

U.S. DEPARTMENT OF ENERGY
Office of New Production Reactors
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**Draft
Environmental Impact Statement
for the Siting, Construction,
and Operation of
New Production Reactor Capacity**

Volume 2: Sections 1-6

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FOREWORD

The U.S. Department of Energy (DOE) has conducted many studies to identify and evaluate alternatives for the production of nuclear weapons material. A chronological description of these studies and their findings is presented below to provide historical background for the New Production Reactor (NPR) Program.

Two classified studies were performed in 1980 by the National Security Council and a joint panel from DOE and the Department of Defense (DOD). The National Security Council study stated that on-going planning for production facilities must address increased material requirements, concerns over aging existing facilities, and the need for new production facilities. The DOE/DOD study found that material needs and production capability required a high degree of production assurance, identified the age of present production facilities as a concern, and reported that production planning should include immediate initiation of two NPR facilities.

In response to these two studies, DOE formed a technical working group to evaluate possible new production alternatives. This group produced a technical and economic analysis of NPR capacity concluding that the light-water reactor (LWR), liquid-metal fast-breeder reactor, replacement N-reactor (RNR), low-temperature heavy-water reactor (LTHWR), and high-temperature gas-cooled reactor (HTGR) were all viable as nuclear material production reactors. The designs selected for this study were large reactor facilities that could meet the goals for production of two defense-related nuclear materials: tritium and plutonium.

To complete the evaluations being performed and support the technical working group's report on reactor technologies, DOE had site evaluations performed for three of its government-owned, contractor-operated facilities: the Hanford Site, Idaho National Engineering Laboratory (INEL), and the Savannah River Site (SRS). This report concluded that each site met all relevant criteria for siting NPR capacity (Burns and Roe 1981). In early 1982, the President's Science and Technology Office conducted a study that confirmed the need for new production facilities and recommended immediate action to acquire them.

In March 1982, an evaluation process for both a proposed NPR site and a proposed NPR concept was established by the DOE Assistant Secretary for Defense Programs. An advisory panel was appointed by the Deputy Secretary of Energy in July 1982 to carry out the technology and site evaluation process. To support this panel's review, additional cost and schedule studies were performed (UE&C 1982), as was a potential power revenue study (Stone and Webster Power Management 1982). These two studies concluded that all of the reactor concepts described above could be built in the same time frame and that power generation shortfalls would occur first in the Northwest and then in the Southeast by the year 2000.

In November 1982, the advisory panel issued a report stating that the NPR should be constructed to ensure an adequate supply of strategic nuclear materials in the 1990s and beyond (Glernan 1982). The panel also stated that the proposed NPR should be an efficient tritium producer and also be able to produce plutonium and other reactor products. The panel recommended construction of a zero-electric-power HWR that would not produce electricity at SRS or, if power production was important, then construction of an LTHWR capable of power production at SRS and an RNR at Hanford.

In August 1983, on the basis of the previous 18 months of studies, the Secretary of Energy directed the Assistant Secretary for Defense Programs to move forward with the National Environmental Policy Act (NEPA) documentation which would lead to a Record of Decision and a recommendation to the President on the NPR (Hodel 1983). The Secretary's preferred alternative was to build a heavy-water reactor (HWR) at INEL. Data were also to be developed on an LWR at Hanford and an HTGR at either Hanford or INEL because it provided the most confident and reliable approach in the shortest period of time and would add diversity by reducing the potential for common-mode deficiencies at SRS.

In August 1983, pursuant to Public Law 97-90, the Secretary of Energy also notified the U.S. Senate and House Armed Services Committees (ASCs) of DOE's intent to prepare an environmental impact statement (EIS) on the NPR project. The Senate ASC agreed with the preparation of the EIS (Tower 1983), but the House ASC did not believe adequate justification had been presented. An update on the status of the NPR project was provided to the House ASC in May 1984, along with a request to reallocate DOE funding and begin the NEPA review process (Hodel 1984). The House ASC agreed to additional NPR studies but objected to proceeding with the EIS (Price 1984). Without the agreement by the House ASC, preparation of an EIS was not begun. A court action was started by the Natural Resources Defense Council in July 1984 alleging that DOE was initiating a "major Federal action significantly affecting the quality of the human environment" without complying with NEPA. That civil action was settled with the Secretary of Energy stating that DOE was merely collecting additional information on the NPR and that DOE had no proposal for pursuing an NPR at that time.

The NPR studies that were begun in 1983 were all completed by 1986. These studies included site descriptions for Hanford, INEL, and SRS; preconceptual designs, cost estimates, and schedules for the HWR, LWR, and HTGR at those three sites; analyses of potential electrical power revenue at the three sites (Exeter Associates 1985); a life-cycle economic study of the HWR, HTGR, and LWR at the three sites (EG&G-12); and a concept for a smaller NPR that evaluated technologies, costs, and schedules for half-size production reactors, including modular high-temperature gas-cooled reactors (MHTGRs).

Following the April 1986 nuclear accident at Chernobyl in the Soviet Union, then Secretary of Energy John S. Herrington requested the National Academy of Sciences (NAS) and the National Academy of Engineering (NAE) to provide an independent assessment of the implications of the accident for the safe operation of DOE's 11 larger reactors. In November 1986, DOE reduced the operating power of the SRS production reactors in response to uncertainties related to the capabilities of the reactors' emergency core cooling systems.

The NAS-NAE Report, issued in October 1987, described a number of technical issues and presented a number of recommendations. In response to the NAS-NAE report, DOE issued an "Action Plan for Resolution of Technical Recommendations" in May 1988. In the spring of 1988, the three SRS reactors entered into maintenance outages for improvements of their safety and management systems.

In October 1987, Congress passed Public Law 100-202 requiring DOE to determine whether NPR capacity was needed, evaluate the use of alternative reactor technologies, prepare a comprehensive comparative cost estimate for the alternative technologies, and recommend a preferred action for NPR capacity.

In response to this legislation, DOE asked the Energy Research Advisory Board to assess reactor technologies to determine their capability to meet U.S. needs in producing defense

nuclear materials, especially tritium (Herrington 1988). In January 1988, DOE also established an internal site evaluation team to evaluate Hanford, INEL, and SRS for their suitability as locations for NPR capacity. The DOE prepared a cost estimate for the concepts presented to the Energy Research Advisory Board by the design sponsors (DOE-62). The board's report concluded that the HWR provided the most mature production technology, but that the LWR and the MHTGR could also meet the tritium production needs with varying degrees of risk regarding cost and schedule (ERAB-1). In its July 1988 report, the DOE site evaluation team found all three sites to be suitable for NPR capacity.

Based on the studies by the Energy Research Advisory Board and the DOE site evaluation team, the Secretary of Energy issued a report to Congress (DOE-2). In that report, DOE confirmed a need for NPR capacity and recommended a preferred "dual" strategy for the urgent construction of two NPRs, each of a different technology and each at a different site. Specifically, DOE recommended constructing a new HWR at SRS and a modular HTGR at INEL. As a further contingency, the report recommended that DOE continue work on target development for the LWR and on solving institutional issues associated with acquisition of WNP-1 (a partially complete commercial LWR located at Hanford). The report also announced initiation of the NEPA review process for NPR capacity. Subsequently, in the September 16, 1988, Federal Register (53 FR 36094), DOE issued a Notice of Intent to prepare this environmental impact statement.

1 INTRODUCTION

A primary mission of the Department of Energy (DOE) is to provide nuclear materials to meet national defense requirements. Specifically, the Atomic Energy Act of 1954, as amended, authorizes DOE to "engage in the production of atomic weapons, or atomic weapons parts..." (42 USC § 2121). The nuclear materials are used in building and maintaining the nation's stockpile of nuclear weapons.

Two nuclear materials that DOE provides that are critical to the nation's nuclear deterrent are high-purity plutonium-239 ("weapons-grade plutonium") and tritium. Weapons-grade plutonium is used primarily in building nuclear weapons. Tritium is used to enhance the performance of nuclear weapons. The use of tritium makes it possible to build smaller, yet more powerful, weapons and to reduce the amount of plutonium in each weapon. Consequently, the United States has based its strategic nuclear systems on designs using both weapons-grade plutonium and tritium, and thus the nation requires a steady, reliable supply of both.

Plutonium-239 has a radioactive half-life of about 25,000 years. Effectively this means that once a given quantity of weapons-grade plutonium has been produced by DOE, it is available for use and reuse for the foreseeable future. This also means that weapons-grade plutonium does not normally have to be replenished in existing weapons (although it is subject to periodic reworking to remove accumulated impurities). This long half-life affords DOE a great amount of flexibility in planning for, and providing, future weapons-grade plutonium requirements.

Based on projected near-term requirements (through the year 2000), there is no foreseeable requirement to produce new weapons-grade plutonium (DOE-67). The potential exists that the current inventory of weapons-grade plutonium in the U.S. nuclear weapons stockpile could, through recycling, satisfy the nation's need for a reliable source of weapons-grade plutonium for the foreseeable future.

Tritium, the radioactive isotope of hydrogen, is found in nature, although in extremely small amounts. Tritium has a relatively short radioactive half-life of 12.3 years, decaying at a rate of 5.5% per year. Because of this radioactive decay, tritium must be replenished periodically in nuclear weapons to ensure their effectiveness. Thus, unlike the situation with weapons-grade plutonium, DOE must have an assured means of producing tritium to replace losses from decay.

When the Notice of Intent to prepare this environmental impact statement (EIS) was published (September 16, 1988, 53 FR 36094-36097), DOE proposed to evaluate new production reactor (NPR) capacity for both tritium and weapons-grade plutonium. Subsequent to that Notice of Intent, however, DOE made two significant decisions. First, DOE decided to prepare a programmatic EIS (PEIS) for the reconfiguration of the nuclear weapons complex (Section 1.3 explains the relationship between the Reconfiguration PEIS and this NPR EIS). Second, DOE determined that there is no urgency to produce new weapons-grade plutonium (DOE-67). Therefore, the proposed action for the NPR EIS does not include the production of weapons-grade plutonium. The long-term need for weapons-grade plutonium production will be evaluated in the Reconfiguration PEIS. There have been other significant changes in the scope of the NPR EIS since the Notice of Intent and Implementation Plan were published; they are described in Section 1.4.

1.1 PROPOSED ACTION

The proposed action is to provide new capacity to produce tritium safely and reliably, in order to meet the nation's defense requirements well into the 21st century (DOE-58). This EIS analyzes this proposed action and its reasonable alternatives on both the programmatic and project-specific levels.

On a broad, or "programmatic," level, the EIS identifies those reasonable alternatives and examines their impact in support of such decisions as (1) whether to build new tritium production facilities, (2) whether to have available more than one facility at more than one site, (3) what size production capacity should be provided, and (4) on what schedule this capacity should be provided.

On a specific, or "project," level, the EIS analyzes the environmental impacts of siting, constructing, and operating one or more NPRs and associated support facilities on an urgent schedule (in or about the year 2000), to enable DOE to maintain a safe and reliable long-term capacity to produce the tritium needed to meet defense requirements.

On both levels, the no-action alternative is also analyzed in this EIS. That alternative is to not construct and operate new tritium production capacity and to continue to rely on the existing tritium production capacity. The preferred programmatic alternative for this EIS is to provide new tritium production capacity on an urgent schedule, that is, in or about the year 2000. There is no project-specific preferred alternative.

1.2 PURPOSE AND NEED

Since 1945, when nuclear weapons came into existence, a nuclear deterrent against aggression has been the cornerstone of the nation's defense policy and entire national security posture. The effectiveness of the U.S. deterrent capability depends not only on the nuclear weapons the nation has or can produce, but also on its ability to reliably and safely provide the tritium needed to support the weapons. As long as U.S. national security is based on nuclear deterrence, it is prudent to maintain tritium production capacity that will ensure a stockpile of reliable and safe nuclear weapons.

This EIS does not analyze the U.S. need for nuclear weapons or discuss the required quantities of nuclear materials such as tritium. The policy of the United States to maintain a nuclear weapons stockpile as a deterrent to war is established and affirmed by the people of the United States through the President and the Congress. The DOE anticipates that nuclear weapons will remain a prime element of U.S. national security for the foreseeable future; thus, DOE must continue to provide the tritium production capacity needed to meet the nation's defense requirements.

The DOE is responsible for providing the tritium needed to meet the requirements set forth in the Nuclear Weapons Stockpile Memorandum (NWSM), which is forwarded annually from the Secretaries of Energy and Defense through the National Security Council to the President for approval. This memorandum establishes the size and composition of the stockpile needed to defend the United States and assesses DOE's ability to support the proposed stockpile.

The Nuclear Weapons Stockpile Memorandum signed by President Bush on July 12, 1990, authorized weapon production and retirements through September 1995. Nuclear material requirements, including tritium requirements, for the 1996-2000 time period are based on the NWSM. The DOE recognizes that the potential exists for tritium requirements to decrease in the future due to the changing world geopolitical situation (for example, potential Strategic Arms Reduction Talk [START] treaties and potential reduction of U.S. tactical presence in the North Atlantic Treaty Organization) and Federal budget constraints. Conversely, there is also a potential that the world geopolitical situation could change to necessitate an increase in tritium requirements.

Over the last 40 years, DOE has built and operated 14 reactors to produce nuclear materials, including tritium. Today, however, most of those reactors have been retired. Currently, DOE's capacity to produce all of the nation's tritium resides with two nuclear reactors (designated K and L) at the DOE Savannah River Site (SRS) in South Carolina. By the year 2000, these production reactors will be more than 45 years old. The National Academy of Sciences (NAS) recognized the uncertainty of depending upon the SRS reactors as the nation's only source of tritium and noted that their useful life would likely be less than the time required to provide replacement capacity (NAS 1987). The NAS also noted that "although no life-limiting mechanisms have been identified for the continued operation of the existing SRS reactors, they cannot be expected to last indefinitely" (NAS 1987).

Since 1988, the existing SRS reactors have been on an extended outage for safety and operational enhancements. An EIS has been completed for their continued operation (see Section 1.3.3), and the Record of Decision (ROD) indicated that restart for K Reactor is expected in the third quarter of 1991, while L Reactor is expected to be ready to resume operation early in 1992. As stated in the ROD, "the continued operation of these two reactors will provide sufficient assurance that future production needs can be met in the near-term" (DOE-66). However, the National Security Council, the U.S. Congress, the Secretary of Defense, the Nuclear Weapons Council, the White House Office of Science and Technology Policy, and the National Research Council have all determined that new production capacity is needed if the United States is to have an assured future supply of tritium.

As a result of concerns regarding the ability of the SRS reactors to provide long-term tritium capacity, the Secretary of Energy created the Office of New Production Reactors in 1988 to accomplish the following mission: to provide new production reactor capacity in a safe and environmentally sound manner, on an urgent* schedule, for an assured supply of nuclear materials, primarily tritium, to maintain the nation's nuclear deterrent capability (DOE-2). This EIS analyzes alternative means of providing new, safe, and reliable tritium production capacity.

This EIS evaluates the impacts of the programmatic issues involved in providing an assured long-term tritium production capacity, specifically the following issues: (1) whether to rely on existing tritium production facilities for long-term capacity or site, construct, and operate new, safe, and reliable tritium production facilities, (2) whether more than one tritium production facility should be available to ensure the capacity to meet tritium needs, (3) what size production capacity should be available to meet potential future requirements, and (4) on what

*For the purpose of the NPR program, "urgent" is defined as "in or about the year 2000."

schedules new production capacity should be available. The decision on schedules will in turn affect the technologies that are reasonable alternatives to supply the needed capacity.

Since there is no feasible method of collecting and concentrating naturally occurring tritium in the quantities needed for defense use, it is necessary to manufacture it. The only demonstrated method of manufacturing tritium in the required quantities is by bombarding lithium "targets" with neutrons in thermal fission reactors. The potential exists that other technologies (mainly fast fission reactors and particle accelerators) could produce tritium in adequate amounts. This EIS assesses the capability of these other technologies to provide future tritium production capacity.

Constructing and operating NPRs on an urgent schedule is but one of the many project-specific alternatives that could be chosen to meet the nation's requirements for tritium production capacity. The project-specific portion of this EIS (Sections 3 through 6) has been prepared to ensure that the alternative of providing NPR in or about the year 2000 has been analyzed under the requirements of the National Environmental Policy Act (NEPA). Because it takes approximately 8 to 10 years to design, build, and test a nuclear reactor before it can begin tritium production, this EIS and the Record of Decision have to be completed now in order to have new tritium production capacity available in or about the year 2000.

The other project-specific alternatives are discussed in Section 2. Project-specific analyses required under NEPA have not been prepared for these alternatives because they are not reasonable alternatives to meet an urgent schedule. If DOE decides it is not necessary to meet the urgent schedule and decides to proceed with any of these reasonable future alternatives as a result of the programmatic decisions in the Record of Decision for this EIS, there would be adequate time to prepare project-specific NEPA documents.

In January 1990, after publication of the Implementation Plan for this EIS (see Section 1.4), the Secretary of Energy announced that the programmatic EIS on reconfiguration of the nuclear weapons production complex would be prepared (see Section 1.3). The Notice of Intent to prepare that EIS and schedule the public scoping meetings was issued in February 1991. A Record of Decision following the Reconfiguration PEIS is scheduled for October 1993. If that decision were to affirm the need to design, construct, and operate new tritium production capacity in or about the year 2000, not enough time would remain for DOE to achieve that objective, and the continuity of the nation's future tritium production capacity could be at risk. By preparing this EIS on NPR capacity now, DOE is providing the basis, consistent with NEPA, for a timely decision to begin the design and construction of such capacity.

There are three reasons why DOE is now evaluating how to carry out its mission to provide long-term, assured tritium production capacity on an urgent schedule:

- *Existing Production Capacity.* The existing DOE tritium production reactors at SRS are more than 35 years old and are the oldest operating large reactors in the world. Because they were built in the mid-1950s, these reactors do not contain many of the technological advances and safety features in nuclear reactor design and construction developed over the past 30 years. Extensive upgrades have been completed on the SRS reactors, to enable them to meet the required safety standards. Because of the age and design

of the reactors, the period of time they will remain available to support defense needs is uncertain. It is prudent to assess alternatives for producing tritium, the shortest-lived material ensuring the nation's nuclear deterrent.

- *Radioactive Decay of Tritium.* Tritium has a relatively short half-life. After 12.3 years, only half of the initial quantity of tritium remains. Because of this relatively rapid radioactive decay, tritium must be replenished periodically in stockpiled weapons to ensure their effectiveness and, thus, the reliability of the nation's nuclear deterrent.
- *Timing.* Nuclear reactors are the only demonstrated means of producing tritium in the quantities potentially required on this urgent schedule. It would take about 8 to 10 years to achieve operation, due to the time required to design, construct, and test a reactor and any new support facilities required.

Several reports have recommended that "new production reactor capacity should be built on an urgent schedule to provide assurance that long-term defense needs will be met" (DOE-2; DOE-59; ERAB-1). In view of the critical importance of a reliable, long-term tritium production capacity, DOE is evaluating alternatives to see which, if any, could meet the urgent schedule. Thus, the alternatives evaluated in the project-specific portion of this EIS (Sections 3 through 6) are technologies that could meet the requirement to provide new tritium production capacity in or about the year 2000.

1.3 RELATIONSHIP TO OTHER DOE ENVIRONMENTAL IMPACT STATEMENTS

Three other DOE environmental impact statements are closely related to this EIS and are discussed here: the Nuclear Weapons Complex Reconfiguration Programmatic EIS, the Environmental Restoration and Waste Management Programmatic EIS, and the Continued Reactor Operation EIS for the K, L, and P reactors at SRS (RO EIS).

1.3.1 Relationship to Nuclear Weapons Complex Reconfiguration Programmatic EIS (Reconfiguration PEIS)

In January 1990, the Secretary of Energy announced that DOE would prepare a programmatic EIS regarding reconfiguration of the nuclear weapons complex. The DOE proposes to reconfigure its nuclear weapons complex to be smaller, less diverse, and less expensive to operate than it is today. The Reconfiguration PEIS will assess the potential environmental consequences of alternative long-term configurations for the nuclear weapons complex envisioned to be in place early in the 21st century (this complex is referred to as "Complex 21"). More specifically, the Reconfiguration PEIS will evaluate such things as sites identified to carry out (or relinquish) specific functions, schedules for transferring responsibilities from one location to another or bringing new facilities (if any) on-line, and the extent of government-owned and private facilities to be used. The scoping process for the Reconfiguration PEIS began on February 11, 1991, and the PEIS is expected to lead to a Record of Decision in late 1993.

One important group of facilities within the nuclear weapons complex consists of facilities used to produce nuclear materials, including tritium. The proposed action described in this EIS constitutes an interim action with respect to the Reconfiguration PEIS and within the meaning of the Council on Environmental Quality (CEQ) regulations because it meets CEQ requirements for such actions. The CEQ regulations provide that an agency may take an interim action as long as the following criteria are met: (1) it must be justified independently; (2) it must be covered by an adequate EIS; and (3) it must not prejudice the ultimate decision that will result from the later EIS.

The NPR EIS is being prepared to evaluate the environmental impacts of siting, constructing, and operating new tritium production capacity. This action is justified on the basis of the need for assured, reliable tritium production capacity well into the 21st century, as described in Section 1.2. This need is independent of the need to reconfigure the DOE weapons complex. Reconfiguration is being planned and undertaken to "... achieve a complex that is smaller, less diverse, and less expensive to operate. Reconfiguring the nuclear weapons complex would serve as a means to maximize efficiency and minimize public health risks" (DOE-69). Regardless of whether DOE reconfigures its weapons complex, DOE needs tritium production capacity. To ensure that this capacity will exist in the future, it is prudent to proceed with the proposed siting, construction, and operation of an NPR, rather than continuing to rely solely on the existing SRS reactors, which were constructed in the 1950s. Ongoing DOE analysis indicates that the probability of these reactors' operating year-to-year decreases substantially over time. Thus, the two actions are independently justified.

This EIS and an associated Record of Decision will be completed, in accordance with CEQ regulations and DOE procedures, before NPR site selection, technology selection, and construction. This action will, therefore, be covered by an adequate EIS meeting the second interim action requirement.

If the decision associated with this NPR EIS is to proceed with construction of new tritium production capacity, subsequent decisions to reconfigure the entire weapons complex would not be prejudiced. The Reconfiguration PEIS will address the environmental impacts of alternative means of achieving a set of goals that are distinct from the need to assure tritium production capacity. Decisions relative to achieving a smaller, less diverse, less expensive, and more efficient complex can be made without regard to the location or technology decided upon for new tritium production capacity. Therefore, decisions regarding the sites, technologies, production capacity, and construction schedule for NPR capacity will not prejudice the decisions to be made following completion of the Reconfiguration PEIS.

1.3.2 Relationship to the Environmental Restoration and Waste Management Programmatic EIS (Waste Management PEIS)

In January 1990, the Secretary of Energy also announced that DOE would prepare a programmatic EIS regarding an environmental restoration and waste management program for DOE (referred to as the Waste Management PEIS). The DOE proposes to integrate its environmental restoration and waste management activities; the Waste Management PEIS will assess the potential environmental consequences of alternatives for achieving such integration at various DOE sites. The scoping process for the Waste Management PEIS began in October 1990; the Record of Decision is expected in 1993.

Both the quantity and content of radioactive and hazardous NPR wastes would be influenced by whether or not spent reactor fuel was reprocessed to recover uranium. For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel reprocessing is analyzed in this EIS as part of the original mission of the NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

1.3.3 Relationship to Continued K, L, and P Reactor Operation EIS (RO EIS)

Currently, the K and L reactors at SRS are DOE's only means to produce tritium. These reactors are more than 35 years old and have been in an extended outage since 1988 to make enhancements to ensure their continued safe operation. The Continued Operation EIS (referred to as the RO EIS) assessed the environmental impacts from continued operation of the K, L, and P reactors (DOE-10). The proposed action includes a range of operation for these reactors from full power to placement in cold standby. Under the February 4, 1991, Record of Decision for the RO EIS (DOE-66), DOE would continue to operate the K and L reactors to produce needed nuclear materials, including tritium, with continued safety and environmental enhancements, at least until replacement capacity has been demonstrated, but would place P Reactor in defueled standby.

The RO EIS referred to construction of NPR capacity as a potential alternative. However, this was not considered a reasonable alternative to the RO EIS proposed action. The RO EIS addressed alternatives to allow DOE to meet requirements at least until new production capacity has been demonstrated because the time required for the procurement, design, and construction of any new capacity would have been too long to satisfy the RO EIS analysis of tritium requirements in the near term.

1.4 SCOPE OF THE NPR ENVIRONMENTAL IMPACT STATEMENT

1.4.1 Organization

This EIS contains both a programmatic portion (Section 2) and a project-specific portion (Sections 3 through 6). Section 1, which describes the proposed action, and the purpose and need, is pertinent to both the programmatic and project-specific portions of the document.

This EIS has been prepared in accordance with Section 102(2)(C) of NEPA, as implemented in regulations promulgated by the Council on Environmental Quality (CEQ) (40 CFR 1500-1508) and as provided in the DOE NEPA Guidelines (52 FR 47662) and DOE NEPA Regulations (10 CFR 1021). In accordance with 40 CFR 1502.10 of the CEQ regulations, the EIS includes the following:

- Cover sheet.
- Summary.

- Table of contents.
- Description of the purpose and need for action (Section 1.2).
- Description and comparison of alternatives, including the environmental consequences, for the programmatic portion of the EIS (Section 2).
- Description and comparison of the project-specific NPR alternatives (Section 3).
- Description of the affected environment for the NPR alternatives (Section 4).
- Description of environmental consequences for the NPR alternatives and a brief description of decontamination and decommissioning (Section 5).
- Description of environmental compliance and permit requirements (Section 6).
- List of cited references (Section 7).
- List of individuals who prepared the EIS (Section 8).
- List of agencies, organizations, and persons to whom copies of the EIS were sent (Section 9).
- List of acronyms, abbreviations, and units of measure (Section 10).
- Glossary (Section 11).
- Index (Section 12).
- Appendixes.

1.4.2 Scoping Process

On September 16, 1988, DOE published a Notice of Intent to prepare an EIS and hold scoping meetings for the NPR EIS (53 FR 36094-36097). This Notice of Intent was amended October 25, 1988 (53 FR 43003-43004), and November 17, 1988 (53 FR 46490), to change some of the scoping meetings. From November 10 through December 8, 1988, DOE held 13 public scoping meetings at various locations in the states of Georgia, Idaho, Oregon, South Carolina, and Washington. Local, state, and Federal officials and members of the public were invited to provide oral or written comments regarding the scope of the EIS until the end of the 90-day scoping period on December 15, 1988. The DOE received responses from 8,609 members of the public, interested groups, and Federal, state, and local officials.

The DOE used these scoping comments to identify the significant issues to be analyzed in this EIS. The results of the scoping comment analysis were documented in the *Implementation Plan for the New Production Reactor Capacity Environmental Impact Statement* (DOE-1).

1.4.3 Implementation Plan

The implementation plan (DOE-1), issued in January 1990, describes the proposed action and alternatives, summarizes EIS assumptions, lists environmental issues to be considered in the EIS (including those identified during the scoping process), lists proposed agency consultations, provides a schedule for EIS preparation and related activities, and gives an annotated outline of the EIS. Subsequent to publication of the implementation plan, DOE decided to prepare two programmatic EISs -- the Reconfiguration PEIS and the Waste Management PEIS, both of which will be related to the NPR EIS (see Section 1.3). Due, in part, to these two PEISs, several noteworthy changes to the original scope of the NPR EIS have resulted. The major changes are described below.

- *Production of Virgin Weapons-Grade Plutonium.* In a programmatic sense, this EIS does not address either the need for, or the production complex necessary for, production of virgin weapons-grade plutonium. As discussed elsewhere in Section 1, there is no need to analyze the programmatic impacts of this potential activity in advance of the planned Reconfiguration PEIS. The Reconfiguration PEIS will assess alternatives that would enable DOE to maintain the long-term capability to provide weapons-grade plutonium to ensure DOE is able to meet any future Atomic Energy Act requirements for this material. Even though the Nuclear Weapons Complex Reconfiguration Study (DOE-67) states that "no additional reactor production of plutonium is required," it also states that "unpredictable changes are likely." Thus, while there is no foreseeable requirement for virgin weapons-grade plutonium production at this time, there is no assurance that this will remain true for the life of the NPRs. Since an NPR would be capable of producing weapons-grade plutonium, an NPR would provide one alternative for this capability. Therefore, the NPR EIS has continued to assess the potential environmental impacts of plutonium-239 production in the reactor as a reasonably foreseeable impact or similar action.

The project-specific portion of the NPR EIS (Sections 3 through 6) assesses the potential environmental impacts of plutonium-239 production that are specifically associated with the operation of the nuclear reactor. This ensures that if the Record of Decision (ROD) approves construction and operation of one or more NPR thermal fission reactors, these reactors would then be available as an alternative in the Reconfiguration PEIS for the capability to produce weapons-grade plutonium, if production is ever required in the future. If the NPR ROD were to select an alternative for new tritium production capacity that is not yet analyzed for project-specific impacts, or if DOE were to determine that virgin weapons-grade plutonium production is required at some time during the life of the NPR(s), then project-specific NEPA reviews would be conducted as required.

- *Disposition of Spent Fuel.* The NPR proposed action does not include spent fuel reprocessing. The NPR would be able to produce tritium whether or not the spent fuel was reprocessed. For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel reprocessing is analyzed in the EIS as a part of the

original mission of the NPR, which included the production of plutonium-239. However, this is no longer part of the NPR mission. The Waste Management PEIS will assess the environmental impacts of wastes from reprocessing of spent fuel from the DOE reactors. Spent fuel could be placed in a monitored retrievable storage (MRS) facility, if one is constructed, or placed in existing storage facilities at DOE sites. No limitations are expected on storage of fuel for the life of the reactors, if required, at any of the NPR alternative sites. No significant differences in environmental impacts of interim spent fuel storage or disposal are expected among the reactor technologies evaluated in this EIS. All three reactor fuels have been stored for various periods of time -- HWR fuel at SRS; MHTGR fuel at the Fort Saint Vrain plant in Platteville, Colorado; and LWR fuel at commercial plants. Interim storage could be in either water-filled pools or possibly dry vaults as proposed for some commercial plants. Direct disposal of fuel from the three reactor types in a Federal repository would also be evaluated. Again, while no significant discriminators are expected, it is recognized that none of the three reactor fuel forms has been certified for direct disposal in a repository. Consequently, some form of repackaging or reprocessing would likely be required. Although fuel reprocessing is not part of the proposed action, the NPR EIS includes assessments of the environmental impacts that might result if spent fuel were reprocessed, based on existing documentation. This information would provide decision makers with information on the relative environmental impacts of spent fuel reprocessing associated with the reactor technologies described in this EIS, should that option be desired for any other reason.

- *Status of Existing Support Facilities.* The NPR EIS describes the impacts of construction and operation of new facilities, as well as the impacts associated with NPR operations utilizing existing facilities where appropriate. The EIS acknowledges that some of these facilities may eventually require upgrades or replacement for technical or programmatic reasons, but the exact timing and extent of these upgrades are not specifically quantifiable at this time. Specifically, at SRS if the no-action alternative were adopted (continued operation of existing reactors), these facilities would need to be upgraded or replaced in any case. The Nuclear weapons Complex Reconfiguration Study states: "As part of the larger reconfiguration effort, a Capital Asset Management Process (CAMP) has been implemented to support repairing or replacing aging facilities within the complex. Until the Reconfiguration ROD, this process will support the minimum effort required to allow the current Complex to continue to perform the Department's defense related mission in compliance with applicable requirements. The results of CAMP will be incorporated into the No Action alternative in the PEIS." In addition, major facility upgrades are being addressed in the Reconfiguration Study with respect to the DOE long-term strategy for continuing fuel reprocessing and virgin plutonium production in facilities like the H and F canyons at SRS. Consequently, while detailed discussion of these actions will be the subject of follow-on project-specific NEPA documentation, this EIS does include the cumulative projected impacts of operation of these facilities. This approach ensures an

adequate bounding of impacts and a basis for comparison of the alternatives.

1.4.4 Assumptions and Basis for Analysis

The analyses and impact assessments presented in this EIS are based on the following factors and assumptions:

1. The proposed action in this EIS constitutes an interim action under the criteria provided in the CEQ regulations (40 CFR 1506.1) that implement NEPA. As an interim action, the proposed action satisfies the following CEQ limitations:
 - a. The proposed action is justified independently of the Reconfiguration PEIS that DOE will prepare after this EIS (this justification is contained in Section 1.2, which details the need for the NPR proposed action, and Section 1.3, which explains the relationship of the NPR EIS to the Reconfiguration PEIS).
 - b. This EIS is being prepared for the proposed action.
 - c. The proposed action will not prejudice the ultimate decisions that may result from the Reconfiguration PEIS (see Section 1.3).
2. The programmatic portion of the EIS analyzes the broad impacts of the reasonable alternatives that would enable DOE to provide safe and reliable tritium production capacity well into the 21st century.
3. The programmatic portion of the EIS analyzes the impacts of siting, constructing, and operating more than one new tritium production facility.
4. The project-specific portion of the EIS analyzes the impacts of three reactor technologies (heavy-water reactor, light-water reactor, and modular high-temperature gas-cooled reactor) at each of three sites (the Hanford Site, Idaho National Engineering Laboratory, and the Savannah River Site), resulting in nine technology/site combinations.
5. As discussed in the project-specific portion of the EIS for the proposed action, the NPR facilities at any site would include the reactor(s), tritium-target and fuel-fabrication facilities, tritium-target processing facilities, and spent fuel storage facilities.
6. Since decisions on whether Complex 21 will produce weapons-grade plutonium and whether spent fuel should be reprocessed are to be made after the NPR Record of Decision, these issues are not a part of the proposed action. However, the project-specific portion of this EIS includes information on the potential environmental impacts for weapons-grade plutonium production and spent fuel reprocessing. This information is

provided to analyze these reasonably foreseeable actions and to provide a reference on environmental impacts that might affect the choice of reactor technologies for tritium production capacity. In Section 3 of this EIS, the environmental impacts for the proposed action are specifically separated from those related to plutonium production and fuel reprocessing. The Waste Management PEIS will assess the potential environmental impacts of wastes from reprocessing of spent fuel from DOE reactors.

7. In the project-specific portion of the EIS that addresses the heavy-water reactor, the potential impacts of transporting heavy water (deuterium oxide) to a site for processing are assessed.
8. The project-specific portion of the EIS evaluates all technologies at a capacity equivalent to that of about a 3,000-megawatt (MWt) heavy-water reactor as a reference basis for analysis (see Sections 2.1 and 2.5 for further discussion). This is considered to be a bounding case environmental analysis; thus, if desired, smaller-capacity reactors could be selected in the Record of Decision. Smaller-capacity facilities are assessed in the programmatic portion of the EIS to indicate the relative environmental impacts that might result if a facility smaller than those analyzed in the project-specific portion of the EIS is selected.
9. Enriched uranium to fuel the fission reactor technologies would be available from existing sources. The impacts of providing enriched uranium fuel are not within the scope of this EIS.
10. Tritium would be extracted from the irradiated targets at the NPR sites. Tritium extracted at either INEL or Hanford would be shipped to SRS, where facilities are located for purifying the tritium and loading it into nuclear weapon reservoirs. The potential impacts of these shipments are assessed in the project-specific portion of this EIS.
11. For the project-specific portion of this EIS, the description of the affected environment includes the projected baseline environmental conditions during the construction period (years 1992-2000) and the operational period (years 2000-2040). The baseline environmental conditions include the effects of operating other existing non-NPR facilities at the three proposed NPR sites during the NPR construction and operational periods. The baseline environmental conditions at SRS are assumed to include operation of the existing K, L, and P production reactors. The baseline environmental conditions at the Hanford site are assumed to also include cold standby of N Reactor.

As determined during the scoping period for this EIS, and as presented in the EIS Implementation Plan, the baseline environmental conditions and the no-action alternative for this EIS are based on the EIS for continued operation of the K, L, and P reactors at SRS (RO EIS) and assume operations of these reactors at 100% capacity until the year 2040. All the

analyses of impacts for this EIS were performed on this basis. In the absence of any stated DOE plans for the operational schedule or lifetime of the existing reactors, this assumption made it possible to assess (in the consequences section of the NPR EIS) the greatest potential cumulative impacts from normal operations, employment, transportation, and waste management.

The assumption of 100% operations allowed the establishment of an upper bound of reactor impacts at SRS below which the actual impacts of NPR plus existing reactors would fall. This is especially true for the estimation of cumulative impacts, where, for the time frame from 2000 to 2040, the specific number of reactors in production at SRS, the power levels, and the periods of operation to meet national requirements are uncertain.

On February 11, 1991, the Department of Energy issued a Record of Decision for the RO EIS that determined that P Reactor will be placed in cold standby and that K Reactor and L Reactor will remain operational. This decision would potentially change the no-action and baseline assumptions with respect to operation of two reactors at 100% capacity until 2040 at SRS.

However, despite the Record of Decision for the RO EIS, the no-action alternative, environmental baseline, and cumulative impact of NPR operations described in this NPR EIS still reflect the assumption of three operating existing SRS reactors. It is recognized this assumption could possibly influence a comparison of impacts with respect to a two-reactor no-action alternative. Therefore, where a change in this assumption could lead to a substantially altered conclusion as to impact magnitude or significance, a discussion of these differences has been added.

12. To the extent that information is available, the project-specific portion of the EIS generically evaluates impacts that may result from decontamination and decommissioning of existing and new facilities ultimately used in the NPR complex. Decontamination and decommissioning (D&D) of NPR facilities would be the subject of a project-specific NEPA review at the appropriate time in the future when these facilities would be proposed for retirement.
13. The project-specific portion of the EIS broadly analyzes the environmental consequences associated with construction and operation of electrical generation capacity. However, DOE has not proposed any agreement for the sale or use of by-product steam for the alternative reactor technologies that are capable of power production. Although the sale of steam for power is reasonably foreseeable, the conditions of such sale are highly uncertain. Appropriate NEPA review would be conducted in connection with any future proposal for the sale of such electricity.
14. The NPR would be capable of producing other radioactive isotopes, such as plutonium-238, for civilian, space, and defense purposes. However,

production of isotopes other than tritium is not part of the proposed action, and appropriate NEPA review would be conducted in connection with any proposal for their production in the NPR. However, in terms of reactor operation, the potential environmental impacts resulting from production of these other isotopes are not expected to be significantly different than the impacts of tritium production. Section 3.3.5.6 discusses use of the NPR to produce these other isotopes.

15. The EIS summarizes or references other related NEPA documentation relevant to the proposed action. In particular, the no-action alternative refers to the final EIS on continued operation of the K, L, and P reactors at SRS (DOE-10).
16. Weapons-grade plutonium would be processed as a metal and shipped to the Rocky Flats Plant in Colorado or another appropriate facility, based on the results of the Reconfiguration PEIS. The Secretary of Energy has expressed a preference that plutonium activities be relocated away from the Rocky Flats site. The location for these activities in the future will be determined after the Reconfiguration PEIS. For the purposes of this NPR EIS, processes showing plutonium material sent to the Rocky Flats Plant are assumed to include the future designated site as well.

2 ANALYSIS OF PROGRAMMATIC ALTERNATIVES

This section describes and analyzes the programmatic alternatives considered for the proposed action to provide new capacity for producing tritium safely and reliably to meet the nation's defense requirements well into the 21st century. These alternatives (and their consequences) embody those issues that must be decided prior to making project-specific decisions. This section also discusses the potential consequences of the programmatic alternatives and summarizes the conclusions in comparative form.

2.1 DESCRIPTION OF PROGRAMMATIC ALTERNATIVES

Figure 2.1 identifies the alternatives considered in this EIS, either on a programmatic level (shaded portion) or on a project-specific level. There are four distinct programmatic decisions that may potentially be made as a result of this EIS. On a programmatic level, the first decision is whether to build new tritium production capacity (preferred alternative) or to rely on existing capacity (no-action alternative). For this decision, the alternative of not having production facilities was also considered, but dismissed as unreasonable (see Section 2.3.1.3). If the decision in the Record of Decision (ROD) for the proposed action is in favor of existing production capacity, no additional programmatic decisions would be necessary, and DOE would continue to provide tritium production capacity from the existing reactors at SRS based upon the analyses provided in the EIS for continued operation of the K, L, and P reactors at SRS, referred to as the RO EIS (DOE-10). If the decision is to build new tritium production capacity, then the issues of the number of new tritium production facilities, size capacity, and schedule number must be addressed. As shown in Figure 2.1, only the decision path of providing new tritium production capacity on an urgent schedule (that is, in or about the year 2000) leads to the project-specific alternatives dealt with in Sections 3 through 7 of this EIS. A decision to provide new tritium production capacity on a later than urgent schedule leads to another set of project-specific alternatives, which would be the subject of a project-specific NEPA review.

2.1.1 Whether to Build New Tritium Production Capacity

It is first necessary to evaluate whether to build new tritium production capacity. One option is to not have DOE production facilities. Tritium recycling from retired weapons, acquisition of tritium from foreign countries or commercial sources, and redesign of weapons to require less tritium are alternatives that may not require a DOE tritium production facility. However, as Section 2.3.1.3 details, these are not reasonable alternatives for the proposed action and have been eliminated from detailed study in this EIS. Therefore, the reasonable alternatives for this programmatic action are as follows:

- *Existing Production Capacity (No Action):* The existing production capacity alternative for tritium involves the continued operation of the K and L nuclear material production reactors located at the Savannah River Site in South Carolina.

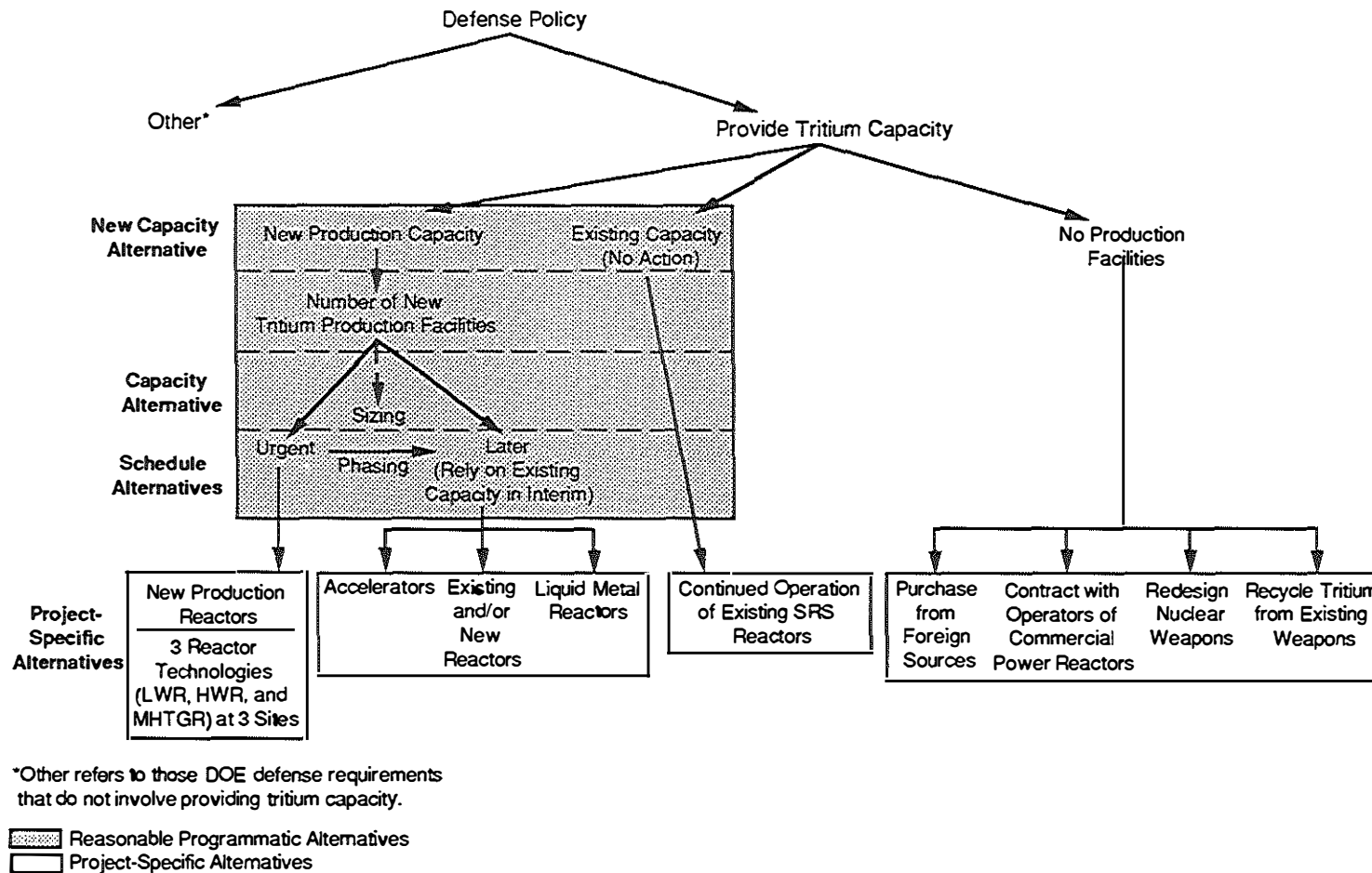


FIGURE 2.1 Programmatic Alternatives Regarding Tritium Production for National Defense Requirements

- *New Production Capacity (Preferred Alternative)*: The new production capacity alternative involves the siting, construction, and operation of one or more facilities that would produce tritium safely and reliably to meet the nation's defense requirements well into the 21st century.

2.1.2 Number of New Tritium Production Facilities

One programmatic issue is whether to site, construct, and operate more than one new tritium production facility. The environmental impacts of this alternative are assessed in Section 2.4.

2.1.3 Capacity for Tritium Production

The purpose of this EIS is to address the alternatives for long-term tritium production capacity, not to satisfy specific production level requirements. The environmental analyses in this EIS are intended to be bounding, to support the choice of production facilities at a single location with a capacity as large as the capacity assessed in this EIS. This bounding capacity was based upon consideration of the reasonably foreseeable long-term tritium capacity that may be required well into the 21st century. A capacity equivalent to that of about a 3,000-megawatt (thermal) (MWt) heavy-water reactor (HWR) was assumed as a reference basis for analysis in this EIS. This capacity is the approximate capacity of the existing production reactors at SRS and is in the range of prudent long-term capacity requirements. There is also an extensive body of experience with both HWRs and light-water reactors (LWRs) in this size range. Further, this capacity is expected to afford DOE the flexibility to produce other nuclear materials if required in the future.

The identification of this capacity as a reference does not impose a requirement that production facilities of these particular capacities be chosen. The decision could be made to build and operate facilities of smaller capacity at a given location, or to build facilities capable of operation at the reference (or full) capacity but to operate them at lower capacities. There are an infinite number of possible capacity alternatives, and it is not reasonable to evaluate every one of them; therefore, to bound the impacts, this EIS evaluates the alternatives for the maximum-sized tritium production capacity that would be installed at any one location. The relative environmental impacts of smaller-capacity reactor facilities are discussed in Section 2.5. A separate discussion of sizing capacity for accelerators is provided in Section 2.6.2.2.

2.1.4 On What Schedule to Provide New Tritium Production Capacity

A programmatic evaluation is necessary to support the determination of when new production facilities for tritium capacity may be required. There are three reasonable alternatives to this question:

1. Providing new production facilities on an urgent schedule (for purposes of this programmatic EIS, urgent is defined to be in or about the year 2000). To establish new production capacity in or about the year 2000, the only technology with the demonstrated capability of providing the nation's tritium requirements is the thermal fission reactor. Thus, the potential

environmental impacts associated with thermal fission reactors are analyzed for this alternative, which is the preferred alternative for this programmatic issue.

2. Providing new production facilities later (later is defined to be more than a few years beyond the year 2000). In addition to thermal fission reactors, there are several other technologies that could provide the capability later than the year 2000 to provide the nation's tritium capacity requirements. Specifically, although not proven tritium production technologies, accelerators and fast fission liquid-metal reactors are potential alternatives. The potential environmental impacts of these technologies are broadly analyzed for this alternative.
3. Providing new production facilities with a combination of urgent and later alternatives utilizing a "phasing" approach. If more than one new tritium production facility is not desired, this alternative would not be pertinent. This alternative involves a combination of alternatives 1 and 2. Under this alternative, some tritium capacity would be provided initially with a new production thermal fission reactor, which would be supplemented after the year 2000 with a different tritium capacity technology.

2.2 IMPLICATIONS OF THE PROGRAMMATIC RECORD OF DECISION

Depending on the course of action determined in the programmatic portion of the ROD, project-specific tiering NEPA documents might be required and would be prepared as appropriate. For alternatives under which new tritium production capacity would be developed in or about the year 2000, a project-specific assessment of environmental impacts has been prepared and makes up the second part of this document (Sections 3 through 7).

2.3 CONSEQUENCES OF PROGRAMMATIC ALTERNATIVES

On a programmatic level, a broad assessment of the potential consequences that might result from each of the reasonable alternatives is necessary so that policy decisions may be made with full consideration of these consequences. The three major discriminators for this assessment are safety, environmental impacts, and reliability. Safety and environmental impacts are of primary importance because DOE is committed to protecting the safety and health of its workers, the public, and the environment. Reliability for tritium capacity is of great importance because the nation's nuclear deterrent capability should not be limited by the availability of nuclear materials. The ROD for this EIS will discuss preferences among the alternatives on the basis of relevant factors, including environmental impacts, safety, reliability, costs, technical considerations, and agency statutory missions.

2.3.1 Consequences of Whether to Build New Tritium Production Capacity

The consequences of relying on existing tritium production facilities to provide the nation's tritium capacity well into the 21st century, or of building new production facilities for this purpose, are assessed in this section.

2.3.1.1 Existing Tritium Production Capacity (No Action)

The alternative of existing tritium production capacity (no action) involves the continued operation of the K and L heavy-water reactors at SRS in South Carolina. The specific environmental consequences of continued operation of these reactors, at least until new production capacity is demonstrated, are addressed in the RO EIS (DOE-10). Sections 3 and 4 of this EIS summarize the environmental impacts of this alternative, assuming operation of the existing SRS reactors, as taken from the project-specific RO EIS.

For this programmatic section, an assessment is presented of the potential consequences of continued operation of the existing reactors well into the 21st century. This assessment of safety, environmental impacts, and reliability is based on the RO EIS and on a study by the National Academy of Sciences (NAS 1987) where relevant to the assessment. However, the ROD for the RO EIS supports continued operation of the K and L reactors at least until replacement production capacity is demonstrated; the uncertainty of extending this assessment for operation well into the 21st century is recognized.

Safety

Over their lifetime, the existing reactors at SRS have undergone extensive upgrades to improve their safety. There have been significant improvements in the management and oversight of the facilities, training of personnel, and plant corrective and preventive maintenance procedures. Also, the addition of several safety support systems has improved the ability of the operators to prevent accidents.

The age and unique designs of the existing tritium production reactors require greater dependency upon human/machine interface for correct response to operational conditions, as opposed to modern reactor design and control systems that are less dependent upon human actions for correct and safe operational control actions. Therefore, the existing reactors are expected to be more prone to problems arising from or exacerbated by human error, but current regulatory standards and guidelines are not expected to be exceeded.

Environmental Impacts

A detailed analysis of the project-specific environmental impacts on resources, and their significance, for existing production reactors is contained in the RO EIS and is summarized in Sections 3 and 4 of this EIS. The broad environmental impacts of operating the existing reactors well into the 21st century would be as follows:

- The existing reactors at SRS rely on confinement systems (that is, systems that control the release of effluents during normal operations and accidents) rather than containment systems. While a containment dome could mitigate environmental impacts of certain severe reactor accidents at the SRS reactors, the NAS and DOE have concluded that this would not substantially improve the safety of the SRS reactors and would not be cost-effective.
- The existing reactors are about 35 years old, and there are problems inherent in the operation of aging facilities. The existing reactors, therefore, are

expected to require more maintenance than new facilities would require. This is expected to produce higher life-cycle costs and more occupational radiation exposure to maintenance workers at the existing facilities.

Reliability

In the context of this EIS, reliability for tritium production capacity can be defined as "the ability to supply the tritium requirements to maintain the nuclear weapons stockpile approved by the President."

Conventional practice would suggest that the SRS reactors, which were built in the 1950s, were designed for lifetimes of 20 to 40 years, and not the 85 years that would be required of them if they were selected to provide the nation's tritium production capacity through the year 2040. Although the SRS reactors have undergone extensive upgrading and modification, and no life-limiting mechanisms have yet been identified, they show definite and understandable signs of aging, including material failures and degradations, intensive maintenance requirements, and greater demand from operators and technicians. Thus, primarily due to the age of these reactors, there is considerable uncertainty about the length of time these production reactors can be prudently relied upon to meet the nation's tritium production requirements. Also, it is unknown whether a new production reactor or alternative means of supplying tritium capacity will be available before each of the existing reactors encounters some age-related problem that precludes safe operation.

Thus, their age alone suggests that operation of the existing reactors may not be possible for as long as the United States would be relying on its nuclear deterrent as a fundamental component of foreign policy. Indeed, it is not prudent to rely on these reactors for 50 more years, even if they prove to be operational within the regulatory safety and environmental envelope for this extended period.

2.3.1.2 New Production Capacity (Preferred Alternative)

The new production capacity alternative involves the siting, construction, and operation of one or more facilities that would provide the capacity to meet the nation's tritium requirements well into the 21st century. The only process currently known for producing tritium in the quantities required for national defense involves bombarding the element lithium with a neutron; this process is shown in Figure 2.2.

Currently, the only demonstrated means to produce the quantities of tritium required is by use of a thermal fission reactor. In the future, other technologies, such as linear accelerators or fast fission reactors, might be developed and demonstrated to be viable means of producing tritium. However, because significant development and testing are required for these alternatives, they are not considered as reasonable alternatives for tritium production capacity on an urgent schedule. Nonetheless, these other technologies may be reasonable long-term alternatives, and, thus, the potential consequences of using them to produce tritium are broadly assessed in Section 2.6.

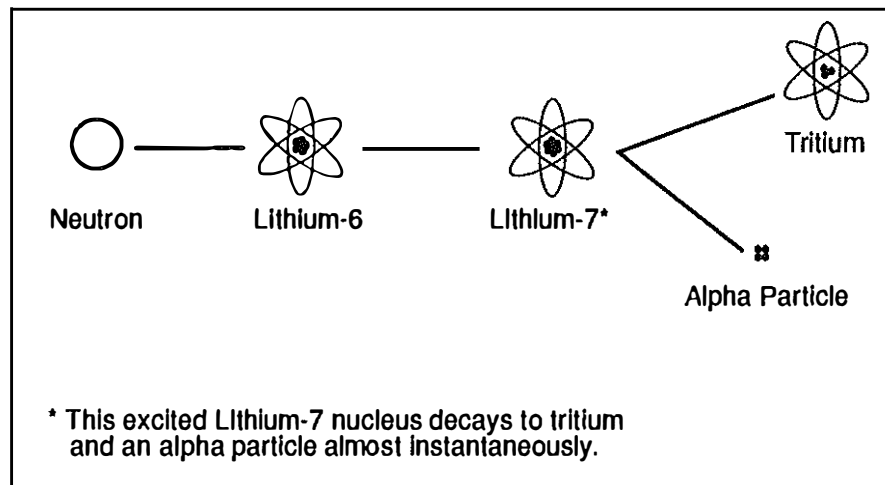


FIGURE 2.2 Fission Process to Produce Tritium

For the purpose of comparison with other programmatic alternatives, the potential impacts of new tritium production capacity using thermal fission reactor technology are presented in this section. Similar to the analysis in Section 2.3.1.1, new production reactor facilities are assessed for safety, environmental impacts, and reliability for operation well into the 21st century. This impact analysis is broad in scope; the specific environmental consequences of the new production reactor alternatives are presented in Section 5 of this EIS.

Safety

The DOE intends to design, construct, and operate the proposed new production reactor facilities in such a way as to provide a level of safety and of safety assurance that meets or exceeds that afforded to the public by modern commercial nuclear power plants. To accomplish this, the new production reactors would:

- Adopt advances in technology that have developed over the past 30 years in nuclear design, construction, and operation.
- Incorporate reactor designs that have advanced safety, instrumentation, and control systems that will simplify operations and reduce the potential for accidents. The designs would also incorporate the use of "passive" systems that rely on natural forces and phenomena, such as convection and gravity, minimizing the need for operator action or external power in order to safely respond to accident situations.
- Include features such as containment to mitigate the release of radioactive materials into the environment.

The significant safety benefits of new production facilities over existing facilities are clear: (1) less risk of potential accidents due to improved design features, including passive and active safety features, containments, and improved reactor design and shielding, and

(2) improved human/machine interface, thus resulting in greater margins of safety and additional lines of defense to protect people both on-site and off-site.

Environmental Impacts

The project-specific environmental impacts to resources for siting, constructing, and operating one or more new production reactors are discussed in Section 5 of this EIS. The broad environmental impacts would be as follows:

- The construction of new reactors would create both environmental and socioeconomic impacts (described for specific site/technology alternatives in Section 5) that existing facilities would not. Socioeconomic impacts from new production reactor operations would not differ significantly from those of the existing production facilities.
- The new reactors would have lower thermal impacts than one of the two existing production facilities because the new reactors would be constructed and operated with closed-cycle cooling towers.
- The new reactors would be designed to meet present regulatory requirements to minimize gaseous and liquid emissions and solid wastes. Current requirements are more stringent than those that were in place when the existing SRS reactors were designed and constructed. Further, new components and subsystems reduce the likelihood of inadvertent releases due to equipment failures. Thus, there is expected to be less potential for radiological and other emission impacts to all resources from both normal operations and inadvertent releases.
- The new reactors would be expected to require significantly less maintenance than the existing facilities would require. The resulting impact is expected to be lower life-cycle costs and lower exposure to maintenance personnel.

Reliability

New production reactors would be designed, constructed, and operated as modern, efficient facilities using advanced technology to ensure reliability, maximize safety, and minimize environmental impacts. Reliability is a very important requirement for the tritium production facility because it is directly linked to national security. If the nation's tritium production facilities are not reliable, the nation's nuclear weapon deterrent, and thus national security, may become unreliable.

New production facilities would be expected to result in less material failures, less maintenance requirements, and less demand from operators and technicians to ensure continuing operation than existing facilities. Incorporation of technology advances would also enable the new facilities to be less dependent upon human/machine interfacing for reliable operations. New facilities would be designed to provide tritium production capacity requirements for the envisioned design lifetime.

Clearly, a new facility that incorporated the latest advancements in technology and lessons learned from the past would be expected to result in a greater ability to meet tritium production capacity requirements than presently exists. Any single new facility alone might not result in meeting requirements at all times, as the reliability criterion is defined.

2.3.1.3 No Production Facilities

Methods for obtaining tritium from other sources, or for reducing the requirements for tritium, have been considered as alternatives to producing tritium in DOE's own facilities. Four potential methods are (1) purchase tritium from other sources, (2) contract with operators of commercial, NRC-licensed nuclear power reactors, (3) recycle tritium from existing weapons, and (4) redesign weapons to require less tritium. As explained below, these methods are not analyzed in detail because they are not considered to be reasonable programmatic alternatives to the proposed action.

Purchase from Foreign Sources

The DOE has considered the purchase of tritium from other sources, including foreign nations. Conceptually, the purchase of tritium from foreign governments could provide a fraction of the tritium requirement. However, it is contrary to national security policy to be dependent on foreign governments for the supply of defense nuclear materials. Based on the uncertainty associated with obtaining tritium from foreign sources, considering national security policy, the purchase of defense nuclear materials from foreign governments is not considered to be a reasonable alternative to the proposed action.

Contract with Operators of Commercial Power Reactors

Nuclear materials could be produced directly in existing light-water reactors, or separated isotopically from high-assay plutonium in existing spent fuel from light-water reactors. Although the law that prohibits the conversion of special material in spent fuel from NRC-licensed reactors to nuclear explosive uses (P.L. 97-415) does not specifically prohibit the production of tritium in commercial nuclear reactors (because tritium is considered a by-product and not special nuclear material), the production of tritium for defense purposes in commercial nuclear reactors would be contrary to the long-standing national policy to separate the commercial nuclear reactor program from the nuclear weapons production program. The use of commercial nuclear reactors for defense purposes could cause other countries to question U.S. nonproliferation policy. Due to the institutional barriers discussed above, DOE does not consider production of defense nuclear materials in commercial nuclear reactors to be a reasonable alternative to the proposed action.

Recycle Tritium from Existing Weapons

Tritium is replaced in weapons when the tritium content decreases, and contamination products increase as a result of tritium decay. It is possible to reprocess the tritium to remove the contaminants and to recycle the recovered tritium into the tritium supply. The DOE

presently does this on a routine basis, and this recycled supply is part of the inventory that maintains the tritium stockpile within the requirements of the Stockpile Memorandum.

Reliance upon recycling of tritium from existing weapons alone to maintain the nuclear weapons stockpile would eventually diminish the supply of tritium to a level insufficient to maintain the nuclear stockpile. If the decision were made not to build new production capacity for tritium, then DOE would effectively rely on the existing means (the SRS reactors and/or tritium recycle from inventory). Thus, only in the sense that depleting the recycle inventory in process yields additional tritium, is tritium recycle an interim means of providing tritium "production" capacity. It is clear, however, that tritium recycle is not a reasonable long-term alternative and would not enable the nation to maintain its current level of nuclear deterrent well into the 21st century. It has been suggested that an arms agreement such as START would significantly reduce tritium requirements. However, the immediate availability of a few thousand warheads would delay a tritium shortfall by, at most, only a few years due to the rapid radioactive decay of tritium. Even a protracted retirement schedule would not be expected to provide enough tritium to meet requirements if no new tritium were available. Therefore, a START treaty does not eliminate, but could defer (in much the same way as tritium recycle), the need for an ongoing tritium supply capacity as required of DOE under the Atomic Energy Act.

Redesign of Weapons to Require Less Tritium

The DOE weapons laboratories are continuing to explore low-tritium weapon design technology. In the long term, if low-tritium weapons were developed and deployed, they could be incorporated in the stockpile. Incorporating the low-tritium weapons would involve a very large development effort, extensive nuclear testing, and a massive replacement of much of the weapons stockpile to substantially reduce the long-term tritium demand. Even if most of the stockpile could be replaced with low-tritium designs, a supply of new tritium would still be needed to maintain the new weapons. Therefore, redesign to use less tritium is not a reasonable short-term or long-term alternative.

2.4 NUMBER OF NEW TRITIUM PRODUCTION FACILITIES

New production capacity would ensure the ability to produce, over the long term, those quantities of tritium that may be required for the nation's security. To accomplish this, the production facilities must be able to ensure safe and reliable production of tritium well into the 21st century. One of the most effective ways to ensure this is with redundancy. One of the programmatic decisions that will be made as a result of this EIS is whether to site, construct, and operate more than one new tritium production facility. The analyses in this EIS support a decision to build one or more new tritium production facilities. However, the analyses in this EIS do not support locating more than one new reactor facility at the same site.

The potential environmental impacts from two production facilities at two different sites would be essentially equivalent to the sum of the environmental impacts resulting from each of the individual production facilities. The impacts of the proposed new production reactors that would meet the urgent schedule are discussed in Section 5. For technologies that might be developed in the future, the programmatic impacts to be considered are presented in Section 2.6. If one of these future alternatives were chosen in the ROD, project-specific NEPA documentation would be prepared as required.

Geographical separation of the new tritium production facilities would result in a minimal amount of cumulative environmental impacts. The cumulative environmental impacts from two facilities that are of greatest concern would be those associated with spent reactor fuel and with the ultimate disposal of radioactive wastes from the facilities. The NPR would be able to produce tritium whether or not spent fuel was reprocessed. For the purposes of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

Regarding more than one new tritium production facility, there would be greater flexibility in scheduling maintenance and performing operations and there would be less operating demand on two plants than one, thus providing a greater margin of safety for each facility. However, DOE requires that its facilities operate with safety as a paramount requirement. Thus, whether there is one tritium production facility or two, DOE would not operate any facility that is not safe. Additionally, more than one new tritium production facility would provide a much higher assurance of reliable supplies of tritium and would significantly lower the risks to maintenance of the nuclear deterrent.

2.5 SIZE CAPACITY OF NEW TRITIUM PRODUCTION FACILITIES

The potential impacts of building and operating smaller-capacity tritium production facilities are presented descriptively, relative to the impacts of full-capacity facilities. These generic impacts are expected to be applicable to potential future technologies such as liquid-metal reactors. However, since accelerators are not a reactor technology, a separate discussion of sizing capacity for accelerators is provided in Section 2.6.2.2.

In 1988, DOE completed a comprehensive study of new production reactor capacity (DOE-60). That study considered 18 various alternatives of size/technology combinations for the NPR program and included an evaluation of both safety and environmental impact of these alternatives. The information below is extracted in part from that source. In terms of environmental impact and safety, smaller-capacity plants would generally be expected to have the effects discussed below relative to the full-capacity plants, which are analyzed in the project-specific portion of this EIS.

2.5.1 Construction

The environmental impacts of constructing a smaller-capacity plant would not differ significantly from a full-capacity plant. While the reactor and many of the support facilities would be smaller (but not in direct proportion to capacity), the reactor containment structure would be essentially the same in size. No major reduction in material or requirements would be expected. In summary, any reductions in construction impacts for a smaller reactor from those of a full-capacity reactor would be small.

2.5.2 Operations

Potential differences in operations of smaller-capacity plants versus full-capacity ones are as follows:

- *Air Quality.* A smaller-capacity plant would produce less atmospheric releases from the reactor and its support facilities, including less drift and water vapor from cooling tower operation. The emissions from emergency power diesels would not be changed substantially, since the diesel sizing and operating requirements would be essentially the same as for a full-sized reactor. (Potential impacts from radioactive releases to the atmosphere are addressed below.)
- *Water Quality.* Because of the lower thermal output of the smaller reactor, less water would be required for cooling purposes, and the thermal discharge would be reduced in approximate proportion to the reactor thermal power. Since the thermal discharge impacts of a full-capacity plant are expected to be insignificant (Section 5), this reduced effect would also be insignificant. (Potential impacts from radioactive releases are addressed below.)
- *Socioeconomics.* A smaller reactor would require essentially the same number of operating and maintenance/support personnel as a full-capacity plant, and, hence, would have similar socioeconomic impacts.
- *Radioactive Releases and Impacts to the Environment (including biota, workers, and the public).* During all scenarios (normal operations, nonsevere accidents, and severe accidents), for a smaller plant there would be correspondingly less impact to the environment (and all resources) in the event of radioactivity releases since the source term would be less than for a larger plant.
- *Spent Reactor Fuel.* A smaller reactor would be expected to generate less spent fuel since it would operate with correspondingly less fuel in its core. However, the reduced amount of spent fuel might not be directly proportional to the power reduction of the plant, since optimization of a lower-powered core can be achieved through variation of several core parameters, such as fuel enrichment and core lattice structure.
- *Accident Risk.* A smaller-capacity plant potentially offers greater passive safety capability. With greater passive safety capability, there would be less risk of environmental impact from any postulated accident, since there is greater margin to prevent or to cope with accidents. Additionally, a smaller plant contains a smaller core inventory of fission products. However, the significance would not be expected to be distinguishing because the risk of environmental impact from any accident at a full-sized plant is expected to be very small (see Section 5 of this EIS). However, the magnitude and significance of this has not been quantified.

2.6 ENVIRONMENTAL CONSEQUENCES OF SCHEDULES TO PROVIDE NEW TRITIUM PRODUCTION CAPACITY

This section of the EIS assesses the potential programmatic environmental consequences that might result from the decision of when to provide new production capacity for tritium. Because this is a timing issue, it involves a degree of foresight with respect to potential technologies and their associated environmental impacts. As a basis for analysis, those technologies that are likely candidates for tritium production in the future are assessed using the most currently available information to DOE.

2.6.1 Environmental Consequences of Urgent New Production Reactors

The programmatic environmental consequences of urgent new production reactors are discussed in Section 2.3.1.2. For the project-specific portion of this EIS, the environmental consequences for the three thermal reactor technology alternatives at each of three potential sites are discussed in Section 5 and compared in Section 3. Those discussions are not repeated here.

2.6.2 Environmental Consequences of Future New Tritium Production Capacity

While DOE has determined that tritium production capacity in or about the year 2000 could only be effectively satisfied with either HWR, LWR, or MHTGR thermal fission reactors, DOE recognizes that future -- that is, beyond the year 2000 -- tritium production capacity might be based on the use of innovative technologies that might possess significant environmental and safety benefits. Two particularly promising technologies that might be used to satisfy DOE's future tritium production capacity requirements are liquid-metal (fast fission) reactors (LMRs) and accelerators. Additionally, fusion reactors are assessed, but they are not considered a reasonable alternative.

The following discussion provides a brief overview of safety, environmental, and reliability concerns associated with the LMR and accelerator technologies. It is relevant to note that much of the specific information necessary for a detailed assessment of these technologies is incomplete and unavailable since neither is fully developed and, more importantly, have never been used to produce tritium. Therefore, much of this assessment is based upon theoretical knowledge and generic scientific evidence for these technologies. For the purpose of this programmatic portion of the EIS, this assessment provides the best available information on safety, environmental, and reliability concerns associated with these technologies. This document does not provide a project-specific review of these technologies because they are not considered to be reasonable alternatives for tritium production capacity on an urgent schedule. If it is determined in the ROD that one of these future technologies might be used to provide new tritium capacity (either alone or in combination), a project-specific NEPA document would be prepared as required.

If a decision is made to build future tritium production facilities, but LMRs and accelerators fail to satisfy DOE requirements, future tritium production capacity could be based on a yet-to-be designed new generation of thermal fission reactors that incorporate yet-to-be identified advances in safety and environmental control technologies. The potential environmental impacts of these future thermal fission reactors would not be expected to significantly differ from those presented in Sections 3 through 7 of this EIS.

