation” includes spent nuclear fuel processing plant wastes that meet the "incidental waste" description included in the Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7. These radioactive wastes are the result of processing plant operations, such as, but not limited to contaminated job wastes, such as laboratory items (clothing, tools, and equipment).

- Evaluation – Waste incidental to reprocessing by “evaluation” includes spent nuclear fuel processing plant wastes that: (1) have been processed, or will be processed to remove key radionuclides to the maximum extent that is technically and economically practical, (2) will be managed to meet safety requirements comparable to the performance standards set forth in Subpart C of 10 CFR 61 (if low-level waste) or will be incorporated in a solid physical form and meet alternative requirements for waste classification and characteristics authorized by DOE (if transuranic waste), and (3) managed as low-level or transuranic waste pursuant to DOE's authority under the Atomic Energy Act in accordance with the applicable provisions of DOE M 435.1-1.

Those waste streams that meet the requirements, either by citation or evaluation, would be excluded from the scope of HLW. In the absence of an “incidental waste” or “waste incidental to reprocessing” determination, DOE would continue management of HLW due to its origin as HLW regardless of its radionuclide content.

Per DOE guidance in DOE G 435.1, the DOE Field Element Manager is responsible for ensuring that waste incidental to reprocessing determinations are made consistent with either the citation or the evaluation process. A determination made using the evaluation process will include consultation and coordination with the DOE Office of Environmental Management. The U.S. Nuclear Regulatory Commission (NRC) has participated in regulatory reviews using these evaluation criteria in the past and has expertise that is expected to complement DOE’s internal review. Hence, consultation with NRC staff regarding the requirements for the evaluation process is strongly encouraged under the guidance for DOE O 435.1.

DOE has consulted with NRC regarding the incidental waste determination for the SRS tank system residuals. To facilitate the consultations, DOE prepared a demonstration that the material remaining in the SRS tank systems at closure satisfies criteria for classification as “incidental waste” (DOE 1997b). NRC has completed its review of the Savannah River Operations Office’s HLW tank closure methodology and concluded that DOE’s methodology reasonably analyzes the relevant considerations for an incidental waste determination (65 FR 62377, October 18, 2000).

Table 7-4. Comparison of modeling results to performance objectives at the seepline.[a]

	Units	Adjusted PO	F-Area GTS impact	Previous closures impact[b]	Tank 17 impact	Remaining PO
Radiological						
Beta-gamma dose	mrem/yr	4.0	1.9	0.0055	0.022	3.99
Alpha concentration	pCi/L	15	3.9×10^{-2}	(c)	(c)	15
Total dose	mrem/yr	4.0	1.9	0.0055	0.022	3.99
Nonradiological						
Nickel	mg/L	0.1	(d)	0	(d)	0.1
Chromium[e]	mg/L	0.1	4.6×10^{-5}	5.0×10^{-6}	1.1×10^{-5}	0.1
Mercury	mg/L	0.002	(d)	0	(d)	0.002
Silver	mg/L	0.05	1.7×10^{-3}	1.9×10^{-4}	4.1×10^{-4}	0.049
Copper	mg/L	1.3	(d)	0	(d)	1.3
Nitrate	mg/L	10 (as N)	1.2×10^{-2}	1.3×10^{-3}	7.5×10^{-3}	10 (as N)
Lead	mg/L	0.015	(d)	0	(d)	0.015
Fluoride	mg/L	4.0	1.1×10^{-3}	1.3×10^{-4}	2.7×10^{-4}	4
Barium	mg/L	2.0	(d)	0	(d)	2

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a. Source: DOE 1997a
b. Tank 20
c. Concentration is less than 1.0×10^{-13} pCi/L.
d. Concentration is less than 1.0×10^{-06} mg/L
e. Total chromium (chromium III and VI).
PO = Performance Objective; GTS = Groundwater Transport Segment.

7.1.4 ENVIRONMENTAL RESTORATION PROGRAM

Upon completion of closure activities for a group of tanks (and their related equipment) in a particular section of a tank farm, responsibility for the tanks and associated equipment in the group would be transferred to the SRS environmental restoration program. The environmental restoration program would conduct soil assessments and remedial actions to address any contamination in the environment (including previous known leaks) and develop a post-closure strategy. Consideration of alternative remedial actions under the remediation program is outside the scope of this EIS, and would be conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. However, DOE has established a formal process to ensure that tank closure activities are coordinated with the environmental restoration program. This process is described in the *High-Level Waste Tank Closure Program Plan* (DOE 1996b). This process requires that, once a group of tanks in a particular section of a tank farm is closed, the HLW operations organization and the environmental restoration organization would establish a Co-Occupancy Plan to ensure safe and efficient soils assessment and remediation.

The HLW organization would be responsible for operational control and the environmental restoration organization would be responsible for environmental restoration activities. The primary purpose of the Co-Occupancy Plan is to provide the two organizations with a formal process to plan, control, and coordinate the environmental restoration activities in the tank farm areas. The activities of the environmental restoration program would be governed by the CERCLA, RCRA corrective action, and the Federal Facility Agreement between DOE, SCDHEC, and EPA. As such, it is beyond the scope of this EIS.

DOE's HLW tank closure strategy was designed to be consistent with the requirements of RCRA and CERCLA under which the Tank Farm will eventually be remediated. The details of the proposed closure configuration for individual tank systems will be detailed in modules that are submitted to SCDHEC for approval. The modules are also provided to the SCDHEC and EPA Region IV Federal Facility Agreement project managers for review to ensure consistency with the Agreement's requirements for overall remediation of the Tank Farms. DOE's intention is that HLW tank closure actions would not interfere with or foreclose remedial alternatives for past releases.

7.2 Statutes and Regulations Requiring Permits or Consultations

Environmental regulations require that the owner or operator of a facility obtain permits for the construction and operation of new (water and air) emissions sources and for new domestic drinking water systems. To obtain these permits, the facility operator must apply to the appropriate government agency for a discharge permit for discharges of wastewater to the waters of the state and submit construction plans and specifications for the new emission sources, including new air sources. The environmental permits contain specific conditions with which the permittee must comply during construction and operation of a new emission source, describe pollution abatement and prevention methods to be utilized for reduction of pollutants, and contain emissions limits for pollutants which will be emitted from the facility. Section 7.2.1 discusses the environmental statutes and regulations under which DOE will be required to obtain permits. Table 7-5 identifies the major State of South Carolina statutes and their implementing regulations applicable to HLW tank system closures. The table also provides the underlying federal statutes and implementing regulations. Table 7-1 lists the permits.

7.2.1 ENVIRONMENTAL PROTECTION PERMITS

Clean Air Act, as amended, (42 USC 7401 et seq.), (40 CFR Parts 50-99); South Carolina Pollution Control Act [Section 48-1-10 et seq., SCDHEC Regulation 61-62]

The Clean Air Act, as amended, 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 Act requires Federal agencies, such as DOE, with jurisdiction over any property or facility that might result in the discharge of air pollutants, to comply with "all Federal, State, interstate, and local requirements" related to the control and abatement of air pollution.

The Act requires EPA to establish National Ambient Air Quality Standards to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 USC 7409). It also requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC 7411) and the evaluation of specific emission increases to prevent a significant deterioration in air quality (42 USC 7470). In addition, the Clean Air Act regulates emissions of hazardous air pollutants, including radionuclides, through the National Emission Standards for Hazardous Air Pollutants (NESHAP) program (42 USC 7412). Air emission standards are established at 40 CFR Parts 50 through 99. The following describes four key aspects of the Clean Air Act.

- ***Prevention of Significant Deterioration*** – Prevention of Significant Deterioration, as defined by the Clean Air Act, applies to major stationary sources and is designed to permanently limit the degradation of air quality from specific pollutants in areas that meet attainment standards. The Prevention

Table 7-5. Major state and federal laws and regulations applicable to high-level waste tank system closures.

South Carolina laws and regulations	Federal laws and regulations
South Carolina Pollution Control Act (SC Code Section 48-1-10)	Clean Air Act (42 USC 7401)
	Clean Water Act (33 USC 1251)
Safe Drinking Water Act (SC Code Section 44-55-10)	Safe Drinking Water Act (42 USC 300(f))
Hazardous Waste Management Act (SC Code Section 44-56-10)	Resource Conservation and Recovery Act (42 USC 6901 et seq.)
R.61-9 *Water Pollution Control Permits*	40 CFR Part 122 *EPA Administered Permit Programs: The National Pollutant Discharge Elimination System*
R.61-58 *State Primary Drinking Water Regulations*	40 CFR Part 141 *National Primary Drinking Water Regulations*
R. 61-62 *Air Pollution Control Regulations and Standards*	40 CFR Part 50 *National Primary and Secondary Ambient Air Quality Standards*
	40 CFR §51.166 *Prevention of Significant Deterioration of Air Quality*
	40 CFR Part 60 *Standards of Performance for New Stationary Sources*
	40 CFR Part 61 *National Emission Standards for Hazardous Air Pollutants*
R.61-68 *Water Classification and Standards* R.61-69 *Classified Waters*	40 CFR 131 *Water Quality Standards*
R.61-79 *Hazardous Waste Management Regulations*	40 CFR Parts 260-266, 268, 270 (RCRA Subtitle C implementing regulations)
R.61-82 *Proper Closeout of Wastewater Treatment Facilities*	No federal equivalent

of Significant Deterioration regulations apply to new construction and to major modifications made to stationary sources. A major modification is defined as a net increase in emissions beyond thresholds listed at 40 CFR 51.166(b)(23). Construction or modifications of facilities that fall under this classification are subject to a preconstruction review and permitting under the program that is outlined in the Clean Air Act. In order to receive approval, DOE must show that the source (1) will comply with ambient air quality levels designed to prevent deterioration of air quality, (2) will employ "best available control technology" for each pollutant regulated under the Clean Air Act that will emit significant amounts, and (3) will not adversely affect visibility.

- ***Title V Operating Permit*** – Congress amended the Clean Air Act in 1990 to include requirements for a comprehensive operating permit program. Title V of the 1990 amendments requires EPA to develop a Federally enforceable operating permit program for air pollution sources to be administered by the state and/or local air pollution agencies. The purpose of this permit program is to consolidate in a single document all of the Federal and state regulations applicable to a source, in order to facilitate source compliance and enforcement. The EPA promulgated regulations at Section 107 and 110 of the Clean Air Act that define the requirements for state programs.

- ***Hazardous Air Pollutants*** – Hazardous air pollutants are substances that may cause health and environmental effects at low concentrations. Currently, 189 compounds have been identified as hazardous air pollutants. A major source is defined as any stationary source, or a group of stationary sources located within a contiguous area under common control, that emits or has the potential to emit at least 10 tons per year of any single hazardous air pollutant or 25 tons per year of a combination of pollutants.

  The 1990 amendments to the Clean Air Act substantially revised the program to regulate potential emissions of hazardous air pollutants. The aim of the new control program is to require state-of-the-art pollution control technology on most existing and all new emission sources. These provisions regulate emissions by promulgating emissions limits reflecting use of the maximum achievable control technology. These emission limits are then incorporated into a facility's operating permit.

- ***National Emission Standards for Hazardous Air Pollutants for Radionuclides*** – Radionuclide emissions other than radon from DOE facilities are also covered under the National Emission Standards for Hazardous Air Pollutants program (40 CFR Part 61, Subpart H). To determine compliance with the standard, an effective dose equivalent value for the maximally exposed members of the public is calculated using EPA-approved sampling procedures, computer models, or other EPA-approved procedures.

  Any fabrication, erection, or installation of a new building or structure within a facility whose emissions would result in an effective dose equivalent to a member of the public that would exceed 0.1 millirem per year would require that an application be submitted to EPA. This application must include the name of the applicant, the location or proposed location of the source, and technical information describing the source. If the application is for a modification of an existing facility, information provided to EPA must include the precise nature of the proposed changes, the productive capacity of the source before and after the changes are completed, and calculations of estimates of emissions before and after the changes are completed.

EPA has overall authority for the Clean Air Act; however, it delegates primary authority to states that have established an air pollution control program approved by EPA. In South Carolina, EPA has retained authority over radionuclide emissions (40 CFR Part 61) and has delegated to SCDHEC the responsibility for the rest of the regulated pollutants under the authority of the South Carolina Pollution Control Act (48-1-10 et. seq.,) and SCDHEC Air Pollution Control Regulation 61-62.

Construction and operation permits or exemptions will be required for new nonradiological air emission sources (diesel generators, concrete batch plants etc.) constructed and operated as part of the HLW tank systems closure process. The permits will contain operating conditions and effluent limitations for pollutants emitted from the facilities (see Table 7-1).

DOE will determine if a NESHAP permit will be required for radiological emissions from any facilities (stacks, process vents, etc.) used in the HLW tank systems closure process. As described in 40 CFR Part 61.96, if all emissions from facility operations would result in an effective dose equivalent to a member of the public that would not exceed 0.1 mllirem per year, an application for approval to construct under 40 CFR Part 61.07 is not required to be filed. 40 CFR Part 61.96 also allows DOE to use, with prior EPA approval, methods other than EPA standard methods for estimating the source term for use in calculating the projected dose. If DOE's calculations indicate that the emissions from the HLW tank system closure operations will exceed 0.1 millirem per year, DOE will, prior to the start of construction, complete an application for approval to construct under 40 CFR 61.07.

Federal Clean Water Act, as amended (33 USC 1251 et seq.); SC Pollution Control Act (SC Code Section 48-1-10 et seq., 1976) (SCDHEC Regulation 61-9.122 et. seq.)

The purpose of the Clean Water Act, which amended the Federal Water Pollution Act, is 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 101). Section 313 of the Act generally 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.

Under the Clean Water Act, states generally set water quality standards, and EPA or states regulate and issue permits for point-source discharges as part of the National Pollutant Discharge Elimination System (NPDES) permitting program. EPA regulations for this program are codified at 40 CFR Part 122. If the construction or operation of the selected action would result in point-source discharges, DOE could need to obtain a National Pollutant Discharge Elimination System permit.

EPA has delegated primary enforcement authority for the Clean Water Act and the NPDES permitting program to SCDHEC for waters in South Carolina. In 1996, SCDHEC, under the authority of the Pollution Control Act (48-1-10 et seq.) and Regulation 61-9.122, issued NPDES Permit SC0000175, which addresses wastewater discharges to SRS streams and NPDES permit SCG250162 which addresses general utility water discharges. Permit SC0000175 contains effluent limitations for physical parameters such as flow and temperature and for chemical pollutants with which DOE must comply. DOE will apply for a discharge permit for HLW tank system closure operations if the process chosen results in discharges to waters of the State (see Table 7-1).

Under the authority of the Pollution Control Act, SCDHEC has issued industrial wastewater treatment "as-built" construction permits numbers 14,338, 14,520, and 17,434-IW covering the SRS HLW tank systems. These permits establish design and operating requirements for the tank systems based on the standards set forth in Appendix B of the SRS Federal Facility Agreement (see Section 7.3.2).

Section 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act. Section 402(p) requires the EPA to establish regulations for the Agency or individual states to issue permits for stormwater discharges associated with industrial activity, including construction activities that could disturb five or more acres (40 CFR Part 122). SCDHEC has issued a General Permit for Storm Water Discharges Associated with Industrial Activities (Permit No. SCR000000) authorizing stormwater discharges to the waters of the State of South Carolina in accordance with effluent limitations, monitoring requirements, and conditions as set forth in the permit. This permit requires preparation and submittal of a Pollution Prevention Plan for all new and existing point source discharges associated with industrial activity. Accordingly, DOE-SR has developed a Storm Water Pollution Prevention Plan for storm water discharges at SRS. The SRS Storm Water Pollution Prevention Plan would need to be revised to include pollution prevention measures to be implemented for HLW tank system operations (See Table 7-1) if industrial activities are exposed to storm water. SCDHEC has issued a General Permit for storm water discharges from construction activities that are "Associated with Industrial Activity" (Permit No. SCR100000). An approved plan would be needed that includes erosion control and pollution prevention measures to be implemented for construction activities.

Section 404 of the Clean Water Act requires that a 404 permit be issued for discharge of dredge or fill material into the waters of the United States. The authority to implement these requirements has been given to the U.S. Army Corps of Engineers. Section 401 of the Clean Water Act requires certification that discharges from construction or operation of facilities, including discharges of dredge and fill material into navigable waters, will comply with applicable water standards. This certification, which is granted by SCDHEC, is a prerequisite for the 404 permit. DOE does not believe that a 404 permit will be required for the HLW tank system closures.

Federal Safe Drinking Water Act, as amended [42 USC 300 (f) et seq., 40 CFR Parts 100-149]; South Carolina Safe Drinking Water Act (Title 44-55-10 et seq.), State Primary Drinking Water Regulations, (SCDHEC R.61-58)

The primary objective of the Safe Drinking Water Act is to protect the quality of water supplies. This law grants EPA the authority to protect quality of public drinking water supplies by establishing national primary drinking water regulations. In accordance with the Safe Drinking Water Act, the EPA has delegated authority for enforcement of drinking water standards to the states. Regulations (40 CFR Part 123, 141, 145, 147, and 149) specify maximum contaminant levels, including those for radioactivity, in public water systems, which are generally defined as systems that serve at least 15 service connections or regularly serve at least 25 year-round residents. Construction and operation permits would be required for lines to drinking water supply systems associated with HLW tank closure activities (see Table 7-1). 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.

As a regulatory practice and policy, the Safe Drinking Water Act maximum contaminant levels are also used as groundwater protection standards. For example, the regulations specify that the average annual concentration of man-made radionuclides in drinking water shall not produce a dose equivalent to the total body or an internal organ dose greater than 4 mrem per year beta-gamma activity. This radionuclide maximum contaminant level is the primary performance objective for the SRS HLW tank system closures.

EPA has delegated primary enforcement authority to SCDHEC for public water systems in South Carolina. Under the authority of the South Carolina Safe Drinking Water Act (44-55-10 et seq.), SCDHEC has established a drinking water regulatory program (R.61-58). SCDHEC has also established groundwater and surface water classifications and standards under R. 61-68. Along with the Federal maximum contaminant levels (40 CFR 141), these South Carolina water quality standards are the groundwater and surface water performance standards applicable to closure of the HLW tank systems.

Resource Conservation and Recovery Act, as amended (Solid Waste Disposal Act) (42 USC 6901 et seq.); South Carolina Hazardous Waste Management Act, Section 44-56-30, South Carolina Hazardous Waste Management Regulations (R.61-79.124 et seq.)

RCRA regulates the treatment, storage, and disposal of hazardous wastes. The EPA regulations implementing RCRA are found in 40 CFR Parts 260-280. These regulations define hazardous wastes and specify hazardous waste transportation, handling, treatment, storage, and disposal requirements. This area of the law deals with two different approaches to regulation. First, RCRA regulates the wastes themselves and sets standards for waste forms that may be disposed of. Second, RCRA regulates the design and operation of the waste management facilities and establishes standards for their performance.

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 the RCRA regulations. These materials are referred to as "listed" hazardous waste. "Mixed waste" is radioactively contaminated hazardous waste. The definition of "solid waste" in RCRA specifically excludes the radiological component (source, special nuclear, or byproduct material as defined by the Atomic Energy Act). 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 Atomic Energy Act for radiological components as implemented by either DOE or the Nuclear Regulatory Commission.

RCRA applies mainly to active facilities that generate and manage hazardous waste. This law imposed management requirements on generators and transporters of hazardous waste and upon owners and operators of treatment, storage, and disposal facilities. EPA has established a comprehensive set of regulations governing all aspects of treatment, storage, and disposal facilities, including location, design, operation, and closure. Pursuant to Section 3006 of the Act, any state that seeks to administer and enforce a hazardous waste program pursuant to RCRA may apply for EPA authorization of its program. EPA has delegated primary enforcement authority to SCDHEC, which has established hazardous waste management requirements under SC Regulation R.61-79.

Under Section 3004(u) of RCRA, DOE is required to assess releases from solid waste management units and implement corrective action plans where necessary. The RCRA corrective action requirements for SRS are set forth in the Federal Facility Agreement (Section 7.3.2).

The HLW managed in the F- and H-Area Tank Farms is considered mixed waste because it exhibits characteristics of RCRA hazardous waste (i.e., corrosivity and toxicity for certain metals) and contains source, special nuclear, or byproduct material regulated under the Atomic Energy Act. Waste removed from the tank systems will be managed in accordance with applicable RCRA requirements (i.e., treated to meet the land disposal restrictions standards prior to disposal). The HLW tank systems are exempt from the design and operating standards and permitting requirements for hazardous waste management units because they are wastewater treatment units regulated under the Clean Water Act [see 40 CFR 260.10, 264.1(g)(6), and 270.1(c)(2)(v)].

The Federal Facility Compliance Act (42 USC 6921 (et. seq.)

The Federal Facility Compliance Act amended RCRA in 1992 and requires DOE to prepare plans for developing treatment capacity for mixed wastes stored or generated at each facility. After consultation with other affected states, the host-state or EPA must approve each plan. The appropriate regulator must also issue an order requiring compliance with the plan.

On September 20, 1995, SCDHEC approved the Site Treatment Plan for SRS. SCDHEC issued a consent order, signed by DOE, requiring compliance with the plan on September 29, 1995. DOE provides SCDHEC with annual updates to the information in the SRS Site Treatment Plan. DOE would be required to notify SCDHEC of any new mixed waste streams generated as result of HLW tank system closure activities.

7.2.2 PROTECTION OF BIOLOGICAL, HISTORIC, AND ARCHAEOLOGICAL RESOURCES

Endangered Species Act, as amended (16 USC 1531 et seq.)

The Endangered Species Act provides a program for the conservation of threatened and endangered species and the ecosystems on which those species rely. All Federal agencies must assess whether the potential impacts of a proposed action could adversely affect threatened or endangered species or their habitat. If so, the agency must consult with the U.S. Fish and Wildlife Service (part of the U.S. Department of the Interior) and the National Marine Fisheries Service (part of the Department of Commerce), as required under Section 7 of the Act. The outcome of this consultation may be a biological opinion by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service that states whether the proposed action would jeopardize the continued existence of the species under consideration. If there is non-jeopardy opinion, but if some individuals might be killed incidentally as a result of the proposed action, the Services can determine that such losses are not prohibited as long as measures outlined by the Services are followed. Regulations implementing the Endangered Species Act are codified at 50 CFR Part 15 and 402.

The HLW tank systems are located within fenced, disturbed industrial areas. Construction associated with closure of the tank systems would not disturb any threatened or endangered species, would not degrade any critical or sensitive habitat, and would not affect any jurisdictional wetland. Therefore DOE concludes that no consultation with the U.S. Fish and Wildlife Service or the National Marine Fisheries Service concerning the alternatives considered in this EIS is required.

The following statutes pertain to protection of animals or plants, historic sites, archaeological resources, and items of significance to Native Americans. DOE does not expect these requirements to apply to the closure of the SRS HLW tank systems since these facilities are located in previously disturbed industrial areas.

- Migratory Bird Treaty Act, as amended (16 USC 703 et seq.)
- Bald and Golden Eagle Protection Act, as amended (16 USC 668-668d)
- National Historic Preservation Act, as amended (16 USC 470 et seq.)
- Archaeological Resource Protection Act, as amended (16 USC 470 et seq.)
- Native American Grave Protection and Repatriation Act of 1990 (25 USC 3001)
- American Indian Religious Freedom Act of 1978 (42 USC l996)

7.3 Statutes and Regulations Related to Emergency Planning, Worker Safety, and Protection of Public Health and the Environment

7.3.1 ENVIRONMENTAL PROTECTION

National Environmental Policy Act of 1969, as amended (42 USC 4321 et seq.)

NEPA requires agencies of the Federal Government to prepare EISs on potential impacts of proposed major Federal actions that may significantly affect the quality of the human environment. DOE has prepared this EIS in accordance with the requirements of NEPA as implemented by Council on Environmental Quality regulations (40 CFR Parts 1500 through 1508) and DOE NEPA regulations (10 CFR Part 1021).

Pollution Prevention Act of 1990 (42 USC 13101 et seq.)

The Pollution Prevention Act of 1990 establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmentally safe recycling, treatment, and disposal. DOE requires each of its sites to establish specific goals to reduce the generation of waste. If the Department were to build and operate facilities, it would also implement a pollution prevention plan.

Comprehensive Guideline for Procurement of Products Containing Recovered Materials (40 CFR Part 247)

This regulation is issued under the authority of Section 6002 of RCRA and Executive Order 12783, which set forth requirements for Federal agencies to procure products containing recovered materials for use in their operations using guidelines established by the EPA. The purpose of these regulations is to promote recycling by using government purchasing to expand markets for recovered materials. RCRA Section 6002 requires that any purchasing agency, when using appropriated funds to procure an item, shall purchase it with the highest percentage of recovered materials practicable. The procurement of materials to be used in HLW tank system closure activities should be conducted in accordance with these regulations.

Toxic Substances Control Act, as amended (USC 2601 et seq.) (40 CFR Part 700 et seq.)

The Toxic Substances Control Act provides EPA with the authority to require testing of both new and old chemical substances entering the environment and to regulate them where necessary. The Act also regulates the manufacture, use, treatment, storage, and disposal of certain toxic substances not regulated by RCRA or other statutes, specifically polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium. DOE does not expect to use these materials during closure of the HLW tank systems. Programs and procedures would need to be implemented to address appropriate management and disposal of waste generated as a result of their use, if necessary.

7.3.2 EMERGENCY PLANNING AND RESPONSE AND PUBLIC HEALTH

This section discusses the regulations that address protection of public health and worker safety and require the establishment of emergency plans and coordination with local and Federal agencies related to facility operations. DOE Orders generally set forth the programs and procedures required to implement the requirements of these regulations. See Section 7.5.

Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.)

The Atomic Energy Act, as amended, provides fundamental jurisdictional authority to DOE and the Nuclear Regulatory Commission over governmental and commercial use of nuclear materials. The Atomic Energy Act ensures proper management, production, possession, and use of radioactive materials. It gives the Nuclear Regulatory Commission specific authority to regulate the possession, transfer, storage, and disposal of nuclear materials, as well as aspects of transportation packaging design requirements for radioactive materials, including testing for packaging certification. Commission regulations applicable to the transportation of radioactive materials (10 CFR Part 71 and 73) require that shipping casks meet specified performance criteria under both normal transport and hypothetical accident conditions.

The Atomic Energy Act provides DOE the authority to develop generally applicable standards for protecting the environment from radioactive materials. In accordance with the Atomic Energy Act, DOE has established a system of requirements that it has issued as DOE Orders.

DOE Orders and regulations issued under authority of the Atomic Energy Act include the following:

- ***DOE Order 435.1 (Radioactive Waste Management)*** – This Order and its associated Manual and Guidance establish authorities, responsibilities, and requirements for the management of DOE HLW, transuranic waste, low-level waste, and the radioactive component of mixed waste. Those documents provide detailed HLW management requirements including waste incidental to reprocessing determinations; waste characterizations, certification, storage, treatment, and disposal; and HLW facility design and closure.

- ***DOE Order 5400.1 (General Environmental Protection Program)*** – This Order establishes environmental protection program requirements, authorities, and responsibilities for DOE operations for ensuring compliance with applicable Federal, state, and local environmental protection laws and regulations as well as internal DOE policies.

- ***DOE Order 5400.5 (Radiation Protection of the Public and the Environment)*** – This Order establishes standards and requirements for DOE and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation. The requirements of this Order are also codified in the proposed 10 CFR Part 834, Radiation Protection of the Public and the Environment.

- ***DOE Order 440.1A (Worker Protection Management for DOE Federal and Contractor Employees)*** – This Order establishes the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE Federal and contractor workers with a safe and healthful workplace.

Section 202(4) of the Energy Reorganization Act of 1974 (42 USC §5842(4)) gives the NRC licensing and related regulatory authority over DOE "facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste generated by the Administration [now known as DOE] which are not used for, or are part of, research and development activities." DOE has determined that NRC's licensing authority is limited to DOE facilities that are (1) authorized by Congress for the express purpose of long-term storage of HLW and (2) developed and constructed after the passage of the Energy Reorganization Act (Sullivan 1998). None of the SRS HLW tank systems meet both of these criteria. DOE's Savannah River Operations Office has consulted with NRC concerning criteria regarding incidental waste for the SRS tank residuals.

Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.) Quantities of Radioactive Materials Requiring Consideration of the Need for an Emergency Plan for Responding to a Release (10 CFR Part 30.72 Schedule C)

This list is the basis for both the public and private sector to determine if the radiological materials they deal with must have an emergency response plan for unscheduled releases. It is one of the threshold criteria documents for DOE Emergency Preparedness Hazard Assessments required by DOE Order 151.1, "Comprehensive Emergency Management System." An emergency response plan addressing HLW tank system closure operations would need to be prepared in accordance with this regulation.

Reorganization Plan No. 3 of 1978, Public Health and Welfare (42 USC 5121 et seq.), Emergency Management and Assistance (44 CFR Part 1-399)

These regulations generally include the policies, procedures, and responsibilities of the Federal Emergency Management Agency, NRC, and DOE for implementing a Federal Emergency Preparedness Program including radiological planning and preparedness. An emergency response plan, including radiological planning and preparedness for HLW tank system closure operations, would need to be prepared and implemented, in accordance with this regulation.

Emergency Planning and Community Right-to-Know Act of 1986 (42 USC 11001 et seq.) (also known as "SARA Title III")

Under Subtitle A of the Emergency Planning and Community Right-to Know Act, Federal facilities, including those owned by DOE, must provide information on hazardous and toxic chemicals to state emergency response commissions, local emergency planning committees, and EPA. 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. This law, implemented at 40 CFR Parts 302 through 372, requires agencies to provide material safety data sheet reports, emergency and hazardous chemical inventory reports, and toxic chemical release reports to appropriate local, state, and Federal agencies.

DOE submits hazardous chemical inventory reports for SRS to SCDHEC. The chemical inventory could change depending on the HLW tank system closure alternative(s) DOE implemented; however, subsequent reports would reflect any change to the inventory.

Hazardous Materials Transportation Act, 49 U.S.C. 1801 and Regulations

Federal law provides for uniform regulation of the transportation of hazardous and radioactive materials. Transport of hazardous and radioactive materials, substances, and wastes is governed by U.S. Department of Transportation, Nuclear Regulatory Commission, and EPA regulations. These regulations may be found in 49 CFR 100-178, 10 CFR 71, and 40 CFR 262, respectively.

U.S. Department of Transportation hazardous material regulations govern the hazard communication (marking, hazard labeling, vehicle placarding, and emergency response telephone number) and transport requirements, such as required entries on shipping papers or EPA waste manifests. Nuclear Regulatory Commission regulations applicable to radioactive materials transportation are found in 10 CFR 71 and detail packaging design requirements, including the testing required for package certification. EPA regulations govern offsite transportation of hazardous wastes. DOE Order 460.1A (Packaging and Transportation Safety) sets forth DOE policy and assigns responsibilities to establish safety requirements for the proper packaging and transportation of DOE offsite shipments and onsite transfers of hazardous materials and for modal transport. (Offsite is any area within or outside a DOE site to which the public has free and uncontrolled access; onsite is any area within the boundaries of a DOE site or facility to which access is controlled.)

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (42 USC 9601 et seq.) National Oil and Hazardous Substance Contingency Plan (40 CFR Part 300 et seq.)

CERCLA, as amended by the Superfund Amendments and Reauthorization Act, authorizes EPA to require responsible site owners, operators, arrangers, and transporters to clean up releases of hazardous substances, including certain radioactive substances. This Act applies to both the Federal government and to private citizens. Executive Order 12580 delegates to heads of executive departments and agencies the responsibility for undertaking remedial actions for releases or threatened releases at sites that are not on the National Priorities List and removal actions other than emergencies where the release is from any facility under the jurisdiction or control of executive departments or agencies.

Sites determined to have a certain level of risk to health or the environment are placed upon the National Priorities List so that their clean up can be scheduled and tracked to completion. SRS was placed on the National Priorities List in 1989.

DOE, SCDHEC, and EPA have signed a Federal Facility Agreement to coordinate cleanup at SRS, as required by Section 120 of CERCLA. The Agreement addresses RCRA corrective action and CERCLA requirements applicable to cleanup at SRS. Section IX of the Agreement sets forth requirements for the SRS HLW tank systems. Design and operating standards for the HLW tank systems are found in Appendix B of the Agreement. DOE has submitted a waste removal plan and schedule for the tank systems that do not meet the applicable secondary containment standards to SCDHEC. The approved waste removal schedule appears in Appendix B of the *High-Level Waste Tank Closure Program Plan* (DOE 1996b). DOE must provide SCDHEC with an annual report on the status of the HLW tank systems being removed from service. After waste removal is completed, the tank systems are available for closure in accordance with general closure strategy presented in DOE (1996a).

CERCLA also establishes an emergency response program in the event of a release or a threatened release to the environment. The Act includes requirements for reporting to Federal and state agencies releases of certain hazardous substances in excess of specified amounts. The requirements of the Act could apply to the proposed project in the event of a release of hazardous substances to the environment.

CERCLA also addresses damages for the injury, destruction, or loss of natural resources that are not or cannot be addressed through the remedial action. The Federal government, state governments, and Indian tribes are trustees of the natural resources that belong to, are managed by, or are otherwise controlled by those respective governing bodies. As trustees, they may assess damages and recover costs necessary to restore, replace, or acquire equivalent resources when there is injury to natural resources as a result of release of a hazardous substance.

Occupational Safety and Health Act of 1970, as amended (29 USC 651 et seq.); Occupational Safety and Health Administration Emergency Response, Hazardous Waste Operations and Worker Right to Know (29 CFR Part 1910 et seq.)

The Occupational Safety and Health Act (29 USC 651) establishes standards to enhance safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration, a U.S. Department of Labor agency. While OSHA and EPA both have a mandate to reduce exposures to toxic substances, OSHA's jurisdiction is limited to safety and health conditions that exist in the workplace environment. In general, under the Act, it is the duty of each employer to furnish all employees a place of employment free of recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the occupational safety and health standards and all rules, regulations, and orders issued under the Act. The OSHA regulations (29 CFR) establish specific standards telling employers what must be done to achieve a safe and healthful working environment. This regulation sets down the OSHA requirements for employee safety in a variety of working environments. It addresses employee emergency and fire prevention plans (Section 1910.38), hazardous waste operations and emergency response (Section 1910.120), and hazard communication (Section 1910.1200) that enable employees to be aware of the dangers they face from hazardous materials at their workplace. DOE places emphasis on compliance with these regulations at its facilities and prescribes through DOE Orders OSHA standards that contractors shall meet, as applicable to their work at Government-owned, contractor-operated facilities. DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths required by OSHA regulations.

Noise Control Act of 1972, as amended (42 USC 4901 et seq.)

Section 4 of the Noise Control Act directs Federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare. This law provides requirements related to noise that would be generated by activities associated with tank closures.

7.4 Executive Orders

The following executive orders would be in effect for the HLW tank system closures. DOE Orders generally set forth the programs and procedures required to implement the requirements of the orders.

Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands)

Executive Order 11988 directs Federal agencies to establish procedures to ensure that any Federal action taken in a floodplain considers the potential effects of flood hazards and floodplain management and avoids floodplain impacts to the extent practicable.

Executive Order 11990 directs Federal agencies to avoid new construction in wetlands unless there is no practicable alternative and unless the proposed action includes all practicable measures to minimize harm to wetlands that might result from such use. DOE requirements for compliance with floodplain and wetlands activity are codified at 10 CFR 1022.

Executive Order 12856 (Right-to-Know Laws and Pollution Prevention Requirements)

This Order directs Federal agencies to reduce and report toxic chemicals entering any waste stream; improve emergency planning, response, and accident notification; and encourage the use of clean technologies and testing of innovative prevention technologies. In addition, the Order states that Federal agencies are persons for purposes of the Emergency Planning and Community Right-to-Know Act (SARA Title III), which requires agencies to meet the requirements of the Act.

Executive Order 12898 (Environmental Justice)

This Order directs Federal agencies, to the extent practicable, to make the achievement of environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations in the United States and its territories and possessions. The order provides that the Federal agency responsibilities it establishes are to apply equally to Native American programs.

Executive Order 12902 (Energy Efficiency and Water Conservation at Federal Facilities)

Executive Order 12902 requires Federal agencies to develop and implement a program for conservation of energy and water resources.

Executive Order 13045 (Protection of Children from Environmental Health Risks and Safety Risks)

Because of the growing body of scientific knowledge that demonstrate that children may suffer disproportionately from environmental health and safety risks, Executive Order 13045 directs each Federal agency to make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children.

Executive Order 13112 (Invasive Species)

Executive Order 13112 requires Federal agencies whose actions may affect the status of invasive species to identify such actions and to use relevant programs and authorities to prevent the introduction of invasive species, detect and respond rapidly to control the populations of such species, monitor invasive species populations, provide for restoration of native species and habitat conditions in ecosystems that have been invaded, conduct research on invasive species and provide for environmentally sound control, and promote public education on invasive species and the means to address them.

7.5 DOE Regulations and Orders

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanisms through which DOE manages its facilities are the promulgation of regulations and the issuance of DOE Orders. Table 7-6 lists the major DOE Orders applicable to the closure of the SRS HLW tank systems.

The DOE regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For the purposes of this EIS, relevant regulations include 10 CFR Part 820, *Procedural Rules for DOE Nuclear Facilities*; 10 CFR Part 830, *Nuclear Safety Management; Contractor and Subcontractor Activities*; 10 CFR Part 835*, Occupational Radiation Protection*; 10 CFR Part 1021*, Compliance with NEPA*; and 10 CFR Part 1022*, Compliance with Floodplains/Wetlands Environmental Review Requirements*. DOE has enacted occupational radiation protection standards to protect DOE and its contractor employees. These standards are set forth in 10 CFR Part 835*, Occupational Radiation Protection*; the rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities, including those conducted by DOE contractors. The activity may be, but is not limited to, design, construction, or operation of DOE facilities.

Table 7-6. DOE Orders and Standards relevant to closure of the HLW tank systems.

	DOE Orders
151.1	Comprehensive Emergency Management System
225.1A	Accident Investigations
231.1	Environment, Safety and Health Reporting
232.1A	Occurrence Reporting and Processing of Operations Information
420.1	Facility Safety
425.1A	Startup and Restart of Nuclear Facilities
430.1A	Life Cycle Asset Management
435.1	Radioactive Waste Management
440.1A	Worker Protection Management for DOE Federal and Contractor Employees
451.1A	National Environmental Policy Act Compliance Program
460.1A	Packaging and Transportation Safety
460.2	Departmental Materials Transportation and Packaging Management
470.1	Safeguards and Security Program
471.1	Identification and Protection of Unclassified Controlled Nuclear Information
471.2A	Information Security Program
472.1B	Personnel Security Activities
1270.2B	Safeguards Agreement with the International Atomic Energy Agency
1300.2A	Department of Energy Technical Standards Program
1360.2B	Unclassified Computer Security Program
3790.1B	Federal Employee Occupational Safety and Health Program
4330.4B	Maintenance Management Program
4700.1	Project Management System
5400.1	General Environmental Protection Program
5400.5	Radiation Protection of the Public and the Environment
5480.19	Conduct of Operations Requirements for DOE Facilities
5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities
5480.21	Unreviewed Safety Questions
5480.22	Technical Safety Requirements
5480.23	Nuclear Safety Analysis Report
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements
5632.1C	Protection and Control of Safeguards and Security Interests
5633.3B	Control and Accountability of Nuclear Materials
5660.1B	Management of Nuclear Materials
6430.1A	General Design Criteria
1020-94	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities
1021-93	Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components
1024-92	Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites for Department of Energy Facilities
1027-92	Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23 Nuclear Safety Analysis Reports
3009-94	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports
3011-94	Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans

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APPENDIX A

TANK FARM DESCRIPTION AND CLOSURE PROCESS

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APPENDIX A. TANK FARM DESCRIPTION AND CLOSURE PROCESS

A.1 Introduction

Over the last 45 years, SRS has produced special radioactive isotopes for various national programs. These isotopes were primarily produced in the site's nuclear reactors, which generated neutrons that bombarded specifically designed targets. The neutrons bombarding the targets result in transmutation of the target atoms to produce the desired radioisotopes. The spent nuclear fuel and the targets were reprocessed to recover unused reactor fuel and the isotopes produced in the reactors. The reprocessing activity involved dissolving the fuel and targets in large, heavily shielded chemical separations facilities, in the F- and H-Areas known as the F-Canyon and H-Canyon, respectively. These facilities concentrated the valuable materials DOE wanted to recover but produced large quantities of highly radioactive liquid waste known as HLW (see Chapter 1 for a more complete definition of high-level waste). The HLW has been stored in the Tank Farms in F- and H-Area.

DOE has recently reviewed its HLW management practices in two recent EISs: the *DWPF Supplemental EIS* (DOE 1994) and the *SRS Waste Management EIS* (DOE 1995). This HLW Tank Closure EIS is focused on closure of the tank farms after the HLW has been removed. Nevertheless, a discussion on how the tank farms fit into the overall SRS HLW management program is useful to understanding the nature of the residual waste in the tanks and the tanks' current use and history. Therefore, Section A.2 provides an overview of HLW management at SRS. Section A.3 describes the tank farm equipment and operations. Section A.4 describes the activities needed to close the tank farms under the various closure alternatives.

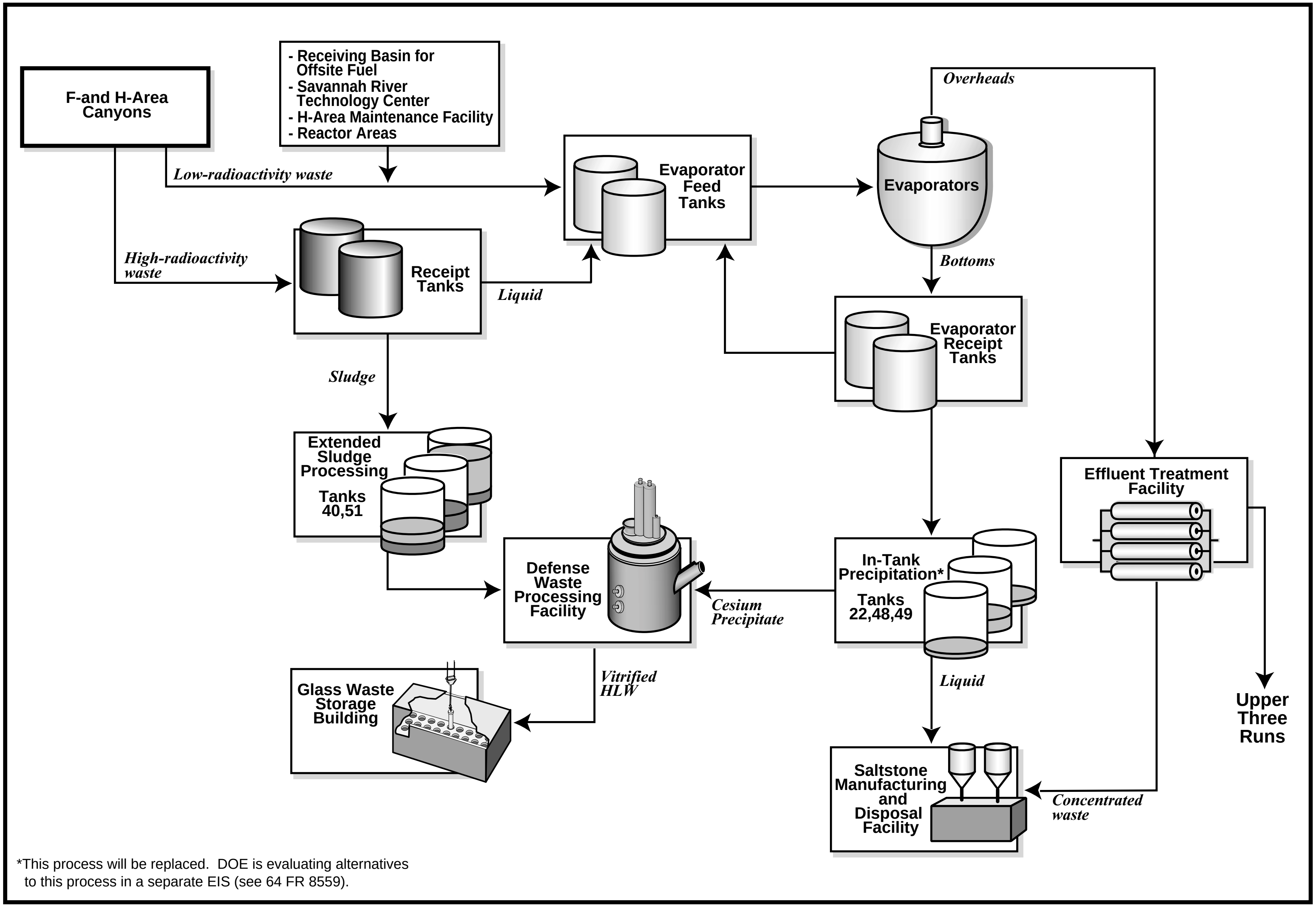
A.2 Overview of SRS HLW Management

The main processes involved in HLW management are generation, storage, evaporation, sludge processing, salt processing, vitrification, and saltstone manufacture and disposal. Figure A-1 shows the process flows among the processes.

Although the F- and H-Canyons are the only facilities at SRS that generate HLW in the regulatory sense, other facilities produce liquid radioactive waste that has characteristics similar to those of HLW. These facilities include the Receiving Basin for Offsite Fuel, the Savannah River Technology Center, the H-Area Maintenance Facility, and the reactor areas. Selected wastes from these facilities are managed at SRS as if they were HLW and are thus sent to the tank farms for storage and ultimate processing. Also, the DWPF, which is the final treatment for SRS HLW, recycles wastewater back to the tank farms.

The tank farms receive the HLW, immediately isolating it from the environment, SRS workers, and the public. The tank farms provide a sufficiently long period of storage to allow many of the short-lived radionuclides to decay to much lower concentrations. After pH adjustment and introduction into the tanks, the HLW is allowed to settle, separating into a sludge layer at the bottom and a salt solution layer at the top known as supernate. SRS uses evaporators to concentrate the supernate to produce a third form of HLW in the tank farms known as crystallized saltcake. As a result of intertank transfers, some of the tanks are now primarily salt tanks, some are primarily sludge tanks, some tanks contain a mixture of salt and sludge, and some tanks are empty.

Before 1994, the Canyons generated two waste streams which were sent to the tank farms. High-radioactivity waste, which contained most of the radionuclides, was aged in a high-radioactivity waste tank before evaporation. Low-radioactivity waste, which contained lower concentration of radionuclides, was sent directly to an evaporator. This historical practice is shown on Figure A-1. Under current SRS operations, high-radioactivity waste is no longer



*This process will be replaced. DOE is evaluating alternatives to this process in a separate EIS (see 64 FR 8559).

NW TANK/Grfx/A-1 HLW mgt.ai

Figure A-1. Process flows for Savannah River Site High-Level Waste Management System.

generated because SRS reactors ceased operation in 1988. All incoming waste streams to the tank farms can be directed to the same receipt tanks and evaporator feed tanks.

SRS designed and built a facility using four H-Tank Farm tanks, known as the In-Tank Precipitation Facility, to process the saltcake and concentrated supernate. This salt processing facility was designed to receive redissolved saltcake and precipitate the chemical cesium that is responsible for the most prominent and penetrating radiation emitting from the waste. The cesium precipitate was designed to go DWPF for processing in the salt cell with the aqueous cesium portion to be melted into a glass matrix and the organic portion sent to the Consolidated Incineration Facility. The remaining liquid salt solution was designed to go to the Saltstone Manufacturing and Disposal Facility for solidification and burial in underground vaults. DOE has concluded that the In-Tank Precipitation Process, as currently configured, cannot achieve production goals and meet safety requirements. Therefore, DOE is now evaluating a replacement salt processing technology in an EIS being prepared concurrently with this one (64 FR 8558).

The sludge in the tanks, which contains approximately 54 percent of the HLW radioactivity, is treated in a process known as Extended Sludge Processing. Extended Sludge Processing uses existing tanks in the H-Area Tank Farm. The process removes aluminum hydroxide and soluble salts from the sludge before transferring the sludge to the DWPF for vitrification. Aluminum affects the hardness of the glass and the overall volume of glass waste. The soluble salts interfere with the desired chemical composition of the glass. The wastewaters from Extended Sludge Processing and the DWPF are recycled back to the tank farm.

The DWPF receives washed sludge and salt precipitate, mixes it with appropriate additives, and melts it into a glass form in a process known as vitrification. The glass is poured into stainless steel canisters and stored in the Glass Waste Storage Building, a facility containing an underground vault for canister storage. Because the In-Tank Precipitation Facility has been inoperable, the DWPF has been vitrifying only sludge waste. The DWPF will continue sludge-only processing until the feed is available from the salt processing facility. In order to minimize the number of HLW canisters that are produced, SRS planning documents (WSRC 1998a) call for maintaining the sludge and salt precipitate feeds to the DWPF in an acceptable balance to avoid having any precipitate left over when all of the sludge inventory has been vitrified. The ultimate disposition of the HLW glass canisters is a geologic repository. Currently, the government is determining whether the candidate repository site at Yucca Mountain in Nevada is appropriate for ultimate disposal of the nation's spent nuclear fuel and HLW (DOE 1999).

The Saltstone Manufacturing and Disposal Facility receives the salt solution after the cesium has been precipitated. The salt solution is mixed with cement, slag, and flyash to form a grout with chemical and physical properties designed to retard the leaching of contaminants over time. The grout is poured into disposal vaults and hardens into what is known as saltstone. This is the final disposition of the salt solution. The Saltstone Manufacturing and Disposal Facility has received salt solution from the In-Tank Precipitation Process demonstration operations and concentrated wastes from the F/H-Area Effluent Treatment Facility and has been producing saltstone from these waste feeds. The Effluent Treatment Facility receives evaporator overheads from the Separations Areas and tank farms evaporators and treats the water for discharge to Upper Three Runs.

A.3 Description of the Tank Farms

The F-Area Tank Farm is a 22-acre site that contains 20 active waste tanks, 2 closed waste tanks, 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure A-2 shows the general layout of the F-Area Tank Farm. The H-Area Tank Farm is a 45-acre site that contains 29 waste tanks, 3 evaporator systems (including the new Replacement High-level Waste Evaporator, 242-25H), the In-Tank Pre-

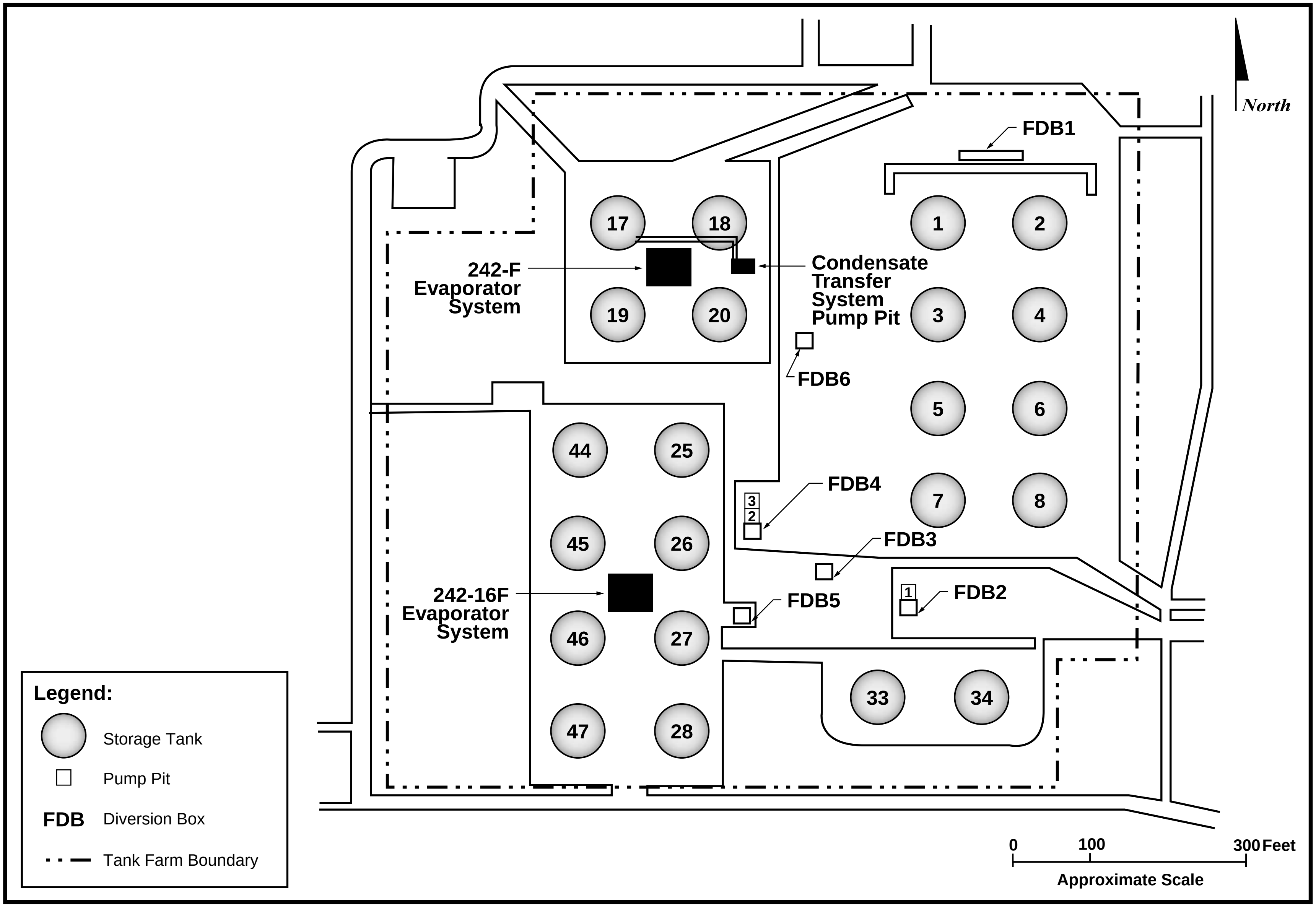


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Figure A-2. General layout of F-Area Tank Farm.

cipitation Process, the Extended Sludge Processing facility, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure A-3 shows the general layout of the H-Area Tank Farm.

A.3.1 TANKS

The F- and H-Area tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. Table A-1 summarizes information about the tanks. Two designs (Types I and II) have 5-foot high secondary annulus "pans" and active cooling (Figure A-4). Figure A-5 indicates the status and content of all 51 tanks.

The 12 Type I tanks (Tanks 1 through 12) were built in 1952 and 1953, 5 of which (Tanks 1, 9 through 12) have known leak sites in which waste leaked from the primary containment to the secondary containment. The leaked waste is kept dry by air circulation, and there is no evidence that the waste has leaked from the secondary containment. The fill line to Tank 8 leaked approximately 1,500 gallons to the soil and potentially to the groundwater in 1961. The tank tops are about 9.5 feet below grade. The bottoms of Tanks 1 through 8, in F-Area, are situated above the seasonal high water table. Tanks 9 through 12 in the H-Area Tank Farm are in the water table.

The four Type II tanks (Tanks 13 through 16) were built in 1956 in the H-Area Tank Farm (Figure A-4). All four have known leak sites in which waste leaked from primary to secondary containment. In 1983, about 100 gallons of waste spilled on to the surface of Tank 13 through a cracked flush water line attached to an evaporator feed pump. No spilled waste reached the subsurface. The spill was cleaned up, and the contaminated material was returned to the waste tank or disposed of (Boore et al., 1986). The contamination remaining is negligible and would affect neither tank closure nor future cleanup of the tank farm area. In Tank 16, the waste overflowed the annulus pan (secondary containment) and a few 10s of gallons of waste migrated into the surrounding soil, presumably through a construction joint in the concrete encasement. Waste removal from the Tank 16 primary vessel was completed in 1980. However, the waste that leaked into the annulus has not been removed. These tanks are above the seasonal high water table.

The eight Type IV tanks (Tanks 17 through 24) were built between 1958 and 1962. These tanks have a single steel wall and do not have active cooling (Figure A-4). Tanks 17 through 20 are in the F-Area Tank Farm and Tanks 21 through 24 are in H-Area. Tanks 19 and 20 have known cracks that are believed to have been caused by groundwater corrosion of the tank wall. Small amounts of groundwater have leaked into these tanks; there is no evidence that waste ever leaked out. Tanks 17 through 20 are slightly above the water table. Tanks 21 through 24 are above the groundwater table; however, they are in a perched water table caused by the original basemat under the tank area. Tanks 17 and 20 have already been closed in a manner described in DOE's Preferred Alternative.

The newest design (Type III) has a full-height secondary tank and active cooling (Figure A-4). All of the Type III tanks (25 through 51) are above the water table. These tanks were placed in service between 1969 and 1986. None of them has known leak sites. In 1989, a Tank 37 transfer line leaked about 500 pounds of concentrated waste to the environment.

By 2022, DOE is required to remove from service and close all the remaining tank systems that have experienced leaks or do not have full-height secondary containment (WSRC 1998a). The 24 Type I, II, and IV tanks have been or will be removed from service before the 27 Type III tanks. Type III tanks will remain in service until there is no further need for the tanks.

Areas of contamination in the tank farms have been identified based on groundwater monitoring past incident reports, and contamination surveys. The areas of significant contamination have been identified in the SRS Federal Facility Agreement and have been designated as RCRA/CERCLA units or Site Evaluation Units. Controls are in place to ensure that any activities performed around thee areas are conducted in a

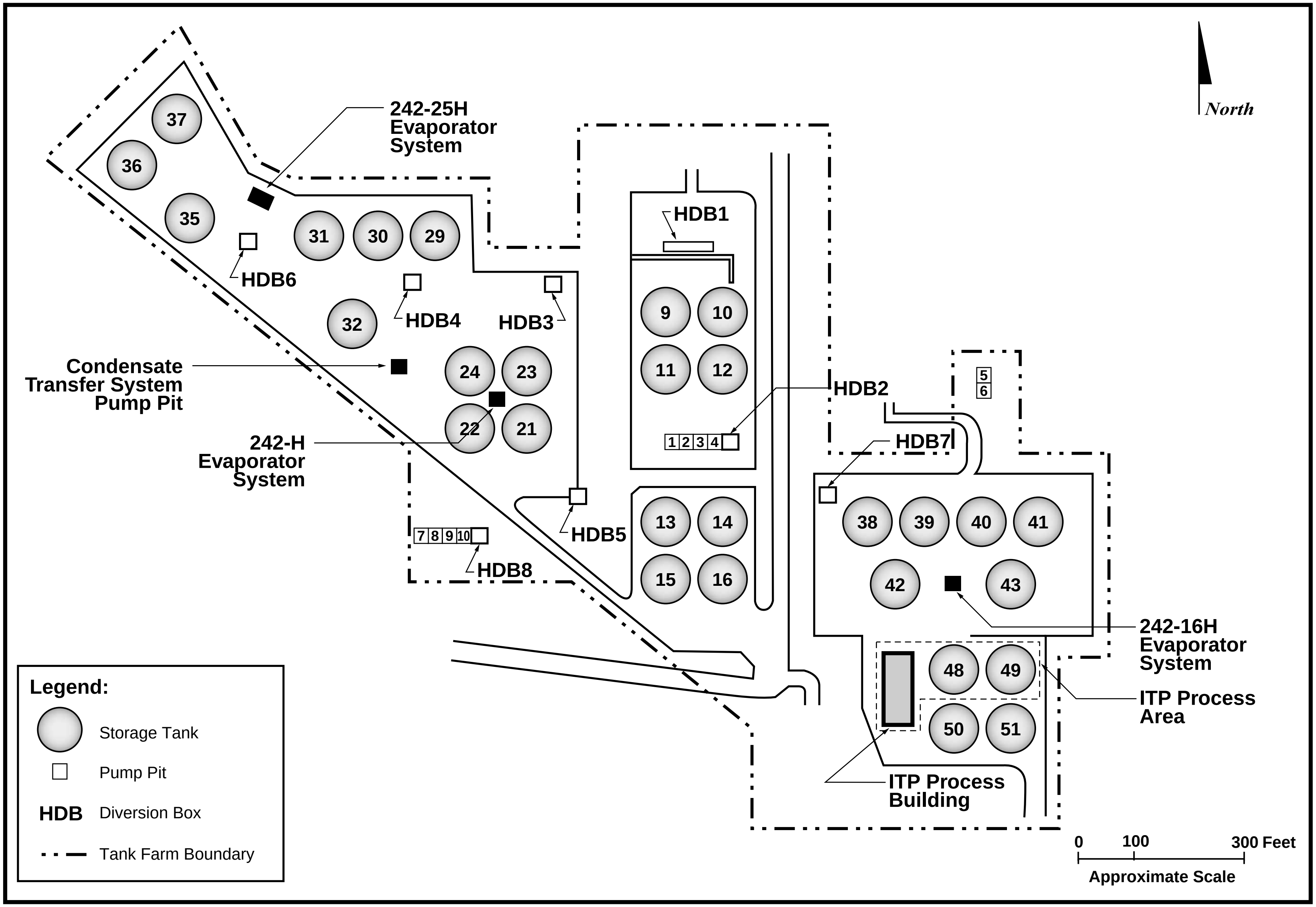

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Figure A-3. General layout of H-Area Tank Farm.

Table A-1. Waste tank usage.[a]

Tank number	Design type	Location	Year constructed	First used	Current usage
1[b]	I	F	1952	1954	Inactive, HHW/LHW salt cake tank
2	I	F	1952	1955	Inactive, HHW/LHW salt cake tank
3	I	F	1952	1954	Inactive, HHW/LHW salt cake tank
4	I	F	1952	1961	Inactive, HHW sludge and salt cake tank
5	I	F	1952	1959	Inactive, HHW sludge tank
6	I	F	1952	1964	Inactive, HHW sludge tank
7	I	F	1952	1954	Inactive, HHW/LHW sludge tank
8	I	F	1952	1958	Inactive, LHW sludge tank
9[b]	I	H	1953	1955	Inactive, HHW/LHW salt cake tank
10[b]	I	H	1953	1955	Inactive, HHW/LHW salt cake tank
11[b]	I	H	1953	1955	Inactive, HHW sludge tank
12[b]	I	H	1953	1956	Inactive, HHW sludge tank
13[b]	II	H	1956	1959	HHW evaporator feed tank (contains HHW sludge)
14[b]	II	H	1956	1957	Inactive, HHW sludge and salt cake tank
15[b]	II	H	1956	1960	Inactive, HHW/LHW sludge tank
16[b]	II	H	1956	1960	Tank is empty, HHW supernate removed, tank interior cleaned out, initial annulus cleaning complete; this tank is not covered by the industrial wastewater permit because it was taken out of service before the Tank farms were permitted by the state (this tank is listed as a RCRA/CERCLA unit under the Federal Facility Agreement)
17	IV	F	1958	1961	Closed
18	IV	F	1958	1958	Inactive, LHW supernate removed, residual LHW sludge remains
19	IV	F	1958	1961	Inactive, LHW supernate removed, residual LHW sludge and salt remains (most of the tank sludge consists of spent CRC ion exchange resin)
20[b]	IV	F	1958	1960	Closed
21	IV	H	1961	1961	LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters
22	IV	H	1962	1965	ITP tank[c], LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters
23	IV	H	1962	1963	LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters

Table A-1. (Continued).

Tank number	Design type	Location	Year constructed	First used	Current usage
24	IV	H	1962	1963	Inactive, LHW supernate removed, residual LHW sludge remains (most of the tank sludge consists of spent CRC ion exchange resin); may be used to hold dilute solutions or recycle wastewaters
25	III	F	1978	1980	HHW/LHW concentrate receipt tank
26	III	F	1978	1980	Fresh LHW receipt tank and LHW evaporator feed, contains LHW sludge
27	III	F	1978	1980	HHW/LHW concentrate receipt tank; also receives occasional wastes (i.e., ion exchange resins from the CRC)
28	III	F	1978	1980	HHW/LHW concentrate receipt tank
29	III	H	1970	1971	HHW concentrate tank
30	III	H	1970	1974	HHW concentrate tank
31	III	H	1970	1972	HHW concentrate tank
32	III	H	1970	1971	HHW receipt tank, future HHW evaporator feed tank (242-25H evaporator system), contains HHW sludge
33	III	F	1969	1969	HHW tank, contains HHW sludge
34	III	F	1972	1972	HHW tank, contains HHW sludge
35	III	H	1976	1977	HHW tank (future HHW concentrate tank), contains HHW sludge
36	III	H	1977	1977	HHW concentrate tank (future HHW tank)
37	III	H	1977	1978	HHW concentrate tank
38	III	H	1979	1981	LHW concentrate tank
39	III	H	1979	1982	HHW tank, contains HHW sludge
40	III	H	1979	1986	Sludge processing/DWPF vitrification sludge feed
41	III	H	1979	1982	LHW concentrate tank
42	III	H	1979	1982	ITP feed/blend tank[c]
43	III	H	1979	1982	Fresh LHW tank and LHW evaporator feed, contains LHW sludge
44	III	F	1980	1982	LHW concentrate tank
45	III	F	1980	1982	LHW concentrate tank
46	III	F	1980	1994	LHW concentrate tank
47	III	F	1980	1980	LHW concentrate tank; also used to receive waste transported by bulk tank truck (i.e., filter backwash waste from the reactor areas and cold runs wastewater from the DWPF Vitrification Facility), contains LHW sludge
48	III	H	1981	1983	ITP reaction tank[c]
49	III	H	1981	1983	ITP precipitate receiver/DWPF vitrification feed tank[c]

Table A-1. (Continued).

Tank number	Design type	Location	Year constructed	First used	Current usage
50	III	H	1981	1983	ITP filtrate receiver/F/H ETF waste concentrate receiver/Z-Area SMDF feed tank[c] (this tank is permitted under SCDHEC Permit No. 14520)
51	III	H	1981	1986	Extended sludge processing/DWPF vitrification sludge feed

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a. Source: WSRC (1991, 1999).
b. Has one or more known cracks in primary tank shell
c. No longer required for ITP. Will be returned to Tank Farm service.

manner protective of human health and the environment, and in a way that minimizes the impact on future investigation, removal, and remedial action. [Reference: SRS Plan for Performing Maintenance in Federal Facility Agreement Areas (Operations and Maintenance Plan), WSRC-RP-96-45, 12/15/96].

A total of 17 RCRA/CERCLA units or Site Evaluation Units have been identified in the tank farms. In 14 of the 17 areas, the contamination is the result of past spills on the surface, and the contamination is on the surface or near the surface. The amount of contamination in these 14 sites appears to be small, and will probably not be a significant contributor to estimated doses in a tank closure performance evaluation.

In 2 of the 17 areas, the contamination came from pipelines located 10 to 15 feet below grade that leaked directly into the ground. The first area was a leak from the secondary containment of a pipeline near tank 8, which happened in 1961, at a depth of about 10 to 15 feet below grade. The leak resulted from an inadvertent overfill of Tank 8. The volume leaked to the soil was estimated to be 1500 gallons (Odum 1976). The second area was a leak from a Concentrate Transfer System near Tank 37 line (between 10 and 15 feet below grade), which was discovered in 1989 (The actual date of the leak is not known). The volume of this leak was estimated to be a few gallons.

The last area, the Tank 16 RCRA/CERCLA unit, is the only instance at SRS where waste is known to have leaked to the soil from a high-level waste tank. In September of 1960, leaks from the Tank 16 primary tank caused the level in the annulus pan (the tank secondary containment) to exceed the top of the pan, which is five feet high. The waste was still contained in the concrete encasement that surrounds the tank, but surveys indicated that some waste leaked into the soil, presumably through a construction joint on the side of the encasement that is located near the top of the annulus pan, about 25 feet below grade. Based on soil borings around the tank, it is estimated that some tens of gallons of waste leaked into the soil. Assuming that the waste did leak from the construction joint, the leaked waste is in the vicinity of the seasonal water table and is at times below the water table.

All tanks at SRS have leak detection, so it is unlikely that waste has leaked from other tanks without being detected. In eight tanks other than Tank 16, observable amounts of waste have leaked from primary containment into secondary containment. But, other than Tank 16, there is no evidence that waste has leaked into the soil from a tank.

A.3.2 EVAPORATOR SYSTEMS

Each tank farm has two single-stage, bent-tube evaporators that concentrate waste following receipt from the canyons. At present, two evaporators are operating, one in each tank farm. An additional evaporator system, the Replacement High-Level Waste Evaporator, has been built in H-Area. Each operating evaporator is made of stainless steel with a hastelloy tube bundle and operates at near atmospheric pressure under alkaline conditions. The older evapo-

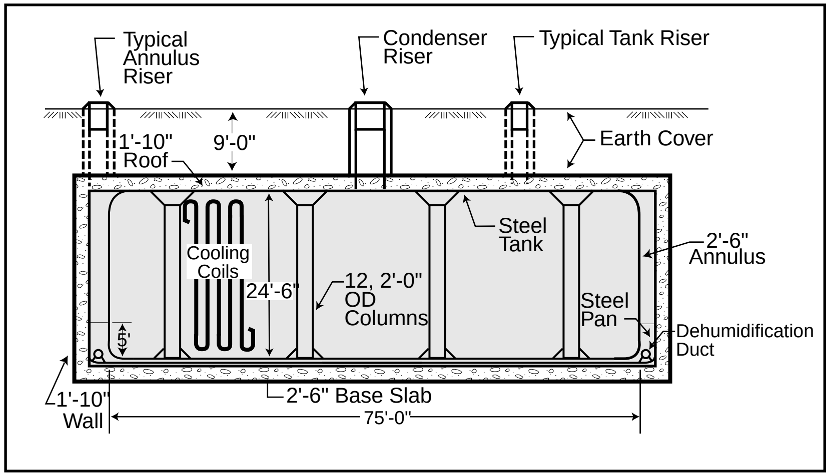


Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

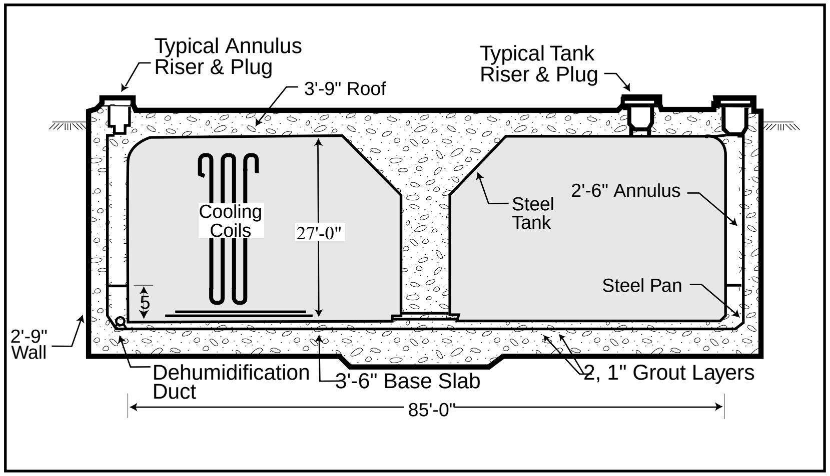


Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

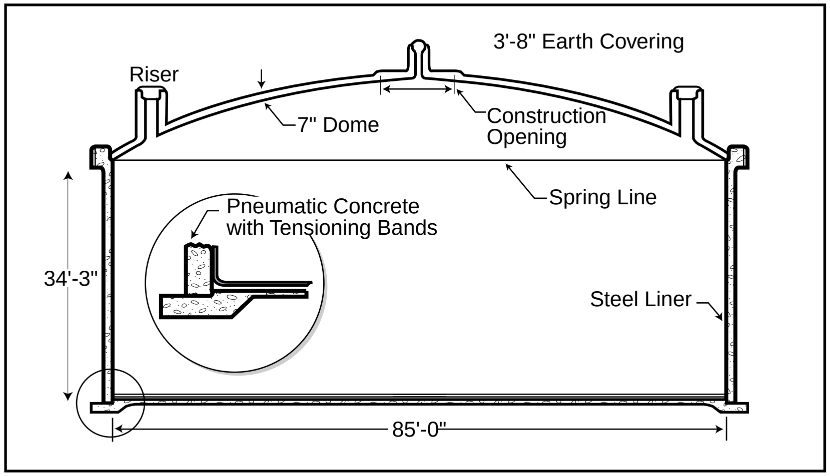


Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

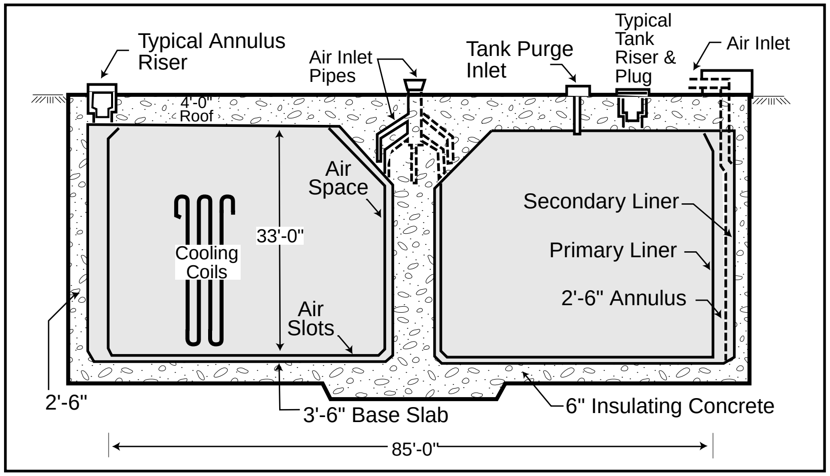
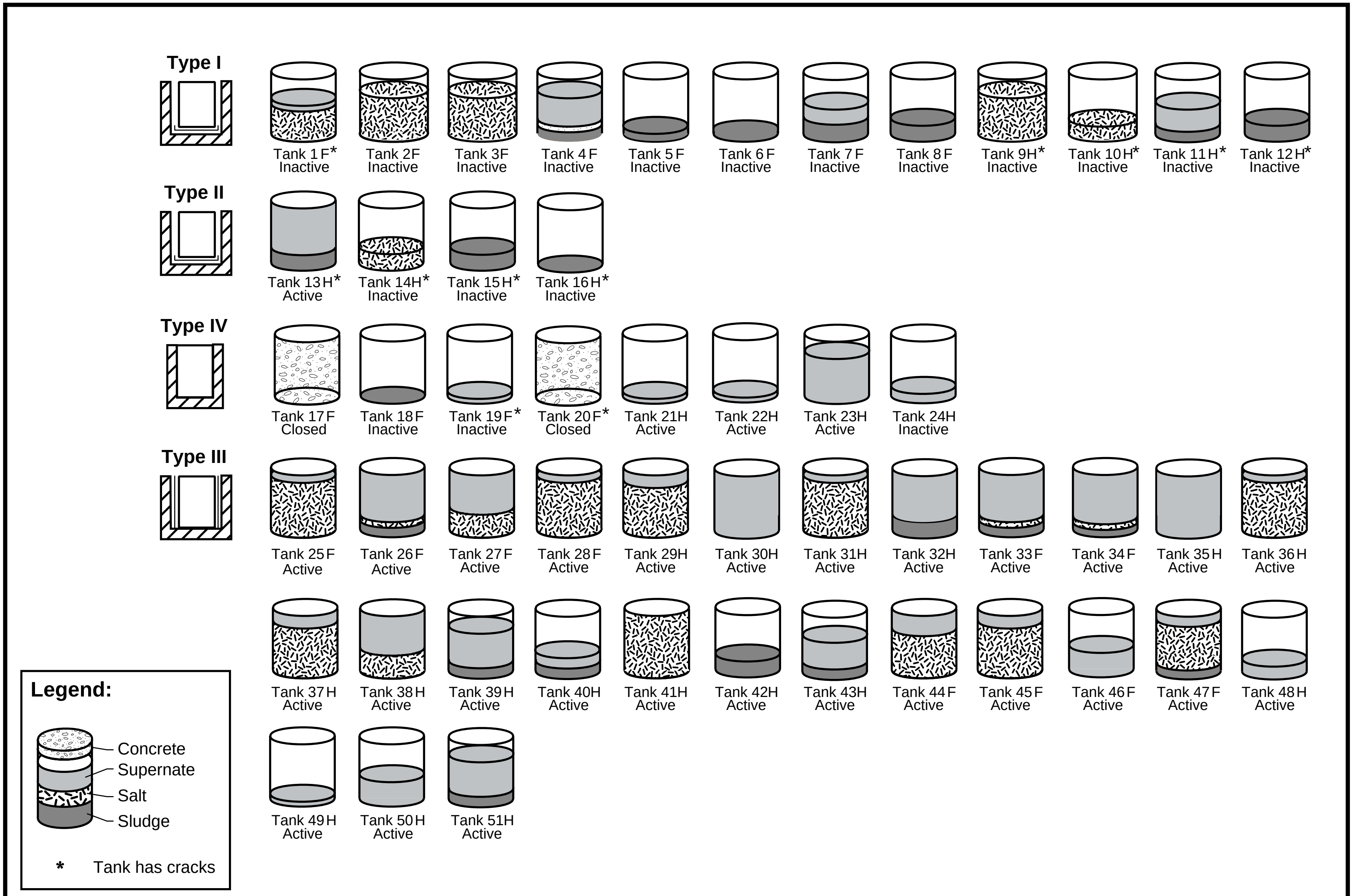


Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

NW TANK/Grfx/A-4 Tank config.ai

Figure A-4. Tank configuration.