2.6.2.1 Liquid-Metal Reactors

In its June 1988 report, the Energy Research Advisory Board (ERAB) reviewed and assessed LMR technology as one of four candidates for new reactor capacity to produce tritium to meet U.S. requirements for nuclear weapons materials (ERAB-1). While ERAB reported that the LMR is potentially a very efficient producer of tritium, it acknowledged the serious weakness that the LMR has no proven target technology or tritium target system. There is good, but limited, experience within DOE, which operates test LMRs, that could be used to develop and qualify target technology. Nevertheless, the various LMR and tritium production concepts require evaluation and selection of a specific approach that can satisfy DOE's tritium production needs. While the general state of LMR technology is approaching commercial status, extensive development, testing, and qualification work remains to successfully design and validate a tritium production version of an LMR. Thus, DOE is evaluating the LMR as a future alternative for tritium capacity rather than as an urgent alternative. Additionally, although no design features for production of plutonium and other isotopes has been determined for the LMR, confidence is high that the LMR would be capable of producing these materials with no significantly different environmental impacts from the other reactor technologies.

It is also noted that ERAB reported that the existing Fast Flux Test Facility, after certain modifications and target technology development, could supply a small, but significant, quantity of tritium. However, ERAB noted that the time needed for modification and development affected the ability of the Fast Flux Test Facility to serve as an urgent tritium production capacity option.

Safety

A key aspect of the history of the LMR program in the United States is a reduced emphasis on breeding and a primary emphasis on safety and economics. As with any reactor technology, LMR facilities must be built, tested, and documented to minimize the potential for accidents and any environmental impacts from normal or abnormal operation. Efforts have focused on modular designs. LMR design based on the use of modular units with inherent safety features, including passive decay heat removal, offers potentially significant advancement in safety over current commercial reactors. Further, inherent safety features have been partially demonstrated in EBR-II.

The LMR technology uses passive principles to mitigate severe accidents. For example, because the thermal conductivity and thermal capacity of sodium are high, an LMR cooling system can temporarily lose sodium pumping power and still remove decay heat from the reactor core. The ERAB reported that proponents' analyses have indicated that certain of the severe accident sequences can be passively mitigated such that reactor damage will not occur for long periods -- i.e., hours or days -- without the intervention of active controls or operators. If these results are confirmed through the detailed design and safety review process, they would represent an improvement in reactor protection and public safety over present designs.

However, there are safety concerns associated with sodium-cooled LMRs that require attention. A principal safety issue with the reactor core is the potential for a power excursion due to the response of the reactor power level to voids (i.e., "bubbles") in the sodium. Since voids could result in unsafe power excursions and damage to the reactor core, engineering solutions must be implemented to avoid them.

Another concern is the chemical reactivity of sodium with most nonmetals. Special precautions must be taken to prevent exposure of sodium to air and water. When exposed to air, sodium readily oxidizes. When exposed to water, sodium reacts vigorously, forming hydroxides and hydrides and releasing hydrogen gas, which in turn can react explosively with oxygen. Therefore, LMR design must include features to prevent sodium reactions with air and water, and to mitigate their effects if they occur.

Safety precautions and procedures for protection of personnel and the environment at an LMR facility would be similar to those at other reactor technology facilities.

In summary, a future LMR facility could be implemented with safety features approximately equal to those available for other reactor technologies. While there is the potential for significant safety improvements in passive designs that mitigate the risks of severe accidents, there also is a requirement for advanced engineering to avoid unsafe power instability effects and sodium reactions with other materials.

Environmental Impacts

As with other reactor technologies, the most significant environmental concern associated with LMR technology is the generation of highly radioactive materials requiring environmentally sound management. Both the types and quantity of radioactive waste generated by LMR technology are expected to compare favorably to other reactor technologies.

As with other fission reactors, LMRs produce radioactive fission products that may escape, for example, into the coolant through defects in the cladding material. The liquid-metal coolant itself is also made radioactive, along with structural materials, by the high neutron radiation produced during fission. It is important to note that DOE is experienced in the management of gaseous, liquid, and solid radioactive wastes, and the technology exists for the safe management of these wastes. Also, it should be noted that the generation of gaseous, liquid, and solid radioactive wastes is not unique to LMR technology; these wastes also are generated by the operation of other fission reactors and accelerators.

In summary, the environmental characteristics of LMR technology are comparable to those of other reactor technologies. Thus, it is expected that the construction and operation of an LMR tritium facility would have similar effects on the environment as those associated with other reactor technologies.

Reliability

As discussed earlier, there is considerable background in LMR technology and, in the long term, this technology is potentially attractive as a future tritium production concept. Further, EBR-II and the Fast Flux Test Facility test reactors, both of moderate size, have operating records with high capacity factors and demonstrated safety of performance. The EBR-II and Fast Flux Test Facility operations have resulted in reliable, but limited, LMR experience. It is expected that an LMR constructed for tritium production would be designed, constructed, and operated as modern, efficient facility using advanced technology to ensure reliability. However, ERAB reported that strong industrial backing for LMR technology as a new tritium production source was not apparent. This alone would require a significant monetary investment solely by DOE. A design for an LMR that has been optimized for tritium production

does not exist and, considering the scope of target development, concept development, and other factors, there is considerable schedule and cost uncertainty.

2.6.2.2 Accelerator Production of Tritium

Using an accelerator to provide tritium production capacity has been suggested as an alternative to the use of available nuclear reactor technology. At the request of the Secretary of Energy, ERAB has evaluated the current status of accelerator and related tritium-target technology to assess whether such a system could meet the nation's tritium needs; the final report to the Secretary was issued in July 1990 (ERAB-2).

The ERAB chose to evaluate the radio-frequency, continuous wave (RF/CW) linear accelerator (linac) as the most suitable accelerator technology for the production of tritium. The ERAB reported that the RF/CW linac approach is technically sound. As envisioned, a facility would consist of an accelerator system, a beam transport system, a target system, a tritium extraction system, and a waste management system. Further research, development, and testing are necessary; however, insurmountable problems are not expected. The least developed of the necessary systems is the target system; to date, target assembly design is only a concept.

The ERAB described a program that provided an accelerator in the shortest possible time and concluded that it may be possible to complete this program 10 years after contractor selection. The ERAB acknowledged, however, that this was an aggressive schedule that requires many activities to be undertaken simultaneously. Additionally, technical and programmatic uncertainties exist; their resolution requires research, development, and testing of several accelerator systems and target technology. In 1988, the ERAB concluded that the accelerator system was not mature enough to provide new production capacity in the next 10 to 12 years. This conclusion was based on the uncertainty of cost-effective full-scale production on an urgent schedule with low risk. It was concluded that a significant research and development (R&D) effort would be required for an accelerator to attain the reliability associated with reactor production of tritium. No new research along these lines was then being carried out, and such R&D would be subject to the uncertainty generally associated with these activities. There are substantial risks associated with applying an extension of research systems to new levels and then depending on them for production.

Engineering development would be needed to design and demonstrate the major components, optimize reliability, improve efficiency, and ensure operability of the integrated system. Each of these activities represents a significant technical challenge. Collectively, this implies a major developmental effort.

The major deficiency associated with this technology, and indeed the reason it cannot meet program objectives, involves an estimated 5 years required for the first project decision point of an accelerator development program. In other words, verification that the accelerator technology could be successfully applied to production-level-capacity tritium supply could not be ascertained for about 5 years after initiation of R&D. If at that time it was determined that the technology could not be applied successfully, proven reactor technology would have been delayed by 5 years or more. This would widen the period of vulnerability during which a tritium supply would be uncertain. Thus, while insurmountable problems are not expected, an accelerator-based tritium production program could experience delays, forcing DOE to either rely

on the current reactor capacity or develop other safe, reliable means of providing tritium. It would appear that a tritium production program based on accelerator technology would create an unacceptable schedule risk for providing new tritium production capacity by the year 2000. Therefore, DOE is evaluating the accelerator as a future alternative, rather than an urgent alternative.

It should be noted that ERAB evaluated the advantages of using accelerators to produce only tritium; thus, the following discussion is limited to issues associated with accelerator-based tritium production. However, ERAB also considered whether accelerators possess the desired flexibility and capability to provide potential plutonium production capacity. The ERAB acknowledged that many of an accelerator's advantages are lost if plutonium production is considered. None of the proponents of accelerators has advocated accelerator-based plutonium production, and ERAB agreed that such use was not desirable. The low radioactivity and better safety and environmental features of accelerator production of tritium do not apply to the production of plutonium. Accelerator-based plutonium production would require uranium targets in which fission would occur, resulting in radioactive fission products, and high target heating. This would also be true for production of other isotopes. To be environmentally safe, such a system would require a massive shielding containment, which might be infeasible. While production of plutonium and other isotopes is not part of the proposed action of this EIS, it is noted that selection of an accelerator for tritium production could preclude its use for other nuclear material production that might be desired in the future.

The General Accounting Office (GAO) has also issued two reports on using a particle accelerator to produce tritium. In its February 1990 report, GAO found the following:

- Accelerator production of tritium appears technically feasible. However, an accelerator with the operating characteristics necessary for tritium production does not currently exist. Engineering development is needed to overcome accelerator uncertainties; specifically, development is needed to design and demonstrate the major components, optimize reliability and efficiency, and ensure sustained operability of an accelerator with the parameters required for tritium production.
- When compared to reactor production, accelerator production of tritium presents fewer safety and environmental concerns. However, because of the amount of electricity required by a large tritium-producing accelerator, a new electric generating plant might be needed. If this is the case, then the accelerator advantages would be partially offset by the environmental consequences associated with fossil fuel or nuclear power electric generating facilities (GAO 1990).

In its February 1991 report, GAO reported that a smaller particle accelerator would use less power than the type previously reviewed by DOE. This feature could make its safety and environmental advantages more attractive. Additionally, due to its modular nature, the particle accelerator might also be more flexible in terms of capacity (GAO 1991).

Safety

As reported by ERAB, an RF/CW linac possesses important safety and environmental advantages compared with nuclear reactors, including the following:

- The lack of uranium, plutonium and fission product inventory;
- Low residual radioactivity and heat;
- Low operating temperature and pressure; and
- Ease of rapid shutdown.

An accelerator offers potential safety advantages relative to nuclear production reactors. It could be built and operated with a low level of risk to the public and an acceptable level of risk to operating staff. Inherent safety features provide confidence that the accelerator could be operated safely. First, controls are designed to stop the beam automatically in response to abnormalities; the proton beam can be shut down in 10 to 15 microseconds, a short enough shutdown time to avoid large destructive energy depositions. Second, the beam would fail to reach the target under almost all failure modes involving equipment, control systems, or human error. Residual heat in the target system is about 100 times lower than that in comparable production reactor fuel/target systems. High-reliability, redundant cooling systems should be possible due to lower power densities.

At equilibrium, an accelerator's target system would contain a tritium inventory similar to that contained in a nuclear reactor. The principal safety concern associated with the target system is that the target matrix could overheat, resulting in melted targets and release of radionuclides to the accelerator or environment. The probability of a release large enough to have a significant off-site dose is expected to be low. The internally initiated accident sequences of concern all require a failure to shut down the beam once a major failure has occurred. However, inherent features in an accelerator target system make the likelihood of significant accidental tritium releases much less than that associated with a reactor. In all cases, safety features would provide a high degree of assurance of no significant releases to the atmosphere.

The highest safety risk is associated with the potential for releases from the target processing facility; however, the risk for accidental releases from the target processing system are about the same as the risk associated with nuclear production reactors. The effects of externally initiated accidents (e.g., earthquakes) on a target processing facility at an accelerator site would be similar to the effects on a target processing facility at a nuclear reactor site.

Because of an inherently low source term, no accident scenarios have been identified that would result in significant releases from the accelerator portion. Inherent safety features in an accelerator provide confidence that the machine can be operated safely.

An occupational concern is linked to short-lived isotopes of oxygen, carbon, and nitrogen formed by the activation of air in the accelerator bays during operation. The bays are kept sealed after the accelerator is shut off to allow activation products to decay to acceptable levels before ventilation. While this process seems adequate, ERAB reported that possible accidents that could release the activated air from the facility should be examined. Still, such

an accidental venting would not likely result in a serious safety concern. Another worker-safety issue is radiation exposures from neutrons reflecting back from the target area toward the accelerator; however, this should not present any significant problems.

Other safety concerns associated with an accelerator include high electromagnetic and prompt radiation fields during operation and activation of some equipment, which might expose maintenance workers to radiation. However, it is expected that adequate personnel protection can be provided through facility design and remote maintenance.

The ERAB reported that no radiological releases have been linked to the beam transport system. This system is expected to have activated components that may require remote maintenance even when the beam is not operating. The beam transport system is of concern as an initiator for target system accidents.

Safety precautions implemented at an accelerator would ensure minimal exposure of workers to hazardous materials that might be used during facility operations. Precautionary steps common to most major industrial facilities would need to be implemented, e.g., handling and processing of large inventories of chemicals will call for carefully designed procedures. However, it is not expected that any of these safety precautions would be beyond the scope of best available practices developed for other industries with similar material handling and processing activities.

Environmental Impacts

When compared with fission reactors, accelerator-based tritium production has several features that result in environmental advantages, principally the lack of uranium, plutonium, and fission product inventory; low residual radioactivity; and much lower thermal discharges. While low-level radioactive waste and residually active materials still will exist, the complete absence of fission products and transuranics eliminates an entire class of environmental issues (LANL/BNL 1989). However, because a full-sized accelerator has not been built, it is difficult to scope the environmental impacts of facility construction and operation. Little detailed information is available about the potential environmental impacts of constructing and operating an accelerator to produce tritium.

Perhaps the most significant environmental concerns associated with an accelerator result from its power requirements. The ERAB examined the characteristics of an accelerator capable of producing a reference quantity of tritium that is consistent with the tritium production capacity of the reactors discussed in this document. The ERAB reported that such an accelerator would require roughly 900 MW of continuous electric power, requirements comparable to the capacity of a commercial power plant. To meet such power needs, DOE would probably prefer to negotiate long-term purchase agreements similar to those for the gaseous diffusion plants; however, projections of future power availability suggest that no location in the United States would be able to supply that level of power (NERC 1989). Thus, an accelerator with the tritium production capability equivalent to that of a 3,000-MW reactor would require construction and operation of a new 900-MW power generating facility.

It is important to note that, as reported by Los Alamos National Laboratory (LANL 1989), downsized tritium-production accelerators could be constructed and operated.

Operating a smaller accelerator would require less power and, depending on accelerator size and location, might eliminate the need to construct new power generating capacity. An accelerator designed to produce one-fourth of the reference quantity of tritium would require roughly one-third the power; thus, several downsized accelerators capable of producing the reference amount of tritium collectively would have higher capital and operating costs than would a single large accelerator capable of producing the entire reference quantity of tritium.

If new power generating capacity would be needed, the environmental effects of constructing and operating the new plant would have to be studied. The environmental advantages of an accelerator might be offset by the impacts of constructing and operating a new fossil fuel or nuclear power plant.

One option for powering the accelerator would be construction and operation of a coal-fired power plant. Major environmental concerns associated with a coal-fired plant include emissions of certain air pollutants that may exacerbate existing problems arising from acid precipitation and ozone; project increases in carbon dioxide (CO₂) and radionuclide emissions; land requirements for and seepage from solid waste management facilities; and control of liquid effluents. These and other concerns have resulted in significant design changes in modern coal-fired power plants. Many documents discuss in detail the environmental concerns associated with coal-fired power plants, including DOE's *Energy Technologies & the Environment: Environmental Information Handbook* (DOE-63).

A second option would be construction of a nuclear power plant. However, the advantages of avoiding a fission reactor for tritium production would be lost with this option. In fact, one of the alternatives evaluated in the project-specific portion of this EIS (an LWR with tritium target development) would clearly be preferable to the accelerator/reactor alternative.

Construction impacts can be estimated based on experience in the construction of other accelerators and large facilities. Further, these impacts would be similar to the effects associated with constructing a new nuclear reactor. If an accelerator were constructed on a DOE reservation, construction and land use-related impacts would be substantially mitigated because these site-specific impacts can be minimized through closely controlled site selection and facility design.

In summary, while accelerator production of tritium offers several significant environmental advantages, the power requirements and lost flexibility to produce other nuclear materials are potentially significant disadvantages.

Further definition of the environmental impacts of the accelerator option is not available. A conceptual design has not been produced to the level of detail required to support a quantitative assessment. The CEQ regulations provide that when the overall costs of obtaining incomplete or unavailable information relevant to the reasonably foreseeable significant adverse impacts are exorbitant, or the means to obtain it are not known, the agency shall always make clear that such information is lacking (40 CFR 1502.22). In the case of using accelerators to produce tritium, there is no further information available. The significant qualitative environmental attributes of an accelerator compared to a reactor have been described based upon theoretical knowledge and generic scientific evidence for this technology as applied to production of tritium. This description is believed to contain sufficient information for a decision to be made on the relative merits of proceeding now with a production reactor option or

embarking on a 5-year R&D program to determine the feasibility of the accelerator option. It must be noted that in its February 1990 report, ERAB estimated that the R&D feasibility costs for the accelerator would be \$300-500 million.

Reliability

A comprehensive discussion of the reliability of tritium-production accelerators is limited by the conceptual nature of the technology. As reported by ERAB, an RF/CW linac is a technically sound approach for producing tritium. To date, however, an integrated accelerator system has not been built and operated. However, the industrial base generally exists to design, develop, and operate accelerator components. The ERAB concluded that feasibility and engineering development issues could be resolved with an adequate research, component and systems development, and engineering demonstration program.

It is expected that tritium-production accelerators would be designed, constructed, and operated as modern, efficient facilities using advanced technology to ensure reliability. However, at this time, the final tritium production rate cannot be confirmed; that rate would be known only after the facility became operational and the first two tritium target batches had been irradiated, processed, and analyzed. Further, while some reliability estimates for individual accelerator components can be made now, it would be very speculative to estimate the overall system reliability before completion of the R&D program.

2.6.2.3 Fusion-Based Tritium Production

While the promise of fusion is bright, the development of a viable fusion reactor continues to elude researchers. At the current state of knowledge, it is uncertain whether this promise will ever become reality. Based upon the considerable uncertainties associated with fusion technology, there is no evidence that a fusion facility could be operational even during the lifetime of the proposed new production reactors evaluated in this EIS. Thus, fusion is not considered as either a reasonable urgent or future alternative for the proposed action.

2.7 COMPARISON OF PROGRAMMATIC TRITIUM PRODUCTION CAPACITY TECHNOLOGY ALTERNATIVES

Table 2.1 provides a comparative summary of the programmatic tritium production capacity alternative technologies (existing reactors at SRS, urgent new production reactors, and future technologies [LMRs and accelerators]) with respect to safety, environmental impacts, and reliability.

TABLE 2.1 A Comparative Summary of Tritium Capacity Technology Alternatives

Technology	Reliability	Safety	Environmental Impacts
Existing Capacity (K and L reactors at SRS)	Long-term availability for reliable tritium production not assured. Extended outage in 1988 for upgrades. Reliability for long-term production uncertain. Potential for additional outages.	Do not maximize use of advances in technology, e.g., advanced safety systems. Greater demand on operator action for safety than new capacity would be expected to require.	Lower power operations offset greater potential for overall environmental impacts.
New Production Reactors (HWR, LWR, MHTGR)	Would be designed, built, and operated using latest advances in reactor technology. Less likelihood of material failures and less maintenance expected than with existing reactors. Reliability expected to be much greater than existing capacity.	Would incorporate designs that have advanced safety systems, passive systems, and containment. This is expected to result in less risk of accidents, less radiation exposure, and less demand on operators for safe operation than existing capacity.	Less potential for radiological and other emission impacts than existing capacity. Overall environmental impacts expected to be lower than existing reactors.
Future Capacity Liquid-metal fast fission reactors	Significant R&D required. Could only be operating later than about the year 2000; thus, existing capacity would be relied upon until new facility operational. Would be designed, built, and operated using latest advances in technology and materials. No expectation of greater reliability than NPR.	Would be designed with advanced safety systems, passive systems, and containment resulting in potentially less risk of accidents, less radiation exposure, and less demand on operators than existing capacity. No significant safety advantages over NPR.	Less potential for radiological and other emission impacts than existing capacity. Occupational exposures and overall environmental impacts expected to be similar to NPR.

TABLE 2.1 (Cont'd)

Technology	Reliability	Safety	Environmental Impacts
Future Capacity (Cont'd) Accelerators	Reliability for accelerator production of tritium is unproven. Significant R&D required to apply technology to tritium production. Uncertainties about tritium production rates. Accelerator technology could only be operating later than about the year 2000; thus, existing capacity would be relied upon until new facility operational. Would be designed, built, and operated using latest advances in technology and materials. No expectation of greater reliability than NPR.	Accelerators possess several potential safety advantages over nuclear reactors, including no uranium and fission product inventory, low residual radioactivity, low operating temperature and pressure, and ease of rapid shutdown.	Accelerators possess several potential environmental advantages over nuclear reactors, including no uranium and fission product inventory, low residential radioactivity, and low operating temperature and pressure. However, accelerators also possess significant environmental impact potential due to a substantial electricity requirement. If production of plutonium and other isotopes is required, handling of fission products and wastes would significantly offset advantages.

3 PROJECT ALTERNATIVES, INCLUDING NO ACTION

This and subsequent sections of the EIS analyze the project-specific alternatives judged to be reasonable, and present information that would enable the Secretary to make decisions regarding siting, construction, and operation of new production reactor (NPR) capacity on an urgent schedule. Section 3 describes and compares the alternative sites at which an NPR might be constructed, the alternative technologies that could achieve tritium production in or about the year 2000, and the no-action alternative. This section also summarizes mitigation, monitoring, and emergency preparedness recommendations that resulted from the analysis of consequences presented in Section 5 of this EIS.

As determined during the scoping period for this EIS, and as presented in the EIS Implementation Plan, the baseline environmental conditions and the no-action alternative for this EIS are based on the EIS for Continued Operation of K, L, and P Reactors at SRS (RO EIS) and assume operations of these reactors at 100% capacity until the year 2040. All the analyses of impacts for this EIS were performed on this basis. The assumption of 100% operations allowed the establishment of an upper bound of reactor operations impacts at SRS below which the actual impacts of NPR plus existing reactors would fall. This is especially true for the estimation of cumulative impacts where, for the time frame from 2000 to 2040, the specific number of reactors in production at SRS, the power levels, and the periods of operation to meet national requirements are uncertain.

On February 11, 1991, the Department of Energy issued a Record of Decision for the RO EIS that determined that P Reactor shall be placed in cold standby and that K and L reactors will remain operational. This decision would change the no action and baseline assumptions, with respect to operation of two reactors at 100% capacity until 2040 at SRS. However, due to the recent issuance of the RO ROD, the no-action alternative and environmental baseline, as well as the cumulative impact of NPR operations, still reflect the assumption of three operating existing SRS reactors. In those instances where the assumption is not an appropriate bounding case, this fact is acknowledged and the discussion is qualified.

3.1 DESCRIPTION OF THE NO-ACTION ALTERNATIVE

The no-action alternative is the option of not siting, constructing and operating new tritium-production capacity. On a project-specific level, it is assumed that the no-action alternative would result in reliance on existing facilities to meet defense needs for tritium. Potential alternatives for tritium production with existing facilities include use of commercial reactors, a reactor at Hanford, research or other DOE reactors, and K and L reactors at SRS as discussed in Section 2.

The DOE operates a nuclear reactor complex at SRS that produces tritium, weapons-grade plutonium, and other isotopes for the U.S. nuclear weapons program and other military and civilian requirements. Two SRS reactors (K and L) are operational, but they currently are undergoing improvements to their safety and management systems. These reactors are 35 years old and cannot be expected to provide reliable tritium-production capacity indefinitely. However, since there are no known reactor-life-limiting mechanisms, continued operation of these reactors would ensure the capability to produce necessary nuclear materials at least until replacement production capacity has been demonstrated.

The DOE has prepared a final EIS (DOE-10) related to continued operation of K, L, and P reactors at full power of 3,000 megawatts thermal (MWt) each. To provide a bounding baseline for comparison in this EIS, these three reactors were assumed to operate at 100% capacity for the period from 2000 to 2040. The DOE has recently announced its decision to continue to operate K and L reactors at SRS and terminate operation of P Reactor in the immediate future and maintain it in cold standby (Record of Decision, February 11, 1991 [DOE-66]). As noted in the Record of Decision, the operation of K and L reactors would ensure the capability to meet nuclear material production requirements at least until replacement production capacity is demonstrated. Therefore, the no-action analysis presented in this EIS, which assumes operation of three SRS reactors at 100% capacity for a period of 40 years beyond 2000, overestimates the potential environmental impacts that might occur with reliance on these existing facilities. As noted in the final EIS for continued operation of K, L, and P reactors, power limits are to be determined from testing programs not yet completed, and operation of the reactors for some extended period at less than 100% of nominal full power is expected.

The existing nuclear materials production complex at SRS includes a fuel and target fabrication plant, four production reactors (two, C and P, are in cold standby), two chemical separations plants for plutonium-target and spent fuel processing, tritium-target processing facilities, a heavy-water rework facility, and waste management facilities. In addition, two new facilities would be available at SRS in the period 2000 to 2040. The Defense Waste Processing Facility, which has been constructed and is in the cold-test phase at SRS, will be used if a decision is made to treat high-level wastes before storage and eventual disposal. Modifications to the SRS nuclear materials production complex include a new Replacement Extraction and Purification Facility for tritium (in H Area).

It is assumed, for the purposes of the no-action alternative in this EIS, that if no NPRs were sited, constructed, or operated, the Hanford and INEL sites would continue operations. By the year 2000, several changes unrelated to the NPRs would occur at both sites (Section 3.2.3). At Hanford, N reactor would continue to remain in cold standby. The Plutonium-Uranium Extraction (PUREX) Plant at Hanford is currently shut down and DOE now has no plan to restart the facility. However, the DOE plans to conduct a NEPA review of alternatives for disposal of Hanford's stored reactor spent fuel (not NPR fuel), and operation of the PUREX facility may be included among the disposal alternatives analyzed in that review. PUREX would be restarted only if that action is determined to be the best alternative.

It is assumed that no new materials production facilities would be constructed and operated at INEL. The new Fuel Processing Facility, presently under construction in the Idaho Chemical Processing Plant complex, would be operational. The percolation ponds at INEL which currently treat wastewater through soil column absorption, would be lined by the year 2000 to prevent groundwater contamination. Other plans for changes in waste management and other facilities are identified in Section 3.2.3.

The consequences of no-action are assessed in Section 5.2 (Hanford), 5.3 (INEL), and 5.4 (SRS) and are summarized and compared with the consequences of the alternatives for the proposed action in Section 3.5. Section 4 describes the environmental conditions at the three alternative sites with other facilities operating as planned in the years 1995 (construction baseline) and 2000 (operations baseline). To compare the consequences of no action with the consequences of the proposed action, major changes anticipated in existing environmental conditions occurring at the alternative sites during the period 1995-2000 are described under the consequences of no action (Sections 5.2, 5.3, and 5.4).

3.2 ALTERNATIVE SITES

This section describes how the reasonable alternative sites for construction and operation of an NPR were identified (Section 3.2.1). The identification of locations for NPR facilities at each alternative site is summarized (Section 3.2.2), and the existing and planned facilities that would support NPR operations are described (Section 3.2.3). The three reasonable site alternatives are the Hanford Site near Richland, Washington; the Idaho National Engineering Laboratory near Idaho Falls, Idaho; and the Savannah River Site near Aiken, South Carolina. Descriptions of the alternative NPR technologies are presented in Section 3.3. Comparisons of the consequences of constructing and operating NPRs at the alternative sites are presented in Section 3.4.

3.2.1 Identification of Alternative Sites

Alternative sites for construction and operation of an NPR were selected by screening 13 federally held and DOE-administered sites where nuclear defense activities have been conducted (Jicha 1988). These 13 sites were (1) the Feed Materials Production Center (FMPC), Fernald, Ohio; (2) Hanford; (3) INEL; (4) the Lawrence Livermore National Laboratory (LLNL), Livermore, California; (5) the Los Alamos National Laboratory (LANL), Los Alamos, New Mexico; (6) the Mound Plant, Miamisburg, Ohio; (7) the Nevada Test Site (NTS), Las Vegas, Nevada; (8) the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; (9) the Pantex Plant, Amarillo, Texas; (10) the Pinellas Plant, Pinellas, Florida; (11) the Rocky Flats Plant (RFP), Golden, Colorado; (12) Sandia National Laboratories (SNL), Albuquerque, New Mexico; and (13) SRS (Figure 3.2-1).

The following three screening criteria were used to determine which of these potential sites were viable alternative sites for NPR facilities (Jicha 1988):

1. Although the proposed NPR facilities would be designed to be comparable to the best commercial reactors, as an added measure of conservatism in siting these facilities, siting requirements will include remoteness from population centers and adequate exclusion area. The site shall be environmentally acceptable. The site shall also encompass emergency planning zone requirements.
2. The site shall have experience in large nuclear reactor programs.
3. The site shall have production-level experience and facilities to support spent fuel and target processing and long-term, high-level waste (HLW) management.

The following paragraphs provide a summary evaluation of the 13 DOE sites against the three criteria. A more complete description of these three criteria and their application in the site-selection process is given by Jicha (1988).

Evaluation Against Criterion No. 1: Eight sites (SNL, LANL, ORNL, RFP, LLNL, FMPC, Mound, and Pinellas) were eliminated from consideration after applying the first criterion (remote areas, adequate exclusion area, environmental acceptability, and emergency planning).

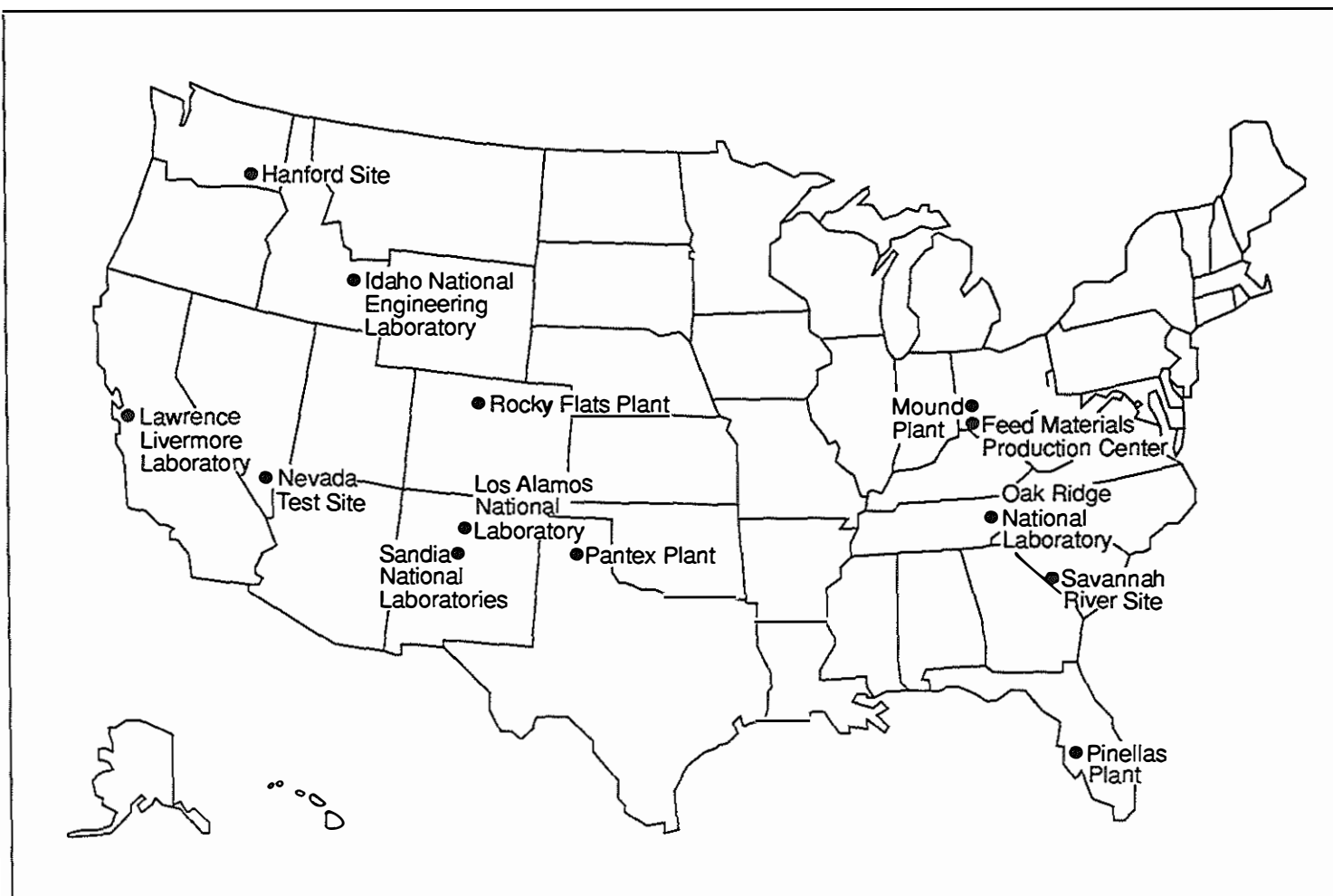


FIGURE 3.2-1 Locations of Potential NPR Sites Originally Considered

All eight sites either are located near population centers or are too small to contain a large production reactor with its associated exclusion area. Only Hanford, INEL, Pantex, NTS, and SRS met the first criterion.

Evaluation Against Criterion No. 2: Nine sites (LLNL, LANL, NTS, SNL, Mound, Pinellas, RFP, FMPC, and Pantex) failed to meet the second criterion of experience with a large reactor. These sites either have small test reactors or none at all. Four sites (Hanford, INEL, ORNL, and SRS) met this criterion by having programs in place that comply with DOE Order 5480.1B, *Environmental Protection, Safety, and Health Protection Program for DOE Operation*, for Category A reactors. A number of production and test reactors have been designed and operated at the Hanford Site. The Hanford Site recently operated two reactors -- the Fast Flux Test Facility and the N Reactor -- that meet the specified criterion. Three reactors at INEL, all recently operated, meet this criterion: the Loss of Fluid Test Facility, the Power Burst Facility, and the Advanced Test Reactor. Two reactors at ORNL meet this criterion: the Oak Ridge Research Reactor and the High-Flux Isotope Reactor. The SRS has two production reactors (L and K reactors). Therefore, the Hanford Site, INEL, ORNL, and SRS are the only sites that satisfy this criterion.

Evaluation Against Criterion No. 3: Ten sites (LLNL, LANL, NTS, SNL, Mound, Pinellas, RFP, FMPC, Pantex, and ORNL) failed to meet the third criterion of both experience with nuclear materials production and HLW management; these sites have limited waste management programs, although some have developed spent-fuel-processing and HLW-handling techniques. However, these sites do not have in situ spent-fuel-processing facilities or production-level processing experience. Hanford, INEL, and SRS met the third criterion by having production-level processing plants and HLW-processing programs planned or in place. At Hanford, the Plutonium Uranium Extraction (PUREX) Plant has been used to recover uranium and plutonium from N Reactor fuels. The Plutonium Finishing Plant has also been used to process scrap, weapons-grade, and fuel-grade plutonium. Hanford's HLW Vitrification Plant, based on the Defense Waste Processing Facility process, is in the design phase. At INEL, fuel from test reactor and naval reactor programs is processed. The INEL also was selected as the site for the Special Isotope Separation Plant, a facility no longer planned to be constructed or operated. At INEL, waste is solidified in the New Waste Calciner. At SRS, driver fuels from three production reactors are processed. Tritium is recovered by processing tritium production targets from the operations of up to three production reactors. The Defense Waste Processing Facility at SRS, which will vitrify HLW for permanent disposal, is nearly completed.

Thus, only Hanford, INEL, and SRS met all three screening criteria. After candidate sites were selected on the basis of the above screening criteria, DOE formed a site-evaluation team to further evaluate the suitability of the three sites (DOE-3). Members of the team visited each site and were briefed on the site's capability to accommodate new production capacity. The team investigated the (1) capability and experience of the sites to perform the required tasks, including fuel fabrication, target fabrication, spent fuel processing, plutonium handling, waste management, and steam or electric power generation; (2) potentials for environmental, safety, and health impacts; (3) projected adequacy of transportation and potential impacts of construction and operations on transportation facilities; (4) impact of site conditions on cost or schedule, and the impact on the cost of providing support facilities; (5) existing safeguards and security at the site; (6) availability of reliable and adequate power and water supplies; and (7) projected availability of adequate public facilities, local services, and infrastructure to support construction and operation. The DOE concluded that all three candidate sites -- Hanford, INEL, and SRS -- are suitable locations for NPR capacity (DOE-3). For the HWR technology, SRS has the advantage of having fuel cycle and tritium production facilities in place. For the LWR

technology, Hanford has the advantage of having Washington Nuclear Plant No. 1 (WNP-1), which is 63% completed. Facilities are in place at INEL to support development of high-temperature gas-cooled reactors and other reactor technologies. On the basis of these evaluations, these three candidate sites have been adopted as site alternatives for constructing and operating NPR facilities. No other site alternatives were identified by public scoping (DOE-1).

3.2.2 Identification of Locations for NPR Facilities at Alternative Sites

The DOE operations offices at each of the three alternative sites -- Hanford, INEL, and SRS -- conducted studies to identify potential locations for the NPR and support facilities within the boundaries of their respective sites (Bean and Olson 1990; Heilman 1989; Spry et al. 1989). These studies included consideration of design requirements, Nuclear Regulatory Commission (NRC) requirements for commercial reactors, cost, safety, and environmental issues. All siting criteria used for each study met and exceeded those used by the DOE Site Evaluation Team (DOE-3) in selecting the three candidate sites and would satisfy NRC requirements for characterizing a reactor site.

Site-selection criteria topics included geology (faults, seismology, vulcanism, and soils), meteorology, hydrology (including flood hazards and floodplains), ecology (including wetlands, habitats, wildlife, and threatened and endangered species), cultural resources (including archaeological and historical sites and paleontological resources), human health (including distance from population centers), utilities and transportation (including water supply, electrical power, steam, road, rail, and barge), site geography, existing facilities, and costs.

The criteria for geology, meteorology, and hydrology were developed from 10 CFR 100, *Reactor Site Criteria*, and NRC Regulatory Guide 1.59, *Design Basis Floods for Nuclear Power Plants*. Seismicity was considered in the geological evaluation in each site-selection process. Vulcanism was included generally in the site-selection process at Hanford and specifically in the site-selection process at INEL. Meteorology (in terms of severe weather), groundwater and surface water hydrology, and flooding were evaluated at all three of the candidate sites.

The criteria for ecology, cultural resources, and human health were developed from 10 CFR 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*; 40 CFR Parts 1500-1508, *Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA*; 50 CFR 17, *Endangered and Threatened Wildlife and Plants*; 10 CFR 20, *Standards for Protection Against Radiation*; 10 CFR 50, *Domestic Licensing of Production and Utilization Facilities*; and various other Federal regulations and regulatory guides. All aspects of these criteria were evaluated in each siting study, with the exception that wetland analysis was not conducted at INEL because of the absence of wetlands at potential sites for the NPR.

Utilities and transportation were evaluated by each siting study, with the exceptions of steam at Hanford and INEL, and barge access at INEL and SRS. Site geography, including location with respect to site boundaries, distances to population centers, and areal dimensions, also was evaluated. The evaluation at INEL included consideration of distance from DOE-acquired lands where a generating plant using steam from the NPR might be located.

Criteria used for evaluation of existing facilities at each of the three sites were developed from 10 CFR 20, *Standards for Protection Against Radiation*, and 10 CFR 100, *Reactor Site Criteria*.

At INEL, specific cost evaluations were made for water wells, road construction, railroad construction, power lines, and excavation. At SRS, costs were evaluated for construction of electric, water, steam, rail lines, and discharge canals.

On the basis of those technical evaluations, the DOE Operations Offices at each candidate site selected preferred locations for an NPR. Two sites (Figure 3.2-2) within a triangle formed by the 400 Area, the WNP-1 site, and the Skagit/Hanford site were chosen as alternative locations of an NPR Reactor Facility at Hanford (Heilman 1989). The partially completed WNP-1 LWR facility was chosen as the proposed location of an LWR, and an undeveloped site, the Hanford NPR site, was chosen as the proposed location for an HWR or MHTGR. The latter site had earlier been proposed as a possible site for a Skagit/Hanford nuclear power plant proposed by Puget Power and Light (NRC-2). At INEL, six possible sites were identified (Sites A through F in Figure 3.2-3) using a selection-criteria weighing system (Spry et al. 1989). These six sites were ranked in decreasing order of acceptability, and based on that ranking, Site E was selected as the proposed NPR site at INEL. Site A was selected as an alternative if further investigations eliminated Site E. At SRS, application of disqualifying-condition criteria identified three areas suitable for an NPR site (Bean and Olson 1990). One potential site then was selected in each area (Figure 3.2-4): L Lake Site, North Site, and Reference Site. Later, K Site, in the same area as L Lake Site, was added because of the possible use of a proposed K Reactor cooling tower for an NPR. The study at SRS proposed that the NPR be located at the Reference Site. Throughout the NPR EIS, the Reference Site is referred to as the SRS NPR site.

3.2.3 Descriptions of Existing Facilities

At each of the three alternative sites, NPR operations would involve use of existing and new facilities. The existing facilities that would support an NPR are described in this section, and new NPR facilities are described in Section 3.3.

3.2.3.1 Hanford Site

The Hanford Site is a DOE nuclear research and defense program facility located near Richland, Washington (Figure 3.2-5). In 1943, the U.S. Army Corps of Engineers selected Hanford as the location for reactor and chemical separation facilities for production and purification of plutonium to be used in the manufacture of nuclear weapons. Nine reactors were constructed, along with chemical separation plants, fuel fabrication facilities, waste storage facilities, and laboratories. Beginning in 1966, by-product steam from N Reactor was used by the Washington Public Power Supply System (WPPSS) to generate electricity. In 1972, WPPSS began constructing the first of three planned commercial power reactors at Hanford. One of those reactors (WNP-2) is currently operating under a license from the NRC. Another reactor (WNP-1) is partially constructed, the project having been mothballed before completion, and remains under an NRC construction permit. The buildings are complete, but the reactor core and fuel were never installed.

As shown in Figure 3.2-6, the Hanford Site is divided into a series of numbered areas, including the 100, 200, 300, 400, 700, 1100, and 3000 areas. The following descriptions of the facilities in these areas are based on the NPR EIS Site-Characterization Report (PNL-1) and the NPR Hanford Site Evaluation Report (DOE-4). Descriptions of the use of these facilities by NPR, as well as any required modifications to support NPRs, are given in Section 3.3.

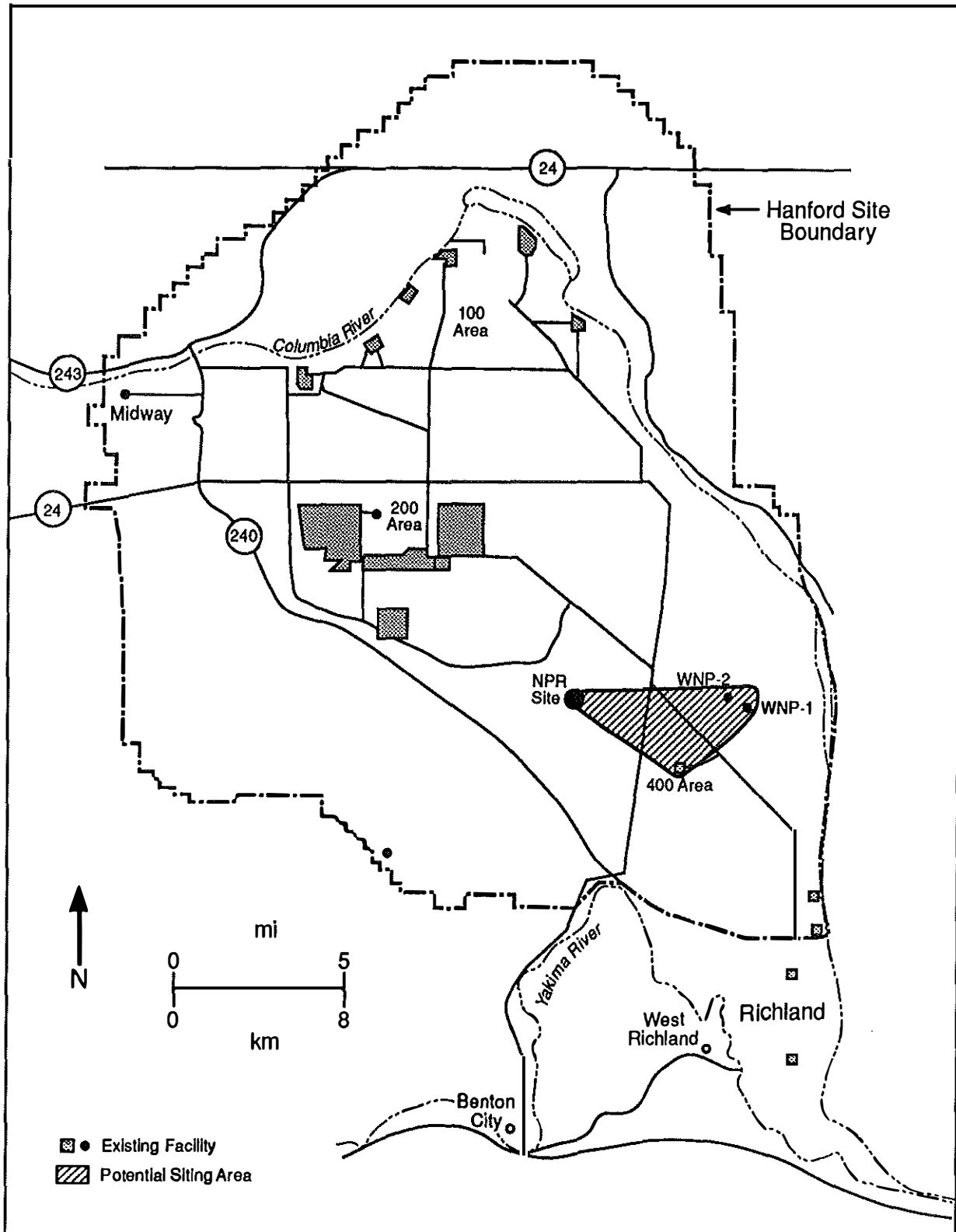


FIGURE 3.2-2 Locations of Potential NPR Sites at Hanford (Source: Modified from PNL-1)

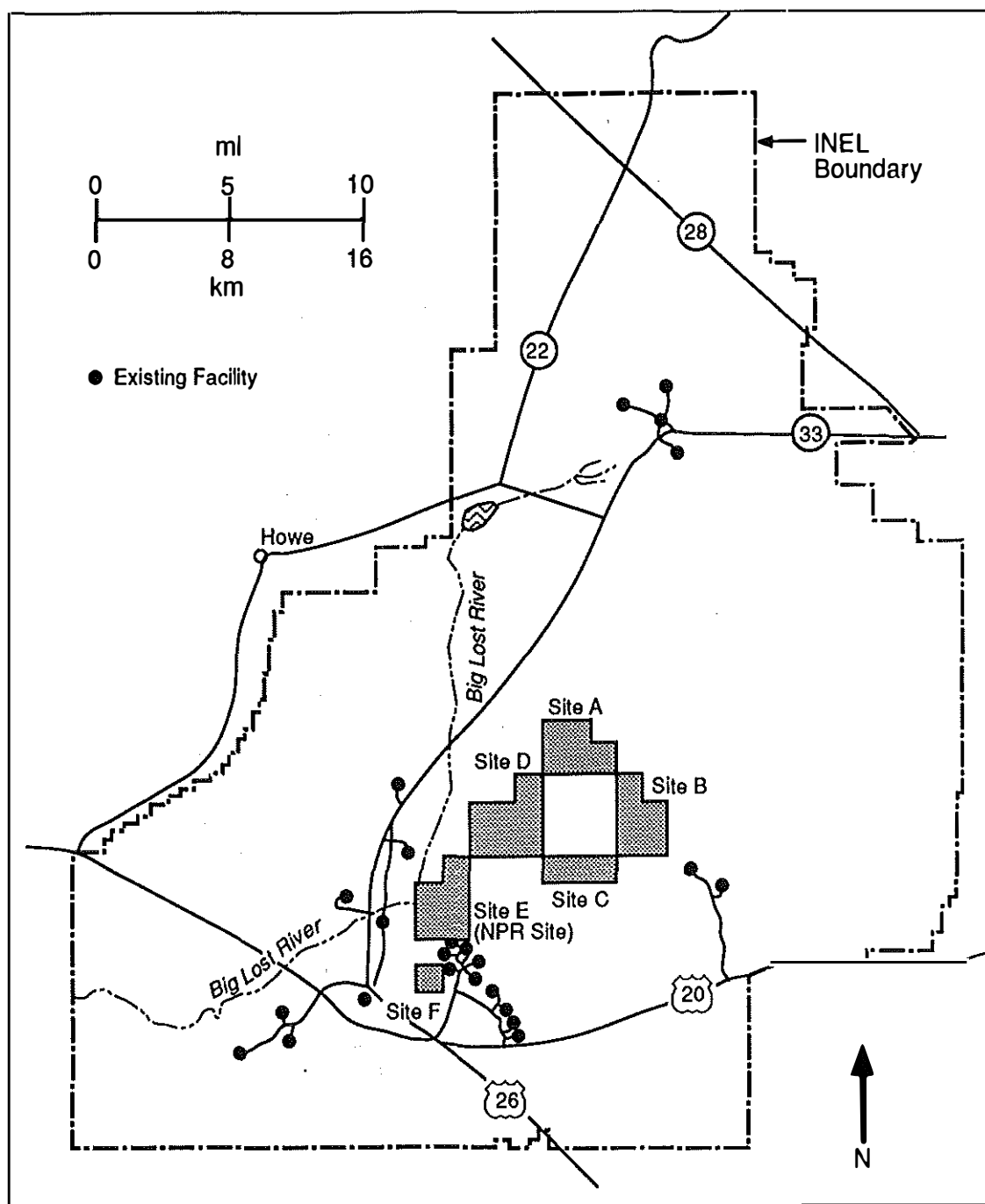


FIGURE 3.2-3 Locations of Potential NPR Sites at INEL (Source: Modified from Spry et al. 1989)

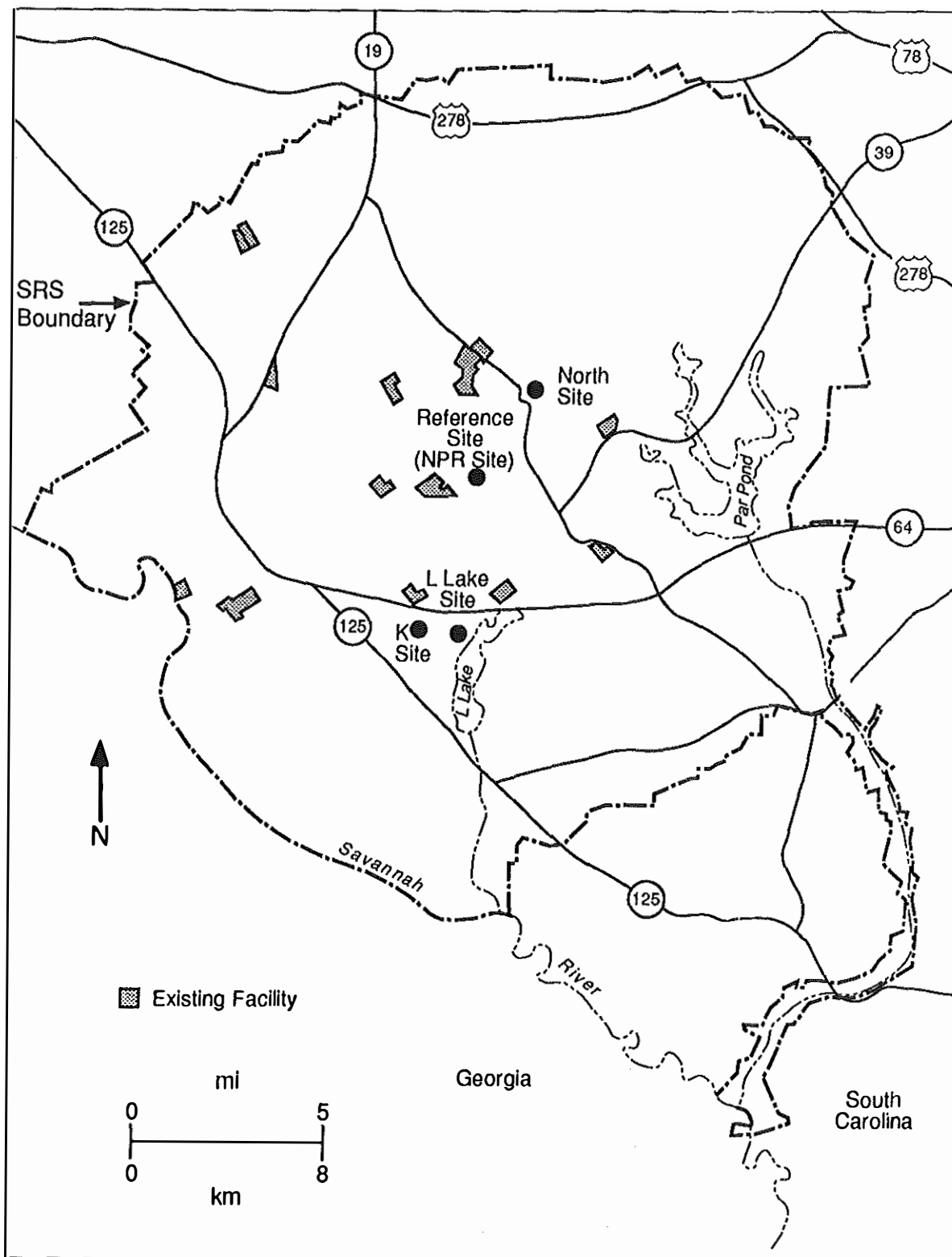


FIGURE 3.2-4 Locations of Potential NPR Sites at SRS (Source: Modified from Bean and Olson 1990)

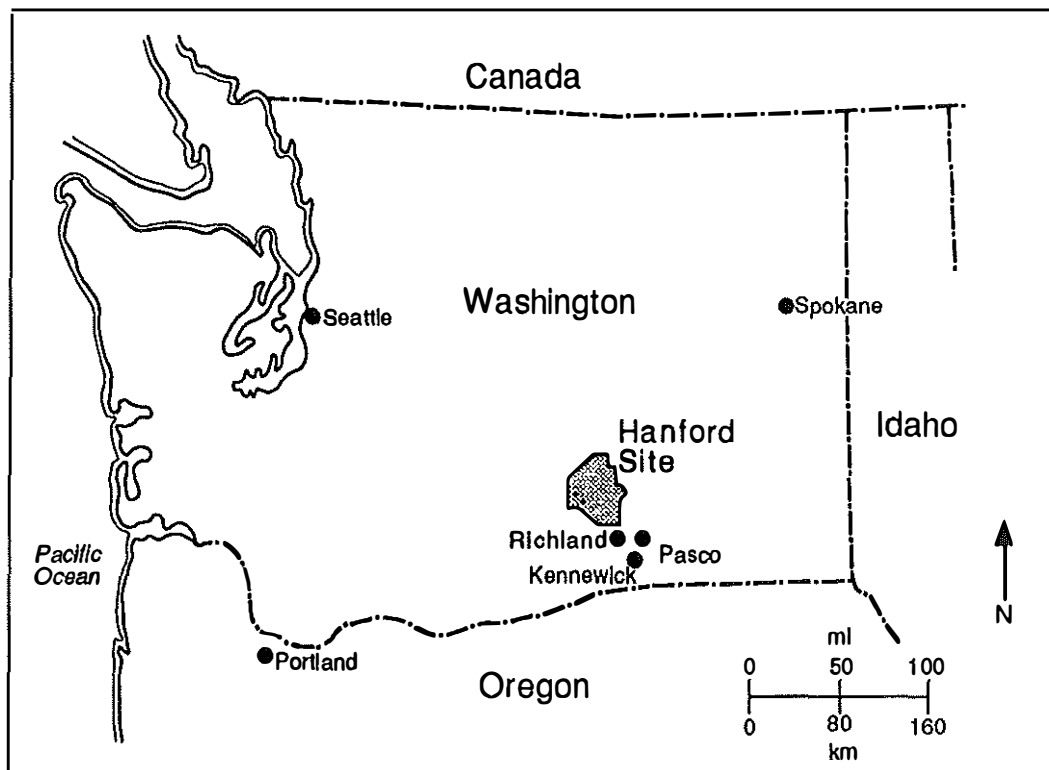


FIGURE 3.2-5 Location of the Hanford Site (Source: Hanford staff)

Hanford's nuclear materials production facilities are located primarily in the 100 and the 200 areas (Figure 3.2-6). Since the 1940s, nine production reactors (B, C, K-East, K-West, D, DR, F, H, and N) have been constructed in the 100 Area. All but N Reactor, which is on cold standby, are shut down. Fuel processing and plutonium separation facilities for materials production are located in the 200 Area. The PUREX Plant, which processes irradiated fuel, was constructed in the 200-East Area between 1953 and 1955. This plant is not currently in operation. The Plutonium Processing Facility in the 200-West Area is used to convert plutonium nitrate either into plutonium oxide or metal. The Fuels and Materials Examination Facility is located in the 400 Area (Figure 3.2-6). This facility would fabricate fuel and targets and process targets in support of an NPR at Hanford.

Hanford's waste management facilities are located primarily in the 200 Area (Section 4.1.10). A major radioactive waste management facility, the Hanford Central Waste Complex, is proposed for construction in the western portion of the 200-West Area. This complex, which will be in service before any NPR would be operational, will consist of a modified Waste Receiving and Processing Facility and the Hanford Waste Isolation Plant. The Waste Receiving and Processing Facility would be used to examine, treat, and package transuranic (TRU) waste in preparation for eventual off-site shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. The Waste Receiving and Processing Facility is scheduled to be modified so it can accept several other types of waste, including low-level radioactive waste (LLW) and mixed waste. Wastes prepared at the Waste Receiving and Processing Facility would be stored in the Hanford Waste Isolation Plant until eventual shipment to WIPP (Merrick 1989).

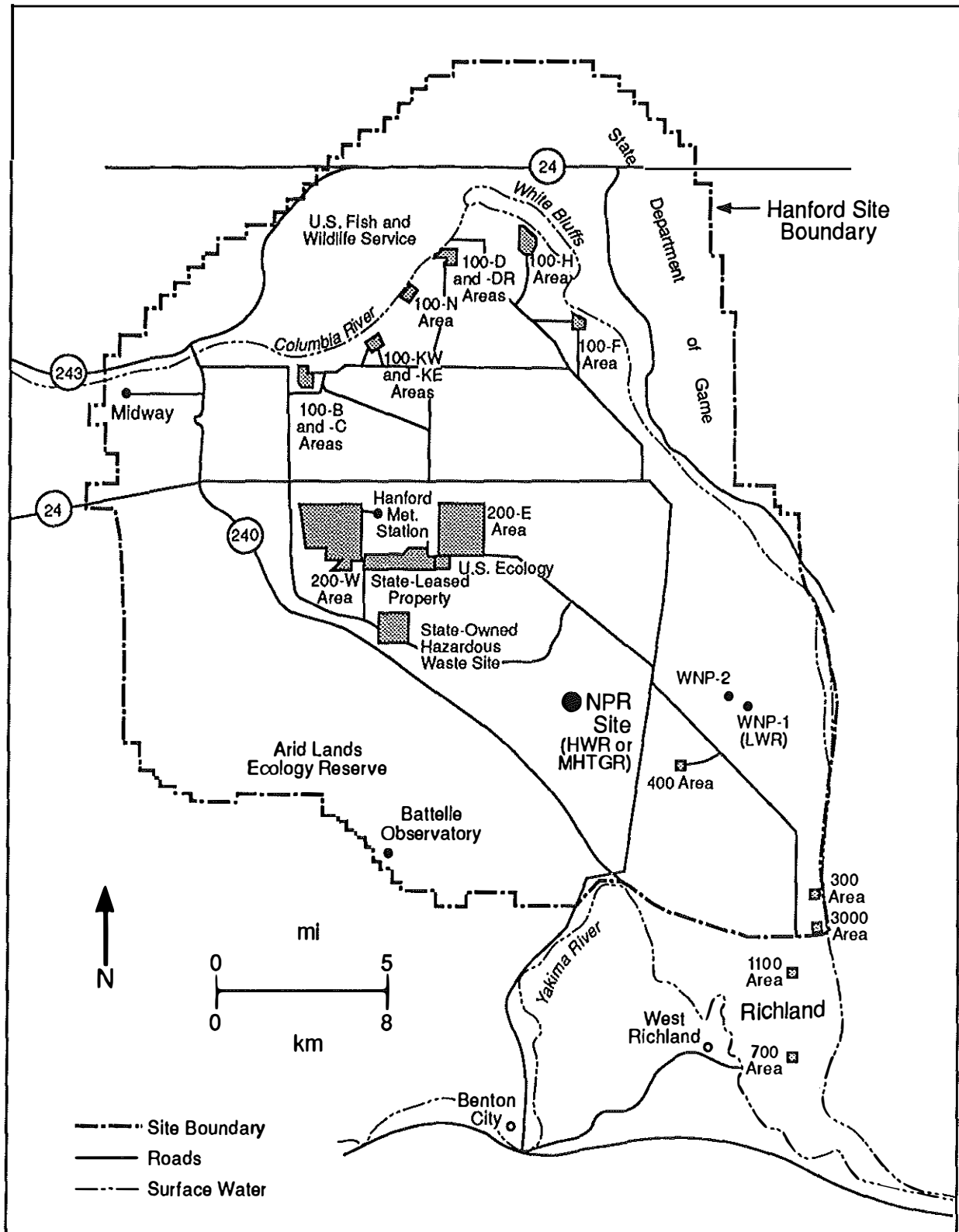


FIGURE 3.2-6 Locations of Existing Facilities and Proposed NPR Site at Hanford (Source: Modified from PNL-1)

Other planned or existing waste management facilities in the 200-West Area include the Radioactive Mixed Waste Storage Facility, a planned facility that will store solid mixed wastes until the Waste Receiving and Processing Facility begins operation; the Waste Encapsulation and Storage Facility, an existing facility used to store encapsulated cesium and strontium; and the Transuranic Waste Storage and Assay Facility, which stores TRU wastes. Other waste management facilities in the 200-East Area include the Hanford Waste Vitrification Facility, which solidifies liquid radioactive wastes by a glassification process; and the Grout Treatment Facility, which solidifies wastes by a cementing process. Other locations near the 200 Area contain radioactive liquid wastes stored in underground tanks and buried radioactive solid wastes (Merrick 1989).

The Nonradioactive Dangerous Waste Storage Facility is located midway between the 200-East and 200-West areas. Hazardous wastes from all of Hanford's operations are stored here before shipment off the Hanford Site for disposal in a licensed hazardous waste disposal facility (Merrick 1989). Compliance Status of Hanford's waste management facilities is described in Section 4.1.10.

The state of Washington leases an area of 4 km² between the 200-East and 200-West areas (Figure 3.2-6). This leased land has been dedicated for disposal of LLW. The state also owns a 2.6-km² area south of the 200 Area and north of the Arid Lands Ecology Reserve. This area may be used in the future for disposal of hazardous wastes (Merrick 1989).

Electrical service to the Hanford Site is provided by WPPSS from the Borneville Power Administration (BPA) power transmission system. The BPA transmits power generated by private and public utilities and by Federal facilities throughout the Pacific Northwest. Hanford is connected to the BPA transmission system at the Ashe Substation, located adjacent to the WNP-2 power station. Both the 200-West and 200-East areas have newly refurbished 13.8-kV distribution systems that originate from the 251-W Substation. This substation is on the Hanford 230-kV transmission loop, which connects the Ashe and Midway substations at the northwestern corner of the Hanford Site.

Water supplies for Hanford are piped from the Columbia River. Water for the 100 and 200 areas is supplied by two pumping stations. These stations can deliver 106 m³/min to storage facilities that have a total capacity of 95,000 m³. Water for the 300, 400, 1100, and 3000 areas, as well as water needed for WNP-2 (service water and makeup water for three cooling towers), is also pumped from the Columbia River.

Steam from a steam-generating powerhouse is distributed through above-grade lines for industrial processes in the 200-East Area. Natural gas used at the Hanford Site is obtained from a natural gas transmission line that passes near the Pasco Airport.

3.2.3.2 Idaho National Engineering Laboratory

The Idaho National Engineering Laboratory (INEL) is a DOE nuclear research and defense program facility located near Idaho Falls, Idaho (Figure 3.2-7). Formerly known as the National Reactor Testing Station, INEL was established by the government in 1949 as a site for constructing, testing, and operating nuclear facilities; 52 reactors were eventually constructed and operated there. The various nuclear reactors and support facilities were built and tested to

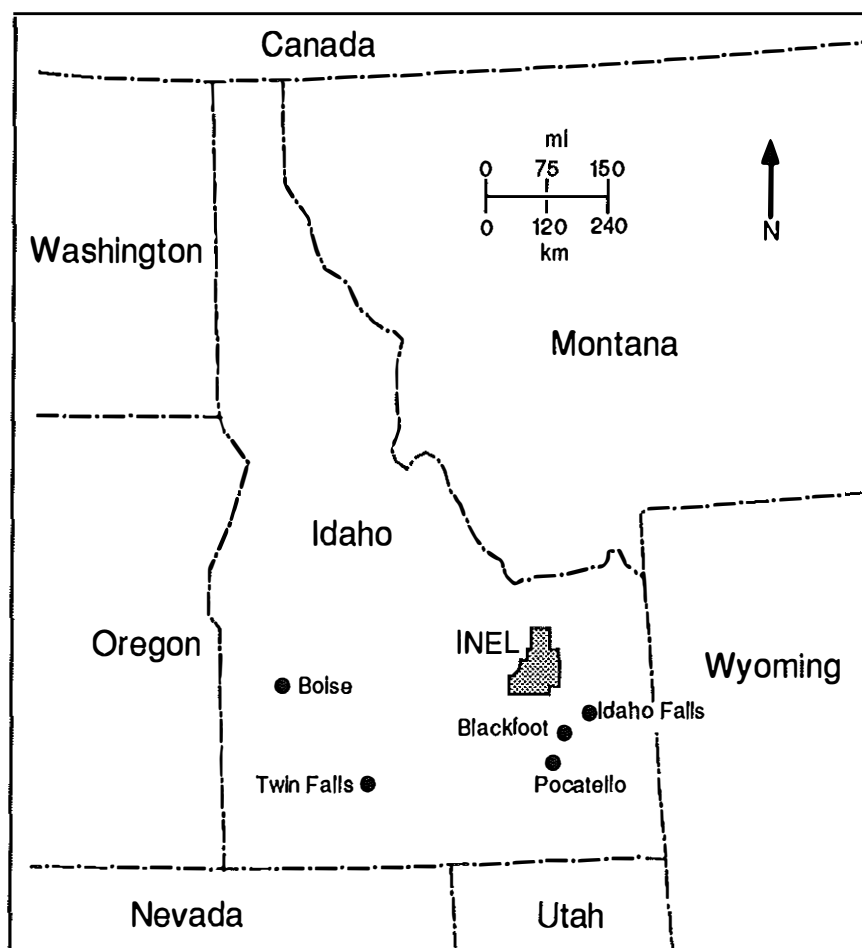


FIGURE 3.2-7 Location of the Idaho National Engineering Laboratory
(Source: Modified from EG&G-1)

demonstrate the applications of reactor technology, to conduct safety research, and to support defense programs. Currently, 13 reactors are operational at INEL; they are used to test fuel and target designs and their safety, and to test entire reactor systems. Current INEL activities also include processing reactor fuel and treating and storing high-level waste. The following descriptions of INEL facilities are based primarily on the *INEL Environmental Characterization Report, Volume I: Summary* (EG&G-1).

Facilities at INEL for production of nuclear materials are centered at the Idaho Chemical Processing Plant. The plant, built in 1951, is located on an 82-ha site in the southwestern quadrant of INEL (Figure 3.2-8). The facility is used to recover uranium and krypton from irradiated reactor fuels and to process highly enriched fuel on a production basis. A secondary purpose of the facility is to develop improved fuel-processing and waste-management methods. Fuel-processing facilities include a main processing building and additional headend systems, which prepare the fuel for processing. The Idaho Chemical Processing Plant will include about 8,100 m² of fuel storage in the fuel storage area of the Fluorinal Dissolution Process and Fuel Storage Facility. Other facilities include the Remote Analytical Laboratory, which is used to analyze radioactive materials before storage or disposal.