Note: Information current as of 6/99. Inactive tanks are no longer receiving waste.

NW TANK/Grfx/A-5 Waste tank.ai

Figure A-5. Savannah River Site high-level waste tanks and status.

rating capacity of approximately 1,800 gallons. The Replacement High-Level Waste Evaporator is fabricated of INCO alloy G3 to allow higher design temperatures; it has almost twice the operating capacity of the existing evaporators. Because of the radioactivity emitted from the waste, the evaporator systems are either shielded (i.e., lead, steel, or concrete vaults) or placed underground. The process equipment is designed to be operated and maintained remotely.

Waste supernate is transferred from the evaporator feed tanks and heated to the aqueous boiling point in the evaporator vessel. The evaporated liquids (overheads) are condensed and, if required, processed through an ion-exchange column for cesium removal. The overheads are transferred to the F/H Effluent Treatment Facility for final treatment before being discharged to Upper Three Runs. The overheads can be recycled back to a waste tank if evaporator process upsets occur. Supernate can be reduced to about 25 percent of its original volume and immobilized as crystallized salt by successive evaporations of liquid supernate.

A.3.3 TRANSFER SYSTEM

A network of transfer lines is used to transfer wastes between the waste tanks, process units, and various SRS areas (i.e., F-Area, H-Area, S-Area, and Z-Area). These transfer lines have diversion boxes that contain removable pipe segments (called jumpers) to complete the desired transfer route. Jumpers of various sizes and shapes can be fabricated and installed to enable the transfer route to be changed. The use of diversion boxes and jumpers allows flexibility in the movement of wastes. The diversion boxes are usually underground, constructed of reinforced concrete, and either sealed with waterproofing compounds or lined with stainless steel.

Pump pits are intermediate pump stations in the F- and H-Area Tank Farm transfer systems. These pits contain pump tanks and hydraulic pumps or jet pumps. Many pump pits are associated with diversion boxes. The pits are constructed of reinforced concrete and have a stainless-steel liner.

A.3.4 PRECIPITATION/FILTRATION SYSTEM

DOE has concluded that the In-Tank Precipitation process as currently configured, cannot achieve production goals and meet safety requirements for processing the salt portion of HLW (64 FR 8559). Therefore, this system is the subject of an ongoing EIS on salt disposition.

The In-Tank Precipitation process consisted of three Type III tanks, one Type IV tank, and an aboveground building that contains filtration equipment, stripper columns, hold tanks, and a laboratory. The In-Tank Precipitation process was designed to remove radionuclides (primarily cesium) from the waste with a precipitation/adsorption reaction with sodium tetraphenylborate and sodium titanate. The resultant precipitate slurry would be continuously pumped to a filter cell, filtered through a sintered metal filter, and returned to the reaction tank for sampling. The filtrate (called decontaminated salt solution) would be combined with the concentrate reject from the Effluent Treatment Facility and transferred to the Saltstone Manufacturing and Disposal Facility for solidification and onsite disposal. The remaining precipitate slurry would undergo a washing step that removes residual soluble salts and process chemicals before transfer to DWPF for vitrification into a solid glass matrix suitable for disposal.

A.3.5 SLUDGE WASHING SYSTEM

The waste streams generated by the F- and H-Area Canyons contain insoluble and highly radioactive metal hydroxides (manganese, iron, and aluminum) that settle to the bottom of the waste tanks to form a sludge layer. In addition to the fresh waste receipt aging, the accumulated sludge is aged to allow radioactive decay. The aged sludge is transferred to the sludge processing tanks for washing and, if necessary, aluminum dissolution with a sodium hydroxide solution. The sludge processing takes place in two Type III tanks in H-Area. The washed sludge slurry is transferred to the DWPF for vitrification into a solid glass matrix that is easier to handle and much more suitable for disposal.

A.4 Tank Farm Closure Activities

A.4.1 WASTE REMOVAL

In the Federal Facility Agreement between DOE, EPA, and the State of South Carolina, DOE committed to removing wastes from older tanks that do not meet secondary containment requirements (Types I, II, and IV). DOE has reviewed bulk waste removal from the HLW tanks in the Waste Management Operations, Savannah River Plant EIS (ERDA-1537) and the Long-term Management for Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization) Savannah River Plant EIS (DOE/EIS-0023). In addition, the SRS Waste Management EIS discusses high-level waste management activities as part of the No Action Alternative (continuing the present course of action), and the Defense Waste Processing Facility Savannah River Plant EIS (DOE/EIS-0082) and the Final Supplemental Environmental Impact Statement Defense Waste Processing Facility (DOE/EIS-0082S) discuss management of high-level waste after it is removed from the tanks. As described in this EIS, however, tank closure activities would comply with the proposed plan and schedule provided under the Agreement. Also, even under the No-Action Alternative, DOE would continue to remove waste from the tanks as their missions cease. All tanks would be empty by 2028.

The schedule for removing waste from the tanks is closely linked to salt and sludge processing capacity and the DWPF schedule. The priorities for determining the sequence of waste removal from the tanks are as follows:

1. maintain emergency tank space in accordance with safety analyses

2. control tank chemistry, including radionuclides and fissile material inventory

3. enable continued operation of the evaporators

4. ensure blending of processed waste to meet salt processing, sludge processing, defense waste processing, and saltstone feed criteria

5. remove waste from tanks with leakage history

6. remove waste from tanks that do not meet the Federal Facility Agreement requirements

7. provide continuous radioactive waste feed to the DWPF

8. maintain an acceptable precipitate balance with the salt processing facility

9. support the startup and continued operation of the Replacement High-Level Waste Evaporator

10. remove waste from the remaining tanks

The general technique for waste removal is hydraulic slurrying. First, slurry pump support structures are installed above the tank top, along with electrical service and motor controls. Then, slurry pumps are installed in the risers of the tank: usually three for salt removal and four for sludge removal. For the salt tanks, the pump discharges are positioned just above the level of the saltcake. Water is added to the tanks and the pumps turned on to agitate and dissolve a layer of salt. When the water becomes saturated with salt, the solution is pumped out. For sludge tanks, the pumps are placed into the top layer of sludge. As with salt removal, water is added and the pumps turned on to agitate the sludge. When the sludge is well mixed, the slurry is pumped out. For both salt and sludge, the pumps are then lowered to continue the process. Pumps may be lowered one or more times before a salt or sludge transfer is made. DOE is also exploring other methods for more efficient waste removal.

A.4.2 DETERMINATION AND USE OF PERFORMANCE OBJECTIVES

DOE has identified pertinent substantive requirements with which it will comply and guidance it will consider (Chapter 7) to ensure that closure of the tank systems will be protective of human health and the environment. DOE will use these requirements and guidance to develop tank system closure performance objectives that provide a basis for comparison of different closure configurations. The performance objectives apply to the completed closure of all 51 tank systems; however, DOE must close the tanks one at a time over a period of decades. (DOE anticipated that the need for HLW tanks will cease some time before 2030. The tanks would be closed as their individual missions end.) Therefore, the Department evaluates the impacts of each tank closure in the context of the entire Tank Farm. This methodology ensures that as tanks are closed, the total closure impacts do not exceed the performance objectives.

To further ensure that closure of the tank system will be protective of human health and the environment, DOE also evaluates contamination from non-tank farm related sources. Studies of groundwater transport (DOE 1996) in the General Separations Area indicate that contaminant plumes from F- and H-Area tanks would not intersect. Therefore, DOE has established independent Groundwater Transport Segments for the two tank farms that represent the contaminant plume from the tank farm. DOE requires that contributions from all contaminant sources within a Groundwater Transport Segment, both tank farm-related and non-tank farm-related, be considered in comparison of modeled impacts to the performance objectives.

A.4.3 TANK CLEANING

DOE's preferred method for tank cleaning is spray water washing. In this process, heated water is sprayed throughout the tank using spray jets installed in the tank risers. After spraying, the contents of the tank are then agitated with slurry pumps and pumped to another HLW tank still in service.

After the spray washing, remotely operated video cameras are used to survey the interior of the tank to identify areas needing further cleaning. Based on experience with two tanks that have been spray washed, DOE has learned that some sludge tends to remain on the bottom of the tank and that the sludge tends to be distributed around the edge of the tank bottom after the single water wash performed as the last phase of waste removal.

Eleven HLW tanks at SRS have shown evidence of cracks in the primary tank shell. In two of the tanks, the cracks are above the current liquid level and there is no evidence that waste escaped primary containment. In the remaining nine tanks, leaked salt has been observed on the exterior of the primary tank shell. The cracks in these tanks are hairline cracks and the annuli in these tanks are ventilated to dry the waste. The waste seeped through the cracks slowly and dried in the annulus. This waste appears as dried salt deposits on the side of the primary tank and sometimes on the floor of the secondary tank (WSRC 2000). DOE has developed methods to clean the annulus using recirculating water jets installed through annulus risers. The water is heated and circulated through the annulus into the primary tank.

In five of the tanks (Tanks 1, 11, 12, 13, and 15), photographic inspections indicate that the amount of leaked waste is small. The waste is limited to salt deposits on the walls of the tank or perhaps covering part of the floor of the annulus. The leaked waste is virtually all salt because sludge is relatively immobile and will not migrate significantly through hairline cracks. The small amount of salt in these annuli should be relatively easy to remove with water.

In the remaining four tanks (Tanks 9, 10, 14, and 16), enough waste has leaked to completely cover the floor of the annulus. The annuli of these four tanks will be the most difficult to clean of all the tanks. Because of the large amount of waste that leaked in these four tanks, some waste may have leaked underneath the primary tanks. Also, waste has entered the ventilation ducts in the annuli. Special waste removal techniques will need to be developed for these tanks to ensure that water penetrates to the locations of the waste.

In three of the four tanks (Tanks 9, 10, and 14), the waste in the annulus is primarily salt, so it should be relatively easy to remove once it is dissolved. The difficulty is primarily getting the water to where it is needed and then removing the salt solution. Since the problem is limited to a few tanks, plans are to develop these techniques when needed. The techniques may differ between tanks (for example, a different annulus cleaning technique would be needed if waste has seeped underneath the primary tank).

Tank 16 is the most badly cracked tank and represents a special case for annulus cleaning. In this tank, a number of welds were sandblasted to understand the stress corrosion cracking phenomena. The sand fell on top of the salt and then mixed with the salt during a waste removal effort in 1978 that removed about 70 percent of the salt. Recent samples have shown that the sand and compounds that formed when the sand mixed with the salt make it more difficult to dissolve the waste in this annulus. Chemical cleaning (such as oxalic acid) may be needed to dissolve the waste in the Tank 16 annulus. Since this will be a one-time operation, plans are to develop the cleaning techniques when needed.

It is possible that some tanks may prove to be more difficult to clean than others. To meet performance criteria for tank closure, DOE may need to perform more rigorous cleaning than spray water washing. The method DOE expects to use is oxalic acid cleaning. In this process, hot oxalic acid is sprayed through the nozzles that were used for spray washing. Oxalic acid was selected above other cleaning agents for the following reasons (Bradley and Hill 1977):

- Oxalic acid dissolves portions of the sludge and causes the particles to break down, allowing removal of sludge deposits that are difficult to mobilize using spray washing alone.

- Oxalic acid is only moderately aggressive against carbon steel. Corrosion rates are on the order of 0.001 inch per week. This rate is acceptable for a short-term process such as cleaning. More aggressive agents such as nitric acid would be more effective in tank cleaning, but they could potentially cause release of contaminants to the environment in a mobile form.

- Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is about twice as effective as spray water washing for removal of radioactivity. However, at the present time potential safety considerations restrict the use of oxalic acid in the high-level waste tanks. The Liquid Radioactive Waste Handling Facility Safety Analysis Report (WSRC 1998b) specifically states that oxalic acid cleaning of any waste tank is prohibited. A Nuclear Criticality Safety Evaluation would be necessary to address oxalic acid use because oxalic acid would reduce the pH of the cleaning solution to the point where a quantity of fissile materials greater than currently anticipated would go into solution. This could create the potential for a nuclear criticality. In addition, an Unreviewed Safety Question evaluation and subsequent SAR revision would be necessary.

Between 1978 to 1980, Tank 16 was the subject of a rigorous waste removal, water washing, and oxalic acid cleaning demonstration. The demonstration determined the increased effectiveness of oxalic acid cleaning. However, the process generates large quantities of sodium oxalate that must be disposed in the Saltstone Manufacturing and Disposal Facility. After oxalic acid cleaning is complete, the tank would be spray washed with inhibited water to neutralize the remaining acid.

A.4.4 STABILIZATION

DOE has identified three options for tank stabilization under the Clean and Stabilize Tanks Alternative as described in Chapter 2: grout fill, sand fill, and saltstone fill. In addition, another alternative would not stabilize the tank but would remove the interior liner (which has been in contact with the HLW) from the concrete vault for disposal in some other location. The sections below describe the activities associated with the action alternatives.

Grout Fill

After tank cleaning, each tank and its associated piping and ancillary equipment would be filled with a pumpable, self-leveling grout, a concrete-like material. The material would have a high pH to be compatible with the carbon steel of the tank. The fill material would also be formulated with chemical properties that would retard the movement of radionuclides and chemical constituents from the closed tank. A combination of different types of grout would be used. They would be mixed at a nearby batch plant constructed for the purpose and pumped to the tank. Figure A-6 shows how the sandwich layers of grout would be poured. The potential combination of layers of grout is as follows:

- Reducing grout is a pumpable, self-leveling backfill material similar in composition to that used at the SRS Saltstone Manufacturing and Disposal Facility, composed primarily of cement, flyash, and blast furnace slag. The chemical properties of the liquid that leaches through this backfill material will reduce the mobility of selected radionuclides and chemical constituents. The formulation of the backfill material for each waste tank will be adjusted based on specific circumstances for each tank. The material is pumped into the waste tank through an available opening (e.g., tank riser). Observations of Tank 20 during pouring of the reducing grout indicate that the grout lifts some of the sludge on the bottom of the tank and carries it like a wave until it eventually envelops the sludge in the grout. Nevertheless, DOE's use of the reducing grout is not dependent on fully enveloping the sludge but upon the grout's ability to chemically alter any water leaching through the grout to the sludge.

- Controlled Low-Strength Material (CLSM) is a self-leveling concrete composed of sand and cement formers. Similar to reducing grout, it is pumped into the tank. The compressive strength of the material is controlled by the amount of cement in the mixture. The advantages of using CLSM rather

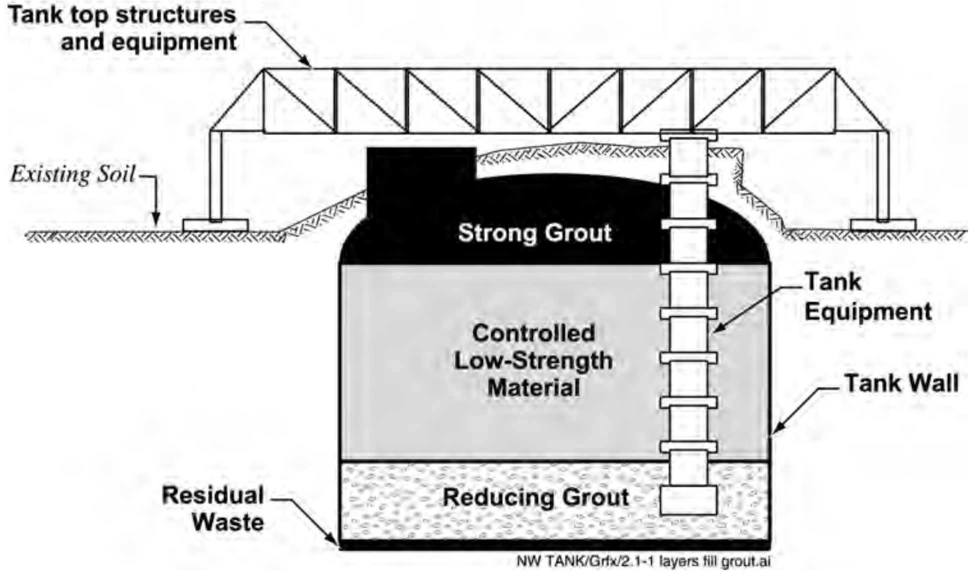


Figure A-6. Typical layers of the fill with grout option.

than ordinary concrete or grout for most of the fill are:

  - The compressive strength of the material can be controlled so that it will provide adequate strength for the overbearing strata and yet could be potentially excavated with conventional excavation equipment. Although excavation of the tank is not anticipated, filling the tank with low-strength material would enhance the opportunity for future removal of tank contaminants or perhaps the tank itself, if future generations were to decide that excavation is desirable.
  - CLSM has a low heat of hydration, which allows large or continuous pours. The heat of hydration in ordinary grout limits the rate at which the material can be placed because the high temperatures generated by thick pours prevent proper curing of the grout. Thus, large pours of grout are usually made in layers, allowing the grout from each layer to cool before the next layer is poured.
  - CLSM is relatively inexpensive.
  - CLSM is widely used at SRS, so there is considerable experience with its formulation and placement, and in controlling the composition to provide the required properties.

- Strong grout is a runny grout with compressive strengths in the normal concrete range. This formulation is advantageous near the top of the tank because:
  - The runny consistency of the grout is advantageous for filling voids near the top of the tank created around risers and tank equipment. The grout would be injected in such a manner to ensure that voids were filled to the extent practicable. This may involve several injection points, each with a vent.
  - A relatively strong grout will discourage an intruder from accidentally accessing the waste if institutional control of the area is discontinued.

Other potential combinations of multiple or single grout layers may be used.

The specific actions needed before and during closure include tank isolation, tank modifications to facilitate introduction of grout, production and installation of grout, and riser cleanup. These activities are described below in more detail.

Mechanical and electrical services would be isolated from the tank such that future use is prohibited. Tank isolation is an activity that must be performed regardless of the closure option. Accessible piping and conduits would be removed and pulled back from each riser so that a physical break is made from the tank. Any transfer lines would be cut and capped.

DOE would leave the tank structures intact. No support steel would be removed unless it is necessary to be removed to disconnect services from the tank risers. Equipment already installed in the tank and equipment directly used in tank closure operations (such as temporary submersible pumps, cables, temporary transfer hoses, backfill transfer pipes or tremmies, and sample pump) would be entombed in the backfill material as part of the closure process. Items removed in preparation for closure under this module (such as slurry pump motors, instrument racks, piping, and insulation) may be decontaminated to such levels that they may be sent to the Solid Waste Management Facilities as scrap. Otherwise, they would be appropriately characterized and shipped as low-level waste.

The tank risers would be modified to permit backfill material to be placed into the tank. Provisions would be made to provide a delivery point into the tank, to manage air displacement, to address bleed water build-up, and to handle any tank top overflow.

Risers would be prepared to allow addition of the backfill material. Equipment located at the riser would be disconnected. A backfill transfer line would be inserted through an access port to allow introduction of the backfill into the tank. Tank venting would be predominately through the existing permanently installed ventilation system until the backfill material nears the top of the tank. However, a newly constructed vent device, equipped with a breather high-efficiency particulate filter, would be supplied for the final filling operation.

During the filling process, excess water (bleed water) is expected to float to the top of the grout and CLSM. The amount of bleed water would be minimized during the actual closure operation by limiting the amount of water in the grout and CLSM and by specifying the fill material cure times. It is expected that any bleed water produced would be re-absorbed back into the fill material. The amount of re-absorption would be dictated by the cure times. Any bleed water not absorbed would be removed from the tank and returned to the tank farm systems by siphoning it off and transferring it through a temporary aboveground transfer line to another waste tank or processed at the Effluent Treatment Facility. The possible overflow of bleed water and grout from around the riser joints would be controlled by constructing forms around the risers and sealing those forms for watertightness as part of pre-closure preparation for riser grouting operations. Each riser would be prepared for local filling and venting to ensure that the top void spaces are filled.

Portable concrete batch plants would supply the grout and CLSM backfill needed to fill the tanks. The plants may require a SCDHEC Bureau of Air Quality permit to operate. All process water would be recycled.

Backfill material produced at the plants would be introduced into the risers of the tanks through piping from the plants located just outside the Tank Farm fence.

The actual backfill material installation would be governed by SRS procedures in accordance with Design Engineering requirements as outlined in the construction and subcontractor work packages. The filling progress would be monitored by an in-tank video camera. The backfill material level would be measured using visual indications. During riser closure operations, containment provisions would be made to restrict or contain grout overflows. Tank components such as the transfer pump, slurry pumps, wiring, cables, steel tapes, hoses, and sample collection apparatus would be encapsulated during tank grouting operations.

The risers and void spaces in the installed equipment remaining in the tank would be filled with highly flowable reducing grout material to ensure that all voids are filled to the fullest extent possible. The tank fill and riser backfilling operations would be performed in such a way as to eliminate rainwater intrusion into the tank. Upon completion of the tank closure, the riser tops would be left in a clean and orderly condition. Risers would be encapsulated in concrete using forms constructed of rolled steel plates or removable wooden forms previously installed around each riser. The riser encapsulation would be completed at the end of the tank dome fill operation.

Piping and conduit at each of the risers that is not removed would be entombed in the riser filling operations. Each riser and the lead lining would be encased in concrete, and decontamination of the remaining riser formwork structures and adjacent areas will be performed, if necessary. The tank appurtenances, such as the riser inspection port plugs, riser plug caps, and the transfer valve box covers, which would have been removed to ensure complete backfilling of the tank, would be entombed at the same time as the associated risers are filled and backfilled.

Sand Fill

This option is similar to the fill with grout option except that sand would be used instead of grout. There would be no layers for intruder protection or chemical conditioning of leaching water. The sand would be carried by truck to an area near the tank farm and conveyed to the tank.

Sand is readily available and is inexpensive. However, its emplacement is more difficult than grout as it does not flow readily into voids. Over time, sand will settle in the tank, creating additional void spaces. The tank top would then become unsupported and would sag and crack, although there would not be the catastrophic collapse that would be anticipated in the no-action case. Also, the sand would tend to protect the contamination to some extent and prevent winds from spreading the contaminants. However, sand is highly porous and rainwater infiltrates rapidly and does not run off. Also, sand is relatively inert and could not be formulated to retard the migration of radionuclides and chemical constituents. Thus, the expected contamination levels in groundwater would be higher than for the grout fill option.

A variation of this alternative could involve filling the tanks with contaminated soils excavated during the remediation of SRS waste sites. Placement of soils in the tanks would present similar disadvantages to those described above for sand fill. In addition, handling contaminated soils would complicate the project, resulting in increased costs. Soils could not be readily formulated to retard the migration of radionuclides and chemical constituents, and the additional contamination associated with the soil fill would have to be factored into the performance evaluation for the closure configuration. Because of these disadvantages, the use of contaminated soils as a fill material is not evaluated further in this EIS.

Saltstone Fill

This option is the same as the fill with grout option except that saltstone would replace the reducing grout and the CLSM. Saltstone is a low-radioactivity fraction separated from HLW mixed with cement, flyash, and slag to form a concrete-like mixture. This option has the advantage of reducing the amount of disposal space needed at the Saltstone Manufacturing and Disposal Facility; however, it has several disadvantages:

- Because of the fast saltstone set-up times, two new saltstone mixing facilities (one in F-Area and one in H-Area) would be required.

- The amount of saltstone to be made is projected to be greater than 160 million gallons. This volume is considerably greater than the capacity of the HLW tanks. Therefore, the existing Saltstone Manufacturing and Disposal Facility in Z-Area would still need to be operated.

- Filling the tank with a grout mixture that is contaminated would considerably complicate the project and increase worker radiation exposure, further adding to expense and risk.

- Saltstone grout cannot be poured as fast as CLSM because of its relatively high heat of hydration. Saltstone grout would have to be poured in discrete pours, allowing sufficient time between pours for the grout to cool.

Clean and Remove Tanks

This alternative involves additional cleaning of the tanks beyond that described in Section A.4.2. Such cleaning could include mechanical cleaning or other steps not yet defined. The steel components (including any piping and ancillary equipment) would be sectioned, removed, placed in burial boxes for disposal, and transported to SRS low-level waste disposal facilities.

For tank removal operations, DOE would enclose the top of the tanks with structures designed to contain airborne contamination. These structures would be fitted air locks and operate at negative pressure during cutting operations. Air discharges from the tanks and enclosures would be filtered with high-efficiency particulate air filters. DOE would backfill the void created by tank removal with a soil type similar to soils currently surrounding the tank.

The advantages of this option are:

- This alternative has the advantage of allowing disposal of the contaminated tank system in a waste management facility that is already approved for receiving low-level waste.

- This option exposes the surrounding soils such that they could be exhumed. This is the only option that has the potential to leave the waste tank area as an unrestricted area for future uses.

The disadvantages include:

- High radiation exposure to workers during the removal process.
- Extremely high cost to remove the tank.
- Considerable impact on other SRS operations.
- Extremely high cost to dispose of the tank components elsewhere. Also, disposal of the tank could create another zone of restricted use (i.e., the restricted use zone is merely shifted rather than being eliminated).

A.4.5 ENVIRONMENTAL RESTORATION PROGRAM ACTIVITIES

After a tank is closed, the SRS Environmental Restoration Program will conduct field investigations and remedial actions. The Environmental Restoration Program is concerned with all aspects of assessment and cleanup of both contaminated facilities in use and of sites that are no longer a part of active operations. Remedial actions, most often concerned with contaminated soil and groundwater, are responsibilities of this program. The investigations will take place after nearby tanks in an operational grouping are closed (to avoid interference with the other operational tanks) and conditions are determined to be safe for Environmental Restoration intrusive sampling. Once an operational grouping is closed, the HLW operations organization and the Environmental Restoration organization will establish a Co-Occupancy Plan to ensure safe and efficient soils assessment and remediation. The HLW organization will be responsible for operational control and the Environmental Restoration organization will be responsible for Environmental Restoration activities. The primary purpose of the Co-Occupancy Plan is to provide the two organizations with a formal process to plan, control, and coordinate the Environmental Restoration activities in the tank farm areas where the existing HLW management and operational procedures can be continuously utilized.

The High-Level Waste Tank Closure Program Plan (DOE 1996) provides general information on postclosure activities and tank-specific closure modules will also address postclosure activities. However, the investigation, determination of remediation requirements, and implementation of potential remedial actions related to soil and groundwater contamination at the tank farms will be conducted in accordance with RCRA/CERCLA requirements pursuant to the Federal Facility Agreement. The Environmental Restoration organization would have the responsibility for these activities. Plans for such postclosure measures as monitoring, inspections, and corrective action plans would also be governed by the Federal Facility Agreement and would be premature to state at this time because conditions that would exist at the restored area are not known. For example, the area may be capped or an *in situ* groundwater treatment system may be installed.

Figure A-7 presents an example of the closure configuration for a group of tanks. The necessity for a low-permeability cap, such as a clay cap, over a tank group to reduce rainwater infiltration will be established in accordance with the environmental restoration program described in the Federal Facility Agreement (EPA 1993). Figure A-7 shows a conceptual cap design. The cap construction would ensure that rain falling on the area drains away from the closed tank(s) and surrounding soil. A soil cover could be placed over the cap and seeded to prevent erosion.

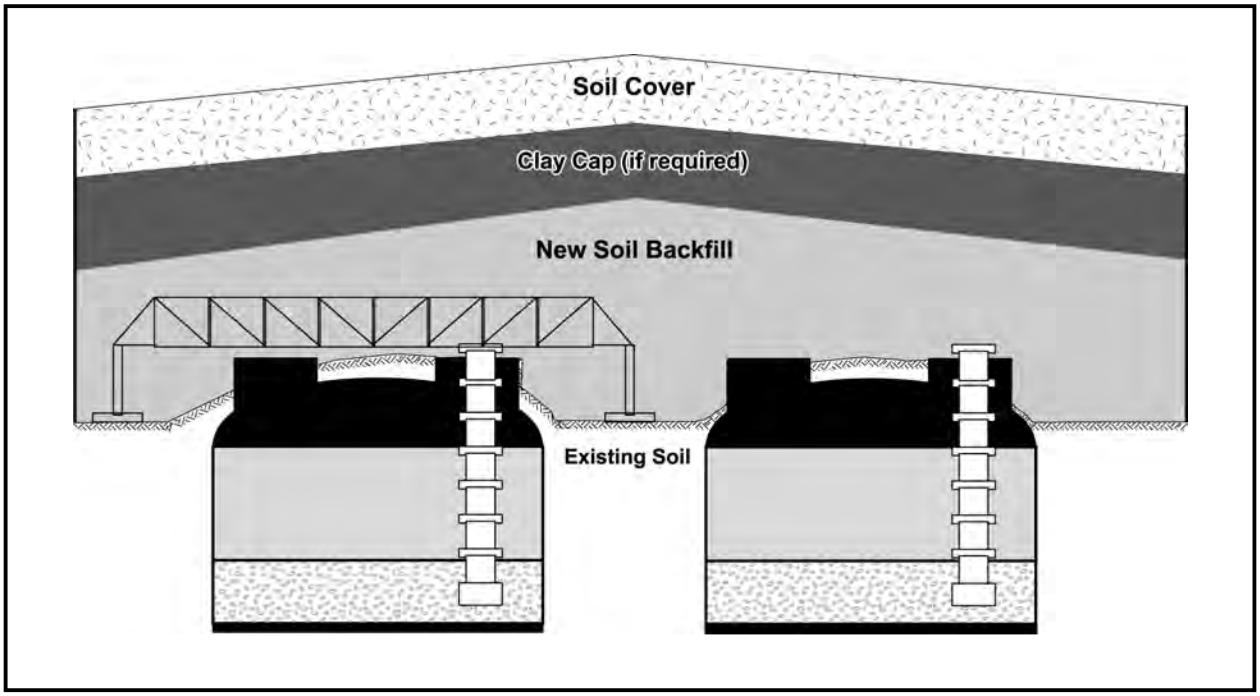


Figure A-7. Area closure example.

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APPENDIX B

ACCIDENT ANALYSIS

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APPENDIX B. ACCIDENT ANALYSIS

This appendix provides detailed information on the potential accident scenarios associated with the closure of the HLW tanks at SRS. The appendix provides estimates of the quantity and composition of hazardous materials that could be released in an accident as well as the consequences to workers and the public, estimated in terms of dose and latent cancer fatalities for radiological releases and of concentration levels for chemical releases.

The primary sources of information for the accident analyses are a specific calculation (Yeung 1999) and the safety analysis report for the Liquid Radioactive Waste Handling Facility (WSRC 1998a).

B.1 General Accident Information

An accident, as discussed in this appendix, is an inadvertent release of radiological or chemical hazardous materials as a result of a sequence of one or more probable events. The sequence usually begins with an initiating event, such as a human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of materials released. Initiating events fall into three categories:

- *Internal initiators* – normally originate in and around the facility but are always a result of facility operations. Examples include equipment or structural failures and human errors.
- *External initiators* – are independent of facility operations and normally originate from outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.
- *Natural phenomena initiators* – are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, lightning, and snow. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

The likelihood of an accident occurring and its consequences usually depend on the initiator and the sequence of events and their frequencies or probabilities. Accidents can be grouped into four categories—anticipated, unlikely, extremely unlikely, and beyond extremely unlikely, as listed in Table B-1. DOE based the frequencies of accidents at the liquid radioactive waste handling facility on safety analyses and historical data about event occurrences.

B.2 Accident Analysis Method

For the alternatives for HLW tank closure, Yeung (1999) identified potential accident scenarios that involved the release of both radiological and non-radiological, hazardous materials. Section B.2.1 provides information about the various alternatives for tank closure. B.2.2 provides details about the specific analyses methods that were employed in this appendix.

The accident sequences analyzed in this EIS would occur at frequencies generally greater than once in 1,000,000 years. However, the analysis considered accident sequences with smaller frequencies if their impacts could provide information important to decisionmaking.

Table B-1. Accident frequency categories.

Accident frequency category	Frequency range (occurrences per year)	Description
Anticipated	Less than once in 10 years but greater than once in 100 years	Accidents that might occur several times during facility lifetime.
Unlikely	Less than once in 100 years but greater than once in 10,000 years	Accidents that are not likely to occur during facility lifetime; natural phenomena include Uniform Building Code-level earthquake, maximum wind gust, etc.
Extremely unlikely	Less than once in 10,000 years but greater than once in 1,000,000 years	Accidents that probably will not occur during facility life cycle; this includes the design basis accidents.
Beyond extremely unlikely	Less than once in 1,000,000 years	All other accidents.

Source: DOE (1994).

B.2.1 HIGH-LEVEL WASTE TANK CLOSURE ALTERNATIVES

DOE has organized the accident data in this appendix by alternative. DOE has also organized the accident impacts in Chapter 4 by alternative to reflect potential accident occurrences for the associated alternative.

Approximately 34 million gallons of HLW are stored in underground tanks in F-Area and H-Area. DOE intends to remove from service all 51 HLW tanks. Because two of these tanks (Tanks 17 and 20) are already closed, this appendix addresses the potential impacts from accidents associated with the closure of the 49 remaining waste tanks.

The alternatives considered in this EIS include:

- No Action Alternative
- Clean and Stabilize Tanks Alternative
  - Clean and Fill with Grout Option (Preferred Alternative)
  - Clean and Fill with Sand Option
  - Clean and Fill with Saltstone Option
- Clean and Remove Tanks Alternative

B.2.2 RADIOLOGICAL HAZARDS

The accidents identified for HLW tank closure are described in Section B.3. These descriptions include an approximation of the material-at-risk (MAR) that would potentially be involved in the accident. Depending on the particular scenario, release fractions have been applied to the MAR to determine the amount of the materials that would be released to the environment. This amount is referred to as the source term. Source terms are provided in Yeung (1999) for airborne, ground surface runoff, and underground releases. The airborne releases are of short duration and could have impacts to the worker and offsite population. The surface runoff and underground releases, however, would not have short-term impacts to any of the analyzed receptors. In the case of surface runoff, DOE would employ mitigative actions to prevent the release from reaching the Savannah River (i.e., clean-up actions, berms, dams in surface water pathways, etc.). In the unlikely event that radionuclides reached the river, DOE's mitigative actions would include notification of municipalities downstream that use the Savannah River for drinking water supply. These mitigative actions would preclude any offsite dose from a liquid release pathway. In the case of underground releases, radiological materials released directly into the soil would take a long period of time to reach any of the human receptors evaluated in this analysis. The potential consequences of such releases are determined as part of the EIS long-term impacts.

The analysis of airborne releases used the computer code AXAIRQ to model accidental atmospheric radioactive releases from SRS that are of relatively short duration. AXAIRQ strictly follows the guidance in Regulatory Guide 1.145 (NRC 1982) on accidental releases and has been verified and validated (Simpkins 1995a and 1995b). Since all considered accidents would occur at or below ground level, the releases for AXAIRQ assumed ground level releases with no modification for release height. In accordance with the regulatory guide, the code considers plume meander and fumigation under certain conditions. Plume rise due to buoyancy or momentum is not available. The program uses a 5-year meteorological database for SRS and determines the shortest distance to the Site boundary in each of the 16 sectors by determining the distance to one of 875 locations along the boundary. The impacts that were derived from the use of this code used the average, or 50 percent, meteorology. Since these accidents could occur in either F- or H-Area at SRS, the largest unit dose conversion factor was chosen (applicable to F- or H-Area) dependent on the receptor being evaluated. The code uses the shortest distance in each sector to calculate the concentration for that sector. DOE used the computer code PRIMUS, which was developed by the Oak Ridge National Laboratory, to consider decay and daughter ingrowth.

Simpkins (1997) provided unit dose conversion factors for a wide list of radionuclides for release locations in F- and H-Areas. These factors were applied to the airborne source terms to calculate the doses to the various receptors.

The analysis assumes that all tritium released would have the form of tritium oxide and, following International Commission on Radiological Protection methodology, the dose conversion factor for tritium has been increased by 50 percent to account for absorption through the skin. For population dose calculations, age-specific breathing rates are applied, but adult dose conversion factors are used. Radiation doses were calculated to the maximally exposed individual, to the population within 50 miles of the facility, and to a noninvolved worker assumed to be 640 meters downwind of the facility.

After DOE calculated the total radiation dose to the public, it used dose-to-risk conversion factors established by the National Council on Radiation Protection and Measurements (NCRP) to estimate the number of latent cancer fatalities that could result from the calculated exposure. No data indicate that small radiation doses cause cancer; however, to be conservative, the NCRP assumes that any amount of radiation has some risk of inducing cancer. DOE has adopted the NCRP factors of 0.0005 latent cancer fatality for each person-rem of radiation exposure to the general public and 0.0004 latent cancer fatality for each person-rem of radiation exposure to radiation workers (NCRP 1993).

B.2.3 CHEMICAL HAZARDS

For chemically toxic materials, the long-term health consequences of human exposure to hazardous materials are not as well understood as those related to radiation exposure. A determination of potential health effects from exposures to chemically hazardous materials, compared to radiation, is more subjective. Therefore, the consequences from accidents involving hazardous materials are expressed in terms of airborne concentrations at various distances from the accident location, rather than in terms of specific health effects.

To determine the potential health effects to workers and the public that could result from accidents involving hazardous materials, the airborne concentrations of such materials released during an accident at varying distances from the point of release were compared to the Emergency Response Planning Guideline (ERPG) values (AIHA 1991). The American Industrial Hygiene Association established these values, which depend on the chemical substance, for the following general severity levels to ensure that the necessary emergency actions occur to minimize exposures to humans.

- <u>ERPG-1 Values</u>. Exposure to airborne concentrations greater than ERPG-1 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects or perception of a clearly defined objectionable odor.

- ERPG-2 Values. Exposures to airborne concentrations greater than ERPG-2 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects or symptoms that could impair a person's ability to take protective action.

- ERPG-3 Values. Exposure to airborne concentrations greater than ERPG-3 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

Not all hazardous materials have ERPG values. For chemicals that do not have ERPG values, a comparison was made to the most restrictive available exposure limits established by other guidelines to control worker accidental exposures to hazardous materials. In this document, the ERPG-2 equivalent that is used is the PEL-TWA (Permissible Exposure Limit – Time Weighted Average) from 29 CFR Part 1910.1000, Subpart Z.

B.3 Postulated Accident Scenarios Involving Radioactive Materials

These sections describe the potential accident scenarios associated with each alternative that could involve the release of radioactive materials. The impacts of these scenarios are shown in Section B.4.

B.3.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

The Clean and Stabilize Tanks Alternative, including all of its stabilization options, would require cleaning the inside of the tank to the extent technically and economically possible. This cleaning would involve a two-step process. Initially, after bulk waste removal, the waste tank interiors would be water-washed using rotary spray jets put down into the tank interior through the tank risers. Water for these jets would be supplied from a skid-mounted tank and pump system. Following water washing, additional cleaning may be required using a hot oxalic acid solution through the same spray jets.

Six potential accident scenarios associated with the cleaning process were identified in Yeung (1999) that required evaluation. These included:

- Deflagration
- Transfer errors
- Vehicle impacts
- Chemical (oxalic acid) spill
- Seismic events
- Tornado

Criticality was not addressed as a potential accident scenario in Yeung (1999) because DOE considers inadvertent criticality to be beyond extremely unlikely in high-level waste tanks (Nomm 1995). The criticality safety of the waste sludge was based on the neutron-absorbing characteristics of the iron and manganese contained in the sludge. However, the review assumed that the waste would remain alkaline and did not address the possibility that chemicals wold be used that would dissolve sludge solids. Therefore, the *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998) specifically states that oxalic acid cleaning of any waste tank is prohibited.

A formal Nuclear Criticality Safety Evaluation (Unreviewed Safety Question evaluation and subsequent Safety Analysis Report revision) must be completed before oxalic acid could be introduced into the Tank Farm. Oxalic acid can dissolve uranium, plutonium, and the two neutron poisons that are credited for preventing a criticality-iron and manganese. The Nuclear Criticality Safety Evaluation would address the relative rates at which each of these species dissolves and would examine potential scenarios that could cause fissile material to concentrate.

Following the cleaning process, the tanks would be back-filled with a pumpable material (grout, sand, or saltstone). Yeung (1999) indicated that the scenarios identified above for the cleaning operations bound all postulated accidents during back-filling the waste tanks with either grout or sand. Since saltstone is a radioactive material, any uncontrolled release of radioactive materials associated with the Clean and Fill with Saltstone Option must be evaluated. WSRC (1992a) evaluated a failure of the Salt Solution Hold Tank. Yeung (1999) identified no accident scenarios for the post-closure period for this alternative.

B.3.1.1 Deflagration

Scenario: One postulated accident during cleaning of the waste tanks would be a release of radiological materials due to an explosion inside of the waste tank. The explosion could possibly consist of a deflagration or detonation. The transition from deflagration to detonation would occur only if the deflagration flame front accelerates to sonic speeds. In order for the deflagration to occur, flammable chemicals must be introduced into the waste tanks as a result of human error, and ignition sources must be present (Yeung 1999).

Probability: The determination of the probability of this event was based on the availability of flammable chemicals, the potential that they would be introduced into the waste tank, and the fact that an ignition source is present. There are no flammable chemicals required for the cleaning process. For a deflagration to occur, multiple operator errors and violation of multiple administrative controls would be required. From Benhardt et al. (1994), the combined probability of violation of an administrative control bringing in the flammable chemical and chemical addition into the tank would be 1.5×10^{-6} per year. Considering that in addition to the above, a significant amount of flammable material would be required to be introduced into the tank (e.g., 440 kilograms of benzene), by engineering judgement the additional probability of this event was estimated to be 1×10^{-2} per year (Yeung 1999). Therefore, the probability of a deflagration during the cleaning process was estimated to be 1.5×10^{-8} per year. Since the tank is relatively free of internal structures, the transition from deflagration to detonation occurs less than one time in a hundred for a near stoichiometric mixture. Therefore, the frequency of a detonation event was estimated to be 1×10^{-10} per year (Yeung 1999).

Since the likelihood of these events is well below 1×10^{-7}, they are considered beyond extremely unlikely and are not evaluated further in this EIS.

B.3.1.2 Transfer Errors

Scenario: The *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998a) reports that all transfer error events in the Liquid Radioactive Waste Handling Facility can be bounded by a waste tank overflow event, which would result in an above-ground spill of 15,600 gallons of waste (520 gpm for 30 minutes). A postulated accident during water spray washing of the waste tanks would be a release of diluted waste due to continuous maximum flow through a transfer line direct to the environment for 30 minutes without operator intervention. WSRC (1998a) assumed that the spill would occur above ground and result in seepage into the ground and evaporation into the air. This scenario would bound all leak/spill events.

Probability: It is considered unlikely that aboveground equipment failures leading to leakage or catastrophic release of the tank contents would go undetected (WSRC 1998a). Therefore, failures of aboveground equipment and the failure of the operators to detect and stop the leaks were considered in Yeung (1999). It was estimated that equipment failures and operator errors to detect and stop the leaks leading to the release of the bounding source terms described below could occur with a frequency of 1×10^{-3} per year (Yeung 1999). This frequency is in the unlikely range.

Source Term: After bulk waste removal and before spray washing, there would be approximately 9,000 gallons of HLW in the form of sludge or sludge slurry left in each tank. Based on the bounding sludge dose potential as given in the Safety Analysis Report (WSRC 1998a), it was assumed that the sludge slurry before spray washing would be characterized by the activities of 81,000 curies (Ci) of plutonium-238 (Pu-238) and 2,180,000 Ci of strontium-90 (Sr-90). The volume of the water used for spray cleaning was assumed to be 140,000 gallons (WSRC 1998b). This would result in a total waste volume of 149,000 gallons with nuclide concentrations in the diluted waste solution estimated at 0.54 Ci/gallons and 14.63 Ci/gallons for Pu-238 and Sr-90, respectively. The instantaneous airborne release for a spill of 15,600 gallons was estimated to be 0.34 Ci of Pu-238 and 9.1 Ci of Sr-90 (Yeung 1999). An additional entrainment source term of 0.34 Ci of Pu-238 and 9.1 Ci of Sr-90 was estimated assuming no mitigative actions were taken within a 10-hour period following the event.

B.3.1.3 Vehicle Impact

Scenario: Another postulated accident during cleaning of the waste tanks would be a release of diluted waste due to failure of the above ground pumping equipment and piping resulting from a construction vehicle impact. It was assumed that the equipment used to pump out the wastewater slurry from the tanks would be damaged to the point where pumping continued releasing the slurry onto the ground.

Probability: The frequency of a vehicle crash occurring over all the Liquid Radioactive Waste Handling Facilities is bounded between 7.4×10^{-4} and 4.7×10^{-3} events per year (WSRC 1998a). The Safety Analysis Report (WSRC 1998a) conservatively assumes that 0.1 percent of the accidents occurring at the H-Area and F-Area Tank Farm impact above-ground equipment, resulting in an overall frequency of 2.7×10^{-6} per year. The possibility that a fire could occur following a crash was also evaluated. Assuming that 97.7 percent of all truck accidents are minor (WSRC 1992b), and that fires resulting from minor accidents have an extremely low probability, the overall frequency of a fire resulting from a vehicle crash is estimated to be 6.2×10^{-8} per year. Therefore, vehicle impacts involving a coincident fire were considered to be beyond extremely unlikely.

Source Term: The MAR for this scenario was assumed to be the same as that in Section 3.1.2. Since the source term for this scenario is the same as estimated for the transfer errors and the expected frequency is smaller, the risk associated with this scenario would be bounded by the transfer error accident. No further evaluation of vehicle impacts are required in this appendix.

B.3.1.4 Chemical (Oxalic Acid) Spill

This accident would involve the release of nonradiological hazardous materials, which is addressed in Section B.5.

B.3.1.5 Seismic Event

Scenario: Yeung (1999) postulated that a design basis earthquake could occur during cleaning of the waste tanks, resulting in a release of liquid radiological materials. Only one tank in each tank farm would undergo closure at any one time. It was therefore assumed that the earthquake would occur immediately following water spray washing, which had been performed on two tanks simultaneously (one in each tank farm). The seismic event was assumed to fail the same transfer piping and equipment as was mentioned in the previous scenarios.

Probability: The design basis earthquake has an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the cleaning of two tanks would take approximately 14 days, a release of the bounding source term would occur at an annual probability of 1.9×10^{-5}. This accident would be categorized as extremely unlikely.

Source Term: The aboveground MAR was assumed to be same as in Section 3.1.2 except that the source term would be doubled because two tanks would be involved. Yeung (1999) provided the source term as an instantaneous airborne release of 0.68 Ci of Pu-238 and 18 Ci of Sr-90. If mitigation measures were not taken, entrainment would result in an additional airborne release of 0.68 Ci of Pu-238 and 18 Ci of Sr-90 over a 10-hour period.

B.3.1.6 Tornado

The design basis tornado was postulated to occur during water spray washing of the waste tanks. From WSRC (1998a), it was assumed that administrative controls stipulate the cessation of waste transfer operations at the first instance of tornado/high wind warning.

All waste tanks are underground and are protected by a concrete roof. With all transfer operations stopped, there would be no MAR aboveground. Some aboveground components of the transfer system may fail, but their contributions to the release of radiological materials were considered insignificant (Yeung 1999). As a result, this scenario would be bounded by several other scenarios and not evaluated further.

B.3.1.7 Failure of Salt Solution Hold Tank

Scenario: This scenario assumes that a Saltstone Mixing Facility would be built in F-area and H-Area similar to that currently operating in Z-Area. This accident would involve a worst-case release of the salt solution contained in a Salt Solution Hold Tank prior to mixing with cement, flyash, and slag to form the saltstone. The Salt Solution Hold Tank was assumed to contain 45,000 gallons of salt solution. The entire volume was assumed to be released and allowed to evaporate over a two-hour period (WSRC 1992a). No credit was taken for operator intervention, absorption into the ground, or containment of the spill in the diked area of the tank. In reality, this would significantly reduce the airborne release. It would take an extremely high-energy event to vaporize such a large quantity in such a short period of time (WSRC 1992a). Failure of the Salt Solution Hold Tank was assumed to occur during the design basis earthquake.

Probability: The design basis earthquake has an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the Salt Solution Hold Tank has a 10 percent chance of failing during the earthquake, a release of the bounding source term was estimated to occur at an annual probability of 5×10^{-5}. This scenario would be extremely unlikely.

Source Term: The 45,000 gallons of salt solution (1.2 kilograms per liter) in the Salt Solution Hold Tank was assumed to contain the radionuclides in Table B-2 (WSRC 1992a). Table B-2 also contains the assumed release fractions resulting in the final estimated source terms (unmitigated) (WSRC 1992a). This accident would also involve the release of non-radiological hazardous materials. The evaluation of these releases is addressed in Section B.5.

B.3.2 CLEAN AND REMOVE TANKS ALTERNATIVE

Following bulk waste removal, water spray washing, and additional cleaning, including the use of oxalic acid, additional cleaning steps (yet to be defined) would be performed until the tanks are clean enough to remove. The additional cleaning steps would increase worker radiation exposure and contamination. They would also increase the potential for industrial safety accidents. Following cleaning, the tank components would be sectioned, removed, placed in burial boxes for disposal, and transported to onsite waste disposal facilities.

The scenarios in Section B.3.1 were assumed to bound any postulated tank accident scenarios associated with this alternative.

B.3.2.1 Flooding

Scenario: Yeung (1999) postulated that abandoning the waste tanks in place following waste removal would lead to long-term tank degradation, failure of the tank roof, and exposure of the radiological materials to potential flooding and release to the environment. DOE has assumed that institutional control would be maintained for at least a period of 100 years. Beyond institutional control, it has been assumed that the waste tanks would retain their basic structural integrity for another 100 years without catastrophic failure. Therefore, this EIS considers any impacts associated with failure of these waste tanks after a period of 200 years to be long-term impacts and not addressed further in this appendix.

Table B-2. Radiological source term for failure of Salt Solution Hold Tank.

Radionuclide	Activity (curies)[a]	Assumed release fraction	Total airborne activity released (curies)[a]
H-3	380	1.0	380
Co-60	15	1.0×10^{-4}	0.0015
Sr-89	13	1.0×10^{-4}	0.0013
Sr-90	13	1.0×10^{-4}	0.0013
Tc-99	210	1.0×10^{-2}	2.1
Ru-106	130	1.0×10^{-2}	1.3
Sb-125	31	1.0×10^{-2}	0.31
I-129	4.2	3.0×10^{-1}	1.3
Cs-137	21	1.0×10^{-2}	0.21
Ba-137m	21	1.0×10^{-2}	0.21
Eu-154	3.4	1.0×10^{-4}	0.00034
Total alpha	11	1.0×10^{-4}	0.0011
Other beta-gamma	840	1.0×10^{-4}	0.084
Total	1680		383

Source: WSRC (1992a)

a. Values rounded to 2 significant figures.

B.3.3 NO ACTION ALTERNATIVE

For the No Action Alternative, no action would be taken to clean the tank beyond that which is included in bulk waste removal. Flooding was the only scenario identified in Yeung (1999), applicable to this alternative, which would result in an airborne release of radiological materials.

B.4 Accident Impacts Involving Radioactive Materials

This section presents the potential impacts associated with the accident scenarios involving the release of radioactive materials identified in Section B.3. Table B-3 provides the accident impacts for each of the scenarios from airborne releases. It also provides the resultant latent cancer fatalities expected from the offsite impacts.

B.5 Postulated Accidents Involving Nonradioactive Hazardous Materials

This section summarizes the potential accident scenarios involving hazardous chemicals for the various alternatives. Two accidents involving hazardous material releases were identified in Yeung (1999).

B.5.1 OXALIC ACID SPILL

Scenario: A postulated accident during cleaning of the waste tanks would be a worst-case spill of 10,000 gallons of 4 percent (concentration) oxalic acid from any cause (vehicle crash, earthquake, or tornado). It was assumed that oxalic acid used for cleaning would be stored in an above ground 10,000-gallon stainless steel portable tank. The oxalic acid was assumed to be heated to a temperature of 80°C. This scenario would bound all accidents involving a chemical release of oxalic acid.

Probability: The annual probability of exceedance for the design basis earthquake is 5.0×10^{-4} (WSRC 1998c). Assuming that the oxalic acid tank would be used for 30 days out of the year, then the overall frequency was calculated to be 4.1×10^{-5} per year. For the design basis tornado, annual probability of exceedance is 2×10^{-5} (WSRC 1998c). Combined with the 30-day time at risk, probability resulted in an overall annual probability of 1.6×10^{-6}. If the tank is moved into a shelter or protected by administrative controls (e.g., erect missile barrier and/or tie

Table B-3. Radiological impacts from airborne releases.

Accident	Total curies released	Accident frequency	Non-involved worker (rem)	Maximally exposed individual (rem)	Offsite population (person-rem)	Latent cancer fatalities
Transfer errors	19	Once in 1,000 years	7.3	0.12	5,500	2.8
Seismic (DBE)	38	Once in 53,000 years	14.6	0.24	11,000	5.5
Salt Solution Hold Tank failure	380	Once in 20,000 years	0.015	0.00042	16.7	0.0084

down the tank), the annual probability for this event could be reduced to 8×10^{-8} (Yeung 1999). If a vehicle crash was considered, then the frequency of a vehicle crash occurring over all the Liquid Radioactive Waste Handling Facilities is bounded between 7.4×10^{-4} and 4.7×10^{-3} events per year (WSRC 1998a). Conservatively assuming that 0.1 percent of the accidents occurring at the F-Area and H-Area Tanks (WSRC 1998a) impact the oxalic acid tank resulted in an overall frequency of 2.7×10^{-6} per year. Considering these three different initiating events, the most credible scenario would be a design basis earthquake with an annual probability of 4.1×10^{-5}. This scenario would be extremely unlikely.

Source Term: The chemical release MAR would consist of 10,000 gallons of 4 percent oxalic acid. The oxalic acid source term was conservatively estimated to be an airborne release of 150 grams of 100 percent oxalic acid at a release rate of 168 milligrams per second (Yeung 1999).

B.5.2 FAILURE OF SALT SOLUTION HOLD TANK

Scenario: As described in Section B.3.1.7, this scenario would involve the failure of the Salt Solution Hold Tank, which would be used in one of the options in the Clean and Stabilize Tanks Alternative during the preparation of the saltstone that would be used to backfill the empty tanks. The Salt Solution Hold Tank would contain both radiological and hazardous materials. The radiological impacts are discussed in Section B.4.

Probability: The initiating event that was assumed to cause the Salt Solution Hold Tank failure was a design basis earthquake with an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the Salt Solution Hold Tank has a 10 percent chance of failing during the earthquake, a release of the bounding source term was estimated to occur at an annual probability of 5×10^{-5}. This scenario would be extremely unlikely.

Source term: The source term for hazardous materials released from the failed Salt Solution Hold Tank is given in Table B-4. They were obtained from the Safety Analysis Report for the Saltstone Facility (WSRC 1992a).

B.6 Accident Impacts Involving Non-radioactive Hazardous Materials

As Section B.4 provided for the radiological consequences of identified accidents, this section provides the potential impacts associated with the release of non-radioactive hazardous materials from the two accident scenarios.

B.6.1 OXALIC ACID SPILL

The oxalic acid spill, described in Section B.5.1, would result in the release of 150 grams of oxalic acid at a release rate of 168 milligrams per second. Table B-5 provides atmospheric dispersion factors for the two individual receptors, the uninvolved worker and the maximally exposed offsite individual (MEI) (Hope 1999). By ap-

Table B-4. Chemical source term for failure of Salt Solution Hold Tank.

Chemical	Total inventory in Salt Solution Hold Tank (kg)	Assumed release fraction	Evaporation release rate (milligrams per second)
Arsenic	170	1.0×10^{-4}	2.4
Barium	170	1.0×10^{-4}	2.4
Cadmium	51	1.0×10^{-4}	0.71
Chromium	340	1.0×10^{-4}	4.7
Lead	170	1.0×10^{-4}	2.4
Mercury	85	1.0×10^{-4}	1.2
Selenium	60	1.0×10^{-4}	0.83
Silver	170	1.0×10^{-4}	2.4
Benzene	0.52	1.0	73
Phenol	170	1.0×10^{-2}	240

Source: Yeung (1999).

Table B-5. Chemical concentrations to various receptors for oxalic acid spill accident.

Chemical	Evaporation release rate (milligrams per second)	Atmospheric dispersion factor (seconds per cubic meter)		Resultant concentration (micrograms per cubic meter)	
		Noninvolved worker	Maximally exposed individual	Noninvolved Worker	Maximally exposed individual
4 percent Oxalic acid	168	1.7×10^{-4}	5.7×10^{-7}	0.03	0.0001

plying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-5.

Since the Permissible Exposure Limit – Time Weighted Average (PEL-TWA), which equates to the ERPG-2 value described in Section B.2.3, is 1.0 milligrams per cubic meter for oxalic acid, there would be no significant impacts to the onsite or offsite receptors from this accident.

B.6.2 FAILURE OF SALT SOLUTION HOLD TANK

The failure of the Salt Solution Hold Tank, described in Section B.5.2, would result in the release of the hazardous chemical inventory provided in Table B-4. Table B-6 provides atmospheric dispersion factors for the two individual receptors, the noninvolved worker and the maximally exposed offsite individual (Hope 1999). By applying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-6.

Since the most restrictive exposure limits for these hazardous materials are no less than 0.5 milligrams per cubic meter, there would be no significant impacts to the onsite or offsite receptors from this accident.

B.7 Environmental Justice

In the event of an accidental release of radioactive or hazardous chemical substances, the dispersion of such substances would depend on meteorology conditions, such as wind direction, at the time. Given the variability of meteorology conditions, the low probability of accidents, the location of minority and low-income communities in relation to SRS, and the small magnitude of estimated offsite impacts, disproportionately high or adverse human health and environmental impacts to minorities or low-income population are not expected to be very likely.

Table B-6. Chemical concentrations to various receptors for failure of the Salt Solution Hold Tank.

		Atmospheric dispersion factor (seconds per cubic meter)		Resultant concentration (milligrams per cubic meter)	
Chemical	Evaporation release rate (milligrams per second)	Noninvolved worker	Maximally exposed individual	Noninvolved Worker	Maximally exposed individual
Arsenic	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Barium	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Cadmium	0.71	1.7×10^{-4}	5.7×10^{-7}	0.0001	4.0×10^{-7}
Chromium	4.7	1.7×10^{-4}	5.7×10^{-7}	0.0022	2.7×10^{-6}
Lead	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Mercury	1.2	1.7×10^{-4}	5.7×10^{-7}	0.0002	6.7×10^{-7}
Selenium	0.83	1.7×10^{-4}	5.7×10^{-7}	0.0001	4.7×10^{-7}
Silver	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Benzene	73	1.7×10^{-4}	5.7×10^{-7}	0.012	4.2×10^{-5}
Phenol	240	1.7×10^{-4}	5.7×10^{-7}	0.040	1.4×10^{-4}

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APPENDIX C

LONG-TERM CLOSURE MODELING

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APPENDIX C. LONG-TERM CLOSURE MODELING

This appendix provides a discussion of the fate and transport modeling that was performed to determine the long-term impacts from the alternatives described in Chapter 2 of this EIS. This modeling estimates the potential human health and ecological impacts of residual contamination remaining in closed HLW tanks for all alternatives and estimates the concentration and dose levels at the location where the groundwater outcrops into the environment (i.e., the seepline).

In the modeling described in this appendix, the F-Area and H-Area Tank Farms were modeled assuming conditions that would exist after tank closure for four scenarios as follows: (1) No Action Alternative, (2) Clean and Fill with Grout Option, (3) Clean and Fill with Sand Option, and (4) Clean and Fill with Saltstone Option. None of the analyzed scenarios took credit for engineered caps to be placed after completion of closure activities.

DOE intends that the area immediately around the tank farms would remain in commercial/industrial use for the entire 10,000-year period of analysis and would be unavailable for residential use. However, DOE has estimated the impacts if residents have access to the tank farm area.

Potential impacts to the following hypothetical individuals were analyzed:

- *Worker:* An adult who has authorized access to, and works at, the tank farm and surrounding areas but is considered to be a member of the public for compliance purposes. This analysis assumes that the worker remains on the banks of Fourmile Branch or Upper Three Runs during working hours.
- *Intruder:* A teenager who gains unauthorized access to the tank farm and is potentially exposed to contaminants.
- *Nearby adult resident:* An adult who lives in a dwelling across either Fourmile Branch or Upper Three Runs downgradient of the tank farms, near the stream.
- *Nearby child resident:* A child who lives in a dwelling across either Fourmile Branch or Upper Three Runs downgradient of the tank farms, near the stream.

In addition to the hypothetical individuals identified above, concentration and dose levels were calculated at the groundwater seepline point of exposure. For H-Area, the seepline is approximately 1,200 meters downgradient from the center of the tank farm, while for F-Area the seepline is roughly 1,800 meters downgradient from the tank farm. These distances are the linear distances to the seepline; the actual travel distances are somewhat greater due to the curved path of the groundwater. Concentration and dose levels were also calculated at 1-meter and 100-meters downgradient from the edge of the F-Area and H-Area Tank Farms, and an estimate of the dose from all pathways at these locations was performed.

Uncertainty in Analysis

In this EIS, DOE has made assumptions on numerical parameters that affect the calculated impacts. There is some uncertainty associated with the values of these parameter due to unavailable data and current state of knowledge about closure processes and long-term behavior of materials.

The principal parameters that affect modeling results are the following:

- **Inventory:** The amount of material in the tank directly affects the concentrations at any given location, unless the amount of material is so great that the solubility limit is exceeded. Once the solubility limit is exceeded, greater amounts of source material do not necessarily result in increased concentrations at receptor locations. In this modeling effort, both plutonium and uranium were assumed to be limited by solubility. Inventory results are based primarily on process knowledge at this time. As each tank is prepared for closure, specific sampling would be conducted to determine the inventory.

- **Hydraulic conductivity:** The actual rate of water movement through the material is ultimately affected by the hydraulic conductivity of the strata underneath the source. Generally, the grout or concrete basemat is the limiting layer with regard to water infiltration. At the time of structural failure, the hydraulic conductivity is increased dramatically, making more water available to carry contaminants to the aquifer. In general, this will result in greater doses/concentrations due to the increased movement of material.

- **Distribution coefficient:** The distribution coefficient (K_d) affects the rate at which contaminates move through strata. Large K_d values provide holdup time for short-lived radionuclides.

- **Vadose zone thickness:** The thickness of the strata between the contaminated region and the aquifer does not necessarily reduce the concentration so much as it slows the progress toward the aquifer. Therefore, for shorter-lived radionuclides, extra time granted by thicker strata can decrease the activity before the contaminants reach the aquifer.

- **Distance downgradient to receptor location:** The distance to a given receptor location affects (a) the time at which contaminants will arrive at the location and (b) how much dispersion occurs. For greater distances, longer travel times will be encountered, resulting in lower activity values for short-lived radioactive constituents and greater dispersion for all constituents.

DOE recognizes that over the period of analysis in this EIS, there is also uncertainty in the structural behavior of materials and the geologic and hydrogeologic setting of the Savannah River Site. DOE realizes that overly conservative assumptions can be used to bound the estimates of impacts; however, DOE believes that this approach could result in masking of differences of impacts among alternatives. Therefore, DOE has attempted to use assumptions in its modeling analysis that are reasonable based on current knowledge so that meaningful comparisons among alternatives can be made.

C.1 Analyzed Scenario

The hydrogeology under various areas of the SRS has been modeled several times in the last few years. Most of the modeling has focused on specific locations (e.g., the Saltstone Manufacturing and Disposal Facility in Z-Area, the seepage basins in H- and F-Areas) and is thus subject to updating as new information becomes available. DOE is continually refining the model for the General Separations Area based on recent hydrogeologic measurements. DOE has prepared this EIS using the methodology and the modeling assumptions as presented in the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste-Tank Systems.* DOE recognizes that future refining of the models described in the closure plan may result in slightly different estimates of impacts. However, DOE believes that using the methodology described in the closure plan provides a consistent basis for evaluating the alternatives.

The tank farms were modeled individually to determine the impacts from the respective source. In the analyzed scenario, the mobile contaminants in the tanks are assumed to gradually migrate downward through unsaturated soil to the groundwater aquifer. The aquifers underneath F-Area Tank Farm were assumed to discharge primarily to Fourmile Branch while the aquifers underneath H-Area Tank Farm were assumed to discharge to both Fourmile Branch and Upper Three Runs. Therefore, the contaminants would be transported by the groundwater to the seepline and subsequently to Fourmile Branch or Upper Three Runs. Upon reaching the surface water, some contaminants would migrate to the sediments at the bottom of the streams and the shoreline. Aquatic organisms in the stream and plants along the shoreline would be exposed to the contaminants. Terrestrial organisms might then ingest the contaminated vegetation and also obtain their drinking water from the contaminated stream. Humans are assumed to be exposed to contaminants through various pathways associated with the surface water.

The following sections describe specific assumptions incorporated into the modeling calculations for the analyzed alternatives.

C.1.1 SCENARIO 1 – NO ACTION ALTERNATIVE

The No Action Alternative assumes that for the 100 years of institutional control, the tanks would contain necessary ballast water that would be treated to minimize corrosion. The tank is assumed to have a constant leak rate (simulated and limited by the hydraulic conductivity of the intact concrete basemat), which causes some passage through the tank bottom. At 100 years, the tanks are filled with water and abandoned but not capped.

At some point in the future, degradation associated with the aging of the tanks would destroy the tanks. The contaminants are then assumed to reside at the bottom of a hole equal to the depth of the tank (generally 30 to 40 feet). Although debris would exist in the hole, it is assumed to play no role in inhibiting infiltration or preventing flow into the soil. Because of the lack of structural support, the tanks and concrete basemat are assumed to fail completely at 100 years, exposing the contaminated media to rainfall with subsequent infiltration to groundwater.

The No Action Alternative is the only alternative that could conceivably expose individuals by the atmospheric pathway from the tank area, because each of the other alternatives would fill the tanks with material that would cover the contaminants and prevent their escape via atmospheric dispersion. The only foreseeable occurrence of an atmospheric release under No Action would be if the tank structures collapsed, causing the suspension of particulates containing contaminants. However, the likelihood of an atmospheric release is considered to be minimal, at best, for the following reasons:

- The amount of rainfall in the area would tend to keep the tank contents damp through the time of failure. After failure, a substantial amount of debris on top of the contaminated material would prevent release even if the contents were to dry during a period of drought.

- The considerable depth of the tanks below grade would tend to discourage resuspension of any of the tanks' contents.

Based on these reasons, no analyses were performed for the atmospheric pathway.

C.1.2 SCENARIO 2 – CLEAN AND FILL WITH GROUT OPTION

Scenario 2 assumes that the tanks would be filled with grout, and engineered structures would not be used to reduce the infiltration of rain water. By analogy with the analysis presented in the *E-Area Vault Radiological Performance Assessment* (WSRC 1994a), the concrete tank structure could enter a period of degraded performance due to cracking at around 1,400 years. Assuming that the approximately 34 feet of grout continue to support the tank roof and provide an additional barrier to infiltration for an indefinite period of time [Z-Area RPA (WSRC 1992)], water infiltration should occur much later than 1,400 years. However, for this scenario, the assumption is made that the tank top, grout, and basemat fail at 1,000 years, with a corresponding increase in their respective hydraulic conductivities.

C.1.3 SCENARIO 3 – CLEAN AND FILL WITH SAND OPTION

Scenario 3 assumes that the tanks would be filled with sand, and engineered structures would not be used to reduce the infiltration of rain water. Eventually, the sides and roof of the tanks would collapse, allowing water to infiltrate the tank and leach the contaminants down to the aquifers. DOE has assumed that the tank fails at 100 years.

C.1.4 SCENARIO 4 – CLEAN AND FILL WITH SALTSTONE OPTION

Scenario 4 is similar to Scenario 2 in that a cementitious material is used to fill the tanks. However, in this scenario, the fill material is saltstone, a composite material made of cement, flyash, slag, and slightly contaminated media from processing of high-level waste. Currently, saltstone is disposed in Z-Area; under this alternative, saltstone would be used to fill the tanks and (as in Scenario 2) would be assumed to remain intact for 1,000 years following tank closure.

C.2 Methodology

C.2.1 HUMAN HEALTH ASSESSMENT

C.2.1.1 General Methodology

Utilizing the Multimedia Environmental Pollutant Assessment System (MEPAS) computer code (Buck et al. 1995), a multi-pathway risk model developed by Pacific Northwest Laboratory, calculations were performed to assess the impacts of the leaching of contaminants to the groundwater for each of the four tank closure scenarios. To model the four closure scenarios, infiltration rates were selected that represent the vertical moisture flux passing through the tanks for each closure alternative. These infiltration rates are dependent upon the chemical and physical characteristics of the tank fill material for each scenario.

Based on the calculated inventories of chemical and radioactive contaminants remaining in the tanks after bulk waste removal and spray washing, the model was set up to simulate the transport of contaminants from the contaminated zone (residual waste layer), through the concrete basemat (first partially saturated zone), the vadose zone directly beneath the basemat (second partially saturated zone), and into the underlying aquifers (saturated zones). Model runs were completed for both early timeframes (before the assumed failure occurs) and late timeframe (after assumed failure occurs) conditions.

In addition to the four tank closure scenarios, modeling was performed for pollutants remaining in the ancillary equipment and piping above the tanks. In this calculation, the piping and equipment were considered to be the contaminated zone while the partially saturated zone was the layer of soil extending from the surface to the saturated zones.

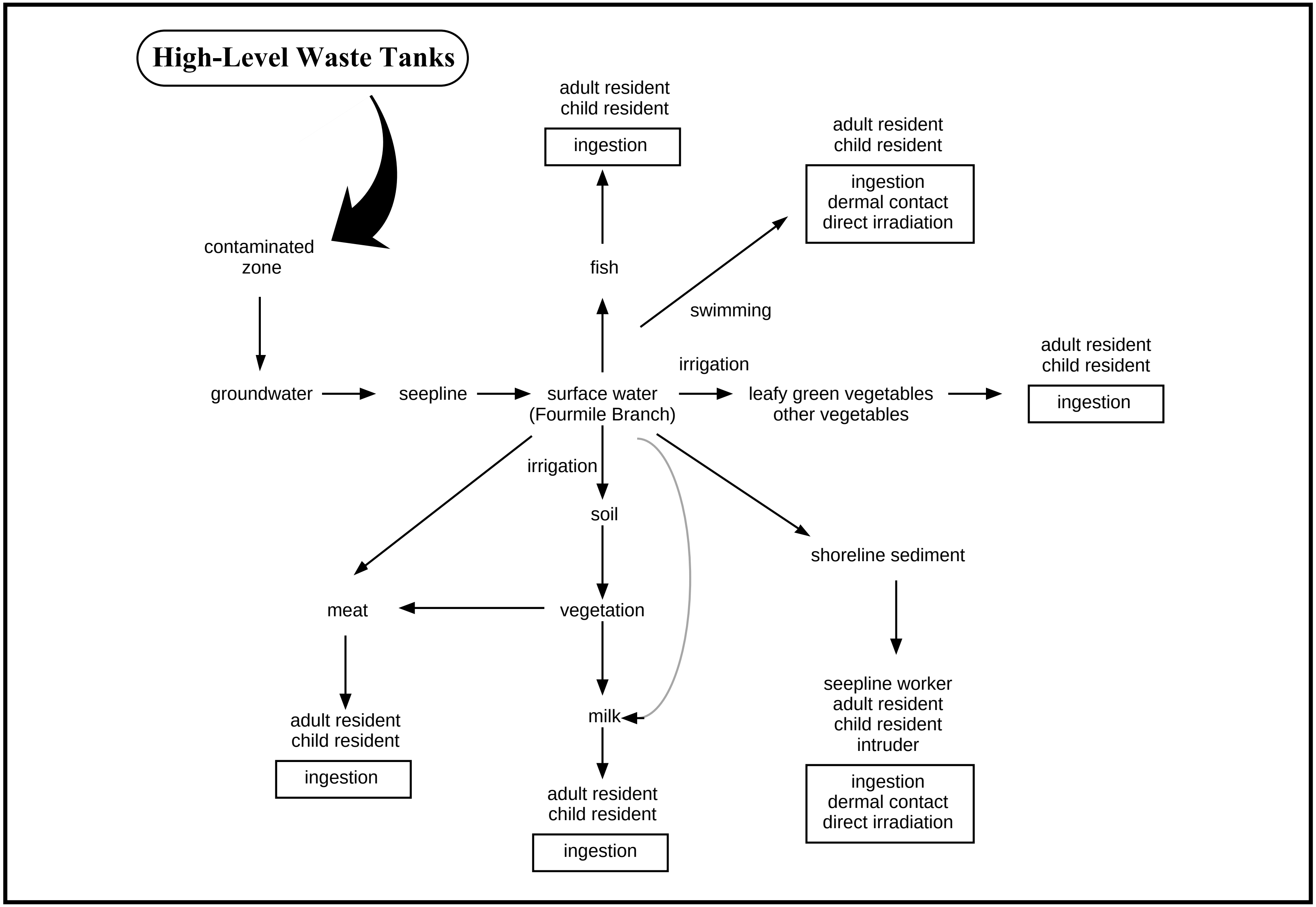
Calculated pollutant concentrations and dose levels are provided at 1 meter and 100 meters downgradient from the edge of the tank farms, at the seepline, and in the surface waters of Fourmile Branch and Upper Three Runs for the hypothetical individuals discussed in Section C.2.1.2. DOE has not calculated groundwater concentrations underneath the tanks because of inherent limitations involved in those calculations. Specifically, the large size of the tank farms and the pattern of groundwater movement make calculations for locations in proximity to the source speculative.

C.2.1.2 Receptors

The potential receptors and exposure pathways are identified in the following sections and illustrated in Figure C-1.

Worker

The worker is assumed to be located in the area including and surrounding either of the tank farms. Because institutional controls are in place, the potential for exposure of the worker to the primary source (residual at the bottom of the tanks) is minimal, owing to the structural integrity of the tank, the lack of any industrial work that would be performed over the tanks, and safety measures that would be taken to further reduce potential exposure. Therefore, this analysis assumes that the worker is located constantly at the nearest place where contaminants



NW TANK/Grfx/C-1 Expo paths.ai

Figure C-1. Potential exposure pathways for human receptors.

would be accessible (i.e., on the bank of Fourmile Branch or Upper Three Runs, as part of his work duties). The assumption is conservative because the worker has a greater potential for exposure to contaminants at the seepline. However, the fact that he is a worker limits, and, hence, eliminates pathways that might be considered if he were considered a resident. The potential exposure pathways for the seepline worker are:

- Direct irradiation from the deposits along the banks of the streams (radioactive contaminants only)
- Incidental ingestion of the soil from the deposits along the banks of the streams
- Dermal contact with dust from the deposits along the banks of the streams

Exposure from inhalation of resuspended soil was not evaluated because the soil conditions at the seepline (i.e., the soil is very damp) are such that the amount of soil resuspended and potentially inhaled would be minimal.

Intruder

Another potential receptor is the intruder, a person who gains unauthorized access to the tank farm site and becomes exposed to the contaminants in some manner. The intruder scenario is analyzed after institutional controls have ceased. Because the intruder is assumed not to have residential habits, he or she would not have exposure pathways like that of a resident (e.g., the intruder does not build a house, grow produce, etc.); instead, the intruder is potentially exposed to the same pathways as the seepline worker but for a shorter duration (4 hours per day, as noted in Section C.3.2.5).

Nearby Adult Resident/Nearby Child Resident

Nearby residents could also potentially be exposed to contaminants from the tank farms. Members of the public are assumed to construct a dwelling near the tank farms on SRS (but outside the tank farm site). The location of the residential dwelling is assumed to be downgradient near one of the two main streams (Fourmile Branch or Upper Three Runs) on the side opposite the tank farms at a point 100 meters downstream of the groundwater outcropping in these streams. The residents of this dwelling include both adults and children. The adult resident was modeled separately from the child resident because of different body weights and consumption rates.