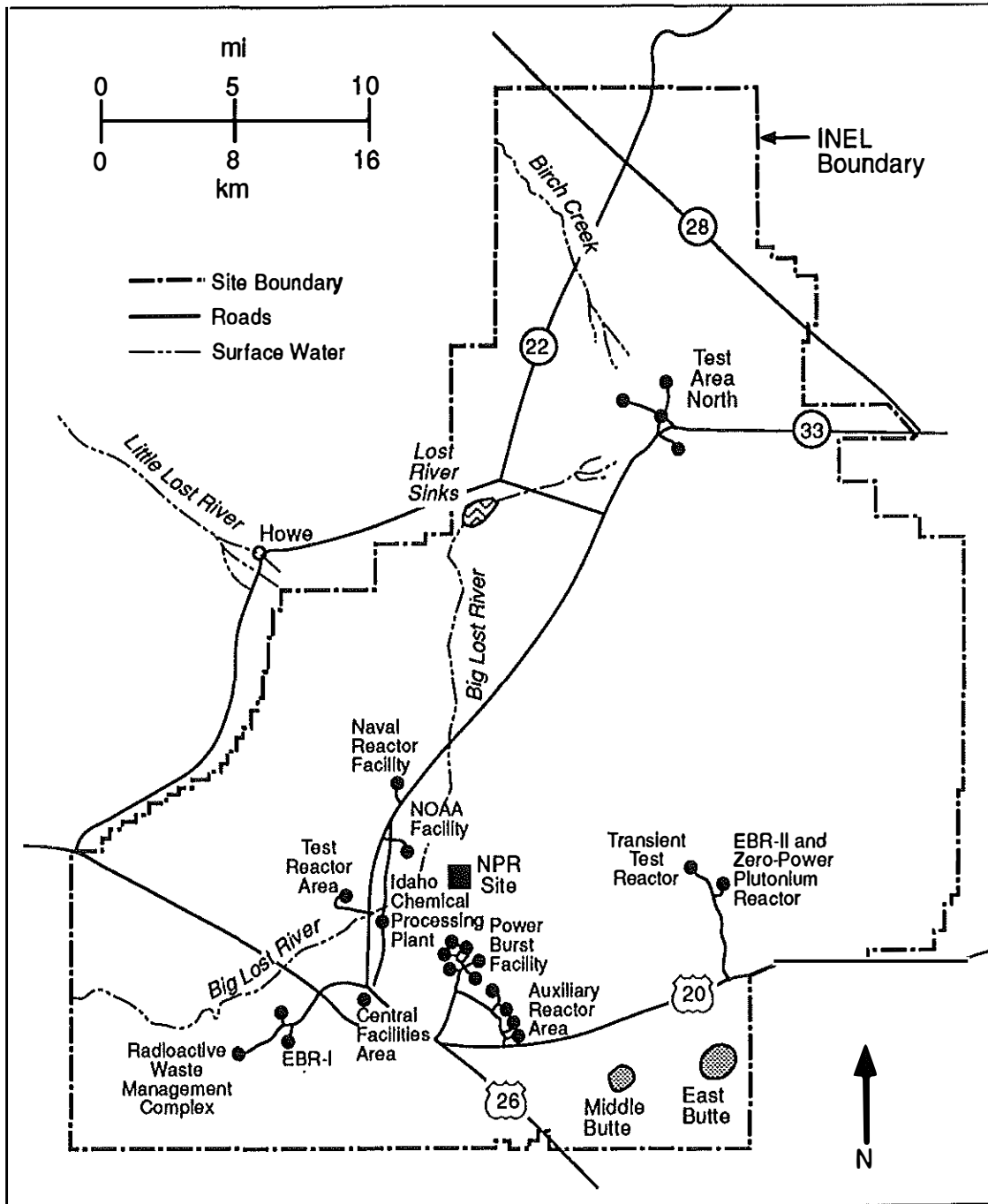


FIGURE 3.2-8 Locations of Existing Facilities and Proposed NPR Site at INEL (Source: Modified from EG&G-1)

The Idaho Chemical Processing Plant can process high-level liquid radioactive waste, which the facility both generates and receives from other INEL activities. These wastes, which are generated primarily by the reprocessing of nuclear fuel, are converted to a solid by a calcination process in the New Waste Calcining Facility. The Radioactive Waste Management Complex (RWMC), which is located in the southwestern quadrant of INEL (Figure 3.2-8), consists of a 36-ha subsurface disposal area for LLW and a 22-ha storage area for TRU wastes. These facilities are used to dispose of INEL-generated wastes, as well as TRU waste storage from Argonne National Laboratory-East, the Rocky Flats Plant, the Mound Plant, and the Bettis Atomic Power Laboratory. Compliance status of INEL waste management facilities is discussed in Section 4.2.10.

Electric power at INEL is generated on-site, as well as provided by the Idaho Power Co. The Experimental Breeder Reactor-I (EBR-I) at INEL (Figure 3.2-8) was the world's first nuclear reactor to generate electric power. This facility, which is no longer operational, has been designated a national historic monument. The Experimental Breeder Reactor-II (EBR-II) at Argonne National Laboratory-West has an electrical-generating capability of 20 MW. The Utah Power and Light Co.'s Antelope Substation, which is located on INEL, connects to the Scoville Substation, from which electricity is distributed to various INEL facilities over a 138-kV loop. This loop allows power to be fed in either direction, thus permitting reverse flow of power from Argonne National Laboratory-West's EBR-II to the power grid.

All water supplies for INEL are obtained from the Snake River Plain aquifer through wells at each developed area. Pumping totals approximately 7 million m³/yr. The Idaho Chemical Processing Plant at INEL is equipped with a coal-fired steam system for operation of that facility. Steam is not generated throughout INEL. Natural gas is not used at INEL.

3.2.3.3 Savannah River Site

The Savannah River Site (SRS) is a DOE defense materials production facility located near Aiken, South Carolina (Figure 3.2-9). Construction of the SRS began in 1951. The SRS contains 15 major production, service, research, and development areas (Figure 3.2-10). The primary facilities are used for production of nuclear materials, principally tritium and plutonium. The SRS also contains research and development facilities for heavy-water reactor components and for development and testing of isotope separation processes. The following descriptions are summarized from several reports prepared by DOE and by Westinghouse Savannah River Co. (DOE-5; DOE-6; WSRC-2).

The nuclear materials production reactors at SRS are located in the 100-series buildings of the P, K, L, C, and R areas near the center of SRS (Figure 3.2-10). Two reactors -- K and L -- are not in production; C Reactor is on cold shutdown, and the R Reactor is shut down. The RO EIS ROD (DOE-66) has determined that K and L reactors will be operated for materials production and recommended that P Reactor operational status be terminated and the reactor placed on cold standby. Chemical separation facilities are located in the 200-series buildings in the F and H areas. Each of these areas has a large, shielded canyon building to process irradiated materials and to concentrate and store radioactive wastes. The F Area contains the main analytical laboratory and the plutonium metallurgical building. The H Area contains tritium process buildings. The 300-series buildings of the M Area include test reactors, uranium metal element fabrication facilities, target and alloy extrusion facilities, as well as a metallurgical

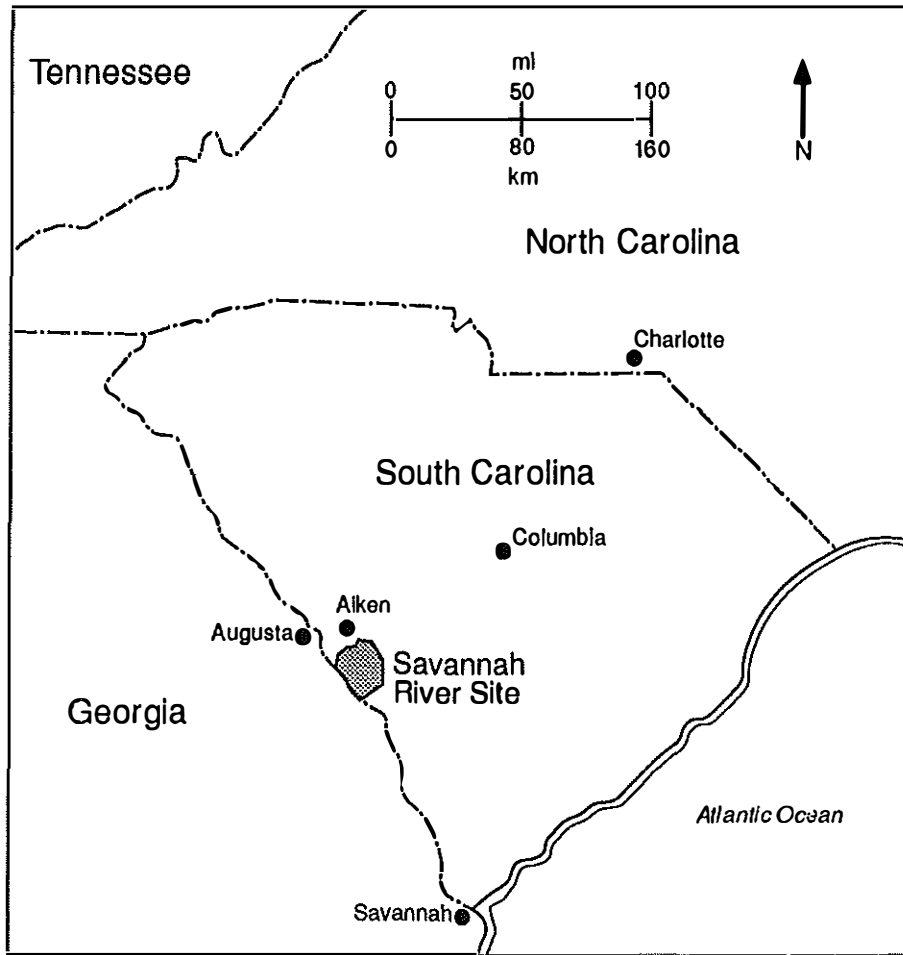


FIGURE 3.2-9 Location of the Savannah River Site (Source: Modified from WSRC-2)

laboratory. The 400-D buildings in the D Area are used to purify the heavy water needed for the production reactors.

Waste management facilities at SRS are located at or adjacent to the F, H, and S areas. Tritium and plutonium separation in the F and H areas produces liquid wastes; the major waste-storage facilities for radioactive liquids, sludges, and salts are adjacent to these separation areas. Storage areas consist of tank farms linked by pipelines to the separation areas and to each other. The Defense Waste Processing Facility is located in the 200-series buildings in the S Area, adjacent to the 200-H Area, where tritium is separated and processed. This new facility has two main functions: (1) to convert the radioactive material in separations-area wastes to a glass form that can be shipped to a Federal repository for disposal and (2) to dispose of salt solutions containing small amounts of radioactivity and hazardous concentrations of heavy metals (mixed waste). The Low-Level Radioactive Waste Disposal Facility is located adjacent to the F and H areas. This facility is used for most of the solid radioactive waste produced at SRS, including LLW, and to store TRU and mixed wastes. The SRS is constructing a new on-site Hazardous/Mixed Waste Disposal Facility. Compliance status of SRS waste management facilities is described in Section 4.3.10.

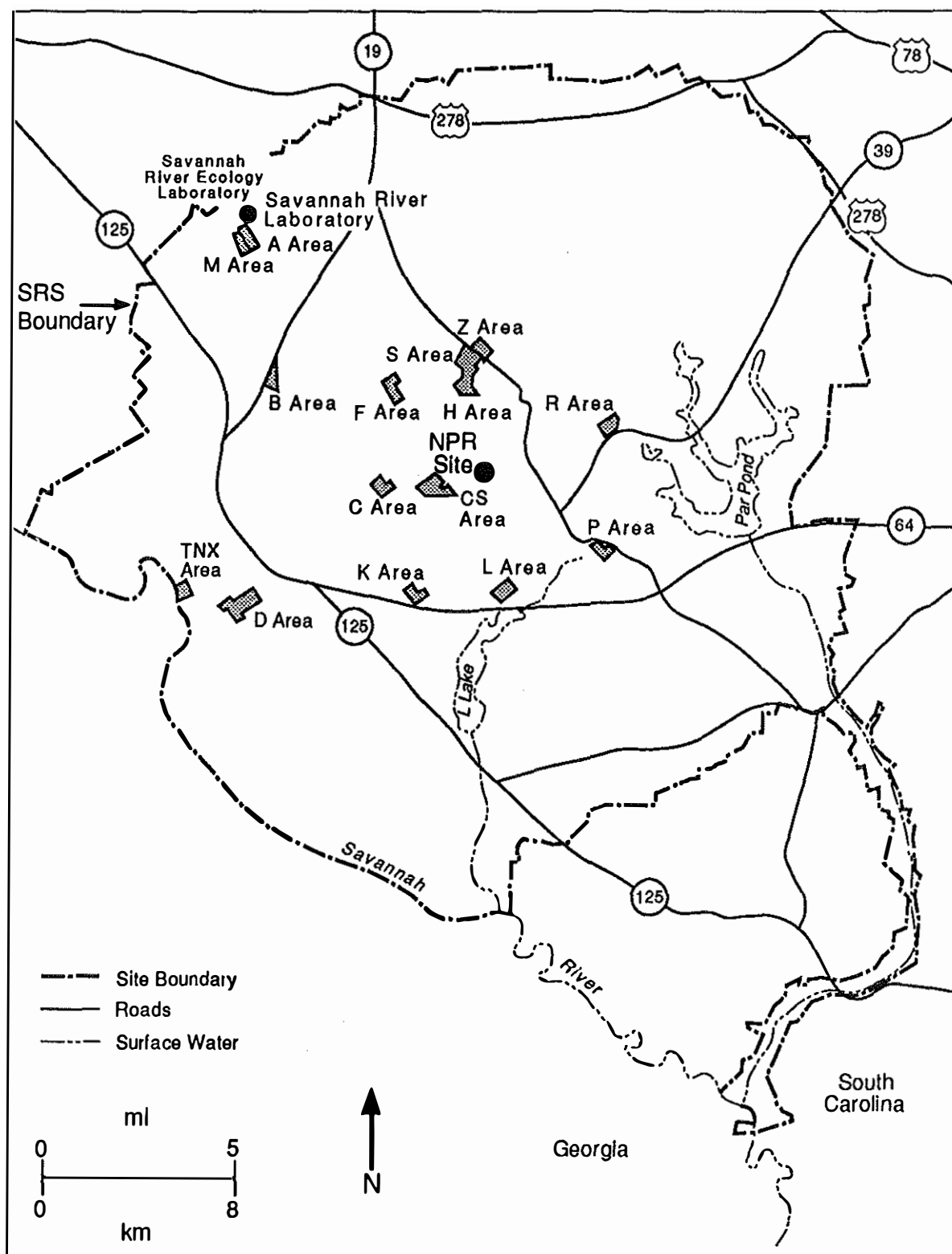


FIGURE 3.2-10 Locations of Existing Facilities and Proposed NPR Site at SRS
(Source: SRS staff)

Electric power is provided to SRS from both on-site and off-site sources. The D Area contains a coal-fired power plant. The electrical distribution system consists of about 145 km of high-voltage transmission lines operating at 100 kV. The system obtains power from two transmission lines originating at South Carolina Electric and Gas Co.'s Urquhart Station and a third line originating at the 230-kV tieline between the power company's Sumner and Canadys stations. The SRS also is linked to the Vogtle Electrical Generating Plant, a nearby commercial nuclear power plant operated by the Georgia Power Company.

Water for cooling the existing SRS reactors, approximately 1 billion m³/yr if three reactors would operate, is withdrawn from the Savannah River or on-site cooling ponds. Three main pumping stations on the Savannah River distribute water throughout SRS. Cross connections allow for distribution from more than one pumping station. A pumping station also is located on Par Pond to withdraw reactor cooling water for P Reactor, when it is in production. The K Reactor will be operating with a cooling tower by mid-1992. Warmed cooling water from L Reactor is discharged into a once-through cooling pond before it is discharged to the Savannah River.

The SRS has an extensive steam system, with a total of 13 boilers producing steam for production systems, electrical power, and domestic heat. All boilers are coal fired. An interarea steam line connects the H and D area powerhouses to users in D, H, TNX, F, and C areas. A second line connects the L and K areas. Demand for steam has decreased in recent years, and some of the boilers are reaching the end of their useful life. The boilers in P and K areas are scheduled for replacement by oil-fired package boilers, which will operate until a replacement steam plant is built. The DOE is currently preparing an EIS for the Replacement Power Facility. Natural gas is not used at SRS.

3.3 ALTERNATIVE TECHNOLOGIES

This section describes the alternative technologies that could be constructed and operated to provide tritium production capacity in or about the year 2000. On a project-specific basis, the HWR, LWR, and MHTGR technologies appear to be reasonable alternatives for an NPR. The environmental consequences of siting, constructing, and operating these technologies are discussed in this section. Technologies that could not provide tritium production capacity in or about the year 2000 are not considered here, but are assessed broadly from a programmatic perspective in Section 2.

Current plans indicate that an HWR could be available in 2000. The first module of an MHTGR could be completed in 2000, with subsequent modules being completed in 6- to 9-month intervals. However, if required, this schedule might be accelerated by building modules concurrently. The LWR alternative at Hanford could be completed by 1998. At other sites, completion of an LWR would be by the year 2000 (SRS) or 2001 (INEL).

Section 3.3.1 describes the functional requirements of an NPR. The facility, resource, construction, and operational requirements for an NPR are described for the HWR (Section 3.3.2), the LWR (Section 3.3.3), and the MHTGR (Section 3.3.4). Other issues related to technology are briefly discussed and assessed as optional components in Section 3.3.5. These issues include the potential sale of steam for power production, options for reactor cooling at INEL, options for transporting large components at SRS, spent fuel processing, weapons-grade plutonium production, production of other plutonium isotopes, and the size of an MHTGR module.

3.3.1 Functional Requirements for the NPR

The NPR, as assessed in this EIS, would consist of a reactor facility plus necessary support facilities as discussed above. Only tritium production and recovery are part of the proposed action. However, spent fuel processing and plutonium-239 production are analyzed as foreseeable future associated activities. Additionally, any of the three alternative reactor technologies would be capable of producing plutonium-238 and certain other isotopes. The reactor impacts related to this production are described in Section 3.3.5.6.

Tritium is produced in a reactor when a specific isotope of lithium (lithium-6) is bombarded with neutrons (subatomic neutral particles) produced by nuclear fission in the reactor's fuel. Weapons-grade plutonium (plutonium-239) is produced in a reactor when an isotope of uranium (uranium-238) is bombarded with neutrons. The lithium and uranium are manufactured separately into components called targets. The targets are inserted into the reactor with enriched uranium-235 fuel. Each load of targets and fuel remains in the operating reactor for a specified time. After the spent fuel and irradiated targets are removed from the reactor, and before processing, the fuel and targets are stored to allow the short-lived radionuclides produced by the fission process to decay to acceptable levels. This storage period is for target and/or fuel cooling and should not be confused with reactor cooling, which is a thermal process. Cooled targets and fuel are sent to separate processing facilities, where they may be mechanically and chemically treated to remove and separate the desired components: tritium, plutonium, and unused uranium. Other materials are disposed of, including a variety of radioactive and nonradioactive wastes. Wastes produced by reactor operations include heated water from the reactor's cooling systems.

Figure 3.3-1 is a generalized diagram of the activities necessary to produce tritium and plutonium at the NPR. Facilities needed to carry out NPR activities include fuel fabrication facilities; tritium-target fabrication facilities; the reactor facility (including temporary fuel and target storage, cooling towers, and a heavy-water processing facility for the HWR); tritium-target processing facilities; and waste management facilities for processing wastes. The Reactor Facility would be similar for each alternative technology; however, the facilities and processes proposed for fuel and target fabrication and processing, and waste management activities for each alternative technology are site-specific because each site would use some existing facilities to support NPR activities. Activities not part of the proposed action, but included as potential associated activities are plutonium-target fabrication, plutonium-target processing, fuel reprocessing (including uranium separation facilities) and high-level waste treatment facilities. The impacts of constructing and operating these facilities are also included in this EIS.

3.3.2 Heavy-Water Reactor Technology Description

The HWR uses heavy water (i.e., water in which the hydrogen atoms are in the form of deuterium, a nonradioactive isotope) as both coolant and moderator. Coolant is used to remove heat from the core of an operating reactor, while a moderator reduces the energy of "fast" neutrons to improve the efficiency of fission of the reactor fuel. The K and L reactors at SRS are currently used to produce tritium.

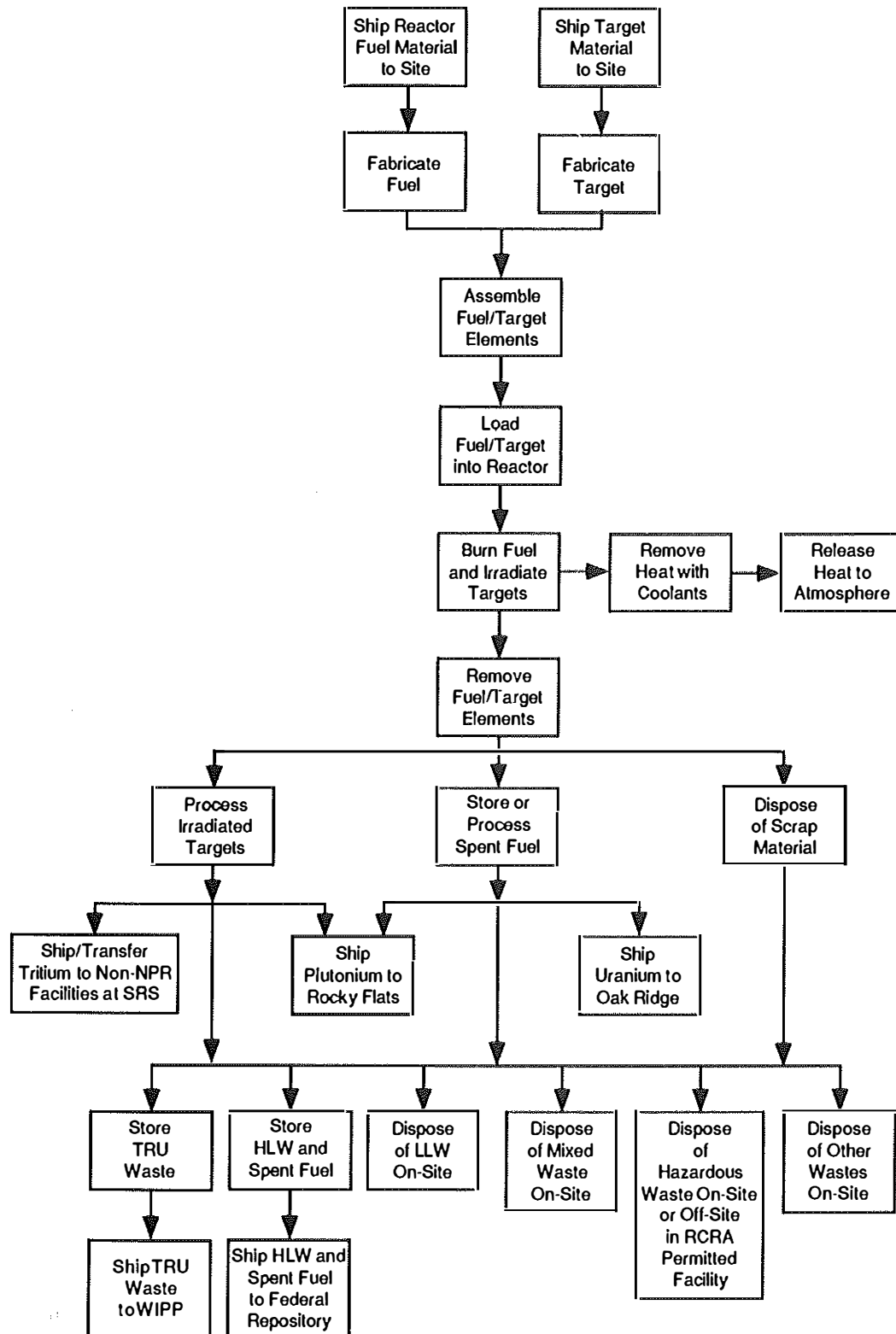


FIGURE 3.3-1 Schematic of Material Flow and Processing Associated with NPR Operations

The following sections identify HWR facility requirements and discuss construction, operation, and waste management for the HWR at the three alternative sites. Figures 3.3-2, 3.3-3, and 3.3-4 illustrate the facility requirements for the HWR at each alternative site. The figures show both new (unshaded) and existing (shaded) facilities that would be required.

Expanded descriptions of the HWR fuel cycle, target cycle, and methods and techniques of operation are presented in Appendix A. The primary sources of information for the HWR technology and its adaptation to the alternative sites are WSRC-4, WSRC-5, WHC-3, WHC-4, and EG&G-6; other sources are cited as appropriate.

3.3.2.1 Reactor Facility

The Reactor Facility for the HWR (Figure 3.3-5) would occupy about 61 ha of land and would contain the reactor, its equipment, and associated buildings; ancillary facilities; and three mechanical draft cooling towers. Construction of an adjacent Heavy-Water Processing Facility would also be required. The reactor would be an updated version of the existing low-temperature (approximately 100°C), low-pressure (0.14-MPa) reactors at SRS. Unlike the existing reactors, however, the new HWR, with its primary cooling system and heat exchanger, would be housed in a steel-lined, reinforced-concrete containment building that would completely surround the reactor and its major systems. The reactor, containment building, and other safety-related equipment and structures of the Reactor Facility would be sited and designed in accordance with DOE Order 5480.6, *Safety of DOE-Owned Nuclear Reactors*, and would meet or exceed current standards applied to a commercial nuclear power plant, whichever is the more stringent requirement (Appendix A, Section A.1.2).

The electric load of the operating reactor would be about 90 MWe. This power would be purchased from an off-site supplier. Emergency power for safety-related equipment, controls, and security-related activities in case of failure of the off-site power supply would come from eight 112-kW diesel-driven DC generators, two 3,000-kW diesel-driven AC generators, and one 100-kW diesel-driven generator.

The Reactor Facility would contain a fuel storage pool. The fuel storage pool would be used to store plutonium targets and fuels from tritium and plutonium production (1-year storage assumed). This would allow decay heat generation to subside and short-lived radioisotopes to decay before processing to recover plutonium and unused fuel. Tritium targets would be stored for 1 month before processing.

The nominal average heat output of the Reactor Facility would be about 2,590 MWt (3,300 MWt peak). Because of the low-pressure, low-temperature design, no steam could be produced during reactor operation, and cogeneration of electricity is not an option. Heavy water would be processed in the Heavy-Water Processing Facility to maintain its chemical and isotopic purity, and to reduce occupational exposure and releases to the environment from tritium in the heavy water. The Heavy-Water Processing Facility would be designed to Nonreactor Safety Class 1 criteria, as defined in DOE 6430.1A, *General Design Criteria*. The building would be inside a 17-ha fenced enclosure. The initial heavy-water inventory would come from existing heavy-water supplies at SRS, which have not been detritiated. This tritiated heavy water would be transported to Hanford and INEL for processing if these sites were chosen for the proposed HWR.

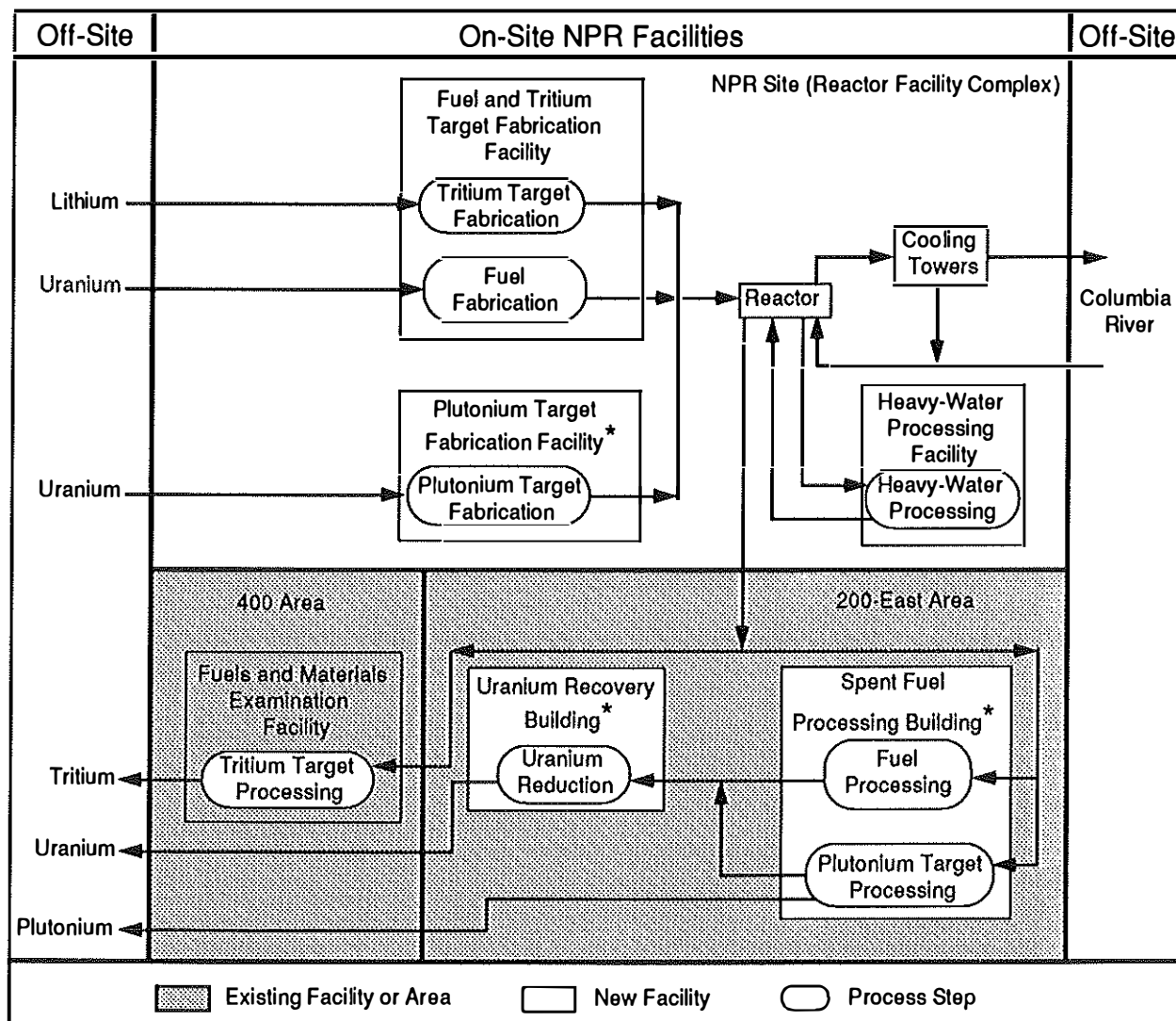


FIGURE 3.3-2 Facility Requirements for the HWR at Hanford (* indicates facilities involved only in weapons-grade plutonium production and spent fuel processing)

If the HWR technology were selected, a new Reactor Facility would be constructed at the NPR site at Hanford, INEL, or SRS. At Hanford, the facility's secondary cooling system makeup water and blowdown would be pumped from and to the Columbia River, respectively. New intake and discharge structures would be required in the Columbia River, and a new pumphouse would be built on or near the shore. At INEL, the facility's secondary cooling system makeup water would be pumped from the Snake River Plain aquifer under the site, and blowdown would be discharged to one or more evaporation ponds, having a total surface area of about 829 ha. The pond(s) would be near the Reactor Facility. At SRS, the facility's secondary cooling system makeup water would be obtained from the existing site cooling water system, which obtains water from the Savannah River. Blowdown would be discharged to Fourmile Branch, an on-site tributary of the Savannah River.

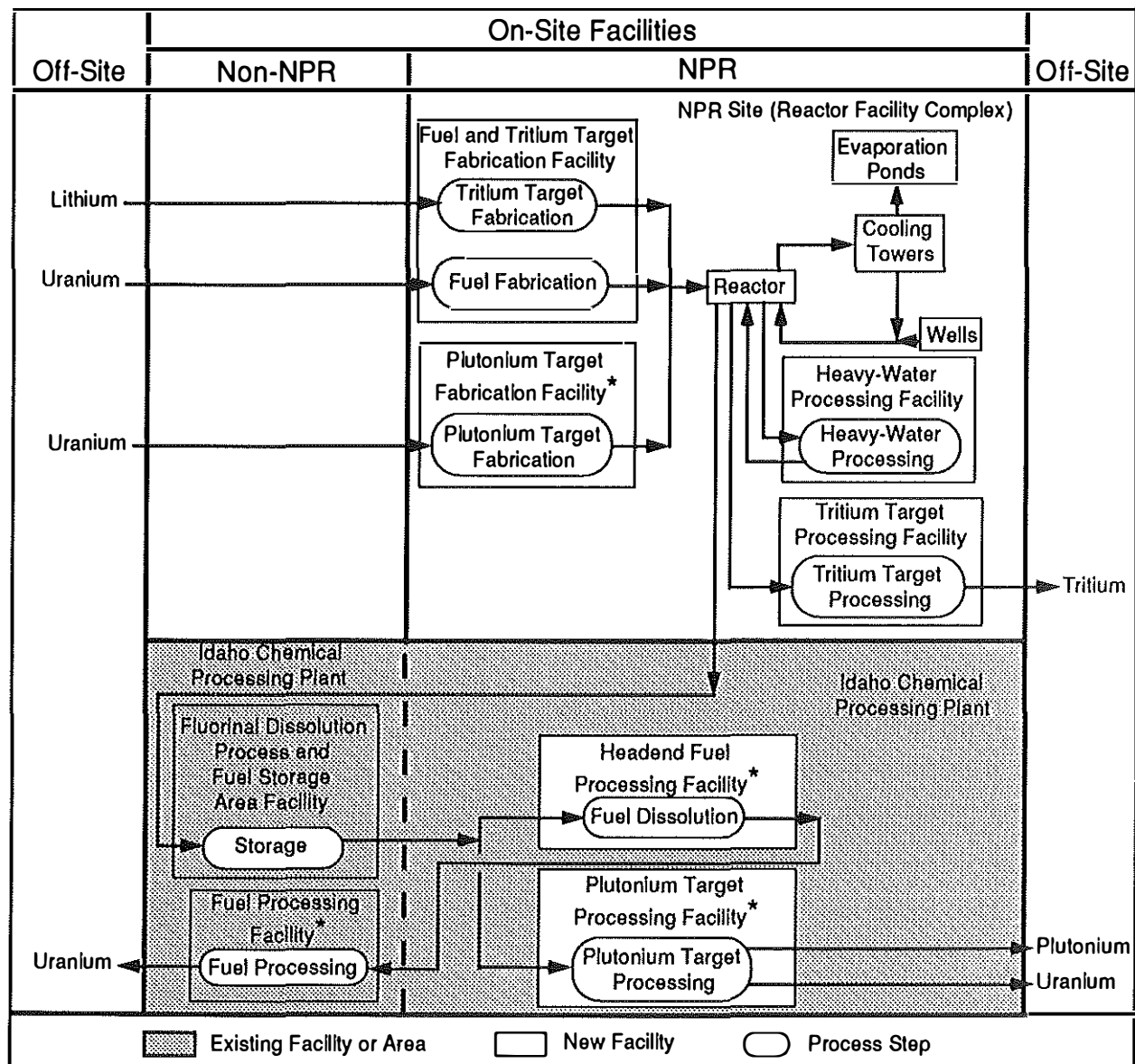


FIGURE 3.3-3 Facility Requirements for the HWR at INEL (* indicates facilities involved only in weapons-grade plutonium production and spent fuel processing)

3.3.2.2 Tritium-Target and Fuel Fabrication Facilities

The Fuel Fabrication Facility would fabricate aluminum-clad tubes of aluminum and uranium (enriched to 60-80 wt% uranium-235) alloy. The Tritium-Target Fabrication Facility would fabricate aluminum-clad tubes of aluminum and lithium (enriched by lithium-6) alloy. After fabrication, the tritium-target tubes would be transferred to the Fuel Fabrication Facility, where they would be combined with the 80% enriched uranium fuel tubes and other mechanical parts to form finished fuel and tritium-target assemblies. Some tritium targets would also be combined with the 60% enriched uranium fuel tubes to form neutron-driver-fuel assemblies for plutonium production.

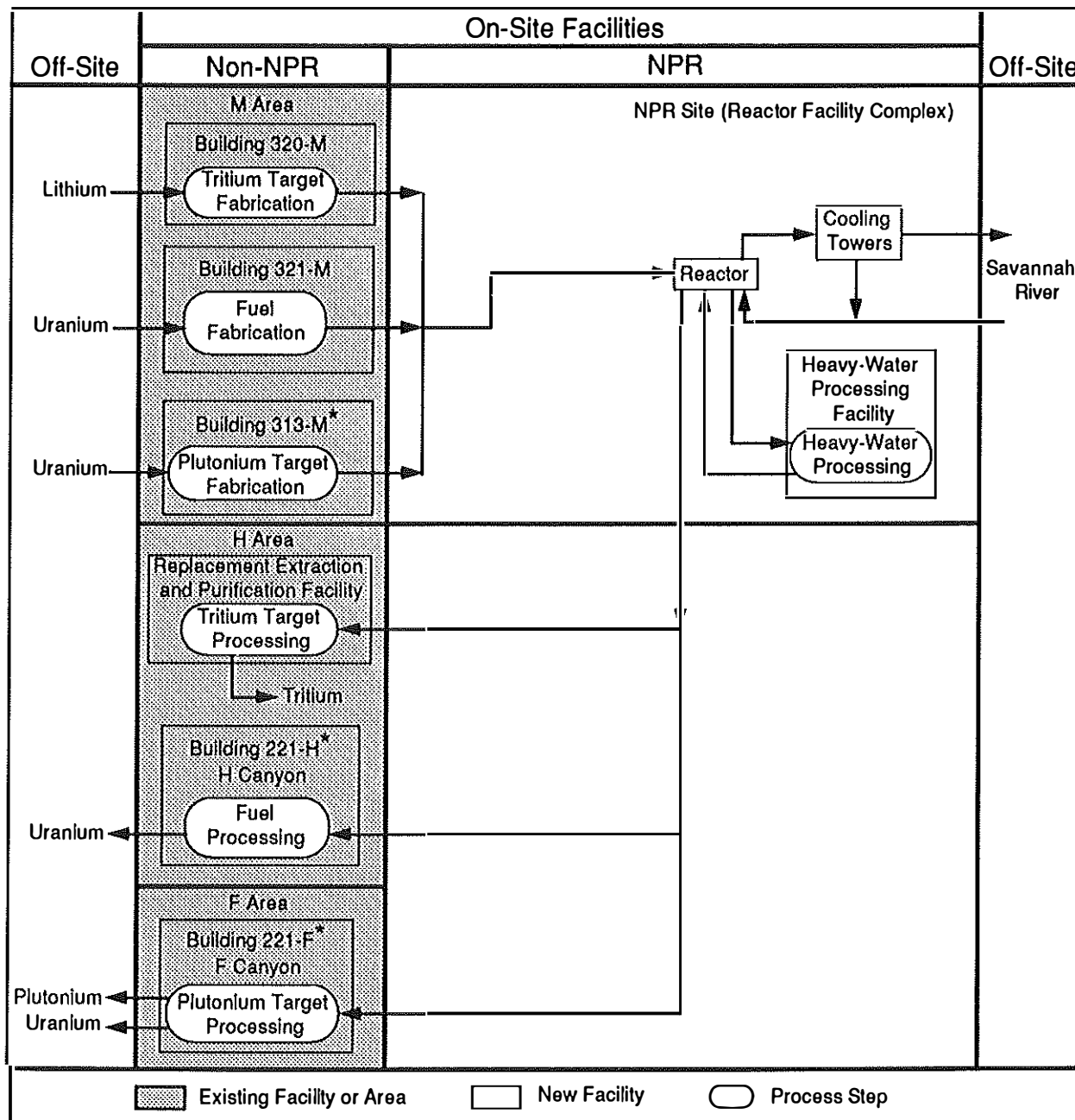


FIGURE 3.3-4 Facility Requirements for the HWR at SRS (* indicates facilities involved only in weapons-grade plutonium production and spent fuel processing)

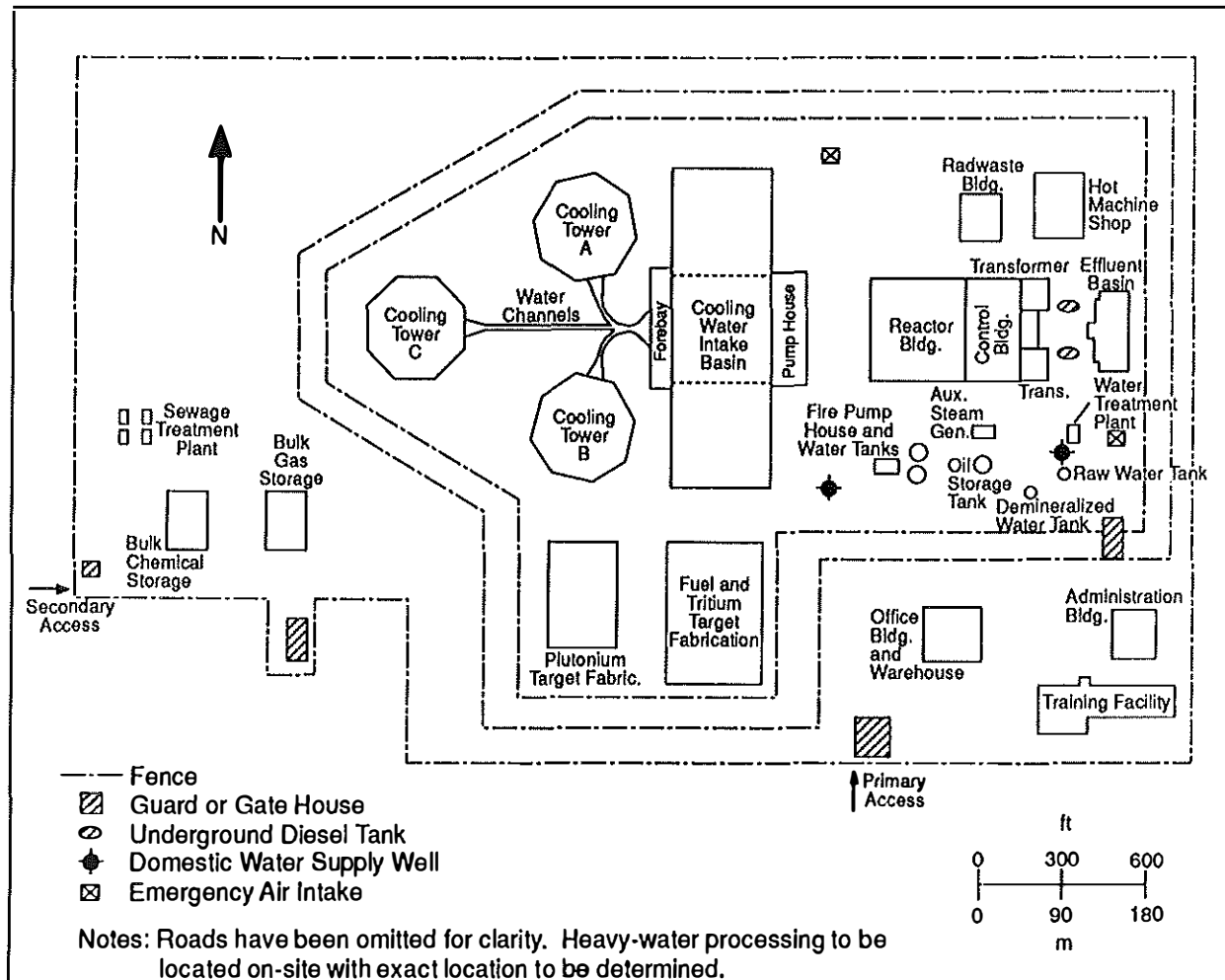


FIGURE 3.3-5 Plan View of the HWR Reactor Facility (Hanford Example) (Source: Modified from WHC-4)

At Hanford or INEL, tritium-target fabrication would be combined with fuel fabrication in a new Fuel and Tritium-Target Fabrication Facility constructed on the NPR site adjacent to the Reactor Facility. At SRS, fuel would be fabricated in existing Building 321-M, which is currently used for that purpose. Tritium targets would be fabricated in existing buildings 320-M and 321-M, which are presently used for that purpose.

3.3.2.3 Fuel/Plutonium-239 Target Fabrication Facility

The Plutonium-Target Fabrication Facility would fabricate aluminum-clad tubes of uranium (depleted to about 0.2 wt% uranium-235). After fabrication, the plutonium-239 targets would be combined with other mechanical parts to form finished plutonium-target assemblies. The plutonium-target assemblies would be transferred to the Reactor Facility, where they would be inserted into the reactor with the neutron-driver-fuel assemblies discussed above.

At Hanford or INEL, the Plutonium-Target Fabrication Facility would also be a new facility and would, in either case, be built on the NPR site adjacent to the Reactor Facility. At SRS, plutonium targets would be fabricated in existing Building 313-M, which is currently used for that purpose.

3.3.2.4 Tritium-Target Processing Facility

The Tritium-Target Processing Facility would receive irradiated tritium-target elements in aluminum shipping containers (bundles) from the Reactor Facility disassembly area. The facility would extract hydrogen (including tritium, an isotope of hydrogen) and other gases from the materials. Tritium would be separated and recovered by thermal, mechanical, and chemical processes. Tritium produced at either Hanford or INEL would be packaged for shipment to non-NPR facilities at SRS; tritium produced at SRS would be transferred to non-NPR facilities on-site. All remaining materials, including the shipping containers, would be wastes (Appendix M) and would be either treated for disposal or pretreated for transfer to sitewide waste management facilities.

At Hanford, the Tritium-Target Processing Facility would be in the existing Fuels and Materials Examination Facility in the 400 Area. The Fuels and Materials Examination Facility is a DOE Nonreactor Safety Class 1 facility for handling special nuclear materials, and meets or exceeds current building design criteria for tritium-target processing activities. At INEL, the Tritium-Target Processing Facility would be a new facility at the NPR site. It would be contained in a two-story building designed to DOE Nonreactor Safety Class 1 criteria. At SRS, tritium targets would be processed in a new Replacement Extraction and Purification Facility currently proposed for construction in the H Area for the current SRS defense materials production activities. This building would be built whether or not NPR were constructed at SRS. It would also be constructed to DOE Nonreactor Safety Class 1 criteria.

3.3.2.5 Fuel Processing Facility

The Reactor Facility would send spent fuel from either the tritium production fuel and target assemblies or the plutonium production neutron-driver-fuel assemblies to the Fuel Processing Facility. This facility would chemically dissolve the fuel, chemically separate the uranium from other materials, and purify the extracted uranium and convert it to an oxide. The uranium oxide would be shipped to the Fuel Fabrication Facility or off-site (for recycle). The Fuel Processing Facility would treat for disposal or pretreat for transfer to sitewide waste management facilities all remaining materials (wastes).

Hanford Site

At Hanford, a new Fuel Processing Facility would be constructed in the 200-East Area, an area that contains similar reactor fuel processing facilities. The Fuel Processing Facility would be contained in two principal buildings. The fuel processing building would contain the high-radiation processes associated with fuel dissolution and uranium separation. The uranium recovery building would contain the low-radiation processes associated with uranium purification and conversion to oxide. The Fuel Processing Facility would be a remotely operated, remotely maintained facility designed to DOE Nonreactor Safety Class 1 criteria. The uranium

recovery building would be a remotely operated, contact-maintained facility also designed to DOE Nonreactor Safety Class 1 criteria. The two buildings would be connected by an underground, double-wall pipe encasement, containing lines to transfer the uranyl nitrate solution from the fuel processing building and the waste solution from the uranium recovery building. Two support facilities (one for the fuel processing building and one for the uranium recovery building) would be constructed for administrative offices, radiation zone clothes-changing rooms, and other office and personnel activities. These buildings would be designed to Uniform Building Code standards for industrial buildings.

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At INEL, spent fuel would be processed in a new Headend Fuel Processing Facility designed to DOE Nonreactor Safety Class 1 criteria. The initial chemical dissolution would take place in the headend facility, and the uranyl nitrate solution that is produced would be transferred to the soon-to-be-completed Fuel Processing Facility at the Idaho Chemical Processing Plant. The new Headend Fuel Processing Facility would be attached to the existing Fluorinal Dissolution Process and Fuel Storage Facility to take advantage of its underwater receiving, inspection, and transfer capabilities. The uranyl nitrate solution would be transferred to the Fuel Processing Facility via an underground, double-wall pipe encasement.

Savannah River Site

At SRS, spent fuel would be processed in Building 221-H (H-Canyon). This building is currently used for HWR fuel processing.

3.3.2.6 Plutonium-239 Target Processing Facility

The Plutonium-Target Processing Facility would receive irradiated plutonium-239 targets from the Reactor Facility storage pool; extract plutonium and uranium; separate the uranium from the plutonium; decontaminate, purify, and process the plutonium to its metallic form for shipment to the Rocky Flats Plant in Golden, Colorado, or another appropriate facility; decontaminate, purify, and process the uranium to its oxide form for recycle; and treat for disposal or pretreat for transfer to sitewide waste management facilities all the remaining materials (wastes).

Hanford Site

At Hanford, two process lines for plutonium processing would be added to the initial processing area (headend) of the fuel processing building. The Fuel Processing Facility would be modified to accommodate the added throughput of plutonium processing. Consequently, no additional buildings would be needed.

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At INEL, a new Plutonium-Target Processing Facility would be constructed at the Idaho Chemical Processing Plant. The building would be a one-story, reinforced-concrete structure designed to DOE Nonreactor Safety Class 1 criteria.

Savannah River Site

At SRS, plutonium targets would be processed in the existing Building 221-F (F-Canyon). This building is currently used for HWR plutonium-target processing.

3.3.2.7 Construction Activities

New facilities would be designed for a 40-year minimum service lifetime. The major resource requirements for HWR construction are listed in Table 3.3-1, along with the peak work force requirements.

Hanford Site

In addition to the new facilities identified in Figure 3.3-2, the HWR at Hanford would require construction of makeup and discharge pipelines between the Columbia River and the Reactor Facility, water intake and discharge structures in the bed of the Columbia River, and a water intake pumphouse at or near the shoreline; redundant electric power supply lines between the Reactor Facility and the H.J. Ashe Substation; a railroad spur; and primary and secondary roads to the NPR site (Figure 3.3-6). Drain tile septic systems would be constructed for each facility on the NPR site. Temporary operation of a concrete batch plant and sand and gravel pits would be needed as a result of construction activities. Construction water for the NPR site would be either supplied from new wells at the NPR site or piped from the 200-Area service water system. Construction water for the 200 Area would be obtained from the 200-Area service water system. Construction water for the Tritium-Target Processing Facility in the Fuels and Materials Examination Facility would be obtained from the 400-Area service water system.

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In addition to the new facilities identified in Figure 3.3-3, the heavy-water reactor at INEL would require construction of one or more evaporation ponds (829 ha total area) and discharge pipelines between the cooling towers and the evaporation pond(s), an electric power supply line between the Reactor Facility and the Antelope Substation and a redundant electric power supply line between the Reactor Facility and the Scoville Substation, a railroad spur, and primary and secondary roads to the NPR site (Figure 3.3-7). Drain tile septic systems would be constructed for each facility on the NPR site. Temporary operation of on-site concrete batch plants and sand and gravel pits would be needed to support construction activities. Construction water for the NPR site would be supplied from new wells into the Snake River Plain aquifer at the NPR site. Construction water for the facilities in the Idaho Chemical Processing Plant would be obtained from the existing service water system. The evaporation pond(s) would likely be perched

TABLE 3.3-1 Resource Requirements for Construction of an HWR

Resource	Unit	Hanford	INEL	SRS
Electric energy	10 ³ MWh	151	138	134
Fuel	10 ⁶ L	16	44	18
Concrete	10 ³ m ³	330	340	260
Carbon steel	10 ³ t	82	85	66
Stainless steel	10 ³ t	5.0	5.8	2.3
Chemicals	10 ⁶ L	100	100	70
Land disturbance	ha	804	1,566 ^a	214
Total effort	worker-yr	18,000	14,200	11,800
Peak work force	workers	2,400	2,600	2,400
Construction duration	years	10	10	8.5
Construction period	-	1992-2002	1992-2002	1992-2000

^aIncludes one or more evaporation ponds (829 ha total area).

pond(s), formed by earthen dikes strategically placed around a natural depression or depressions in the landscape. Additional soil, rock, and imported materials for pond construction might need to be moved, but, because pond design is not well advanced, quantities are currently unknown. Alternative cooling systems are being evaluated. Resources for construction of the pond are not included in Table 3.3-1.

Savannah River Site

In addition to the new facilities identified in Figure 3.3-4, the heavy-water reactor at SRS would require construction of a makeup water pipeline between the existing SRS cooling water system and the cooling towers and a discharge line from the cooling towers to the C-Area discharge canal, redundant electric power supply lines between the Reactor Facility and the 504-2G and 504-3G substations, a railroad spur, and primary and secondary roads to the NPR site (Figures 3.3-8 and 3.3-9). Temporary operation of a concrete batch plant and sand and gravel pits would be needed to support construction activities. Construction of the Reactor Facility might involve some site dewatering activities because of the high water table. The water would be pumped to a settling basin before discharge to a local stream. The water would be monitored and treated, if necessary, before discharge. Sediments collected in the pond would be removed periodically for disposal at existing SRS landfills. A sanitary waste treatment plant designed to accommodate a population sufficient to operate the facility would be constructed as part of the Reactor Facility. Construction water would be supplied from wells drilled to lower Cretaceous sands beneath the NPR site.

3.3.2.8 Operation Activities

Batch-mode operation would be used for both tritium and plutonium production. The number of fuel and target batches irradiated would be about 1.5 per year for the tritium production mode and about 5 per year for the plutonium production mode. Because the neutron-driver-fuel assemblies would be replaced at every third plutonium-target change, the number of plutonium neutron-driver-fuel batches would be about 2 per year.

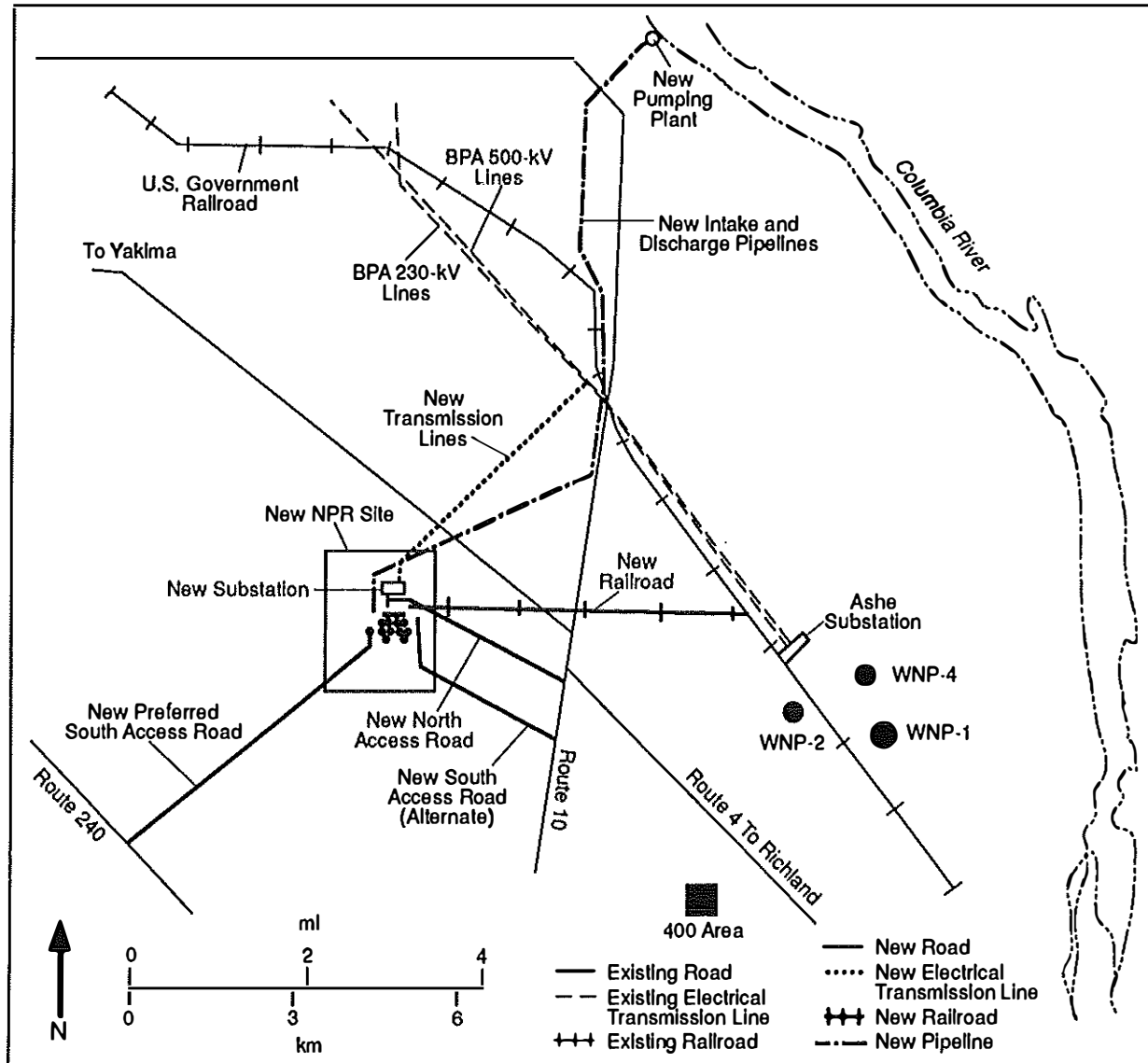


FIGURE 3.3-6 Additional Construction Required to Support HWR and MHTGR Alternatives at the Hanford NPR Site

The estimated annual requirements of energy, materials, and work force for operation of the HWR in the tritium and plutonium production modes at the three alternative sites is presented in Table 3.3-2. Resources are estimated on the basis of facility operation in support of one HWR operating at 2,590-MWt nominal power.

To ensure immediate availability of emergency power in case of loss of off-site power, the primary emergency diesel generators would be on-line at all times during reactor operation. If the current scheme of production reactor operation is used for the NPR, the uranium fuel would be fabricated from enriched uranium stock.

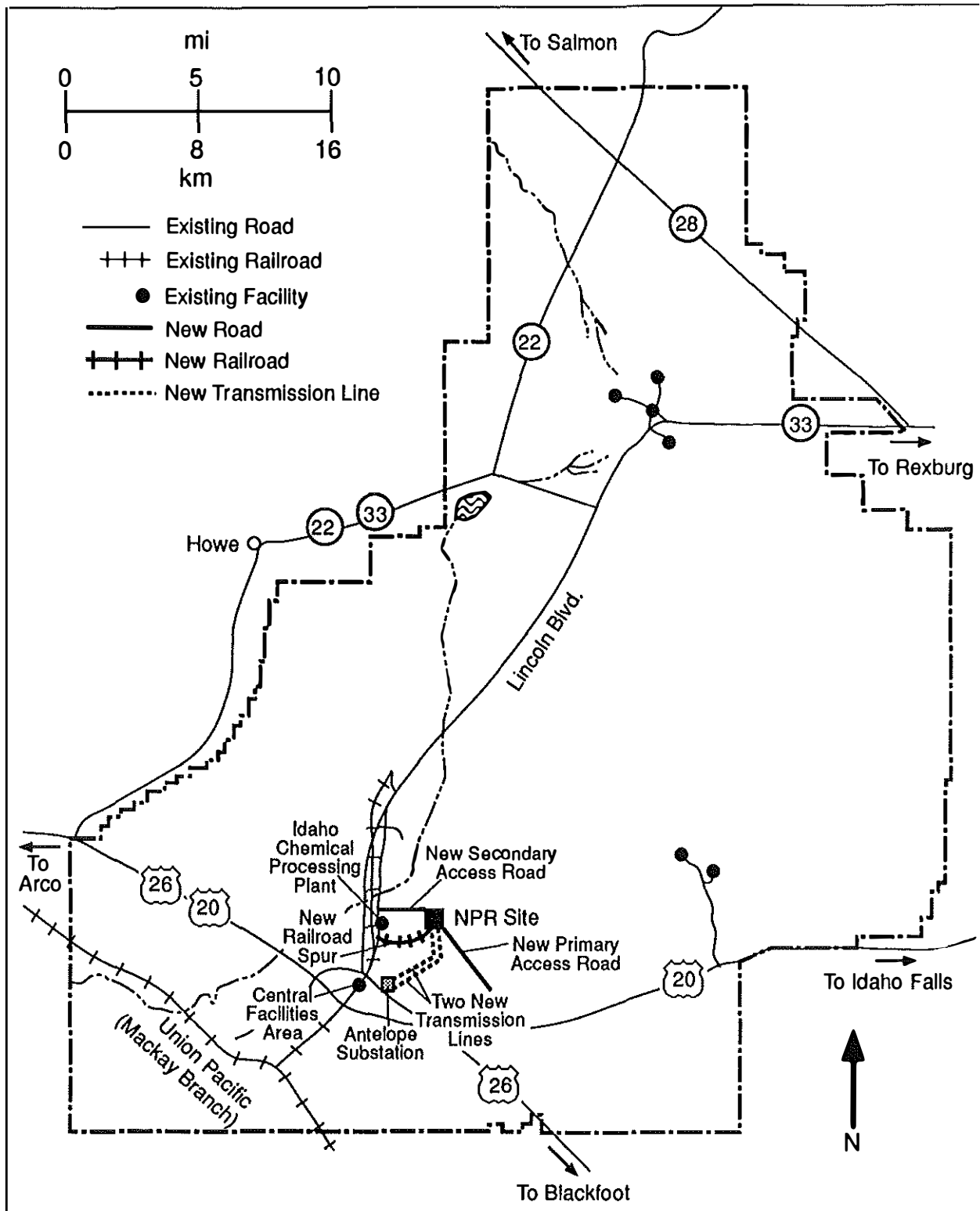


FIGURE 3.3-7 Additional Construction Required to Support the NPR at the INEL Site

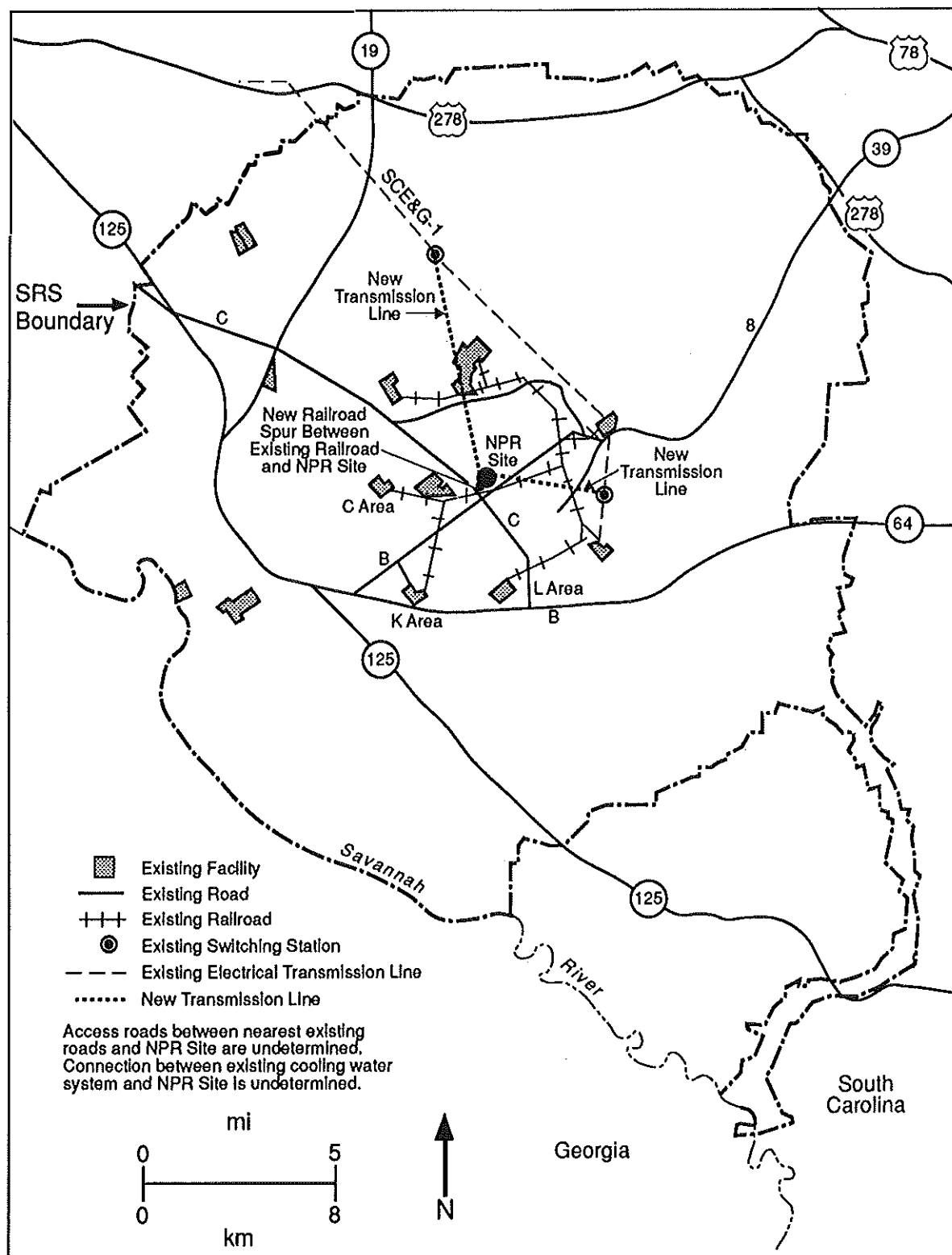


FIGURE 3.3-8 Additional Construction Required to Support the NPR at SRS

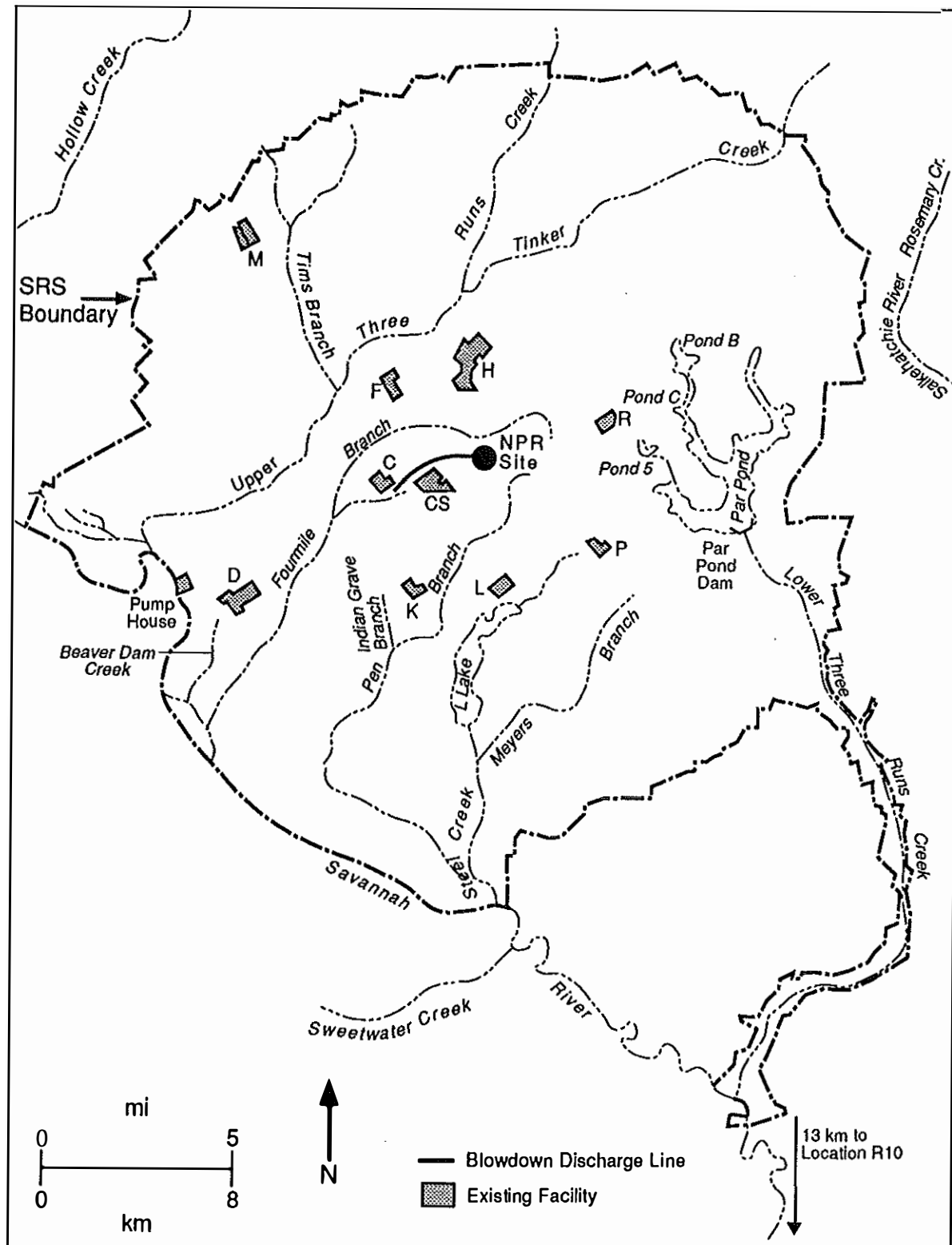


FIGURE 3.3-9 Blowdown Discharge Line from the NPR Site to the C Area Discharge Canal

TABLE 3.3-2 Estimated Annual Commodity Requirements for Operation of the HWR Complex

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Energy							
Electric energy	MWh	774,000	813,000	757,000	793,000	796,000	791,000
Fuel (diesel, gasoline, kerosene)	L	1.33×10^6	1.33×10^6	1.27×10^6	1.26×10^6	3.78×10^6	4.39×10^6
Steam	kg	6.64×10^8	6.92×10^8	6.63×10^8	6.61×10^8	9.31×10^7	9.98×10^7
Steam coal ^a	t	440	7,740	Electric	Electric	10,000	16,000
Materials							
Metals							
Aluminum for alloying/casting	t	18	8.60	18	8.60	18	8.60
Aluminum components	t	27	15.5	27	15.5	27	15.5
Depleted uranium (0.2% U-235)	t	0	414	0	414	0	414
HEU ^b metal (60-80% U-235)	t	2.6	2.5	2.5	2.5	2.6	2.5
Lithium metal (Li-6 enriched)	kg	280	45	280	45.4	280	45
Stainless steel	kg	150	10	150	10	150	10
Chemicals/cleaners/dissolvers							
Decontamination solutions	L	75,000	119,000	80,000	107,000	75,000	119,000
Degreaser	t	19	9.30	19	9.30	19	9.30
Hydroxylamine nitrate (18%)	t	4.95	28	0	0	0	60
Hydrazine (11.3M)	t	40	47	38.6	38.6	38.6	38.6
Nitric acid (fresh) (50 wt%)	L	180,000	960,000	53,000	1.35×10^6	310,000	2.1×10^6
Phosphoric acid	t	0.50	13.6	0.50	13	0.50	11

TABLE 3.3-2 (Cont'd)

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Chemicals/cleaners/ dissolvers (cont'd)							
Sodium hydroxide (50 wt%)	t	86.6	427	29	388	169	423
Sodium nitrate	t	0	86.4	0	114	0	787
Sodium nitrite	t	0	22.7	0	22.7	3	10.8
Sulfuric acid	t	1,800	1,800	1,800	1,800	1,770	1,770
Water							
Cooling system	m ³	4.3×10^7	4.3×10^7	4.26×10^7	4.26×10^7	5.53×10^7	5.53×10^7
Process and other	m ³	1.29×10^6	1.54×10^6	1.83×10^6	1.98×10^6	4.02×10^6	3.32×10^6
Work force ^c	Workers	1,249	1,124	1,037	1,532	851	971

^aSome Hanford steam electrically produced; all INEL steam electrically produced; all SRS steam obtained from existing coal-fired steam plants.

^bHEU = highly enriched uranium.

^cHWR operation at SRS assumes concurrent operation of existing K, L, and P reactors.

Source: Roman 1991.

Hanford Site

At Hanford, water for the reactor's secondary cooling system would come from the Columbia River. The quantities of cooling tower makeup flow are estimated on the basis of five cycles of concentration in the cooling towers. The water in the cooling tower would be chlorinated to control biofouling in the system. Potable water for the NPR would be obtained from well fields near the facilities, but Columbia River water could also be used.

Process water would also be obtained from the Columbia River. Process and potable water for the Tritium-Target Processing Facility (in the 400 Area) and the fuel and plutonium-processing facilities (in the 200-East Area) would be obtained from existing water supplies in those areas. Sanitary wastes from these facilities, like those at the NPR site, would be disposed of via septic tanks and drain fields constructed at each facility.

About 100 MW of electricity would be required to operate the NPR facilities at Hanford. Electricity to the NPR site would be supplied from the Bonneville Power Administration transmission grid via the H.J. Ashe Substation. Process steam, primarily for the Heavy-Water Processing Facility, and steam for heating the facilities on the NPR site would be produced using reactor heat. The reactor heat would be supplemented by electric heat during reactor operation. When the reactor was shut down, process steam and steam for heating would be supplied by electric heat alone. The process and heating steam for NPR facilities in the 200-East Area would be obtained from the existing 200-Area coal-fired steam supply system. The process and heating steam at the Fuels and Materials Examination Facility (in the 400 Area) would be supplied from a packaged electric boiler in the 400 Area.

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At INEL, water for operations would be obtained from the Snake River Plain aquifer. The quantities of cooling tower makeup water are estimated on the basis of five cycles of concentration in the cooling tower. Blowdown from the cooling towers would be discharged to one or more evaporation ponds, having an area of about 829 ha. The evaporation pond(s) would be designed to prevent freezing in the winter, and would be lined to prevent seepage into the groundwater. They would also need to be fenced and netted to prevent access by birds and animals.

About 100 MW of electricity would be required to operate the NPR facilities. At the NPR site, process steam, primarily for heavy-water processing, and steam for heating would be produced, using reactor heat supplemented by electric heating during reactor operation and by electric heat alone when the reactor was shut down. Process and heating steam for NPR activities in the Idaho Chemical Processing Plant would be obtained from the existing steam system in the Idaho Chemical Processing Plant.

Savannah River Site

At SRS, the new HWR facilities would consist of the Reactor Facility and the Heavy-Water Processing Facility. Other facilities needed to support the NPR program exist or are currently scheduled for construction at SRS to support existing isotope production activities. Existing facilities in support of the HWR would have sufficient extra capacity to accommodate

the processing required by the NPR without detriment to their current activities. Recent or planned facility upgrading (environmental impacts addressed in DOE-10) is assumed to be adequate to allow operation of the existing facilities for a considerable time. Additionally, long-term operation will be addressed in the Reconfiguration EIS.

Water for the reactor's secondary cooling system would come from the Savannah River via the existing SRS cooling water system and a new 1-km pipeline to the NPR site. Makeup water requirements are estimated on the basis of 2.5 cycles of concentration in the cooling towers and river water blending to reduce temperature differentials at the point of discharge (see Section 3.3.5.8 for possible mitigation measures). The water in the cooling tower would be chlorinated to control biofouling in the system. Process water and potable water would be obtained from well fields at the NPR site or from existing wells at existing facilities used by the HWR.

About 100 MW of electricity would be required to operate the NPR facilities at SRS. This EIS assumes that process steam at the NPR site, primarily required for heavy-water processing, would be provided from an existing SRS steam supply system via an existing SRS steam distribution system. Coal would be used to generate both process and facility heating steam. A Replacement Power Facility has been proposed, and an EIS will be prepared for that facility. However, insufficient information was available on potential air emissions to include the facility in the SRS environmental baseline. Two new water treatment systems would be used at the Reactor Facility. One system would treat the potable water from facility wells. A second system would condition cooling system (river) water. The water would be treated with hypochlorite, and the pH would be adjusted.

3.3.3 Light-Water Reactor Technology Description

The LWR uses light water (i.e., common water) as both coolant and moderator. The LWR is the most widely used nuclear technology for commercial power production. At present, 111 LWRs operate in the United States.

The following sections identify LWR facility requirements and discuss construction, operation, and waste management aspects for the LWR at each of the three alternative sites. Figures 3.3-10, 3.3-11, and 3.3-12 illustrate the facility requirements for the LWR at each alternative site, including tritium production, plutonium production, and spent fuel processing facilities. The figures show both new (unshaded) and existing (shaded) facilities; activities outside the boxes would occur off-site.

Expanded descriptions of the fuel cycle, target cycle, and methods and techniques of operation are presented in Appendix B. The primary sources of information for the LWR technology and its adaptation to the alternative sites are WHC-5, WHC-9, WHC-8, EG&G-7, WSRC-5, and WSRC-13; other sources are cited as appropriate.

3.3.3.1 Reactor Facility

The general description of a Reactor Facility for the LWR at the three alternative sites was developed from an existing, partially constructed LWR on the Hanford Site. Equipment to produce electricity is included in the Reactor Facility design because the LWR was designed to

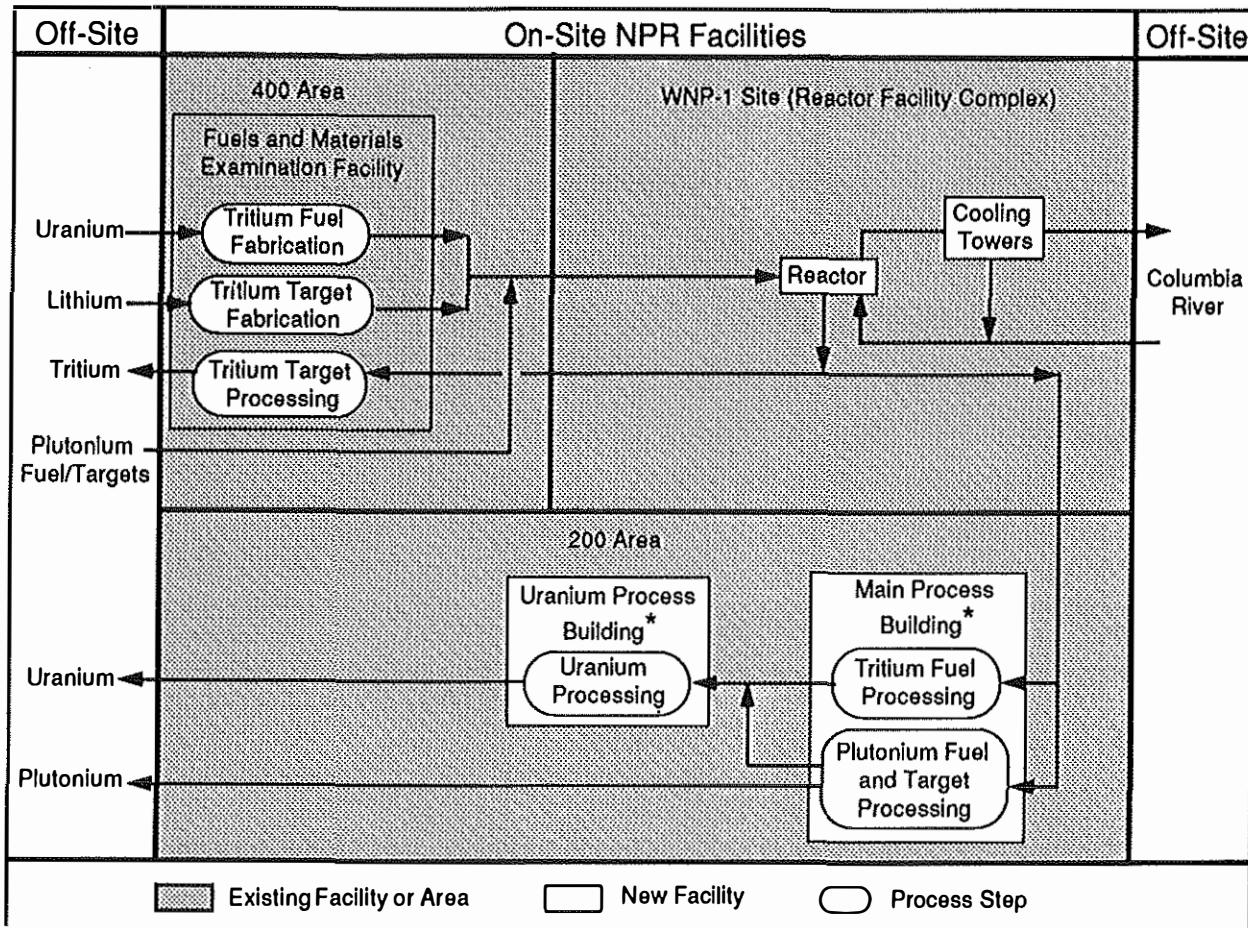


FIGURE 3.3-10 Facility Requirements for the LWR at Hanford (* indicates a facility used only for plutonium production or spent fuel processing)

produce high-temperature (330°C), high-pressure (15.2-MPa) steam that could be used to produce power (1,250 MWe). The conceptualized Reactor Facility (Figure 3.3-13) would occupy about 61 ha of land and would include a containment building, a turbine building and electrical switchyards, a general service building, a steam condensing facility, three mechanical draft cooling towers, a spray pond for emergency reactor cooling, and a waste treatment plant. The reactor, the primary cooling system with steam generating heat exchangers (steam generators), and the reactor safety systems would be housed in the containment structure. The reactor and all safety-related equipment and structures of the Reactor Facility would be sited and designed in accordance with DOE Order 5480.6, *Safety of DOE-Owned Nuclear Reactors*, and would meet or exceed current standards applied to commercial nuclear power plants, whichever is the more stringent requirement (Appendix A, Section A.1.2).

The electric load of the operating Reactor Facility would be about 100 MWe, which would be supplied either by the LWR generator or by purchased power. Emergency power would be provided by two 7,000-kW, one 1,200-kW and two 150-kW diesel generators.

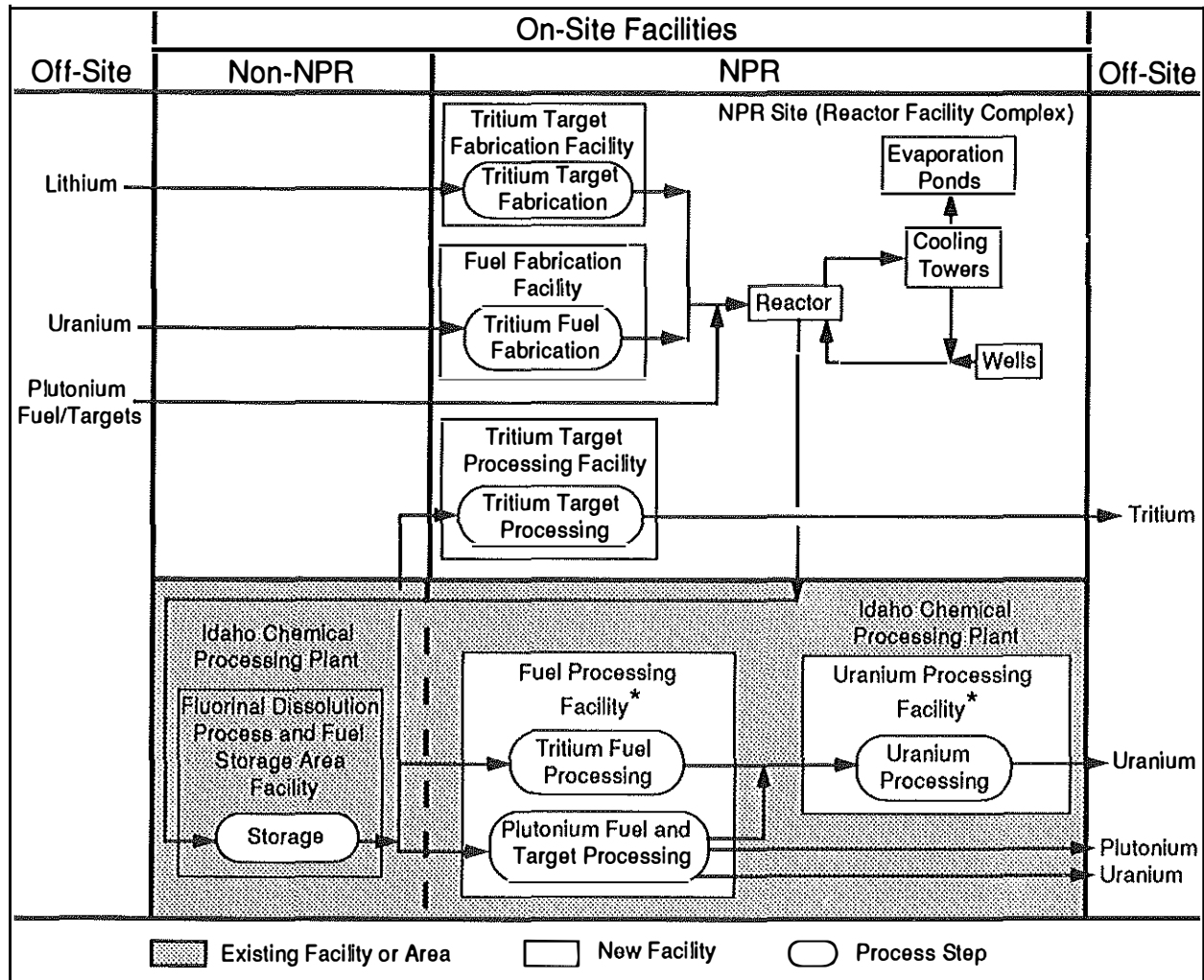


FIGURE 3.3-11 Facility Requirements for the LWR at INEL (* indicates a facility used only for plutonium production or spent fuel processing)

The Reactor Facility would contain a fuel storage pool. The fuel storage pool would be used to store plutonium targets and spent fuel from tritium and plutonium production (1-year storage assumed). This would allow decay heat generation to subside and short-lived radioisotopes to decay before processing to recover plutonium and unused fuel. Tritium targets would be cooled for 1 month before processing.

The reactor would generate about 3,800 MWt of heat. If electricity were produced by steam generated in the steam generators, about 33% of the heat would be used to produce electricity; about 67% would be released to the environment through the three mechanical draft cooling towers. If electricity were not generated, because the turbine generators were not operational, steam produced in the secondary cooling system would be partially cooled by high-pressure steam condensers before circulating through the cooling towers.

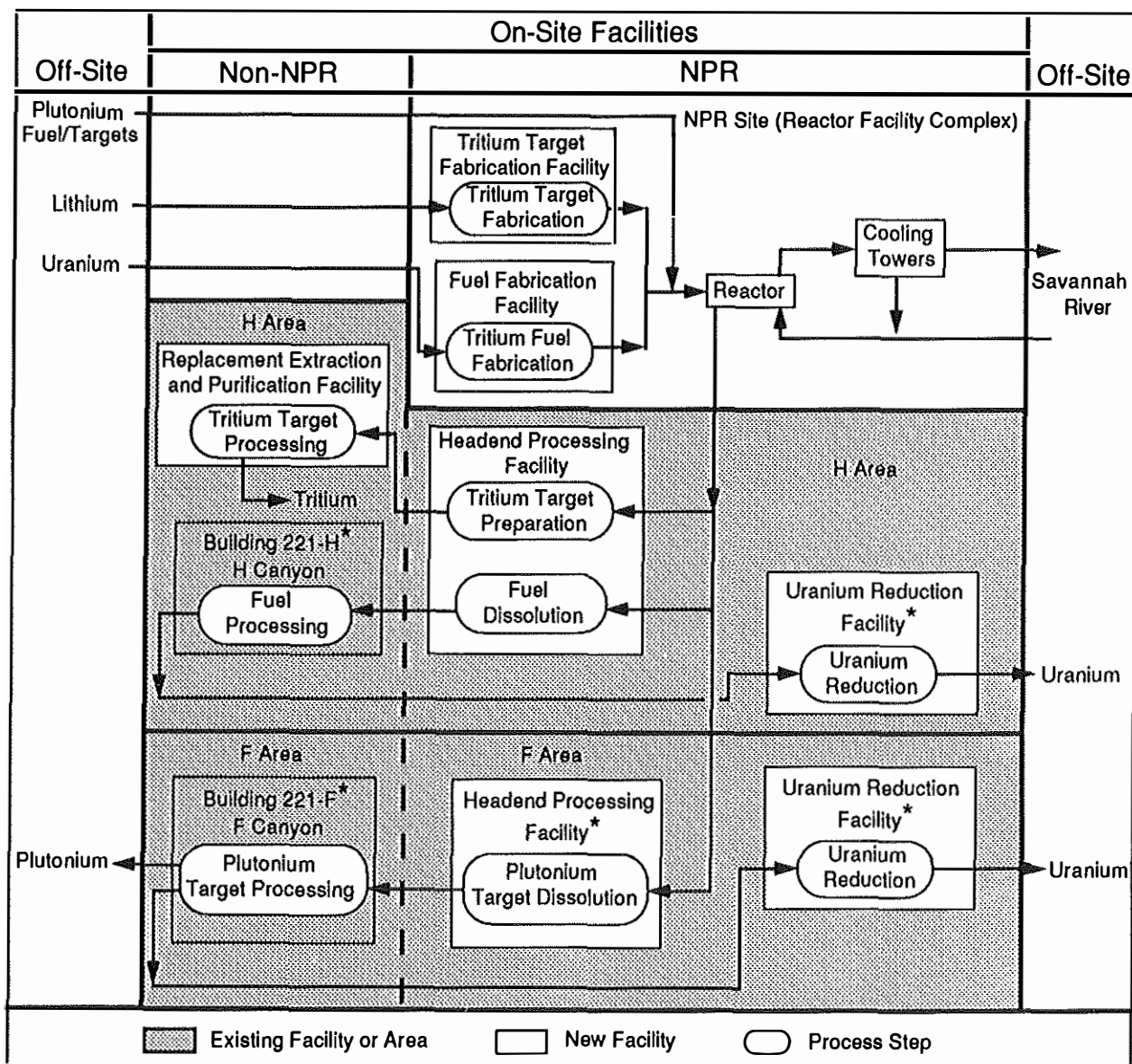


FIGURE 3.3-12 Facility Requirements for the LWR at SRS (* indicates a facility used only for plutonium production or spent fuel processing)

At Hanford, the Reactor Facility would consist of a partially constructed LWR power plant, WNP-1, currently owned by the Washington Public Power Supply System. Construction of WNP-1 was suspended in April 1982 when the plant was 63% complete; WNP-1 has been actively maintained to preserve the existing structures, equipment, and records to allow resumption of construction at any time. Three mechanical draft cooling towers, the raw water intake, the raw water supply pumphouse and pipeline, and the blowdown discharge pipeline and discharge structure are in place. Reactor components, safety systems, and a new steam condensing facility would need to be installed.

At INEL, the Reactor Facility would consist of a new facility constructed at the NPR site. The facility would also include three mechanical draft cooling towers. Makeup water would be

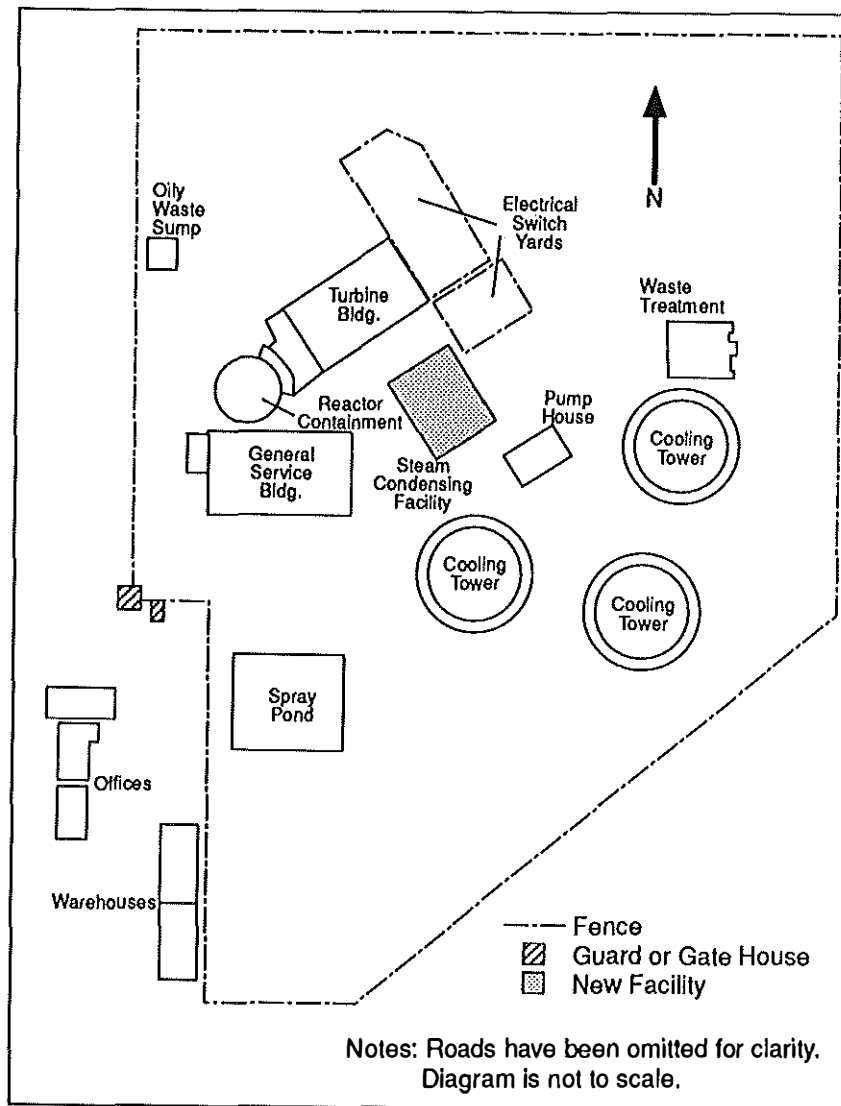


FIGURE 3.3-13 Plan View of the Generic LWR Reactor Facility (Hanford Adaptation) (Source: Modified from WHC-8)

obtained from groundwater supplies. Blowdown from the cooling towers would be discharged to one or more evaporation ponds, having a total area of 855 ha. The evaporation pond(s) would be located near the Reactor Facility. As with the HWR, an alternative dry cooling tower design would eliminate the evaporation pond(s).

At SRS, the Reactor Facility would be a new facility constructed at the NPR site. The facility would also include three mechanical draft cooling towers. Cooling tower makeup water would be obtained via a new pipeline from an existing cooling water system that obtains its water from existing water intakes on the Savannah River. Blowdown would be discharged via the existing lined discharge canal in the C Area to Fourmile Branch, which enters the Savannah River.

3.3.3.2 Tritium-Target and Fuel Fabrication Facilities

The Tritium-Target Fabrication Facility would fabricate tritium-target rods, consisting of enriched (lithium-6) lithium aluminate pellets encased in stainless steel tubes. After fabrication, the tritium-target tubes would be transferred to the Fuel Fabrication Facility, where they would be assembled with fuel rods and other mechanical parts to form finished tritium production assemblies. The neutron-driver-fuel rods for tritium production would also be fabricated at the Fuel Fabrication Facility; these rods would consist of enriched (8-12 wt% uranium-235) uranium pellets encased in zircaloy tubes. The uranium for fuel rod fabrication would come either from off-site or from on-site uranium recovery activities. Once assembled, the target and fuel assemblies would be stored in the Fuel Fabrication Facility until they were transferred to the Reactor Facility, where they would be inserted into the reactor core.

At Hanford, the existing Fuels and Materials Examination Facility in the 400 Area would be used to fabricate tritium targets and fuel for tritium production (8-10%). At INEL or SRS, a new Tritium-Target Fabrication Facility and a new Fuel Fabrication Facility would be constructed at the NPR site. The Tritium-Target Fabrication Facility would be designed to comply with Uniform Building Code standards for industrial buildings. In contrast, the Fuel Fabrication Facility, which would process fissionable materials, would be constructed to DOE Nonreactor Safety Class 1 criteria. Auxiliary facilities would include a waste treatment plant to process radioactive and hazardous wastes for further treatment in existing facilities.

3.3.3.3 Fuel/Plutonium-239 Target Fabrication Facility

The rods of the LWR fuel/plutonium-target assembly contain pellets that are both targets and fuel; consequently, only one type of rod would be fabricated. The rods would consist of slightly enriched (1.7 wt% uranium-235) uranium encased in zircaloy tubes. These are very similar to nuclear power plant fuel rods and would be purchased from a commercial vendor. Therefore, no plutonium-target or plutonium-239 fuel fabrication facility would be constructed at Hanford, INEL, or SRS.

3.3.3.4 Tritium-Target Processing Facility

The Tritium-Target Processing Facility would receive irradiated tritium-target rods from the Reactor Facility. Hydrogen (including the tritium isotope of hydrogen) and other gases would be recovered from the rods by mechanical and thermal processes; then the tritium would be separated by mechanical and chemical processes. Tritium produced at either Hanford or INEL would be packaged for shipment to non-NPR facilities at SRS; tritium produced at SRS would remain at SRS in non-NPR facilities. The remaining materials, including the shipping canisters, would be wastes (Appendix M) and would be either treated for disposal or pretreated for transfer to on-site waste management facilities.

At Hanford, the Tritium-Target Processing Facility would be housed in the existing Fuels and Materials Examination Facility in the 400 Area. The facility would meet or exceed DOE Nonreactor Safety Class 1 criteria. At INEL, the Tritium-Target Processing Facility would be a new facility on the NPR site. The facility would be designed to DOE Nonreactor Safety Class 1 criteria. At SRS, tritium targets would be processed at the Replacement Extraction and Purification Facility in H Area, which would be constructed by the year 2000 to meet existing materials production requirements at SRS. This facility would be constructed whether or not the

NPR were constructed and operated at SRS and would meet or exceed DOE Nonreactor Safety Class 1 criteria.

3.3.3.5 Fuel/Plutonium-239 Target Processing Facility

Both tritium-target fuel and plutonium-239 targets would be processed in the same facility because fuel/plutonium-target processing involves extraction and separation of plutonium and uranium from similar feed materials. The LWR Fuel Processing Facility would be similar to the HWR facility (Section 3.4.3), except the fuel/plutonium-target rods would be chopped before dissolution. Plutonium separated in the facility would be converted to a metallic form that would be shipped to the Rocky Flats Plant or another appropriate facility. Enriched (from fuel processing) or depleted (from plutonium-target processing) uranium would either be recycled for fuel or plutonium-target fabrication or shipped to Oak Ridge, Tennessee, for other DOE use. After uranium and plutonium are extracted, separated, purified, and converted to final form, the remaining wastes would be either treated for disposal or pretreated for transfer to on-site waste management facilities.

Hanford Site

At Hanford, the Fuel Processing Facility would be a new Spent Fuel Processing Complex in the 200-East Area. The facility would consist of two buildings. The main processing building would be used for high-radiation processing tasks. The uranium recovery building would be used for low-radiation tasks. The main processing building would be a remotely operated, remotely maintained facility designed to DOE Nonreactor Safety Class 1 criteria. Uranium and plutonium would be extracted from targets and fuel, decontaminated (to reduce levels of radioactivity), and separated from each other. The plutonium would be purified and converted to a metallic form for shipment. The uranium, in the form of a nitrate solution, would be transferred by underground pipeline to the uranium recovery building for purification and conversion to an oxide. The uranium recovery building would be a remotely operated, contact-maintained facility designed to DOE Nonreactor Safety Class 1 criteria.

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At INEL, a new Low-Enriched Fuel Processing Facility would be constructed at the Idaho Chemical Processing Plant complex. The facility would be almost identical to the Hanford Fuel Processing Facility. The new facility would be needed because low-enrichment fuel processing is not compatible with the processing of high-enriched fuel at the soon-to-be-completed Fuel Processing Facility at the Idaho Chemical Processing Plant. The Low-Enriched Fuel Processing Facility would be constructed adjacent to the existing Fluorinal Dissolution Process and Fuel Storage Facility so that the receiving, inspection, and underwater transfer capability of that facility could be used.

Savannah River Site

At SRS, plutonium-target processing and fuel processing would take place in a combination of new and existing structures. The initial stages (headend) of plutonium-target

processing would take place in a new Headend Plutonium-Target Processing Facility adjacent to the existing Building 221-F (F-Canyon) in the F Area. The initial stages (headend) of fuel processing would take place in a new Headend Fuel Processing Facility adjacent to the existing Building 221-H (H-Canyon) in the H Area. Both new headend facilities would be designed to DOE Nonreactor Safety Class 1 criteria. In these facilities, plutonium targets and fuels would undergo chopping, extraction, and initial decontamination before being transferred to the F and H canyons for final processing. Two new office and personnel support facilities, built to Uniform Building Code standards for industrial buildings, would also be constructed -- one adjacent to each headend facility. Uranium trioxide produced in the F and H canyons would be reduced to uranium dioxide in two new uranium reduction facilities, adjacent to the F and H canyons, respectively.

3.3.3.6 Construction Activities

New facilities would be designed for a 40-year minimum service lifetime. The major resource requirements for LWR construction are listed in Table 3.3-3, along with the peak work force requirements.

Hanford Site

Construction of the LWR at Hanford would include completion of the WNP-1 power plant. A new railroad spur to the 200-E Area would be constructed (Figure 3.3-14). Temporary operation of an on-site concrete batch plant and sand and gravel pits would be needed to support construction of support facilities. Water for construction at the WNP-1 site would be obtained from the existing WNP-1 water supply system from the Columbia River. Water for construction in the 200-East Area and the 400 Area would come from existing water supplies in those areas.

TABLE 3.3-3 Resource Requirements for Construction of an LWR

Resource	Unit	Hanford	INEL	SRS
Electric energy	10 ³ MWh	98	176	179
Fuel	10 ⁶ L	3	36	18
Concrete	10 ³ m ³	60	240	250
Carbon steel	10 ³ t	15	110	110
Stainless steel	10 ³ t	2.4	4.2	3.6
Chemicals	10 ⁶ L	40	92	67
Land disturbance	ha	118	1,128 ^a	242
Total effort	worker-yr	18,330	29,900	26,300
Peak work force	workers	5,800	4,100	4,000
Construction duration	years	5.8	9.3	8.8
Construction period	-	1992-1998	1992-2001	1992-2000

^aIncludes one or more evaporation ponds (855 ha total area).

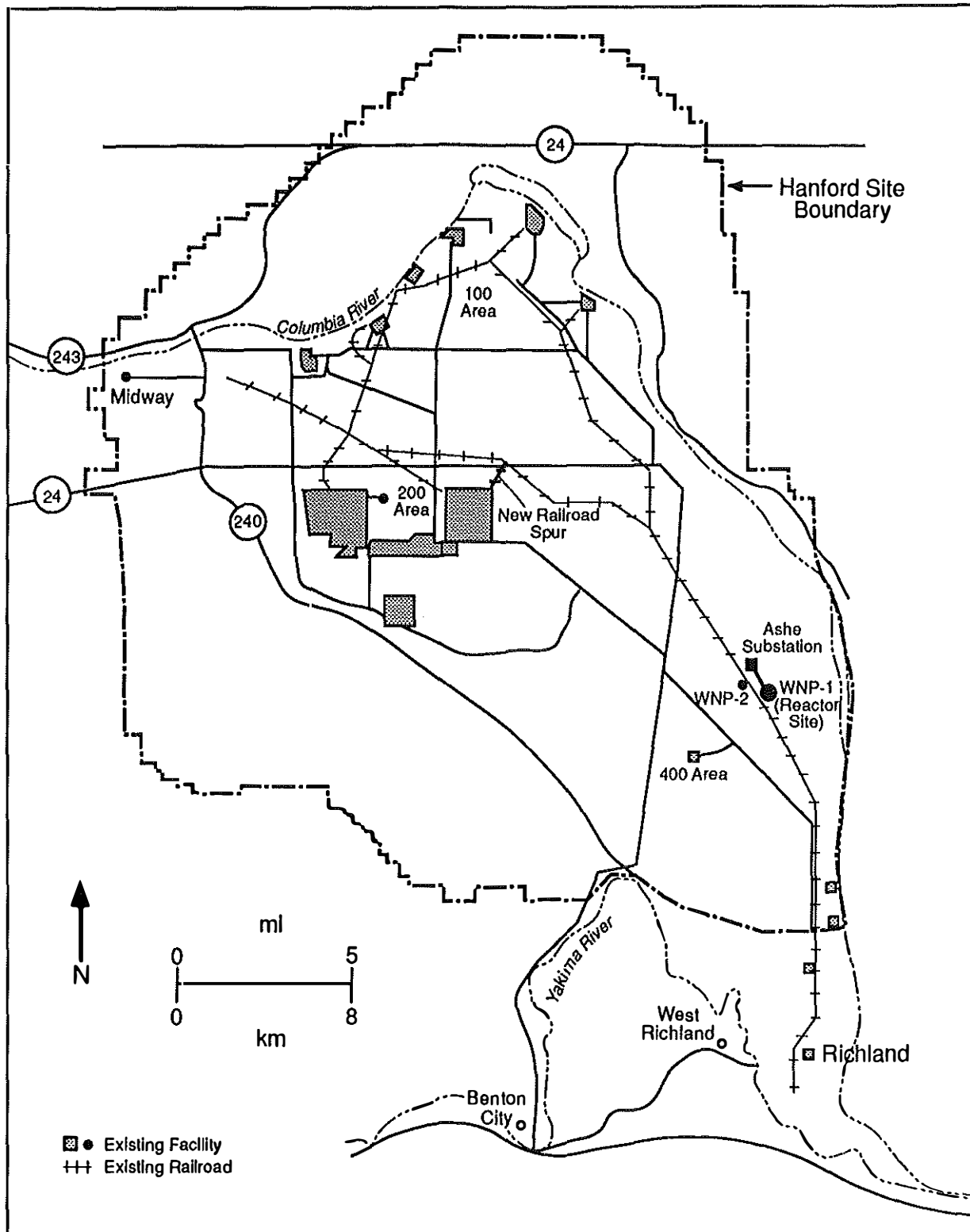


FIGURE 3.3-14 Additional Requirements for Construction of the LWR at Hanford

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In addition to the new facilities identified in Figure 3.3-11, construction of a light-water reactor at INEL would include one or more evaporation ponds totalling 855 ha, a pipeline between the Reactor Facility and the evaporation ponds, one electric power line between the Reactor Facility and the Antelope Substation and one between the Reactor Facility and the Scoville Substation, a railroad spur (Figure 3.3-7), and primary and secondary roads to the NPR site. Temporary operation of a concrete batch plant and sand and gravel pits would be needed to support construction activities. Water for construction at the NPR site would be supplied from new wells drilled into the Snake River Plain aquifer at the site. Water for construction of facilities at the Idaho Chemical Processing Plant complex would come from existing water supply systems in that area.

Savannah River Site

In addition to the new facilities identified in Figure 3.3-13, construction of a light-water reactor at SRS would include a pipeline between the SRS cooling water system and the cooling towers, a discharge line from the cooling towers to the C-Area discharge canal, two electric power lines between the Reactor Facility and the 504-2G and 504-3G substations, a railroad spur (Figure 3.3-8), and primary and secondary roads to the NPR site. Because the NPR site has a shallow water table (12 m) at SRS, some excavations would need dewatering. Water from dewatering activities would be pumped into a sedimentation pond before release to an existing watercourse. The water would be monitored and, if necessary, treated before discharge. Sediments collected in the pond would be removed periodically for disposal at existing SRS landfills. A sanitary waste treatment plant designed to accommodate a population sufficient to operate the facilities on the NPR site would be constructed as part of the Reactor Facility. Water for construction at the NPR site would be supplied from new wells. Water for construction in the H and F areas would be supplied from existing water systems in those areas.

3.3.3.7 Operation Activities

Batch-mode operation would be used for both tritium and plutonium production. The number of fuel and target batches irradiated would be about one per year for the tritium production mode and about four per year for the plutonium production mode.

The estimated annual requirements of energy, materials, and work force for operation of the LWR at the three alternative sites are presented in Table 3.3-4. Resources are estimated on the basis of facility operation in support of one LWR operating at 3,800-MWt nominal reactor power.

Hanford Site

During LWR operation at Hanford, cooling tower makeup water and potable water for the WNP-1 site would be withdrawn from the Columbia River. Potable water for NPR activities in the 200-East Area and the 400 Area would come from existing water supply systems in those areas. Process steam and heating steam for 200-Area facilities would be supplied by an existing coal-fired boiler, and for the 400-Area facilities by a packaged electric boiler. About 107 MW of

TABLE 3.3-4 Estimated Annual Commodity Requirements for Operation of the LWR Complex

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Energy							
Electric	MWh	633,000	655,000	671,000	655,000	650,000	641,000
Fuel (diesel, gasoline, kerosene)	L	254,000	235,000	240,000	235,000	240,000	235,000
Steam	kg	4.15×10^7	1.15×10^8	4.15×10^7	1.13×10^8	4.95×10^7	1.99×10^8
Steam, coal	t	3,200	9,200	Electric	Electric	5,444	21,854
Materials							
Metals							
Aluminum oxide	t	1.60	0	1.60	0	1.60	0
HEU ^a as UO ₂		47.1	560	47.1	560	47.1	560
Inconel metal	t	0.30	5.2	1.30	5.2	1.30	5.2
Lithium carbonate (Li-6 enriched)	t	1.18	0	1.18	0	1.18	0
Plutonium							
Fuel/target assemblies	Each	0	820	0	820	0	820
Fuel/target rods	Each	0	285,000	0	285,000	0	285,000
Stainless steel	t	7.70	4	7.70	4	7.70	4
Zircaloy metal	t	20.9	p38	20.9	138	20.9	138
Chemicals/cleaners/dissolvers							
Al. nitrate nonanhydrate (50 wt%)	L	144,000	2.01×10^6	144,000	2.01×10^6	144,000	2.01×10^6
Ammonia (28 vol%)	t	3.60	3.60	3.60	3.60	3.60	3.60
Boric acid	t	54	54	54	54	54	54
Calcium hydroxide	t	63.5	63.5	63.5	63.5	63.5	63.5
Hydrozlamine nitrate (19 wt%)	L	41	48	41	48	41	48

TABLE 3.3-4 (Cont'd)

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Chemicals/cleaners/dissolvers (cont'd)							
Hydrazine (35 vol%)	t	13.3	17.6	13.3	17.6	13.3	17.6
Nitric acid, fresh		693,000	1.26×10^6	693,000	1.26×10^6	693,000	1.26×10^6
Sulfuric acid	t	1,800	1,800	1,800	1,800	1,800	1,800
Sodium aluminate	t	104	104	104	104	104	104
Sodium carbonate	t	11.8	15.9	11.8	15.9	11.8	15.9
Sodium hydroxide (50 wt%)	t	183	580	183	580	184	580
Sodium nitrite	t	5.91	25.8	5.91	25.8	5.91	25.8
Gases							
Ammonia	t	22.7	181	22.7	181	22.7	181
Chlorine	t	50	50	50	50	50	50
Hydrogen	m ³	12,600	6,800	12,600	6,800	12,600	6,800
Water							
Cooling system	L	4.3×10^7	4.3×10^7	4.51×10^7	4.52×10^7	6.26×10^7	6.26×10^7
Process and other	L	364,000	572,000	360,000	570,000	293,000	498,000
Work force ^b	Workers	1,808	1,463	1,808	1,463	1,519	1,326

^aHEU = highly enriched uranium; tritium mode enrichment: 8-12 wt%; plutonium mode enrichment: 1.7 wt%.

^bOperation at SRS assumes concurrent operation of existing K, L, and P reactors. Waste management workers are included.

Source: Roman 1991.

electricity would be required to operate all NPR facilities. Electricity to operate the Reactor Facility would be supplied by the facility's generator when it is operating or from the Bonneville Power Administration's power supply system when the generator is not operating. Sanitary wastes from the WNP-1 site would be processed by an existing waste treatment system operated by the Washington Public Power Supply System. Sanitary wastes from NPR facilities in the 200-East and 400 areas would be disposed of in septic tanks and drain fields in those areas. Blowdown from the cooling tower would be discharged via the existing WNP-1 discharge structure buried in the bed of the Columbia River, downstream from the existing cooling water intake structures.

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At INEL, all water for operations would be obtained from the Snake River Plain aquifer. The quantities of cooling tower makeup water are estimated on the basis of five cycles of concentration in the cooling tower. Blowdown from the cooling towers would be discharged to one or more evaporation ponds, having a total area of 855 ha; the evaporation pond(s) would be designed to prevent freezing in the winter and would be lined to prevent seepage into the groundwater. About 109 MW of electricity would be required to operate all NPR facilities. At the NPR site, process steam and steam for heating would be produced, using reactor heat supplemented by electric heating during reactor operation and by off-site electric heat alone when the reactor was shut down. Process and heating steam for NPR activities in the Idaho Chemical Processing Plant would be obtained from the plant's existing steam system.

Savannah River Site

At SRS, water for the reactor cooling towers would come from the Savannah River via the existing cooling water system. The quantities of cooling tower makeup water are estimated on the basis of 2.5 cycles of concentration in the cooling towers. Cooling tower blowdown would be mixed with river water to satisfy state of South Carolina discharge temperature requirements. The water in the cooling tower would be chlorinated to control biofouling in the system. Process water and potable water would be obtained from new well fields at the NPR site or from existing wells in the H and F areas. About 108 MW of electricity would be required to operate the NPR facilities at SRS. This EIS assumes that process steam at the NPR site would be provided by an existing steam supply system via an existing steam distribution system. Coal would be used to generate both process and facility heating steam. A Replacement Power Facility has been proposed, and an EIS will be written for that facility; however, insufficient information was available on air emissions to include the facility in the environmental baseline for SRS. Two new water treatment systems would be used at the Reactor Facility; one would treat the potable water from the facility wells, and one would condition service system (river) water. The water would be treated with hypochlorite, and the pH would be adjusted.

3.3.4 Modular High-Temperature Gas-Cooled Reactor Technology Description

Gas-cooled reactors were developed in the 1950s and have been used as commercial power reactors in the United States and Europe. The proposed MHTGR uses graphite as a moderator and helium as a coolant. The MHTGR would consist of six or eight reactors in two sets of three or four units each.

The following sections identify MHTGR facility requirements for eight modules and discuss construction, operation, and waste management for the MHTGR at the three alternative sites. Discussion of how a six-module MHTGR would differ is presented in Section 3.3.5.7 and Appendix R. Figures 3.3-15, 3.3-16, and 3.3-17 illustrate the facility requirements for the MHTGR at each alternative site. The figures show both new (unshaded) and existing (shaded) facilities; activities outside the boxes would occur off-site.

Expanded descriptions of the fuel cycle, target cycle, and methods and techniques of operation are presented in Appendix C. The primary sources of information for the MHTGR technology and its adaptation to the alternative sites are EG&G-2 [with Errata (EG&G-5)], WHC-6, WHC-7, WSRC-6, and WSRC-14; other sources are cited as appropriate.

3.3.4.1 Reactor Facility

Figure 3.3-18 is a plan view of the conceptual design of an MHTGR complex. The complex would contain an eight-module Reactor Facility (two nuclear islands of four modules each), a Tritium-Target Fabrication Facility, a Plutonium-Target Fabrication Facility, a Fuel Fabrication Facility, and a Tritium-Target Processing Facility. This plan would generally apply to the adaptation of the MHTGR technology at each of the three alternative sites. Although no Fuel Processing Facility or Plutonium-Target Processing Facility is shown in the complex, these facilities would also be used, but they would not be located at the complex.

The MHTGR, which uses helium gas as the primary coolant, would operate at sufficiently high temperature (helium gas exit temperature of 686°C) to produce superheated steam to generate electricity. Consequently, the complex includes an Energy Conversion Area that would contain steam-driven turbine generators to produce electricity, and two cooling towers to dissipate waste heat to the environment. The eight reactors would produce about 2,800 MWt of thermal power that could be used to produce about 1,100 MW of electricity. If electricity were not generated, the steam would move through pressure-reducing equipment directly to an air-blast heat exchanger, bypassing the turbine generator and its condenser, and would serve as an alternate method of cooling the reactor.

The complex would occupy about 130 ha of land; approximately 52 ha would be enclosed by a security fence encompassing the reactors and other associated buildings. The turbine buildings, cooling towers, and associated electricity production equipment would be outside the security fence because the Energy Conversion Area would not be used in isotope production.

The Reactor Facility would need about 80 MWe of power to operate. The power would be supplied either from the Energy Conversion Area or purchased from an off-site supplier. Four 2,500-kW diesel generators (or gas turbine generators) would provide emergency power in case of loss of off-site power. Each emergency power unit would run for 2 hours per month to verify availability and operability. The Reactor Facility would contain fuel and target handling facilities. In these facilities, tritium or plutonium targets would be inserted into fuel blocks before the blocks were inserted into the reactor. The reactors and all safety-related equipment and structures of the Reactor Facility would be sited and designed in accordance with DOE Order 5480.6, *Safety of DOE-Owned Nuclear Reactors*, and would meet or exceed current standards applied to a commercial nuclear power plant, whichever is the more stringent requirement (Section A.1.2).

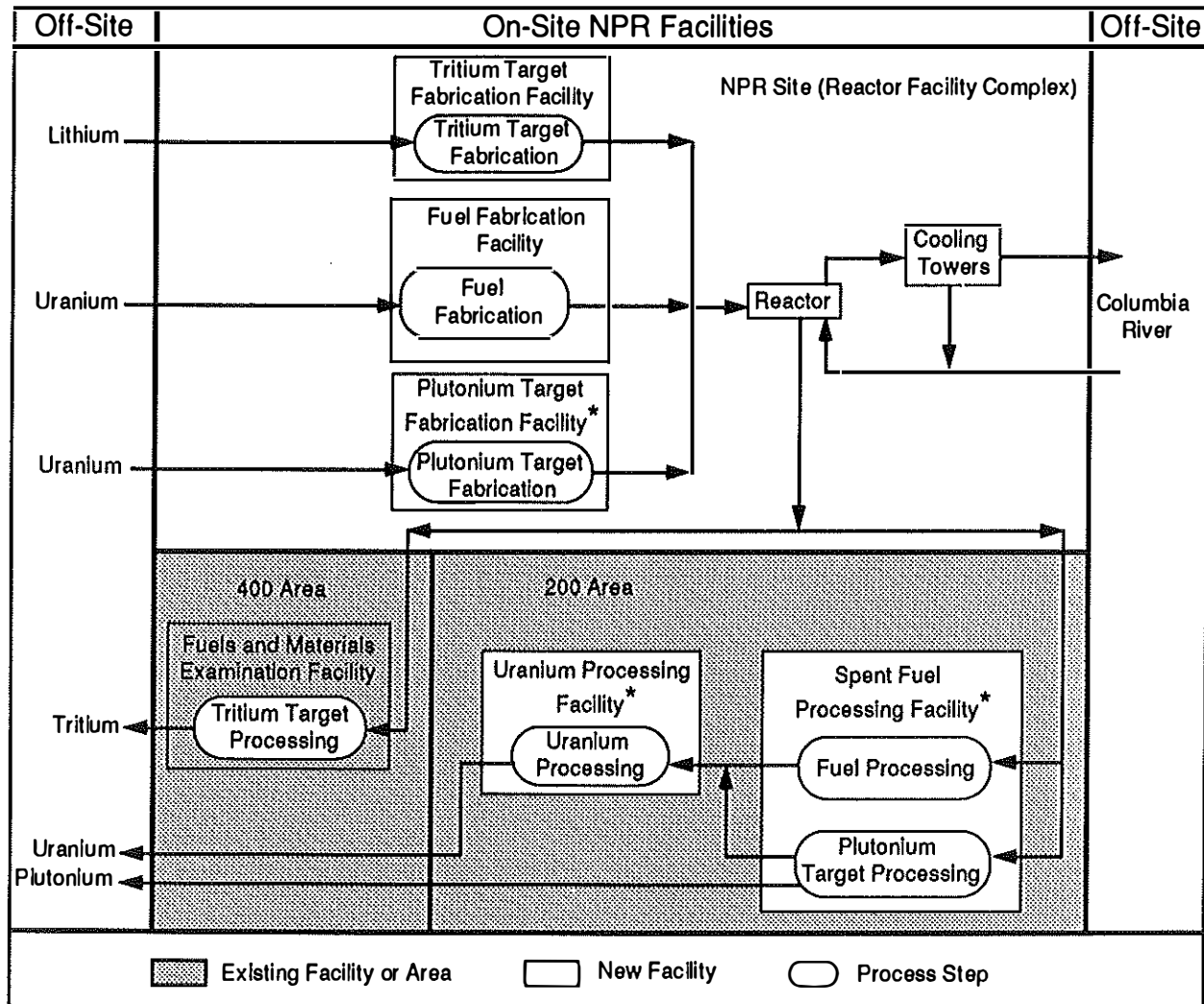


FIGURE 3.3-15 Facility Requirements for the MHTGR at Hanford (* indicates a facility used only for plutonium production or spent fuel processing)

At Hanford, the new MHTGR complex (Figure 3.3-18), less the Tritium-Target Processing Facility, would be located on the NPR site. The Tritium-Target Processing Facility would be installed in the existing Fuels and Materials Examination Facility in the 400 Area. New cooling water makeup and discharge lines would be required between the cooling towers and the Columbia River. New intake and discharge structures would be required in the Columbia River, and a new pumphouse would be built on or near the shoreline.

At INEL, the MHTGR complex (Figure 3.3-18) would be constructed on the NPR site. Cooling water makeup would be from on-site wells, and discharge would be to one or more evaporation ponds, having a total area of about 673 ha.

At SRS, the MHTGR complex (Figure 3.3-18) would be constructed on the NPR site. Tritium targets would be processed in the planned Replacement Extraction and Purification

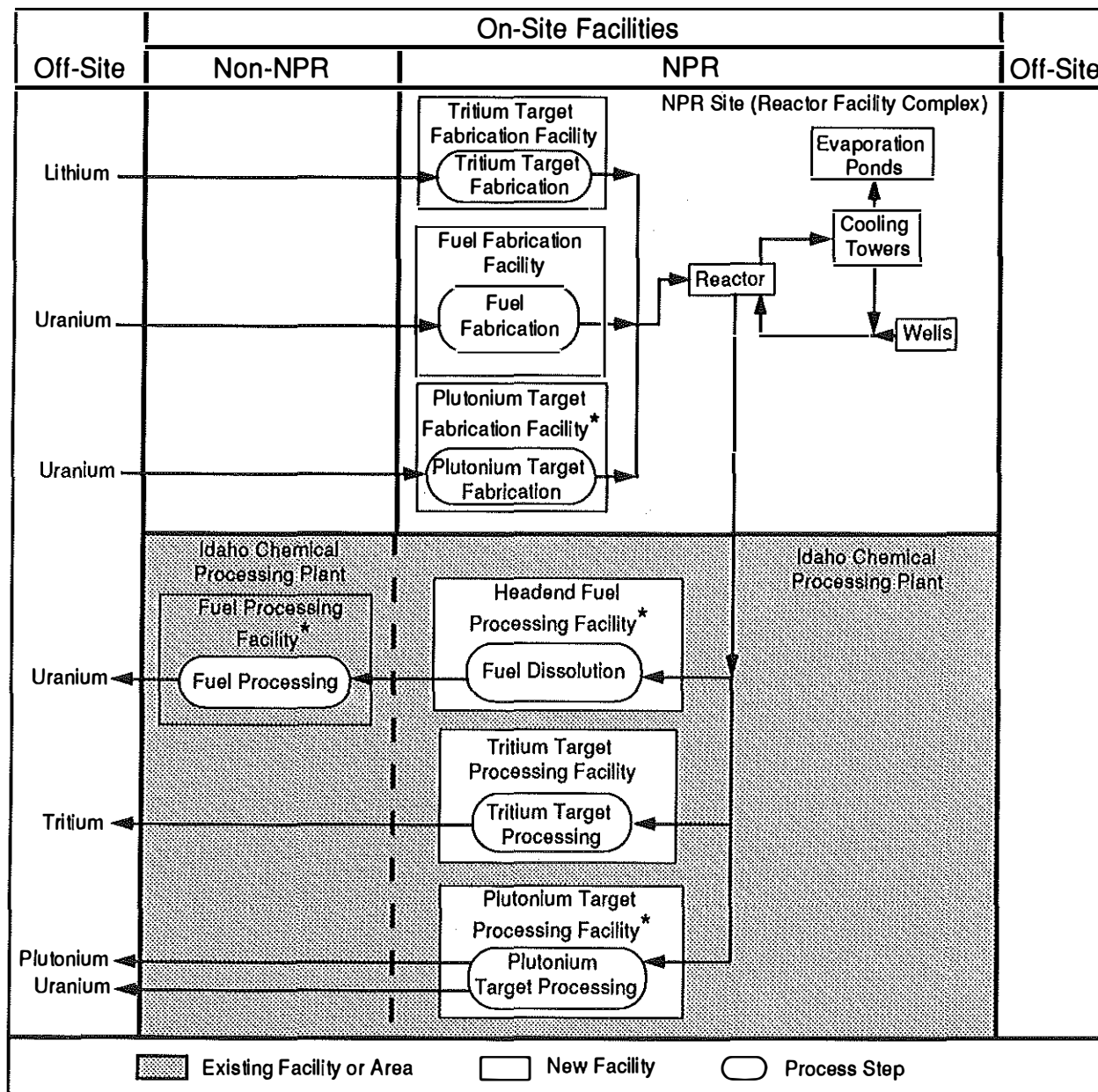


FIGURE 3.3-16 Facility Requirements for the MHTGR at INEL (* indicates a facility used only for plutonium production or spent fuel processing)

Facility in the H Area (not an NPR facility). A new headend facility would be required to prepare tritium targets for processing. Cooling water makeup would come from the existing cooling water system and would be discharged to Fourmile Branch, an on-site tributary of the Savannah River.

3.3.4.2 Tritium-Target and Fuel Fabrication Facilities

The Tritium-Target Fabrication Facility would be located at the production complex inside the security enclosure (Figure 3.3-18) and would be designed to Uniform Building Code

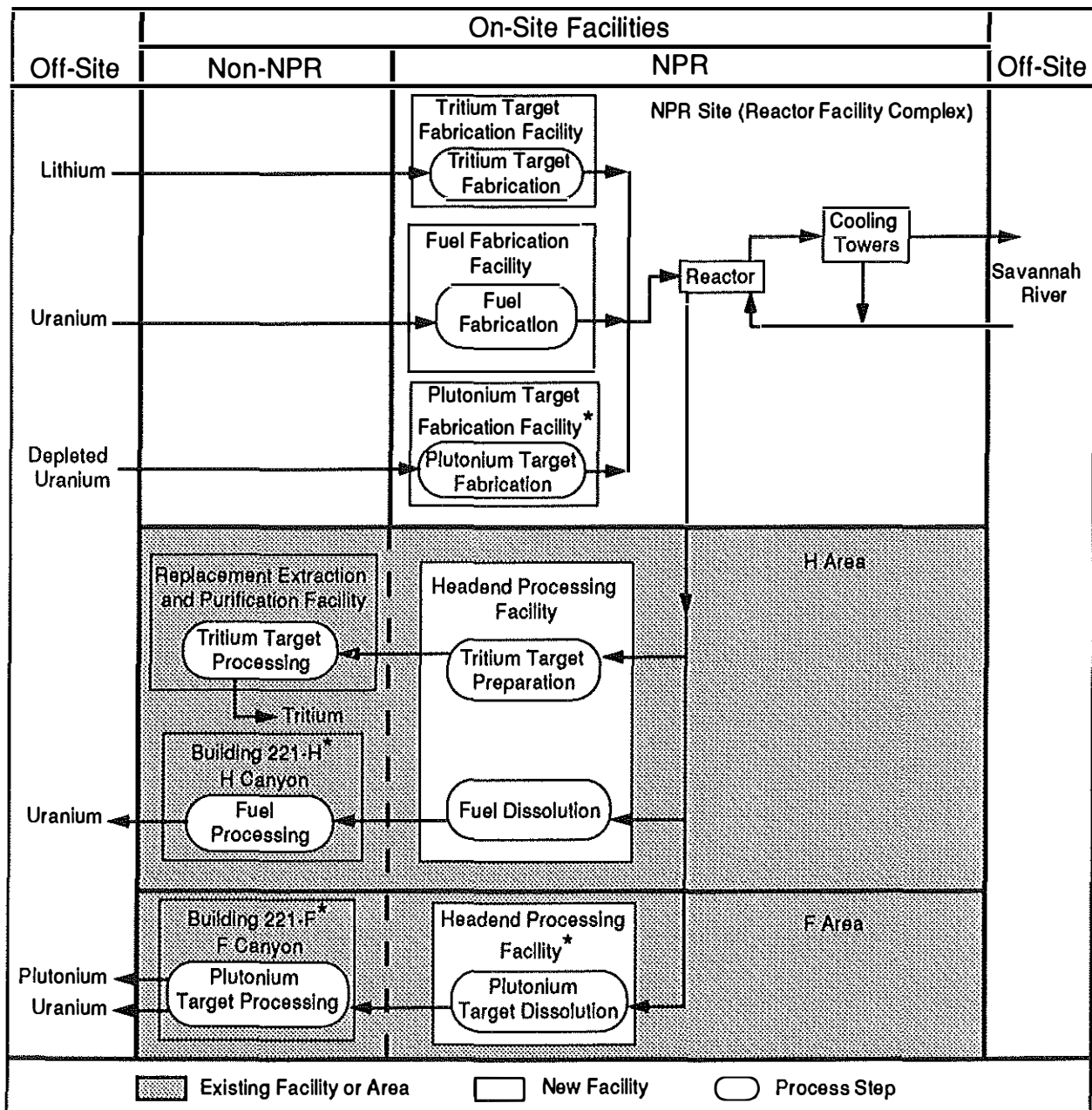


FIGURE 3.3-17 Facility Requirements for the MHTGR at SRS (* indicates a facility used only for plutonium production or spent fuel processing)

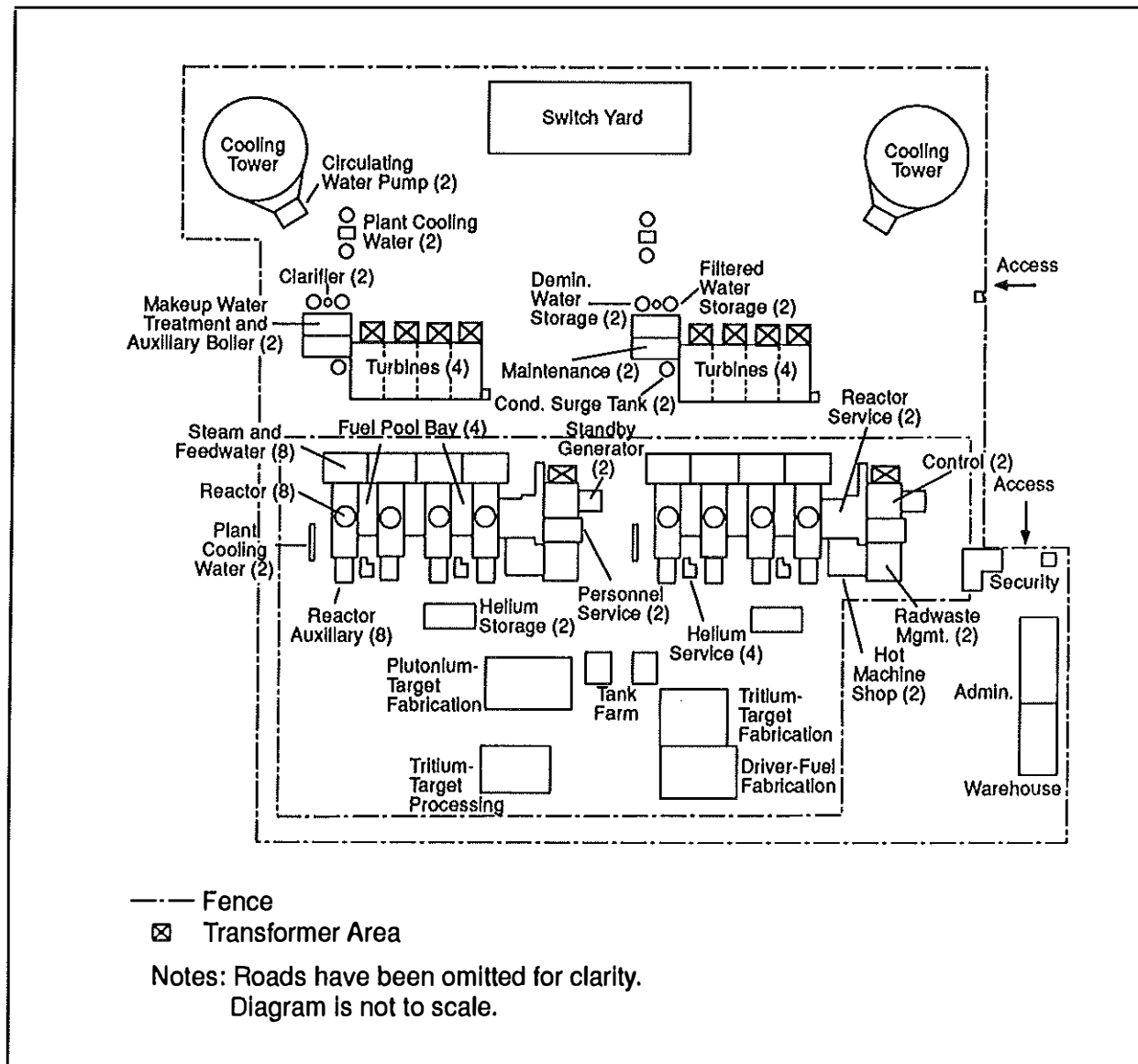


FIGURE 3.3-18 Plan View of an Eight-Unit MHTGR Complex (Hanford Adaptation) (Source: Modified from WHC-7)

standards for industrial buildings. It would be used to fabricate tritium-target elements containing carbon-shelled microspheres with centers of enriched (lithium-6) lithium aluminate. The target elements would be transferred to underground fuel handling systems in the Reactor Facility.

The Fuel Fabrication Facility would also be located at the production complex inside the security enclosure (Figure 3.3-18) and would be designed to DOE Nonreactor Safety Class 1 criteria. It would be used to produce graphite fuel blocks containing fuel elements of enriched (93 wt% uranium-235) uranium-oxycarbide-centered microspheres. The fuel blocks would also be transferred to the fuel handling systems in the Reactor Facility. The fuel handling systems

would be used to install the tritium targets (or plutonium targets) into fuel blocks before irradiation.

3.3.4.3 Fuel/Plutonium-239 Target Fabrication Facility

The Plutonium-Target Fabrication Facility would be located at the production complex inside the security enclosure (Figure 3.3-18) and would be designed to DOE Nonreactor Safety Class 1 criteria. For criticality safety, the facility would be physically separated from the Fuel Fabrication Facility. Plutonium-239 targets would be produced in the Plutonium-Target Fabrication Facility. The design of the plutonium targets is proprietary, but they would contain depleted (0.2% uranium-235) uranium-dioxide-centered microspheres. After fabrication, the target elements would be transferred to the fuel handling systems in the Reactor Facility, where they would be inserted into fuel blocks for irradiation during the plutonium production mode.

3.3.4.4 Tritium-Target Processing Facility

The Tritium-Target Processing Facility would receive irradiated tritium targets after a minimum of 1-month storage in the reactor service building. Tritium would be extracted by mechanical and thermal processes and purified by mechanical and chemical processes. Tritium produced at either Hanford or INEL would be packaged for shipment to SRS. Tritium produced at SRS would be transferred to a non-NPR facility.

At Hanford, the Tritium-Target Processing Facility would be a new facility, but it would be installed in the existing Fuels and Materials Examination Facility, which was designed to meet or exceed DOE Nonreactor Safety Class 1 criteria. At INEL, the Tritium-Target Processing Facility would be housed in a new two-story structure inside the security enclosure (Figure 3.3-18) and would be designed to DOE Nonreactor Safety Class 1 criteria. At SRS, tritium targets would be processed in the Replacement Extraction and Purification Facility currently planned for construction as part of the existing SRS production program. A new headend facility would be required to prepare tritium targets for processing. This facility will also be designed to meet DOE Nonreactor Safety Class 1 criteria.

3.3.4.5 Fuel Processing Facility

The fuel blocks would be either reloaded with new targets and recycled to the reactor or, if the fuel blocks have ended their useful life, would be placed in water-cooled, helium-filled storage wells (located below grade in the reactor service building) for about 4 months to allow decay heat generation to subside. Then the fuel blocks would be stored for an additional 8 months or more to allow decay of short-lived radioisotopes.

After storage, the graphite blocks containing the spent fuel would be transferred to a spent fuel processing facility, where the fuel elements would be removed from the graphite blocks for processing. Various mechanical, thermal, and chemical extraction and separation processes would be used in processing the spent fuel to a low-radioactivity uranyl nitrate solution. The uranyl nitrate solution would be further processed to uranium oxide. All wastes would be either treated for disposal or pretreated for transfer to on-site waste management

systems. The uranium oxide recovered through spent fuel processing would be recycled to the Fuel Fabrication Facility or shipped off-site for reclamation.

Hanford Site

At Hanford, the new Fuel Processing Facility would be located inside the fenced enclosure of the 200-East Area. About 16 ha of land would be required for the facility, and about 12 ha would be fenced for security. The facility would consist of four buildings, including a fuel processing building, a uranium recovery building, and two administrative and support buildings. Transfers of uranyl nitrate solution to the uranium recovery building, and of waste solutions to the spent fuel processing building, would be made via special radiation-shielded underground transfer lines between the buildings. The fuel processing and uranium recovery buildings would be designed to DOE Nonreactor Safety Class 1 criteria. The administration and support buildings would be built to Uniform Building Code standards for industrial buildings. The Spent Fuel Processing Facility would be a remotely operated, remotely maintained building, and its inner core, which would contain all the radioactive equipment and processes, would be entirely below grade. The uranium recovery building would be a remotely operated, contact-maintained facility.

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At INEL, a new Headend Fuel Processing Facility, designed to DOE Nonreactor Safety Class 1 criteria, would be constructed. This facility would be used for the initial processing steps. Uranyl nitrate solution from the headend facility would be transferred via underground transfer lines to the Fuel Processing Facility at the Idaho Chemical Processing Plant (currently under construction), where it would be processed to uranium oxide and wastes. The processes involving high-level radioactivity would take place in shielded cells below grade.

Savannah River Site

At SRS, a new Headend Fuel Processing Facility, designed to DOE Nonreactor Safety Class 1 criteria, would be constructed. The facility would be used for the initial processing steps. The headend facility would be located adjacent to the existing Building 221-H Fuel Processing Facility, so that the uranyl nitrate produced by headend processing could be transferred to Building 221-H to finish processing. Building 221-H has sufficient capacity to process the additional spent fuel produced by the NPR. The processes involving high-level radioactivity would take place in shielded cells below grade.

3.3.4.6 Plutonium-239 Target Processing Facility

After 1 year of storage at the Reactor Facility, plutonium-239 targets would be transferred to the Plutonium-Target Processing Facility. Various mechanical, thermal, and chemical extraction and separation methods would be used to process the intermediate products to low-radioactivity nitrate solutions of uranium and plutonium. The plutonium nitrate solutions would be further processed to metallic plutonium for shipment to the Rocky Flats Plant or another appropriate facility. The uranyl nitrate solution would be further processed to uranium

oxide for return to the Plutonium-Target Fabrication Facility for recycle. The wastes would be either treated for disposal or pretreated for transfer to on-site waste management systems.

Hanford Site

At Hanford, plutonium targets would be processed in the new Fuel Processing Facility in the 200-East Area. Significant additions of equipment would be required to safely and efficiently handle the plutonium and depleted uranium and to accommodate the larger material throughputs associated with plutonium processing. Consequently, the new Fuel Processing Facility at Hanford would be designed to accommodate either fuel processing or plutonium-target processing.

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At INEL, plutonium targets would be processed in a new Plutonium-Target Processing Facility at the Idaho Chemical Processing Plant. The facility would use a design similar to the design of the four-building Hanford Fuel Processing Facility (Section 3.3.4.5). The INEL facility would also be designed to DOE Nonreactor Safety Class 1 criteria, and the processes involving high-level radioactivity would be performed in shielded, below-grade cells.

Savannah River Site

At SRS, the plutonium targets would be transferred to a new Headend Plutonium-Target Processing Facility constructed adjacent to the Building 221-F processing facility. The nitrate solutions produced in the headend facility would be transferred to Building 221-F for production of the final products. Building 221-F has sufficient capacity to process the additional targets produced by the NPR. The new Headend Plutonium-Target Processing Facility at SRS would be designed to DOE Nonreactor Safety Class 1 criteria, and the processes involving high-level radioactivity would be performed in shielded, below-grade cells.

3.3.4.7 Construction Activities

New facilities would be designed for a 40-year **minimum** service lifetime. The major resource requirements for MHTGR construction are listed in Table 3.3-5, along with the peak work force requirements.

Hanford Site

In addition to the new facilities identified in Figure 3.3-15, the MHTGR at Hanford would require construction of water intake structures and a water discharge structure in the bed of the Columbia River, a water intake pumphouse on or near the shoreline of the river, underground makeup and discharge pipelines between the river and the cooling towers, two power lines between the Energy Conversion Area and the H.J. Ashe Substation, a railroad spur, and primary and secondary roads to the NPR complex (Figure 3.3-6). Drain tile septic systems would be constructed for each facility on the NPR site. Temporary operation of a concrete batch

TABLE 3.3-5 Resource Requirements for Construction of an MHTGR

Resource	Unit	Hanford	INEL	SRS
Electric energy	10 ³ MWh	175	175	170
Fuel	10 ⁶ L	27	49	28
Concrete	10 ³ m ³	620	600	520
Carbon steel	10 ³ t	124	120	114
Stainless steel	10 ³ t	10	10	8
Chemicals	10 ⁶ L	1.2	1.3	1.2
Land disturbance	ha	463	1,203 ^a	251
Total effort	worker-yr	13,100	10,770	10,300
Peak work force	workers	2,000	1,100	900
Construction duration	years	10	10	10
Construction period	-	1992-2002 ^b	1992-2002 ^b	1992-2002 ^b

^aIncludes one or more evaporation ponds (673 ha total area).