The resident is assumed to use the stream for recreational purposes; to grow and consume produce irrigated with water from the stream; to obtain milk from cows raised on the residential property; and to consume meat that was fed contaminated vegetation from the area. Therefore, potential exposure pathways for both the nearby adult and nearby child resident are the following:

- Incidental ingestion of contaminated soil from deposits along the banks of the streams
- Inhalation of contaminated soil from deposits along the banks of the streams
- Direct irradiation from deposits along the banks of the streams (radioactive contaminants only)
- Direct irradiation from surface water (radioactive contaminants only - recreation)
- Dermal contact with surface water
- Incidental ingestion of surface water
- Ingestion of contaminated meat
- Ingestion of produce grown on contaminated soil irrigated with water from Fourmile Branch
- Ingestion of milk from cows that are fed contaminated vegetation
- Ingestion of aquatic foods (e.g., fish) from Fourmile Branch

Because of the physical circumstances of the fate and transport modeling, the most likely location for soil ingestion is on the shoreline of the streams. Figure C-1 shows this pathway, which is identified as "shoreline sediment" along with the appropriate exposure pathways: ingestion, dermal contact, and direct irradiation. While analyses of some waste sites do show that soil ingestion is a dominant pathway, this usually occurs when the residents have direct access to the highly contaminated soils excavated from the waste site. Because of the depth of the waste tanks so far below grade and the fill material that would be in place, there is n credible situation by which the residents could have direct access to this material in this EIS; therefore, the soil ingestion pathway is not dominant.

Although the basic assumption for the residents is that they are not located at the tank farms, DOE has nevertheless estimated the impact if residents are allowed access to the tank farms.

Atmospheric Pathway Receptors

Based on the reasoning presented in Sections C.1.1 and C.2.1.2, no analyses were performed for the atmospheric pathway.

C.2.1.3 Computational Code

Groundwater and surface water concentrations and human health impacts were calculated using the MEPAS computer code (Buck et al. 1995). MEPAS was developed by Pacific Northwest National Laboratories under DOE contract and integrates source-term, transport, and exposure models for contaminants. In the MEPAS code, contaminants are transported from a contaminated area to potentially exposed humans through various transport pathways (groundwater, surface water, soils, food, etc.). These exposed individuals then receive doses, both chemical and radiation, through exposure or intake routes (ingestion, dermal contact, inhalation, etc.) and numerous exposure pathways (drinking water, leafy vegetables, meat, etc.).

MEPAS includes models to estimate human health impacts from radiation exposure (radionuclides and direct radiation), carcinogenic chemicals, and noncarcinogenic chemicals. Health effects resulting from radiation and radionuclide exposures are calculated as annual dose (millirem per year). Cancer incidence rates are calculated for carcinogens.

The MEPAS code is widely used (PNL 1999) and accepted throughout the DOE complex and has been presented to and accepted by other regulatory agencies such as EPA. Examples of its use by DOE include the EH-Environmental Survey Risk Assessment and the Complex-Wide Programmatic Waste Management EIS Impact Analysis. This code has been used to demonstrate environmental impacts in RCRA-Subpart X permit applications to various EPA regions; these analyses were accepted and permits based on them were issued.

C.2.1.4 Calculational Methodology

The modeling results presented in this appendix are based on the amount of contaminants remaining in the tanks after bulk waste removal and spray washing (except for No Action, which assumes only bulk waste removal with no spray washing). The results can generally be scaled to differing amounts of residual contaminants left in a tank. Although the waste is present as supernate (salt solution), damp saltcake and sludge, the total residual waste volume was assumed to be sludge, based on the assumption that all the residual contaminants reside in the sludge (Newman 1999).

Analyses were performed specifying infiltration rates that relate to the four closure scenarios. An infiltration rate of 40 centimeters per year (average infiltration rate for SRS soils) was used to model time periods after tank failure (WSRC 1994a). This value takes into account the average annual precipitation and the amount of rainfall that evaporates, flows to streams and land surface, etc. and is not available for infiltration into soil. An infiltration rate of 122 centimeters per year was used for the No Action Alternative to simulate infiltration of 100 percent of the average annual precipitation assuming no runoff or evaporation. The latter assumption is considered to be reasonable given the fact that the tanks are located in a depression that could fill with rainwater if the storm drain system fails.

As discussed in Section C.1.1, tank failure for the No Action Alternative would involve an initial release of the ballast water that would be limited by the hydraulic conductivity.

MEPAS calculations were performed for early (before structural failure) and late (after structural failure) conditions for each closure scenario. As discussed above, a failure time was assumed for each closure scenario based on anticipated performance of the tank fill material and concrete basemat. The tank fill and concrete basemat were assumed to fail simultaneously and completely in terms of retaining waste. Failure was simulated for modeling purposes by increasing the infiltration rate to 40 centimeters per year (except for No Action which remains at 122 centimeters per year) and increasing the hydraulic conductivity of the basemat to that of sand. Because radionuclide and chemical pollutants could leach though the concrete before failure occurs, the original source term was reduced by an amount equal to the quantities released to the aquifer during the prefailure period. In addition, radionuclides continually decay, further changing the source term. Thus, for late runs, in addition to changing the infiltration rates and hydraulic conductivities, the source term concentrations were adjusted to reflect losses and decay occurring before failure.

In the groundwater transport pathway, infiltration causes leaching of pollutants from the tanks through distinct media found below the waste unit down to the groundwater aquifer (saturated zone). To model the movement of the pollutants from the waste unit to the aquifer, MEPAS requires that the distinct strata that the pollutants encounter be identified. For modeling the tank farms, the residual at the bottom of the tanks was considered to be the contaminated zone.

Between the contaminated zone and the saturated zone, two discernible layers were identified: the concrete basemat of the tank and the unsaturated (vadose) zone. Parameters describing the concrete layer were defined for both pre- and postfailure conditions because values for parameters such as porosity, field capacity, and hydraulic conductivity change with degradation state. Analysis of flow through the vadose zone is complicated in that movement varies with soil-moisture content and wetting and drying conditions. Therefore, values for saturated zone soil parameters (e.g., density, porosity) were used to describe the unsaturated zone.

For each of the four layers identified for this site (contaminated zone, concrete basemat, vadose zone, and saturated zone), surface distribution coefficients, K_d values, were selected for each radionuclide and chemical for each modeled layer. Because distribution coefficients are a chemical property, the K_d values were not changed for degraded or failed materials. The identification and derivation of the K_d values is discussed in detail in Section C.3.2.1.

As contaminants are transported from the contaminated zone to the seepline, they are longitudinally (along the streamline of fluid flow), vertically, and transversely (out sideways) dispersed by the transporting medium. MEPAS incorporates longitudinal dispersivity of pollutants moving downward through the partially saturated zone layers (i.e., concrete basemat and vadose zone) in concentration calculations. In the saturated zone, MEPAS incorporates into concentration calculations the three-dimensional dispersion along the length of travel. Dispersion distances were calculated through the concrete basemat, the vadose zone, and the groundwater aquifer. Logically, dispersion generally increases with longer travel distances, and it should be noted that the travel distance is determined by the hydraulic gradients and not by linear distance.

Groundwater concentrations and doses due to ingestion of water are calculated at hypothetical wells at 1 meter and 100 meters downgradient from the edge of the respective tank farms, at the respective seeplines, and in Fourmile Branch and Upper Three Runs.

As discussed earlier, impacts to adult and child residential receptors are evaluated at a point 100 meters downstream of the groundwater outcropping in Fourmile Branch and Upper Three Runs. The concentration of contaminants in the streams was also calculated. Based on the dimensions, flow rate, and stream velocities, MEPAS accounts for mixing of the contaminant-containing water from the aquifer with stream water and other groundwater contributions. For both adult and child residents, ingestion rates were based on site-specific parameters. Parameters and associated assumptions used in calculating human impacts are presented in Section C.3.2.5.

In addition to the four closure scenarios, MEPAS runs were performed to determine the effects of leaving in place the piping, vessels, and other tank-specific systems outside the tanks, all of which contain residual pollutants. It was assumed that an additional 20 percent of the radioactive contaminants remaining in the tanks after bulk cleaning and spray washing would be distributed in the ancillary equipment (d'Entremont 1996). Modeling was performed for two options: (1) leaving the piping and other equipment as they currently exist (assumed for the No Action Alternative and Clean and Fill with Sand Option), and (2) filling, where possible, the piping and other outside equipment with grout (assumed for the Clean and Fill with Grout and Clean and Fill with Saltstone Option). For modeling in MEPAS, the ancillary equipment was considered to be the contaminated zone, and the entire distance between the contaminated zone and the saturated zone was characterized as one layer of typical SRS soil. Therefore, no credit was taken for the additional reduction of leachate afforded by the tanks, thus providing conservative results.

C.2.2 ECOLOGICAL RISK ASSESSMENT

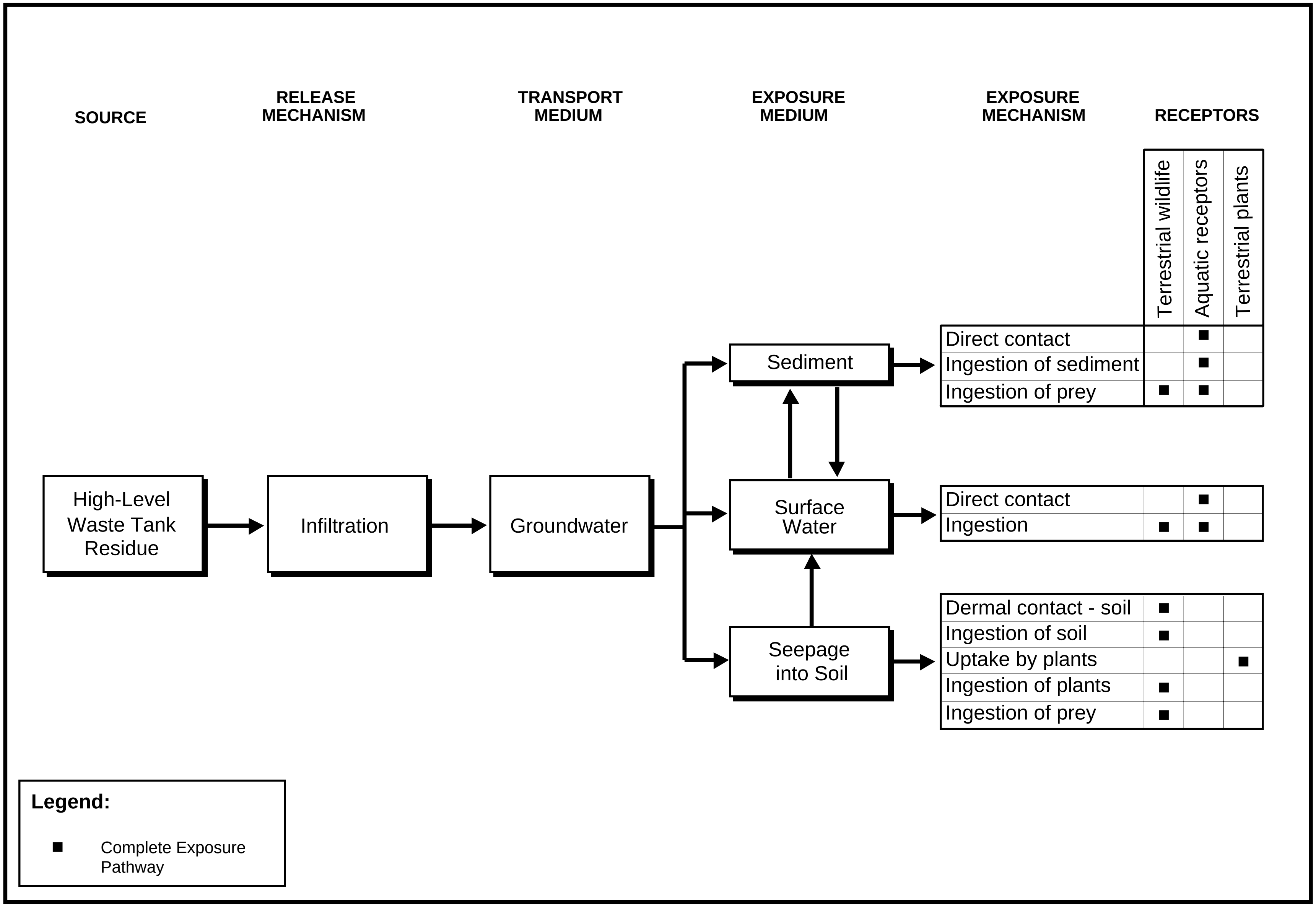
C.2.2.1 General Methodology

Several potential contaminant release mechanisms were considered for assessing ecological risks associated with tank closure. These included contamination of runoff water during rainstorms, soil contamination from air emissions following tank collapse, and contamination of groundwater. Onsite inspection showed that the tanks are well below (4 to 7 meters) the surrounding, original land surface. Therefore, runoff or soil contamination was not a reasonable assumption. Groundwater contamination was determined to be the most likely means of contaminant transport.

Several contaminant migration pathways were evaluated, which for half of H-Area (south of the groundwater divide) include seepage of the groundwater from the Water Table and Barnwell-McBean Aquifers at a downgradient outcrop (seepline) and subsequent mixing in Fourmile Branch and outcrop from the Congaree Aquifer and subsequent mixing in Upper Three Runs. For the other half of H-Area (north of the groundwater divide), all three aquifers outcrop at Upper Three Runs with subsequent mixing with this stream. For F-Area, the analysis included seepage of the groundwater from the Water Table and Barnwell-McBean Aquifers at a downgradient outcrop (seepline) and subsequent mixing in Fourmile Branch, and outcrop from the Congaree Aquifer and subsequent mixing in Upper Three Runs. Each of these migration pathways was evaluated using four methods for tank stabilization, which include the Clean and Fill with Grout Option, the Clean and Fill with Sand Option, the Clean and Fill with Saltstone Option, and the No Action Alternative (no stabilization). The groundwater-to-surface water contaminant migration pathway, together with potential routes of entry into ecological receptors, is shown in the conceptual site model (Figure C-2).

The habitat in the vicinity of the seeplines is bottomland hardwood forest. On the upslope side of the bottomland, the forest becomes a mixture of pine and hardwood.

Potential impacts to terrestrial receptors at the seepline and aquatic receptors in Fourmile Branch and Upper Three Runs were evaluated. For the assessment of risk due to toxicants, the aquatic receptors are treated as a group because



	Terrestrial wildlife	Aquatic receptors	Terrestrial plants
Direct contact		■	
Ingestion of sediment		■	
Ingestion of prey	■	■	
Direct contact		■	
Ingestion	■	■	
Dermal contact - soil	■		
Ingestion of soil	■		
Uptake by plants			■
Ingestion of plants	■		
Ingestion of prey	■		

NW TANK/Grfx/C-2 Eco Risk.ai

Figure C-2. Ecological Risk Assessment Conceptual Site Model.

water quality criteria have been derived for protection of aquatic life in general. These criteria, or equivalent values, are used as threshold concentrations. For the radiological risk assessment, the redbreast sunfish was selected as an indicator species due to its abundance in Fourmile Branch and Upper Three Runs (Halverson et al. 1997).

There are no established criteria for the protection of terrestrial organisms from toxicants. Receptor indicator species are usually selected for risk analysis and the results extrapolated to the populations, communities, or feeding groups (e.g., herbivores, predators) they represent. Two terrestrial animal receptors, the southern short-tailed shrew and the mink, were selected in accordance with EPA Region IV guidance, which calls for investigation of small animals with small home ranges. The guidance also calls for investigation of predators when biomagnifying contaminants (such as mercury) are being studied. The southern short-tailed shrew is small and one of the most common mammals on the SRS; the mink is a small-bodied predator associated with waterways and is found on SRS (Cothran et al. 1991). Species that are more abundant on SRS than the mink with similar eclogues were considered for use in this assessment, including the raccoon. However, the mink has a small body size relative to similar species, which results in a more conservative estimate of exposure. Also, the mink is considered to be a highly contaminant-sensitive species, and is almost exclusively carnivorous (which maximizes toxicant exposure). The short-tailed shrew and mink are also used in the radiological assessment.

The seepage areas are estimated to be small, about 0.5 hectare (DOE 1997), so risk to plant populations would be negligible even if individual plants were harmed. The only case in which harm to individual plants might be a concern in such a small area would be if protected plant species are present. Because no protected plant species are known to occur in these areas, risks to terrestrial plants are not treated further in the risk assessment.

The following exposure routes were chosen for calculating absorbed radiation dose to the terrestrial mammals of interest (shrew and mink) located on or near the seeplines: ingestion of food (earthworms, slugs, insects and similar organisms for the shrew, and shrews for the mink); ingestion of soil; and ingestion of water. The following exposure routes were chosen for calculating absorbed dose to aquatic animals of interest (sunfish) living in Fourmile Branch and Upper Three Runs: uptake of contaminants from water and direct irradiation from submersion in water. Standard values for parameter such as mass, food ingestion rate, water ingestion rate, soil ingestion rate, and bioaccumulation factors were used (see Section C.3.3).

C.2.2.2 Exposure and Toxicity Assessment

Exposure to Chemical Toxicants

Exposure for aquatic receptors is simply expressed as the concentration of contaminants in the water surrounding them. This is the surface-water exposure medium shown in the conceptual site model (Figure C-2). The conceptual model also includes sediment as an exposure medium; sediment can become contaminated from the influence of the surface water or from seepage that enters sediment directly. However, this exposure medium was not evaluated because estimating sediment contamination from surface water inputs would be highly speculative and seepage into sediment is not considered in the groundwater model; all of the transported material is assumed to come out at the seepline.

Exposure for terrestrial receptors is based on dose, expressed as milligrams of contaminant ingested per kilogram of body mass per day. The routes of entry (exposure routes) used for estimating dose were ingestion of food and water. Dermal absorption is a possibility, but the fur of shrews and minks was considered to be an effective barrier against this route. The food of shrews is mainly soil invertebrates, and the mink eats small mammals, fish, and a variety of other small animals. Contaminants in seepage water were considered to be directly ingested as drinking water (shrew), ingested as drinking water after dilution in Fourmile Branch (mink), ingested in aquatic prey (mink), and transferred to soil, soil invertebrates, shrews, and mink through a simple terrestrial food chain.

Chemical Toxicity Assessment

The goal of the toxicity assessment is to derive threshold exposure levels which are protective of the receptors (Table C.2.2-1). For aquatic receptors, most of the threshold values are ambient water quality criteria for chronic exposures. Others include the concentration for silver, which is an acute value (no chronic level was available).

For terrestrial receptors, toxicity thresholds are based on the lowest oral doses found in the literature that are no-observed-adverse-effect-levels (NOAELs) or lowest-observed-adverse-effect-levels (LOAELs) for chronic endpoints that could affect population viability or fitness (Table C.2.2-2). Usually the endpoints are adverse effects on reproduction or development. Uncertainty factors are applied to these doses to extrapolate from LOAELs to NOAELs and from subchronic or acute-to-chronic study durations. The derivation of these values is listed in Table C.2.2-3. Adjustments for differences in metabolic rates between experimental animals, usually rats or mice, and indicator species are made by applying a factor based on relative differences in estimated body surface area to mass ratios.

C.2.2.3 Calculational Design

Chemical Contaminants

For terrestrial receptors, the exposure calculation is a ratio of total contaminant intake to body mass, on a daily basis. This dose is divided by the toxicity threshold value to obtain a hazard quotient. Modeled surface water concentrations in Fourmile Branch and Upper Three Runs were divided by aquatic threshold levels to obtain a hazard quotient.

Radioactive Contaminants

Animal ingestion dose conversion factors (DCFs) for both terrestrial animals (shrew and mink) were estimated, for purposes of these calculations, by assuming that the animals possess similar metabolic processes as humans with regard to retention and excretion of radioisotopes; the chemistry of radioisotopes in the animals' bodies is assumed to be similar to that of humans. This assumption is appropriate because much of the data used to determine the chemistry of radioisotopes in the humans' bodies was derived from studies of small mammals. Equations from International Commission on Radiological Protection (ICRP) Publication 2 (ICRP 1959) were used to predict the uptake rate and body burden of radioactive material over the life span of the animals. All isotopes were assumed to be uniformly distributed throughout the body of the animal. Dose conversion factors for the aquatic animal, sunfish, were calculated by assuming a steady-state concentration of radioactive material within the tissues of the animal and a uniform concentration of radioactive material in the water surrounding the sunfish.

The quantity of radioactivity ingested by the organisms of interest was estimated by assuming that the organisms live their entire lives in the contaminated region (the seepline area for the terrestrial organisms and Fourmile Branch and Upper Three Runs near the seepline for the sunfish). The shrews are assumed to drink seepline water at the maximum calculated concentrations of radioactivity and to eat food that lives in the soil/sediments near the seepline. The concentrations of radioactivity in these media were derived from the calculated seepline and Fourmile Branch or Upper Three Runs concentrations. The mink is assumed to drink Fourmile Branch or Upper Three Runs water and eat only shrews that live near the seepline.

The estimated amount of radioactivity that the terrestrial organisms would ingest, through all postulated pathways, was then multiplied by the

Table C.2.2-1. Threshold toxicity values.

Contaminant	Aquatic receptors (milligrams per liter)	Terrestrial receptors (milligrams per kilograms per day)	
		Shrew	Mink
Aluminum	0.087	27.7	6.4
Barium	0.0059	1.78	0.41
Chromium	0.011	11.6	2.7
Copper	0.0014[a]	52.2	12
Fluoride	NA[b]	8.3	2.5
Iron	1.0	NA	NA
Lead	0.00013[a]	0.012	0.003
Manganese	NA	52.9	12.1
Mercury	0.000012	0.082	0.019
Nickel	0.019[a]	29.7	6.8
Nitrate (as N)	NA	(c)	–
Silver	0.000055[a]	0.33	0.077
Uranium	0.00187	4.48	1.01
Zinc[a]	0.0127	14.0	3.17

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a. Based on a hardness of 8.2 mg $CaCO_3$/L.

b. Screening for MCL (10 mg/L) in seep water considered protective for nitrate.

NA: Not applicable (normally not a toxin for this type of receptor).

DCFs to calculate an annual radiation dose to the organism. For the sunfish, the concentration of radioactivity in the surface water was multiplied by the submersion and uptake dose conversion factors to calculate an annual radiation dose. These radiation doses are compared to the limit of 1,000 millirad per day (365,000 millirad per year).

C.3 Assumptions and Inputs

C.3.1 SOURCE TERM

C.3.1.1 Radionuclides

Radioactive material source terms for the tank farms and ancillary piping residuum used for the modeling are listed in Table C.3.1-1. These source terms relate to quantities remaining after bulk waste removal and spray washing. The ancillary piping and evaporator residual was conservatively estimated to be equal to 20 percent of the tank inventories.

The No Action Alternative analyzed in this EIS assumes that only bulk waste removal is performed. Based on experience in removing waste from Tanks 16, 17, and 20, DOE has assumed that the amount of radionuclides remaining after only bulk waste removal would be five times higher than that reported in Table C.3.1-1. Also, the Clean and Fill with Saltstone Option would introduce additional radioactive material into the HLW tanks. DOE used inventory estimates from the *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility* (DOE 1994) for saltstone content to account for this additional radioactivity.

C.3.1.2 Chemicals

Chemical material source terms used in this modeling are listed in Table C.3.1-2. As with the radioactive source term, the ancillary piping and evaporator residual was conservatively estimated to be equal to 20 percent of the tank inventories. In addition, the lead in the tank top risers (500 pounds per riser, 6 risers per tank) was modeled.

Table C.2.2-2. Toxicological basis of NOAELs for indicator species.

Analyte	Surrogate species	LOAEL (milligrams per kilograms per day)	Duration	Effect	NOAEL (milligrams per kilograms per day)	Reference	Notes
Inorganics							
Aluminum	Mouse	–	13 mo	Reproductive system	19	Ondreicka et al. (1966) in ATSDR (1992)	
Barium	Rat	5.4	16 mo	Systemic	0.54	Perry et al. (1983) in Opresko et al. (1995)	
Chromium VI	Rat	–	1 y	Systemic	3.5	Mackenzie et al. (1958) in ATSDR (1993)	
Copper	Mink	15	50 w	Reproductive	12	Aulerich et al. (1982) in Opresko et al. (1995)	
Fluoride	Rat	5	60 d	Reproductive	–	Araibi et al. (1989) in ATSDR (1993)	
	Mink	5	382 d	Systemic	–	Aulerich et al. (1987) in ATSDR (1993)	Systemic LOAEL < reproductive
Iron							Data inadequate; essential nutrient
Lead	Rat	0.28	30 d	Reproductive	0.014	Hilderbrand et al. (1973)	
Manganese	Rat	–	100-224 d	Reproductive	16	Laskey et al. (1982)	
Mercury	Mink	0.25	3 mo	Death; devel.	0.15	Wobeser et al. (1976) in Opresko et al. (1995)	
Nickel	Rat	18	3 gens	Reproductive	–	Ambrose et al. (1976)	Based on first-generation effects
Nitrate (as N)							MCL of 10 mg/L at seepline is protective
Silver	Mouse	23	125 d	Behavioral	–	Rungby & Danscher (1984)	
Uranium	Mouse	–	~102 d	Reproductive	3.07	Paternain et al. (1989) in Opresko et al. (1995)	
Zinc	Mouse	96	9-12 mo	Systemic	–	Aughey et al. (1977)	Small data base

Table C.2.2-3. Derivation of NOAELs for indicator species.

Contaminant of concern	Surrogate species	NOAEL or LOAEL in surrogate species (milligrams per kilograms per day)	UF[a]	Body surface area conversion factor	Indicator species	Indicator species NOAEL (milligrams per kilograms per day)	Notes
Inorganics							
Aluminum	Mouse	19	1	0.33	Mink	6.4	
	Mouse	19	1	1.46	Shrew	27.7	
Barium	Rat	0.54	1	0.76	Mink	0.41	
	Rat	0.54	1	3.30	Shrew	1.78	
Chromium VI	Rat	3.5	1	0.76	Mink	2.7	
	Rat	3.5	1	3.30	Shrew	11.6	
Copper	Mink	12	1	1.00	Mink	12.0	
	Mink	12	1	4.35	Shrew	52.2	
Fluoride	Mink	5	2	1.00	Mink	2.5	UF from less serious LOAEL
	Rat	5	2	3.30	Shrew	8.3	UF from less serious LOAEL
Iron							Data inadequate; essential nutrient
Lead	Rat	0.014	4	0.76	Mink	0.003	UF for study duration
	Rat	0.014	4	3.30	Shrew	0.012	UF for study duration
Manganese	Rat	16	1	0.76	Mink	12.1	
	Rat	16	1	3.30	Shrew	52.9	
Mercury	Mink	0.15	8	1.00	Mink	0.019	UF for study duration
	Mink	0.15	8	4.35	Shrew	0.082	UF for study duration
Nickel	Rat	18	2	0.76	Mink	6.8	UF from LOAEL: NOAEL in 2nd and 3rd generations
	Rat	18	2	3.30	Shrew	29.7	UF from LOAEL: NOAEL in 2nd and 3rd generations
Nitrate (as N)							MCL of 10 mg/L at seepline is protective
Silver	Mouse	23	100	0.33	Mink	0.077	UF for LOAEL and nature of study
	Mouse	23	100	1.46	Shrew	0.33	UF for LOAEL and nature of study
Uranium	Mouse	3.07	1	0.33	Mink	1.01	
	Mouse	3.07	1	1.46	Shrew	4.48	
Zinc	Mouse	96	10	0.33	Mink	3.17	UF: LOAEL to NOAEL
	Mouse	96	10	1.46	Shrew	14.0	UF: LOAEL to NOAEL

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a. UF = Uncertainty factor.

Table C.3.1-1. Tank farm residual after bulk waste removal and spray washing (curies).[a]

Radionuclide	F-Area Tank Farm	H-Area Tank Farm
Se-79	1.2	1.7
Sr-90	6.2×10^4	9.5×10^4
Tc-99	20	29
Sn-126	2.2	2.2
Cs-135	0.013	0.02
Cs-137	4,300	5,600
Eu-154	350	1,200
Np-237	0.06	0.12
Pu-238	0[b]	1,680
Pu-239	130	22

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a. Derived from Newman (1999) and Hester (1999). Ancillary equipment is assumed to constitute an additional 20 percent of contaminants.
b. Only trace amounts of Pu-238 are present in F-Area Tank Farm.

Table C.3.1-2. Tank farm residual after bulk waste removal and spray washing (kilograms).[a]

Constituent	F-Area Tank Farm	H-Area Tank Farm
Iron	2,300	1,000
Manganese	240	140
Nickel	55	26
Aluminum	820	250
Chromium VI	20[b]	6.7[b]
Mercury	6.3	89
Silver	27	0.9
Copper	14	1.7
Uranium	450	4.3
Nitrate	150	62
Zinc	27	8.6
Fluoride	14.2	2
Lead [c]	24	12

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a. Derived from Newman (1999) and Hester (1999). Ancillary equipment is assumed to constitute an additional 20 percent of contaminants.
b. All chromium was modeled as Chromium VI.
c. Additional lead from risers are not included in this value.

The No Action Alternative analyzed in this EIS assumes that only bulk waste removal is performed. Consequently, DOE has assumed that the amount of chemical constituents remaining after only bulk waste removal would be five times higher than that reported in Table C.3.1-2. Also, the Clean and Fill with Saltstone Option would introduce additional material into the HLW tanks. DOE used inventory estimates from the *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility* (DOE 1994) for saltstone content to account for this additional material.

C.3.2 CALCULATIONAL PARAMETERS

The modeling described in this appendix was designed to be specific to the tank farms. This was accomplished by utilizing site-specific data where available. For the hundreds of MEPAS input parameters, default values were used only for the distribution coefficients for chemical constituents.

For the four closure scenarios modeled, the majority of the MEPAS input parameters remain constant. Examples of constant parameters include contaminants of concern (radionuclide and chemical) and their respective initial source terms, spatial dimensions and elevation of the contaminated zone, strata thicknesses, chemical and physical properties (hydraulic conductivity and gradient, distribution coefficients) of SRS soil, exposure pathways, dose conversion factors and downgradient distances to compliance points.

Input parameters that changed for the various closure scenarios and were shown by sensitivity analyses to markedly affect the breakthrough times and peak concentrations include constituent and strata specific distribution factors, rainwater infiltration factors, and concrete basemat hydraulic conductivities. These and other important parameters are discussed in the following sections.

C.3.2.1 Distribution Coefficients

The distribution coefficient, K_d, is defined for two-phased systems as the ratio of the constituent concentration in the solid (soil) to the concentration of the constituent in the interstitial liquid (leachate). For a given element, this parameter may vary over several orders of magnitude depending on such conditions as soil pH and clay content. Experiments have been performed (Bradbury and Sarott 1995) that have demonstrated that strong oxidizing or reducing environments tend to affect the K_d values markedly. Because this parameter is highly sensitive in relation to breakthrough and peak times (but not necessarily peak concentration), careful selection is imperative to achieve reasonable results. For this reason, several literature sources were used to assure the most current and appropriate K_d values were selected for the example calculation.

For modeling purposes, four distinct strata were used for groundwater contaminant transport for all four closure scenarios (except for ancillary equipment and piping, which used only three, see below). These four strata are identified as (1) contaminated zone (CZ), (2) first partially saturated zone or concrete basemat, (3) second partially saturated zone or vadose zone, and (4) saturated zone. Distribution coefficients for each of these zones differ depending on the closure scenario-specific chemical and physical characteristics.

The models for ancillary equipment/piping and tanks were similar, except the piping model was assumed to have only one partially saturated zone. For this model, the concrete basemat was conservatively assumed to have no effect on reducing the transport rate of contaminants to the saturated zone. The thickness of the vadose zone was increased to 45 feet to reflect the higher elevation of the piping in relation to the saturated zone.

Distribution coefficients for each strata under various conditions are listed in Table C.3.2-1. A detailed discussion of the selection process is provided for each closure scenario.

Scenario 1 – No Action Alternative

For this scenario, K_d values for the CZ were assumed to behave similarly to that of clay found in the vicinity of the SRS tank farms. For the radionuclides and chemicals of interest, these K_d values are listed in Column V of Table C.3.2-1.

For the first partially saturated zone (concrete basemat), K_d values were selected for concrete in a non-reducing environment and are listed in Column II of Table C.3.2-1. K_d values for the second partially saturated zone (vadose zone) and the saturated zone are the same and were selected to reflect characteristics of SRS soil. These values are listed in Column I of Table C.3.2-1. For the ancillary equipment and piping, K_d values for the CZ are presented in Column V, partially saturated and saturated zones are listed in Column I of Table C.3.2-1.

Scenario 2 – Clean and Fill With Grout Option

This scenario assumes that the tanks and ancillary piping would be filled with a strongly reducing grout. Therefore, for the tank model, K_d values for the CZ, first and second partially saturated zones, and the saturated zone are listed in Columns IV, III, I, and I of Table C.3.2-1, respectively.

Similarly, for the piping model, K_d values for the CZ, partially saturated zone, and the saturated zone are listed in Columns IV, I, and I of Table C.3.2-1, respectively.

Scenario 3 – Clean and Fill With Sand Option

This scenario uses the same K_d values as for scenario 1.

Scenario 4 – Clean and Fill With Saltstone Option

This scenario assumes that the tanks and ancillary piping would be filled with saltstone with composition like that in the Z-Area Saltstone Manufacturing and Disposal Facility. There-

Table C.3.2-1. Radionuclide and chemical groundwater distribution coefficients, cubic centimeters per gram.

	I		II		III		IV		V		VI	
	SRS Soil	Ref.	Non-Reducing Concrete[l]	Ref.	Reducing[j] Concrete	Ref.	Reducing[j] CZ	Ref.	Non-Reducing CZ	Ref.	Saltstone	Ref.
Se-79[a]	5	b	0	b	0.1	i	0.1	i	740[m]	b	7	s
Sr-90	10	b	10	b	1	i	1	i	110[m]	b	10	s
Tc-99	0.36	b	700	b	1,000	i	1,000	i	1[m]	b	700	s
Sn-126	130	b	200	b	1,000	i	1,000	i	670[m]	b	t	
Cs-135, 137	100	b	20	b	2	i	2	i	1,900[m]	b	t	s
Eu-154[p]	800[d]	c	1,300	e	5,000[q]	i	5,000[q]	i	1,300	e	t	
Np-237	10	b	5,000	b	5,000	b	5,000	i	55	b	t	
Pu-238, 239	100	b	5,000	b	NA	f	NA	f	5,100[m]	b	t	
Iron	15	g	15	n	1.5	o	1.5	o	15	n	t	
Manganese	16.5	g	36.9	n	100	i	100	i	36.9	n	t	
Nickel	300	b	650	n	100	i	100	i	650	n	t	
Aluminum	35,300	g	35,300	n	353	o	353	o	35,300	n	t	
Chromium VI[h]	16.8	g	360	n	7.9	o	7.9	o	360	n	t	
Mercury	322	g	5,280	n	5,280	o	5,280	o	5,280	n	t	
Silver	0.4	g	40	n	1	i	1	i	40	n	t	
Copper	41.9	g	336	n	33.6	o	33.6	o	336	n	t	
Uranium	50	b	1,000	n	NA	u	NA	u	1,600	b	t	
Nitrate	0	g	0	n	0	o	0	o	0	n	0	s
Zinc	12.7	g	50	n	5	o	5	o	50	n	t	
Fluoride	0	g	0	n	0	o	0	o	0	n	t	
Lead	234	g	NA	r	NA	r	NA	r	NA	r	NA	r

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a. Values also used for chemical contaminants.
b. E-Area RPA (WSRC 1994a), Table 3.3-2, page 3-69.
c. Yu et al. (1993), Table 32.1, page 105.
d. Value used for loam from c.
e. Value used for clay from c.
f. Solubility limit of 4.4×10^{-13} mols/liter used, WSRC (1994a), page C-32.
g. MEPAS default for soil <10% clay and pH from 5-9.
h. For conservatism, all chromium modeled as VI valence.
i. Bradbury and Sarott (1995), Table 4, Region 1, page 42.
j. Reducing environment assumed for grout fill.
k. Non-reducing environments assumed for No Action and sand fill option.
l. Values used for basemat concrete for No Action and sand fill option.
m. Value used for clay from WSRC (1994a).
n. MEPAS default used for soil >30% clay and pH from 5-9.
o. MEPAS default used for soil >30% clay and pH >9.
p. Characteristics similar to Sm per Table 3, page 16 of Bradbury and Scott (1995).
q. Characteristics similar to Am per Table 3, page 16 of Bradbury and Scott (1995).
r Lead is outside of reducing environments for all cases. Therefore, value from Column I is used for all cases.
s Z-Area Saltstone Radiological Performance Assessment (WSRC 1992), page A-13.
t Values of K_d for these contaminants were based on non-reducing concrete.
u Solubility limit of 3.0×10^{-10} μ/liter used to determine K_d, E-Area (WSRC 1994a) p. D-34.

fore, for the tank model, K_d values for the CZ, first and second partially saturated zones, and the saturated zone are listed in Columns VI, III, I, and I of Table C.3.2-1, respectively.

C.3.2.2 MEPAS Groundwater Input Parameters

Table C.3.2-2 lists input parameters used for the partially saturated zones for the various closure scenarios, and Table C.3.2-3 lists input parameters for the saturated zone. The values used for the concrete basemat and vadose layer for the partially saturated zone were constant for all tank groups within both tank farms with the exception of the vadose zone thickness. Because there are significant differences in the bottom elevation between the various tank groups, the thickness of the vadose zone was modeled specifically for each tank group. Some tank groups in the H-Area were modeled without a vadose zone because the tanks are situated in the Water Table Aquifer. When horizontal flow was modeled in each of the aquifer layers all of the overlying layers were treated as part of the partially saturated zone (i.e., vertical transport only) for that simulation.

The values for the remaining partially saturated zone layers and for all of the saturated zone layers are constant for all tank groups within either the F- or H-Area that have groundwater flow to the same point of discharge (i.e., to Fourmile Branch or Upper Three Runs). The parameters do vary, however, among the different layers and along different groundwater flow paths. For this reason, Tables C.3.2-2 and C.3.2-3 contain three sets of input parameters: flow from the F-Area Tank Farm toward Fourmile Branch (all tank groups); flow from the H-Area Tank Farm toward Fourmile Branch (four tank groups); and flow from the H-Area Tank Farm toward Upper Three Runs (three tank groups). Because only one-dimensional vertical flow was considered for the Tan Clay and Green Clay layers in both the partially saturated and saturated conditions, the input parameters were the same for these layers for each of the groupings shown in the tables.

C.3.2.3 Hydraulic Conductivities

Because leach rate is ultimately limited by the lowest hydraulic conductivity of the strata and structures above and below the contaminated zone, this parameter is highly sensitive in its effect on breakthrough times and peak concentrations at the receptor locations. For modeling purposes, it was assumed that excess water has a place to run off (over the sides of the basemat) and that ponding above the contaminated zone does not occur.

C.3.2.4 Human Health Exposure Parameters and Assumed Values

Because the impact on a given receptor depends in large part on the physical characteristics and habits of the receptor, it is necessary to stipulate certain values to obtain meaningful results. Certain of these values are included as default values in MEPAS; however, others must be specified so the receptors are modeled appropriately for the scenario being described.

For this modeling effort, site-specific values were used as much as possible; that is, values that had been used in other modeling efforts for the SRS were incorporated when available and appropriate. Table C.3.2-4 lists the major parameters that were used in assigning characteristics to the receptors used in the calculations.

C.3.3 ECOLOGICAL RISK ASSESSMENT

The exposure factors used in calculating doses to the shrew and mink are listed in Table C.3.3-1. An important assumption of the exposure calculation is that no feeding or drinking takes place outside the influence of the seepage, even though the home ranges of the shrew and the mink typically are larger than the seep areas. EPA (1993) presents a range of literature-based home ranges for the short-tailed shrew that vary from 0.03 to 1.8 ha. Home ranges for the mink also vary widely in the literature from 7.8 to 770 ha (EPA 1993). The bioaccumulation factor for soil and soil invertebrates is 1 for all metals, as is the factor

Table C.3.2-2. Partially saturated zone MEPAS input parameters.

	Concrete basemat		Vadose Zone layer	Water Table layer	Tan clay layer	Barnwell-McBean layer	Green clay layer
	Intact	Failed					
F-Area Tank Farm, flow toward Fourmile Branch							
Thickness (centimeters)	18[a]	18[a]	Varies[b]	1,200[c]	91[c]	1,800[c]	150[c]
Bulk density (grams per cubic centimeters)	2.21[d]	1.64[e]	1.59[d]	1.59[d]	1.36[e]	1.59[d]	1.39[e]
Total porosity	15%[d]	38%[e]	35%[f]	35%[f]	40%[f]	35%[f]	40%[f]
Field Capacity	15%[d]	9%[e]	12%[e]	35%[e]	33.4%[e]	35%[e]	32.5%[e]
Longitudinal dispersion (centimeters)[g]	0.18	0.18	Varies	12	0.91	18	1.5
Vertical hydraulic conductivity (centimeters per second)	9.6×10^{-9}[d]	6.6×10^{-3}[e]	7.1×10^{-4}[h]	7.1×10^{-4}[h]	1.6×10^{-6}[h]	5.6×10^{-4}[h]	4.4×10^{-9}[h]
H-Area Tank Farm, flow toward Fourmile Branch							
Thickness (centimeters)	18[a]	18[a]	Varies[b]	1,900[i]	300[i]	2,000[i]	300[i]
Bulk density (grams per cubic centimeters)	2.21[d]	1.64[e]	1.59[d]	1.59[d]	1.36[e]	1.59[d]	1.39[e]
Total porosity	15%[d]	38%[e]	35%[f]	35%[f]	40%[f]	35%[f]	40%[f]
Field capacity	15%[d]	9%[e]	12%[e]	35%[j]	33.4%[j]	35%[j]	32.5%[j]
Longitudinal dispersion (centimeters)[g]	0.18	0.18	Varies	19	3.0	20	3.0
Vertical hydraulic conductivity (centimeters per second)	$9.\times10^{-9}$[d]	6.6×10^{-3}[e]	1.6×10^{-4}[i]	1.6×10^{-4}[i]	3.2×10^{-7}[i]	1.6×10^{-4}[i]	3.5×10^{-8}[i]
H-Area Tank Farm, flow toward Upper Three Runs							
Thickness (centimeters)	18[a]	18[a]	Varies[b]	1,900[i]	300[i]	1,800[i]	300[i]
Bulk density (grams per cubic centimeters)	2.21[d]	1.64[e]	1.59[d]	1.59[d]	1.36[e]	1.59[d]	1.39[e]
Total porosity	15%[d]	38%[e]	35%[f]	35%[f]	40%[f]	35%[f]	40%[f]
Field capacity	15%[d]	9%[e]	12%[e]	35%[j]	33.4%[j]	35%[j]	32.5%[j]
Longitudinal dispersion (centimeters)[g]	0.18	0.18	Varies	19	3.0	18	3.0
Vertical hydraulic conductivity (centimeters per second)	9.6×10^{-9}[d]	6.6×10^{-3}[e]	1.3×10^{-4}[i]	1.3×10^{-4}[i]	3.0×10^{-7}[i]	1.3×10^{-4}[i]	3.5×10^{-8}[i]

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a. Type IV tank shown; Type I = 3.54, Type III = 2.74.
b. Distance between tank bottom elevation (see a. above) and historic groundwater elevation.
c. GeoTrans (1987).
d. WSRC (1994a). Radiological Performance Assessment for the E-Area Vaults Disposal Facility (U), WSRC-RP-94-218.
e. Buck et al. (1995), MEPAS Table 2.1.
f. Aadland (1995).
g. Buck et al. (1995); calculated using MEPAS formula for longitudinal dispersivity, based on total travel distance.
h. GeoTrans (1993); where Kz = 0.1 Kx for aquifer layers.
i. WSRC (1994b). WSRC E-7 Procedure Document Q-CLC-H-00005, Revision 0.
j. Buck et al. (1995), MEPAS Table 2.1; assumes aquifer layers are saturated and clay layers nearly saturated.

Table C.3.2-3. MEPAS input parameters for the saturated zone.

	Water Table Aquifer	Barnwell-McBean Aquifer	Congaree Aquifer
F-Area Tank Farm, flow toward Fourmile Branch			
Thickness (centimeters) [a]	1,200	1,800	3,000
Bulk density (grams per cubic centimeter) [b]	1.59	1.59	1.64
Total porosity [c]	35%	35%	34%
Effective porosity [d]	20%	20%	25%
Longitudinal dispersion (centimeters)		1/20 th of the flow distance	
Hydraulic conductivity (centimeters per second)	7.1×10^{-3}	5.6×10^{-3}	0.013
Hydraulic gradient [a]	0.006	0.004	0.006
H-Area Tank Farm, flow toward Fourmile Branch			
Thickness (centimeters) [a]	1,900	2,000	3,000
Bulk density (grams per cubic centimeter) [b]	1.59	1.59	1.64
Total porosity [c]	35%	35%	34%
Effective porosity [d]	20%	20%	25%
Longitudinal dispersion (centimeters)		1/20 th of the flow distance	
Hydraulic conductivity (centimeters per second)	1.6×10^{-3}	1.6×10^{-3}	1.4×10^{-3}
Hydraulic gradient [a]	0.014	0.011	0.004
H-Area Tank Farm, flow toward Upper Three Runs			
Thickness (centimeters) [a]	1,900	1,800	3,000
Bulk density (grams per cubic centimeter) [b]	1.59	1.59	1.64
Total porosity [c]	35%	35%	34%
Effective porosity [d]	20%	20%	25%
Longitudinal dispersion (centimeters)		1/20 th of the flow distance	
Hydraulic conductivity (centimeters per second)	1.3×10^{-3}	1.3×10^{-3}	1.4×10^{-3}
Hydraulic gradient [a]	0.015	0.009	0.003

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a. GeoTrans (1987 and 1993).
b. Buck et al. (1995), MEPAS Table 2.1.
c. Aadland (1995)
d. EPA (1989) and WSRC (1994b) WSRC E-7 Procedure Document Q-CLC-H-00005, Revision 0.

Table C.3.2-4. Assumed human health exposure parameters.

Parameter	Applicable receptor	Value	Comments
Body mass	Adult	70 kg	This value is taken directly from ICRP (1975). In radiological dose calculations, this is the standard value in the industry.
	Child	30 kg	This value was obtained from ICRP (1975). Both a male and female child of age 9 have an average mass of 30 kg.
Exposure period	All	1 year	This value is necessary so that MEPAS will calculate an annual radiation dose. Lifetime doses can be calculated by multiplying the annual dose by the assumed life of the individual.
Leafy vegetable ingestion rate	Adult	21 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	8.53 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Other vegetables ingestion rate	Adult	163 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	163 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Meat ingestion rate	Adult	43 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	16 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Milk ingestion rate	Adult	120 L/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	128 L/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Water ingestion rate	All	2 L/day	This value is standard in MEPAS and is consistent with maximum drinking water rates in NRC (1977).
Finfish ingestion rate	Adult	9 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	2.96 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Time spent at shoreline	Adult resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Child resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Seepline worker	2080 hrs/yr	This value is based on the assumption of continuous exposure of the seepline worker during each working day.
	Intruder	1040 hrs/yr	This value is based on the conservative assumption of half-time exposure during each working day.
Time spent swimming	Adult resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Child resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).

Table C.3.3-1. Parameters for foodchain model ecological receptors.

Receptor	Feeding group	Parameter	Value	Notes; Reference
Southern short-tailed shrew (*Blarina carolinensis*)	Insectivore	Body weight	9.7 grams	Mean of 423 adults collected on SRS; Cothran et al. (1991)
		Water ingestion	2.2 grams/day	0.223 g/g/day X 9.7g; EPA (1993)
		Food ingestion	5.2 grams/day	0.541 g/g/day X 9.7g; Richardson (1973) cited in Cothran et al. (1991)
		Soil ingestion	10% of diet	Between vole (2.4%) and armadillo (17%); Beyer et al. (1994)
		Home range	0.96 ha	Mean value on SRS; Faust et al. (1971) cited in Cothran et al. (1991)
Mink (*Mustela vison*)	Carnivore	Body weight	800 grams	“Body weight averages 0.6 to 1.0 kg”; Cothran et al. (1991)
		Water ingestion	22.4 grams/day	0.028 g/g/day X 800g; EPA (1993)
		Food ingestion	110 grams/day	Mean of male and female estimates; EPA (1993)
		Soil ingestion	5% of diet	Between red fox (2.8%) and raccoon (9.4%); Beyer et al. (1994)
		Home range	variable	7.8-20.4 ha (Montana); 259-380 ha (North Dakota; EPA 1993) Females: 6-15 ha, males: 18-24 ha (Kansas; Bee et al. 1981)

for soil invertebrates and shrews. K_d values for estimating-contaminant concentrations in soil due to the influence of seepage are from Baes et al. (1984). Bioconcentration factors for estimating contaminant concentrations in aquatic prey items are from the EPA Region IV water quality criteria table. For contaminants with no listing in the Region IV table for a bioconcentration factor, a factor of 1 is used. The mink was modeled as obtaining half of its diet from shrews at the seep area and the other half from aquatic prey downstream of the seepline.

C.4 Results

C.4.1 HUMAN HEALTH ASSESSMENT

For each scenario, the maximum concentration or dose was identified for each receptor and for each contaminant along with the time period during which the maximum occurred within a 10,000-year performance period. In addition, for radiological constituents, the total dose was calculated to allow evaluation of the impact of all radiological constituents. Because the maximum doses for each radionuclide do not necessarily occur simultaneously, it is not appropriate to add the maximum doses for each radionuclide. Rather, it is more appropriate to assess the doses as a function of time, sum the doses from all radionuclides for each time increment, and then select the maximum total dose from this compilation. Therefore, the total dose reported in the following tables for radiological constituents may not necessarily correlate to the maximum dose or time period for any individual radionuclide because of the contributions from all radionuclides at a given time. In addition to total dose, the gross alpha concentration was calculated to enable comparison among the alternatives

Non-radiological constituent concentrations in the various water bodies were calculated to allow direct comparison among the alternatives. For each constituent, the maximum concentration was calculated along with the time period during which the maximum concentration occurred. None of the non-radiological constituents are known ingestion carcinogens; therefore cancer risk was not calculated for these contaminants.

Tables C.4.1-1 through C.4.1-26 list impact estimates for the four scenarios described in Section C.2. For those tables describing radiological impacts, doses are presented for postulated individuals (i.e., Adult Resident, Child Resident, Seepline Worker, and Intruder) and at the seepline. Additional calculations were performed at groundwater locations close to the tank farm and are reported as drinking water does to allow comparison to the appropriate maximum contaminant level. DOE estimates that the total dose at the locations would not exceed the drinking water doses by more than 20%. For nonradiological constituents, the maximum concentration of each contaminant is reported for each water location.

For the case of No Action, the reported doses are those arising strictly from the water pathways; impacts from air pathways, in principle, would increase the total dose to a given receptor. It is expected, however, that atmospheric release of the tanks' contents would not be appreciable because:

- The amount of rainfall in the area would tend to keep the tank contents damp through the time of failure. After failure, a substantial amount of debris on top of the contaminated material would prevent release even if the contents were to dry during a period of drought.

- The considerable depth of the tanks below grade would tend to discourage resuspension of any of the tanks' contents.

As discussed in Chapters 3 and 4 of this EIS, DOE performed groundwater modeling calculations for the three uppermost aquifers underneath the tank farms: the Water Table Aquifer, the Barnwell-McBean Aquifer, and the Congaree Aquifer. Tables C.4.1-1 through C.4.1-26 present results for each tank farm and by aquifer. Although more than one aquifer may outcrop to the same point on the seepline, the

Table C.4.1-1. Radiological results for F-Area Tank Farm in the Water Table Aquifer (millirem per year).

		Maximum concentration			
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	Maximum value	1.9×10^{-2}	2.9×10^{-2}	1.7×10^{-1}	3.3
	Time of maximum (yrs)	385	175	7035	1155
Child resident (total dose)	Maximum value	1.7×10^{-2}	2.7×10^{-2}	1.6×10^{-1}	3.1
	Time of maximum (yrs)	385	175	7035	1155
Seepline worker (total dose)	Maximum value	(a)	(a)	(a)	9.6×10^{-3}
	Time of maximum (yrs)	(a)	(a)	(a)	105
Intruder (total dose)	Maximum value	(a)	(a)	(a)	4.8×10^{-3}
	Time of maximum (yrs)	(a)	(a)	(a)	105
1-meter well (drinking water dose)	Maximum value	4.3×10^{1}	1.3×10^{2}	3.0×10^{2}	3.6×10^{5}
	Time of maximum (yrs)	385	35	5705	245
100-meter well (drinking water dose)	Maximum value	1.6×10^{1}	5.1×10^{1}	1.4×10^{2}	6.0×10^{3}
	Time of maximum (yrs)	315	35	7035	315
Seepline (drinking water dose)	Maximum value	1.0	1.4	9.5	1.8×10^{2}
	Time of maximum (yrs)	385	175	7455	1155
Surface water (drinking water dose)	Maximum value	6.9×10^{-3}	1.1×10^{-2}	6.3×10^{-2}	1.2
	Time of maximum (yrs)	385	175	7035	1155

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a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-2. Radiological results for F-Area Tank Farm in the Barnwell-McBean Aquifer (millirem per year).

		Maximum concentration			
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean with water, fill with saltstone	No Action Alternative
Adult resident (total dose)	Maximum value	2.7×10^{-2}	5.1×10^{-2}	3.7×10^{-1}	6.2
	Time of maximum (yrs)	875	245	7525	1225
Child resident (total dose)	Maximum value	2.4×10^{-2}	4.7×10^{-2}	3.4×10^{-1}	5.7
	Time of maximum (yrs)	875	245	7525	1225
Seepline worker (total dose)	Maximum value	(a)	(a)	1.0×10^{-3}	1.8×10^{-2}
	Time of maximum (yrs)	(a)	(a)	7525	1225
Intruder (total dose)	Maximum value	(a)	(a)	(a)	9.0×10^{-3}
	Time of maximum (yrs)	(a)	(a)	(a)	1225
1-meter well (drinking water dose)	Maximum value	1.3×10^{2}	4.2×10^{2}	7.9×10^{2}	3.5×10^{4}
	Time of maximum (yrs)	665	105	6965	35
100-meter well (drinking water dose)	Maximum value	5.1×10^{1}	1.9×10^{2}	5.1×10^{2}	1.4×10^{4}
	Time of maximum (yrs)	665	105	6685	35
Seepline (drinking water dose)	Maximum value	1.9	3.5	2.5×10^{1}	4.3×10^{2}
	Time of maximum (yrs)	875	245	6475	1225
Surface water (drinking water dose)	Maximum value	9.8×10^{-3}	1.9×10^{-2}	1.3×10^{-1}	2.3
	Time of maximum (yrs)	875	245	7525	1225

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a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-3. Radiological results dose for F-Area Tank Farm in the Congaree Aquifer (millirem per year).

		Maximum concentration			
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	Maximum value	(a)	(a)	1.4×10^{-2}	1.1×10^{-1}
	Time of maximum (yrs)	(a)	(a)	8855	1365
Child resident (total dose)	Maximum value	(a)	(a)	1.3×10^{-2}	1.0×10^{-1}
	Time of maximum (yrs)	(a)	(a)	8855	1365
Seepline worker (total dose)	Maximum value	(a)	(a)	(a)	(a)
	Time of maximum (yrs)	(a)	(a)	(a)	(a)
Intruder (total dose)	Maximum value	(a)	(a)	(a)	(a)
	Time of maximum (yrs)	(a)	(a)	(a)	(a)
1-meter well (drinking water dose)	Maximum value	9.1×10^{-1}	1.2	3.0×10^{1}	1.7×10^{2}
	Time of maximum (yrs)	4935	2905	6615	1155
100-meter well (drinking water dose)	Maximum value	2.2×10^{-1}	2.5×10^{-1}	6.4	4.2×10^{1}
	Time of maximum (yrs)	1225	3115	8435	1295
Seepline (drinking water dose)	Maximum value	6.5×10^{-3}	8.7×10^{-3}	1.9×10^{-1}	1.6
	Time of maximum (yrs)	5495	3325	7805	1295
Surface water (drinking water dose)	Maximum value	(a)	(a)	5.0×10^{-3}	4.2×10^{-2}
	Time of maximum (yrs)	(a)	(a)	8855	1365

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a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-4. Radiological results dose for H-Area Tank Farm in the Water Table Aquifer (millirem per year).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	1.4×10^{-3}	1.2×10^{-2}	2.6×10^{-2}	1.2
		Time of maximum (years)	455	105	6125	105
	South of Groundwater Divide	Maximum value (mrem/yr)	1.0×10^{-2}	1.6×10^{-2}	1.9×10^{-1}	2.4
		Time of maximum (years)	455	175	6125	1015
Child resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	1.3×10^{-3}	1.1×10^{-2}	2.4×10^{-2}	1.1
		Time of maximum (years)	455	105	6125	105
	South of Groundwater Divide	Maximum value (mrem/yr)	9.3×10^{-3}	1.5×10^{-2}	1.8×10^{-1}	2.2
		Time of maximum (years)	455	175	6125	1015
Seepline worker (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	3.5×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	105
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	7.0×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1015
Intruder (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	1.7×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	105
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	3.5×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1015
1-meter well (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	1.0×10^{5}	1.3×10^{5}	1.0×10^{5}	9.3×10^{6}
		Time of maximum (years)	175	175	175	105
	South of Groundwater Divide	Maximum value (mrem/yr)	1.2×10^{2}	2.5×10^{2}	5.5×10^{2}	8.3×10^{5}
		Time of maximum (years)	315	385	4725	245
100-meter well (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	3.0×10^{2}	9.2×10^{2}	8.7×10^{2}	9.0×10^{4}
		Time of maximum (years)	245	35	5915	35
	South of Groundwater Divide	Maximum value (mrem/yr)	2.9×10^{1}	6.1×10^{1}	2.9×10^{2}	6.1×10^{3}
		Time of maximum (years)	315	35	5635	35
Seepline (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	2.5	2.5×10^{1}	4.6×10^{1}	2.5×10^{3}
		Time of maximum (years)	455	105	5635	105
	South of Groundwater Divide	Maximum value (mrem/yr)	9.5×10^{-1}	1.4	1.6×10^{1}	2.0×10^{2}
		Time of maximum (years)	455	175	5425	1015
Surface water (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	4.3×10^{-3}	9.6×10^{-3}	4.5×10^{-1}
		Time of maximum (years)	(a)	105	6125	105
	South of Groundwater Divide	Maximum value (mrem/yr)	3.7×10^{-3}	6.0×10^{-3}	7.1×10^{-2}	9.0×10^{-1}
		Time of maximum (years)	455	175	6125	1015

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a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-5. Radiological results for H-Area Tank Farm in the Barnwell-McBean Aquifer (millirem per year).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	2.1×10^{-3}	1.1×10^{-2}	2.4×10^{-1}
		Time of maximum (years)	(a)	455	6195	385
	South of Groundwater Divide	Maximum value (mrem/yr)	3.4×10^{-3}	7.8×10^{-3}	1.2×10^{-1}	1.4
		Time of maximum (years)	4515	385	6335	1155
Child resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	2.0×10^{-3}	1.0×10^{-2}	2.2×10^{-1}
		Time of maximum (years)	(a)	455	6195	385
	South of Groundwater Divide	Maximum value (mrem/yr)	3.1×10^{-3}	7.2×10^{-3}	1.1×10^{-1}	1.3
		Time of maximum (years)	4515	385	6335	1155
Seepline worker (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	4.2×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1155
Intruder (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	2.1×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1155
1-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	9.7×10^{1}	1.9×10^{3}	1.7×10^{3}	1.7×10^{5}
		Time of maximum (years)	1155	105	4165	105
	South of Groundwater Divide	Maximum value (mrem/yr)	5.3×10^{1}	1.4×10^{2}	4.3×10^{2}	2.5×10^{4}
		Time of maximum (years)	4445	245	5005	945
100-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	3.2×10^{1}	4.6×10^{2}	6.4×10^{2}	5.8×10^{4}
		Time of maximum (years)	1155	105	5845	105
	South of Groundwater Divide	Maximum value (mrem/yr)	1.6×10^{1}	5.1×10^{1}	2.7×10^{2}	4.9×10^{3}
		Time of maximum (years)	1155	245	6405	105
Seepline (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	7.5×10^{-1}	4.5	2.3×10^{1}	4.9×10^{2}
		Time of maximum (years)	4515	385	6125	385
	South of Groundwater Divide	Maximum value (mrem/yr)	3.5×10^{-1}	8.4×10^{-1}	1.3×10^{1}	1.6×10^{2}
		Time of maximum (years)	4445	385	6895	1155
Surface water (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	4.2×10^{-3}	8.8×10^{-2}
		Time of maximum (years)	(a)	(a)	6195	385
	South of Groundwater Divide	Maximum value (mrem/yr)	1.2×10^{-3}	2.9×10^{-3}	4.6×10^{-2}	5.3×10^{-1}
		Time of maximum (years)	4515	385	6265	1155

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a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-6. Total radiation dose for H-Area Tank Farm in the Congaree Aquifer (millirem per year).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	1.1×10^{-2}	8.6×10^{-2}
		Time of maximum (years)	(a)	(a)	6825	805
	South of Groundwater Divide	Maximum value (mrem/yr)	1.6×10^{-3}	2.0×10^{-3}	6.6×10^{-2}	4.3×10^{-1}
		Time of maximum (years)	5285	3395	6755	1645
Child resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	1.0×10^{-2}	7.9×10^{-2}
		Time of maximum (years)	(a)	(a)	6825	805
	South of Groundwater Divide	Maximum value (mrem/yr)	1.4×10^{-3}	1.8×10^{-3}	6.1×10^{-2}	4.0×10^{-1}
		Time of maximum (years)	5285	3395	6755	1645
Seepline worker (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	1.2×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1645
Intruder (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
1-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	3.2×10^{1}	9.8×10^{1}	7.7×10^{2}	9.7×10^{3}
		Time of maximum (years)	5005	595	5145	595
	South of Groundwater Divide	Maximum value (mrem/yr)	1.2×10^{1}	1.6×10^{1}	2.0×10^{2}	3.2×10^{3}
		Time of maximum (years)	5215	3115	5355	1505
100-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	5.6	2.5×10^{1}	2.5×10^{2}	2.5×10^{3}
		Time of maximum (years)	4935	665	6475	595
	South of Groundwater Divide	Maximum value (mrem/yr)	1.7	2.3	6.4×10^{1}	4.6×10^{2}
		Time of maximum (years)	4935	3185	7105	1435
Seepline (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	9.8×10^{-2}	2.7×10^{-1}	3.2	2.5×10^{1}
		Time of maximum (years)	5005	805	6755	805
	South of Groundwater Divide	Maximum value (mrem/yr)	1.9×10^{-2}	2.3×10^{-2}	7.7×10^{-1}	4.8
		Time of maximum (years)	5285	3325	7665	1645
Surface water (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	4.0×10^{-3}	3.2×10^{-2}
		Time of maximum (years)	(a)	(a)	6825	805
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	2.4×10^{-2}	1.6×10^{-1}
		Time of maximum (years)	(a)	(a)	6755	1645

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a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-7. Alpha concentration for F-Area Tank Farm in the Water Table Aquifer (picocuries per liter).

		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action
1-meter well	Maximum value	5.2	5.3	5.2	7.6×10^{2}
	Time of maximum (yrs)	1855	945	1855	455
100-meter well	Maximum value	1.9	1.9	1.9	2.4×10^{2}
	Time of maximum (yrs)	1995	1085	1995	595
Seepline	Maximum value	2.6×10^{-2}	2.6×10^{-2}	2.6×10^{-2}	5.6
	Time of maximum (yrs)	3885	2905	3885	9555
Surface water	Maximum value	1.8×10^{-4}	1.8×10^{-4}	1.8×10^{-4}	4.1×10^{-2}
	Time of maximum (yrs)	3885	2975	3885	9555

Table C.4.1-8. Alpha concentration for F-Area Tank Farm in the Barnwell-McBean Aquifer (picocuries per liter).

		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action
1-meter well	Maximum value	1.3×10^{1}	1.3×10^{1}	1.3×10^{1}	1.7×10^{3}
	Time of maximum (yrs)	2695	1785	2695	875
100-meter well	Maximum value	4.7	4.6	4.7	5.3×10^{2}
	Time of maximum (yrs)	2905	1995	2905	1085
Seepline	Maximum value	3.9×10^{-2}	3.9×10^{-2}	3.9×10^{-2}	9.2
	Time of maximum (yrs)	6405	5495	6405	9975
Surface water	Maximum value	2.2×10^{-4}	2.2×10^{-4}	2.2×10^{-4}	4.8×10^{-2}
	Time of maximum (yrs)	6265	5355	6265	9975

Table C.4.1-9. Alpha concentration for F-Area Tank Farm in the Congaree Aquifer (picocuries per liter).

		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action
1-meter well	Maximum value	3.1×10^{-3}	3.1×10^{-3}	3.1×10^{-3}	1.7
	Time of maximum (yrs)	8295	7315	8295	9975
100-meter well	Maximum value	1.3×10^{-3}	1.2×10^{-3}	1.3×10^{-3}	3.6×10^{-1}
	Time of maximum (yrs)	8225	8225	8225	9975
Seepline	Maximum value	3.7×10^{-5}	3.7×10^{-5}	3.7×10^{-5}	9.4×10^{-3}
	Time of maximum (yrs)	9345	8435	9345	9975
Surface water	Maximum value	1.0×10^{-6}	1.0×10^{-6}	1.0×10^{-6}	2.6×10^{-4}
	Time of maximum (yrs)	8365	7455	8365	9975

Table C.4.1-10. Alpha concentration for H-Area Tank Farm in the Water Table Aquifer (picocuries per liter).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	North of Groundwater Divide	Maximum value	2.4×10^{1}	2.9×10^{2}	2.4×10^{1}	1.3×10^{4}
		Time of maximum (years)	1925	175	1925	1715
	South of Groundwater Divide	Maximum value	8.6-	8.6	8.6	1.1×10^{3}
		Time of maximum (years)	1855	945	1855	455
100-meter well	North of Groundwater Divide	Maximum value	7.0	3.8×10^{1}	7.0	3.8×10^{3}
		Time of maximum (years)	2205	455	2205	455
	South of Groundwater Divide	Maximum value	2.0	2.0	2.0	2.0×10^{2}
		Time of maximum (years)	2065	1155	2065	665
Seepline	North of Groundwater Divide	Maximum value	1.5×10^{-1}	3.3×10^{-1}	1.5×10^{-1}	3.4×10^{1}
		Time of maximum (years)	4655	2695	4655	2345
	South of Groundwater Divide	Maximum value	1.9×10^{-2}	1.9×10^{-2}	1.9×10^{-2}	4.9
		Time of maximum (years)	4585	3675	4585	8925
Surface water	North of Groundwater Divide	Maximum value	3.1×10^{-5}	6.1×10^{-5}	3.1×10^{-5}	6.2×10^{-3}
		Time of maximum (years)	4585	2765	4585	2695
	South of Groundwater Divide	Maximum value	7.9×10^{-5}	7.9×10^{-5}	7.9×10^{-5}	2.2×10^{-2}
		Time of maximum (years)	4655	3745	4655	8855

Table C.4.1-11. Alpha concentration for H-Area Tank Farm in the Barnwell-McBean Aquifer (picocuries per liter).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	North of Groundwater Divide	Maximum value	3.8	2.1×10^{1}	3.8	2.2×10^{3}
		Time of maximum (years)	5355	3185	5355	2975
	South of Groundwater Divide	Maximum value	1.9	1.9	1.9	6.6×10^{2}
		Time of maximum (years)	5005	4095	5005	8435
100-meter well	North of Groundwater Divide	Maximum value	1.2	5.7	1.2	6.0×10^{2}
		Time of maximum (years)	5845	3605	5845	3325
	South of Groundwater Divide	Maximum value	5.2×10^{-1}	5.2×10^{-1}	5.2×10^{-1}	1.2×10^{2}
		Time of maximum (years)	5355	4445	5355	8785
Seepline	North of Groundwater Divide	Maximum value	1.0×10^{-2}	6.4×10^{-2}	1.0×10^{-2}	6.0
		Time of maximum (years)	9975	9975	9975	9625
	South of Groundwater Divide	Maximum value	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.7
		Time of maximum (years)	9205	8295	9205	7875
Surface water	North of Groundwater Divide	Maximum value	2.0×10^{-6}	1.2×10^{-5}	2.0×10^{-6}	1.1×10^{-3}
		Time of maximum (years)	9975	9975	9975	9765
	South of Groundwater Divide	Maximum value	3.8×10^{-5}	3.8×10^{-5}	3.8×10^{-5}	6.4×10^{-3}
		Time of maximum (years)	9555	8645	9555	7735

Table C.4.1-12. Alpha concentration for H-Area Tank Farm in the Congaree Aquifer (picocuries per liter).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	North of Groundwater Divide	Maximum value	7.3×10^{-4}	7.2×10^{-2}	7.3×10^{-4}	9.5
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	2.5×10^{-4}	1.2×10^{-3}	2.5×10^{-4}	4.0×10^{-1}
		Time of maximum (years)	9975	9975	9975	9975
100-meter well	North of Groundwater Divide	Maximum value	1.9×10^{-4}	1.6×10^{-2}	1.9×10^{-4}	2.1
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	5.2×10^{-5}	2.8×10^{-4}	5.2×10^{-5}	1.0×10^{-1}
		Time of maximum (years)	9975	9975	9975	9975
Seepline	North of Groundwater Divide	Maximum value	6.7×10^{-9}	4.4×10^{-6}	6.7×10^{-9}	7.8×10^{-4}
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	7.8×10^{-10}	1.6×10^{-8}	7.8×10^{-10}	1.8×10^{-5}
		Time of maximum (years)	9975	9975	9975	9975
Surface water	North of Groundwater Divide	Maximum value	2.6×10^{-11}	6.4×10^{-9}	2.6×10^{-11}	1.1×10^{-6}
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	8.0×10^{-11}	9.3×10^{-10}	8.0×10^{-11}	8.8×10^{-7}
		Time of maximum (years)	9975	9975	9975	9975

Table C.4.1-13. Concentration in groundwater and surface water of silver (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.2×10^{-1}	7.9×10^{-2}	1.2×10^{-1}	8.2×10^{-1}	8.6×10^{-3}	6.3×10^{-3}	8.6×10^{-3}	5.3×10^{-1}	9.7×10^{-4}	7.2×10^{-4}	9.7×10^{-4}	4.9×10^{-2}
	Time (yr)	1015	245	1015	105	1015	245	1015	105	1015	245	1015	105
	Barnwell-McBean	3.2×10^{-1}	2.0×10^{-1}	3.2×10^{-1}	3.4	7.1×10^{-4}	9.4×10^{-4}	7.1×10^{-4}	9.3×10^{-2}	8.8×10^{-5}	8.9×10^{-5}	8.8×10^{-5}	9.0×10^{-3}
	Time (yr)	1155	385	1155	245	2695	1855	2695	1785	2765	1715	2765	1645
	Congaree	3.1×10^{-5}	3.1×10^{-5}	3.1×10^{-5}	3.3×10^{-4}	2.0×10^{-5}	2.4×10^{-5}	2.0×10^{-5}	2.3×10^{-3}	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-4}
	Time (yr)	4165	3325	4165	3115	9975	9765	9975	9555	9975	9205	9975	9205
100-meter well	Water Table	2.3×10^{-2}	1.4×10^{-2}	2.3×10^{-2}	1.8×10^{-1}	1.5×10^{-3}	1.9×10^{-3}	1.5×10^{-3}	1.5×10^{-1}	2.0×10^{-4}	1.7×10^{-4}	2.0×10^{-4}	1.1×10^{-2}
	Time (yr)	1015	245	1015	105	1015	35	1015	35	1015	245	1015	175
	Barnwell-McBean	6.5×10^{-2}	3.9×10^{-2}	6.5×10^{-2}	9.0×10^{-1}	1.2×10^{-4}	1.9×10^{-4}	1.2×10^{-4}	1.8×10^{-2}	1.7×10^{-5}	1.6×10^{-5}	1.7×10^{-5}	1.7×10^{-3}
	Time (yr)	1155	385	1155	245	2625	1785	2625	1785	2765	1645	2765	1645
	Congaree	5.7×10^{-6}	5.7×10^{-6}	5.7×10^{-6}	6.7×10^{-5}	3.1×10^{-6}	4.0×10^{-6}	3.1×10^{-6}	3.7×10^{-4}	(a)	(a)	(a)	2.0×10^{-5}
	Time (yr)	4235	3325	4235	3115	9905	9695	9905	9835	(a)	(a)	(a)	9415
Seepline	Water Table	7.1×10^{-4}	5.8×10^{-4}	7.1×10^{-4}	1.1×10^{-2}	4.5×10^{-5}	5.8×10^{-5}	4.5×10^{-5}	6.0×10^{-3}	5.2×10^{-6}	5.1×10^{-6}	5.2×10^{-6}	5.5×10^{-4}
	Time (yr)	1085	315	1085	245	1155	175	1155	175	1155	385	1155	245
	Barnwell-McBean	1.7×10^{-3}	1.2×10^{-3}	1.7×10^{-3}	2.1×10^{-2}	3.9×10^{-6}	5.7×10^{-6}	3.9×10^{-6}	4.8×10^{-4}	(a)	(a)	(a)	6.7×10^{-5}
	Time (yr)	1365	525	1365	455	3115	2275	3115	2065	(a)	(a)	(a)	1925
	Congaree	(a)	(a)	(a)	1.9×10^{-6}	(a)	(a)	(a)	4.0×10^{-6}	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	3185	(a)	(a)	(a)	9835	(a)	(a)	(a)	(a)
Surface Water	Water Table	4.5×10^{-6}	3.8×10^{-6}	4.5×10^{-6}	7.8×10^{-5}	(a)	(a)	(a)	1.2×10^{-6}	(a)	(a)	(a)	2.4×10^{-6}
	Time (yr)	1085	315	1085	245	(a)	(a)	(a)	245	(a)	(a)	(a)	245
	Barnwell-McBean	8.8×10^{-6}	6.5×10^{-6}	8.8×10^{-6}	1.1×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	1365	595	1365	455	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-14. Concentrations in groundwater and surface water of aluminum (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-15. Concentrations in groundwater and surface water of barium (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	6.3×10^{-5}	(a)	6.3×10^{-5}	2.9×10^{-4}	1.9×10^{-4}	2.2×10^{-5}	1.9×10^{-4}	7.2×10^{-4}	(a)	(a)	(a)	(a)
	Time (yr)	9975	(a)	9975	9975	7945	8435	7945	6475	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	(a)	(a)	2.6×10^{-6}	(a)	(a)	(a)	4.0×10^{-6}	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-16. Concentrations in groundwater and surface water of fluoride (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.1×10^{-2}	6.5×10^{-2}	1.1×10^{-2}	4.2×10^{-1}	1.2×10^{-2}	1.3×10^{-2}	1.2×10^{-2}	7.4×10^{-1}	2.6×10^{-3}	9.1×10^{-3}	2.6×10^{-3}	5.1×10^{-1}
	Time (yr)	105	105	105	105	35	35	35	35	105	105	105	105
	Barnwell-McBean	2.0×10^{-1}	2.1×10^{-1}	2.0×10^{-1}	1.9	1.2×10^{-2}	1.2×10^{-2}	1.2×10^{-2}	9.5×10^{-1}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0
	Time (yr)	1015	105	1015	105	1015	105	1015	105	1015	105	1015	105
	Congaree	1.1×10^{-3}	1.2×10^{-3}	1.1×10^{-3}	1.0×10^{-2}	2.2×10^{-3}	3.1×10^{-3}	2.2×10^{-3}	2.7×10^{-1}	1.2×10^{-3}	1.3×10^{-3}	1.2×10^{-3}	1.4×10^{-1}
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
100-meter well	Water Table	3.8×10^{-3}	1.2×10^{-2}	3.8×10^{-3}	1.1×10^{-1}	3.2×10^{-3}	3.6×10^{-3}	3.2×10^{-3}	3.3×10^{-1}	6.0×10^{-4}	1.8×10^{-3}	6.0×10^{-4}	1.3×10^{-1}
	Time (yr)	105	105	105	105	35	35	35	35	105	105	105	105
	Barnwell-McBean	4.5×10^{-2}	4.7×10^{-2}	4.5×10^{-2}	5.0×10^{-1}	2.3×10^{-3}	2.4×10^{-3}	2.3×10^{-3}	2.2×10^{-1}	1.7×10^{-3}	1.7×10^{-3}	1.7×10^{-3}	1.7×10^{-1}
	Time (yr)	1015	105	1015	105	1015	35	1015	35	1015	105	1015	105
	Congaree	2.0×10^{-4}	2.2×10^{-4}	2.0×10^{-4}	2.1×10^{-3}	3.5×10^{-4}	6.0×10^{-4}	3.5×10^{-4}	4.8×10^{-2}	1.7×10^{-4}	2.0×10^{-4}	1.7×10^{-4}	2.1×10^{-2}
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
Seepline	Water Table	1.8×10^{-4}	7.0×10^{-4}	1.8×10^{-4}	8.4×10^{-3}	1.5×10^{-4}	1.7×10^{-4}	1.5×10^{-4}	1.6×10^{-2}	1.9×10^{-5}	8.4×10^{-5}	1.9×10^{-5}	7.8×10^{-3}
	Time (yr)	105	105	105	105	35	35	35	35	105	105	105	105
	Barnwell-McBean	1.1×10^{-3}	1.4×10^{-3}	1.1×10^{-3}	2.0×10^{-2}	6.3×10^{-5}	8.0×10^{-5}	6.3×10^{-5}	5.9×10^{-3}	5.5×10^{-5}	5.5×10^{-5}	5.5×10^{-5}	4.1×10^{-3}
	Time (yr)	1015	105	1015	105	1085	175	1085	175	1085	175	1085	105
	Congaree	5.8×10^{-6}	6.3×10^{-6}	5.8×10^{-6}	6.8×10^{-5}	5.6×10^{-6}	8.1×10^{-6}	5.6×10^{-6}	5.5×10^{-4}	1.6×10^{-6}	1.9×10^{-6}	1.6×10^{-6}	1.8×10^{-4}
	Time (yr)	1085	175	1085	175	1225	315	1225	315	1225	315	1225	315
Surface Water	Water Table	1.2×10^{-6}	4.8×10^{-6}	1.2×10^{-6}	6.1×10^{-5}	(a)	(a)	(a)	3.0×10^{-6}	(a)	(a)	(a)	3.5×10^{-5}
	Time (yr)	105	105	105	105	(a)	(a)	(a)	35	(a)	(a)	(a)	105
	Barnwell-McBean	5.7×10^{-6}	7.3×10^{-6}	5.7×10^{-6}	1.1×10^{-4}	(a)	(a)	(a)	1.1×10^{-6}	(a)	(a)	(a)	1.4×10^{-5}
	Time (yr)	1015	105	1015	105	(a)	(a)	(a)	175	(a)	(a)	(a)	105
	Congaree	(a)	(a)	(a)	1.8×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	5.8×10^{-6}
	Time (yr)	(a)	(a)	(a)	175	(a)	(a)	(a)	(a)	(a)	(a)	(a)	315