^bFirst module complete in 1999, last module in 2003.

plant and on-site sand and gravel pits would also be needed as a result of construction activities. Construction water for the NPR site would be either supplied from new wells at the NPR site or piped from the 200-Area service water system. Water for construction in the 200 Area would be obtained from the 200-Area service water system. Water for construction of the Tritium-Target Processing Facility in the Fuels and Materials Examination Facility would be obtained from the 400-Area service water system.

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In addition to the new facilities identified in Figure 3.3-16, construction of the MHTGR at INEL would require one or more evaporation ponds, having a total area of 673 ha, and a discharge pipeline between the cooling towers and the pond(s), a power line between the Reactor Facility and the Antelope Substation and a power line between the Reactor Facility and Scoville Substation, a railroad spur, and a primary and a secondary road to the NPR site (Figure 3.3-7). Drain tile septic systems would be constructed for each facility on the NPR site. Temporary operation of on-site concrete batch plants and sand and gravel pits would be needed to support construction activities. Water for construction at the NPR site would be supplied from new wells into the Snake River Plain aquifer. Water for construction of the facilities in the Idaho Chemical Processing Plant complex would be obtained from the existing service water system in that area. Because dry cooling towers are being considered as an alternative, pond design is not well advanced and resources for pond construction are not included in Table 3.3-5.

Savannah River Site

In addition to the new facilities identified in Figure 3.3-17, the MHTGR at SRS would require construction of a cooling tower makeup pipeline between the existing SRS cooling water system and the cooling towers, a blowdown discharge line from the cooling towers to Fourmile

Branch, redundant power lines between the Reactor Facility and the 504-2G and 504-3G substations, a railroad spur, and primary and secondary roads to the NPR site (Figure 3.3-8). Temporary operation of an on-site concrete batch plant and sand and gravel pits would also be needed as a result of construction activities. Besides excavation of dirt and rock, Reactor Facility construction would involve extensive site dewatering activities because of the deep foundations of the reactor silos and the high water table at SRS. The water would be pumped to a settling basin before discharge to a local stream. The water would be monitored and, if necessary, treated before discharge. Sediments collected in the pond would be removed periodically for disposal at existing SRS landfills. A sanitary waste treatment plant designed to accommodate a population sufficient to operate the facilities at the NPR site would be constructed as part of the Reactor Facility. Construction water would be supplied from wells drilled to lower Cretaceous sands beneath the NPR site.

3.3.4.8 Operation Activities

Batch-mode operation would be used for both tritium and plutonium production. The number of fuel and target batches irradiated would be about two per year for the tritium production mode and about four per year for the plutonium production mode.

The estimated annual requirements of energy, materials, and work force for operation of the MHTGR at the three alternative sites are presented in Table 3.3-6. Resources are estimated on the basis of facility operations in support of eight MHTGRs operating at 350-MWt nominal reactor power (2,800 MWt total).

The electric load of the Reactor Facility would be about 80 MWe. The power would be supplied either from the Energy Conversion Area or by purchased power. Four 2,500-kW diesel generators (or gas turbine generators) would provide for emergency power in case of loss of off-site power.

Hanford Site

At Hanford, the water for the secondary cooling system would come from the Columbia River. Cooling tower makeup flow requirements are estimated on the basis of five cycles of concentration in the cooling towers. The cooling tower water would be chlorinated to control biofouling in the system. Potable water for the NPR site would be obtained from well fields near the facilities, but Columbia River water could also be used. Process water would be obtained from the Columbia River. Process and potable water requirements for the 400 Area and 200-East Area facilities would be obtained from the existing water supplies in those areas. Sanitary wastes from those facilities, like those at the NPR site, would be disposed of via septic tanks and drain fields constructed at the respective locations.

About 89 MW and 93 MW of electricity would be required to operate the NPR facilities at Hanford in the tritium and plutonium production modes, respectively. Electricity to the NPR site would be supplied from the Bonneville Power Administration transmission grid via the H.J. Ashe Substation. Process steam and steam for heating the facilities on the NPR site would be produced using reactor heat supplemented by electric heating during reactor operation and

TABLE 3.3-6 Estimated Annual Commodity Requirements for Operation of the MHTGR Complex

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Energy							
Electric	MWh	600,000	600,000	600,000	600,000	600,000	600,000
Fuel (diesel, gasoline, kerosene)	L	231,000	394,000	200,000	200,000	291,000	382,000
Steam	kg	1.17×10^7	1.23×10^8	5.00×10^6	3.49×10^8	5.00×10^6	3.50×10^8
Steam, coal	t	530	3,530	Electric	Electric	14,400	48,500
Materials							
Metals							
HEU ^a as U ₃ O ₈ (93.1% U-235)	t	2.17	2.27	2.17	2.27	2.17	2.27
DU ^b as U ₃ O ₈ (0.2% U-235)	t	0	720	0	720	0	720
Lithium nitrate (Li-6 enriched)	t	3.40	0	3.40	0	3.40	0
Aluminum oxide	t	5	0	5	0	5	0
Carbon power	t	0.40	104	0.40	104	0.40	104
Graphite blocks	t	176	264	176	264	176	264
Graphite canisters	t	116	0	116	0	116	0
Graphite granules	t	32.50	3.50	32.50	3.50	32.50	3.50
Chemicals/cleaners/dissolvers							
Attapulgite clay	t	10	0	10	0	10	0
Asphalt	t	10	0	10	0	10	0
Betz 2020	L	375,000	375,000	375,000	375,000	375,000	375,000
Betz 2040	t	680	680	680	680	680	680
Betz 3612	L	17,000	17,000	17,000	17,000	17,000	17,000
Betz C-77-P	t	3.86	3.86	3.86	3.86	3.86	3.86
Calcium hydroxide	t	320	2,470	320	2,470	320	2,470
Calcium oxide	t	104	212	106	212	113	212
Decontamination solutions	L	74,500	174,000	78,100	178,000	73,700	174,000

TABLE 3.3-6 (Cont'd)

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Chemicals/cleaners/ dissolvers (cont'd)							
Methyl chloroform (CH ₃ CCl ₃)	t	0.70	191	0.70	186	0.70	186
Methyltrichlorosilane	t	1.80	472	1.80	472	1.80	472
Sodium carbonate	t	1.10	19.3	15	11.5	2	17
Nitric acid, fresh	L	83,100	1.75 × 10 ⁶	85,000	1.31 × 10 ⁶	83,095	1.75 × 10 ⁶
Sodium hydroxide	L	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷
Sulfuric acid (for pH control)	L	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷
Gases							
Acetylene	m ³	65,600	2.31 × 10 ⁶	79,800	2.31 × 10 ⁶	66,000	2.31 × 10 ⁶
Ammonia	m ³	445	5,620	445	5,620	420	5,620
Water							
Cooling system	L	4.3 × 10 ⁷	4.3 × 10 ⁷	4.26 × 10 ⁷	4.26 × 10 ⁷	5.53 × 10 ⁷	5.53 × 10 ⁷
Process and other	L	1.29 × 10 ⁶	1.54 × 10 ⁶	1.83 × 10 ⁶	1.98 × 10 ⁶	4.02 × 10 ⁶	3.32 × 10 ⁶
Work force ^c	Workers	1,389	1,675	1,210	2,084	1,071	1,201

^aHEU = highly enriched uranium.

^bDU = depleted uranium.

^cOperation of an MHTGR at SRS assumes concurrent operation of existing K, L, and P reactors. Waste management workers are included.

Source: Roman 1991.

by electric heat alone when the reactor was shut down. The process and heating steam for NPR facilities in the 200-East Area would be obtained from the existing 200-Area coal-fired steam supply system. The process and heating steam requirements at the Fuels and Materials Examination Facility (in the 400 Area) would be supplied from a packaged electric boiler in the 400 Area.

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At INEL, water for all operations would be obtained from the Snake River Plain aquifer. The quantities of cooling tower makeup water are estimated on the basis of five cycles of concentration in the cooling tower. Blowdown from the cooling towers would be discharged to one or more evaporation ponds (673 ha total area); the pond(s) would be designed to prevent freezing in the winter and would be lined to reduce seepage into the groundwater table.

About 87 MW and 90 MW of electricity would be required to operate the NPR facilities at INEL in the tritium and plutonium production modes, respectively. At the NPR site, process steam and steam for heating would be produced using reactor heat supplemented by electric heating during reactor operation and by electric heat alone when the reactor was shut down. Process and heating steam for NPR activities in the Idaho Chemical Processing Plant would be obtained from the existing steam system in the plant.

Savannah River Site

At SRS, water for the secondary cooling system would come from the Savannah River via the existing cooling water system. Cooling water makeup requirements are estimated on the basis of 2.5 cycles of concentration in the cooling towers. Blowdown would be mixed with river water to reduce temperature differentials at the point of discharge. The water in the cooling tower would be chlorinated to control biofouling in the system. Process water and potable water would be obtained from well fields at the NPR site or from existing wells. Two new water treatment systems would be used at the Reactor Facility; one system would treat the potable water from facility wells, and one system would condition cooling system (river) water. The water would be treated with hypochlorite, and the pH would be adjusted. Process steam and heating steam would be provided from existing SRS powerhouses via an extension to the existing SRS steam distribution system. Coal would be used to generate both process and heating steam.

About 87 MW and 90 MW of electricity would be required to operate the NPR facilities at SRS in the tritium and plutonium production modes, respectively. Sanitary wastes from the facilities at the NPR site would be processed by the new sanitary waste treatment plant constructed at the Reactor Facility. Sanitary wastes at the facilities in the H and F areas would be processed by the existing sanitary waste treatment plants in those areas.

3.3.5 Optional Components of Alternative Technologies

This section identifies the environmental consequences of several potential options to NPR technologies. These issues result from reasonably foreseeable future activities. Some of these options will be subject to other ongoing NEPA reviews (such as the Reconfiguration PEIS

and the Waste Management PEIS) and other reviews conducted as part of NPR conceptual design, or to future decisions related to the NPR project. For those options not covered by the Reconfiguration PEIS or the Waste Management PEIS, separate NEPA reviews may be required to proceed with the options. A brief assessment of the optional components of NPR technologies is included in this EIS to assist any decisions regarding NPR alternative sites and alternative technologies.

3.3.5.1 Sale of Steam for Power Production

Two of the three alternative reactors, the LWR and the MHTGR, operate at temperatures high enough to support production of electricity. Heat transferred to the secondary cooling system could be used to generate steam that would drive turbine generator units. The LWR and MHTGR, as described in the EIS, include energy conversion facilities. Thus, this EIS includes the consequences of the production of electricity. Impacts to air, water, land, and human resources from energy production are bounded by the analyses of consequences in Section 5; however, distribution and transmission of generated power by the NPR are not assessed in Section 5. Because sale of steam for generation of electricity is a reasonable future option if the LWR or MHTGR were constructed, the potential impacts of that option are discussed briefly here. However, a separate NEPA review may be required to support a decision to sell steam for power production.

Construction of an electric distribution or transmission line could result in significant visual impacts if the line were incompatible with the surrounding visual environment, or if the line were constructed in an area that did not have any other obvious structures. Construction of an electric distribution or transmission line would also disturb terrestrial habitats. For example, any crossed wetlands or riparian areas might be disturbed by activities to clear vegetation, place transmission towers, construct maintenance road access, and string cables. With time, disturbed areas in the rights-of-way would undergo natural succession, with only occasional disturbances by maintenance traffic. In humid climates, vegetation growth in the rights-of-way would be controlled periodically by mowing, clearing, or herbicide treatment to permit access and to prevent interference with the lines.

Birds could also be affected by transmission lines. At times, birds collide with lines or transmission towers, usually resulting in the bird's death (Avery, Springer, and Dailey 1978). The most frequent victims of such collisions are large migratory water birds (Thompson 1978) and raptors. Although line collisions generally contribute only a small percentage to overall bird mortality (approximately 0.01% [Thompson 1978]), placement of lines in areas where birds congregate (e.g., roosting areas, lakes, wetlands) could increase the significance of impact. Raptors are often attracted to power lines, particularly in open areas, and may find supporting structures suitable for nesting and roosting.

Transmission lines produce a corona, which is a physical manifestation of energy loss. This phenomenon results in audible noise, radio and television interference, and the production of ozone in the immediate area of the lines. Typically, transmission lines are designed to be free of corona and all other sources of energy loss to the extent possible. As a consequence and because of the remoteness of the installation, these impacts would not be significant. Like electric equipment and household appliances, transmission lines also produce electric and magnetic fields. An assessment of the environmental consequences of electric fields from a 230-kV, double-circuit line was conducted (DOE-65). The assessment determined that crops,

gardens, and natural vegetation beneath the transmission lines would not be affected adversely. Livestock behavior might be affected in the rights-of-way, but these impacts could be avoided by fencing if necessary. An assessment of the environmental consequences of magnetic fields on human health concluded that the "overwhelming weight of scientific evidence available to date indicates that exposure to electric and magnetic fields, be they from power lines or other sources, do not constitute a risk to health" (DOE-65). This conclusion was based on comments by six panels of experts who reviewed the scientific literature on the biological effects of electric and magnetic fields (Florida 1985; World Health Organization [WHO] 1984; WHO 1987; National Academy of Sciences 1977; American Institute of Biological Sciences 1985; New York State Power Lines Project 1987).

There have also been several epidemiological studies that have linked magnetic fields to cancer (usually leukemia, lymphomas, and nervous system cancers). However, electricity usage has doubled a number of times in the past 40 years, while there has been no corresponding increase in childhood leukemia. Also, without clear laboratory evidence that magnetic fields cause or promote cancer, the results of the epidemiological studies completed to date remain ambiguous (Pool 1990). There are design modifications that can be incorporated into new transmission lines that could reduce magnetic fields. Nevertheless, transmission lines do not contribute substantially to an individual's overall exposure, since few people live close to them (Moore 1990). The distribution lines near homes and indoor appliances and wiring are of more concern as they contribute more substantially to an individual's overall exposure to magnetic fields.

3.3.5.2 Cooling Tower Operations at INEL

The consequences analysis in this EIS suggests that, as a mitigative measure, optional cooling tower concepts be adopted at INEL to eliminate the requirement for a large area of blowdown evaporation ponds.

The system proposed for the reactor cooling system at INEL would require wildlife exclusion. Up to 855 ha of habitat would be occupied by one or more evaporation ponds used for cooling tower blowdown. In an arid environment, such as INEL, these ponds would attract wildlife, including waterbirds, elk, deer, raptors, and bats. Patterns of habitat use, population biology, and migration might be significantly affected by the evaporation ponds. In addition, animals drinking or feeding from the ponds would be exposed to any contaminants present in the blowdown or bioaccumulated by aquatic organisms colonizing the ponds; levels of tritium in the ponds could be slightly above the drinking water standard. Also, several potential users of the ponds are species classed as special status. Exclusion of wildlife would require that the ponds be both fenced and netted. However, netting such a large area would be difficult to achieve, and the netting might be hazardous to birds or bats attracted to the ponds.

The INEL has studied the feasibility of alternative cooling system concepts that would eliminate the need for large blowdown evaporation ponds (Section 3.6.2). A dry cooling tower system that uses air-cooled heat exchangers would eliminate secondary system blowdown effluent because this system is not based on evaporation. Studies under way indicate that the dry cooling tower system may be preferable to the referenced wet-cooling tower system because the large evaporative ponds (670-855 ha) can be eliminated, resulting in improved environmental impacts, lower construction costs, and lower operating costs. A dry cooling tower system is feasible for the MHTGR and LWR concepts.

Alternative blowdown effluent reduction systems under investigation include mechanical evaporative units, powered by steam or electricity, and reverse osmosis technology. These control technologies could be used for any of the three reactor concepts, but primarily for the HWR concept. The mechanical evaporative system would result in some solids discharge (approximately 20,000 t/yr), which would be disposed per state environmental requirements. In addition, since wet-cooling towers would still be employed, water vapor plumes and possible fogging and icing could still occur. Both the HWR and LWR concepts would remove water from blowdown, but the cooling towers would still release moisture to the atmosphere. Thus, while the blowdown evaporation ponds would be eliminated, the cooling towers would still produce plumes and contribute to local fogging and icing. In addition, a disposal area would be required for the solids produced by the evaporators or reverse osmosis system.

3.3.5.3 Transportation of Large Components at SRS

The consequences analysis in this EIS includes the shipment of the reactor by barge to Hanford and by road to INEL and SRS. However, transportation of the reactor vessel by barge to SRS may also be feasible.

In the past, bulky, heavy items were shipped from the city of Savannah on the Savannah River to the vicinity of Augusta, Georgia; however, in the late 1970s, commercial shipments declined. In 1977, the Corps of Engineers began a 5-year program to restore and maintain a 3-m channel. This program did not result in increased commercial traffic on the river, so the shipping channel has not been maintained. Additional study would be needed to determine whether transporting reactor components via barge would be feasible by 1995, and if so, what restoration or modifications would be necessary. Because of the generic nature of the NPR project design, the facility designs have not been completed and transportation requirements have not been examined in detail. If studies are completed and indicate that the NPR components should be delivered by barge, a separate NEPA review may be required.

3.3.5.4 Production Modes

While the purpose of the NPR is to produce tritium, it would also be capable of, and is also being designed to, produce weapons-grade plutonium. At a minimum, tritium production would require a Fuel-Fabrication Facility, a Tritium-Target Fabrication Facility, a Reactor Facility, and a Tritium-Target Processing Facility. The tritium production mode would also include a Fuel Processing Facility if uranium were to be recovered for recycle. Dual production capability, for both tritium and weapons-grade plutonium, would require additional facilities for fuel/plutonium-target fabrication and plutonium-target processing. Facilities for both tritium and weapons-grade plutonium are described in this EIS.

The following discussion identifies the differences in consequences between an NPR capable of producing both tritium and weapons-grade plutonium and an NPR producing only tritium. Spent fuel processing is assumed for both cases. A tritium-only NPR would not require facilities for plutonium-target fabrication at Hanford, plutonium-target fabrication or plutonium-target processing at INEL, or headend processing or uranium reduction in the F Area at SRS (Figures 3.3-2, 3.3-3, 3.3-4, 3.3-10, 3.3-11, 3.3-12, 3.3-15, 3.3-16, and 3.3-17).

A tritium-only NPR and a combined tritium and plutonium production NPR would have similar impacts to air quality; cooling towers and noise sources; water resources; land use, recreational, and visual environment; biotic resources; cultural resources; socioeconomic resources; and nonradiological transportation. The impacts in these areas primarily result from construction activities at the NPR site and from Reactor Facility operations. Because fuel/plutonium-target fabrication and processing facilities would be located at an existing complex or facility (Hanford, SRS, INEL, fuel processing) or would be a small part of activities at the NPR site (INEL, plutonium-target fabrication), the incremental impacts would be insignificant compared with the impacts from the entire NPR complex. Small differences in water use, emissions of air pollutants, and number of workers would not change the impact conclusions presented in Section 5. Targets and fuels used for plutonium production would be processed in existing facilities or in modifications of existing facilities at all sites, and do not contribute significantly to the impacts analyzed.

The difference in radiological consequences from normal operations is very small for tritium production as compared to plutonium production at Hanford (Table 5.2.6-1), INEL (Table 5.3.6-1), or SRS (Table 5.4.6-1). In-plant worker exposure is greater for the plutonium production mode by a factor of up to three (for example, 130 person-rem compared with 360 person-rem for the MHTGR at Hanford). Differences in exposure of a hypothetical maximally exposed individual or of the general population within 80 km of an NPR site range from approximately 50% to up to 10 times greater for the tritium production mode.

The consequences of postulated nonsevere accidents at reactors and support facilities are estimated on the basis of both tritium and plutonium production (Avci and Biwer 1991; Kier and Avci 1991). The bounding nonsevere accidents are associated with spent fuel processing, which would occur with either tritium or plutonium production. Plutonium-target processing would either be part of fuel processing or would take place in a similar facility with the potential for similar nonsevere accidents. Therefore, the potential consequences of nonsevere accidents are not dependent on the production mode. The risks from severe reactor accidents would be bound by tritium production (Hong et al. 1991). Frequencies of accidents and release fractions are assumed identical for both tritium and plutonium production, but different core designs and radionuclide inventories would result in greater releases in case of an accident during tritium production. The activities of the radionuclides that would be released to the atmosphere from a severe reactor accident are generally higher for the tritium production mode. Radiological exposures of the public from a severe accident during plutonium production would be less than one-half of those from a severe accident during tritium production (Hong et al. 1991).

Assuming that socioeconomic impacts of the NPR are directly related to the work force, the differences between tritium-only production and combined tritium and plutonium production can be estimated from work force projections. Except for the LWR and HWR at Hanford, larger work forces would be needed for plutonium production, a difference of 66 workers for the HWR at SRS to as many as 774 workers for the LWR at INEL. At Hanford, the work force needed for the LWR and HWR alternatives would be greater for tritium production by 337 and 286 workers, respectively, because of site-specific differences in processes and support facilities.

Waste volumes generated by tritium and plutonium production are similar and do not vary by more than 50%, except for the generation of transuranic (TRU) wastes. Because plutonium is a transuranic isotope, the plutonium production mode could generate as much as ten times more TRU waste than the tritium production mode. Sitewide waste management

facilities are capable of handling the volumes of TRU wastes generated by plutonium production (Sections 5.2.10, 5.3.10, and 5.4.10), but tritium-only production would require significantly less interim on-site storage of TRU wastes until the Waste Isolation Pilot Plant or another appropriate facility becomes available.

3.3.5.5 Spent Fuel Disposition

The NPR could be constructed and operated with or without spent fuel processing. For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel processing is analyzed in this EIS as part of the original mission of NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from spent fuel processed from DOE reactors. Spent fuel could be stored at the site where it is produced, placed in a monitored retrievable storage facility if one is constructed, or placed in existing storage facilities at the DOE sites. There are not expected to be any limitations on storage of fuel, if required, for the life of the reactors at any of the NPR alternative sites. Ultimately, the stored spent fuel would be repackaged into a form acceptable for disposal in a repository.

A tritium-only NPR without spent fuel processing would not require plutonium-target fabrication facilities, plutonium-target processing facilities, or spent fuel processing facilities (including uranium purification facilities). Because these facilities are largely in existing industrial areas, the impacts from construction and operations would be as stated in Section 5 for cooling tower operations; noise impacts; land use, recreation, and visual environment; biotic resources; and cultural resources. Tritium-only production with no spent fuel processing would reduce the quantities of air emissions from support facilities. However, with or without fuel reprocessing, the potential impacts of air emissions on air quality are not significant. Impacts to water resources would remain as stated in Sections 5.2.2, 5.3.2, and 5.4.2 because withdrawals are mainly for reactor operations. Water withdrawals for support facilities are minor, and their elimination would not change the significance of NPR impacts.

Reactor operations and tritium processing account for the greatest magnitude of radiological consequences from normal operations. Elimination of spent fuel processing would result in few changes to the doses and resultant health effects to the public from normal operations. Postulated nonsevere accidents at tritium-target processing facilities at Hanford, INEL, and SRS would also have consequences. Thus, tritium-only operation without spent fuel processing would not reduce the consequences in the case of the worst postulated nonsevere accident.

Assuming that socioeconomic impacts from the NPR are directly related to the work force, the differences between tritium-only production without spent fuel processing can be estimated from postulated work force differences. Spent fuel processing and uranium purification work force requirements for the NPR would range from 75 workers (for the HWR at SRS) to 575 workers (for the LWR at Hanford). These requirements reflect approximately 8% to 30% of the workers required for the NPR in the tritium production mode with spent fuel processing.

If tritium were produced without spent fuel processing, radionuclides in the high-level waste fuel would be contained within the spent fuel assemblies and would not be considered

HLW; HLW is, by definition, a product of dissolution of fuel elements. Spent fuel assemblies would be stored for an indefinite period of time. Prior to disposal, certification studies would be performed to determine eligibility for the Federal repository. Some form of processing might be necessary prior to disposal in the Federal repository. Because spent fuel processing results in the recovery of some radionuclides for recycle, the total radionuclide inventory in HLW would be less than the radionuclide inventory in the fuel. Spent fuel processing would also reduce the volume of material to be sent to the HLW repository.

If tritium were produced without fuel processing, TRU waste production would be eliminated. The transuranics in TRU waste originate in the irradiated uranium fuel and the irradiated uranium of targets used for plutonium production. Therefore, no TRU wastes would be sent to WIPP from tritium-only production unless some form of fuel processing were necessary to meet Federal repository certification requirements. Tritium production without spent fuel processing would reduce the generation of LLW at NPR facilities by 70% to 80%. Mixed wastes would be essentially eliminated for the MHTGR and would be reduced by 15% for the HWR and LWR. Hazardous wastes would be reduced by 85% for the HWR, by 10% for the LWR, and by 70% for the MHTGR. Other wastes would be reduced because of the reduction in work force, in some cases up to 30%. Detailed waste generation information, from which these conclusions were derived, is given in Appendix M.

3.3.5.6 Other Isotope Production

It is reasonably foreseeable that the NPR might also be used for the production of plutonium-238, as well as other isotopes, since these isotopes have been produced in the existing production reactors at SRS. These isotopes are usually produced by irradiation, in a reactor, of targets and subsequent materials extraction. Target fabrication and processing could occur at the NPR site or elsewhere in existing or new facilities. The Waste Management PEIS will assess the disposal of wastes from processing of spent fuel from DOE reactors. The impacts of spent fuel processing in this EIS would provide decision makers with information on the relative impacts associated with each of the reactor technologies described herein, should they be used for plutonium-238 production. Plutonium-238 is used in NASA's space program for heat sources for radioisotope thermoelectric generators and for other applications in defense programs. Whether and how to produce plutonium-238 and other isotopes will not be addressed in this EIS. As discussed below, each of the alternative reactor technologies appears capable of producing these isotopes. Accordingly, going forward now with construction of new production reactors does not prejudice any Reconfiguration PEIS alternatives.

Any of the three alternative reactor technologies would be capable of producing plutonium-238 and certain other isotopes of plutonium, uranium, neptunium, americium, and curium. This production has been demonstrated in the existing HWRs at SRS. The same HWRs technology could be used for an NPR. Plutonium-238 has also been produced in an LWR demonstration program for this purpose (Roach and Mullett 1972), and an NPR could make use of this LWR technology base to ensure capability of production. An MHTGR design assessment for plutonium-238 production is being conducted for an NPR. Confidence in technical feasibility is high for the MHTGR. However, specific design features required for plutonium-238 production need to be determined. Plutonium-238 would be produced in the tritium production mode by insertion of targets with neptunium-237. The consequences related to reactor operations in the tritium production mode are expected to bound the consequences for plutonium-238 production. Plutonium-238 production in the existing production reactors at SRS

is assessed in the Continuing Operations EID (DOE-10). This assessment is based on a comparison of the amount of plutonium-238 present in the reactor core compared to total plutonium in the core and the relative importance of plutonium isotopes to radiation doses from accidents. In these accidents, tritium and other gases dominate the doses because of their gaseous nature and high release fraction. Plutonium would be in a particulate form, and the release fraction would be much smaller for particulates than gases. There would be no difference in environmental effects associated with normal reactor operations because normal effluents from the facility would not change.

3.3.5.7 Six-Module MHTGR

This EIS addresses the consequences of construction and operation of an eight-module MHTGR, with each module rated at 350 MW. However, preliminary engineering work, initiated in the latter half of 1990, disclosed that optimizing plant design could potentially allow higher reactor module thermal ratings without affecting the general overall plant design or inherent MHTGR safety features.

This section and Appendix R address the potential impacts associated with construction, operation, and decommissioning of a 6×450 (2,700 MWt) MHTGR complex relative to the 8×350 (2,800 MWt) MHTGR complex, for the full range of issues addressed in the EIS. The assessment concludes that the majority of the 6×450 MHTGR complex environmental impacts are slightly less than or equal to those of the 8×350 MHTGR complex.

Radiological impacts of normal operations do not change for a 6×450 MHTGR complex and are bounded by the 8×350 MHTGR complex, which would comply with all regulatory requirements. Only reactor accidents (both nonsevere and severe) would have impacts that increase because of the higher core power and increased core temperatures. The nonsevere reactor accident impacts would increase by approximately 60 to 80% for the maximally exposed individual and the maximally exposed population, but still would be less than the regulatory limits by at least an order of magnitude. Scoping studies for severe accidents indicate that while health risks increase by a factor of 2 to 4, the overall risks for siting a 6×450 MHTGR complex is still several orders of magnitude lower than the NPR safety goals cited in the *New Production Reactors Requirements Document* (DOE-8). These results hold true for all three NPR sites.

3.3.5.8 Alternative Cooling-Tower Blowdown Discharge at SRS

This EIS addresses the consequences of discharging cooling-tower blowdown water to the C-Area discharge canal, which empties into Fourmile Branch. The consequences analysis in this EIS suggests that, as a mitigation measure, alternative discharge points should be considered to reduce the impacts to water and biotic resources within Fourmile Branch. Expected impacts to Fourmile Branch are related to the release of relatively warm water, which would exceed state water quality criteria at certain times of the year, and to the increase in the flow rate of the stream. One alternative, release of blowdown water to Par Pond, would result in the reduction or elimination of impacts to water and biotic resources. This alternative would have similar construction requirements as the proposed action because the length of pipeline needed would be approximately the same.

3.4 COMPARISON OF ALTERNATIVES

This section compares the significant impacts that distinguish among alternative sites and technologies. Tables 3.4-1, 3.4-2, and 3.4-3 compare the impacts for Hanford, INEL, and SRS, respectively. The impacts for each reactor technology are compared in Tables 3.4-4, 3.4-5, and 3.4-6, respectively. These tables summarize the results of the impact analyses presented in Section 5.

For comparison of the impacts of construction and operation of an NPR at either Hanford or INEL (Tables 3.4-1 and 3.4-2), the no-action alternative is to continue operations of existing production facilities at SRS. Thus, the no-action column in these two tables contains the impacts of continued operations at SRS.

The consequences listed in these six tables are primarily those that either (1) represent major differences among the sites or among the technologies or (2) are considered environmentally significant, based on the analyses in Section 5. In the case of radiological effects, all results are summarized in the tables, even though they may not be significant in terms of impacts and may not differ significantly from site to site or technology to technology.

3.4.1 Facility Requirements

Some existing material production facilities would be used for NPR activities at each of the alternative sites (Section 3.3). The environmental consequences of construction would be related primarily to the number of new facilities that would be added for each of the alternatives and to the areas of land disturbed by construction of new facilities. On the other hand, the environmental consequences of operations would consist of the impacts of operating both existing and new facilities used for NPR activities.

The amount of land disturbed by construction for the three technology alternatives at each of the three sites is listed in Table 3.4-7. These totals include acreages for the reactor facility and support facilities for tritium production, plutonium production, and spent fuel processing.

The no-action alternative, which consists of reliance on the existing reactors at SRS for tritium production, would not require construction or operation of any new facilities.

An HWR at SRS would require only a new reactor facility (including a heavy-water processing capability), because nearly all of the support functions would be carried out at existing facilities. The other technologies at SRS would rely to a lesser extent on existing SRS production facilities, and new headend processes would be needed to use existing support facilities for target and fuel processing.

An LWR at Hanford would not require a new reactor facility* since the partially completed WNP-1 reactor would be completed for NPR use. However, an additional 30 acres of land would be temporarily disturbed by construction associated with the existing facility.

* Reactor facility includes the reactor, cooling tower, steam condensing system, and other associated systems.

TABLE 3.4-1 Hanford Site: Comparison of Impacts for Alternative NPR Technologies

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
AIR RESOURCES AND NOISE	Watering of roads and construction areas may be necessary to control dust during construction. Otherwise pollutant releases during construction and operations would be well below Federal (NAAQS) and state and local regulations and standards. Cooling tower operations would not cause fogging or icing on any public roadway. Noise from construction or operations would cause little or no public annoyance.			Pollutant releases during operations of existing SRS production facilities would be below Federal (NAAQS), state, and local regulations and standards.
WATER RESOURCES Water withdrawals (m ³ /yr)	43,000,000 Water withdrawn from and returned to Columbia River.	45,000,000	35,000,000	Withdrawal from Savannah River for operations of existing production facilities.
HWR and MHTGR only: Construction in floodplain; permit required from Corps of Engineers.				
LAND USE, RECREATION, AND VISUAL ENVIRONMENT				
Land Use	277 ha of land dedicated for life of project.	299 ha of land dedicated for life of project.	267 ha of land dedicated for life of project.	SRS site remains dedicated to materials production.
Recreation	No discernible impacts to recreational resources from any of the technologies or from no action.			
Visual Environment	No visible cooling tower plume beyond site boundary.	Cooling tower plume visible beyond site boundary about 0.1% of the time.	No visible cooling tower plume beyond site boundary.	Plumes from K Reactor cooling tower at SRS visible off-site.

TABLE 3.4-1 (Hanford, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
BIOTIC RESOURCES				
Loss of Habitat	Destruction of 270-300 ha of habitat for construction and operations.			At SRS, continued wetland impacts from once-through cooling of existing reactors.
Threatened and Endangered Species	HWR and MHTGR only: Possible short-term disturbance of potential perching site for bald eagles.			No impacts to threatened and endangered species from operation of existing SRS reactors.
Loss of Resources	Some impingement and entrainment of fish eggs, larvae, and fish at cooling water intake structures in Columbia River. Some destruction of animal and plant species at construction sites.			Continued impingement and entrainment of fish eggs, larvae, and fish at existing cooling water intake in the Savannah River.
CULTURAL RESOURCES				
	HWR and MHTGR: Possible disturbance of one known historic site.			No disturbance of any cultural sites at SRS.
RADIOLOGICAL IMPACTS				
Normal Operations: Radiation Dose from 1 Year of Operation in Tritium Production Mode				At SRS, dose to average individual is 0.3 rem/yr from natural background.
Maximally exposed off-site individual, CEDE (rem)	1.6×10^{-4}	3.6×10^{-4}	6.8×10^{-5}	Dose to maximally exposed individual would be 1.3×10^{-3} rem/yr from all other sources, including SRS reactors.
Off-site population within 80 km, collective CEDE (person-rem)	6.9	7.7	3.0	
In-plant worker, collective CEDE (person-rem)	180	640	130	

TABLE 3.4-1 (Hanford, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Postulated Nonsevere Accidents at Reactor: Incremental Health Effects				From continuing operation of SRS reactors, dose to maximally exposed off-site individual from the bounding design-basis accident, CEDE: 0.51 rem. Calculation based on different accident scenario and different method of calculation (DOE-10).
Cancer risk (fatalities/accident)				
Maximally exposed off-site individual	2×10^{-4}	1×10^3	3×10^{-4}	
Population within 80 km, worst sector	3	10	6	
Maximally exposed colocated worker	6×10^{-5}	1×10^{-5}	2×10^{-5}	
Genetic risk to population within 80 km worst sector (genetic effects/accident)	1	6	4	
Postulated Nonsevere Accidents at Support Facilities: Incremental Health Effects				SRS support facilities continue to operate, and risks are assumed to be equivalent to NPR risks and effects
Cancer risk (fatalities/accident)				
Maximally exposed off-site individual	0.002	0.002	0.002	5×10^{-4}
Population within 80 km, worst sector	30	30	30	6
Maximally exposed colocated worker	0.001	1×10^{-4}	0.001	7×10^{-5}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	20	20	20	4
Postulated Severe Accidents: Incremental Radiation Dose and Health Risks to the General Public and Colocated Workers				From continuing operation of SRS reactors, dose risk to general public is 900 person-rem/yr; cancer fatality risk is 0.19 fatalities/yr.
Dose risk (person-rem/yr)				
Reactor	0.7	1	0.04	
Support facilities	6×10^{-5}	6×10^{-5}	6×10^{-5}	
Early fatality risk (fatalities/yr)				
Reactor	$<1 \times 10^{-10}$	5×10^{-8}	$<1 \times 10^{-10}$	
Support facilities	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	
Cancer fatality risk (fatalities/yr)				
Reactor	3×10^{-4}	5×10^{-4}	2×10^{-5}	
Support facilities	3×10^{-8}	3×10^{-8}	3×10^{-8}	

TABLE 3.4-1 (Hanford, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Incident-Free Transportation of Radioactive Materials: Radiation Dose and Incremental Health Effects				No additional transportation of radioactive materials with no action.
Dose to maximally exposed individual (rem/yr)				
On-site	0.21	0.15	0.33	
Off-site	1.5	1.5	1.5	
Cancer risk to maximally exposed individual (fatalities/yr)				
On-site	8×10^{-5}	6×10^{-5}	1×10^{-4}	
Off-site	6×10^{-4}	6×10^{-4}	6×10^{-4}	
Dose to population (person-rem/yr)	60	72	28	
Cancer risk to population (fatalities/yr)	0.02	0.03	0.02	
Genetic risk to population (genetic effects/yr)	0.02	0.01	0.01	
Transportation Accidents Involving Radioactive Material: Radiation Dose and Incremental Health Effects				No additional transportation of radioactive materials with no action.
Dose to maximally exposed individual (rem/accident)	4.7 24	4.7 22	4.7 22	
On-site				
Off-site				
Cancer risk to maximally exposed individual (fatalities/accident)	0.002 0.01	0.002 0.01	0.002 0.01	
On-site	0.15	0.064	0.026	
Off-site	6×10^{-5}	2×10^{-5}	1×10^{-5}	
Dose risk to population (person-rem/yr)	6×10^{-5}	2×10^{-6}	3×10^{-7}	
Cancer risk to population (fatalities/yr)				
Genetic risk to population (genetic effects/yr)				
Nonradiological Risks from Transportation of Radioactive Material (fatalities/yr)	0.05	0.05	0.03	No additional transportation of radioactive material with no action.

TABLE 3.4-1 (Hanford, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
POSTULATED ON-SITE ACCIDENTS INVOLVING NONRADIOACTIVE HAZARDOUS MATERIALS				
Chlorine (no. persons affected/accident)			(not used)	No additional risk.
Odor perception	0-200	0-200	NA ^a	
Serious health effects	0-20	0-20	NA	
Life-threatening effects	0	0	NA	
Ammonia (no. persons affected/accident)	(not used)			No additional risk.
Odor perception	NA	0-20	40-24,000	
Serious health effects	NA	0	0-20	
Life-threatening effects	NA	0	0	
SOCIOECONOMICS				
Construction Period (years)	1992-2002	1992-1997	1992-2002	No additional workers required for operation of existing production facilities at SRS.
Regional population increase				
Number of people in-migrating	4,500	12,000	3,600	
Percentage increase in region of interest	3	8	2	
Incremental facilities and services ^b				
Number of housing units	1,551	4,180	1,239	
Number of new students	711	1,913	569	
Number of police officers and firefighters	9	26	7	
Earnings (10 ⁶ \$)	1,900	560	1,900	
Operational Period				No additional workers required with no action.
Regional population increase				
Number of people in-migrating	3,306	4,766	4,958	
Percentage increase in region of interest	2	3	3	

TABLE 3.4-1 (Hanford, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Incremental facilities and services ^b				
Number of housing units	1,114	1,605	1,670	
Number of new students	523	753	784	
Number of police officers and firefighters	7	11	11	
Earnings (10 ⁶ \$/yr)	130	130	145	
TRANSPORTATION				
Off-site Effects on Level of Service	Peak-flow level of service would deteriorate for SR 240 during NPR construction and operation.			No additional vehicle traffic with no action.
Vehicular Accidents				
Baseline (fatalities/yr)				
On-site	0.38	0.38	0.38	2.44
Off-site	0.58	0.58	0.58	2.25
NPR-related, construction period (% increase in fatalities)				
On-site	21	21	26	0
Off-site	5	5	7	0
NPR-related, operational period (% increase in fatalities)				
On-site	30	30	30	0
Off-site	7	7	7	0
WASTE MANAGEMENT ^c				
High-Level Waste: total final volume (m ³)	600	720	1,500	At SRS for existing facilities: 3,600
	No identified additional requirements for any technology or for no action.			
Transuranic Waste: total volume (m ³)	3,500	10,000	5,200	At SRS for existing facilities: 26,000
	No identified additional requirements for any technology or for no action.			

TABLE 3.4-1 (Hanford, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Low-Level Waste: additional near-surface grout disposal vault volume (m ³)	270,000	290,000	140,000	16,000
Mixed and Hazardous Waste: additional disposal for mixed waste (m ³)	47,000	44,000	17,000	12,000

^aNA = not applicable.

^bThe housing impact during LWR construction is potentially significant. Some school districts are over capacity at present.

^cThe numbers shown in this table are the largest wastes generated by either the tritium or the plutonium production mode.

TABLE 3.4-2 Idaho National Engineering Laboratory: Comparison of Impacts for Alternative NPR Technologies

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
AIR RESOURCES AND NOISE	Watering of roads and construction areas may be necessary to control dust during construction. Otherwise, pollutant releases during construction and operations would be well below Federal (NAAQS), state, and local regulations and standards. Cooling tower operations would not cause fogging or icing on any public roadway. Noise from construction or operations would cause little or no public annoyance.			Pollutant releases during operations of existing SRS production facilities would be below Federal (NAAQS), state and local regulations and standards.
WATER RESOURCES Water withdrawals (m ³ /yr)	42,600,000 Water withdrawn from Snake River aquifer. No significant adverse impacts to surface water or groundwater. Possible need to renegotiate water withdrawal agreements with state. Tritium levels in large evaporation ponds could exceed EPA drinking water standards.	45,000,000	34,600,000	Continued use of Savannah River water for reactor cooling.
LAND USE, RECREATION, AND VISUAL ENVIRONMENT				
Land Use	1,153 ha of land dedicated for life of project.	1,041 ha of land dedicated for life of project.	803 ha of land dedicated for life of project.	Operations of SRS existing complex continued.
Recreation	No discernible impacts to recreational resources from any of the technologies or from no action.			
Visual Environment	Cooling tower plumes could be occasionally visible from Craters of the Moon National Monument, a Class I visual area, for any of the technologies.			Plumes from K Reactor at SRS visible off-site.
BIOTIC RESOURCES				
Loss of Habitat	Loss of 1,100-1,600 ha of habitat. Possible disturbance of ferruginous hawk and Swainson's hawk nesting sites.			No habitat loss from no action.

TABLE 3.4-2 (INEL, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Threatened and Endangered Species	No impacts to threatened and endangered species.			No impacts to threatened and endangered species from operation of existing SRS reactors.
Loss of Resources	Some destruction of small animal and plant species at construction site.			At SRS, continued wetland impacts from once-through cooling of existing reactors.
CULTURAL RESOURCES	Potential disturbance of up to five unidentified significant archeological sites, mitigated through avoidance or data recovery in consultation with State Historic Preservation Officer.			No disturbance of sites at SRS.
RADIOLOGICAL IMPACTS				
Normal Operations: Radiation Dose from 1 Year of Operation in Tritium Production Mode				At SRS dose to average individual is 0.3 rem/yr from natural background. Dose to maximally exposed individual would be 1.3×10^{-3} rem/yr from all other sources, including SRS reactors.
Maximally exposed off-site individual, CEDE (rem)	1.4×10^{-4}	3.2×10^{-4}	1.6×10^{-4}	
Off-site population within 80 km, collective CEDE (person-rem)	2.0	5.0	2.4	
	85	440	130	
In-plant worker, collective CEDE (person-rem)				
Postulated Nonsevere Accidents at Reactor: Incremental Health Effects				From continuing operation of SRS reactors, dose to maximally exposed off-site individual from the bounding design-basis accident, CEDE: 0.51 rem. Calculation based on different accident scenario and different method of calculation (DOE-10).
Cancer risk (fatalities/accident)				
Maximally exposed off-site individual	2×10^{-4}	8×10^{-4}	4×10^{-4}	
Population within 80 km, worst sector	2	6	3	
Maximally exposed colocated worker	8×10^{-6}	3×10^{-6}	2×10^{-6}	
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	1	4	2	

TABLE 3.4-2 (INEL, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Postulated Nonsevere Accidents at Support Facilities: Incremental Health Effects				SRS reactors continue to operate; assumed equivalent to NPR support facilities at SRS:
Cancer risk (fatalities/accident)				
Maximally exposed off-site individual	8×10^{-4}	8×10^{-4}	8×10^{-4}	5×10^{-4}
Population within 80 km, worst sector	2	2	2	6
Maximally exposed colocated worker	3×10^{-5}	3×10^{-5}	3×10^{-5}	7×10^{-5}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	1	1	1	4
Postulated Severe Accidents: Incremental Radiation Dose and Health Risks to the General Public and Colocated Workers				From continuing operation of SRS reactors, dose risk to general public is 900 person-rem/yr; cancer fatality is 0.19 fatality/yr.
Dose risk (person-rem/yr)				
Reactor	0.7	2	0.04	
Support facilities	7×10^{-5}	7×10^{-5}	7×10^{-5}	
Early fatality risk (fatalities/yr)				
Reactor	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	
Support facilities	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	
Cancer fatality risk (fatalities/yr)				
Reactor	3×10^{-4}	6×10^{-4}	1×10^{-5}	
Support facilities	3×10^{-8}	3×10^{-8}	3×10^{-8}	
Incident-Free Transportation of Radioactive Materials: Radiation Dose and Incremental Health Effects				No change in transportation of radioactive material with no action.
Dose to maximally exposed individual (rem/yr)				
On-site	0.0024	0.0022	0.01	
Off-site	0.51	1.5	0.60	
Cancer risk to maximally exposed individual (fatalities/yr)				
On-site	1×10^{-4}	9×10^{-7}	2×10^{-4}	
Off-site	2×10^{-4}	6×10^{-4}	2×10^{-4}	
Dose to population (person-rem/yr)	7.8	22	12	
Cancer risk to population (fatalities/yr)	0.003	0.009	0.004	
Genetic risk to population (genetic effects/yr)	0.002	0.006	0.004	

TABLE 3.4-2 (INEL, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No Action Alternative
Transportation Accidents Involving Radioactive Material: Radiation Dose and Incremental Health Effects				No change in transportation of radioactive material with no action.
Dose to maximally exposed individual (rem/accident)				
On-site	21	21	21	
Off-site	24	24	22	
Cancer risk to maximally exposed individual (fatalities/accident)				
On-site	0.008	0.008	0.008	
Off-site	0.01	0.01	0.01	
Dose risk to population (person-rem/yr)	0.13	0.018	0.031	
Cancer risk to population (fatalities/yr)	5×10^{-5}	7×10^{-6}	1×10^{-5}	
Genetic risk to population (genetic effects/yr)	4×10^{-5}	5×10^{-8}	8×10^{-8}	
Nonradiological Risks from Transportation of Radioactive Material (fatalities/yr)	0.03	0.03	0.03	No additional transportation of radioactive materials required.
POSTULATED ON-SITE ACCIDENTS INVOLVING NONRADIOACTIVE HAZARDOUS MATERIALS				
Chlorine (no. persons affected/accident)			(not used)	No additional risks.
Odor perception	0-10	0-10	NA ^a	
Serious health effects	0-10	0-10	NA	
Life-threatening effects	0	0	NA	
Ammonia (no. persons affected/accident)	(not used)			No additional risks.
Odor perception	NA	0	0-155	
Serious health effects	NA	0	0-2	
Life-threatening effects	NA	0	0	

TABLE 3.4-2 (INEL, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
SOCIOECONOMICS				
Construction Period (years)	1992-2002	1992-2001	1992-2002	No additional workers required at SRS for operation of existing production facilities.
Regional population increase				
Number of people in-migrating	5,300	9,000	2,200	
Percentage increase in region of interest	2	3	1	
Incremental facilities and services ^b				
Number of housing units	1,963	3,304	806	
Number of new students	1,264	2,128	854	
Number of police officers and firefighters	29	48	11	
Earnings (10 ⁶ \$)	1,800	1,700	2,000	
Operational Period				No additional workers required with no action.
Regional population increase				
Number of people in-migrating	4,300	4,700	6,000	
Percentage increase in region of interest	2	2	2	
Incremental facilities and services ^b				
Number of housing units	1,560	1,706	2,202	
Number of new students	1,037	1,129	1,456	
Number of police officers and firefighters	33	24	33	
Earnings (10 ⁶ \$/yr)	160	160	190	
TRANSPORTATION				
Off-site Effects on Level of Service	No significant adverse impacts from any of the technologies or from no action.			
Vehicular Accidents				
Baseline (fatalities/yr)				
On-site	0.56	0.56	0.56	2.25
Off-site	0.87	0.87	0.87	2.25

TABLE 3.4-2 (INEL, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
NPR-related, construction period (% increase in fatalities)				
On-site	36	36	36	0
Off-site	9	20	5	0
NPR-related, operational period (% increase in fatalities)				
On-site	58	70	82	0
Off-site	15	18	22	0
WASTE MANAGEMENT^c				
High-Level Waste: total final volume (m ³)	160	840	120	At SRS, all facilities: 3,600
	No additional requirements for any technology or for no action.			
Transuranic Waste: total volume (m ³)	4,400	800	8,000	At SRS, all facilities: 26,000
	No additional requirements for any technology or for no action.			
Low-Level Waste: additional subsurface disposal capacity (m ³)	91,000	144,000	220,000	160,000
Mixed and Hazardous Waste: additional interim storage capacity (m ³)	17,000	6,400	240	480

^aNA = not applicable.

^bHousing impacts potentially significant during construction period for LWR and during operational period for MHTGR.
Public education impacts potentially significant during construction period for LWR.

^cThe numbers shown in this table are the largest wastes generated by either the tritium or the plutonium production mode.

TABLE 3.4-3 Savannah River Site: Comparison of Impacts for Alternative NPR Technologies

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
AIR RESOURCES AND NOISE	Watering of roads and construction areas may be necessary to control dust during construction. Otherwise, pollutant releases during construction and operations would be well below Federal (NAAQS), state, and local regulations and standards. Cooling tower operations would not cause fogging or icing on any public roadway. Noise from construction or operations would cause little or no public annoyance.			Pollutant releases during operations of existing SRS production facilities would be below Federal (NAAQS), state, and local regulations and standards.
WATER RESOURCES water withdrawals (m ³ /yr)	90,400,000 Water withdrawn from and returned to Savannah River via Fourmile Branch. Clean Water Act Section 316a Demonstration required for blowdown discharge to Fourmile Branch.	100,800,000	74,300,000 MHTGR only: Dewatering required for excavation through water table.	Continued withdrawal of Savannah River water for site operations.
LAND USE, RECREATION, AND VISUAL ENVIRONMENT				
Land Use	148 ha of land dedicated for life of project	171 ha of land dedicated for life of project	164 ha of land dedicated for life of project	SRS remains dedicated to nuclear materials production and R&D.
Recreation	No discernible impacts to recreational resources from any of the technologies or from no action.			
Visual Environment	Cooling tower plumes could be visible off-site from any of the technologies. However, impacts would be incremental because of plume from K-reactor cooling tower currently under construction.			When K-reactor cooling tower becomes operational, the plume will be visible off-site.

TABLE 3.4-3 (SRS, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
BIOTIC RESOURCES				
Loss of Habitat	Loss of 260-300 ha of habitat. Up to 8 ha of wetlands impacted, unless avoided. No net loss.			Continued wetland effects from once-through cooling of existing reactors.
Threatened and Endangered Species	No adverse effects to threatened and endangered species.			No impacts to threatened and endangered species from operations of existing SRS reactors.
Loss of Resources	Some impingement and entrainment of fish eggs, larvae, and fish at cooling water intakes in Savannah River. Some destruction of small animal and plant species at construction site.			Impingement and entrainment of fish eggs, larvae, and fish at existing cooling water intakes in Savannah River.
CULTURAL RESOURCES				
	Possible disturbance of 1-3 known significant archeological sites, mitigated by avoidance or data recovery in consultation with State Historic Preservation Officer.			No adverse impacts from no action.
RADIOLOGICAL IMPACTS				
Normal Operations: Radiation Dose from 1 Year of Operation in Tritium Production Mode				Dose to average individual is 0.3 rem/yr from natural background. Dose to maximally exposed individual would be 1.3×10^{-3} rem/yr from all other sources, including SRS reactors.
Maximally exposed off-site individual, CEDE (rem)	1.5×10^{-4}	1.2×10^{-4}	1.9×10^{-4}	
Off-site population within 80 km, collective CEDE (person-rem)	8.5	16	14	
In-plant worker, collective CEDE (person-rem)	180	640	130	

TABLE 3.4-3 (SRS, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Postulated Nonsevere Accidents at Reactor: Incremental Health Effects				From continuing operation of SRS reactors, dose to maximally exposed off-site individual from the bounding design-basis accident, CEDE: 0.51 rem. Calculation based on different accident scenario and different method of calculation (DOE-10).
Dose to maximally exposed off-site individual, CEDE (rem)	0.18	0.39	0.24	
Cancer risk (fatalities/accident)				
Maximally exposed off-site individual	7×10^{-5}	2×10^{-4}	1×10^{-4}	
Population within 80 km, worst sector	1	2	2	
Maximally exposed colocated worker	4×10^{-6}	2×10^{-6}	9×10^{-7}	
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	none ^a	1	1	
Postulated Nonsevere Accidents at Support Facilities: Incremental Health Effects				SRS support facilities continue to operate with risks and health effects similar to NPR.
Cancer risk (fatalities/accident)				
Maximally exposed off-site individual	5×10^{-4}	5×10^{-4}	5×10^{-4}	
Population within 80 km, worst sector	6	6	6	
Maximally exposed colocated worker	7×10^{-5}	7×10^{-5}	7×10^{-5}	
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	4	4	4	
Postulated Severe Accidents: Incremental Radiation Dose and Health Risks to the General Public and Colocated Workers				From continuing operation of SRS reactors, dose risk to general public is 900 person-rem/yr; cancer fatality risk is 0.19 fatality/yr.
Dose risk (person-rem/yr)				
Reactor	1	1	0.06	
Support facilities	2×10^{-3}	2×10^{-3}	2×10^{-3}	
Early fatality risk (fatalities/yr)				
Reactor	2×10^{-10}	1×10^{-10}	$<1 \times 10^{-10}$	
Support facilities	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	
Cancer fatality risk (fatalities/yr)				
Reactor	4×10^{-4}	6×10^{-4}	2×10^{-5}	
Support facilities	1×10^{-6}	1×10^{-6}	1×10^{-6}	

TABLE 3.4-3 (SRS, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Incident-Free Transportation of Radioactive Materials: Radiation Dose and Incremental Health Effects				No change in transportation of radioactive materials with no action.
Dose to maximally exposed individual (rem/yr)				
On-site	0.47	0.77	0.54	
Off-site	1.2	1.2	1.2	
Cancer risk to maximally exposed individual (fatalities/yr)				
On-site	2×10^{-4}	3×10^{-4}	2×10^{-4}	
Off-site	5×10^{-4}	5×10^{-4}	5×10^{-4}	
Dose to population (person-rem/yr)	23	43	41	
Cancer risk to population (fatalities/yr)	0.009	0.02	0.01	
Genetic risk to population (genetic effects/yr)	0.006	0.011	0.011	
Transportation Accidents Involving Radioactive Material: Radiation Dose and Incremental Health Effects				No change in transportation of radioactive materials with no action.
Dose to maximally exposed individual (rem/accident)				
On-site	0.26	0.26	0.26	
Off-site	0.29	0.29	0.29	
Cancer risk to maximally exposed individual (fatalities/accident)				
On-site	1×10^{-4}	1×10^{-4}	1×10^{-4}	
Off-site	1×10^{-4}	1×10^{-4}	1×10^{-4}	
Dose risk to population (person-rem/yr)	0.56	0.67	1.0	
Cancer risk to population (fatalities/yr)	2×10^{-4}	2×10^{-4}	4×10^{-4}	
Genetic risk to population (genetic effects/yr)	4×10^{-7}	2×10^{-5}	6×10^{-5}	
Nonradiological Risks from Transportation of Radioactive Material (fatalities/yr)	0.014	0.03	0.036	No additional transportation required with no action.

TABLE 3.4-3 (SRS, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
POSTULATED ON-SITE ACCIDENTS INVOLVING NONRADIOACTIVE HAZARDOUS MATERIALS				
Chlorine (no. persons affected/accident)			(not used)	No additional risks.
Odor perception	0-300	0-300	NA ^b	
Serious health effects	0	0	NA	
Life-threatening effects	0	0	NA	
Ammonia (no. persons affected/accident)	(not used)			No additional risks.
Odor perception	NA	0	300-7,000	
Serious health effects	NA	0	0-40	
Life-threatening effects	NA	0	0	
SOCIOECONOMICS				
Construction Period (years)	1992-2000	1992-2000	1992-2002	No additional workers required for operation of existing production facilities at SRS.
Regional population increase				
Number of people in-migrating	3,300	6,862	866	
Percentage increase in region of interest	<1	<1	<1	
Incremental facilities and services ^c				
Number of housing units	1,060	2,251	284	
Number of new students	567	1,204	152	
Number of police officers and firefighters	9	20	0	
Earnings (10 ⁶ \$)	1,500	1,700	2,000	
Operational Period				No additional workers required with no action.
Regional population increase				
Number of people in-migrating	2,471	4,800	3,477	
Percentage increase in region of interest	<1	1	<1	
Incremental facilities and services ^c				
Number of housing units	790	1,538	1,111	
Number of new students	256	498	360	
Number of police officers and firefighters	6	13	9	
Earnings (10 ⁶ \$/yr)	160	160	180	

TABLE 3.4-3 (SRS, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
TRANSPORTATION				
Off-site Effects on Level of Service	Peak-flow level of service would deteriorate for SR 19, SR 64, and SR 125 during construction and operation.			No additional vehicle travel with no action.
Vehicular Accidents	Equal to baseline			
Baseline (fatalities/yr)				
On-site	2.44	2.44	2.44	2.44
Off-site	2.25	2.25	2.25	2.25
NPR-related, construction period (% increase in fatalities)				
On-site	4	8	2	0
Off-site	5	10	2	0
NPR-related, operational period (% increase in fatalities)				
On-site	4	7	6	0
Off-site	5	8	6	0
WASTE MANAGEMENT ^d				
High-Level Waste: total final volume (m ³)	1,200	600	1,200	3,600
	Additional interim storage capacity required.			
Transuranic Waste: total volume (m ³)	4,400	4,400	6,000	26,000
	No additional requirements identified for any technology or for no action.			
Low-Level Waste: total volume (m ³)	150,000	160,000	220,000	1,200,000
	No additional requirements identified for any technology or for no action.			

TABLE 3.4-3 (SRS, Cont'd)

Type of Impact	HWR	LWR	MHTGR	No-Action Alternative
Mixed and Hazardous Waste: disposal (m ³)	23,000	19,000	5,400	160,000

^anone = much less than 1.

^bNA = not applicable.

^cPublic education impacts are potentially significant for all technologies.

^dThe numbers shown in this table are the largest wastes generated by either the tritium or the plutonium production mode.

TABLE 3.4-4 HWR: Comparison of Impacts for Alternative NPR Sites

Type of Impact	Hanford	INEL	SRS
AIR RESOURCES AND NOISE	Watering of roads and construction areas may be necessary during construction, particularly at Hanford and SRS. Otherwise, pollutant releases would be below Federal (NAAQS), state, and local regulations and standards. Cooling tower operations would not cause fogging or icing on any public roadway at any site. Noise from construction or operations would cause little or no public annoyance at any site.		
WATER RESOURCES	Water (up to 45,000,000 m ³ /yr) withdrawn from and returned to Columbia River. Permit required from Corps of Engineers for construction in the floodplain.	Reactor cooling water (up to 28,000,000 m ³ /yr) taken from Snake River Plain aquifer. Tritium levels in large evaporation ponds could exceed EPA drinking water standards. Need additional water rights withdrawal permit from state of Idaho.	Water (up to 100,800,000 m ³ /yr) withdrawn from and returned indirectly to Savannah River via Fourmile Branch. Clean Water Act Section 316a Demonstration required for blowdown discharge to Fourmile Branch.
LAND USE, RECREATION, AND VISUAL ENVIRONMENT			
Land Use	277 ha of land dedicated for life of project, less than 1% of site area.	1,153 ha of land dedicated for life of project, less than 1% of site area.	148 ha of land dedicated for life of project, less than 1% of site area.
Recreation	No discernible impacts to recreational resources from any of the NPR sites.		

TABLE 3.4-4 (HWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Visual Environment	No visible cooling tower plume beyond site boundary.	Cooling tower plume could be occasionally visible from Craters of the Moon National Monument, a Class I visual area.	Cooling tower plume could be visible off-site. However, impacts would be similar to plume from K-reactor cooling towers currently under construction.
BIOTIC RESOURCES			
Loss of Habitat (ha)	280	1,100	280 Up to 8 ha of wetlands impacted, unless avoided. No net loss.
Threatened and Endangered Species	Possible disturbance of potential perching sites for bald eagles.	No impact to threatened or endangered species.	No impact to threatened or endangered species.
Loss of Resources	Hanford and SRS only: Some impingement and entrainment of fish eggs, larvae, and fish at cooling water intake structures in Columbia River (Hanford) and Savannah River (SRS). At all sites, some destruction of small animal and plant species at construction site.		
CULTURAL RESOURCES			
	Possible disturbance of a known historic site.	Potential disturbance of up to 5 unidentified significant archeological sites.	Possible disturbance of 1-3 known significant archeological sites.
	Mitigation by avoidance or data recovery in consultation with State Historic Preservation Officer.		

TABLE 3.4-4 (HWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
RADIOLOGICAL IMPACTS			
Normal Operations: Radiation Dose from 1 Year of Operation in Tritium Production Mode			
Maximally exposed off-site individual, CEDE (rem)	1.6×10^{-4}	1.4×10^{-4}	1.5×10^{-4}
Off-site population within 80 km, collective CEDE (person-rem)	6.9	2.0	8.5
In-plant worker, collective CEDE (person-rem)	180	85	180
Postulated Nonsevere Accidents at Reactor: Incremental Health Effects			
Cancer risk (fatalities/accident)			
Maximally exposed off-site individual	2×10^{-4}	2×10^{-4}	7×10^{-5}
Population within 80 km, worst sector	3	2	1
Maximally exposed colocated worker	6×10^{-5}	8×10^{-6}	4×10^{-6}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	1	1	none ^a
Postulated Nonsevere Accidents at Support Facilities: Incremental Health Effects			
Cancer risk (fatalities/accident)			
Maximally exposed off-site individual	0.002	8×10^{-4}	5×10^{-4}
Population within 80 km, worst sector	30	2	6
Maximally exposed colocated worker	0.001	3×10^{-5}	7×10^{-5}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	20	1	4

TABLE 3.4-4 (HWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Postulated Severe Accidents: Incremental Radiation Dose and Health Risks to the General Public and Colocated Workers			
Dose risk (person-rem/yr)			
Reactor	0.7	0.7	1
Support facilities	6×10^{-5}	7×10^{-5}	2×10^{-3}
Early fatality risk (fatalities/yr)			
Reactor	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	2×10^{-10}
Support facilities	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$
Cancer fatality risk (fatalities/yr)			
Reactor	3×10^{-4}	3×10^{-4}	4×10^{-4}
Support facilities	3×10^{-8}	3×10^{-8}	1×10^{-6}
Incident-Free Transportation of Radioactive Materials: Radiation Dose and Incremental Health Effects			
Dose to maximally exposed individual (rem/yr)			
On-site	0.21	0.0024	0.47
Off-site	1.5	0.51	1.2
Cancer risk to maximally exposed individual (fatalities/yr)			
On-site	8×10^{-5}	1×10^{-4}	2×10^{-4}
Off-site	6×10^{-4}	2×10^{-4}	5×10^{-4}
Dose to population (person-rem/yr)	60	7.8	23
Cancer risk to population (fatalities/yr)	0.02	0.003	0.09
Genetic risk to population (genetic effects/yr)	0.02	0.002	0.006
Transportation Accidents Involving Radioactive Material: Radiation Dose and Incremental Health Effects			
Dose to maximally exposed individual (rem/accident)			
On-site	4.7	21	0.26
Off-site	24	24	0.29

TABLE 3.4-4 (HWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Cancer risk to maximally exposed individual (fatalities/accident)			
On-site	0.002	0.008	1×10^{-4}
Off-site	0.01	0.01	1×10^{-4}
Dose risk to population (person-rem/yr)	0.15	0.13	0.56
Cancer risk to population (fatalities/yr)	6×10^{-5}	5×10^{-5}	2×10^{-4}
Genetic risk to population (genetic effects/yr)	6×10^{-5}	4×10^{-5}	4×10^{-7}
Nonradiological Risks from Transportation of Radioactive Material (fatalities/yr)	0.05	0.03	0.014
ON-SITE ACCIDENTS INVOLVING NONRADIOACTIVE HAZARDOUS MATERIALS			
Chlorine (no. persons affected/accident)			
Odor perception	0-200	0-10	0-300
Serious health effects	0-20	0-10	0
Life-threatening effects	0	0	0
Ammonia	(not used)	(not used)	(not used)
SOCIOECONOMICS			
Construction Period (years)	1992-2002	1992-2002	1992-2000
Regional population increase			
Number of people in-migrating	4,500	5,300	3,300
Percentage increase in region of interest	3	2	<1
Incremental facilities and services ^b			
Number of housing units	1,551	1,963	1,060
Number of new students	711	1,264	567
Number of police officers and firefighters	9	29	9
Earnings (10^6 \$)	1,900	1,800	1,500

TABLE 3.4-4 (HWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Operational Period			
Regional population increase			
Number of people in-migrating	3,306	4,300	2,471
Percentage increase in region of interest	2	2	<1
Incremental facilities and services ^b			
Number of housing units	1,114	1,560	790
Number of new students	523	1,037	256
Number of police officers and firefighters	7	33	6
Earnings (10 ⁶ \$/yr)	130	160	160
TRANSPORTATION			
Off-site Effects on Level of Service	Peak-flow level of service would deteriorate for SR 240 during construction and operation.	No significant adverse impacts.	Level of service would deteriorate for SR 19, SR 64, and SR 125 during construction and operation.
Vehicular Accidents (fatalities/yr)			
Baseline			
On-site	0.38	0.56	2.44
Off-site	0.58	0.87	2.25
NPR-related, construction period			
On-site	0.08	0.18	0.09
Off-site	0.03	0.08	0.11
NPR-related, operational period			
On-site	0.11	0.29	0.09
Off-site	0.04	0.13	0.11

TABLE 3.4-4 (HWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
WASTE MANAGEMENT ^c			
High-Level Waste: final volume (m ³)	600 No additional re- quirements for capacity at site.	160 No additional re- quirements for capacity at site.	1,200 Need additional on-site interim storage capacity.
Transuranic Waste: volume (m ³)	3,500	4,400	150,000
Low-Level Waste	Need additional grout disposal vaults for 270,000 m ³ .	Need additional subsurface disposal for 91,000 m ³ .	No additional capacity needed.
Mixed and Hazardous Waste	Need additional disposal for 47,000 m ³ of mixed waste.	Need additional interim storage for 17,000 m ³ of mixed wastes.	Need additional disposal for 23,000 m ³ of mixed and hazardous waste.

^anone = much less than 1.

^bPublic education impacts potentially significant during construction at Hanford and SRS and during operations at SRS. Some Hanford-area school districts are over capacity at present.

^cThe numbers shown in this table are the largest wastes generated by either the tritium or the plutonium production mode.

TABLE 3.4-5 LWR: Comparison of Impacts for Alternative NPR Sites

Type of Impact	Hanford	INEL	SRS
AIR RESOURCES AND NOISE	Watering of roads and construction areas may be necessary during construction, particularly at Hanford and SRS. Otherwise, pollutant releases would be below Federal (NAAQS), state, and local regulations and standards. Cooling tower operations would not cause fogging or icing on any public roadway at any site. Noise from construction or operations would cause little or no public annoyance at any site.		
WATER RESOURCES	Water (up to 45,000,000 m ³ /yr) withdrawn from and returned to Columbia River.	Reactor cooling water (up to 45,000,000 m ³ /yr) taken from Snake River Plain aquifer. Tritium levels in large evaporation ponds could exceed EPA drinking water standards. Need additional water rights withdrawal permit from state of Idaho.	Water withdrawn (up to 100,800,000 m ³ /yr) from and returned indirectly to Savannah River via Fourmile Branch. Clean Water Act Section 316a Demonstration required for blowdown discharge to Fourmile Branch.
LAND USE, RECREATION, AND VISUAL ENVIRONMENT			
Land Use	299 ha of land dedicated for life of project, less than 1% of site area.	1,041 ha of land dedicated for life of project, less than 1% of site area.	171 ha of land dedicated for life of project, less than 1% of site area.
Recreation	No discernible impacts to recreational resources for any site.		

TABLE 3.4-5 (LWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Visual Environment	Cooling tower plume visible beyond site boundary about 0.1% of the time.	Cooling tower plume could be occasionally visible from Craters of the Moon National Monument, a Class I visual area.	Cooling tower plume could be visible off-site. However, impacts would be similar to plume from K-reactor cooling towers currently under construction.
BIOTIC RESOURCES			
Loss of Habitat (ha)	300	1,000	300 Up to 8 ha of wetlands impacted, unless avoided. No net loss.
Threatened and Endangered Species	No impacts to threatened and endangered species.		
Loss of Resources	Hanford and SRS only: Some impingement and entrainment of fish eggs, larvae, and fish at cooling water intake structures in Columbia River (Hanford) and Savannah River (SRS). At all sites, some destruction of small animal and plant species at construction sites.		
CULTURAL RESOURCES			
	Possible disturbance of a known historic site.	Potential disturbance of up to 5 unidentified significant archeological sites.	Possible disturbance of 1-3 known significant archeological sites.
	Mitigation by avoidance or data recovery in consultation with State Historic Preservation Officer.		

TABLE 3.4-5 (LWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
RADIOLOGICAL IMPACTS			
Normal Operations: Radiation Dose from 1 Year of Operation in Tritium Production Mode			
Maximally exposed off-site individual, CEDE (rem)	3.6×10^{-4}	3.2×10^{-4}	1.2×10^{-4}
Off-site population within 80 km, collective CEDE (person-rem)	7.7	5.0	16
In-plant worker, collective CEDE (person-rem)	640	440	640
Postulated Nonsevere Accidents at Reactor: Incremental Health Effects			
Cancer risk (fatalities/accident)			
Maximally exposed off-site individual	1×10^{-3}	8×10^{-4}	2×10^{-4}
Population within 80 km, worst sector	10	6	2
Maximally exposed colocated worker	1×10^{-5}	3×10^{-6}	2×10^{-6}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	6	4	1
Postulated Nonsevere Accidents at Support Facilities: Incremental Health Effects			
Cancer risk (fatalities/accident)			
Maximally exposed off-site individual	0.002	8×10^{-4}	5×10^{-4}
Population within 80 km, worst sector	30	2	6
Maximally exposed colocated worker	1×10^{-4}	3×10^{-5}	7×10^{-5}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	20	1	4

TABLE 3.4-5 (LWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Postulated Severe Accidents: Incremental Radiation Dose and Health Risks to the General Public and Colocated Workers			
Dose risk (person-rem/yr)			
Reactor	6×10^{-5}	7×10^{-5}	2×10^{-3}
Support facilities			
Early fatality risk (fatalities/yr)			
Reactor	5×10^{-8}	$<1 \times 10^{-10}$	1×10^{-10}
Support facilities	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$
Cancer fatality risk (fatalities/yr)			
Reactor	5×10^{-4}	6×10^{-4}	6×10^{-4}
Support facilities	3×10^{-8}	3×10^{-8}	1×10^{-6}
Incident-Free Transportation of Radioactive Materials:			
Radiation Dose and Incremental Health Effects			
Dose to maximally exposed individual (rem/yr)			
On-site	0.15	0.0022	0.77
Off-site	1.5	1.5	1.2
Cancer risk to maximally exposed individual (fatalities/yr)			
On-site	6×10^{-5}	9×10^{-7}	3×10^{-4}
Off-site	6×10^{-4}	6×10^{-4}	5×10^{-4}
Dose to population (person-rem/yr)	72	22	43
Cancer risk to population (fatalities/yr)	0.03	0.009	0.02
Genetic risk to population (genetic effects/yr)	0.01	0.006	0.011
Transportation Accidents Involving Radioactive Material:			
Radiation Dose and Incremental Health Effects			
Dose to maximally exposed individual (rem/accident)			
On-site	4.7	21	0.26
Off-site	22	24	0.29

TABLE 3.4-5 (LWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Cancer risk to maximally exposed individual (fatalities/accident)			
On-site	0.002	0.008	1×10^{-4}
Off-site	0.01	0.01	1×10^{-4}
Dose risk to population (person-rem/yr)	0.064	0.018	0.67
Cancer risk to population (fatalities/yr)	2×10^{-5}	7×10^{-6}	2×10^{-4}
Genetic risk to population (genetic effects/yr)	2×10^{-6}	5×10^{-8}	2×10^{-5}
Nonradiological Risks from Transportation of Radioactive Material (fatalities/yr)	0.05	0.03	0.03
ON-SITE ACCIDENTS INVOLVING NONRADIOACTIVE HAZARDOUS MATERIALS			
Chlorine (no. persons affected/accident)			
Odor perception	0-200	0-10	0-300
Serious health effects	0-20	0-10	0
Life-threatening effects	0	0	0
Ammonia (no. persons affected/accident)	(not used)		
Odor perception	NA ^a	0	0
Serious health effects	NA	0	0
Life-threatening effects	NA	0	0
SOCIOECONOMICS			
Construction Period (years)	1992-1997	1992-2001	1992-2000
Regional population increase			
Number of people in-migrating	12,000	9,000	6,862
Percentage increase in region of interest	8	3	1
Incremental facilities and services ^b			
Number of housing units	4,180	3,304	2,251
Number of new students	1,913	2,128	1,204
Number of police officers and firefighters	26	48	20
Earnings (10^6 \$)	560	1,700	1,700

TABLE 3.4-5 (LWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Operational Period			
Regional population increase			
Number of people in-migrating	4,766	4,700	4,800
Percentage increase in region of interest	3	2	3
Incremental facilities and services ^b			
Number of housing units	1,605	1,706	1,538
Number of new students	753	1,129	498
Number of police officers and firefighters	11	24	13
Earnings (10 ⁶ \$/yr)	130	160	160
TRANSPORTATION			
Off-site Effects on Level of Service	Peak-flow level of service would deteriorate for SR 240 during construction and operation.	No significant adverse impacts.	Level of service would deteriorate for SR 19, SR 64, and SR 125 during construction and operation.
Vehicular Accidents (fatalities/yr)			
Baseline			
On-site	0.38	0.56	2.44
Off-site	0.58	0.87	2.25
NPR-related, construction period			
On-site	0.08	0.37	0.19
Off-site	0.03	0.17	0.23
NPR-related, operational period			
On-site	0.11	0.35	0.16
Off-site	0.04	0.16	0.19

TABLE 3.4-5 (LWR, Cont'd)

Type of Impact	Hanford	INEL	SRS
WASTE MANAGEMENT^c			
High-Level Waste: volume (m ³)	720 No additional requirement for storage capacity.	840 No additional requirement for storage capacity.	600 Need additional on-site interim storage capacity for 600 m ³ .
Transuranic Waste: volume (m ³)	10,000 No additional requirements identified for any site.	4,400	4,400
Low-Level Waste	Need additional grout disposal vaults for 290,000 m ³ .	Need additional subsurface disposal for 144,000 m ³ .	Burial ground disposal for 160,000 m ³ .
Mixed and Hazardous Waste	Need additional disposal for 44,000 m ³ of mixed waste.	Need additional interim storage for 6,400 m ³ of mixed waste.	Need additional disposal for 19,000 m ³ of mixed and hazardous waste.

^aNA = not applicable.

^bHousing impacts potentially significant during construction at Hanford and INEL. Public education impacts potentially significant during construction at INEL and SRS and during operations at SRS. Some Hanford-area school districts are over capacity at present.

^cThe numbers shown in this table are the largest wastes generated by either the tritium or the plutonium production mode.

TABLE 3.4-6 MHTGR: Comparison of Impacts for Alternative NPR Sites

Type of Impact	Hanford	INEL	SRS
AIR RESOURCES AND NOISE	Watering of roads and construction areas may be necessary during construction, particularly at Hanford and SRS. Otherwise, pollutant releases would be below Federal (NAAQS), state, and local regulations and standards. Cooling tower operations would not cause fogging or icing on any public roadway. Noise from construction or operations would cause little or no public annoyance at any site.		
WATER RESOURCES	Water (up to 45,000,000 m ³ /yr) withdrawn from and returned to Columbia River. Permit required from Corps of Engineers for construction in floodplain.	Reactor cooling water (up to 34,600,000 m ³ /yr) taken from Snake River Plain aquifer. Tritium levels in large evaporation ponds could exceed EPA drinking water standards.	Water (up to 74,300,000 m ³ /yr) withdrawn from and returned indirectly to Savannah River via Fourmile Branch. Clean Water Act Section 316a Demonstration required for blow-down discharge to Fourmile Branch. Dewatering required for excavation through water table.
LAND USE, RECREATION, AND VISUAL ENVIRONMENT			
Land Use	267 ha of land dedicated for life of project, less than 1% of site area.	803 ha of land dedicated for life of project, less than 1% of site area.	164 ha of land dedicated for life of project, less than 1% of site area.
Recreation	No discernible impacts to recreational resources from any of the NPR sites.		

TABLE 3.4-6 (MHTGR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Visual Environment	No visible cooling tower plume beyond site boundary.	Cooling tower plume could be occasionally visible from Craters of the Moon National Monument, a Class I visual area.	Cooling tower plume could be visible off-site. However, impacts would be similar because of plume from K-reactor cooling towers currently under construction.
BIOTIC RESOURCES			
Loss of Habitat (ha)	270	800	270 Up to 8 ha of wetlands impacted, unless avoided during construction. No net loss.
Threatened and Endangered Species	Possible disturbance of potential perching sites for bald eagles.	No impact to threatened or endangered species.	No impact to Federal threatened or endangered species.
Loss of Resources	At all sites, some destruction of small animal and plant species at construction sites. Hanford and SRS only: Some impingement and entrainment of fish eggs, larvae, and fish at cooling water intake structures in Columbia River (Hanford) and Savannah River (SRS).		
CULTURAL RESOURCES			
	Possible disturbance of a known historic site.	Potential disturbance of up to 5 unidentified significant archeological sites.	Possible disturbance of 1-3 known significant archeological sites.
	Mitigation by avoidance or data recovery in consultation with State Historic Preservation Officer.		

TABLE 3.4-6 (MHTGR, Cont'd)

Type of Impact	Hanford	INEL	SRS
RADIOLOGICAL IMPACTS			
Normal Operations: Radiation Dose from 1 Year of Operation in Tritium Production Mode			
Maximally exposed off-site individual, CEDE (rem)	6.8×10^{-5}	1.6×10^{-4}	1.9×10^{-4}
Off-site population within 80 km, collective CEDE (person-rem)	3.0	2.4	14
In-plant worker, collective CEDE (person-rem)	130	130	130
Postulated Nonsevere Accidents at Reactor: Incremental Health Effects			
Cancer risk (fatalities/accident)			
Maximally exposed off-site individual	3×10^{-4}	4×10^{-4}	1×10^{-4}
Population within 80 km, worst sector	6	3	2
Maximally exposed colocated worker	2×10^{-5}	2×10^{-6}	9×10^{-7}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	4	2	1
Postulated Nonsevere Accidents at Support Facilities: Incremental Health Effects			
Cancer risk (fatalities/accident)			
Maximally exposed off-site individual	0.002	8×10^{-4}	5×10^{-4}
Population within 80 km, worst sector	30	2	6
Maximally exposed colocated worker	0.001	3×10^{-5}	7×10^{-5}
Genetic risk to population within 80 km, worst sector (genetic effects/accident)	20	1	4

TABLE 3.4-6 (MHTGR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Postulated Severe Accidents: Incremental Radiation Dose and Health Risks to the General Public and Colocated Workers			
Dose risk (person-rem/yr)			
Reactor	0.04	0.04	0.06
Support facilities	6×10^{-5}	7×10^{-5}	2×10^{-3}
Early fatality risk (fatalities/yr)			
Reactor	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$
Support facilities	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$	$<1 \times 10^{-10}$
Cancer fatality risk (fatalities/yr)			
Reactor	2×10^{-5}	1×10^{-5}	2×10^{-5}
Support facilities	3×10^{-8}	3×10^{-8}	1×10^{-7}
Incident-Free Transportation of Radioactive Materials: Radiation Dose and Incremental Health Effects			
Dose to maximally exposed individual (rem/yr)			
On-site	0.33	0.01	0.54
Off-site	1.5	0.60	1.2
Cancer risk to maximally exposed individual (fatalities/yr)			
On-site	1×10^{-4}	2×10^{-4}	2×10^{-4}
Off-site	6×10^{-4}	2×10^{-4}	5×10^{-4}
Dose to population (person-rem/yr)	28	12	41
Cancer risk to population (fatalities/yr)	0.02	0.004	0.01
Genetic risk to population (genetic effects/yr)	0.01	0.004	0.011

TABLE 3.4-6 (MHTGR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Transportation Accidents Involving Radioactive Material:			
Radiation Dose and Incremental Health Effects			
Dose to maximally exposed individual (rem/accident)			
On-site	4.7	21	0.26
Off-site	22	22	0.29
Cancer risk to maximally exposed individual (fatalities/accident)			
On-site	0.002	0.008	1×10^{-4}
Off-site	0.01	0.01	1×10^{-4}
Dose risk to population (person-rem/yr)	0.026	0.031	1.0
Cancer risk to population (fatalities/yr)	1×10^{-5}	1×10^{-5}	4×10^{-4}
Genetic risk to population (genetic effects/yr)	3×10^{-7}	8×10^{-8}	6×10^{-5}
Nonradiological Risks from Transportation of Radioactive Material (fatalities/yr)	0.03	0.03	0.036
ON-SITE ACCIDENTS INVOLVING NONRADIOACTIVE HAZARDOUS MATERIALS			
Chlorine	(not used)	(not used)	(not used)
Ammonia (no. persons affected/accident)			
Odor perception	40-24,000	0-155	300-7,000
Serious health effects	0-20	0-2	0-40
Life-threatening effects	0	0	0
SOCIOECONOMICS			
Construction Period (years)	1992-2002	1992-2002	1992-2002
Regional population increase			
Number of people in-migrating	3,600	2,200	866
Percentage increase in region of interest	2	1	<1

TABLE 3.4-6 (MHTGR, Cont'd)

Type of Impact	Hanford	INEL	SRS
Incremental facilities and services ^a			
Number of housing units	1,239	806	284
Number of new students	569	854	152
Number of police officers and firefighters	7	11	100
Earnings (10 ⁶ \$)	1,900	2,000	2,000
Operational Period			
Regional population increase			
Number of people in-migrating	4,958	6,000	3,477
Percentage increase in region of interest	3	2	<1
Incremental facilities and services ^a			
Number of housing units	1,670	2,202	1,111
Number of new students	784	1,456	360
Number of police officers and firefighters	11	33	9
Earnings (10 ⁶ \$/yr)	145	190	180
TRANSPORTATION			
Off-site Effects on Level of Service	Peak-flow level of service would deteriorate for SR 240 during construction and operation.	No significant adverse impacts.	Level of service would deteriorate for SR 19, SR 64, and SR 125 during construction and operation.
Vehicular Accidents (fatalities/yr)			
Baseline			
On-site	0.38	0.56	2.44
Off-site	0.58	0.87	2.25
NPR-related, construction period			
On-site	0.01	0.08	0.05
Off-site	0.04	0.04	0.05

TABLE 3.4-6 (MHTGR, Cont'd)

Type of Impact	Hanford	INEL	SRS
NPR-related, operational period			
On-site	0.11	0.41	0.13
Off-site	0.19	0.19	0.15
WASTE MANAGEMENT ^b			
High-Level Waste: final volume (m ³)	1,500 No additional requirements for interim storage capacity.	120 No additional requirement for interim storage capacity.	1,200 Need additional on-site interim storage capacity for 1,200 m ³ .
Transuranic Waste	5,200 No identified additional requirements at any site.	8,000	6,000
Low-Level Waste	Need additional grout disposal vaults for 140,000 m ³ .	Need additional subsurface disposal for 220,000 m ³ .	Need additional burial ground for 220,000 m ³ .
Mixed and Hazardous Waste	Need additional disposal for 17,000 m ³ of mixed waste.	Need additional interim storage for 240 m ³ of mixed wastes.	Need additional disposal for 5,400 m ³ of mixed and hazardous waste.

^aPublic education impacts potentially significant during construction and operation at SRS. Housing impacts potentially significant during operation at INEL. Some Hanford area school districts are over capacity at present.

^bThe numbers shown in this table are the largest wastes generated by either the tritium or the plutonium production mode.

TABLE 3.4-7 Areas of Land Disturbed during
Construction of New Facilities at Alternative Sites

Facility	Area Disturbed (ha)		
	Hanford	INEL	SRS
HWR			
Reactor	716	728	214
Support facilities	88	9	0
Evaporation pond ^a	-	829	-
Total	804	1,566	214
LWR			
Reactor	30	257	232
Support facilities	88	16	10
Evaporation pond ^a	-	855	-
Total	118	1,128	242
MHTGR			
Reactor	375	518	243
Support facilities	88	12	8
Evaporation pond	-	673	-
Total	463	1,203	251

^aEvaporation pond would be used only at INEL.

Because of the use of an existing reactor facility, and the small area of undisturbed land impacted by construction, the LWR at Hanford would have the least construction impacts of all alternatives except no action. The existing Fuels and Materials Examination Facility would be used for target and fuel fabrication. However, new spent fuel processing facilities would be required if a decision is made in the future to reprocess. Implementation of the HWR or MHTGR technology at Hanford would require a new reactor facility, new fuel and target fabrication facilities (for both plutonium and tritium production), and new fuel and plutonium target processing facilities.

At INEL, a new reactor facility, new fuel and target fabrication facilities (for both tritium and plutonium production), new headend for the fuel processing facility, new tritium target processing facility, and new plutonium target processing facility would be required for all three technologies. In addition, one or more ponds of up to 855 ha in total area would be required for evaporation of cooling tower blowdown water.

Thus, the alternatives with the least land disturbance during construction would be the Hanford LWR (118 ha) and the SRS HWR, LWR, and MHTGR (214 ha, 242 ha, and 251 ha, respectively). At INEL, adoption of the option to eliminate the evaporation pond by changing cooling tower design would eliminate disturbance of 673 ha (MHTGR) to 855 ha (LWR) of land.

3.4.2 Air Resources and Noise

At all three sites, PM_{10} concentrations are expected to be close to or exceed the 24-hour ambient PM_{10} standards during the peak construction period. Standards could be exceeded during very dry or windy conditions (Sections 5.2.1.1, 5.3.2.1, and 5.4.2.1). Otherwise, emissions from construction or operation of any of the technologies at any of the sites would not result in violation of any Federal, state, or local air quality regulation or standard. Cooling tower operations could not cause fogging or icing on any public roadway at any of the sites (Sections 5.2.1.2, 5.3.1.2, and 5.4.1.2).

Noise impacts from construction and operation would not violate any Federal, state, or local standards, and increases in noise levels beyond the boundaries of Hanford, INEL, or SRS would cause little or no public annoyance (Sections 5.2.1.3, 5.3.1.3, and 5.4.1.3).

3.4.3 Water Resources

An NPR would require water both for construction and operations. The major water use would be for cooling of the reactor during operations, when up to 63 million m^3/yr of water might be required. Water requirements differ among technologies and sites (Sections 5.2.2, 5.3.2, and 5.4.2). At Hanford and SRS, water would be taken from the Columbia and Savannah Rivers, respectively. At INEL, water would be withdrawn from the underground Snake River Plain aquifer. Water rights for an HWR or LWR would have to be negotiated with the state of Idaho. Water withdrawals from the Columbia River for NPR operations would be minor fractions of the minimum flows of that river. Water withdrawals from the Savannah River for NPR operations at SRS would be about 1-3% of the minimum river flow, which would not affect minimum flow conditions in the Savannah River. Water withdrawals from the Snake River aquifer at INEL would not significantly affect availability of groundwater off the site.

The South Carolina Department of Health and Environmental Control (SCDHEC) limits the temperature rise of waters receiving heated effluents to no more than $2.8^{\circ}C$. During cooler months of the year, Savannah River water, which would be mixed with cooling tower blowdown for temperature control, is more than $2.8^{\circ}C$ warmer than water in Fourmile Branch, to which blowdown could be discharged. Under these conditions, the temperature rise limit could not be met, and a Clean Water Act Section 316a Demonstration would be required to show that a balanced biological community could be maintained.

All water effluents from reactor operations would contain trace amounts of radionuclides originating from the reactor cooling system. At INEL, tritium concentrations in the cooling water blowdown evaporation pond could slightly exceed EPA drinking water standards. Constituent concentrations of water released to the Columbia River at Hanford and to Fourmile Branch and the Savannah River at SRS would be well within drinking water standards and water quality standards applicable to these waters (Sections 5.2.2, 5.3.2, and 5.4.2). Impacts of NPR construction and operation on floodplains are considered to be insignificant for all technologies at all sites. At INEL, groundwater withdrawals for HWR and LWR operations could exceed the existing water withdrawal agreements between INEL and the Idaho Department of Water Resources. Water withdrawal agreements would need to be renegotiated for operation of either of these two NPRs at INEL. No groundwater rights issues would occur at Hanford or SRS.

3.4.4 Land Use, Recreation, and Visual Environment

Each of the alternative sites proposed for NPR construction is already dedicated to activities similar to those of the NPR project; thus, the NPR project would not constitute a change in land use (Sections 5.2.3, 5.3.3, and 5.4.3). Each alternative site has restricted public access and is not normally available for public recreation. Regional recreational resources would not be significantly affected by worker in-migration, since construction worker requirements for the NPR would, in general, be relatively small (less than 2-3% of the regional work force). The existing facilities at each laboratory are relatively isolated from public view because of the large areal expanse of the sites. At Hanford and SRS, plumes from cooling tower operations would not create significant visual impacts either off-site or along public roadways on-site. At INEL, cooling tower plumes could occasionally be visible from Craters of the Moon National Monument and Wilderness Area, a Class I visual area. During final design, impact could be mitigated by adoption of a dry alternative cooling system at INEL for the LWR or MHTGR, because this type of system has no visible plume.

3.4.5 Biotic Resources

The areas that would be disturbed by construction of an NPR and support facilities both at Hanford and INEL consist of shrub-steppe habitat, supporting such plants as sagebrush and various grasses (Sections 5.2.4 and 5.3.4). At SRS, the affected area consists primarily of loblolly and slash pine forest (Section 5.4.4).

Areas subject to long-term disturbance for any of the NPR technologies at Hanford would total about 300 ha (this would include only about 50 ha of additional disturbed area for LWR at Hanford since the WNP-1 structures already exist). At SRS, 150-170 ha would be disturbed on a long-term basis by construction of a NPR. At INEL, 803-1,153 ha would be disturbed. The amount of land needed for the evaporation pond(s) that would be required for all NPR technologies at INEL accounts for the relatively large size of these areas.

Some salt would be deposited from cooling tower drift at all three sites. This deposition would diminish rapidly with distance from the tower. At a distance of 1 km from the cooling towers, where cooling tower plumes would contact the ground, the estimated maximum deposition would be 0.54 kg/ha·mo at Hanford, 0.59 kg/ha·mo at INEL, and 0.03 kg/ha·mo at SRS. These values are well below the 17 kg/ha·mo of sodium chloride that studies have shown to be the threshold for development of visible salt stress symptoms on sensitive plant species.

At Hanford, cooling water would be taken from the Columbia River and returned to that river after use. No new discharge structures would be required for the LWR alternative at Hanford, but construction of intake and discharge structures for the HWR and MHTGR alternative would temporarily disturb several hundred square meters of habitat in the Columbia River. Neither construction nor operation of any of the NPR technologies would result in significant impacts to aquatic organisms from construction in the river, water withdrawal, water discharge, or impingement and entrainment of aquatic organisms. Since water for NPR operations at INEL would be taken from wells and discharged to one or more evaporation ponds, there would be no effects on aquatic life from any of the NPR technologies at INEL. At SRS, water would be taken from, and returned to, the Savannah River for each of the NPR technologies. No new intake or discharge structures would be required for an NPR at SRS.

At INEL, no wetlands would be disturbed for either construction or operations. At SRS, up to 5.9 ha of bottomland hardwood forest and 2.2 ha of emergent wetland could be impacted directly or indirectly by construction, unless the areas were avoided. Any loss of wetland habitat would be mitigated in consultation with the U.S. Army Corps of Engineers to provide no net loss of wetlands. At Hanford, 0.25 ha of wetlands could be temporarily disturbed by construction of water intake/discharge structures along the Columbia River for both HWR and MHTGR technologies.

At Hanford, some disturbance of bald eagles (Federal threatened species) and destruction of potential eagle perching sites could occur during construction of the pumphouse and intake structure on the Columbia River for either the HWR or MHTGR. This construction could also affect the Swainson's hawk, giant Columbia River limpet, giant Columbia River spiral snail, and Columbia yellow cress (Federal Category 2 species). In addition, construction of an HWR or MHTGR at Hanford could disturb or destroy nesting and foraging habitat for the long-billed curlew (a Federal Category 2 species and Washington threatened species), and potential nest sites for the Swainson's hawk and the ferruginous hawk (Federal Category 2 species) could be disturbed. If these impacts were determined by the U.S. Fish and Wildlife Service to require conservation measures, such measures would be developed in consultation with the U.S. Fish and Wildlife Service.

Unless wildlife are excluded, the one or more cooling blowdown evaporation ponds at INEL could attract individuals of one or more of the following species: bald eagle, peregrine falcon (both Federal endangered species), Townsend's western big-eared bat (Federal Category 2 species), white-faced ibis (state species of special concern). The cost and impacts of fencing and netting to exclude wildlife could be avoided with the adoption of modified cooling systems for INEL that eliminated the need for large evaporation ponds.

During NPR construction at INEL there would be some destruction of foraging habitat and potential destruction of nesting habitat on the NPR site for Swainson's hawk and ferruginous hawk (both Federal Category 2 species), and burrowing owl and bobcat (state species of special concern). The oxytheca plant (a state species of special concern) is known to occur on the NPR site at INEL; some individual plant specimens could be destroyed and some habitat for the species could be disturbed or destroyed by construction activities.

At SRS, several Federal Category 2 plant species and one Federal Category 2 animal species could occur on the NPR site: Elliott's croton, smooth purple coneflower, swamp lobelia, nestronia, and Carolina crawfish frog. Any individuals of these species present in construction areas could be destroyed or otherwise affected by development of NPR facilities. During NPR operations, individuals of several Federal- or state-listed fish species could be impinged or entrained at water intake structures in the Savannah River. These species are the bighead redhorse (Federal Category 2), Atlantic sturgeon (state threatened), and blueback herring, hickory shad, and American shad (all state species of special concern).

3.4.6 Cultural Resources

Cultural resources include archaeological sites, historic structures, Native American religious and cultural sites, and paleontological localities. Potentially significant cultural resources (as defined by potential eligibility for listing on the National Register of Historic Places) exist at each of the proposed NPR sites, and these resources could be affected by

construction of an NPR and its support facilities (Sections 5.2.5, 5.3.5 and 5.4.5). However, it would be possible to mitigate impacts to significant cultural sites through avoidance and/or data recovery.

At Hanford, the only potentially affected sites are along the Columbia River, and could, by design, be avoided. At INEL, up to five significant archeological sites would likely be affected by the proposed action, but additional survey and testing are necessary to assess the number and distributions of such sites. At SRS, it appears that at least one significant archeological site would likely be affected by NPR activities, and two additional sites might be impacted. At both SRS and INEL, it would be necessary to mitigate unavoidable impacts to significant sites through data recovery (i.e., collection and/or excavation). The DOE has initiated consultations with affected tribes to identify Native American religious sites that would be impacted by the NPR. Significant paleontological localities appear unlikely to be affected at any of the sites.

3.4.7 Radiological Impacts

Results from calculations of radiological impacts for normal NPR operations, for nonsevere and severe accidents, and for transportation of radioactive materials are reported in some detail in Tables 3.4-1 through 3.4-6. All radiological impacts from normal (incident-free) operations of the NPR and its associated activities at all of the proposed sites have been determined to be within applicable Federal guidelines and standards (Sections 5.2.6, 5.3.6, and 5.4.6). The calculations on which these conclusions are founded are based on conservative assumptions, and the results are thus considered to indicate an upper bound on potential impacts. Furthermore, all activities are required to be practiced in accord with the as-low-as-reasonably-achievable (ALARA) principle, which would tend to reduce the actual exposures to both workers and the general public below the levels calculated.

Under normal operations, the radiological impacts of an NPR and its support facilities would be similar for all technologies and sites. As a result of NPR operations (all technologies), the maximally exposed member of the public would receive an annual dose of no more than 0.36 mrem at Hanford, 0.32 mrem at INEL, and 0.35 mrem at SRS. These doses, when combined with existing baseline doses at each of the sites, are well within the regulatory limits of 10 mrem/yr established by the Clean Air Act and 4 mrem/yr established by the Safe Drinking Water Act. As explained in Sections 5.2.6, 5.3.6, and 5.4.6, such impacts would be much less than other impacts normally encountered in daily life.

At each of the alternative sites, the estimated annual doses to the population, including the off-site population and in-plant workers, are about 700 person-rem (slightly more than this, 740, at INEL), which amounts to a risk of one fatal cancer in about 3 to 5 years of continuous operation of NPR and its support facilities. Estimated impacts from normal operations deviate by a factor of 2 to 5 among the three reactor technologies at the three sites. By comparison, the annual natural background radiation doses to the total population within 80 km of each of the sites (based on an estimated 0.3 rem/person-yr) are calculated to be 100,000 person-rem at Hanford, which would result in a cancer risk of 40 fatalities per year; 60,000 person-rem at INEL, which would result in a cancer risk of 20 fatalities per year; and 280,000 person-rem at SRS, which would result in a cancer risk of 100 fatalities per year.

Differences exist among the sites in dose risks and health risks for off-site transportation of radioactive material, although the risks themselves are insignificant compared with risks from natural background radiation. The differences in risk for accident-free transportation are directly related to the distance between the particular alternative site and the Federal repository for high-level wastes.

Potential nonsevere and severe accidents* were evaluated for each reactor technology and its support facilities at each site. For postulated nonsevere accidents, the highest estimated consequence would not exceed 30 additional cancer fatalities over a 50-year period per accident. This consequence is postulated to result from a tritium deflagration (fire explosion) accident at the tritium-target processing facility at Hanford, assuming no restrictions on ingestion of contaminated food following that accident. Preventing consumption of contaminated food would reduce the estimated incremental impact to less than one additional cancer fatality over that period. Most of the other postulated nonsevere accidents would not result in any cancer fatalities. For postulated severe accidents, estimates show few or no early fatalities (less than 10^{-10} fatality/yr in most cases). The estimated latent public health risks from severe accidents are no more than 0.0006 cancer fatality per year in all cases.

In the event of accidents (both for reactor operations and transportation of radioactive material), effective short-term mitigation measures would be implemented according to the emergency preparedness procedures in effect at each of the proposed sites to reduce the radiological impacts (see Section 3.5). Long-term mitigation measures, such as land decontamination and crop interdiction, would be implemented by the appropriate government authorities according to Federal guidelines, thus lowering the impacts. It is estimated that if such mitigation actions were implemented, the accident impacts could be reduced by 90% or more below those indicated, because the food pathway of exposure would be eliminated.

Some differences exist in radiological impacts at the different sites, primarily because of differences in population, population distribution, and/or meteorological conditions. In the postulated bounding case accidents, differences among the three alternative technologies are considered to be minor.

3.4.8 Accidents Involving Nonradioactive Hazardous Materials

The analyses in Sections 5.2.7, 5.3.7, and 5.4.7 indicate that in the event of complete rupture of tanks containing hazardous materials, emergency action might be necessary. A number of options are available to reduce these risks, including use of smaller storage containers.

*The term "nonsevere accident" is used in this EIS to denote a class of postulated accidents that are traditionally known as design-basis accidents (DBAs), which are the types of accidents that nuclear facilities are designed to withstand. Therefore, the impacts from these accidents, if they were to occur, would, by design, be within acceptable limits. A class of prescriptive DBAs has not yet been established for NPR facilities, pending completion of final designs and safety analyses. Instead, a group of accidents for the three technologies has been specified for both the reactors and support facilities to bound the spectrum of accidents that NPR facilities would be designed to control. These are called nonsevere accidents. The term "severe accident" is used to denote a class of postulated accidents that, although extremely unlikely, could result in extensive damage to buildings and facilities. An example of a severe accident would be the crash of a large airplane directly into a reactor or support facility building.

Risks to humans could be odor perception, mild transient health effects, or impairment of ability to take protective action, depending on the distance from event and the amount of material released. No life-threatening effects would result off-site, even from the catastrophic failure of the largest storage tank.

3.4.9 Socioeconomics

Differences in socioeconomic effects would be due primarily to the differences in the estimated number (in particular the peak number) of workers required to build and operate alternative technologies at the different sites (Sections 5.2.8, 5.3.8, and 5.4.8). In every case, housing would be needed for in-migrating workers and their families; alternatives that could potentially result in housing shortages are the LWR at Hanford and INEL during construction and the MHTGR at INEL during operations. Immigration of workers with children could also cause a shortage of classroom facilities. Some school districts in communities surrounding Hanford are currently over capacity. Classroom capacity might be strained with the LWR at Hanford and at INEL during the construction period and for all three technologies at SRS during operations. Additional requirements for police and fire protection are summarized in Tables 3.4-3 through 3.4-6.

The significance of the socioeconomic impacts would depend on the actual residential locations of the in-migrating workers. A socioeconomic monitoring and mitigation plan would be a suitable mechanism for tracking changes in worker projections as NPR design and planning proceed. Such a plan would also track projections of potential socioeconomic impacts.

3.4.10 Transportation Systems

The increased population and material transport at each of the alternative sites for construction and operation of the alternative NPRs would result in additional automobile and truck traffic on and near the sites. On the basis of the estimated increases in on- and off-site vehicle miles traveled due to NPR-associated employee and construction-material-hauling traffic, the number of traffic fatalities would increase. A decrease in level of service would be experienced because of increased traffic congestion during peak hours on State Road 240 at Hanford for all technologies, and for State Roads 19, 64, and 125 at SRS for all technologies. No decrease in level of service on highways near INEL would be expected.

3.4.11 Waste Management

The analysis of the consequences of NPR operation on waste management activities assumes that existing waste generation at Hanford, INEL, and SRS would continue at the present levels, and that existing waste treatment facilities would be used for disposal of NPR waste (Sections 5.2.9, 5.3.10, and 5.4.10). The analysis also assumes the existence of a Federal disposal facility for high-level radioactive waste, a transuranic waste disposal facility (the Waste Isolation Pilot Plant), and a mixed waste disposal facility.

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental

laws, regulations and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

Tables 3.4-1 through 3.4-6 indicate the consequences of NPR operations on existing waste facilities at each of the sites. As indicated in the tables, capacities of some existing facilities might need to be expanded for all NPR technologies at all sites.

At Hanford, these needs would include new near-surface grout disposal vaults for low-level waste and increased mixed-waste storage capacity. In addition, hazardous waste shipments to an off-site, permitted disposal facility would increase by 30-290%.

At INEL, the addition of NPR waste to the site's low-level waste processing stream would cause the processing capacities to be exceeded for the liquid effluent treatment facility (for the LWR), the process equipment waste evaporator (for the LWR), and the compactor in the experimental reduction facility (for the MHTGR). In addition, for all technologies, additional units of subsurface disposal area would be required at INEL's low-level waste disposal facility.

At SRS, additional interim storage capacity for high-level waste would be needed until the Federal repository is able to accept waste.

3.5 MONITORING, MITIGATION, AND EMERGENCY PREPAREDNESS

During construction and operation of an NPR, environmental consequences would be controlled by monitoring, mitigation, and emergency preparedness. A number of suggestions regarding these control activities have been made as a result of the evaluations of environmental consequences reported in this EIS. These measures, intended to reduce or avoid significant environmental consequences and protect the public health and welfare, would be incorporated into final project designs and plans.

In addition to preparing this EIS, DOE would prepare and enforce requirements specified in General Safety Requirements Documents related to emergency preparedness, radiation protection, reactor siting, fire protection, release of radioactive materials into the environment, and monitoring of radioactive materials. The DOE also will develop an NPR Environmental Requirements Document identifying monitoring and mitigation necessary for enhanced environmental, health, and safety compliance and monitoring. The purpose of these programs is to ensure that all NPR facilities shall, to the maximum extent practicable, be designed, constructed, operated, and decommissioned in a manner that will integrate the

fundamental goals of (1) reduction of waste, (2) minimization of exposure of workers and the public to all hazards to levels that are as low as reasonably achievable (ALARA), (3) elimination of all pollutants to the maximum extent practicable, and (4) utilization of real-time monitoring.*

3.5.1 Monitoring

All three alternative sites operate extensive, ongoing environmental monitoring programs, and the results of effluent monitoring and environmental surveillance are published annually (e.g., PNL-2; DOE-27; WSRC-7). These monitoring activities span more than 40 years and include analyses of air, water, soils, biota, and environmental and human exposure to radiological and nonradiological emissions and effluents. Monitoring for NPR-related environmental effects would be accomplished under these site wide programs, as well as in program-specific monitoring plans developed for final project designs. The objectives of the site wide monitoring programs are as follows:

- Verify compliance with applicable regulations and DOE orders;
- Determine compliance with environmental impact mitigation commitments;
- Evaluate effectiveness of effluent treatment and controls;
- Identify potential problems and the need for mitigation;
- Support the environmental permitting process;
- Detect, characterize, and report unplanned releases;
- Characterize and define trends in the physical, chemical, and biological conditions of the environment; and
- Establish baselines of environmental quality as required by DOE Order 5400.1, *General Environmental Protection Program*.

In addition to provisions of the general site monitoring programs, the NPR General Requirements Document will specify monitoring requirements for radioactive releases to the environment. The DOE's NPR Environmental Requirements Document specifies an integrated approach to facility design and environmental compliance. Designers are required to identify (1) all contaminant and thermal effluents capable of being emitted or discharged to the environment, (2) control strategies, and (3) monitoring approaches to achieve real-time monitoring. Where practicable, real-time monitoring would be used to minimize environmental impacts during construction and operations.

In addition to the monitoring discussed above, monitoring of socioeconomic consequences (Sections 5.2.8, 5.3.8, and 5.4.8) would be conducted according to a socioeconomic monitoring and mitigation plan to be developed for inclusion in the EIS ROD Mitigation Action Plan. The action plan would be prepared subsequent to the Record of Decision. The

*Real-time monitoring refers to techniques and programs that provide data on conditions as they occur, as opposed to techniques that characterize conditions as they existed at some previous point in time.

Socioeconomic Monitoring and Mitigation Plan would include monitoring of the number and residential location of in-migrating NPR workers, evaluation of NPR-related impacts on schools and other public services, and evaluation of the ability of local jurisdictions to provide for NPR-related increased demands for services and facilities. This monitoring would be intended to determine whether Payments in Lieu of Taxes or Grants Equivalent would be needed to mitigate socioeconomic impacts of NPR construction or operations.

3.5.2 Mitigation

The assessments of the environmental consequences of construction and operation of NPR facilities have identified several mitigation measures that could be implemented to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse impacts (40 CFR 1508.20). Subsequent to the EIS Record of Decision, and depending on the course of action selected, a Mitigation Action Plan would be prepared stipulating mitigation requirements. The mitigation measures suggested for construction and operation of an NPR are discussed below.

Good construction engineering practices would be used for earthmoving and other construction activities that disturb soil. Where applicable, soil erosion would be controlled by spraying water on exposed soil, grading, water diversion, riprapping, and revegetation. These practices would reduce fugitive dust emissions, soil erosion by wind and water, and sedimentation.

Best available control technology would be used to limit air emissions if final design data indicated that proposed new sources of air emissions would exceed Prevention of Significant Deterioration (PDS) limitations. If required by the Clean Air Act Amendments of 1990, maximum available control technology would be applied to emissions of toxic air pollutants (if any).

Should cooling tower operation cause hazards to workers by formation of glaze ice on roadways adjacent to the NPR site, deicing materials would be routinely applied during periods of freezing conditions. Cooling tower design would include a mist eliminator system that would be carefully maintained in order to minimize icing and salt drift. Signs warning of potentially hazardous conditions would be posted as appropriate.

Workers exposed to excessive noise during construction or operation would be required to wear protective devices to prevent temporary or permanent hearing impairment.

The designs for NPRs at INEL include up to 855 ha of evaporation ponds for cooling water blowdown. Alternative cooling concepts have been proposed (and are being studied) that would eliminate the requirement for a large area of ponds. These concepts include mechanical evaporation of blowdown for the HWR, mechanical evaporation of blowdown or dry cooling towers for the LWR, and dry cooling towers for the MHTGR. Because they would reduce or eliminate the cooling blowdown evaporation ponds, these changes would reduce the amount of land disturbed, and eliminate any effects of the attractiveness of the ponds to wildlife. Since a dry cooling tower for the MHTGR would not have a visible plume, any potential visual impacts to Craters of the Moon National Monument and Wilderness Area, a Class I visual area, would also be eliminated.

Areas containing important resources, such as wetlands or habitat used by threatened and endangered species, would be avoided wherever possible. In addition, site clearing and construction activities would be timed to minimize disturbance to threatened and endangered species and other important species (e.g., salmon). The Mitigation Action Plan for NPR would be developed in consultation with the Fish and Wildlife Service and the National Marine Fisheries Service to minimize impacts to threatened and endangered species and with the COE and EPA to minimize impacts to wetlands and aquatic resources.

Any new water intakes or discharge pipes into the Columbia River for the HWR or MHTGR technology at Hanford would be constructed using best available technology and good construction practices. These practices would include, but not be limited to, placing riprap around the intake and discharge structures along the disturbed river banks and revegetating disturbed land areas.

At Hanford, water withdrawn from potentially contaminated aquifers would be monitored to prevent use and release of contaminated groundwater during construction or operations. This may require a deeper withdrawal from a well, use of wells in different locations, or use of water supplied from the Columbia River.

At Savannah River, a Clean Water Act 316a Demonstration of a balanced biological community would be required for discharge of blowdown water to Fourmile Branch.

To mitigate potential impacts to cultural resources, avoidance of such sites would be considered in final designs and in construction planning. If avoidance were not possible, direct impacts would be mitigated through archaeological data recovery. This would entail, at a minimum, detailed mapping and collection of artifacts, where necessary. If an archaeological or historical site were identified that would be disturbed by construction activities, data recovery could include excavation of the site. All mitigation measures would be undertaken within the context of a comprehensive mitigation plan developed in consultation with the State Historic Preservation Officer and the Advisory Council on Historic Preservation. No potential adverse impacts to Native American cultural resources have been identified, but if such impacts were discovered, DOE would attempt to mitigate adverse effects through consultation with the affected tribes. If any paleontological materials were encountered, a qualified paleontologist would be employed to evaluate and, if necessary, recover materials.

Although radiological impacts calculated for NPR operations have been determined to be within Federal guidelines, all releases of radioactive materials to the environment would be kept as low as reasonably achievable. In the event of an accident with radiological consequences or with consequences from release of hazardous, nonradiological materials, the population near the NPR would be sheltered and evacuated if such action was necessary in order to prevent adverse effects on human health. These protective measures would be established in the Emergency Response Plans for NPR facilities. If ground contamination levels from an NPR accident exceeded Federal action guidelines for radiological contamination, long-term mitigation measures, such as land decontamination and crop interdiction, would be implemented. Since such measures could cause economic impacts, compensation for crop losses might be necessary. Safety Analysis Reviews will be prepared prior to both construction and operation for NPR facilities to evaluate the consequences and risks from both radiological and nonradiological postulated accidents. Information on emergency preparedness plans is presented in Section 3.5.3.

Specific mitigation measures for hazardous materials are inclusion of planning for these materials in the NPR Emergency Response Plan, of excess inventories, and reduction of vessel storage sizes. Potential impacts also would be mitigated by providing additional secondary containments around vessels, substitution of hazardous materials with nonhazardous materials when possible, and appropriate training for workers.

As discussed in Section 3.5.1, a socioeconomic monitoring and mitigation plan will be developed subsequent to the EIS Record of Decision. This plan would be used to identify any NPR-related socioeconomic impacts that would require remedial action.

If necessary, measures would be taken to minimize impacts from transportation and traffic congestion. These measures would include the use of flexible or staggered work hours.

Waste management impacts would be minimized by proper handling of waste and by waste reduction. During the storage of liquid waste in tank farms, an equivalent of one tank (at a minimum) would be kept empty so it could be used for transfer of a material from a leaking tank. Waste volume reduction includes the concentration of liquid waste and the conversion of this concentrated liquid waste into a solid form. Waste would be processed and handled in such a way that the need for additional capacity would be minimized. At SRS, an effort would be made to segregate the large quantity of low-level waste from fabrication facilities from the small amount of existing liquid waste streams. This practice would minimize the quantity of mixed waste generated.

3.5.3 Emergency Preparedness

The DOE has issued a series of orders specifying the requirements for emergency preparedness (DOE 5500.1A, DOE 5500.2A, DOE 5500.3, draft DOE 5500.3A, DOE 5500.4, and DOE 5500.9), and each DOE site has established an emergency management program. These programs are developed and maintained to ensure adequate response for most accident conditions and to provide the framework to readily extend response efforts for accidents not specifically considered. The emergency management program incorporates activities associated with planning, preparedness, and response. Officials at each candidate NPR site have issued orders specifying the emergency preparedness requirements for the DOE facilities under their jurisdiction.

Emergency preparedness requirements for the Hanford Site are specified by the DOE Richland Operations Office in a series of DOE-RL Orders -- 5500.3, 5500.4, 5500.1A, and 5500.2A, and the *Emergency Plan*. The emergency preparedness requirements for INEL are specified by the DOE Idaho Operations Office in ID Orders 5500.2 and 5500.4. The emergency preparedness requirements for SRS are specified by the DOE Savannah River Operations Office in SR Orders 5500.2A, 5500.3A, and 5500.4A. All existing facilities have emergency plans and procedures that either implement the DOE and site requirements or are integrated with the site planning. If a DOE site were selected for construction and operation of an NPR, that site's emergency preparedness requirements would be revised to include NPR facilities.

Based on existing requirements and plans, the following procedures would be implemented for NPR emergency planning. The NPR facilities would list and assess the hazards

and potential accidents associated with each facility, operation, and activity. An emergency planning zone would be identified for each facility, operation, and activity. Special planning and preparedness efforts would be required for that zone to ensure that prompt and effective protective actions could be taken to minimize the risk to on-site personnel, the general public, and the environment in the event of an emergency. Procedures would be developed to implement the emergency plan. An emergency response organization would be established and maintained. That organization would consist of experienced and trained personnel responsible for timely emergency response functions. The emergency response activities and the day-to-day duties and responsibilities of the personnel would be correlated.

In the event of an emergency, the situation would be classified according to preestablished criteria. Emergency response organization personnel would be promptly notified, and the appropriate *emergency action level* would be implemented for the corresponding level and/or class of emergency. For a hazardous material emergency, state and local organizations responsible for protection of the public would be notified within 15 minutes of classification. The DOE Headquarters Emergency Operations Center would be notified within 15 minutes after declaration of an alert, site, or general emergency. Accurate information regarding the emergency would be disseminated to the news media in a timely manner. A spokesperson would be designated to dispel rumors and inform the public.

The program would be tested at least annually in emergency drills that allow each on-site person to participate. Emergency drill scenarios would be developed in an attempt to test various aspects of the emergency management program. These drills would give the groups that would be required to respond in an actual emergency a chance to coordinate their efforts and appreciate the skills and knowledge of other respondents. All aspects of the program, including coordination with state and local organizations, would be tested every 5 years.

Emergency responses would be implemented both off- and on-site. An off-site transportation accident could have many of the same hazards as an on-site accident. Procedures and agreements among DOE, other Federal agencies, and state agencies are in place to allow for an effective response by all appropriate parties. If a vehicle transporting NPR hazardous material was involved in an accident, emergency response individuals from DOE, other Federal agencies, and state agencies would be available to mitigate the impacts to the public.

4 AFFECTED ENVIRONMENT OF ALTERNATIVE SITES

This section describes the environment at each of the alternative sites that would be affected by siting, construction, and operation of an NPR. The description of the affected environment is based on descriptions of existing site conditions as modified by any planned activities that are reasonably certain to occur by the time of NPR construction (starting in 1996) and operations (2000-2040). In addition, the K, L, and P reactors at Savannah River are assumed to be in full operation, as described in the Continued Operations EIS (DOE-10). The affected environment in this EIS is equivalent to the no-action alternative, which is described in Section 3.1.

4.1 HANFORD SITE

4.1.1 Geology

This section summarizes the geologic setting, including potential geologic hazards, at the Hanford Site. Soils of the proposed NPR site are evaluated with respect to the agronomic classifications "Prime Farmland" and "Unique Farmland." Appendix D contains a more detailed exposition of these topics.

4.1.1.1 Geologic Setting

The Hanford Site is located near Pasco, Washington, in the Columbia Basin of the Pacific Northwest. The Columbia Basin is bounded by the Cascade Mountains on the west, the northern Rocky Mountains on the north and east, and the Blue Mountains on the south. The geology of Hanford, as well as the Columbia Basin, is dominated by thick accumulations of basaltic lava. These lava formations -- greater than 3 km thick in the Pasco Basin -- constitute the Columbia River Basalt Group. The eruptions occurred during Miocene time between approximately 17 and 6 million years ago. During Pliocene time, the fan-shaped conglomerates of the Ringold Formation were deposited over the basalt. Catastrophic floods associated with Pleistocene glaciers resulted in extensive sedimentary deposits (Bretz 1969). The last of these floods occurred about 13,000 years ago (Myers et al. 1979). At Hanford, these sediments are represented by the Hanford Formation, which is largely composed of cobble-sized material.

4.1.1.2 Geologic Structures

The several mountain ranges that traverse Hanford (Figure 4.1.1-1) represent potential earthquake sources and were therefore considered in the seismic analyses summarized in Section 4.1.1.4. Structurally, the mountains are characterized by asymmetric anticlinal highs separated by broad synclinal valleys. Wrench faults and thrust faults are associated with these structures. On Gable Mountain, wrench faults as long as 3 km have been identified. South of Rattlesnake Mountain, the Rattlesnake-Wallula alignment is a right-lateral strike-slip fault (DOE-14). Thrust faults have been observed on some of the limbs of the anticlinal mountains. Some of the faults at and near Hanford are categorized in DOE-14 as *capable* as that term is defined in 10 CFR 100, Appendix A. (Appendix D contains a definition of *capable* fault.)

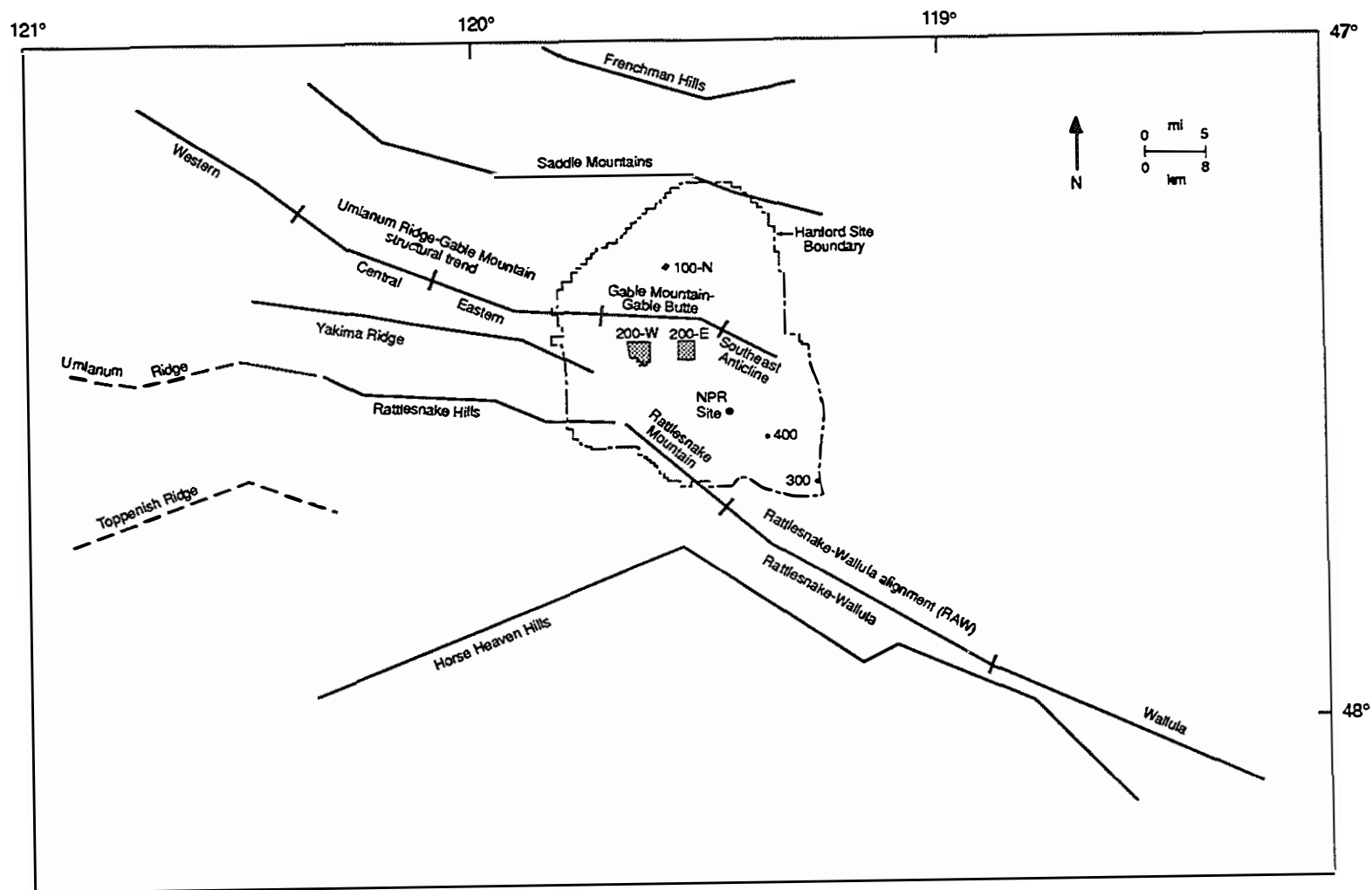


FIGURE 4.1.1-1 Mountain Ranges and the Potential Earthquake Sources Considered in the Seismic Analyses (Source: Tallman 1989)

4.1.1.3 Volcanism

Quaternary and Holocene volcanic activity has occurred in the Cascade Mountains west of Hanford. Mount St. Helens and Mount Adams are, respectively, about 220 and 165 km west of Hanford. In May 1980, 0.1 cm of ash accumulated at Hanford during a 9-hour period after the violent eruption of Mount St. Helens. About 6,600 years ago, up to 10 cm of tephra accumulated in eastern Washington after the eruption of Mount Mazama in southern Oregon.

Because of their close proximity, the volcanic mountains of the Cascades are the principal volcanic hazard at Hanford. Although probabilistic risk assessments for this hazard at Hanford have not been conducted, the engineering design for the WNP-2 nuclear power plant allows for a design-basis ash fall of 7.5 cm (stated as 3 compacted inches) within a 20-hour period (Tallman 1989). The major concern is how an ash fall might affect the operation of cooling towers, communications equipment, and electronic devices.

4.1.1.4 Seismicity

The locations of historic (1850-1969) seismic events with respect to the Hanford Site are shown in Figure 4.1.1-2. Instrumental data gathered subsequently are shown in Figure 4.1.1-3 for events of magnitude 3 or larger. Historical earthquakes are reported as Modified Mercalli Intensities (MMI). As shown in Appendix D, the Modified Mercalli Intensity scale is a measure of the strength of ground motion and as such is partly a function of distance from earthquake source. Here these values are reported as the maximum values that would be felt closest to the source. A scale showing comparable calculated Richter magnitude is also given in Figure 4.1.1-2. Instrumental data for Hanford were reported from coda-length magnitudes. Coda-length magnitudes are measured from the concluding part of the seismograph record. For purposes of comparison in this case, these can be taken as approximately equal to Richter magnitude.

Large earthquakes have occurred in the Pacific Northwest in historic time. In 1872, an earthquake with an estimated magnitude of 7 struck north-central Washington approximately 130 km from the Hanford Site (Malone and Bor 1979) (Figure 4.1.1-2). Hanford is estimated to have been in MMI zone V for this event. Hanford is estimated to have been in MMI zone IV for the 1936 Milton-Freewater, Oregon, earthquake, which had a magnitude of 5.75.

Seismic hazard analyses have been conducted for nuclear facilities at Hanford. The seismic hazard curves constructed for a number of areas at Hanford are based on ground accelerations and recurrence intervals greater than magnitude 5 (see Figure 4.1.1-4). In 1989, Rohay analyzed earthquake recurrence rates based on historical and instrumental data for the Yakima fold belt, as well as for the eastern Washington region (see Figure D.4). He concluded that the appropriate recurrence rate for Hanford (based on events of greater than magnitude 5) was the same as the recurrence rate based on historical data for the eastern Washington region (Rohay 1989; Woodward-Clyde Consultants 1989). Because the probability of large accelerations is greatest close to Gable Mountain, and because the proposed NPR site is about 5 km closer to Gable Mountain than the 400 Area, the NPR site may have a higher hazard curve. Hazard curves like the ones presented here in Figure 4.1.1-4 have been used to project theoretical peak ground accelerations for the development of severe radiological accident scenarios at NPR support facilities. The results of these seismic analyses, which are being conducted by Lawrence Livermore National Laboratory (1990) and Murray and Wesley (1990), are presented in Appendix J.

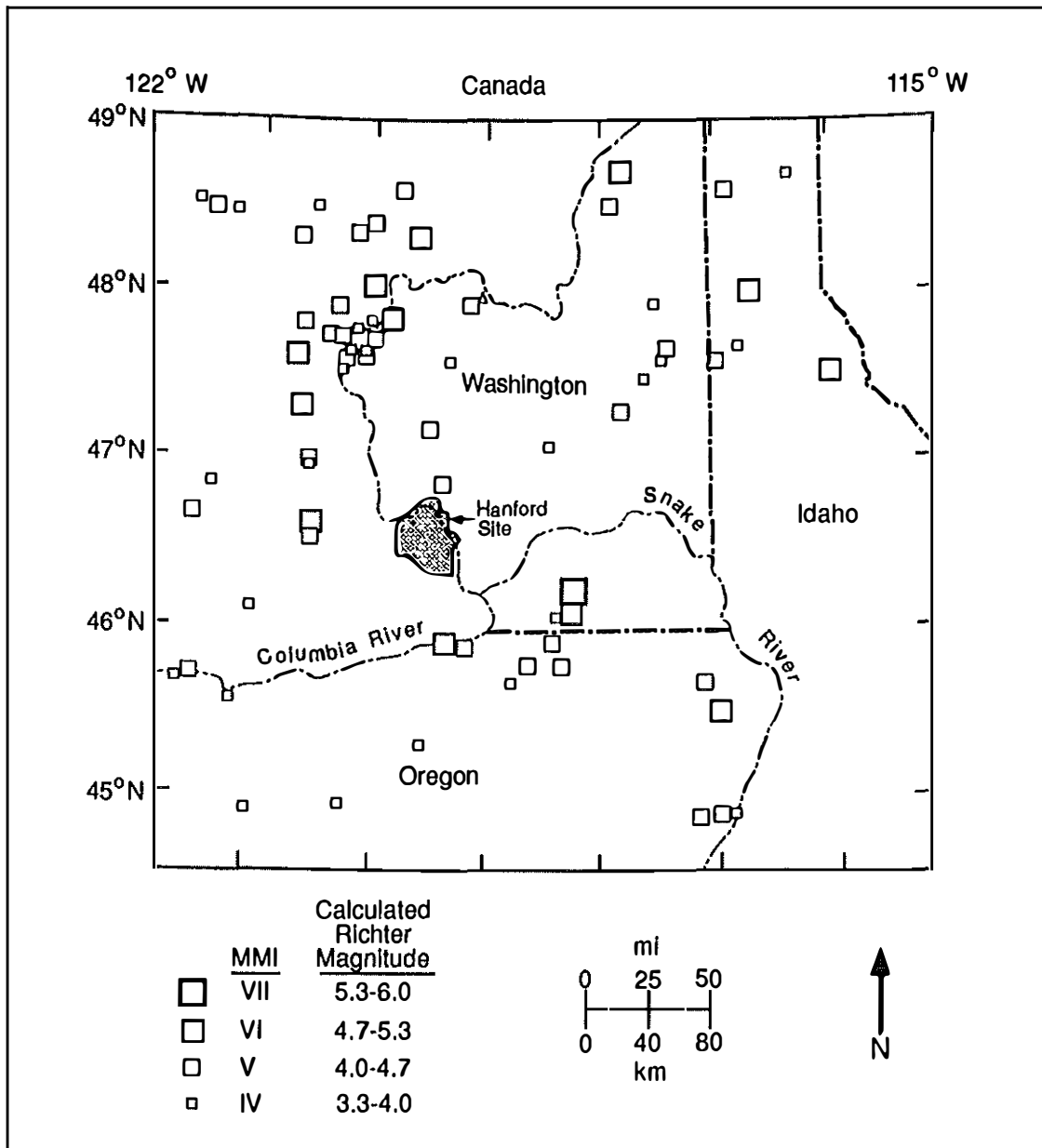


FIGURE 4.1.1-2 Historic Seismicity of the Hanford Area, 1850-1969 (includes all earthquakes with a Modified Mercalli Intensity [MMI] of IV or larger and a magnitude of 3.3 or larger) (Source: Modified from Rohay 1989)

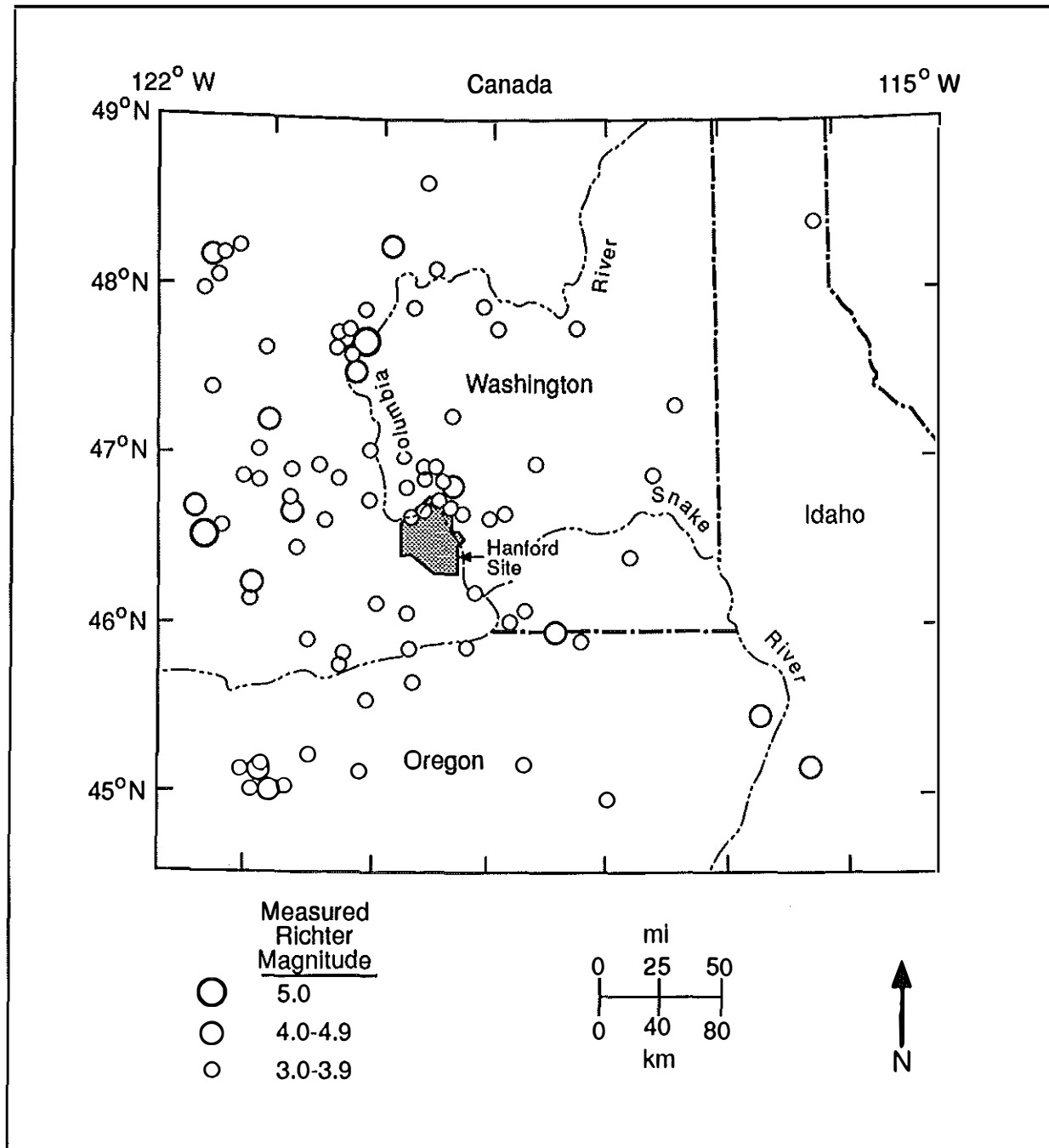


FIGURE 4.1.1-3 Recent Seismicity of the Hanford Area, 1969-1989 (includes all earthquakes with a magnitude of 3 or larger) (Source: Modified from Rohay 1989)

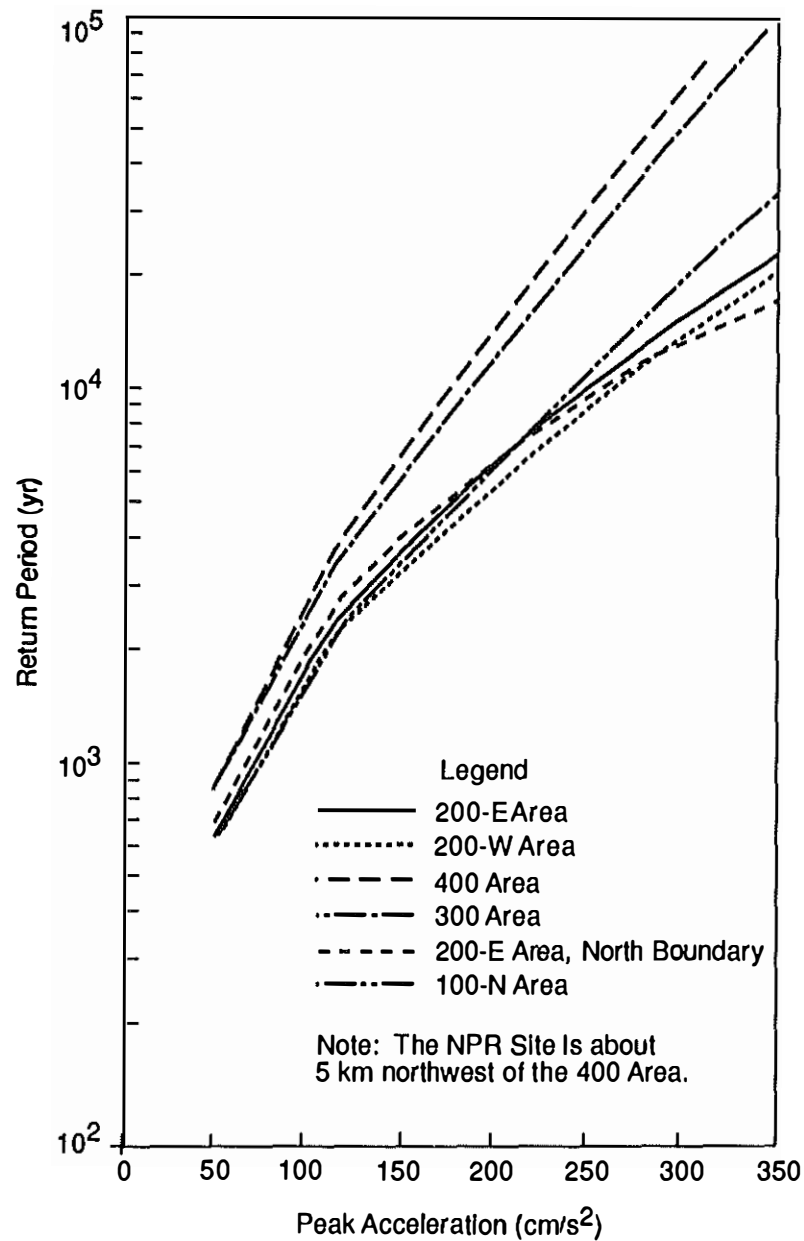


FIGURE 4.1.1-4 Seismic Hazard Curves for Six Sites at Hanford
(Source: Modified from Tallman 1989)

4.1.1.5 Soils

Hajek (1966) lists and describes 15 different soil types at Hanford. The soil types vary from sand to silty and sandy loam. The soils of the WNP-1 and NPR sites have not been classified by the U.S. Department of Agriculture's Soil Conservation Service with respect to Prime Farmland and Unique Farmland criteria. None of the soils of the WNP-1 or NPR sites would be classified as Unique Farmland; however, they might be classified as Prime Farmland (Appendix D, Section D.1).

4.1.2 Air Resources

4.1.2.1 Climate and Meteorology

The climate at the Hanford Site and in the surrounding region is characteristically that of a semiarid steppe. The humidity is low, and winters are mild.

The meteorological data from the Hanford Meteorological Station (Appendix E, Figure E.1) and the Hanford Townsite Station (located 16 km to the northeast) are considered representative of regional climatic conditions. The following climatological and meteorological information is primarily based on data collected from these two stations and summarized in reports prepared by Pacific Northwest Laboratory (PNL-4) and Stone et al. (1983).

Wind

Prevailing wind directions at Hanford are from the west-northwest, with a secondary maximum frequency from the southwest. The annual average wind speed measured at the 15-m level at the Hanford Meteorological Station is 3.4 m/s. Monthly average wind speeds range from 2.7 m/s in November and December to 4.1 m/s in June. Winds with speeds well above average are usually from the southwest.

Temperature and Humidity

The annual average temperature at Hanford is 11.7°C; monthly average temperatures vary from -1.5°C in January to 24.7°C in July. The annual average relative humidity at Hanford is 54%, with monthly average values ranging from 32% in July to 80% in December.

Precipitation and Evapotranspiration

The average annual precipitation at Hanford is 16.0 cm. More than 40% of the annual precipitation occurs from December through February. Snowfall accounts for about 38% of the total precipitation during winter.

The nearest sites where evaporation data are collected are located approximately 39 km southwest of the Hanford Meteorological Station (DOE-12). Potential evapotranspiration is five to nine times higher than average annual precipitation (DOE-12). Results from studies underway

for several years indicate that, given the low precipitation, the semiarid climate, and sandy soils with little or no vegetation, the amount of deep seepage or drainage below the Hanford Site is small (DOE-13).

Fog and Visibility

Fog (visibility ≤ 9.6 km) occurs an average of 42 days per year at Hanford, and heavy fog (visibility ≤ 0.4 km) occurs an average of 25 days per year. The average duration of heavy fog is 4 hours per day, and the maximum duration from 1953 to 1980 was 47 hours.

The regional background visual range in the Hanford area is estimated to be about 60 km (Trijonis and Shapland 1978). Phenomena other than fog (e.g., dust, blowing dust, and smoke) can also reduce visibility. The number of days with restricted visibility (i.e., ≤ 9.6 km) is small, averaging 5 days per year due to blowing dust and less than 1 day per year due to smoke.

Severe Weather

Strong winds at Hanford are associated with the summertime southwesterly winds and afternoon drainage winds and thunderstorms. The summertime drainage winds, which are generally from the northwest, frequently reach 13 m/s. The strongest winds estimated for the 15-m level at the Hanford Meteorological Station having recurrence intervals of 10, 100, and 1,000 years are 32, 38, and 44 m/s, respectively.