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-17. Concentrations in groundwater and surface water of chromium (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	2.1×10^{-2}	8.5×10^{-3}	2.1×10^{-2}	1.9×10^{-1}	5.4×10^{-3}	2.7×10^{-3}	5.4×10^{-3}	3.2×10^{-1}	3.6×10^{-3}	1.8×10^{-3}	3.6×10^{-3}	2.1×10^{-1}
	Time (yr)	1715	1925	1715	805	1645	1855	1645	805	1575	1785	1575	805
	Barnwell-McBean	2.3×10^{-2}	1.9×10^{-2}	2.3×10^{-2}	3.8×10^{-1}	2.9×10^{-6}	1.1×10^{-5}	2.9×10^{-6}	3.8×10^{-3}	1.4×10^{-6}	1.4×10^{-5}	1.4×10^{-6}	3.7×10^{-3}
	Time (yr)	3745	4025	3745	2065	9975	9975	9975	9975	9975	9975	9975	9975
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	2.7×10^{-3}	1.5×10^{-3}	2.7×10^{-3}	3.5×10^{-2}	7.6×10^{-4}	5.4×10^{-4}	7.6×10^{-4}	7.4×10^{-2}	5.2×10^{-4}	4.1×10^{-4}	5.2×10^{-4}	3.4×10^{-2}
	Time (yr)	1855	2065	1855	945	1995	2415	1995	1155	2065	2065	2065	1155
	Barnwell-McBean	4.4×10^{-3}	3.7×10^{-3}	4.4×10^{-3}	8.1×10^{-2}	(a)	1.2×10^{-6}	(a)	3.8×10^{-4}	(a)	1.4×10^{-6}	(a)	4.3×10^{-4}
	Time (yr)	4165	4305	4165	2485	(a)	9975	(a)	9975	(a)	9975	(a)	9975
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	3.1×10^{-5}	2.9×10^{-5}	3.1×10^{-5}	5.2×10^{-4}	1.5×10^{-5}	1.3×10^{-5}	1.5×10^{-5}	1.0×10^{-3}	9.2×10^{-6}	9.2×10^{-6}	9.2×10^{-6}	4.4×10^{-4}
	Time (yr)	4865	4865	4865	3955	5495	5565	5495	4235	6265	5775	6265	4935
	Barnwell-McBean	4.6×10^{-5}	4.5×10^{-5}	4.6×10^{-5}	8.0×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	9625	9625	9625	8015	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	3.7×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	2.0×10^{-6}
	Time (yr)	(a)	(a)	(a)	4095	(a)	(a)	(a)	(a)	(a)	(a)	(a)	4935
	Barnwell-McBean	(a)	(a)	(a)	4.2×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	7945	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-18. Concentrations in groundwater and surface water of copper (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	6.0×10^{-3}	4.6×10^{-3}	6.0×10^{-3}	6.2×10^{-2}	9.0×10^{-4}	7.1×10^{-4}	9.0×10^{-4}	6.6×10^{-2}	4.5×10^{-4}	3.4×10^{-4}	4.5×10^{-4}	2.9×10^{-2}
	Time (yr)	2765	2905	2765	1295	2695	2835	2695	1295	2555	2695	2555	1295
	Barnwell-McBean	9.4×10^{-3}	8.8×10^{-3}	9.4×10^{-3}	1.5×10^{-1}	(a)	(a)	(a)	8.0×10^{-4}	(a)	(a)	(a)	6.5×10^{-4}
	Time (yr)	6195	6405	6195	3115	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975
	Congaree	(a)	(a)	(a)	5.2×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9835	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	7.6×10^{-4}	6.8×10^{-4}	7.6×10^{-4}	1.1×10^{-2}	1.2×10^{-4}	1.1×10^{-4}	1.2×10^{-4}	1.4×10^{-2}	4.5×10^{-5}	4.7×10^{-5}	4.5×10^{-5}	4.2×10^{-3}
	Time (yr)	3255	3465	3255	1785	3465	4025	3465	2135	3465	3745	3465	2345
	Barnwell-McBean	1.5×10^{-3}	1.6×10^{-3}	1.5×10^{-3}	2.7×10^{-2}	(a)	(a)	(a)	2.0×10^{-5}	(a)	(a)	(a)	2.4×10^{-5}
	Time (yr)	6895	7385	6895	4095	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	7.9×10^{-6}	8.1×10^{-6}	7.9×10^{-6}	1.2×10^{-4}	1.5×10^{-6}	1.6×10^{-6}	1.5×10^{-6}	1.6×10^{-4}	(a)	(a)	(a)	4.0×10^{-5}
	Time (yr)	9975	9975	9975	8505	9835	9975	9835	9835	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	1.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9905	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-19. Concentrations in groundwater and surface water of iron (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	2.6	2.7	2.6	3.0×10^{1}	1.1	1.1	1.1	8.2×10^{1}	4.8×10^{-1}	4.8×10^{-1}	4.8×10^{-1}	2.9×10^{1}
	Time (yr)	1575	735	1575	385	1575	665	1575	385	1505	665	1505	385
	Barnwell-McBean	4.7	4.7	4.7	7.4×10^{1}	4.5×10^{-1}	4.5×10^{-1}	4.5×10^{-1}	6.2×10^{1}	2.2×10^{-1}	2.1×10^{-1}	2.2×10^{-1}	2.6×10^{1}
	Time (yr)	2485	1645	2485	805	3605	2695	3605	1575	3465	2485	3465	1435
	Congaree	5.9×10^{-3}	6.0×10^{-3}	5.9×10^{-3}	7.6×10^{-2}	1.5×10^{-2}	2.5×10^{-2}	1.5×10^{-2}	2.6	4.1×10^{-3}	6.2×10^{-3}	4.1×10^{-3}	6.1×10^{-1}
	Time (yr)	4795	4095	4795	2695	9975	9905	9975	9345	9975	9975	9975	9835
100-meter well	Water Table	3.4×10^{-1}	3.3×10^{-1}	3.4×10^{-1}	4.7	1.3×10^{-1}	1.4×10^{-1}	1.3×10^{-1}	1.1×10^{1}	7.4×10^{-2}	7.6×10^{-2}	7.4×10^{-2}	4.6
	Time (yr)	1785	875	1785	595	1995	1085	1995	735	1925	1085	1925	875
	Barnwell-McBean	7.4×10^{-1}	7.2×10^{-1}	7.4×10^{-1}	1.3×10^{1}	6.2×10^{-2}	6.4×10^{-2}	6.2×10^{-2}	7.1	4.7×10^{-2}	4.5×10^{-2}	4.7×10^{-2}	3.7
	Time (yr)	2835	1925	2835	1225	4445	3535	4445	2275	4095	3185	4095	1995
	Congaree	1.1×10^{-3}	1.1×10^{-3}	1.1×10^{-3}	1.6×10^{-2}	2.1×10^{-3}	4.2×10^{-3}	2.1×10^{-3}	3.9×10^{-1}	9.2×10^{-4}	1.5×10^{-3}	9.2×10^{-4}	1.2×10^{-1}
	Time (yr)	4865	3955	4865	2695	9975	9975	9975	9695	9975	9905	9975	9345
Seepline	Water Table	3.9×10^{-3}	3.9×10^{-3}	3.9×10^{-3}	6.0×10^{-2}	2.3×10^{-3}	2.4×10^{-3}	2.3×10^{-3}	1.6×10^{-1}	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	7.7×10^{-2}
	Time (yr)	4585	3605	4585	3255	5145	4165	5145	3675	5425	4585	5425	4305
	Barnwell-McBean	5.8×10^{-3}	5.8×10^{-3}	5.8×10^{-3}	9.2×10^{-2}	1.7×10^{-4}	3.3×10^{-4}	1.7×10^{-4}	3.1×10^{-2}	7.9×10^{-4}	7.9×10^{-4}	7.9×10^{-4}	4.6×10^{-2}
	Time (yr)	7665	6825	7665	6055	9975	9975	9975	9975	9065	8225	9065	6895
	Congaree	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	4.1×10^{-4}	(a)	(a)	(a)	2.8×10^{-4}	(a)	(a)	(a)	7.3×10^{-5}
	Time (yr)	6405	5495	6405	4445	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975
Surface Water	Water Table	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	4.2×10^{-4}	(a)	(a)	(a)	3.7×10^{-5}	6.2×10^{-6}	6.2×10^{-6}	6.2×10^{-6}	3.5×10^{-4}
	Time (yr)	4445	3535	4445	3255	(a)	(a)	(a)	3815	5635	4725	5635	4235
	Barnwell-McBean	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	4.9×10^{-4}	(a)	(a)	(a)	5.6×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	1.7×10^{-4}
	Time (yr)	7665	6825	7665	6195	(a)	(a)	(a)	9905	8785	7945	8785	6615
	Congaree	(a)	(a)	(a)	1.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	2.6×10^{-6}
	Time (yr)	(a)	(a)	(a)	4585	(a)	(a)	(a)	(a)	(a)	(a)	(a)	9975

(a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-20. Concentrations in groundwater and surface water of mercury (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	2.6×10^{-5}	3.6×10^{-5}	2.6×10^{-5}	1.6×10^{-3}	1.4×10^{-3}	7.4×10^{-4}	1.4×10^{-3}	1.2×10^{-1}	(a)	(a)	(a)	1.2×10^{-1}
	Time (yr)	9975	9975	9975	9975	9835	5285	9835	9975	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	2.7×10^{-6}	(a)	1.3×10^{-4}	3.0×10^{-5}	5.3×10^{-5}	3.0×10^{-5}	5.3×10^{-3}	(a)	(a)	(a)	2.8×10^{-5}
	Time (yr)	(a)	9975	(a)	9905	9975	9975	9975	9975	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-21. Concentrations in groundwater and surface water of nitrate (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.2×10^{-1}	6.7×10^{-1}	4.2×10^{3}	4.8	2.3×10^{-1}	2.7×10^{-1}	2.4×10^{4}	1.5×10^{1}	7.5×10^{-2}	2.5×10^{-1}	8.7×10^{3}	1.3×10^{1}
	Time (yr)	105	105	385	105	35	35	35	35	105	105	245	105
	Barnwell-McBean	2.1	2.2	4.4×10^{4}	2.2×10^{1}	2.8×10^{-1}	2.8×10^{-1}	3.5×10^{4}	2.3×10^{1}	2.9×10^{-1}	2.9×10^{-1}	3.4×10^{4}	2.7×10^{1}
	Time (yr)	1015	105	1015	105	1015	105	1015	105	1015	105	1015	105
	Congaree	1.2×10^{-2}	1.2×10^{-2}	4.2×10^{2}	1.2×10^{-1}	5.2×10^{-2}	7.2×10^{-2}	1.6×10^{4}	6.2	3.2×10^{-2}	3.7×10^{-2}	5.3×10^{3}	3.4
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
100-meter well	Water Table	3.9×10^{-2}	1.3×10^{-1}	1.0×10^{3}	1.3	6.5×10^{-2}	7.6×10^{-2}	6.8×10^{3}	6.9	2.1×10^{-2}	6.0×10^{-2}	2.3×10^{3}	3.6
	Time (yr)	105	105	1015	105	35	35	35	35	105	105	1015	105
	Barnwell-McBean	4.7×10^{-1}	4.9×10^{-1}	1.8×10^{4}	5.8	6.1×10^{-2}	6.1×10^{-2}	1.4×10^{4}	4.6	5.9×10^{-2}	5.9×10^{-2}	9.9×10^{3}	4.6
	Time (yr)	1015	105	1015	105	1015	105	1015	35	1015	105	1015	105
	Congaree	2.0×10^{-3}	2.3×10^{-3}	7.1×10^{1}	2.4×10^{-2}	8.9×10^{-3}	1.4×10^{-2}	2.1×10^{3}	1.1	5.6×10^{-3}	6.9×10^{-3}	9.3×10^{2}	5.6×10^{-1}
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
Seepline	Water Table	1.8×10^{-3}	7.4×10^{-3}	5.8×10^{1}	1.0×10^{-1}	3.1×10^{-3}	4.2×10^{-3}	3.0×10^{2}	3.4×10^{-1}	9.8×10^{-4}	3.5×10^{-3}	1.5×10^{2}	2.2×10^{-1}
	Time (yr)	105	105	1015	105	35	105	35	35	1015	105	1015	105
	Barnwell-McBean	1.2×10^{-2}	1.5×10^{-2}	4.2×10^{2}	2.4×10^{-1}	1.7×10^{-3}	2.1×10^{-3}	3.3×10^{2}	1.5×10^{-1}	2.5×10^{-3}	2.5×10^{-3}	4.2×10^{2}	1.1×10^{-1}
	Time (yr)	1015	105	1085	105	1085	175	1085	175	1085	175	1085	105
	Congaree	6.1×10^{-5}	6.5×10^{-5}	2.3	8.1×10^{-4}	1.5×10^{-4}	2.0×10^{-4}	3.0×10^{1}	1.3×10^{-2}	7.0×10^{-5}	8.5×10^{-5}	1.2×10^{1}	5.1×10^{-3}
	Time (yr)	1085	175	1085	175	1225	315	1225	315	1225	315	1225	315
Surface Water	Water Table	1.2×10^{-5}	5.0×10^{-5}	3.9×10^{-1}	7.3×10^{-4}	(a)	(a)	5.5×10^{-2}	6.5×10^{-5}	4.4×10^{-6}	1.5×10^{-5}	6.6×10^{-1}	9.9×10^{-4}
	Time (yr)	105	105	1015	105	(a)	(a)	35	35	1015	105	1015	105
	Barnwell-McBean	5.9×10^{-5}	7.7×10^{-5}	2.3	1.3×10^{-3}	(a)	(a)	6.0×10^{-2}	2.7×10^{-5}	9.3×10^{-6}	9.4×10^{-6}	1.6	4.1×10^{-4}
	Time (yr)	1015	105	1085	105	(a)	(a)	1085	175	1085	175	1085	105
	Congaree	1.6×10^{-6}	1.7×10^{-6}	5.9×10^{-2}	2.2×10^{-5}	(a)	(a)	3.8×10^{-2}	1.7×10^{-5}	2.3×10^{-6}	2.8×10^{-6}	3.8×10^{-1}	1.7×10^{-4}
	Time (yr)	1085	175	1085	175	(a)	(a)	1225	315	1225	315	1225	315

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-22. Concentrations in groundwater and surface water of manganese (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.9×10^{-1}	2.2×10^{-1}	1.9×10^{-1}	2.2	2.9×10^{-1}	3.5×10^{-1}	2.9×10^{-1}	2.5×10^{1}	5.5×10^{-2}	6.2×10^{-2}	5.5×10^{-2}	4.0
	Time (yr)	1995	875	1995	455	1295	245	1295	245	1925	805	1925	455
	Barnwell-McBean	3.6×10^{-1}	3.8×10^{-1}	3.6×10^{-1}	5.5	2.2×10^{-2}	4.5×10^{-2}	2.2×10^{-2}	6.0	1.8×10^{-2}	2.0×10^{-2}	1.8×10^{-2}	2.2
	Time (yr)	3115	1925	3115	945	5145	2765	5145	2415	4445	3885	4445	2415
	Congaree	2.4×10^{-4}	2.4×10^{-4}	2.4×10^{-4}	3.6×10^{-3}	1.3×10^{-6}	1.6×10^{-4}	1.3×10^{-6}	3.1×10^{-2}	(a)	8.7×10^{-6}	(a)	4.9×10^{-3}
	Time (yr)	6405	5425	6405	4795	9975	9975	9975	9975	(a)	9975	(a)	9975
100-meter well	Water Table	2.8×10^{-2}	3.1×10^{-2}	2.8×10^{-2}	7.0×10^{-1}	4.3×10^{-2}	3.9×10^{-2}	4.3×10^{-2}	4.1	6.4×10^{-3}	6.5×10^{-3}	6.4×10^{-3}	5.6×10^{-1}
	Time (yr)	2205	1085	2205	805	1715	665	1715	665	2345	1155	2345	875
	Barnwell-McBean	6.2×10^{-2}	6.1×10^{-2}	6.2×10^{-2}	1.6	6.2×10^{-3}	1.1×10^{-2}	6.2×10^{-3}	1.3	2.8×10^{-3}	3.2×10^{-3}	2.8×10^{-3}	3.5×10^{-1}
	Time (yr)	3535	2345	3535	1505	6125	3675	6125	3045	5215	4445	5215	3115
	Congaree	4.6×10^{-5}	4.6×10^{-5}	4.6×10^{-5}	1.1×10^{-3}	(a)	3.0×10^{-5}	(a)	6.0×10^{-3}	(a)	(a)	(a)	6.3×10^{-4}
	Time (yr)	6755	5705	6755	4585	(a)	9975	(a)	9975	(a)	(a)	(a)	9975
Seepline	Water Table	3.8×10^{-4}	3.8×10^{-4}	3.8×10^{-4}	1.2×10^{-2}	5.4×10^{-4}	5.5×10^{-4}	5.4×10^{-4}	4.7×10^{-2}	6.8×10^{-5}	6.7×10^{-5}	6.8×10^{-5}	6.4×10^{-3}
	Time (yr)	5215	4165	5215	3535	5215	4305	5215	3815	6195	5005	6195	4585
	Barnwell-McBean	5.6×10^{-4}	5.6×10^{-4}	5.6×10^{-4}	1.8×10^{-2}	4.0×10^{-6}	4.2×10^{-5}	4.0×10^{-6}	5.4×10^{-3}	3.4×10^{-5}	3.7×10^{-5}	3.4×10^{-5}	3.7×10^{-3}
	Time (yr)	8855	7805	8855	6545	9975	9975	9975	9975	9905	9485	9905	8155
	Congaree	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	4.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	8225	7175	8225	6335	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	2.5×10^{-6}	2.5×10^{-6}	2.5×10^{-6}	8.5×10^{-5}	(a)	(a)	(a)	9.5×10^{-6}	(a)	(a)	(a)	2.8×10^{-5}
	Time (yr)	5215	4165	5215	3745	(a)	(a)	(a)	4025	(a)	(a)	(a)	4515
	Barnwell-McBean	2.9×10^{-6}	2.9×10^{-6}	2.9×10^{-6}	9.8×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	1.3×10^{-5}
	Time (yr)	8785	7735	8785	7035	(a)	(a)	(a)	(a)	(a)	(a)	(a)	7875
	Congaree	(a)	(a)	(a)	1.1×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	6335	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L

Table C.4.1-23. Concentrations in groundwater and surface water of nickel (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.0×10^{-4}	2.2×10^{-5}	1.0×10^{-4}	1.1×10^{-1}	4.8×10^{-3}	4.7×10^{-3}	4.8×10^{-3}	2.9×10^{-1}	5.8×10^{-4}	2.4×10^{-4}	5.8×10^{-4}	5.9×10^{-2}
	Time (yr)	9975	9975	9975	6335	5495	4725	5495	5285	9975	9975	9975	6335
	Barnwell-McBean	(a)	(a)	(a)	6.7×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	(a)	(a)	1.9×10^{-2}	2.9×10^{-4}	3.4×10^{-4}	2.9×10^{-4}	3.4×10^{-2}	(a)	(a)	(a)	3.4×10^{-3}
	Time (yr)	(a)	(a)	(a)	9905	9975	9975	9975	9905	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-24. Concentrations in groundwater and surface water of lead (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	5.2×10^{-4}	2.9×10^{-4}	5.2×10^{-4}	2.3×10^{-2}	7.3×10^{-4}	2.0×10^{-4}	7.3×10^{-4}	8.5×10^{-2}	3.9×10^{-4}	1.4×10^{-5}	3.9×10^{-4}	3.0×10^{-2}
	Time (yr)	9975	6055	9975	6475	9975	3745	9975	6965	9975	9975	9975	6545
	Barnwell-McBean	(a)	(a)	(a)	1.3×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	8.3×10^{-5}	8.0×10^{-5}	8.3×10^{-5}	4.2×10^{-3}	3.7×10^{-5}	3.4×10^{-5}	3.7×10^{-5}	8.1×10^{-3}	(a)	(a)	(a)	2.9×10^{-3}
	Time (yr)	8575	8505	8575	9765	9975	9765	9975	9975	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-25. Concentrations in groundwater and surface water of uranium (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	7.6×10^{-5}	4.0×10^{-5}	4.0×10^{-5}	4.0×10^{-5}	1.7×10^{-4}	3.7×10^{-5}	3.7×10^{-5}	3.7×10^{-5}	2.2×10^{-4}
	Time (yr)	8365	7035	8365	9975	9975	8925	9975	9695	9695	8785	9695	9345
	Barnwell-McBean	(a)	1.4×10^{-6}	(a)	1.5×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	9975	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	6.4×10^{-6}	6.5×10^{-6}	6.4×10^{-6}	4.5×10^{-5}	1.3×10^{-5}	1.3×10^{-5}	1.3×10^{-5}	1.0×10^{-4}	1.3×10^{-5}	1.3×10^{-5}	1.3×10^{-5}	1.3×10^{-4}
	Time (yr)	8995	8435	8995	9695	9485	8505	9485	9485	9975	9065	9975	9135
	Barnwell-McBean	(a)	(a)	(a)	6.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-26. Concentrations in groundwater and surface water of zinc (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	4.4×10^{-3}	4.4×10^{-3}	4.4×10^{-3}	8.7×10^{-2}	6.7×10^{-4}	4.8×10^{-4}	6.7×10^{-4}	5.4×10^{-2}	1.5×10^{-3}	1.5×10^{-3}	1.5×10^{-3}	2.4×10^{-2}
	Time (yr)	2135	1155	2135	595	2135	1225	2135	1925	2555	1645	2555	1015
	Barnwell-McBean	3.3×10^{-3}	5.7×10^{-3}	3.3×10^{-3}	1.3×10^{-1}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	9975	9975	9975	5425	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	1.5×10^{-3}	1.5×10^{-3}	1.5×10^{-3}	2.8×10^{-2}	1.6×10^{-4}	1.6×10^{-4}	1.6×10^{-4}	1.5×10^{-2}	7.4×10^{-4}	7.4×10^{-4}	7.4×10^{-4}	1.1×10^{-2}
	Time (yr)	2205	1295	2205	735	2345	1435	2345	2205	2975	2065	2975	1295
	Barnwell-McBean	1.2×10^{-3}	1.2×10^{-3}	1.2×10^{-3}	3.2×10^{-2}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	7315	6335	7315	5845	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	2.3×10^{-5}	2.3×10^{-5}	2.3×10^{-5}	5.5×10^{-4}	3.7×10^{-6}	3.7×10^{-6}	3.7×10^{-6}	5.3×10^{-4}	2.3×10^{-5}	2.3×10^{-5}	2.3×10^{-5}	3.1×10^{-4}
	Time (yr)	8855	7875	8855	4375	5005	4165	5005	4375	5775	4865	5775	4515
	Barnwell-McBean	9.3×10^{-6}	1.8×10^{-5}	9.3×10^{-6}	9.0×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	9975	9975	9975	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	3.9×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	1.4×10^{-6}
	Time (yr)	(a)	(a)	(a)	4375	(a)	(a)	(a)	(a)	(a)	(a)	(a)	4165
	Barnwell-McBean	(a)	(a)	(a)	4.7×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

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a. Concentration is less than 1×10^{-6} mg/L.

concentration values at the seepline are not additive. Therefore, DOE used only the maximum seepline concentration for Fourmile Branch and Upper Three Runs from the alternatives in its comparison of impacts among the alternatives.

C.4.2 ECOLOGICAL RISK ASSESSMENT

C.4.2.1 Nonradiological Analysis

H-Area: Upper Three Runs – Barnwell McBean, Water Table, and Congaree Aquifers

Aquatic Hazard Quotients (HQs) for each contaminant were summed to obtain an aquatic Hazard Index (HI). All HIs were less than 1.0 for all four alternatives. All terrestrial HQs for the shrew and the mink were less than 1.0 for all four scenarios: (Tables C.4.2-1 through C.4.2-4). Thus potential risks to ecological receptors at and downgradient of the Upper Three Runs seeps (from all aquifers under H-Area) are negligible.

H-Area: Fourmile Branch – Barnwell McBean and Water Table Aquifers, Upper Three Runs – Congaree Aquifers

Aquatic HQs for each contaminant were summed to obtain an aquatic Hazard Index (HI). All HIs were less than 1.0 for the four scenarios. All terrestrial HQs for the shrew and the mink were less than 1.0 for these alternatives and options (Tables C.4.2-5 through C.4.2-8). Thus potential H risks to ecological receptors at and downgradient of the Fourmile Branch seep (from the Barnwell McBean and Water Table Aquifers and under H-Area) are negligible, as are those for the Congaree at Upper Three Runs.

F-Area: Fourmile Branch – Barnwell McBean and Water Table Aquifers; Upper Three Runs – Congaree Aquifer

Aquatic HQs for each contaminant were summed to obtain an aquatic Hazard Index (HI). All aquatic HIs were less than 1.0 for the Clean and Fill with Sand and Clean and Fill with Saltstone Options. The maximum HI for the Clean and Fill with Grout Option with the Water Table Aquifer was 1.42. In addition, HIs for the No Action Alternative with the Barnwell McBean and Water Table Aquifers were greater than 1.0: 2.0 and 1.42, respectively. This suggests some potential risks, although the relatively low HI values suggest that these risks are generally low. HQs for the shrew and the mink were less than 1.0 for all four scenarios (Tables C.4.2-9 through C.4.2-12). The exception was a silver HQ of 1.55 for the shrew under the No Action Alternative (Barnwell-McBean Aquifer). Although this indicates that risks are possible at the Fourmile Branch seep (via groundwater under F-Area), the relatively low HQ suggests that these risks are somewhat low.

C.4.2.2 Radiological Analysis

Calculated absorbed doses to the referenced organisms are presented in Tables C.4-2-13 through C.4.2-21. All calculated doses are below the regulatory limit of 365,000 mrad per year (365 rad per year).

C.5 Ecological Risk Assessment Uncertainties

Most of the data and assumptions used in the exposure calculations (exclusive of the exposure concentrations, which were calculated by the groundwater model) are average or midpoint values. Uncertainty for these values is largely a question of precision in measurement or variability about these points. However, two assumptions are conservative, meaning that they are likely to overestimate risk.

The relationship between seep area and home range has already been mentioned; the lack of correction for home range is likely to overestimate risk to an individual shrew by a factor of two and to an individual mink by a factor greater than ten. The other assumption is that when contaminants in seepage adsorb to the soil, they are not removed from the water. In other words, the seepage concentration is used to predict soil concentrations and downstream water concentrations without adjustment for losses.

Table C.4.2-1. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Grout Option.

	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1 × 10^{-2}.
NA = Not applicable.

Table C.4.2-2. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Sand Option.

	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1 × 10^{-2}.
NA = Not applicable.

Table C.4.2-3. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Saltstone Option.

	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
NA = Not applicable.

Table C.4.2-4. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), No Action Alternative.

	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	2.19×10^{-2}	3.94×10^{-2}	4,235
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	2.43×10^{-2}	5.76×10^{-2}	175	b	b	NA	6.6×10^{-2}	1.56×10^{-1}	35
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	1.93×10^{-2}	3.54×10^{-2}	2,065	b	b	NA	2.41×10^{-1}	4.43×10^{-1}	175
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
NA = Not applicable.

Table C.4.2-5. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Grout Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1 × 10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-6. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Sand Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.

b. HQ is less than ~ 1×10^{-2}.

c. Congaree Aquifer discharges to Upper Three Runs for this scenario.

NA = Not applicable.

Table C.4.2-7. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Saltstone Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

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a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-8. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), No Action Alternative.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	1.69×10^{-2}	4.0×10^{-2}	105	b	b	NA	3.22×10^{-2}	7.61×10^{-2}	105
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	2.21×10^{-2}	4.06×10^{-2}	245
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-9. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Grout Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	1.14×10^{-2}	2.05×10-2	3,955
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	1.07×10^{-2}	1,015	b	b	NA	3.47×10^{-2}	8.2×10^{-2}	105
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	6.83×10^{-2}	1.25×10^{-1}	1,365	b	b	NA	4.42×10^{-1}	8.12×0^{-1}	245
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1 × 10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-10. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Sand Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	1.37×10^{-2}	105	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	4.82×10^{-2}	8.85×10^{-2}	525	b	b	NA	2.33×10^{-2}	4.28×10^{-2}	315
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-11. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Saltstone Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	1.07×10^{-2}	1,105	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	6.83×10^{-2}	1.25×10^{-1}	1,365	b	b	NA	2.85×10^{-2}	5.24×10^{-2}	1,085
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than $\sim 1 \times 10^{-2}$.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-12. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), No Action Alternative

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
Analyte	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	1.76×10^{-2}	3.15×10^{-2}	8,015	b	b	NA	1.14×10^{-2}	2.05×10^{-2}	3,955
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	8.25×10^{-2}	1.95×10^{-1}	105	b	b	NA	3.47×10^{-2}	8.2×10^{-2}	105
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	8.44×10^{-1}	1.55	455	b	b	NA	4.42×10^{-1}	8.12×10^{-1}	245
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

---

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-13. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for F-Area Tank Farm – Water Table Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	0.0027	0.0016	0.025	0.49
Shrew dose	10.1	6.3	94.9	2,530
Mink dose	1.1	0.9	9.9	1,690

Table C.4.2-14. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for F-Area Area Tank Farm – Barnwell-McBean Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	0.0038	0.0072	0.053	0.89
Shrew dose	18.7	34.5	372	4,320
Mink dose	2.0	3.6	265	452

Table C.4.2-15. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for F-Area Tank Farm – Congaree Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	6.7×10^{-5}	8.9×10^{-5}	0.002	0.016
Shrew dose	0.1	0.1	1.9	15.8
Mink dose	0	0	0.2	1.7

Table C.4.2-16. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Four Mile Branch – Water Table Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	0.0014	0.0023	0.027	0.35
Shrew dose	9.5	14.4	158.9	2,260
Mink dose	1.0	1.5	17.8	669.1

Table C.4.2-17. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Four Mile Branch – Barnwell-McBean Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	2.2×10^{-4}	0.0011	0.018	0.21
Shrew dose	0.2	8.3	126.6	1,580
Mink dose	0	0.9	13.3	165.7

Table C.4.2-18. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Four Mile Branch – Congaree Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	4.8×10^{-4}	2.8×10^{-4}	0.0095	0.061
Shrew dose	3.5	0.2	7.6	47.5
Mink dose	0.4	0	0.8	5.0

Table C.4.2-19. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Upper Three Runs – Water Table Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	2.1×10^{-4}	0.0017	0.0037	0.039
Shrew dose	24.8	244.5	460.5	24,450
Mink dose	3.3	25.6	48.7	2,560

Table C.4.2-20. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Upper Three Runs – Barnwell-McBean Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	5.4×10^{-5}	3.1×10^{-4}	0.0016	0.014
Shrew dose	7.5	44.6	230.1	4,890
Mink dose	0.8	4.7	24.1	512

Table C.4.2-21. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Upper Three Runs – Congaree Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	4.8×10^{-5}	1.3×10^{-4}	0.0016	0.012
Shrew dose	1.0	2.7	31.6	244.5
Mink dose	0.1	0.3	3.3	25.6

Uncertainty in the toxicity assessment includes the selection of a particular dose and the factors applied to ensure that it is protective. The fluoride dose selected as a threshold, a LOAEL of 5 milligram per kilogram per day associated with relatively less serious effects in rats and minks, could have been a higher dose based on effects more likely to cause decreased fitness. The data base available for silver toxicity is not good, and this is reflected in the high uncertainty factor (100X) used to lower the selected dose.

Because toxicity data is mostly limited to individual responses, a risk assessment is usually limited to the probability of risk to an individual. This makes the evaluation of risk to populations, communities, and ecosystems a speculative and uncertain undertaking, even though characterization of risks to populations is the typical goal of an ecological risk assessment. In the case of the seep, it is reasonable to assume that terrestrial effects will be limited to this area because the contaminants have not been shown to bioaccumulate in terrestrial systems. Surface water is the only likely pathway for contaminants to exit the seep area. [Mercury is known to accumulate in aquatic food chains, but only a minimal amount of mercury is transported to the seepline during the 10,000 year modeled time period.]

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APPENDIX D

PUBLIC SCOPING SUMMARY

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APPENDIX D. PUBLIC SCOPING SUMMARY

This Appendix describes how DOE defined the scope of the *Savannah River Site High-Level Waste Tank Systems Closure Program Environmental Impact Statement*. It also describes the comments received from the stakeholders of SRS on this planned environmental impact statement (EIS), the issues raised during the scoping process, and the DOE responses to these comments.

D.1 Scoping Process

On December 29, 1998, DOE announced its intent to prepare an EIS to assess the environmental impacts of closing the HLW tanks at the SRS in accordance with the *Industrial Wastewater Closure Plan for F-and H-Area High Level Waste Tank Systems*. The Notice of Intent began a scoping period, which extended until February 12, 1999, and announced that DOE would hold scoping meetings in Columbia and North Augusta, South Carolina during the scoping period. The scoping meetings were subsequently announced in newspapers in the vicinity of the meeting locations.

DOE encouraged SRS stakeholders and other interested parties to submit comments for consideration in the preparation of the EIS and established several methods for such submittals:

- By letter to the Savannah River Operations Office
- By voice mail using a toll-free telephone number
- By facsimile transmission (fax) using a toll-free telephone number
- By electronic mail to an address at the Savannah River Site
- Orally or in writing at public scoping meetings

DOE held scoping meetings on the planned EIS in North Augusta, South Carolina on January 14, 1999 and in Columbia, South Carolina on January 19, 1999. DOE held an afternoon and an evening session at each meeting. Each session included an introduction to the NEPA process in relation to the tank closure proposal, a description of the HLW tanks and alternatives for closure, and a video showing some aspects of the closure of Tank 17 at the SRS. Each session also included opportunities to ask questions of DOE officials and opportunities to offer comments on the scope of the EIS for the record. Transcripts of the question and answer and comment portions of the meetings are available for inspection at the DOE Public Reading Room, Gregg-Graniteville Library, University of South Carolina at Aiken, University Parkway, Aiken, South Carolina.

D.2 Summary of Scoping Comments and Issues

During the scoping period DOE received the following:

- Three comment letters
- One comment E-mail
- One recommendation from the Savannah River Site Citizens Advisory Board
- Seven verbal comments given at the scoping meetings

In these submittals and presentations, DOE identified thirty-six separate comments. The Department reviewed and categorized these comments. The following paragraphs discuss the comments and provide DOE's responses to them.

Comments Relative to the Alternatives: Six comments recommended changes or additions to the alternatives. Comments included the following:

- The scope of this EIS should be expanded to include identification of an alternative, such as ion exchange, to the In-Tank Precipitation process.

DOE Response: DOE has chosen to prepare a separate Supplemental EIS on the construction and operation of a new salt disposition technology to replace In-Tank Precipitation. The selection of a new technology is independent of tank closure, from both technical and regulatory viewpoints. The two EISs are being prepared on similar schedules, and overlap of DOE staff assigned to support the two programs ensures consistent treatment of common issues.

- The EIS should include an alternative of completely emptying the tanks and thoroughly washing them. This alternative would provide the greatest long-term protection of the environment around and down gradient of the tanks as well as the most protection to future generations.

DOE Response: This suggested alternative is essentially what would happen for both the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative.

- Any alternative for tank closure that is premised on the re-classification of residual high-level waste as "incidental waste," violates the 1982 Nuclear Waste Policy Act ("NWPA"), §§ 10101 et seq., and therefore cannot be considered as a viable alternative in the proposed EIS.

DOE Response: DOE has evaluated the characteristics of the expected residual waste relative to the DOE Order 435.1 process for incidental waste, and has concluded that the Order requirements will be met for waste left in the tanks.

- Add an alternative "Delayed Tank Closure" pending research and development activities. Delay subsequent tank closures (but not tank emptying and cleaning activities) beyond 2003; perform technology development to enable removal of residual tank waste.

DOE Response: DOE finds the "Delayed Closure" proposed alternative to be no different than no action. DOE has ongoing research and development efforts underway aimed at improving closure techniques.

- Add an alternative to have separate actions: tank removal and grouting taking place in different tanks, as needed.

DOE Response: This Draft EIS examines the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet the performance requirements for a given tank, the decisionmaker may elect to remove a tank if it is not possible to meet the performance requirements by another method. This Draft EIS examines the alternative of cleaning the tanks and removing them for appropriate disposal.