On the average, thunderstorms occur 10 times per year. Only about 2% of the thunderstorms observed at the Hanford Meteorological Station can be classified as "severe," that is, having wind gusts of 26 m/s or greater. In the northwest portion of the United States, tornadoes are generally small and rarely occur. From 1916 to 1982, 22 tornadoes were reported within 160 km of the Hanford Site, an average of about one tornado every 3 years. The estimated probability of a tornado striking a point at Hanford is 10^{-5} /yr (Ramsdell and Andrews 1986).

Atmospheric Dispersion Characteristics

Atmospheric dispersion improves if the wind speed increases, stability conditions become more unstable, and the depth of the mixing-layer increases. Annual and seasonal data on the frequency distribution of wind speed by wind direction and atmospheric stability class at the Hanford Meteorological Station are summarized in Stone et al. (1983).

Remote sensors have been used at the Hanford Meteorological Station to estimate mixing-layer depths (PNL-4). The approximate annual and seasonal morning and afternoon mixing-layer depths at Hanford, as estimated by Holzworth (1972), are listed in Table E.1.

4.1.2.2 Ambient Air Quality

Most of the Hanford Site is located within the South Central Washington Intrastate Air Quality Control Region (AQCR), with a small portion of the site being located in the Eastern

Washington-Northern Idaho Interstate AQCR. As of 1990, none of the areas within the Hanford Site and its surrounding counties was designated as a nonattainment area with respect to any of the National Ambient Air Quality Standards (NAAQS) (40 CFR 81.348). The NAAQS and Washington state ambient air quality standards are listed in Table E.2.

The major sources of criteria air pollutants at Hanford are (1) the coal-burning boilers (steam generation) located in the 200 and 300 areas, (2) an oil-fired boiler in the 100 Area, and (3) the Plutonium-Uranium Extraction Plant in the 200 Area. Other emissions include fugitive particulate emissions from coal piles, other process emissions, vehicular emissions, and temporary emissions from various construction activities. Emission estimates for these sources are presented in Table E.3.

Prevention of Significant Deterioration (PSD) regulations (40 CFR 52.21) limit the maximum allowable incremental increases in ambient concentrations of sulfur dioxide (SO₂), nitrogen dioxide (NO₂), and particulate matter (PM) as total suspended particulate (TSP) above established baseline conditions. The PSD regulations, which are designed to protect ambient air quality in attainment areas, apply to major new sources and major modifications to existing sources. The maximum allowable PSD increments are listed in Table E.4. The PSD concentration increments consumed at the Hanford Site boundary by the PSD sources issued permits to date in the Hanford area are estimated to be very small. (See Table E.5 for the PSD concentration increments consumed to date at the Hanford Site boundary.)

Ambient air quality within and near the Hanford Site is currently monitored for NO₂ (seven locations) and PM (one location for PM₁₀ and four locations for total suspended particulate [TSP]) (Figure E.1). The ambient air quality data collected at these stations during 1988 (given in Table E.6) were well below applicable ambient standards, except for the PM concentrations at off-site stations farther from the Hanford Site boundary (stations 12-14 in Figure E.1). The PM concentrations at the off-site stations were either very close to or above applicable standards.

Ambient concentrations of other pollutants (e.g., SO₂ and carbon monoxide [CO]) have been periodically monitored in the communities and commercial areas southeast of the Hanford Site and/or on-site (NRC-2). Estimates of maximum ambient background concentrations of criteria air pollutants, on the basis of data collected in the vicinity of the Hanford Site (PNL-4), are listed in Table E.2.

Toxic air pollutants that would be released from the proposed NPR and its support facilities, and for which ambient standards have been established by the Washington Department of Ecology (WDOE), include ammonia (NH₃), acetone (C₃H₆O), 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), and nitric acid (HNO₃). The annual emission rates of these pollutants from existing Hanford facilities and the maximum 24-hour average ground-level concentrations resulting from these emissions, as estimated at the Hanford Site boundary, are listed in Table E.21. The concentrations for NH₃, C₃H₆O, and TCA are significantly below their respective maximum allowable ambient standards established by WDOE (WDOE-1). There does not at present exist a Washington Department of Ecology standard for Freon-113 as a toxic air pollutant.

4.1.2.3 Acoustic Conditions

The major noise sources within the Hanford Site include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, construction and materials-handling equipment, and vehicles). At the Hanford boundary, away from most of these industrial facilities, noise from these sources would be barely distinguishable from background noise levels.

Data from two noise surveys (NRC-2; Coleman 1988), which are summarized in PNL-4, indicate that background noise levels (L_{eq}) during the daytime at a reference boundary location (western shore of the Columbia River about 4.0 km east of the WNP-1 site) were in the range of 47-52 dBA. These noise levels were influenced by recreational boating activities on the river. At remote areas (i.e., upstream section of the Columbia River), background noise levels (L_{eq}) ranged from about 30 to 33 dBA.

The EPA guideline recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA-1). For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.

The Noise Control Act of 1972, together with its subsequent amendments (Quiet Communities Act of 1978, 42 USC 4901-4918), leaves it to the states to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. The maximum allowable noise limits at the various classes of receptor areas applicable to the Hanford Site under the Washington State Noise Control Regulations are listed in Table E.7.

Receptor areas nearest to the Hanford Site boundary are a few farmhouses about 4.5 km east of the WNP-1 site and an industrial area about 11 km south of the boundary at the northern border of Richland.

4.1.3 Water Resources

This section describes current characteristics of water resources at the Hanford Site. Potential changes in water resources from future closure of the Plutonium-Uranium Extraction Plant (PUREX), a non-NPR facility, are discussed under the impacts of no action (Section 5.2.2.1). That analysis defines the baseline conditions against which NPR impacts are assessed. Surface water features that might be significantly affected by construction and operation of an NPR or by closure of the PUREX facility are the Columbia River, West Lake, and two wastewater disposal ponds near the 200 and 400 areas (B Pond and the Fast Flux Test Facility [FFTF] Pond in Figure 4.1.3-1). Groundwater features that might be significantly affected include the unconfined aquifer of the Hanford and Ringold Formations. The potential for and significance of impacts to these water resources from construction and operation of an NPR are discussed in Section 5.2.2. Wetlands in the Hanford vicinity are described in Section 4.1.5.2.

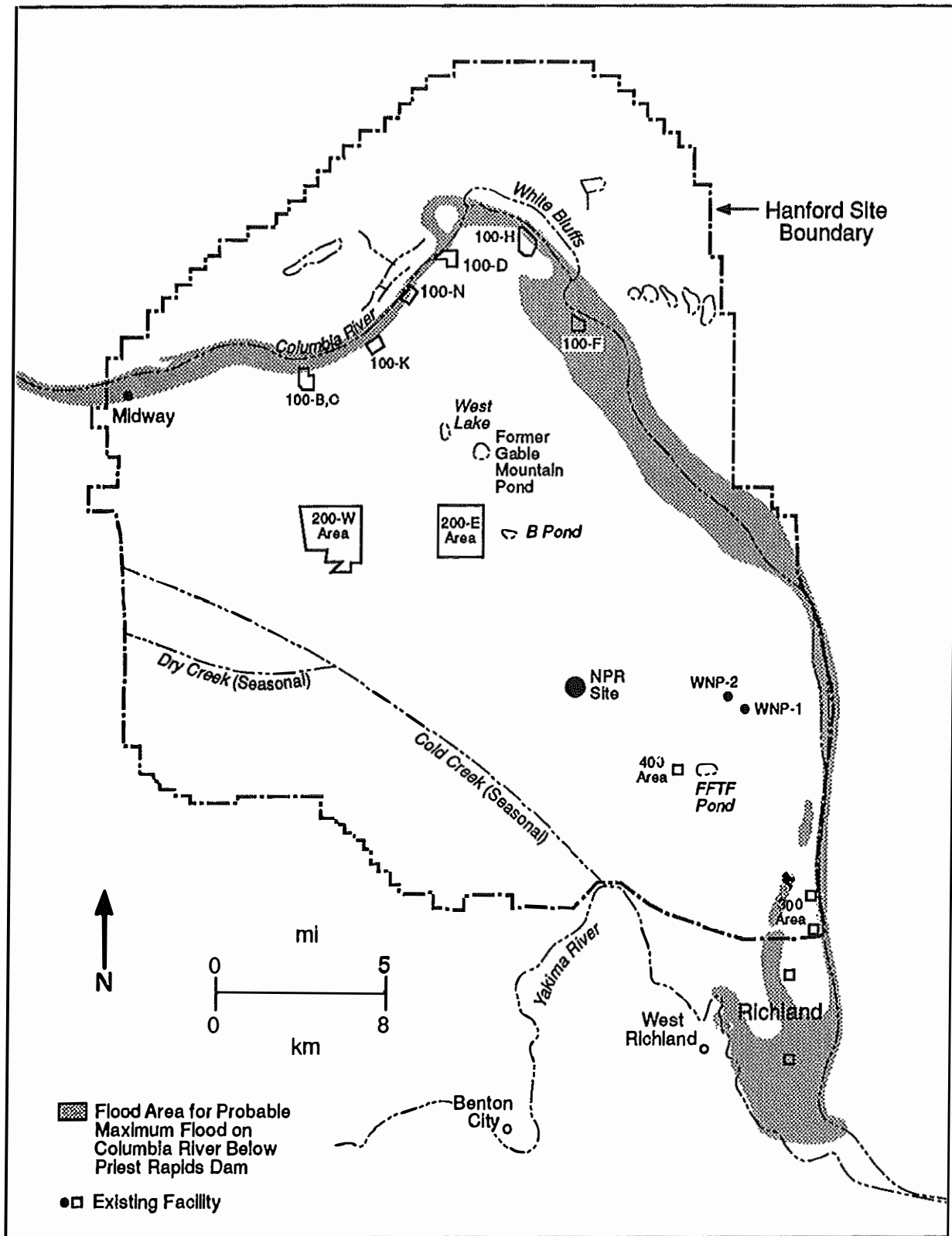


FIGURE 4.1.3-1 Surface Water Features at the Hanford Site and Estimated Floodplain Boundaries for the Probable Maximum Flood (Source: Modified from DOE-14)

4.1.3.1 Surface Water

Description

The areas proposed for NPR facilities at Hanford, including the WNP-1 site, the NPR site, the 200-East Area, and the 400 Area, are all within the watershed of the Columbia River. The portion of the Columbia River in the Hanford Site vicinity is referred to as the Hanford Reach. The Hanford Reach extends from Priest Rapids Dam, about 8 km upstream of the northern boundary of the Hanford Site, to the headwaters of Lake Wallula, about 80 km downstream of the southern boundary of Hanford. The Hanford Reach is the single remaining free-flowing stretch of the Columbia River in the United States; however, flow is regulated by the seven upstream dams operated by the Corps of Engineers (Figure 4.1.3-2). Approximately two-thirds of the surface runoff from the Hanford Site, including the NPR site, flows toward the Columbia River; however, losses from infiltration to the ground and evaporation prevent this runoff from reaching the river.

Flow in the Hanford Reach has been described in detail by the Corps of Engineers (DOE-14). The maximum recorded flow at what is now the Hanford Site was 20,900 m³/s on June 1, 1894. The probability of recurrence of similar flows has been greatly reduced by installation of upstream dams. For a 72-year period ending September 1989, the average annual flow in the Hanford Reach at Priest Rapids Dam was 3,490 m³/s (USGS 1990). A minimum flow of approximately 1,010 m³/s is maintained in the Hanford Reach along the Hanford Site.

West Lake, located near the 200-East Area, is a naturally occurring body of water that is recharged by groundwater. Before Hanford operations began, West Lake was a seasonal surface water feature. However, infiltration from Hanford waste disposal activities has raised the groundwater level at the West Lake area, and the lake now contains water year-round. West Lake does not receive planned discharges from Hanford operations. Three man-made, unlined ponds that receive waste effluent discharges, or have received them in the past, include B Pond, FFTF Pond, and Gable Mountain Pond (Figure 4.1.3-1). B Pond receives cooling water from fuel processing and other liquid waste discharges from operations in the 200-East Area. The FFTF Pond primarily receives cooling water effluent from 400 Area facilities. Gable Mountain Pond was used for disposal of liquid waste discharges from the 200-East Area before 1987. This pond was decommissioned in 1987. It was backfilled and stabilized with grasses and no longer exists as a surface water feature.

Surface Water Quality

Columbia River water is routinely analyzed for radioactive and nonradioactive constituents (PNL-2). This monitoring is conducted both upstream of the Hanford Site waste streams (at either the Priest Rapids Dam or the Vernita Bridge) and downstream (at Richland, Washington).

Concentrations of radioactive constituents in river water samples collected at the Priest Rapids Dam and at Richland in 1987 are listed in Tables F.1 and F.2, respectively. Although tritium levels in samples were higher downstream of the Hanford Site than upstream, levels of all radioactive constituents in upstream and downstream samples were below both the state of

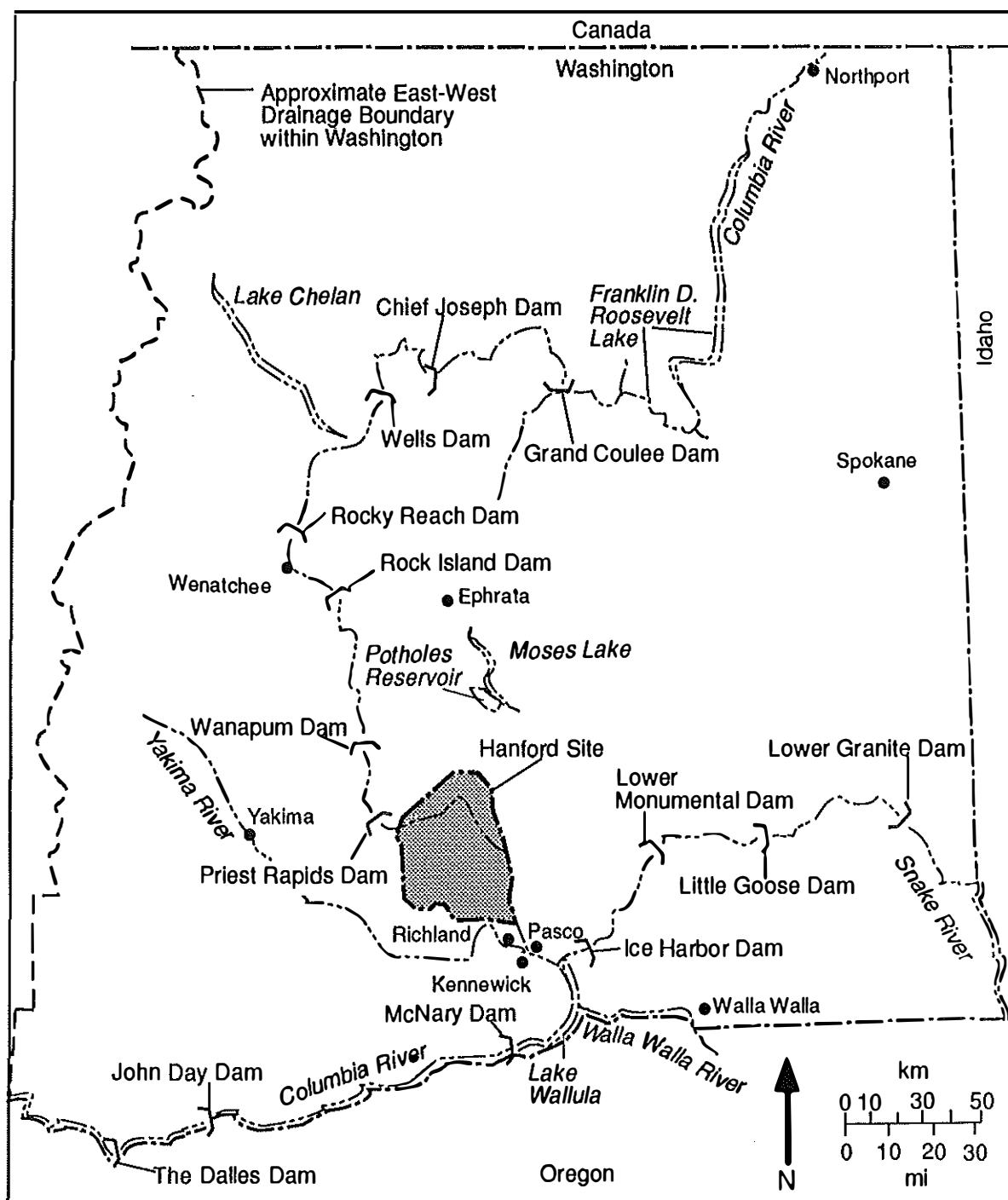


FIGURE 4.1.3-2 Locations of Dams along the Columbia River (Source: Modified from Cushing 1990)

Washington's drinking water standards and the Federal drinking water standards established by the Safe Drinking Water Act. In 1987, nonradioactive constituents in Columbia River water samples both at the Vernita Bridge and at Richland were mostly within the state's water quality standards for the Hanford Reach (Table F.3). The Washington Department of Ecology has classified the water quality of the Columbia River between the Grand Coulee Dam, upstream of the Hanford Site, and the mouth of the Columbia River near Astoria, Oregon, downstream of the Hanford Site, as Class A, Excellent. The Class A designation requires that the water be usable for substantially all needs, including drinking water, recreation, and wildlife (PNL-2).

Radioactive constituents in discharges from the Hanford Site to the Columbia River are listed in Table F.4. All nonradioactive discharges from Hanford Site operations to the Columbia River must meet requirements of National Pollutant Discharge Elimination System (NPDES) Permit WA-000374-3. The eight drains on the Hanford Site that discharge to the Columbia River consist of five in the 100-N Area, two in the 100-K Area, and one in the 300 Area (Figure 4.1.3-1).

Cooling water discharges from the WNP-2 nuclear power plant produce the only thermal plume in the Columbia River that results from activities at Hanford. Measurements in 1988 indicated that at 90 m downstream of the WNP-2 discharge, no water temperature differences attributable to the plume could be detected. That condition meets the requirements of the NPDES permit for WNP-2.

Water quality data for radioactive constituents in West Lake and the discharge ponds for 1987 and 1988 are shown on Tables F.6 and F.7. Elevated levels of gross alpha and gross beta activity are present in West Lake. The concentration of naturally occurring uranium is believed to contribute most to the unusual levels of this gross alpha and gross beta contamination. In 1987 and 1988, radioactive constituents at B Pond, FFTF Pond, and the now-dry Gable Mountain Pond were within the EPA Drinking Water Standards (PNL-2).

Water quality data for nonradioactive constituents in West Lake are shown in Table F.8. The lake is alkaline (pH >9.0) and saline. The very high levels of sodium, sulfate, and chloride are typical of a natural evaporation basin.

Floodplain

The floodplain at the Hanford Site has been delineated based on an estimate for the probable maximum flood, which is determined from the potentially maximum precipitation on the Columbia River basin upstream of the site and other hydrologic factors (e.g., soil moisture conditions, snowmelt, and tributary conditions) that result in maximum runoff. The probable maximum flood for the Columbia River below Priest Rapids Dam has been estimated to be 40,000 m³/s (DOE-14). The estimate did not consider the effects of dam failure upstream of the Hanford Site. The floodplain associated with the probable maximum flood is shown in Figure 4.1.3-1.

Surface Water Use

The Columbia River is not designated as a Wild and Scenic River or a Study River by the U.S. Department of the Interior; however, Public Law PL-100-605 (study of the Hanford Reach of the Columbia River) has authorized a study of the Hanford Reach to identify and evaluate its outstanding features (see Section 6.3.4).

Dams on the Columbia River regulate flows for hydropower production, flood control, and irrigation. In the area around the Hanford Site, Columbia River water is diverted for domestic, industrial, and agricultural use (Cushing 1990). Agricultural usage accounts for about 59% of the diversion, industrial usage accounts for 32%, and municipal usage accounts for 9% (Table F.9 and Figure F.1). The Hanford Site accounts for 23% of the total withdrawal. However, with the N Reactor currently in cold standby, the Hanford Site withdrawals account for only about 1.3% of the total withdrawal in the Hanford vicinity.

Surface Water Rights

The Washington Public Power Supply System currently holds a permit to withdraw water from the Columbia River for WNP-1. The DOE has asserted a Federally reserved water right with respect to Hanford operations and believes no water withdrawal permit is necessary for either the construction or operation of an NPR at Hanford.

4.1.3.2 Groundwater

Description

Important water-bearing geologic formations beneath the Hanford Site include the Hanford Formation, the Ringold Formation, and the Columbia River Basalt. A west-to-east cross-sectional view of these formations and of depth-to-water data across the Hanford Site is illustrated in Figure 4.1.3-3. The Hanford Formation is a series of sands, gravels, and some silts formed by the action of rivers and glaciers and deposited by water flow. The Ringold Formation, which includes the Middle Ringold, Lower Ringold, and the Basal Ringold units, consists of river and lake sediments. Groundwater in both the Hanford Formation and Ringold Formation flows in unconfined aquifers. The Columbia River Basalt is a thick series of basaltic flows and sedimentary interbeds that form confined aquifers in which water moves laterally, primarily along the top and bottom of individual basalt flows and in the interbeds (DOE-12). In the 200-East Area, the NPR site, and the WNP-1 site, groundwater in the aquifers moves generally to the east toward the Columbia River. This west-to-east flow is, however, interrupted locally by basalts intruding above the water table and by groundwater mounds created by surface water discharges. Both features impede water flow, as, for example, in the 200-East Area, where flow is diverted to the north by a large groundwater mound.

Depth to water is about 15 m at the WNP-1 site and 38 m at the NPR site. Figure 4.1.3-4 shows water-table elevations and the direction of groundwater movement in the unconfined aquifer at the Hanford site in June 1988. At the NPR site, groundwater in the unconfined aquifer flows generally from west to east and ultimately discharges to the Columbia River.

The unconfined aquifers at the Hanford Site are dynamic and respond to changes in natural and artificial recharge and to water withdrawals. Natural recharge to the unconfined aquifer of the Hanford Formation by surface water is rare because of high evaporation and transpiration. The unconfined aquifer is recharged naturally by upward leakage from the confined aquifer in the northern and eastern sections of the Hanford Site and artificially by infiltration of discharges to B Pond and FFTF Pond (DOE-14).

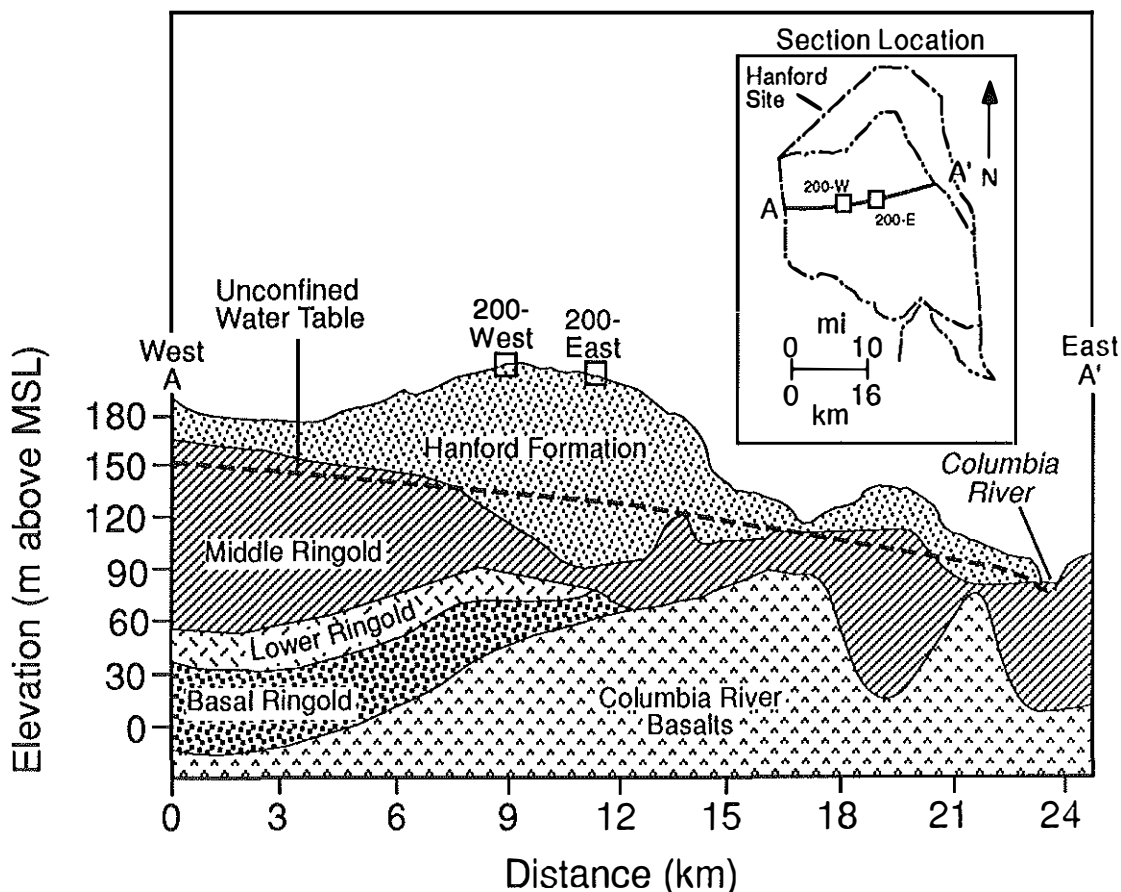


FIGURE 4.1.3-3 Geologic Cross Section and Water Table Elevation in the 200 Area of the Hanford Site (Source: Modified from PNL-2)

Groundwater Quality

Groundwater monitoring data have been published in the Hanford Site Environmental Report annually since 1956 (PNL-2). During 1988, samples were collected from 511 on-site wells in the unconfined and confined aquifers to monitor radioactive constituents and from 158 on-site wells to monitor nonradioactive constituents (PNL-2). The unconfined aquifer contains both radiological and nonradiological contaminants. Contamination in the confined aquifer typically is limited to areas where there is communication with the unconfined aquifer. Tritium and nitrate concentrations are monitored to define the extent of groundwater contamination in the unconfined aquifer. These two contaminants are monitored because both are present in most waste streams and both are mobile, moving at nearly the same velocity as the groundwater.

Tritium plumes have been identified in the unconfined aquifer in the vicinity of the 200 Area (Figure 4.1.3-5). Three of the plumes are moving generally southeast toward the Columbia River. One of the plumes correlates with Reduction-Oxidation Plant activities, and the other two are associated with discharges from the PUREX facility. One of those is associated with pre-1983 PUREX operations, and another correlates with post-1983 PUREX activities.

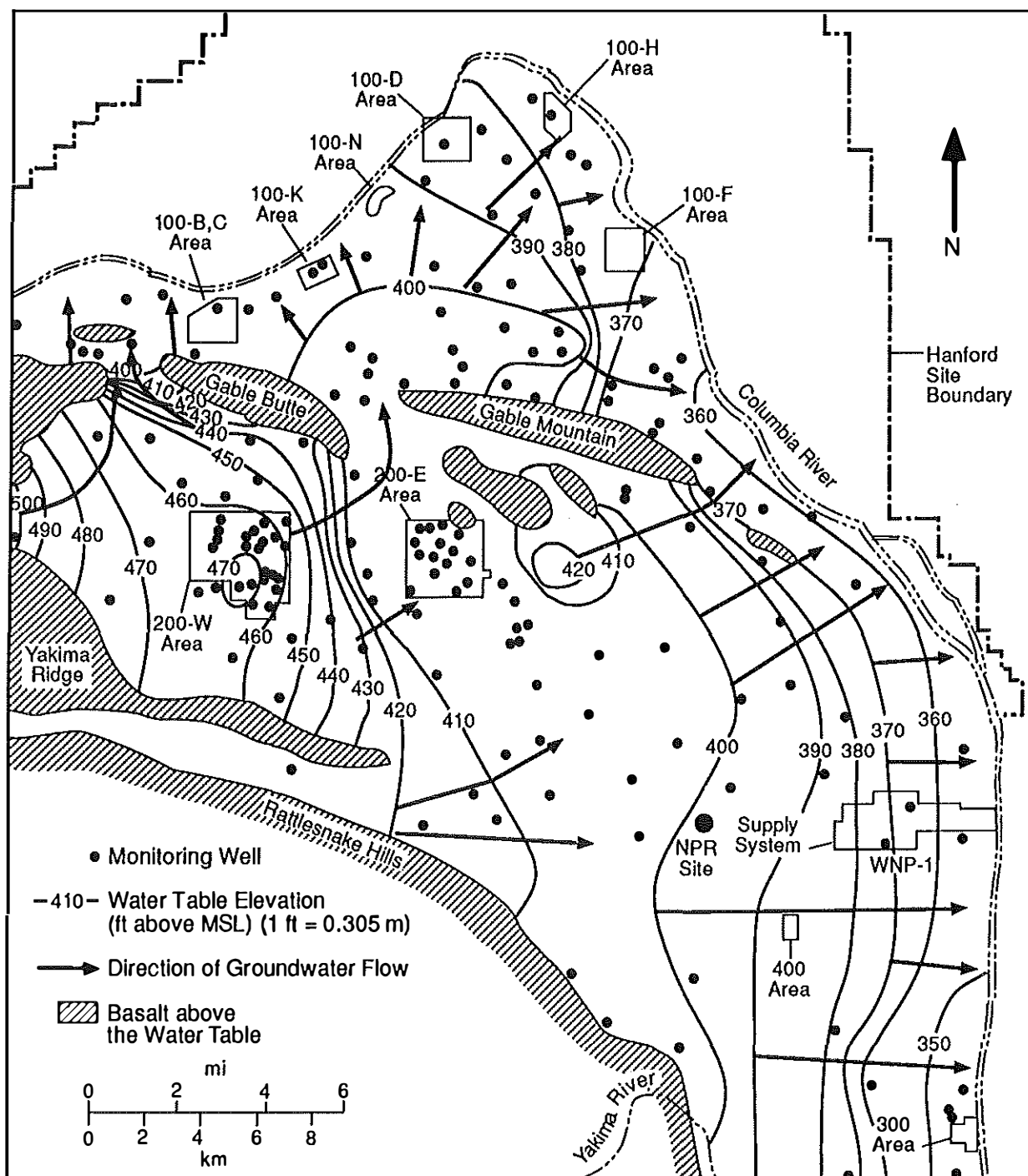


FIGURE 4.1.3-4 Water Table Elevations and the Direction of Groundwater Flow in the Vicinity of the NPR Site, June 1988 (Source: PNL-2)

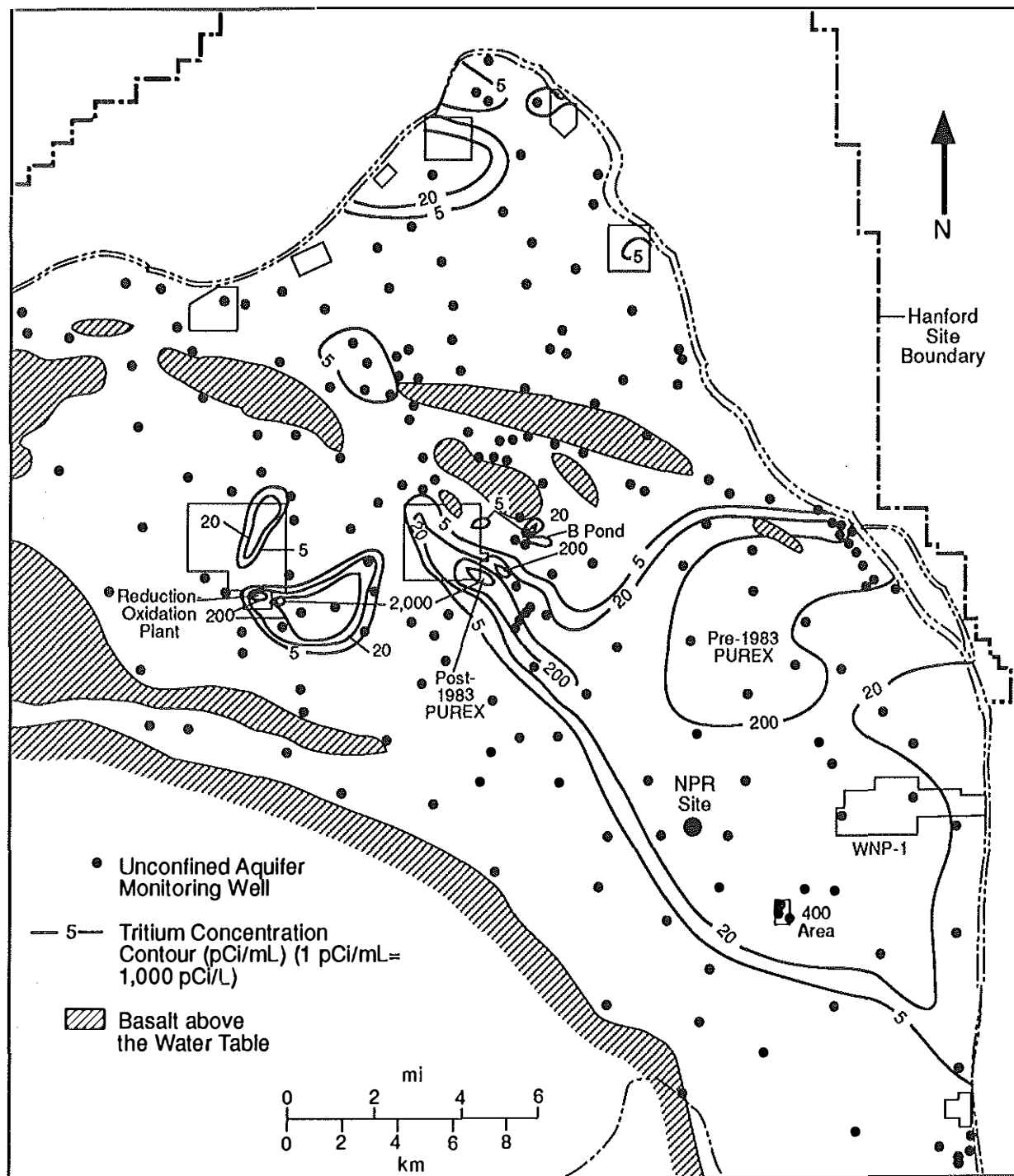


FIGURE 4.1.3-5 Tritium Concentrations in the Hanford Site Unconfined Aquifer, 1988 (Source: PNL-2)

Because the pre-1983 PUREX plume has already reached the Columbia River, a maximum travel distance of 24 km in 25 to 35 years, it is estimated that the migration velocity of these plumes ranges from 2 to 3 m/d.

Nitrate is used to estimate the extent of chemical contamination in the unconfined aquifer because, like tritium, it is present in most waste streams and is mobile in groundwater. The concentration distribution of nitrate in the Hanford Site unconfined aquifer in 1988 is shown in Figure 4.1.3-6. Nitrate is associated with liquid waste disposal facilities and with the use of nitric acid in decontamination and chemical reprocessing operations.

Groundwater Use

Approximately 50% of the water wells in the Pasco Basin (Figure F.1 in Appendix F) are for domestic use and are generally shallow (less than 150 m). Agricultural wells, used for irrigation and stock supply, account for about 24% of the wells. Only 3% of the wells in the Pasco Basin are for industrial use. The principal groundwater users within the Hanford Site are the Fast Flux Test Facility, with a 1988 withdrawal of 142,000 m³ from the unconfined aquifer, and Pacific Northwest Laboratory, with a water supply from a spring near Rattlesnake Hills (Figure 4.1.3-6) (Cushing 1990). Other groundwater uses on the Hanford Site include small supplies used to support remote training and laboratory facilities.

Groundwater Rights

The DOE has asserted a Federally reserved water right with respect to Hanford operations and believes that no water withdrawal permit is necessary for either construction or operation of an NPR at Hanford.

4.1.4 Land Use, Recreation, and Visual Environment

The Hanford Site is owned by the Federal government and operated for DOE by the Westinghouse Hanford Company in conjunction with the Hanford Environmental Health Foundation, Pacific Northwest Laboratory, Kaiser Engineers Hanford Company, U.S. Ecology, and the Washington Public Power Supply System. U.S. Ecology and the Washington Public Power Supply System occupy land leased from DOE. A commercial low-level waste disposal site, licensed by the state of Washington, and a commercial nuclear power plant, licensed by the U.S. Nuclear Regulatory Commission, are located within the Hanford Site.

Current land uses in the areas proposed for construction and operation of the NPR are industrial facilities or open land (Figure 4.1.4-1). Industrial facilities are located at the 200 East Area, the 400 Area, and the existing WNP-1 facility. The NPR site for the MHTGR and HWR reactors is open land. The majority of the Hanford Site is open land with shrub-steppe vegetation and terrain that alternates between hilly areas and flat, barren land along access roads. Because of the frequent variation in elevation, the line of sight is often interrupted by hilly terrain near or immediately adjacent to Hanford's roads. Long-distance views (greater than 5 km) occur most often on roadways that are used to access buildings and structures. Transmission lines can be seen from almost all locations at Hanford. A high, flat ridge follows

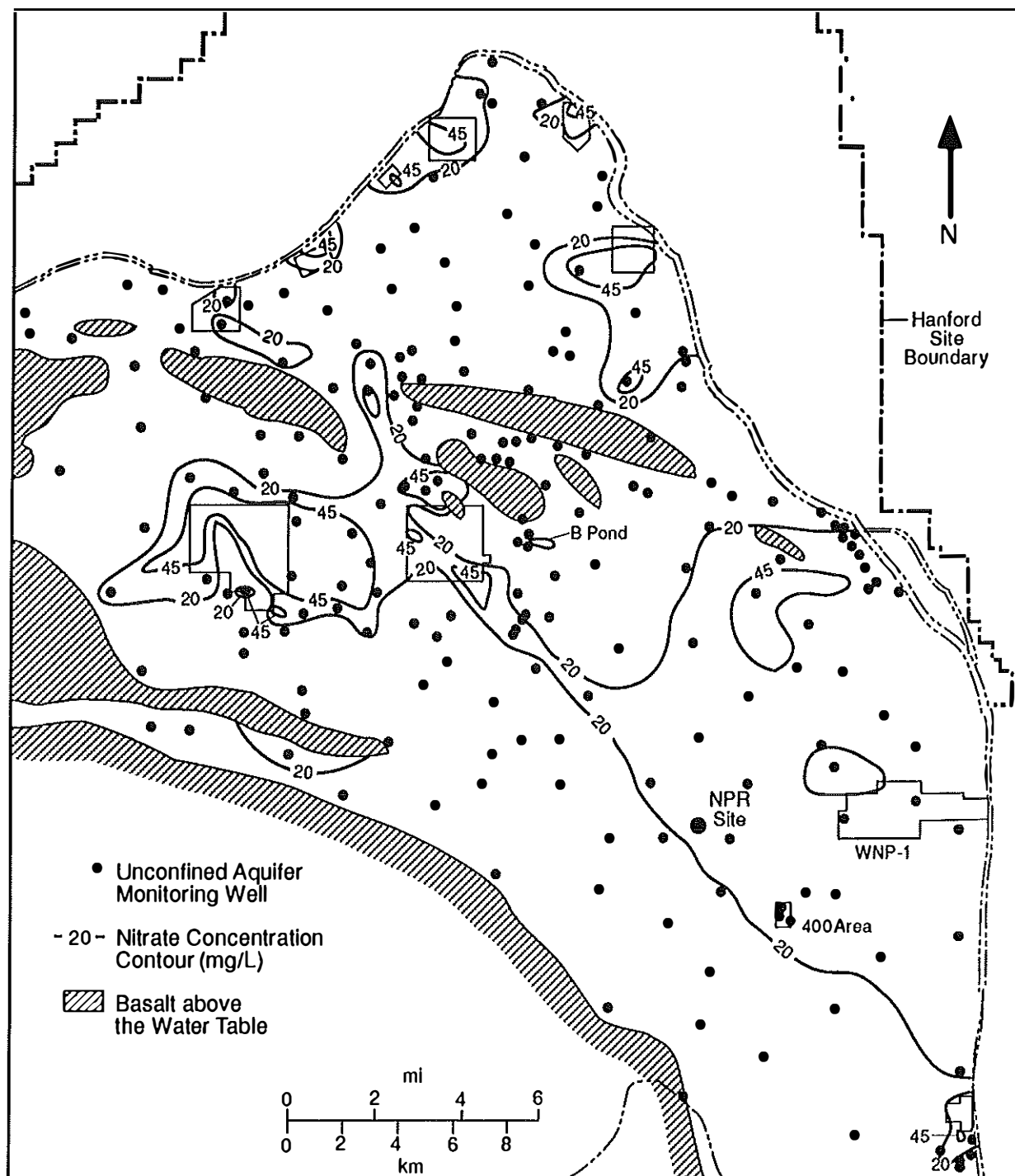


FIGURE 4.1.3-6 Nitrate Concentrations in the Hanford Site Unconfined Aquifer, 1988 (Source: PNL-2)

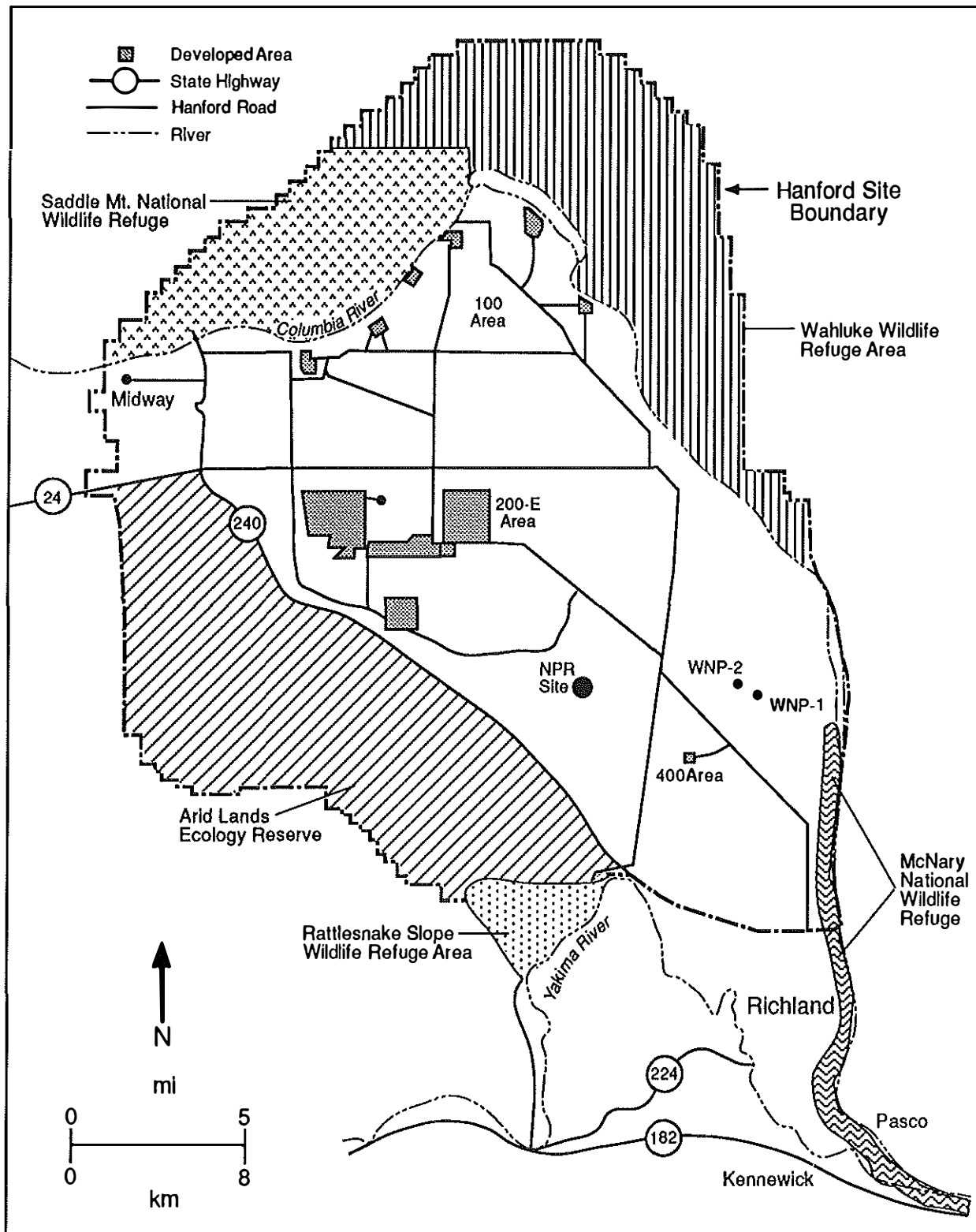


FIGURE 4.1.4-1 Land Use at the Hanford Site (Source: Modified from Cushing 1990)

the northern and eastern banks of the Columbia River at the eastern border of the Hanford Site. The land east of the ridgeline, primarily farmland, provides long-distance views of Hanford.

The entire Hanford Site is designated as a National Environmental Research Park (DOE-29). Ecological data have been collected there for more than 40 years. Areas constituting nearly one-half of the Hanford Site are designated as wildlife refuges (Figure 4.1.4-1). These refuges, which buffer developed areas, include the Rattlesnake Slope and Wahluke wildlife refuge areas, managed by the Washington State Department of Game; the Saddle Mountain and McNary national wildlife refuges (including all the islands in the Columbia River adjacent to and bounding the Hanford Site), managed by the U.S. Fish and Wildlife Service; and the Arid Lands Ecology Reserve, managed by DOE.

About 90% of the land in the three-county area that includes and surrounds the Hanford Site is used for agriculture (irrigated and dry-land farming and grazing), and 10% consists of urban/built-up area. Much of the regional industry is associated with agricultural and energy-production activities. Agricultural land use is stable and expected to remain so (Cushing 1989). Major crops include grains (such as wheat and corn), fruits (such as apples and grapes), and vegetables. Hanford workers live in the urban/built-up areas, which are located primarily south of the Hanford Site. The cities of Richland, Pasco, and Kennewick are the principal communities in the region and are collectively referred to as the Tri-Cities.

The Columbia, Snake, and Yakima rivers converge at the Tri-Cities, and the area provides a wide range of boating, fishing, camping, and picnicking facilities. Lakes formed by dams on the Columbia River attracted more than 3 million visitors in 1986 (Cushing 1989). Fishing for steelhead, sturgeon, trout, walleye, and bass; and hunting for migratory waterfowl and upland game birds are popular recreational activities. Other recreational facilities in the area include 12 indoor and 80 outdoor tennis courts, 7 golf courses, 4 bowling centers, several public and private swimming pools, numerous ball fields, skating rinks, and several hundred camp sites.

4.1.5 Biotic Resources

This section describes the biotic resources of the Hanford Site, with emphasis on those components that might be affected by construction and operation of an NPR. More detailed information on these resources, including common and scientific names of plant and animal species, is presented in Appendix G, Section G.1. Additional descriptions of the ecology of the Hanford Site are in reports by the Energy Research and Development Administration (ERDA-1), Rogers and Rickard (1977), Jamison (1982), Watson et al. (1984), Rickard and Poole (1989), and Cushing (1989).

4.1.5.1 Terrestrial Resources

Most of the land on the Hanford Site is undeveloped, providing an undisturbed area of shrub-steppe desert (Daubenmire 1970); however, clusters of large buildings associated with nuclear materials production occur at widely spaced locations. Ten major plant communities have been identified on the Hanford Site (Figure 4.1.5-1) (Cushing 1989), but in general, the site is dominated by big sagebrush with scattered stands of antelope bitterbrush, rabbitbrush, and

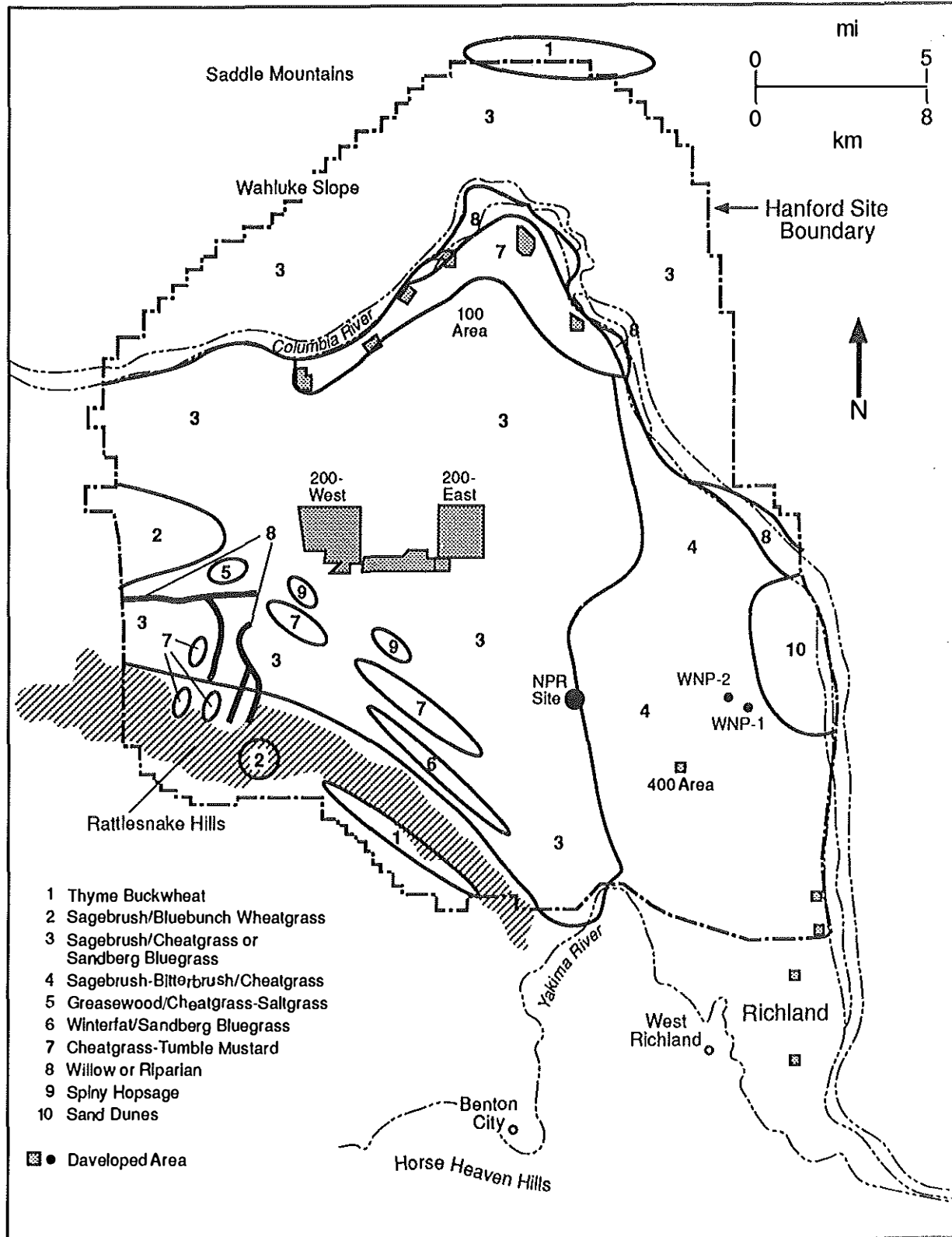


FIGURE 4.15-1 Distribution of Major Plant Communities on the Hanford Site (Source: Cushing 1990)

several other shrub species (Rickard and Poole 1989). The most common grasses on the site are native perennial bunchgrasses, such as bluebunch wheatgrass and Sandberg's bluegrass. Areas previously disturbed by agricultural activities are dominated by nonnative species, such as cheatgrass (Cushing 1990; Rickard and Rogers 1983).

Hanford provides suitable habitat for numerous animal species, including 15 species of reptiles and amphibians, 125 species of birds, and 30 species of mammals (Cushing 1989; see also Appendix G, Table G.1). Common animal species on the Hanford Site include the side-blotched lizard, gopher snake, western meadowlark, horned lark, Great Basin pocket mouse, and black-tailed jackrabbit. Although Hanford supports several species of game animals (including waterfowl, chukar, elk, and mule deer), the only hunting allowed on the site is for waterfowl along the Columbia River.

The land on and in the vicinity of the Hanford NPR site, where an HWR or MHTGR would be located, is similar to other undisturbed areas of shrub-steppe habitat on Hanford (Cushing 1990). Detailed surveys have not been conducted on the NPR site to determine the relative abundance of plant and animal species, but reconnaissance surveys have identified general habitat characteristics there (Cushing 1990). Shrubs, especially big sagebrush and bitterbrush, are widely spaced on the NPR site and provide less than 20% canopy cover (Cushing 1990). The dominant understory plants on the NPR site are grasses, especially cheatgrass, Sandberg's bluegrass, Indian ricegrass, June grass, and needle-and-thread grass.

The WNP-1 site, where an LWR would be located, is near the middle of a relatively flat plain dominated by sagebrush, native perennial grasses, and introduced annual grasses. The site is surrounded by a fence and contains the nearly complete WNP-1 reactor and its associated facilities. Most of this area has been disturbed during construction of WNP-1 facilities. Support facilities for an HWR, LWR, or MHTGR would be located in the 400 and 200-East areas. These areas are fenced, support ongoing industrial activities associated with Hanford operations, and contain little undisturbed habitat.

4.1.5.2 Wetlands

Natural wetlands on the Hanford Site consist of riparian areas along the Columbia River and several small, spring-fed streams (Figure 4.1.5-1). Several semipermanent artificial ponds that receive cooling water or irrigation wastewater are also present on Hanford and have wetland vegetation (e.g., cattails, reeds, and willows) around their periphery. These wetlands provide important habitat for songbirds, shorebirds, and waterfowl (Fitzner and Price 1973; Fitzner and Rickard 1975; Fitzner and Schreckhise 1979).

No wetlands occur at the WNP-1 site, the Hanford NPR site, or in areas where support facilities would be constructed. Wetlands in the vicinity of proposed NPR facilities off the NPR site and near the existing WNP-1 water intake structures are limited to a narrow band (about 10 m wide) of riparian vegetation along the Columbia River. This vegetation consists mostly of willows.

4.1.5.3 Aquatic Resources

Three types of aquatic habitats occur at Hanford -- the Columbia River, which flows through Hanford; the small, spring-fed streams and seeps located mainly in the Rattlesnake Hills along the southwestern boundary of Hanford; and the artificial water bodies (both ponds and ditches) formed as a result of wastewater disposal practices at the site (Cushing 1989). These water bodies provide habitat for a variety of fish (listed in Table G.1). Ponds on the site are temporary and will vanish with cessation of the industrial activities with which they are associated; however, they currently support aquatic ecosystems complete with representative flora and fauna. No surface water bodies occur on the NPR or WNP-1 sites or in areas where support facilities would be constructed. The water intake structures for the HWR or MHTGR options would be located in the Columbia River near the historical Hanford Townsite. The existing water intake for WNP-1 is located in the Columbia River.

The Columbia River supports a large and diverse community of plankton (small organisms that float within the water column), benthic (bottom dwelling) invertebrates, and fish (Cushing 1990). The Columbia River has been dammed both upstream and downstream of the Hanford Site, and the reach flowing through the area (the Hanford Reach) is the last free-flowing length of the river in the United States. Forty-four species of fish have been collected within the Hanford Reach (Gray and Dauble 1977; Cushing 1990). The species of greatest economic importance are chinook salmon, sockeye salmon, coho salmon, and steelhead trout (Cushing 1990). These salmonids use the Hanford Reach as a migration route to and from upstream spawning areas. Both the fall chinook salmon and steelhead trout also spawn in the Hanford Reach, and since 1962, the Hanford Reach spawning population has represented 15% to 20% of the total fall chinook production in the Columbia River (Cushing 1990). The destruction of other mainstream salmonid spawning areas on the Columbia River by river impoundments (dams) has increased the relative importance of the Hanford Reach for spawning (Cushing 1990). The taking of salmon from Columbia River stocks is subject to the United States-Canada Salmon Interception Treaty discussed in Section 5.2.11.

4.1.5.4 Threatened and Endangered Species

Federally and state-listed threatened and endangered species that occur on the Hanford Site and vicinity are listed in Appendix G (Table G.2). Seven of these species occur on or in the vicinity of the proposed site for HWR or MHTGR facilities (Table 4.1.5-1). These species are discussed in greater detail in Appendix G. No threatened or endangered species occur on the existing WNP-1 site proposed for the LWR alternative at Hanford. No critical habitat, as defined in the Endangered Species Act, exists on the Hanford Site (50 CFR 17.11 and 17.12).

The bald eagle is the only Federally listed species that is known to occur in the NPR project area (Cushing 1990). Bald eagles are regular winter residents along the Hanford Reach of the Columbia River and forage there for salmon and waterfowl. Trees in the historic Hanford Townsite area, the proposed location of the pumphouse and intake and discharge lines for the HWR or MHTGR alternatives, are used by eagles for perching. The peregrine falcon, also Federally listed, occurs as a migrant in the Hanford area and could occasionally be found in the vicinity of NPR facilities.

TABLE 4.1.5-1 Threatened and Endangered Species that Could Be Found in the Vicinity of NPR Facilities on the Hanford Site

Species	Status ^a		Known or Potential Location on NPR Site or Affected Areas
	Federal	State	
Plants			
Columbia yellow cress	C2	E	Riparian areas along Columbia River ^b
Mollusks			
Giant Columbia River limpet	C2	NL	Hanford Reach of Columbia River ^c
Giant Columbia River spire snail	C2	NL	Hanford Reach of Columbia River ^c
Birds			
Bald eagle	T	T	Hanford Townsite ^c
Peregrine falcon	E	E	NPR site, ^b Hanford Reach of Columbia River ^b
Swainson's hawk	C2	NL	NPR site, ^c Hanford Townsite ^c
Ferruginous hawk	C2	T	NPR site ^c
Long-billed curlew	C2	NL	NPR site ^c
White pelican	NL	E	Hanford Reach of Columbia River ^c
Sandhill crane	NL	E	NPR site, ^b Hanford Reach of the Columbia River ^c
Common loon	NL	C	Hanford Reach of Columbia River ^c

^aStatus: C = state candidate species; C2 = Category 2 species; E = endangered species; NL = not listed; and T = threatened species.

^bPotentially on NPR site or affected area.

^cKnown to occur on NPR site or affected area.

Source: Modified from Cushing 1989.

Several species that are candidates for listing by the Federal government (Category 2 species) are found in areas where construction activities would occur (Cushing 1990). These species include the long-billed curlew (nests throughout the NPR site), the ferruginous hawk (nests on the 230- and 500-kV transmission towers approximately 1 km from the NPR site and forages over the NPR site), and the Swainson's hawk (forages over the NPR site and nests at the Hanford Townsite). Habitats similar to those used by these species for foraging are relatively common on Hanford; nesting sites, however, are more limited. Two other Category 2 species -- the giant Columbia River limpet and the giant Columbia River spire snail -- are found in the Hanford Reach of the Columbia River. Although Category 2 species do not receive legal protection under the Endangered Species Act, the U.S. Fish and Wildlife Service (FWS) recommends that impacts to these species be considered in project planning.

Five salmon stocks currently are candidates for listing by the National Marine Fisheries Service (NMFS) as threatened or endangered. These stocks include the Snake River sockeye salmon; Lower Columbia coho salmon; and the spring, summer, and fall Snake River chinook salmon. The confluence of the Snake River with the Columbia River is approximately 40 km

downstream of the Hanford NPR site; therefore, Snake River salmon stocks are considered outside the affected environment of an NPR. The Lower Columbia coho salmon also is considered outside of the affected environment because that species spawns in areas below Bonneville Dam on the Columbia River, approximately 275 km downstream of the Hanford NPR site.

Columbia yellow cress, a Federal Category 2 and state-endangered plant species, occurs in riparian areas along the Columbia River (Cushing 1989) and could be present in areas disturbed during construction of the pumphouse and cooling water intake and discharge lines for an HWR or MHTGR. Several other state-listed species occur in areas that would be affected by an NPR. These include the white pelican and sandhill crane (both endangered) and the common loon (a candidate for listing) (Cushing 1989). All three of these species use the Hanford Reach of the Columbia River, and the sandhill crane could also be found on the NPR site. State laws do not provide legal protection for state-listed species on Federally owned land, but these species are considered here because of their regional importance.

4.1.6 Cultural Resources

Fifteen surveys have been conducted in areas that would be affected by the construction of an NPR at the Hanford Site. These surveys, combined with other data, indicate that the affected areas contain two isolated artifacts (NPR site), one prehistoric site and the historic Hanford Townsite (water intake and discharge corridor for the NPR site), two historic archaeological sites (near the NPR site), and five historic structures (200-East Area). Determinations of eligibility for the National Register of Historic Places (NRHP) will be made by the Washington State Historic Preservation Officer (SHPO). Consultations with potentially affected Native American groups, some of whom consider the area a homeland, have been initiated by DOE.

4.1.6.1 Regional Prehistory, History, and Ethnography

The archaeological record of the mid-Columbia region begins more than 11,000 years ago with Clovis hunters, whose distinctive spear points have been found scattered throughout the Northwest. Subsequently (10,700-3,500 years before present [B.P.]), people lived as nomadic foragers in the more arid central portions of the region, which includes the current Hanford Site. By 3,500-3,000 B.P., people had adopted a collector strategy (subsistence based on food harvesting and storage). During productive seasons, these people focused on harvesting and preserving provisions, which they later consumed while spending the winters in large pithouses. By 2,000 B.P., pithouses had become aggregated into villages in a pattern that continued into the period of Euro-American contact. Introduction of the horse in the mid-eighteenth century transformed settlement and subsistence patterns among many peoples in the region (Chatters 1989; Daugherty 1962; Leonhardt and Rice 1970).

In late prehistoric and early historic times, Wanapums lived along the west bank of the Columbia River from south of the Richland area upstream to the Vantage area (Relander 1956; Spier 1936). Some of their descendants still live nearby, and others have been incorporated into the Yakima and Umatilla reservations. Palus people, whose descendants now live on the Nez Perce, Yakima, Umatilla, and Colville reservations, inhabited parts of the east bank of the Columbia River (Relander 1956; Trafzer and Scheuerman 1986).

The earliest Euro-Americans in the region were Lewis and Clark, who traveled along the Columbia and Snake rivers during their 1803-1806 expedition. Fur trappers subsequently filtered into the Columbia Basin, but it was not until the 1860s that merchants set up stores, a freight depot, and a ferry on the Hanford Reach of the Columbia River. Cattle ranches were established in the 1880s, followed by farms. Several small towns (including Hanford, White Bluffs, and Ringold) appeared along the river during the early twentieth century. These towns and nearly all other structures were abandoned in the early 1940s when the U.S. government acquired the land for the then-called Hanford Nuclear Reservation as part of the Manhattan Project.

4.1.6.2 Archaeological Sites and Historic Structures

The inventory and evaluation of archaeological sites and historic structures at Hanford are conducted within the framework of the Hanford Cultural Resources Management Plan (Chatters 1989). More than 60 field surveys have been performed at Hanford. Overall, these surveys indicate that most archaeological sites are concentrated along the Columbia River; in areas more than 400 m from the river, sites are common only on ridges and adjacent to perennial water sources. The few finds that have been made on level, unwatered landforms are typically located within 200 m of historic Native American trails identified on Government Land Office maps drawn in the 1860s (Chatters 1989; ERTEC 1982; Morgan 1981; Rice 1981a,b; Rice, Stratton, and Lindman 1978; Smith et al. 1977).

The proposed NPR site is characterized by limited topographic variability, sparse shrub-steppe vegetation, and the absence of perennial water sources. Fifteen surveys have been conducted in this area (Appendix Q). These surveys covered a total area of 21.5 km², which is approximately 32% of the land surface of the affected area; 100% of the undisturbed 200-East Area was examined. The surveys entailed pedestrian surface reconnaissance, conducted along transect intervals ranging from 20 to 100 m; no subsurface testing was performed. Given the character of the landscape (i.e., topography, vegetation, geologic history, and distribution of surface water), this sample provides a more than adequate basis for archaeological site inventory.

Only two isolated projectile points have been reported for the NPR site. No significant archaeological or historical properties have been found in the areas covering all possible sites for the NPR and the probable site of the fuel processing facility in the 200-East Area. Two potentially significant properties were identified during survey and test excavations along the proposed water intake and discharge corridor for the HWR and MHTGR facilities: 43BN305 (containing a range of material dating to as early as 7,000 B.P.) and the historic Hanford Townsite (an early twentieth century settlement). Two historic archaeological sites are located near the NPR site: 45BN305H and 45BN298H (ERTEC 1982). Site 45BN305H contains the remains of a sheepherder's cabin and corral; site 45BN298H consists of a scattering of cans and other trash. Neither site is considered by DOE to be potentially eligible for the NRHP; NRHP eligibility determinations will be made by the Washington SHPO.

Structures and facilities associated with more recent historic events are located in the 200-East Area. Five buildings (271-B, 224-B, 272-E, 272-EA, and 284-E) were constructed during World War II as part of the Manhattan Project. Building 271-B, or B Plant, was used for plutonium separation; the other structures were support facilities (shop, storehouses, and powerhouse). One other building was constructed during early years of the Cold War -- the 2101-M Support Laboratory, built in 1953. The eligibility of these structures for the NRHP is scheduled to be determined by the SHPO in the near future.

4.1.6.3 Native American Cultural Resources

Because Native American people hold the land sacred, in their terms they consider the entire Hanford Site culturally important. However, within that larger area, some locations have been identified by tribal elders as being of special significance (Relander 1956; Chatters 1989). Certain landmarks, especially Rattlesnake Mountain, Gable Mountain, Gable Butte, Goose Egg Hill, Coyote Rapids, and the White Bluffs Reach of the Columbia River, have particular significance. The hill and mountains are places that figure in the mythology of creation and have long been used as sites for the spirit quest. Coyote Rapids was the site of the first Seven Drums ceremony in the nineteenth century and was also an important fishing place. The White Bluffs Reach of the Columbia River was an important winter camp location and offered the best salmon fishing in the area. The many Native American cemeteries found along the Columbia River are also considered sacred; many Native Americans hold sacred all archaeological sites left by their ancestors.

Traditional foods and medicinal plants that may be found on the Hanford Site are also important to local tribal groups. Foremost among these is the salmon, which spawns in great numbers, especially in the White Bluffs area.

Neither the WNP-1 site nor the NPR site is in direct contact with any of the areas identified as especially important. However, they are within sight of Rattlesnake Mountain and, to a lesser degree, Gable Mountain. Goose Egg Hill, which is especially important to members of the Wanapum Band, is 8.8 km from the NPR site.

4.1.6.4 Paleontological Resources

Paleontological remains of Pliocene and late Pleistocene age have been found on the Hanford Site. The Upper Ringold Formation, of late Pliocene age (Section 4.1.1), consists of fluvial deposits containing the remains of fish, reptiles, amphibians, and various mammals (Gustafson 1978). Mammoth bones are frequently found in the Touchet beds, slack-water fluvial sediments of late Pleistocene age that were deposited along the slopes of ridges surrounding the site (Chatters 1989). Pasco gravels, which underlie all areas being considered for NPR construction, are of late Pleistocene age but lack paleontological remains.

4.1.7 Environmental Radiation Sources and Exposure

Major sources of radiation exposure to individuals in the vicinity of the Hanford Site are presented in Table 4.1.7-1. Routinely encountered sources of background radiation are radon in the environment, terrestrial radiation, cosmic radiation, and naturally occurring terrestrial radiation emitters internal to the body, e.g., potassium-40 – resulting in a total dose of about 0.3 rem/yr (expressed as committed effective dose equivalent from 1 year of exposure) (NCRP-1). Based on a population of 340,000 within 80 km of the Hanford Site (1988 estimate), the total population dose from natural background is estimated to be about 100,000 person-rem/yr. The dose from 1 year of exposure to residual fallout from nuclear weapons testing is less than 0.001 rem/yr, which would add about 300 person-rem to the population dose (NCRP-1).

TABLE 4.1.7-1 Major Sources of Radiation Exposure to Individuals in the Vicinity of the Hanford Site

Source of Exposure	Dose to Average Individual ^a (rem/yr)
Natural background ^b	
Inhaled radon and radon decay products ^c	0.2
External terrestrial radiation	0.03
Cosmic radiation	0.03
Internal terrestrial radiation	0.04
Fallout radiation ^b	<0.001
Site operations ^d	2.0×10^{-5}
Total ^e	0.3

^aCommitted effective dose equivalent from 1 year of exposure to radiation sources or site operations (see Appendix H, Section H.2, for an explanation of radiation dose units).

^bAverage dose per year of exposure for components, as estimated in NCRP-1.

^cThe inhaled radon and radon decay product dose varies widely with geographic location; the 0.2 rem/yr value represents the U.S. population average.

^dCalculated by dividing the 80-km population dose given in PNL-2 and Card et al. (1989) by the 80-km population.

^eThe total dose is not exactly 0.3 because the values have been rounded to one significant figure.

The dose to the population within 80 km of the Hanford Site from the operation of DOE facilities and the Washington Public Power Supply System's WNP-2 reactor in 1988 has been estimated to be 5 person-rem (see PNL-2 for DOE facility operations and Card et al. 1989 for WNP-2 operations). The dose to the average off-site individual from these operations in 1988 was estimated to be 2×10^{-5} rem. The dose to the maximally exposed off-site individual in 1988 was estimated to be 8×10^{-5} rem for DOE facilities (PNL-2) and 2×10^{-4} rem for WNP-2 (Card et al. 1989).

Applicable regulatory standards for radiological exposure from nuclear facilities are given in Section 5.1.7.1. These standards do not involve background dose; background doses are presented for comparative purposes only. The estimated contribution of the proposed NPR facilities to doses from site operations at Hanford are given in Section 5.2.6.1. The Hanford environmental monitoring program, which monitors the release of radioactive and nonradioactive hazardous materials to the environment, is identified in Section 3.5. Information

on applicable safety criteria that could be used for NPR designs is included under project descriptions in Appendixes A, B, and C.

4.1.8 Socioeconomics

Hanford directly or indirectly provides many employment opportunities in Benton and Franklin counties in Washington State. The following sections describe the socioeconomic and community characteristics (i.e., economic activity, population, housing, community services, fiscal structure, and quality of life) of the Hanford area and examine the bases for the local economy supporting whatever growth would be associated with development of the NPR at Hanford. The local area is described in detail in Cushing (1989, 1990) and Scott et al. (-1, -2). The following sections summarize portions of the above sources.