- Add the alternative "complete tank removal," with point of compliance for groundwater contamination located within F- and H-Area Tank Farms, and no reliance on long-term institutional controls for intruder scenario exposures evaluated for the impact assessment.

DOE Response: DOE has evaluated in the draft EIS potential contamination at 1 meter and 100 meters from the tank farm for each alternative. Intruder scenarios are evaluated without consideration of institutional controls after 100 years. DOE intends however, to maintain long-term institutional control, consistent with applicable regulations.

Comments Related to Data Needs: Three comments suggested data to be included. Comments included the following:

- DOE should include the total volume of waste and the total amount of each radionuclide and chemical expected to remain in the tanks.

- DOE should include a description of the grout or other material proposed to fill the tanks.

- DOE should include potential release of contaminants from closed tanks.

DOE Response: A list of radionuclides and their half-lives that may remain in the tanks is provided in the Draft EIS. See Appendix C, Table C.3.1-1. DOE has described the types of grout used to fill the tanks and provided reference to the research and development methods and results. See Appendix A, Section A.4.3. The potential for release of contaminants from closed tanks to the soil is described in the Draft EIS. Section Chapter 4, Section 4.2.1.

Comments Related to Evaluations and Analyses: Eleven comments suggested evaluations to be used or concerns about analyses. Comments included the following:

- DOE should remove one tank to see what the ground is like underneath.

DOE Response: The cost and risk to workers to remove one tank would make the suggested procedure difficult to perform. As part of the overall closure process conditions around and under the tanks would be assessed using monitoring and sampling data, and the results used as part of the closure module modeling.

- DOE should use an evaluation technique cited in a 1995 article from the Harvard School of Public Health.

DOE Response: This approach applies to setting priorities, not deciding on a particular action and, therefore, does not apply. For example, even if the evaluation recommended by this comment showed that more lives would be saved by funding public health and safety instead of closing the tanks, DOE could not do so.

- The interaction of all contamination from the tanks with all other sources at the SRS should be considered.

DOE Response: The Closure Plan requires that the process of establishing performance requirements for closure modules for individual tanks explicitly examine the sources of contamination that could interact with residual waste in the tank.

- The effects of contamination as they impact subsistence sportsmen should be included.

DOE Response: In the Draft EIS, DOE has estimated the potential health effects to a hypothetical maximally exposed individual, who drinks water, eats food (including fish), and breathes air exposed to SRS releases. In addition, the SRS Annual Environmental Monitoring report estimates the exposure of a recreational sportsman resulting from SRS releases via all pathways.

- Intergenerational concerns and long-term hazards to local ecosystems should be discussed.

DOE Response: DOE calculates adverse health effects to workers and the general public in terms of an estimated number of total fatal cancers. The calculated numbers of excess cancers reported in the Draft EIS are less than one for all alternatives. The risk of genetic effects is smaller than the latent cancer risk (on a per person-rem basis); therefore DOE does not expect any cross-generational effects from implementation of any of the alternatives.

In the Draft EIS DOE has addressed the issue of the potential for long-term hazards to ecosystems. See Chapter 4, section 4.2.3.

- Analyses should use using the data obtained from the closure of Tanks 17 and 20, including (1) data from emptying and cleaning work; (2) analyses of residual waste (predictions from process records and actual measurements); (3) worker dosimetry; (4) regulatory and legal issues; and (5) costs.

- Dosimetric records of workers performing closure of Tanks 17 and 20 must be included in the EIS, and contrasted with the EA-1164 estimates for worker exposure.

<u>DOE Response</u>: One of the primary purposes of the EIS is to incorporate lessons learned from closure of tanks 17 and 20 into actions for closure of the remainder of the tanks. DOE has used (1) data from emptying and cleaning work; (2) analyses of residual waste (predictions from process records and actual measurements); (3) worker dosimetry; and (4) cost. DOE has made the dosimetric comparisons and contrasts for workers to the extent possible given the availability of the required information.

- DOE cannot rely on the current groundwater transport modeling (MEPAS) to support the EIS conclusions.

<u>DOE Response</u>: DOE does not find the MEPAS model inadequate for representing contaminant fate and transport. The South Carolina Department of Health and Environmental Control and the Environmental Protection Agency – Region IV have concurred with DOE's use of the MEPAS code for fate and transport modeling.

- New data from recent measurements at the Nevada Test Site have shown that more rapid groundwater transport of actinides can occur via the mechanism of actinide binding with colloids, should be used in the EIS analysis.

<u>DOE Response</u>: DOE has reviewed the Nevada data. DOE finds that the data represent phenomena specific to conditions at the Nevada Test Site. The modeling for this Draft EIS represents site specific conditions wherever possible.

- Horizontal groundwater flow and tank failure due to this horizontal flow must be modeled.

<u>DOE Response</u>: DOE has performed the necessary calculations to account for the differences in groundwater flows. The results are represented in the fate and transport modeling in the Draft EIS. See Appendix C.

<u>Comments Related to Criteria and Regulations</u>: Six comments dealt with concerns about criteria used or regulatory compliance. Comments included the following:

- The EIS should clearly define the criteria for assessing technical and economic feasibility, solicit public comment on the criteria, and then should use the criteria in assessing alternatives.

<u>DOE Response</u>: The criteria for assessing technical and economic feasibility are given in the "waste incidental to reprocessing" process in DOE Order 435.1. Public input to this Order was solicited when this Order went through the standards review / development process which all DOE Orders must have.

- Ensure that the EIS data and conclusions feed into the CERCLA process to save time and costs.

<u>DOE Response</u>: DOE will ensure that the EIS data gathering and analysis supports the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) process for the ultimate closure of the Tank Farms. See Chapter 7, Section 7.3.2.

- DOE should include in the EIS a full discussion of applicable requirements of the Resource Conservation and Recovery Act, Comprehensive Emergency Response, compensation, and Liability Act, and the Nuclear Regulatory Commission (NRC) criteria.

<u>DOE Response</u>: The Draft EIS has a full discussion of applicable laws and regulations in Chapter 7.

- The choice of the seepline as the point-of-compliance for evaluation provides a highly misleading measure of the significant environmental contamination resulting from tank closure.

<u>DOE Response</u>: In addition to the point of compliance information, the Draft EIS presents estimated groundwater contamination at distances of 1 meter and 100 meters from the tank farm. See Section 4.2.

- Activities that result in residual High-Level Waste cannot be conducted with the approval of the SCDHEC if the NRC does not classify residual waste as "incidental."

- This reclassification of the residual High-Level Waste as "incidental" violates the 1982 NWPA and, accepting arguendo its legitimacy, is inconsistent with the narrow scope of the exemption for incidental waste.

DOE Response: The Draft EIS discusses the bases for determining that residual waste remaining after tank cleaning is "waste incidental to reprocessing."

Comments Related to Schedule and Process: Two comments dealt with schedule or EIS process. Comments include the following:

- Sweeping the SRS tank closure into a national program has or will slow down the process of closing the tanks at SRS.

- The EIS should be cancelled unless there are significant worker safety, public health and environmental protection issues that need to be addressed. But if the EIS proceeds, it should be done in a minimum amount of time with a minimum expenditure of funds.

DOE Response: Preparing an EIS at this time will not slow down the tank closure process. SRS is committed to closing additional tanks in 2003 in accordance with the Federal Facility Agreement. Bulk waste removal will proceed as scheduled while the EIS is being prepared. DOE will continue the EIS process. While DOE knows of no new issues, the EIS process involves a more thorough look at worker and public safety and health issues, and environmental protection issues, than was accomplished with the 1996 environmental assessment. DOE will devote the amount of funds and time necessary to complete the EIS.

Comments Covering Miscellaneous Topics: Four comments dealt with a variety of topics that do not fit in any of the areas given above. Comments include the following:

- Tanks that are being considered for closure are the same tanks that have been reported to have leaked in the past.

DOE Response: Some of the high-level waste tanks at SRS have leaked in the past. The HLW tanks are of four different designs (identified as Type I, II, III, or IV), all constructed of carbon-steel inside reinforced concrete containment vaults. The major design features and dimensions of each tank design are shown in Figure 1-5.

There are 12 Type I tanks (4 in H-Area and 8 in F-Area) that were built in 1952 and 1953. These tanks have partial-height secondary containment and active cooling. The tank tops are 9.5 feet below grade, and the bottoms of Tanks 1 through 8 in F-Area are above the seasonal high water table. The bottoms of Tanks 9 through 12 in H-Area are in the water table. Tanks 1 and 9 through 12 are known to have leak sites where waste has leaked from the primary to the secondary containment. There is no evidence that the waste has leaked from the secondary containment.

Four Type II tanks, Tanks 13 through 16, were built in 1956 in H-Area. These tanks have partial-height secondary containment and active cooling. These tanks are above the water table. All four tanks have known leak sites where waste has leaked from the primary to the secondary containment. In Tank 16, waste overflowed the annulus pan (secondary containment) and migrated into the surrounding soil. Waste removal from the Tank 16 primary vessel was completed in 1980, but waste that leaked into the annulus has not been removed.

Eight Type IV tanks, Tanks 17 through 24, were built between 1958 and 1962. These tanks have single steel walls and do not have active cooling. Tanks 17 through 20 in the F-Area Tank Farm are slightly above the water table. Tanks 19 and 20 have known cracks that are believed to have been caused by groundwater corrosion of the tank walls in the past. Small amounts of groundwater have leaked into these tanks, but there is no evidence that waste ever leaked out. Tanks 17 and 20 have been closed in the manner described in the Clean and Fill with Grout Option of the Clean and Stabilize Tanks Alternative evaluated in the EIS. Tanks 21 through 24 in the H-Area Tank Farm are above the groundwater table, but are in a perched water table, caused by the original construction of the tank area.

The newest design, Type III tanks, have a full-height secondary tank and active cooling. These 27 tanks were placed in service between 1969 and 1986, with 10 in the F-Area and 17 in the H-Area Tank Farms. All Type III tanks are above the water table.

- There is a problem in getting the solidified material from the bottom of the tanks.

DOE Response: The Draft EIS discusses the difficulty of removing sludge from the bottom of the tanks, and it describes and evaluates the options for removing such materials and stabilizing the residue that remains after cleaning.

- New SRS missions will add to the amount of high-level waste and prolong the closure.

DOE Response: DOE has recently selected SRS as the site for several new missions. The Pit Disassembly and Conversion Facility, Mixed Oxide Fuel Facility, Immobilization Facility, and the Tritium Extraction Facility will not add HLW to the current SRS inventory. Stabilizing plutonium residues from the Rocky Flats Environmental Technology Site at SRS is expected to result in the equivalent of five DWPF canisters. The melt and dilute facility for management of spent nuclear fuel would add the equivalent of 17 DWPF canisters. These canisters are in addition to the approximately 6,000 canisters DOE expects to produce absent the new missions.

- It is not reasonable for the EIS to assume that groundwater remediation could compensate for radionuclide release to the environment.

DOE Response: DOE has not assumed in the Draft EIS that groundwater remediation could compensate for long-term releases of contamination to the groundwater after tank closure. The *Industrial Waste Water Closure Plan for F- and H-Area High-Level Waste Tank Systems* also does not make this assumption.

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This section lists the individuals who contributed to the technical content of this environmental impact statement (EIS). The preparation of the EIS was directed by J. N. Knox and L. T. Ling of the U.S. Department of Energy (DOE) and P. L. Young of Tetra Tech NUS, Inc.

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TECHNICAL EXPERIENCE: Seven years in botany and plant community investigations.

EIS RESPONSIBILITY: Prepared Cultural Resources section of Chapter 3.

NAME: **JOHN KNOX**

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EDUCATION: M.S., Botany, 1974
B.S., Biology, 1972

TECHNICAL EXPERIENCE: Four years preparing or reviewing NEPA documents; 24 years in environmental analysis and environmental management.

EIS RESPONSIBILITY: Prepared Chapter 1; principal DOE reviewer of Draft EIS; contributed to Chapter 3.

NAME: **LARRY T. LING**

AFFILIATION: U. S. Department of Energy

EDUCATION: B.S., Chemical Engineering, 1982

TECHNICAL EXPERIENCE: Three years preparing or reviewing NEPA documents; over 17 years experience in nuclear facilities and systems.

EIS RESPONSIBILITY: Document Manager; DOE reviewer of Draft EIS; contributed to Chapters 1, 2, and 6, and Appendix A.

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AFFILIATION: Tetra Tech NUS, Inc.

EDUCATION: M.S., Mechanical Engineering, 1989
B.S., Chemical Engineering, 1984

TECHNICAL EXPERIENCE: Fourteen years experience in chemical-environmental engineering.

EIS RESPONSIBILITY: Prepared Waste and Materials sections of Chapters 3 and 4; prepared Utilities and Energy section of Chapter 4; prepared Chapter 7.

NAME: **PHILIP R. MOORE**

AFFILIATION: Tetra Tech NUS, Inc.

EDUCATION: M.S., Wildlife and Fisheries Biology, 1983
B.A., English, 1975

TECHNICAL EXPERIENCE: Seventeen years experience as fishery biologist and aquatic ecologist.

EIS RESPONSIBILITY: Prepared Surface Water and Ecological sections of Chapters 3 and 4.

NAME: **APARAJITA S. MORRISON**

AFFILIATION: Tetra Tech NUS, Inc.

EDUCATION: B.S., Health Physics, 1985

TECHNICAL EXPERIENCE: Eleven years experience in environmental and occupational radiological programs including management of an environmental monitoring laboratory, startup testing of nuclear instrumentation, training, and technical assessments of environmental and radiation protection programs.

EIS RESPONSIBILITY: Prepared Health and Safety sections of Chapters 3 and 4; prepared Chapter 5.

NAME: **JAMES L. OLIVER**

AFFILIATION: Tetra Tech NUS, Inc.

EDUCATION: B.S., Biology (Fisheries), 1971

TECHNICAL EXPERIENCE: Twenty-three years experience in research and impact assessment projects for the U.S. Department of Interior and DOE. Reviews environmental and natural resource management issues and performs strategic planning for National Environmental Policy Act documentation for DOE.

EIS RESPONSIBILITY: Prepared Chapter 6. Management Reviewer.

NAME: **JOSEPH W. RIVERS**

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EDUCATION: B.S., Mechanical Engineering, 1982

TECHNICAL EXPERIENCE: Three years experience in preparing NEPA documents; 16 years in commercial and DOE nuclear projects; design, systems engineering, safety and accident analysis, and regulatory compliance.

EIS RESPONSIBILITY: Prepared Accident Analysis section of Chapter 4; prepared Appendix B.

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AFFILIATION: Tetra Tech NUS, Inc.

EDUCATION: M.E., Nuclear Engineering, 1994
B.S., Nuclear Engineering Sciences, 1990

TECHNICAL EXPERIENCE: Six years in air permitting, fate and transport modeling, human health impacts, environmental compliance, and health physics.

EIS RESPONSIBILITY: Prepared Air Resources sections of Chapters 3 and 4; contributed to Appendix C.

NAME: **THOMAS TEMPLES**

AFFILIATION: U. S. Department of Energy

EDUCATION: Ph.D., Geology, 1996
M.S, Geology, 1978
B.S., Geology, 1976

TECHNICAL EXPERIENCE: Four years preparing NEPA documents; 18 years as a geophysicist.

EIS RESPONSIBILITY: Contributed to Chapter 3.

NAME: **ALAN L. TOBLIN**

AFFILIATION: Tetra Tech NUS, Inc.

EDUCATION: M.S., Chemical Engineering, 1970
B.E., Chemical Engineering, 1968

TECHNICAL EXPERIENCE: Twenty-three years experience in analyzing radiological and chemical contaminant transport in water resources.

EIS RESPONSIBILITY: Contributed to Appendix C.

NAME: **PHILIP L. YOUNG, CHP**

AFFILIATION: Tetra Tech NUS, Inc.

EDUCATION: M.S., Health Physics, 1989
B.S., Radiation Health (Health Physics), 1988

TECHNICAL EXPERIENCE: Ten years experience in environmental health physics and environmental impact assessment, with emphasis on radiological effluent monitoring, environmental surveillance, environmental dosimetry, radiological risk assessment, and radioactive waste management.

EIS RESPONSIBILITY: Project Manager; technical reviewer; contributed to Appendix C.

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE ENVIRONMENTAL IMPACT STATEMENT FOR CLOSURE OF HIGH-LEVEL WASTE TANKS AT THE SAVANNAH RIVER SITE, SOUTH CAROLINA

CEQ Regulations at 40 CFR 1506.5c, which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)." See 46 FR 18026-18031.

In accordance with these requirements, the offeror and the proposed subcontractors hereby certify as follows: (check either (a) or (b) and list financial or other interest if (b) is checked).

(a) ☑ Contractor has no financial or other interest in the outcome of the project.

(b) ☐ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interest

1.

2.

3.

Certified by:

Daniel M Evans
Signature

Daniel M. Evans
Name (Printed)

General Manager
Title

Tetra Tech NUS, Inc.
Company

June 10, 1999
Date

DISTRIBUTION LIST

DOE provided copies of the *Savannah River Site, High-Level Waste Tank Closure Draft Environmental Impact Statement* EIS to Federal, state, and local elected and appointed officials and agencies of government; Native American groups; Federal, state, and local environmental and public interest groups; and other organizations and individuals listed below. Copies will be provided to other interested parties upon request as identified in the cover sheet of this EIS.

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A. UNITED STATES CONGRESS

A.1 SENATORS FROM AFFECTED AND ADJOINING STATES

The Honorable Max Cleland
United States Senate

The Honorable Zell Miller
United States Senate

The Honorable Ernest F. Hollings
United States Senate

The Honorable Strom Thurmond
United States Senate

A.2 UNITED STATES SENATE COMMITTEES

The Honorable Mary Landrieu
Ranking Minority Member
Subcommittee on Strategic Forces
Committee on Armed Services

The Honorable Robert C. Byrd
Ranking Minority Member
Committee on Appropriations

The Honorable Pete V. Domenici
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Subcommittee on Energy and Water Development
Committee on Appropriations

The Honorable Carl Levin
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Committee on Armed Services

The Honorable Harry Reid
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Committee on Appropriations

The Honorable Robert Smith
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Subcommittee on Strategic Forces
Committee on Armed Services

The Honorable Ted Stevens
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Committee on Appropriations

The Honorable John Warner
Chairman
Committee on Armed Services

A.3 UNITED STATES HOUSE OF REPRESENTATIVES FROM AFFECTED AND ADJOINING STATES

The Honorable James E. Clyburn
U.S. House of Representatives

The Honorable Nathan Deal
U.S. House of Representatives

The Honorable Lindsey Graham
U.S. House of Representatives

The Honorable Jack Kingston
U.S. House of Representatives

The Honorable Cynthia McKinney
U.S. House of Representatives

The Honorable Charlie Norwood
U.S. House of Representatives

The Honorable Mark Sanford
U.S. House of Representatives

The Honorable Floyd Spence
U.S. House of Representatives

The Honorable John M. Spratt, Jr.
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A.4 UNITED STATES HOUSE OF REPRESENTATIVES COMMITTEES

The Honorable Peter Visclosky
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Subcommittee on Energy and Water Development
Committee on Appropriations

The Honorable Duncan L. Hunter
Chairman
Subcommittee on Military Procurement
Committee on National Security

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The Honorable Norman Sisisky
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Subcommittee on Military Procurement
Committee on National Security

The Honorable Ike Skelton
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The Honorable Floyd Spence
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C. STATE OF SOUTH CAROLINA

C.1 STATEWIDE OFFICES AND LEGISLATURE

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Mr. David Pittman

Mr. W. Lee Poe

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Carver Heights Community Org.

Ms. Dorene L. Richardson

Mr. Wayne Rickman
Sonalysts, Inc.

Mr. F. A. Riemann

Mr. Jacob Charles Robertson

Mr. Paul Robinson
Southwest Research & Information Center

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Mr. Edward Scalsky

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Project Performance Corporation

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Mr. Donald J. Skinner

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Mr. Paul Stansbury
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Mr. Alan Vaughan
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Mr. Martin Vorum
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Mr. Jim Wanzeck

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Mr. Michael Witunski

Mr. Mel Woods

Dr. Abe Zeitoun
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I. READING ROOMS AND LIBRARIES

Freedom of Information Public Document Room
University of South Carolina at Aiken SC
Gregg-Graniteville Library
Aiken, SC

Freedom of Information Reading Room
U.S. Department of Energy
Washington, D.C.

Battelle-Pacific Northwest Laboratories
Attn: Technical Library
Richland, WA

Librarian
Chatham-Effingham-Liberty Regional Library
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Librarian
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Head, Document Department
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Parsons Brinckerhoff Library
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Argonne, IL

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Ms. Felicia Yeh
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Georgia Institute of Technology Library
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Librarian
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Librarian
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Librarian
County Library
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Librarian
Government Information Dept.
Zimmerman Library
University of New Mexico
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Public Reading Room
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Librarian
Information Resource Center
Oak Ridge, TN

Public Reading Room
Idaho Falls, ID

GLOSSARY

Terms in this glossary are defined based on the context in which they are to be used in this EIS.

accident

An unplanned sequence of events that results in undesirable consequences.

alpha-emitter

A radioactive substance that decays by releasing an alpha particle.

alpha particle

A positively charged particle consisting of two protons and two neutrons, that is emitted during radioactive decay from the nucleus of certain nuclides. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

alpha waste

Waste containing alpha-emitting transuranic radionuclides with activities between 10 and 100 nanocuries per gram.

alternative

A major choice or strategy to address the EIS "Purpose and Need" statement, as opposed to the engineering options available to achieve the goal of an alternative.

annulus

The space between the two walls of a double-wall tank.

applicable or relevant and appropriate requirements (ARARs)

Requirements, including cleanup standards, standards of control, and other substantive environmental protection requirements and criteria for hazardous substances as specified under Federal and State law and regulations, that must be met when complying with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

aquifer

A body of permeable rock, rock fragments, or soil through which groundwater moves.

as low as reasonably achievable (ALARA)

A process by which a graded approach is applied to maintaining dose levels to workers and the public, and releases of radioactive materials to the environment at a rate that is as far below applicable limits as reasonably achievable.

atomic number

The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

background radiation

Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices.

backfill
Material such as soil or sand used in refilling an excavation.

basemat
The concrete and steel portion of the tank below the residual material and above the vadose zone.

beta-emitter
A radioactive substance that decays by releasing a beta particle.

beta particle
A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

beyond design basis accident (BDBA)
An accident with an annual frequency of occurring between 1 in 1,000,000 and 1 in 10,000,000 ($1.0\times^{-6}$ and 1.0×10^{-7}).

biodiversity
Pertains to the variety of life (e.g., plants, animals and other organisms) that inhabits a particular area or region.

blackwater stream
Water in coastal plains, creeks, swamp, and/or rivers that has been imparted a dark or black coloration due to dissolution of naturally occurring organic matter from soils and decaying vegetation.

borosilicate
A form of glass with silica sand, boric oxide, and soda ash.

borrow material
Material such as soil or sand that is removed from one location and used as fill material in another location.

bounding accident
A postulated accident that is defines to encompass the range of anticipated accidents and used to evaluate the consequences of accidents at facilities. The most conservative parameters (e.g., source terms, and meteorology) applied to a conservative accident resulting in a bounding accident analysis.

cancer
The name given to a group of diseases characterized by uncontrolled cellular growth.

canister
A container (generally stainless steel) into which immobilized radioactive waste is placed and sealed.

capable fault
In part, a capable fault is one that may have had movement at or near the ground surface at least once within the past 35,000 years, or has had recurring movement within the past 500,000 years. Further definition can be found in 10 CFR 100, Appendix A.

carcinogen

A radionuclide or nonradiological chemical that has been proven or suspected to be either a promoter or initiator of cancer in humans or animals.

characterization

The determination of waste composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis, generally done for the purpose of determining appropriate storage, treatment, handling, transport, and disposal requirements.

chronic exposure

The absorption of hazardous material (or intake of hazardous materials) over a long period of time (for example, over a lifetime).

Code of Federal Regulations (CFR)

A document containing the regulations of Federal executive departments and agencies.

collective effective dose equivalent

Sum of the effective dose equivalents for individuals composing a defined population. The units for this are person-rem or person-sievert.

committed dose equivalent

Total dose equivalent accumulated in an organ or tissue in the 50 years following a single intake of radioactive materials into the body.

committed effective dose equivalent

The sum of committed radiological dose equivalents to various tissues in the body, each multiplied by the appropriate weighing factor and expressed units of rem.

condensate

Liquid that results from condensing a gas by cooling below its saturation temperature.

confining (unit)

A rock layer (or stratum) having very low hydraulic conductivity (or permeability) that restricts the movement of groundwater either into or out of adjacent aquifers.

contaminant

Any gaseous, chemical or organic material that contaminates (pollutes) air, soil, or water. This term also refers to any hazardous substance that does not occur naturally or that occurs at levels greater than those naturally occurring in the surrounding environment (background).

contamination

The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

critical

A condition where in uranium, plutonium or tritium is capable of sustaining a nuclear chain reaction.

criticality

State of being critical. Refers to a self-sustaining nuclear chain reaction in which there is an exact balance between the production of neutrons and the losses on neutrons in the absence of extraneous neutron sources.

curie (CI)

The basic unit used to describe the intensity of radioactivity in a sample of material. he curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

decay, radioactive

The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation (see half-life, radioactive).

decommissioning

The process of removing a facility from operation followed by decontamination, entombment, dismantlement, or conversion to another use.

decontamination

The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive contamination from facilities, soil, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

design basis accident (DBA)

For nuclear facilities, a postulated abnormal event that is used to establish the performance requirements of structures, systems, and components that are necessary to maintain them in a safe shutdown condition indefinitely or to prevent or mitigate the consequences so that the general public and operating staff are not exposed to radiation in excess of appropriate guideline values.

design basis earthquake

The maximum intensity earthquake that might occur along the nearest fault to a structure. Structures are built to withstand a design basis earthquake.

DOE Orders

Requirements internal to the U.S. Department of Energy (DOE) that establish DOE policy and procedures, including those for compliance with applicable laws.

dosage

The concentration-time profile for exposure to toxicological hazards.

dose (or radiation dose)

A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

dose equivalent

Product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem. A millirem is one one-thousandth of a rem.

effective dose equivalent (EDE)

The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. It includes the dose from radiation sources internal and/or external to the body and is expressed in units of rem. The International Commission on Radiation Protection defines this as the effective dose.

effluent

Liquid or gaseous waste streams released from a facility.

effluent monitoring

Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

endemic

Native to a particular area or region.

environmental restoration

Cleanup and restoration of sites and decontamination and decommissioning of facilities contaminated with radioactive and/or hazardous substances during past production, accidental releases, or disposal activities.

environmental restoration program

A DOE subprogram concerned with all aspects of assessment and cleanup of both contaminated facilities in use and of sites that are no longer a part of active operations. Remedial actions, most often concerned with contaminated soil and groundwater, and decontamination and decommissioning are responsibilities of this program.

evaporator

A facility that mechanically reduces the water contents in tank waste to concentrate the waste and reduce storage space needs.

exposure pathways

The course a chemical or physical agent takes from the source to the exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a release site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium such as air or water is also included.

external accident (or initiator)

An accident that is initiated by manmade energy sources not associated with operation of a given facility. Examples include airplane crashes, induced fires, transportation accidents adjacent to a facility, and so forth.

facility basemat

For this purposes of this EIS, basemat is defined as the concrete pad beneath the HLW tank.

fissile material

Any material fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

floodplain

The level area adjoining a river or stream that is sometimes covered by flood water.

gamma-emitter

A radioactive substance that decays by releasing gamma radiation.

gamma ray (gamma radiation)

High-energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or uranium. Gamma rays are similar to x-rays, but are usually more energetic.

geologic repository

A deep (on the order of 600 meter [1,928 feet] or more) underground mined array of tunnels used for permanent disposal of radioactive waste.

groundwater

Water occurring beneath the earth's surface in the intervals between soil grains, in fractures, and in porous formations.

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 purposes.

habitat

The sum of environmental conditions in a specific place occupied by animals, plants, and other organisms.

half-life

The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

hazard index

The sum of several hazard quotients for multiple chemicals and/or multiple exposure pathways. A hazard index of greater than 1.0 is indicative of potential adverse health effects. Health effect could be minor temporary effects or fatal, depending on the chemical and amount of exposure.

hazard quotient

The ratio of an exposure level to a substance to a toxicity reference value selected for risk assessment purposes.

hazardous chemical

A term defined under the Occupational Safety and Health Act and the Emergency Planning and Community Right-to-Know Act as any chemical that is a physical hazard or a health hazard.

hazardous material

A substance or material, including a hazardous substance, which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

hazardous substance

Any substance that when released to the environment in an uncontrolled or unpermitted fashion becomes subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

hazardous waste

Under the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed. Source, special nuclear material, and by-product material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

heavy metals

Metallic elements with high atomic weights (for example, mercury, chromium, cadmium, arsenic, and lead) that can damage living things at low concentrations and tend to accumulate in the food chain.

high-efficiency particulate air (HEPA) Filter

A filter with an efficiency of at least 99.95 percent used to separate particles from air exhaust streams prior to releasing that air into the atmosphere.

high-level waste

As defined by the Nuclear Waste Policy Act [42 U.S. C. 10101], High Level Waste means (a) the 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 that contains [a combination of transuranic and] fission products [nuclides] in sufficient concentrations; and (b) other highly radioactive material that the [U.S. Nuclear Regulatory] Commission, consistent with existing law, determines by rule requires permanent isolation.

hydrology

The study of water, including groundwater, surface water, and rainfall.

immobilization

A process (e.g., grouting or vitrification) used to stabilized waste. Stabilizing the waste inhibits the release of waste to the environment.

inadvertent intrusion

The inadvertent disturbance of a disposal facility or its immediate environment by a potential future occupant that could result in loss of containment of the waste or exposure of personnel. Inadvertent intrusion is a significant consideration that shall be included either in the design requirements or waste acceptance criteria of a waste disposal facility.

incidental waste

Wastes that are not defined as high-level waste (i.e., originating from nuclear fuel processing).

inhibited water

Water to which sodium hydroxide has been added to inhibit corrosion.

in situ

A Latin term meaning “in place.”

institutional control

The control of waste disposal sites or other contaminated sites by human institutions in order to prevent or limit exposures to hazardous materials. Institutional control may be accomplished by (1) active control measures, such as employing security guards and maintaining security fences to restrict site access, and (2) passive control measures, such as using physical markers, deed restrictions, government regulations, and public records and archives to preserve knowledge of the site and prevent inappropriate uses.

internal accidents

Accidents that are initiated by man-made energy sources associated with the operation of a given facility. Examples include process explosions, fires, spills, criticalities, and so forth.

involved worker

Workers that would be involved in a proposed action as opposed to workers that would be on the site of a proposed action but not involved in the action.

isotope

One of two or more atoms with the same number of protons, but different numbers of neutrons, in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

latent cancer fatality

A fatality resulting from cancer caused by an exposure to a known or suspected radionuclide or carcinogenic chemical.

low-level waste (LLW)

Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel, or byproduct tailings containing uranium or thorium from processed ore (as defined in Section II e(2) of the Atomic Energy Act).

low-level mixed waste (LLMW)

Waste that contains both hazardous waste under the Resource Conservation and Recovery Act and source, special nuclear, or by-product material subject to the Atomic energy Act of 1954 (42 USC 2011, *et seq.*).

macroinvertebrate

Small animal, such as a larval aquatic insect, that is visible to the naked eye and has no vertebral column.

maximally exposed individual (MEI)

A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question.

millirad

One thousandth of a rad (see rad).

millirem

One thousandth of a rem (see rem).

mixed waste

Waste that contains both hazardous wastes under the Resource Conservation and Recovery Act and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

nanocurie

One billionth of a curie (see curie).

natural phenomena accidents

Accidents that are initiated by phenomena such as earthquakes, tornadoes, floods, and so forth.

noninvolved workers

Workers in a fixed population outside the day-to-day process safety management controls of a given facility area. In practice, this fixed population is normally the workers at an independent facility area located a specific distance (often 100 meters) from the reference facility area.

nuclear criticality

A self-sustaining nuclear chain reaction.

nuclide

A general term referring to all known isotopes, both stable (279) and unstable (about 5,000), of the chemical elements.

offsite

Away from the SRS site.

offsite population

For facility accident analyses, the collective sum of individuals located within an 80-kilometer (50-mile) radius of a facility and within the path of the plume with the wind blowing in the most populous direction.

oxalic acid

A water soluble organic acid, $H_2C_2O_4$, being considered as a cleaning agent to use in spray-washing tanks because it dissolves sludge and is only moderately aggressive against carbon steel, the material used in the construction of the waste tanks.

particulate

Pertains to minute, separate particles. An example of dry particulate is dust.

performance objectives

Parameters within which a facility must perform to be considered acceptable.

permanent disposal

For high level waste the term means emplacement in a repository for high-level radioactive waste, spent nuclear fuel, or other highly radioactive material with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste.

permeability

The degree of ease with which water can pass through a rock or soil.

person-rem

A unit used to measure the radiation exposure to an entire group and to compare the effects of different amounts of radiation on groups of people. It is obtained by multiplying the average dose equivalent (measured in rems) to a given organ or tissue by the number of persons in the population of interest.

pH

A measure of the relative acidity or alkalinity of a solution. A neutral solution has a pH of 7, acids have a pH of less than 7, and bases have a pH of greater than 7.

picocurie

One trillionth of a curie (see curie).

pollutant migration

The movement of a contaminant away from its initial source.

population

For risk assessment purposes, population consists of the total potential members of the public or workforce who could be exposed to a possible radiation or chemical dose from an exposure to radionuclides or carcinogenic chemicals.

population dose

The overall dose to the offsite population.

rad

The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

radiation (ionizing radiation)

Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as it is used here, does not include nonionizing radiation such as radio- or microwaves, or visible, infrared, or ultraviolet light.

radiation worker

A worker who is occupationally exposed to ionizing radiation and receives specialized training and radiation monitoring devices to work in such circumstances.

radioactive waste

Waste that is managed for its radioactive content.

radioactivity

The property or characteristic of material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel).

radioisotope

An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. approximately 5,000 natural and artificial radioisotopes have been identified.

radionuclide

The radioisotopes that together comprise 95 percent of the total curie content of a waste package by volume and have a half-life of at least 1 week. Radionuclides that are important to a facility's radiological performance assessment and/or a safety analysis and are listed in the facility's waste acceptance criteria are considered major radionuclides.

Record of Decision (ROD)

A public document that records the final decision(s) concerning a proposed action.

reducing grout

A grout formulated to behave as a chemical reducing agent. A chemical reducing agent is a substance that reduces other substances (i.e., decreases their positive charge or valence) by supplying electrons. The purpose of a reducing grout in closure of the high-level waste tanks would be to provide long-term chemical durability against leaching of the residual waste by water. Reducing grout would be composed primarily of cement, blast furnace slag, masonry sand, and silica fume.

rem

A unit of radiation dose that reflects the ability of different types of radiation to damage human tissues and the susceptibility of different tissues to the damage. Rems are a measure of effective dose equivalent.

risk

Quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

Safety Analysis Report (SAR)

A report, prepared in accordance with DOE Orders 5481.1B and 5480.23, that summarize the hazards associated with the operation of a particular facility and defines minimum safety requirements.

saltcake

Salt compounds that have crystallized as a result of concentrating the liquid.

saltstone

Concrete-like substance formed when the low-activity fraction of high-level waste is mixed with cement, flyash, and slag.

seepline

An area where subsurface water or groundwater emerges from the earth and slowly flows overland.

segregation

The process of separating (or keeping separate) individual waste types and/or forms in order to facilitate their cost-effective treatment and storage or disposal.

seismicity

The phenomenon of earth movements; seismic activity. Seismicity is related to the location, size, and rate of occurrence of earthquakes.

sludge

Solid material that precipitates or settles to the bottom of a tank.

solvent

Substance (usually liquid) capable of dissolving one or more other substances.

source material

(a) Uranium, thorium, or any other material that is determined by the U.S. Nuclear Regulatory Commission pursuant to the provisions of the Atomic Energy Act of 1954, Section 61, to be source material; or (b) ores containing one or more of the foregoing materials, in such concentration as the U.S. Nuclear Regulatory Commission may by regulation determine from time-to-time [Atomic Energy Act 11(z)]. Source material is exempt from regulation under to Resource Conservation and Recovery Act.

source term (Q)

the quantity of radioactive material released by an accident or operation that causes exposure after transmission or deposition. Specifically, it is that fraction of respirable material at risk (MAR) that is released to the atmosphere from a specific location. The source term defines the initial condition for subsequent dispersion and consequence evaluations. Q = material at risk (MAR) damage ration (DR) x airborne release fraction (ARF) x respirable fraction (RF) x leak path factor (LPF). The units of Q are quantity at risk averaged over the specified time duration.

spent nuclear fuel

Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.

stabilization

Treatment of waste to protect the environment from contamination. This includes rendering a waste immobile or safe for handling and disposal.

subsurface

The area below the land surface (including the vadose zone and aquifers).

tank farm

An installation of multiple adjacent tanks, usually interconnected for storage of liquid radioactive waste.

total effective dose equivalent

The sum of the external dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

transuranic waste

Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (a) high-level radioactive waste; (b) waste that the U.S. Department 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 40 CFR 191; or (c) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

treatment

Any activity that alters the chemical or physical nature of a hazardous waste to reduce its toxicity, volume, mobility or to render it amenable for transport, storage or disposal.

vadose zone

The zone between the land surface and the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. Also called the zone of aeration and the unsaturated zone.

vitrification

A method of immobilizing waste (e.g., radioactive, hazardous, and mixed). This involves adding frit and waste to a joule-heated vessel and melting the mixture into a glass. The purpose of this process is to permanently immobilize the waste and to isolate it from the environment.

volatile organic compound (VOC)

Compounds that readily evaporate and vaporize at normal temperatures and pressures.

waste minimization

An action that economically avoids or reduces the generation of waste by source reduction, reducing the toxicity of hazardous waste, improving energy usage, 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 with similar physical form, radiological properties, U. S. Environmental Protection Agency waste codes, or associated land disposal restriction treatment standards. It may be the result of one or more processes or operations.

wetlands

Area that are inundated or saturated by surface water or groundwater and that typically support vegetation adapted for life in saturated soils. Wetlands generally include swamps, marshes, bogs, and similar areas.

wind rose

A star-shaped diagram showing how often winds of various speeds blow from different directions. This is usually based on yearly average.