More than 92% of all Hanford employees reside in Benton (84.7%) and Franklin (7.5%) counties. Most of the other employees reside in Yakima County. In 1986, Hanford employment represented about 26% of total employment and about 39% of total earnings in Benton County. The construction and operation work forces for the NPR project would likely reside in Benton and Franklin counties. Those counties were therefore chosen as the study area, or region of influence (ROI) (also referred to as the Hanford region), to assess potential socioeconomic impacts arising from construction and operation of the NPR and its associated facilities. In many cases, the discussion focuses on the Tri-Cities area, which consists of Pasco in Franklin County and Richland and Kennewick in Benton County.

4.1.8.1 Employment and Income

Agriculture (including food processing), DOE and its contractors, and the Washington Public Power Supply System have been the principal forces in the Tri-Cities economy since the 1970s. In addition to providing employment and payrolls directly, these major sectors of the local economy support many secondary jobs through the purchase of equipment, supplies, and services.

Other major employers in the Hanford area include Advanced Nuclear Fuels in North Richland, Sandvik Special Metals in Kennewick, Boise-Cascade in Wallula, Burlington Northern Railroad, and Iowa Beef Processors. Tourism, including business conventions, is a major component of the area economy. Another important sector consists of employees retired from the Hanford Site. Government transfer payments, in the form of pension benefits, constitute a significant portion of total disposable income in the local economy.

In 1988, Hanford employment accounted directly for 21% of total nonagricultural employment (63,300 persons) in Benton and Franklin counties and 0.6% of all nonagricultural jobs in Washington. At the state level, this percentage represented more than the total employment in the aluminum industry and almost equaled the employment in the pulp and paper industry.

Previous studies indicate that each Hanford employee supports about 1.2 additional jobs in the service sector of Benton and Franklin counties, and about 1.5 additional jobs in the state's service sector (Scott et al.-2). On the basis of these multipliers, Hanford directly or indirectly accounts for more than 40% of all jobs in the ROI.

From October 1987 through September 1988, DOE and its contractors purchased about \$96 million worth of goods and services in Washington. The most recent study indicates that DOE procurements have supported about 800 jobs in Benton and Franklin counties, primarily in the wholesale and retail sectors.

Table 4.1.8-1 summarizes Hanford work force projections for the high-case scenario in Cluett and Clark (1990). The Hanford work force is projected to remain near historically high levels.

Table 4.1.8-2 summarizes work force projections by construction occupation for Washington and for the Hanford ROI for 1995. Because the peak construction work force is expected to be larger than the operation work force, the availability of construction craft workers is a key consideration in identifying potential in-migration and associated socioeconomic impacts arising from NPR activities.

Total personal and per capita incomes in Benton and Franklin counties are shown in Table 4.1.8-3. In 1987, total personal income was \$1.6 billion in Benton County and \$0.5 billion in Franklin County. Benton County accounts for almost 80% of personal income in the region. Benton County's per capita income is currently about 15% higher than Franklin County's but is about 8% lower than the state average. Although these comparisons reflect a recent decline in ROI per capita income compared with that of the state, the 20-year average is approximately the same for both areas (Section 4.1.8.6).

Agriculture in Benton and Franklin counties accounts for almost 11,500 jobs, or almost one-sixth of total employment in the region. Crop and livestock production employs almost 4,900 persons (value based on unemployment insurance compensation records). Seasonal farm workers increase this total.

Agricultural services, supplies, and equipment (including irrigation) employed almost 1,200 persons in 1986. More than 20 food processing plants are located in Benton and Franklin counties and employ an average of about 2,500 persons per year. Grape production and an associated wine industry are increasing in volume.

TABLE 4.1.8-1 Projected Hanford Work Force, by Sector, 1990-2035

Sector	1990	2000	2010	2020	2030	2035
Chemicals ^a	6,748	9,311	8,575	7,114	5,723	5,017
Miscellaneous services ^a	6,551	6,152	8,018	9,766	11,403	12,017
Total ^b	13,299	15,463	16,593	16,880	17,126	17,034

^aProjections are for the high-case scenario.

^bTotals do not always add because of rounding.

Source: Cluett and Clark 1990.

TABLE 4.1.8-2 Projected State and Regional Work Forces, by Construction Occupation, 1995

Construction Occupation	Washington	Hanford ROI
Pipefitters/welders	7,417	246
Boilermakers	1,153	38
Carpenters	18,397	621
Equipment operators	7,310	256
Linemen	2,037	68
Teamsters/laborers	78,440	2,647
Electricians	13,593	479
Ironworkers	1,473	53
Concrete finishers	1,987	68
Other crafts	1,393	76

TABLE 4.1.8-3 Personal and Per Capita Income in the Hanford ROI, 1982 and 1987

County	Total Personal Income (millions of dollars)		Per Capita Income (dollars)	
	1982	1987	1982	1987
Benton	1,429	1,641	12,222	14,491
Franklin	391	456	10,614	12,357

Source: Bureau of Economic Analysis 1990.

In 1988, farm-related sales in Benton and Franklin counties were \$253 million for field crops, \$32 million for vegetables, and about \$66 million for livestock sales. Principal crops are apples, potatoes, wheat, and corn.

4.1.8.2 Population Characteristics

Table 4.1.8-4 lists the 1982, 1988, and 1990 regional population estimates prepared by the Washington Office of Financial Management. The 1988 population of Benton County (104,100) was about 7% less than the 1982 peak (111,700). For Franklin County, the 1988 population (35,500) decreased about 2% from 1982 (36,200). The peak regional populations in 1982 corresponded to construction of the WNP-1 plant and other employment at Hanford. Census projections for 1990 show very little growth throughout the ROI between 1982 and 1990.

About 26% of all persons in Benton County and about 41% of all persons in Franklin County reside in unincorporated areas. The Tri-Cities area of Richland (30,140), Kennewick (37,180), and Pasco (18,430) accounts for more than 60% of the total population within the region. More than 49% of the population is under the age of 30, compared with 43% for the state as a whole. Almost 10% of the regional population is under the age of 5.

TABLE 4.1.8-4 Distribution of Population and Hanford Work Force, by Place of Residence for Counties and Selected Communities in the Hanford ROI, 1982, 1988, and 1990

Location	1982 Population (thousands)	1988		1990 Population Estimated (thousands)
		Population (thousands)	Percentage of Hanford Work Force ^a	
Benton County	111.7	104.1	84.7	112.1
Richland	32.3 ^b	30.1	45.4 ^c	32.4 ^b
Kennewick	39.9 ^b	37.2	27.7 ^c	40.0 ^b
Franklin County	36.2	35.5	7.5	36.9
Pasco	18.8 ^b	18.4	7.3 ^d	19.1 ^b
Hanford ROI	147.9	139.6	92.2	149.0

^aPercentage of Hanford work force residing in specified location.

^bEstimates for municipalities are based on 1988 population distributions.

^cDistribution is based on 1986 employment.

Sources: Cushing 1989; Scott et al.-1; 1990 population estimate from U.S. Bureau of the Census, Public Affairs Office, 1991.

Population projections for the region are presented in Table 4.1.8-5. The principal uncertainty with the projections relates to assumptions regarding closure of the Fast Flux Test Facility, the N Reactor, and nuclear materials production facilities at Hanford. However, waste management and environmental restoration activities are expected to increase site employment. Because Hanford activities dominate the local economy, population projections depend more on the operations scenario for the site than on such demographic factors as birth rates, deaths, and in-migration. To provide a conservative impacts analysis (i.e., to provide an upper-bound estimate of the socioeconomic impacts of the NPR project), the population projections shown in Table 4.1.8-5 are based on the high-employment forecasts for Hanford found in Cluett and Clark (1990). This forecast is based on the historical maximum employment at Hanford, which occurred in 1986 and 1987. Population growth is forecast throughout the period of NPR construction and operation. From 1990 to 2040, the population is expected to increase by nearly 50%.

4.1.8.3 Housing

Almost 88% of all housing in the Tri-Cities (38,337 units) was occupied in 1988. Single-unit housing, which represents 57% of the total units, had an average 93% occupancy rate throughout the Tri-Cities. Multiple-unit housing had an occupancy rate of about 81%. Pasco had the lowest occupancy rate in all categories of housing: single units, 93%; multiple units,

TABLE 4.1.8-5 Projected Population for Counties and Selected Cities in the Hanford ROI, 1990-2040

Location	Population (thousands), by Decade					
	1990	2000	2010	2020	2030	2040
Benton County	112	120	135	152	160	167
Richland	32	35	39	44	46	48
Kennewick	40	43	48	54	57	60
Franklin County	37	36	40	44	47	49
Pasco	19	19	21	23	24	25
Hanford ROI ^a	149	156	175	196	207	216

^aTotals are rounded.

Sources: The 1990 regional estimates are from the U.S. Bureau of the Census, Public Affairs Office, 1991; county-level projections are from Cluett and Clark 1990; distributions by city are based on 1988 population distributions (Table 4.1.8-4).

78%; and mobile homes and trailers, 84%. Overall, almost 4,600 units were vacant in the Tri-Cities in 1988 (Scott et al.-2). In 1980, 66.5% of the year-round housing was owner occupied, with 33.5% being renter occupied within the ROI.

Average single-family home prices in the Tri-Cities area declined from a peak of \$73,100 in 1981 to \$58,800 in 1988, although the sales volume remained at about the same level. The exception was the sharp decrease in the number of homes sold in 1982 and 1985.

Since about the second quarter of 1988, the local real estate market has experienced a significant turnaround. Through June 1990, average prices once again increased at about 1% per month to \$65,000. There has been a 50% increase in the number of units sold per month and a significant decline in the number of units available for sale (i.e., from an average of about 1,200 to about 450). Rental housing has also become increasingly scarce. According to the U.S. Department of Housing and Urban Development in Seattle, Tri-Cities average multifamily vacancy rates were down to 3.5% as of June 1990. The vacancy rate was 16.5% in 1988. The housing supply is increasing in response to this demand. A reported 239 units of single-family housing were started in 1990, and 213 mobile homes were added in the first part of that year. Several local developers were planning additional multifamily construction projects (HUD 1990). Permits for mobile homes have dominated new housing activity since 1980. Data on typical rental rates are unavailable. As indicated in Table 4.1.8-6, housing permits peaked in 1980 before leveling off at an average of 294 permits per year for the ROI.

TABLE 4.1.8-6 Housing Permits in the Hanford ROI, 1980-1990

Location	1980	1981	1982	1983	1984	1985
Benton County	631	513	169	159	110	106
Kennewick	307	175	24	31	27	17
Richland	114	156	61	21	16	36
Franklin County	185	107	52	46	35	19
Pasco	145	58	27	23	9	3
Hanford ROI	816	620	221	205	145	125

	1986	1987	1988	1989	1990	1980-89 Average
Benton County	293	226	45	137	188	238.9
Kennewick	160	41	12	54	128	84.8
Richland	71	151	13	47	NR ^a	68.6
Franklin County	27	34	13	29	45	54.7
Pasco	5	4	2	1	4	27.7
Hanford ROI	320	260	58	166	233	293.6

^aNot recorded.

Source: U.S. Bureau of the Census 1982, 1984, 1986, 1988, 1990.

4.1.8.4 Public and Community Services

Public and community services in the Hanford region are described for Benton and Franklin counties, and the Tri-Cities (i.e., Kennewick, Pasco, and Richland), along with the respective school districts. The state of Washington and the Federal government also provide services to residents in Benton and Franklin counties. Existing levels of education, health care, and police and fire protection in the Hanford region are discussed in turn.

Education

Public primary and secondary education in the Hanford area is provided by six public school districts in Benton County and four in Franklin County. The school districts range in enrollment size from 14 students in Star School District to more than 10,000 students in Kennewick School District (Table 4.1.8-7). School districts in both counties are operating at, near, and, in one case, over capacity. Kennewick School District is rapidly approaching enrollment capacity; both Finley and Pasco school districts are currently operating at capacity; and Prosser School District is operating above capacity through the use of portable classrooms. Student/teacher ratios in the ROI range from 7.0 in Star School District to 23.0 in Kiona-Benton and Prosser school districts. The average ratio is 17.8. Per pupil expenditures average \$4,148 in the ROI, ranging from \$3,682 in Kiona-Benton School District to \$12,437 in Star School District.

TABLE 4.1.8-7 Characteristics of School Districts in the Hanford ROI

School District	Enrollment	Enrollment Capacity	Student/Teacher Ratio	Per Pupil Expenditure (\$)
Benton County	21,416			
Finley	1,015	1,015	20.0	4,107.62
Kennewick	10,527	11,500	17.9	4,006.91
Kiona-Benton	1,093	1,400	23.0	3,682.54
Paterson	47	72	15.7	5,180.08
Prosser	2,297	2,000	23.0	4,258.94
Richland	6,437	8,086	17.1	3,908.35
Franklin County	8,464			
Kahlotus	91	100	12.0	9,337.15
North Franklin	1,548	1,992	15.5	4,378.84
Pasco	6,811	7,000	19.3	4,493.23
Star	14	24	7.0	12,436.99
Total/average	29,880	33,189	17.8	4,148.76

Source: Fuller 1991.

Health Care

The Tri-Cities area has three major hospitals and four minor emergency centers, for a total capacity of about 300 beds. All three hospitals offer general medical services, providing 24-hour emergency rooms, surgical services, intensive care, and neonatal care. In 1989, Kadlec Medical Center, located in Richland, operated at about 40% capacity, with 5,000 admissions. Nearly two-thirds of these admissions were non-Medicare/Medicaid patients who averaged about three days per admission. Kennewick General Hospital maintained about a 45% occupancy rate, with almost 3,100 admissions in 1989. These occupancy rates indicate sufficient capacity in this area. Our Lady of Lourdes Hospital, located in Pasco, had an occupancy rate of about 45%, with 3,100 admissions in 1989. This hospital performs a substantial amount of outpatient care. Table 4.1.8-8 summarizes the health care service ratios for the ROI counties.

Police and Fire Protection

Police protection in Benton and Franklin counties is provided by county sheriff's offices, local municipal police forces, and the Washington State Patrol Division. Table 4.1.8-9 summarizes law enforcement service ratios for jurisdictions in the ROI. The Kennewick Police Department has the largest staff of sworn officers in the ROI (48) and maintains a level of service of 1.14 sworn officers per 1,000 people. The next largest forces are the Richland Police Department (40 sworn officers; 1.24 officers per 1,000 population) and the Pasco Police Department (38 sworn officers; 1.89 officers per 1,000 population).

TABLE 4.1.8-8 Health Care Service Ratios for the Hanford ROI

County	Population/ Doctors	Population/ RN/LPN	Population/ Hospital Beds
Benton	723	144/391	501
Franklin	1,118	228/559	NA ^a
ROI	793	159/422	NA

^aNot available.

Source: Cushing 1990.

TABLE 4.1.8-9 Police and Fire Protection Services in the Hanford ROI

Police Protection Services		
County/Agency	Sworn Officers	Officers/ 1,000 people
Benton		
Benton County Sheriff's Office	31	0.28
Kennewick Police Department	48	1.14
Richland Police Department	40	1.24
Franklin		
Franklin County Sheriff's Office	14	0.38
Pasco Police Department	38	1.89
Fire Protection Services		
County/Agency	Fire Fighters	Fire Fighters/ 1,000 people
Benton		
Benton County Rural Fire Department No. 1	5	-
Benton County Rural Fire Department No. 2	0	-
Benton County Rural Fire Department No. 4	2	-
Kennewick Fire Department	39	0.93
Richland Fire Department	38	1.17
Franklin		
Pasco Fire Department	21	1.04

Six fire departments provide fire protection for the Tri-Cities area: three municipal departments and three rural fire departments. The municipalities of Kennewick, Richland, and Pasco maintain the largest staffs in the region: 39, 38, and 21 professional fire fighters, respectively, and level-of-service ratios of 0.93, 1.17, and 1.04 fire fighters per 1,000 population, respectively (Cushing 1990). Because rural fire districts tend to rely heavily on volunteer forces whose staffing and availabilities are dynamic, constant per capita ratios do not describe levels of services very accurately.

4.1.8.5 Public Finances

Revenues, expenditures, and fund balances of potentially affected cities, counties, and school districts in the ROI are presented in Table 4.1.8-10. The data reflect actual revenues and expenditures of each jurisdiction's general fund, and, as applicable, a jurisdiction's special revenue funds. These funds generally account for all of a jurisdiction's tax-supported expenditures for services provided by the jurisdiction. Examples of other funds maintained by cities and counties include enterprise funds, special assessment funds, and utility funds. These funds are generally self-supporting through user charges and do not contribute to the general tax burden of a jurisdiction. When the activities of these funds are relatively important in a local community (e.g., revenues and expenditures of utility enterprise funds), the most recent year's revenues and expenditures are reported.

Data are reported for jurisdictions expected to experience the majority of impacts associated with NPR project activities.

TABLE 4.1.8-10 General and Special Revenue Fund Revenues, Expenditures, and Fund Balances for Selected Jurisdictions for Fiscal Year 1989 in the Hanford ROI^a

Jurisdiction	Revenues (\$1,000)	Expenditures (\$1,000)	Fund Balance (\$1,000)
Benton County	21,419	20,170	8,590
City of Richland	14,062	12,937	4,554
City of Kennewick	15,232	14,905	2,622
Richland School District	26,289	25,162	2,022
Kennewick School District	42,739	42,182	1,403
No. 17			
Franklin County	10,384	10,324	626
City of Pasco	9,093	7,908	2,455
Pasco School District	27,446	27,102	837
No. 1			

^aFor school districts, values represent general fund data.

Sources: Washington State Auditor 1990; Pasco School District No. 1 1990; Richland undated; Benton County undated; Kennewick 1990; Underwood 1990; Franklin County undated; Richland School District 1990.

Benton County

Public services provided by Benton County are funded principally through the county's general fund and special revenue funds. In fiscal year (FY) 1988, revenues and expenditures were \$21.4 million and \$20.2 million, respectively. Fund balances were \$8.6 million, which represents about 42% of operating expenditures in that year. Property taxes and intergovernmental revenue are the principal revenue sources of the county. The assessed valuation in the county was approximately \$2.9 billion in FY 1988, which was down from more than \$3.0 billion in FY 1986.

City of Richland

Public services provided by Richland are funded principally by the general and special revenue funds. In FY 1989, revenues and expenditures were \$14.1 million and \$12.9 million, respectively. Property taxes and intergovernmental revenues are the principal revenue sources of the city. Fund balances for FY 1989 were \$4.6 million, up from \$3.5 million for FY 1987. The assessed valuation in the city was approximately \$908 million for FY 1989, down from \$933 million in FY 1987. The legal debt limitation for Richland is 0.75% of the assessed property valuation, or approximately \$6.8 million. Additional debt capacity is available, at 1.75% of the assessed valuation, with a vote of the people. Richland's outstanding general obligation debt for FY 1989 was about \$3 million.

City of Kennewick

Public services provided by Kennewick are funded principally by the general fund and special revenue funds. In FY 1989, revenues and expenditures were \$15.2 million and \$14.9 million, respectively. Fund balances were \$2.6 million in that year. The assessed valuation for Richland was approximately \$886 million in FY 1989. Kennewick's legal debt margin is 2.5% of the assessed property valuation. The total outstanding general obligation debt for FY 1989 was approximately \$12.4 million, and the remaining capacity was about \$16.7 million.

Richland School District

Services provided by the Richland School District are funded principally through the district's general fund. In FY 1989, revenues and expenditures were \$26.3 million and \$25.2 million, respectively. Fund balances were \$2 million, which represents about 8% of operating expenditures in that year. Reserve bonding capacity is \$38.3 million.

Kennewick School District No. 17

Services provided by the Kennewick School District No. 17 are primarily funded through the district's general fund. In FY 1989, revenues and expenditures were \$42.7 million and \$42.2 million, respectively. State revenues, the principal source of revenue for the school district, represented 78% of all revenues in FY 1989. The general fund balance for FY 1989 was \$1.4 million, up \$300,000 from FY 1987 but down from FY 1988 levels of about \$1.6 million. The assessed valuation for the district was \$1.2 billion in FY 1989, down slightly from \$1.3 billion in

FY 1986. In FY 1989, the district had general obligation bond indebtedness of approximately \$8.2 million.

Franklin County

Public Services provided by Franklin County are funded principally through the county's general fund and special revenue funds. In FY 1988, revenues and expenditures were \$10.4 million and \$10.3 million, respectively. Property taxes and intergovernmental revenues are the principal revenue sources of the county. Fund balances were \$620,000 in FY 1988. The general fund balance has been negative since FY 1986, although the level is decreasing, that is, from negative \$416,000 in FY 1986 to negative \$15,000 in FY 1988. The assessed valuation in the county was approximately \$1.1 billion in FY 1988.

City of Pasco

In FY 1989, revenues were approximately \$9.1 million, and total expenditures were about \$7.9 million. Fund balances were \$2.5 million. Property taxes and intergovernmental revenues are the principal revenue sources for the city. In FY 1989, the assessed property valuation was \$358 million. The legal debt limitation for Pasco is 2.5% of the assessed valuation. In 1989, the outstanding general obligation debt was about \$1.5 million, and the remaining capacity was \$7.5 million.

Pasco School District No. 1

Services provided by the Pasco School District No. 1 are primarily funded by the general fund. In FY 1989, the revenues and expenditures were \$27.5 million and \$27.1 million, respectively. State revenues, the principal source of revenues for the school district, represented about 75% of all revenues received. The general fund balance for FY 1989 was \$837,000, up slightly from \$623,000 in FY 1988.

4.1.9 Transportation Systems

This section discusses the existing transportation environment at and around Hanford. Personnel and most material shipments are transported by road. Bulk materials or large items are shipped by barge. Rail transportation is used only to move irradiated fuel and certain high-level radioactive solid wastes and to transport equipment and materials, primarily coal. The on- and off-site transportation networks are shown in Figures 4.1.9-1 and 4.1.9-2, respectively. High-level and low-level wastes from spent fuel processing are transported to waste management facilities by pipeline.

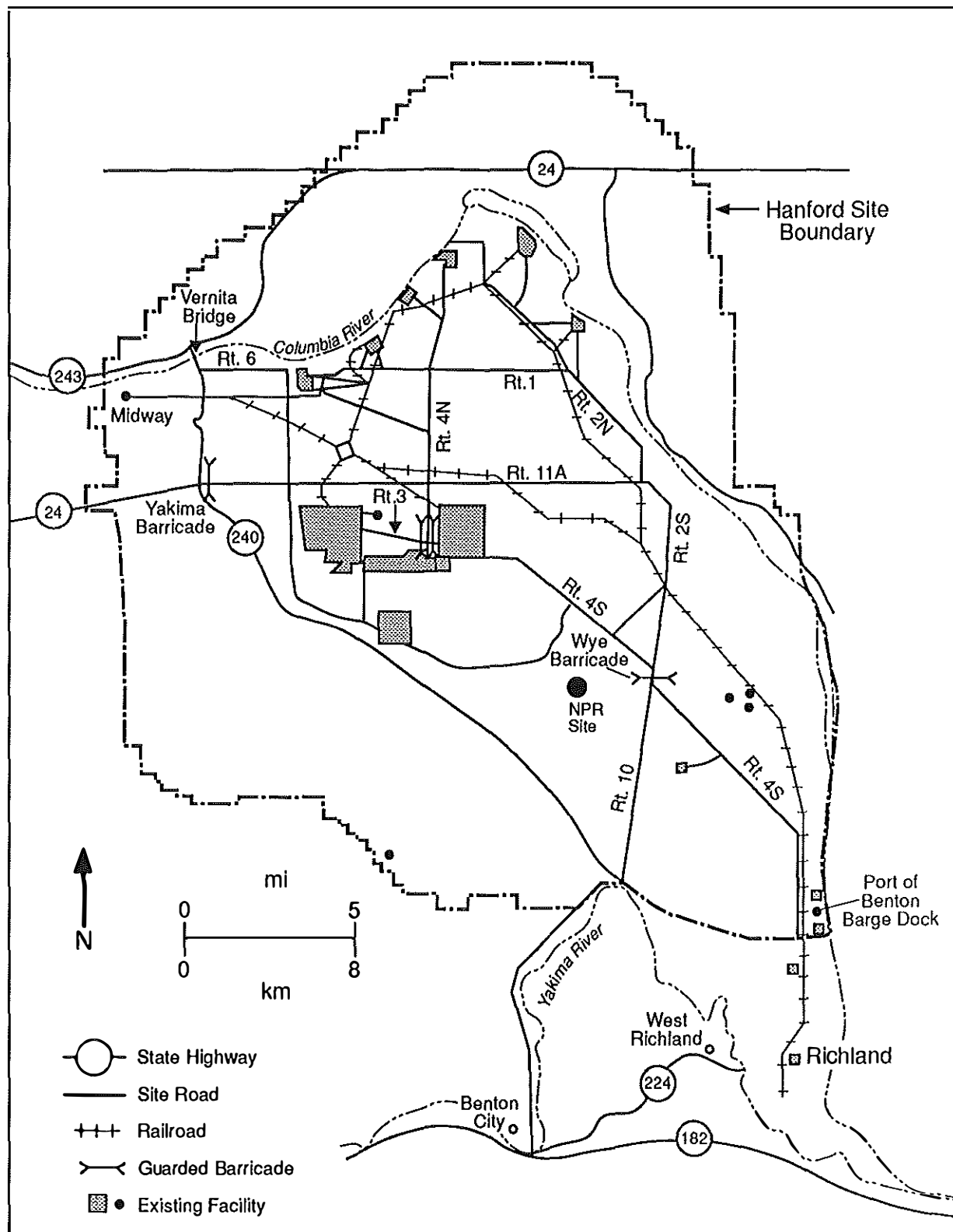


FIGURE 4.1.9-1 Transportation Routes at the Hanford Site (Source: Modified from WHC-1)

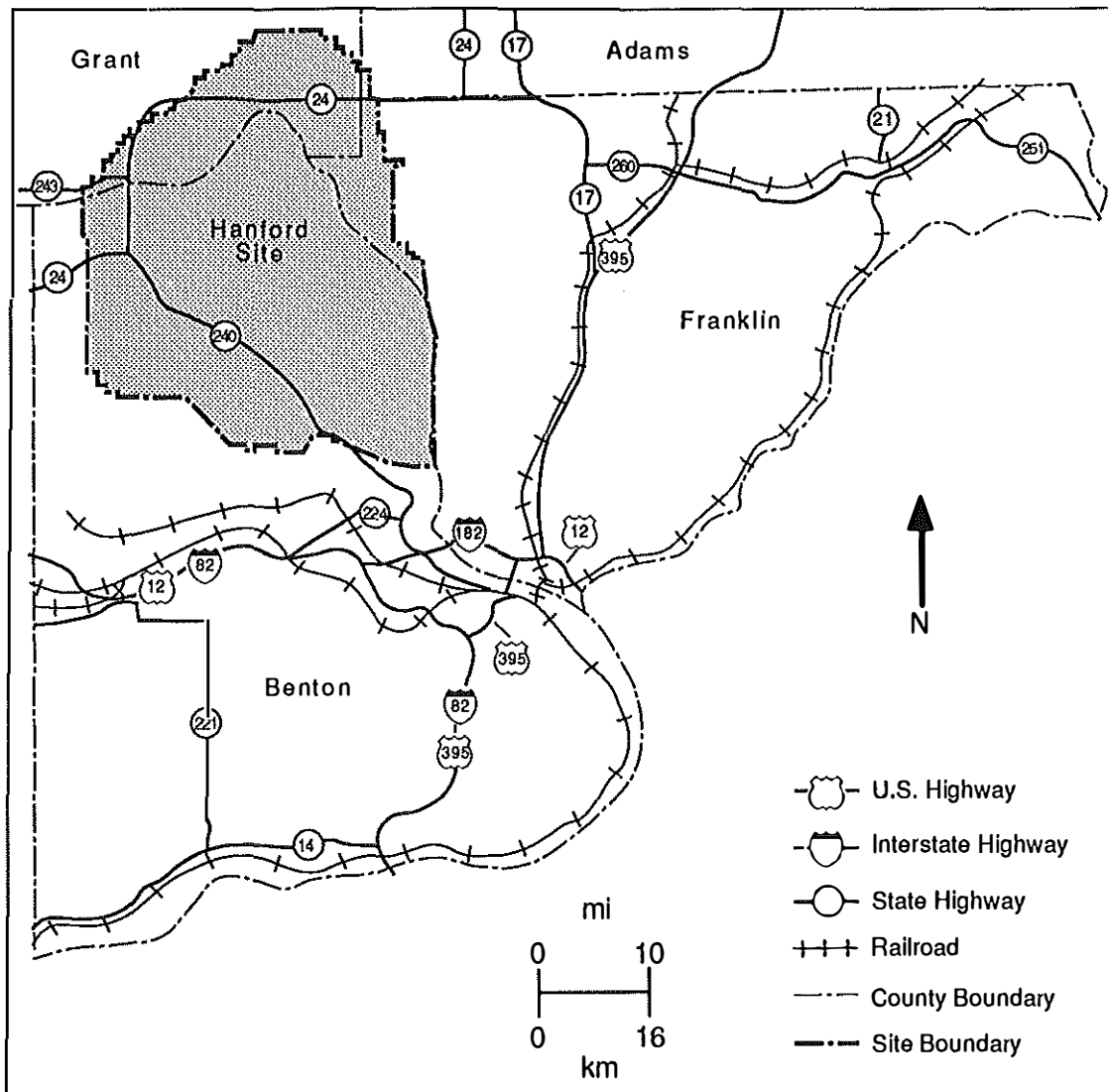


FIGURE 4.1.9-2 Transportation Routes in the Hanford Vicinity (Source: Based on DOI-1)

4.1.9.1 Road Transportation

Hanford's on-site road network consists of rural arterial routes. Only 65 of the 288 mi* of paved roads at Hanford are accessible to the public. Most on-site employee travel occurs along Route 4, access to which is controlled at the Yakima and Wye barricades. Washington State Route (SR) 240 is the main public route through the site. Public highways SR 24 and SR 243 also traverse the site.

The regional transportation network in the Hanford vicinity, shown in Figure 4.1.9-2, includes the areas in Benton and Franklin Counties from which 93% of the commuter traffic associated with the site originates.

*1 mi = 1.609 km.

Interstate (I) highways that serve the area are I-82, I-182, and I-90. I-82 is 5 mi south-southwest of the site. I-182, a 15-mi urban connector route 5 mi south-southeast of the site, provides an east-west corridor linking I-82 to the Tri-Cities area. I-90, located north of the site, is the major link to Seattle and Spokane and extends to the East coast. SR 224, also south of the site, serves as a 10-mi link between I-82 and SR 240. SR 243 exits the site's northwestern boundary and serves as a primary link between the site and I-90. SR 24 enters the site from the west, continues eastward across the northernmost portion of the site, and intersects SR 17 approximately 15 mi east of the site boundary. SR 17 is a north-south route that links I-90 to the Tri-Cities and joins U.S. Route (US) 395, which continues south through the Tri-Cities. These primary highway routes, their associated functional classifications, and 1988 traffic volumes in terms of annual average daily traffic (AADT) and vehicle miles traveled (VMT) are presented in Table 4.1.9-1.

General weight, width, and speed limits have been established for highways in the Hanford vicinity. However, no unusual laws or restrictions that have been identified would significantly influence general regional transportation.

TABLE 4.1.9-1 Information on Major Transportation Routes around the Hanford Site

Road Segment ^a	Functional Classification	AADT ^b (vehicles)	Annual VMT ^c (millions of miles)
SR 17 (from junction with US 395 to Adams County line)	Principal arterial	1,950	10.2
SR 24 (within Benton County)	Minor arterial	450	2.14
I-82 (from junction with US 12 to junction with US 395)	Interstate	10,200	303
I-182 (entire route)	Interstate	14,600	76.6
SR 224 (entire route)	Minor arterial	4,900	17.7
SR 240 (entire route)	Minor arterial	8,050	127
US 395 (from junction with I-82 to Adams County line)	Principal arterial	7,400	130

^aRoute prefixes: I (Interstate), US (United States Route), SR (State Route).

^bAADT = annual average daily traffic.

^cVMT = vehicle miles traveled.

Conversion factor: 1 mi = 1.609 km.

Sources: WHC-1; Toohey 1989.

Resurfacing, sealing, and restoration programs are currently planned for segments of SR 17, SR 224, SR 240, and US 395. However, except for the possible widening of US 395 in northern Franklin County, no major improvements are planned (Lenzi 1989).

In 1988 about 32% of the work force at Hanford worked in offices in Richland. The remaining work force was on the site. Approximately 80% of the work force resides in Richland (45%), Kennewick (28%), and Pasco (7%). Approximately 1,600 of the employees on the site use bus transportation (WHC-1).

In 1988, nearly 12 million mi were logged by DOE vehicles at Hanford. In addition, an estimated 3,300 privately owned vehicles were driven on-site each weekday, and another 560 were driven on-site each weekend day. Assuming a round-trip distance of 30 mi on-site for each of these vehicles, a total of about 40 million mi were driven annually by workers on-site.

The primary highways used by commuters are SR 24, SR 240, and I-182; 10, 90, and 10% of the work force use these routes, respectively (totals to more than 100% because some commuters use two of the routes). With these commuting patterns, workers annually travel about 27 million mi off-site. Trucks used for material shipment to Hanford compose about 5% of the vehicular traffic on and around the site.

No significant on- or off-site vehicle congestion points currently exist at Hanford (WHC-1; Toohey 1989).

During 1988, 169 accidents were reported on-site, 20 involving DOE vehicles. The other accidents involved privately owned vehicles and included seven injury accidents and one fatal accident on SR 240. Among off-site highway segments of concern, most accidents occurred along I-82. According to available data, the 15 accidents involving trucks in 1987 in the two-county study area resulted in 13 injuries and 3 fatalities (DOT-1).

4.1.9.2 Rail Transportation

On-site rail transport is provided by a short-line railroad owned and operated by DOE. This line connects just south of the Yakima River with the Union Pacific, which in turn interchanges with the Washington Central and Burlington Northern at Kennewick. Approximately 145,000 rail mi were logged at Hanford in 1988, primarily transporting coal to steam plants. Two noninjury rail accidents occurred at Hanford in 1988.

4.1.9.3 Barge Transportation

The Hanford Site infrequently uses the Port of Benton dock facilities on the Columbia River for off-loading large shipments (Holman 1989). Overland wheeled trailers are then used to transport those shipments to the site. No barge accidents were reported in 1988 (DOT-3).

4.1.10 Waste Management

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory

authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

The objective of waste management at Hanford is to manage and dispose of all existing and future Hanford waste in accordance with applicable Federal, state, and local regulations and in a manner that protects the health and safety of the public, site employees, and the environment. Waste types generated and processed at Hanford include HLW, TRU waste, LLW, mixed waste, hazardous waste, and nonradioactive nonhazardous waste (designated for the purposes of this EIS as "other waste"). Waste types and regulatory definitions of waste are described in Appendix M. This section describes Hanford's waste management facilities and operations and identifies those that would be used to process NPR-related waste.

Most of the waste handling facilities that are part of the Hanford waste management program (WHC-11) are located in or near the 200-West and 200-East areas. A 40-ha portion of land between the 200-East and 200-West areas has been leased to the state of Washington for nuclear-related disposal. Waste management facilities, baseline waste storage and generation rates, and capacities of DOE waste-handling facilities at Hanford are summarized in Tables 4.1.10-1 and 4.1.10-2. An overview of Hanford waste storage, treatment, and disposal facilities that would support the NPR project is presented in Appendix M, Figure M.1.

As of 1990, no production reactors are operating at Hanford. At the start of the NPR project, most of Hanford's non-NPR waste would consist of existing HLW, TRU waste, and LLW stored on-site in tanks. After 1990, small quantities of radioactive waste would be generated from past or present operations at the Fast Flux Test Facility, the PUREX Facility, and the Plutonium Finishing Plant. The PUREX plant is currently shut down, and DOE has no current plan to restart the facility. However, DOE is planning to conduct a NEPA review of disposal of Hanford's stored reactor fuel (not NPR fuel), and PUREX plant operation may be included in disposal alternatives in that review. PUREX would be restarted only if that is determined to be the best alternative. For this EIS, the baseline waste input at Hanford would consist of the inventory waste and the small amounts of newly generated waste that would be processed concurrently with NPR-related waste. Baseline estimates do not include waste resulting from cleaning out or shutting down existing processing facilities.

One component of the overall Hanford waste management plan involves waste minimization and waste reduction (WHC-11). Examples of waste reduction and waste minimization at Hanford include (1) segregation of waste according to its hazardous characteristics, thus minimizing the volume of mixed waste needing disposal; (2) segregation of TRU solid waste from non-TRU solid waste, thus reducing the overall volume of TRU solid waste; and (3) evaporation of nonhazardous components of waste, thus reducing the quantity of HLW stored in double-shell tanks.

TABLE 4.1.10-1 Baseline Waste Quantities as of the Year 2000 at Hanford^a

Waste Identification	Annual Disposal Volume from Processing Operations Wastes (m ³ /yr)	Annual Disposal Volume from Processing Stored Wastes (m ³ /yr)	Total Annual Disposal Volume from all Waste Processing (m ³ /yr)	Disposition
High-level waste Solid ^b	0	240	240 ^c	Interim on-site storage ^d
Transuranic waste Solid ^e	0	170	170 ^c	Interim on-site storage ^f
Low-level waste Solid ^g	13,000	7,000	20,000	On-site disposal
Mixed waste Solid ^g	300	0	300	Interim on-site storage
Hazardous waste Liquid and solid	100	0	100	Off-site disposal
Other waste Nonhazardous				
Liquid	2,000,000	10,000,000	12,000,000	Liquid effluent
Solid	38,000	0	38,000	On-site disposal
Sewage				
Liquid ^h	210,000	0	210,000	Liquid effluent
Solid ⁱ	4	0	4	On-site disposal

^aBaseline values projected from 1988 data.

^bLiquid HLW is held in interim storage and then processed to a solid form for disposal.

^cBaseline value taken from 1988 data for planned future activities.

^dThese wastes are targeted for disposal at a Federal repository.

^eLiquids containing transuranics are processed as HLW.

^fThese wastes are targeted for disposal at WIPP.

^gSolidified or absorbed-liquid-waste quantities are included in the solid waste quantity.

^hLiquid effluents from sewage treatment operations.

ⁱSolids from sewage treatment operations.

Source: Merrick 1989.

TABLE 4.1.10-2 Baseline Waste Management Facilities as of the Year 2000 at Hanford^a

Waste Identification	Facility Description	Facility Function	Facility Input Capacity (m ³ or m ³ /yr) ^b	Percentage of Capacity Used for Processing Operations Wastes	Percentage of Capacity Used for Processing Stored Wastes	Comment
High-level waste						
Liquid	Storage tanks	Storage	12,000	0	65	
Solid	Waste Vitrification Plant	Treatment	240 ^c	0	100	Planned to be operational as of 2001
	Interim storage	Storage	Expandable ^d	Variable ^e	Variable ^e	
Transuranic waste						
Solid ^f	Transuranic Waste Storage and Assay Facility and Waste Receiving and Processing Facility	Treatment and storage	4,400 ^c	0	4	Planned to be operational as of 2000
	Interim storage	Storage	Expandable ^d	Variable ^e	Variable ^e	
Low-level waste						
Liquid	242-A Evaporator	Treatment	38,000	3	50	
	Grout Treatment Facility	Treatment	25,000	1	40	
Solid ^g	Near-surface vaults	Disposal	Expandable ^d	Variable ^e	Variable ^e	
	Low-Level Waste Disposal Facility	Disposal	Expandable ^d	Variable ^e	Variable ^e	
Mixed waste						
Solid ^g	Mixed waste storage facilities	Storage	Expandable ^d	Variable ^e	Variable ^e	Planned to be operational as of 1994
	Waste Receiving and Processing Facility ^b	Treatment	560	54	0	Planned to be operational as of 2000
Hazardous waste						
Liquid and solid	Nonradioactive Dangerous Waste Storage Facility	Storage	100	Variable ^e	Variable ^e	Waste regularly shipped off-site

TABLE 4.1.10-2 (Cont'd)

Waste Identification	Facility Description	Facility Function	Facility Input Capacity (m ³ or m ³ /yr) ^b	Percentage of Capacity Used for Processing Operations Wastes	Percentage of Capacity Used for Processing Stored Wastes	Comment
Other waste						
Nonhazardous						
Liquid	Discharge canal	Disposal	Expandable ^d	Variable ^e	Variable ^e	NPDES ⁱ -permitted
	Evaporation ponds	Treatment	Expandable ^d	Variable ^e	Variable ^e	
Solid	Central landfill	Disposal	Expandable ^d	Variable ^e	Variable ^e	
Sewage						
Liquid ^j	Sanitary tile fields	Disposal	Expandable ^d	Variable ^e	Variable ^e	
Solid ^k	Central landfill	Disposal	Expandable ^d	Variable ^e	Variable ^e	

^aBaseline values projected from 1988 data.

^bFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^cBaseline value taken from 1988 data for planned future capacity.

^dSufficient space is available within the boundaries of the facility to accommodate additional storage/treatment disposal units, which can be constructed as needed.

^ePercentage used will vary with additional unit construction schedule.

^fLiquids containing transuranics are processed as HLW.

^gSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^hFinal holding capacity to be established if NPR is to be located at Hanford.

ⁱNPDES is National Pollutant Discharge Elimination System.

^jLiquid effluents from sewage treatment operations.

^kSolids from sewage treatment operations.

Source: Merrick 1989.

4.1.10.1 High-Level Waste

At Hanford, HLW (along with some TRU waste and LLW) is stored in 28 double-shell tanks having a total storage capacity of 120,000 m³. All tank waste is managed as HLW according to guidelines in DOE Order 5820.2A. The double-shell tanks are interconnected via underground pipes, and waste is transferred between tanks depending on waste composition and processing status. For example, some tanks may contain primary (untreated) waste that may later be discharged for treatment and returned as processed waste for storage before final disposition. Because of the complex interactions between the double-shell tanks and waste processing and disposal facilities, both the amount and type of waste present in the tanks at any given time varies. Hanford operates such that at least one tank volume (approximately 4,300 m³) remains available throughout the tank storage system to contain waste overflow in the event of a tank failure.

During NPR operations, the waste inventory in the double-shell tanks (approximately 78,000 m³) would be treated at the B-Plant. That treatment would generate an LLW fraction to be solidified and disposed of in near-surface vaults and an HLW fraction to be routed to the Waste Vitrification* Plant for immobilization in glass and shipment for disposal at a Federal repository. The NPR proposed action does not include spent fuel processing. It is assumed that NPR spent fuel would ultimately be disposed of in a Federal repository. However, it is reasonably foreseeable that spent fuel could also be reprocessed under such a scenario. The NPR-generated HLW would not be sent to the B-Plant. It would be separated into HLW and LLW fractions at the NPR Spent Fuel Reprocessing Complex. After the initial separation, the NPR-generated HLW would be processed at the vitrification facility (Section 4.1.10.3). Uranium-salt waste is discussed as an NPR waste in Section 5.2.10.

Hanford also has 144 single-shell tanks containing damp saltcakes and sludge accumulated from 1944 to 1980. The integrity of the tanks and tank contents is to be characterized over a 15-year period. Eventual waste treatment and disposal by means of Hanford waste management facilities would depend on the waste type. The single-shell tanks do not receive any new waste. No NPR-generated waste would be sent to single-shell tanks.

4.1.10.2 Transuranic Waste

Since 1973, liquid streams containing TRU waste have been stored in double- and single-shell tanks. These liquids will be processed at the B-Plant. The TRU waste from these liquids will then be immobilized in a glass matrix (along with HLW) at the Waste Vitrification Plant before being sent to a Federal repository for final disposal.

Approximately 15,000 m³ of solid TRU waste has been segregated from other radioactive waste and stored aboveground on asphalt pads in the 200 areas. Beginning in 1996, this TRU waste will be processed at the planned Waste Receiving and Processing Facility. This process will produce three waste streams: (1) packaged, certified TRU waste destined for eventual shipment to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico; (2) LLW to be disposed of on-site at the Low-Level Radioactive Waste Disposal Facility; and (3) mixed waste,

*See Appendix M for a description of vitrification.

which will be in interim storage at Hanford until proper treatment and disposal procedures are developed (see Sections 4.1.10.4 and 5.2.10.3).

The 170 m³/yr of TRU waste generated by continuing operations at the PUREX Plant and the Plutonium Finishing Plant is assayed and certified at the Transuranic Storage and Assay Facility, where it will be stored prior to off-site disposal at WIPP. After 1996, certification and interim storage of newly generated TRU will take place at the planned Waste Receiving and Processing Facility. TRU waste packaged at NPR facilities will be certified at the Transuranic Waste Storage and Assay Facility. TRU-contaminated waste (including NPR-related waste) that requires processing prior to certification will be treated at the Waste Receiving and Processing Facility.

4.1.10.3 Low-Level Waste

The three types of LLW at Hanford can be grouped according to the planned disposal routing: (1) liquid LLW that is to be stored in double-shell tanks before being disposed of as solids in surface vaults, (2) other liquid LLW that is to be disposed of in cribs or evaporation ponds, and (3) solid LLW that is now being containerized and disposed of in Hanford landfills. The liquid LLW sent to double-shell tanks consists of dilute aqueous solutions or slurries from Hanford laboratory operations, B-Plant effluent, PUREX Plant waste, and interstitial liquids removed from single-shell tanks. Liquid LLW is pretreated by evaporation to reduce the volume (average volume reduction factor of 13:1) before being sent to the tanks. The LLW streams derived from pretreatment of double-shell tank waste will be solidified with grout at the Grout Treatment Facility and disposed of in near-surface vaults in the Low-Level Radioactive Waste Disposal Facility. The Grout Treatment Facility combines cementlike grout solids with liquid LLW. Once combined, the slurry is pumped into near-surface lined vaults, where the material is allowed to harden in situ. The amount of grouted material disposed of as LLW in the near-surface vaults is 7,000 m³/yr.

Other liquid LLW originates from 33 effluent streams associated with existing waste processing facilities and defense reactor or chemical processing facilities. The effluent streams are ranked by level of radioactivity into high-priority and low-priority effluents. Both effluent streams are discharged to cribs or ponds. (Cribs are engineered structures, built into the ground, that allow liquid effluent to percolate into the subsurface.) The 19 high-priority streams discharge 6,000 m³/yr of water containing 4,100 Ci of activity, and the 14 low-priority streams discharge 17,000 m³/yr of water containing 300 Ci of activity.

The Hanford waste management strategy calls for high-priority effluents to undergo primary treatment using "best available technology." If required, further treatment would be conducted at a secondary treatment facility. Final disposal plans for the high-priority waste are scheduled for implementation by 1995 and may include effluent recycle, soil column percolation, evaporation, or discharge to the Columbia River. Low-priority effluents would be sent to lined retention ponds before eventual disposal by means of cribs, evaporation, system recycle, or discharge to the Columbia River. The NPR-generated liquid LLW would be treated similarly to the corresponding Hanford liquid LLW, consistent with applicable DOE orders and state requirements.

Solid LLW includes radioactively contaminated equipment and process waste (e.g., ion-exchange columns). The current forecast for generation of solid LLW is 13,000 m³/yr from

FY 1989 through FY 2017. Solid LLW, including NPR-related solid LLW, will be certified, treated if necessary, and containerized and disposed of in on-site landfills in accordance with applicable regulations.

4.1.10.4 Mixed Waste and Hazardous Waste

Mixed liquid LLW at Hanford is stored in double-shell tanks. Specialized treatment for this waste is still being evaluated.

The current forecast for generation of mixed solid LLW is 300 m³/yr from FY 1989 through FY 2017. Beginning in 1996, this waste will be segregated and stored for future treatment in the Waste Receiving and Processing Facility, which is planned to be in operation in 2000. Final disposal is planned for Hanford or another DOE facility, pending development of regulations for final disposal of mixed waste. Interim storage is being provided at the Hanford Central Waste Complex until appropriate treatment can be determined. This complex, which will be in operation in FY 1991, includes the following: (1) flammable mixed waste storage modules for storing flammable LLW, TRU waste, low-level mixed waste, and TRU mixed waste with flash points below 38°C; (2) the Plutonium/Polychlorinated Biphenyl Facility for storing mixed waste contaminated with PCBs; (3) mixed waste storage buildings (operational in 1990) having a total storage capacity of 2,400 m³; and (4) a large Mixed Waste Storage Facility, which will begin operations in 1991 and which will have additional capacity coming on line through 1994 (total capacity for mixed waste storage will increase to 11,600 m³).

Hazardous waste is stored at the Nonradioactive Dangerous Waste Storage Facility, which stores waste prior to off-site shipment. Operated (under interim RCRA status for hazardous waste) as a storage facility, the facility consists of six storage cells designed to segregate different types of hazardous waste. Current plans are to continue to dispose of hazardous waste off-site through RCRA-permitted disposers. The formerly used Nonradioactive Dangerous Waste Landfill is closed; however, studies are being conducted to determine if it can be reactivated for disposal of non-NPR- and NPR-related hazardous waste. NPR-generated mixed waste and hazardous waste will be treated and disposed of along with the corresponding Hanford baseline waste.

4.1.10.5 Other Waste

Liquid sanitary waste from remote and widely separated facilities is treated and disposed of in conventional tile fields (i.e., soil absorption systems). Nonradioactive, nonhazardous solid waste is disposed of in the Hanford Central Landfill, which is located 4.8 km southeast of the 200-East Area. This conventional landfill facility has sufficient capacity for increased waste disposal. Solid other waste from NPR facilities would be disposed of in the landfill.

4.1.10.6 Remedial Activities

Activities at Hanford have generated radioactive and hazardous waste. The DOE has established an Environmental Restoration Program consistent with the Tri-Party Agreement (May 15, 1989) among DOE, EPA, and the Washington Department of Ecology. The Tri-Party

Agreement outlines a 30-year plan at Hanford that includes CERCLA site investigation and remedial actions and RCRA permitting and corrective action requirements. Within the scope of the first 5-year period, 44 remedial investigations and 13 remedial cleanup actions on operable units will be initiated.

Planned remedial activities would not directly affect the NPR project. However, treating and disposing of waste, including radioactive liquids from single- and double-shell tanks, and processing solid waste containing transuranics would utilize many of the same waste management facilities involved in processing NPR-related waste.

4.2 IDAHO NATIONAL ENGINEERING LABORATORY

4.2.1 Geology

This section summarizes the geologic setting, including potential geologic hazards, at INEL. Soils of the proposed NPR site are evaluated with respect to the agronomic classifications "Prime Farmland" and "Unique Farmland." Appendix D contains a more detailed exposition of these topics.

4.2.1.1 Geologic Setting

The INEL is located near Idaho Falls, Idaho, in the Eastern Snake River Plain physiographic province. The dominant geologic features of the Snake River Plain were formed by volcanism. However, the plain is bordered by Basin and Range mountains that were created by movement on normal faults.

4.2.1.2 Geologic Structures

The INEL is in southeastern Idaho on the Eastern Snake River Plain, a physiographic province extending from the Idaho-Oregon border to the Island Park-Yellowstone Volcanic Plateau (Figure D.6). The Eastern Snake River Plain is bordered on the northwest and southeast by the Basin and Range province. The Snake River Plain apparently began developing in southwestern Idaho approximately 15 million years ago as the North American plate moved westward over a stationary plume or "hot spot" in the earth's mantle (Armstrong, Leeman, and Malde 1975; Smith and Christiansen 1980; Mabey 1982). The distribution of major Basin and Range faults in the region and the location of volcanic caldera are shown in Figure 4.2.1-1.

4.2.1.3 Volcanism

Volcanic activity in the Snake River Plain has occurred in two stages. First, a rhyolitic stage of explosive volcanism results in massive deposits of ash-flow tuffs. This stage was followed by less energetic extrusion of basaltic lava. These basalt flows dominate the surface geology of INEL. Concomitant with the compositional change from rhyolitic to basaltic volcanism is a gradual shift in the centers of eruption from southwest to northeast. Older volcanic rocks occur in the western part of the Snake River Plain. The surface basalt at the NPR site is approximately 230,000 years old. The rocks become progressively younger to the east, with the youngest rocks occurring in the Yellowstone Volcanic Plateau, where the rhyolitic stage of volcanism is taking place. This pattern is consistent with the geologic theory of "hot spot" tracks (Vink et al. 1985). Volcanic activity is theorized to result when tectonic plates move across hot spots deep in the earth's mantle (Armstrong, Leeman, and Malde 1975; Mabey 1982).

The Blacktail, Blue Creek, and Kilgore calderas are the three major calderas associated with rhyolitic volcanism on the Snake River Plain in eastern Idaho. Inferred from geologic mapping and geophysical investigations (Morgan, Doherty, and Leeman 1984), they range in age from 6.5 to 4.3 million years old. In contrast, the youngest tuff of the Yellowstone caldera to the

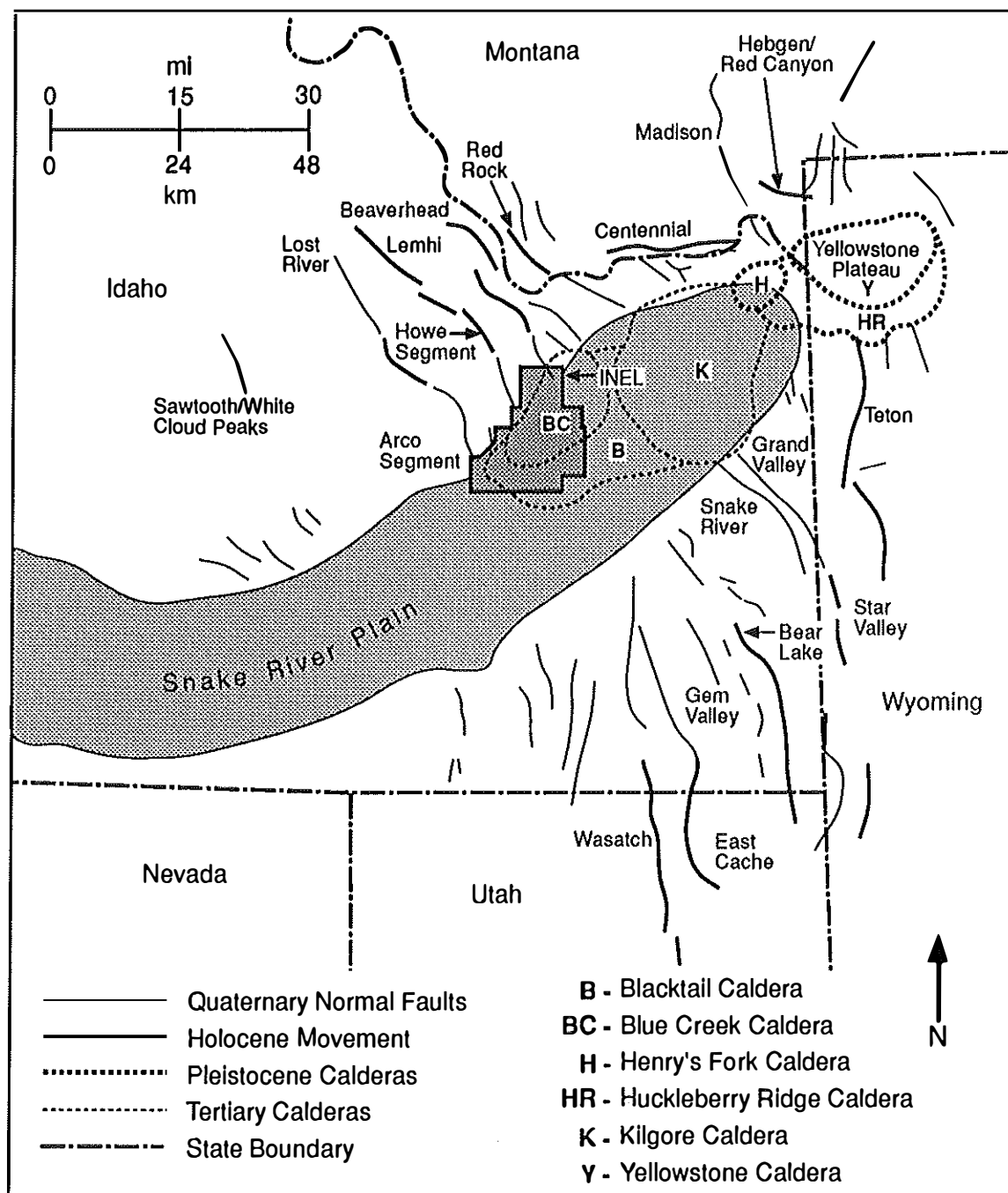


FIGURE 4.2.1-1 Major Fault Systems and Volcanic Calderas near the Eastern Snake River Plain
(Sources: Anders et al. 1989; Hackett and Morgan 1988)

east in western Wyoming is only 600,000 years old. Because these volcanic centers have been moving to the east across the Yellowstone-Snake River Plain area, the likelihood of further caldera-forming eruptions on the Eastern Snake River Plain is thought to be low.

Subsequent to the rhyolitic eruptions and basalt lava flows, rhyolite lava domes formed on the Eastern Snake River Plain. Three of these -- Big Southern Butte, Middle Butte, and East Butte -- are close neighbors of or are inside the boundaries of INEL.

Basaltic volcanism has been shown to occur in association with volcanic rift zones (Kuntz et al. 1986). Four of these zones are postulated to cross the Eastern Snake River Plain (Figure 4.2.1-2): Great Rift, Arco, Lava Ridge-Hell's Half Acre, and Circular Butte-East Kettle Butte. The last three of these cross INEL. Beginning about 5,000 years ago, and most recently about 2,000 years ago, basaltic lava flowed from the Great Rift to create the volcanic features of the Craters of the Moon National Monument, which is located 72 km from the proposed NPR site. Basalt flowed from a vent about 10 km southwest of the proposed NPR site, creating the surficial geology seen there today, analyzed to be about 230,000 years ago (Kuntz et al. 1990). If basalt were to flow from the same zone today, the proposed NPR site would probably not be affected because the site is 12-15 m higher than the surrounding area. This difference in elevation is greater than the 4-m average thickness of basalt flows on the Eastern Snake River Plain. Lawrence Livermore National Laboratory has undertaken a study of the volcanic hazards of the proposed NPR site. Study results will be considered in the design of NPR facilities.

The Site E drill hole, which is close to the western boundary of the NPR site, was drilled in the spring of 1984 to a depth of 185.6 m. Reliable ages were obtained for seven of the nine lava flows encountered (Champion, Lanphere, and Kuntz 1988). The ages show that the eruptions took place between 641,000 and 233,000 years ago (Figure D.8). The average recurrence interval during that period of activity was 51,000 years. The time interval since the last activity (233,000 years) is about 4.6 times the average recurrence interval and 3 times the largest recurrence interval. These data suggest that the source or sources of basaltic lava at the NPR site are no longer active and therefore not expected to erupt again. If basaltic lava were to erupt from nearby volcanic rift zones, the flows would have to travel 10-20 km to reach the NPR site. Further, such lava flows would be unlikely to directly affect the site because the median thickness of lava flows on the Eastern Snake River Plain is about 4 m and the site is 12-15 m higher than the surrounding area.

4.2.1.4 Seismicity

Historical earthquakes are reported as Modified Mercalli Intensities (MMI). As shown in Appendix D, the Modified Mercalli Intensity scale is a measure of the strength of ground motion and as such is partly a function of distance from earthquake source, declining with distance. Instrumental data for INEL were reported from coda-length magnitudes, body-wave magnitudes, or surface-wave magnitudes. Coda-length magnitudes are measured from the concluding part of the seismograph record. Body-wave magnitudes are a function of the ratio of the amplitude to the period of seismic body waves moving through the earth's interior. Surface-wave magnitudes are a function of the amplitude of 20-second-period seismic surface waves.

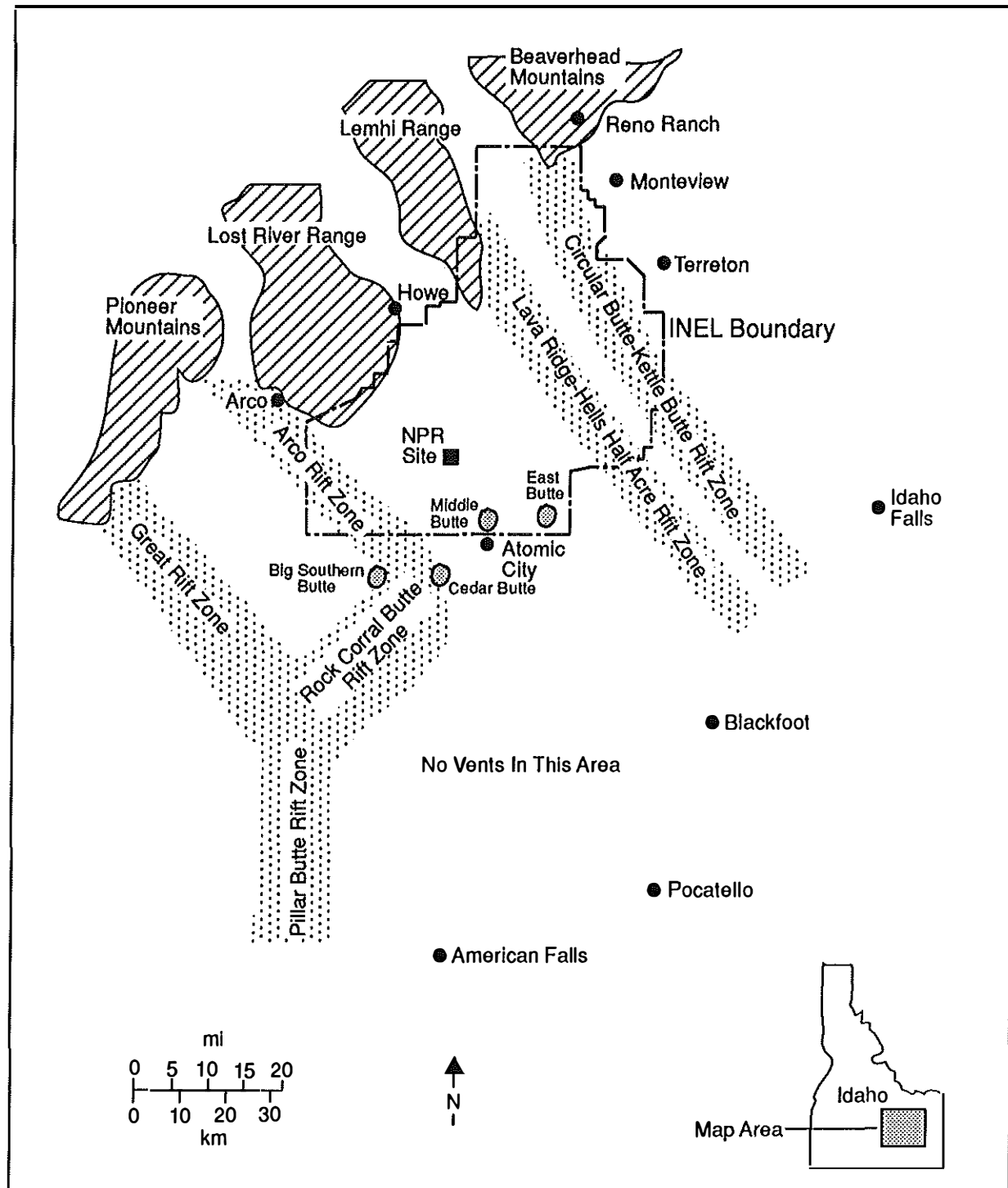


FIGURE 4.2.1-2 Postulated Volcanic Rift Zones on the Eastern Snake River Plain (Source: Modified from Kuntz 1978)

Figure 4.2.1-3 shows the distribution of earthquakes of magnitude larger than 2.5 for a radius of 322 km around the proposed NPR site. Regional seismicity is largely confined to the Intermontaine Seismic Belt (Richins et al. 1987). Large events include the 1983 Borah Peak earthquake (of magnitude 7.3) located near Mackay, Idaho, and the 1959 Hebgen Lake earthquake (of magnitude 7.5). The geographical relationship of these events to INEL is shown in Figure 4.2.1-3. The Borah Peak earthquake ruptured 36 km of the Thousand Springs and Warm Springs segments of the Lost River fault system (Crone et al. 1987).

In contrast to the high level of seismic activity in the Basin and Range mountains, earthquakes of large magnitude have not been recorded on the Eastern Snake River Plain (Figure 4.2.1-4). One possible exception is a 1905 event of magnitude 5.7. However, the location of this event, which was calculated from historical data, has an epicentral error of about 0.5° of latitude/longitude (i.e., ± 82 km east/west and ± 107 km north/south). This magnitude of error may mean that this event did not occur on the Plain.

Figure 4.2.1-5 is the seismic hazard curve for Argonne National Laboratory-West, which is part of INEL. The curve indicates the ground accelerations that could result from earthquakes for a range of return periods. New curves based on additional data now available are being developed for the proposed NPR site by Lawrence Livermore National Laboratory. These curves will be considered in the design of NPR facilities. Hazard curves like the one presented here have been used to project theoretical peak ground accelerations for the development of severe radiological accident scenarios at NPR support facilities. The results of these seismic analyses, which are being conducted by Lawrence Livermore National Laboratory (1990) and Murray and Wesley (1990), are presented in Appendix J.

4.2.1.5 Soils

Soils are distributed discontinuously at the proposed NPR site because of the frequent rock outcrops (Breckenridge and McGrath 1989). The U.S. Department of Agriculture's Soil Conservation Service has not conducted surveys on this part of INEL. Soils at the proposed NPR site would not satisfy either Prime Farmland or Unique Farmland criteria.

4.2.2 Air Resources

4.2.2.1 Climate and Meteorology

The climate at INEL and in the surrounding region is characteristically that of a semiarid steppe. Mountain barriers deplete a large portion of the moisture from the maritime air masses from the Pacific Ocean, a condition that contributes to the semiaridness.

Meteorological data have been collected at more than 45 locations at and near INEL. The weather stations closest to the proposed NPR site are the Grid 3 Station, which is located just north of the Idaho Chemical Processing Plant, and the Central Facilities Area Weather Station, which is located about 8 km southwest of the proposed NPR site (Appendix E, Figure E.2). The following climatological and meteorological information is based primarily on data collected from these two locations and summarized in reports prepared by Clawson, Start, and Ricks (1989) and EG&G Idaho, Inc. (EG&G-1).

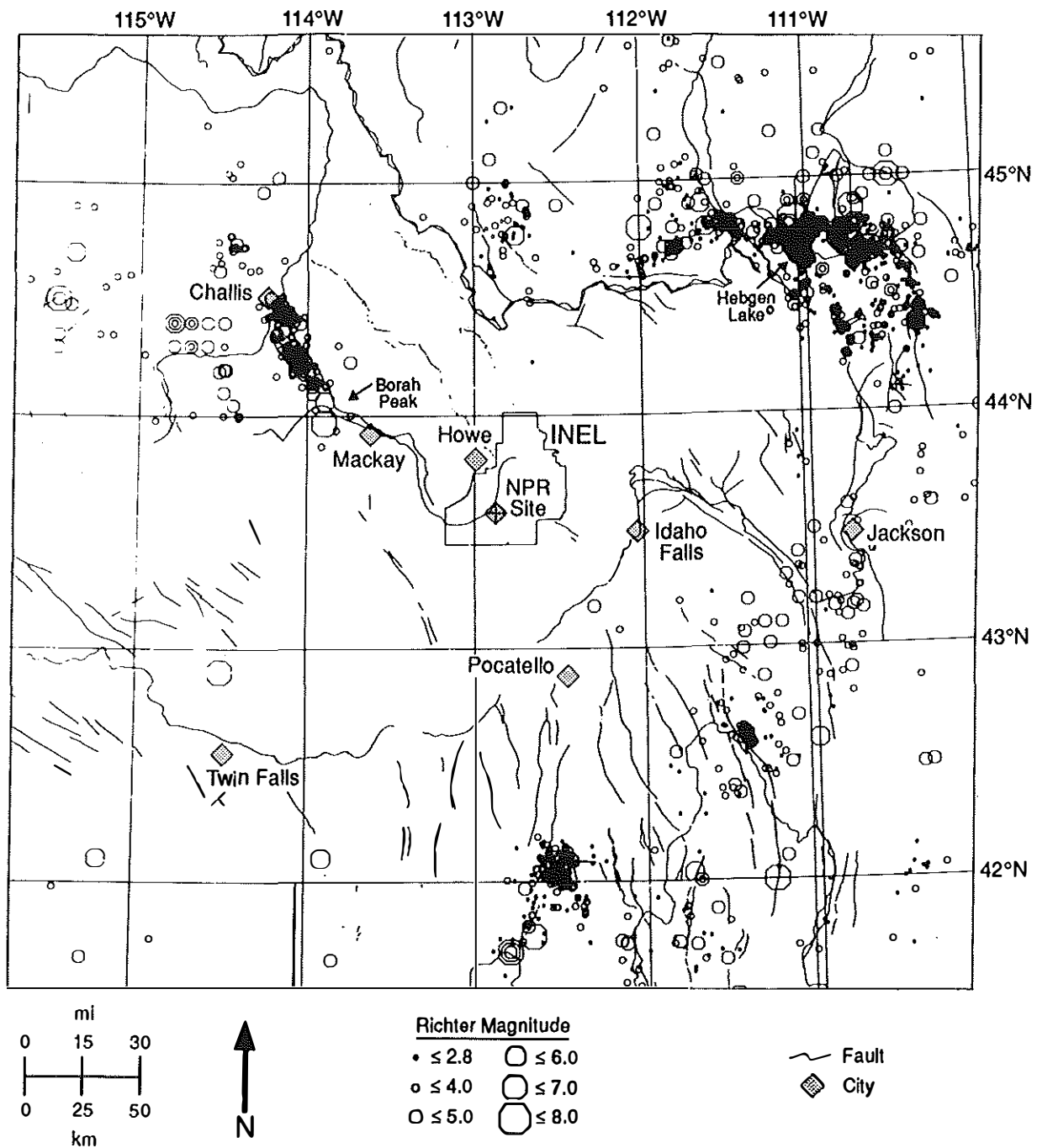


FIGURE 4.2.1-3 Seismicity within a Radius of 322 km of INEL (large earthquakes occur within the Intermontaine Seismic Belt and not on the Eastern Snake River Plain) (Source: LLNL 1990)

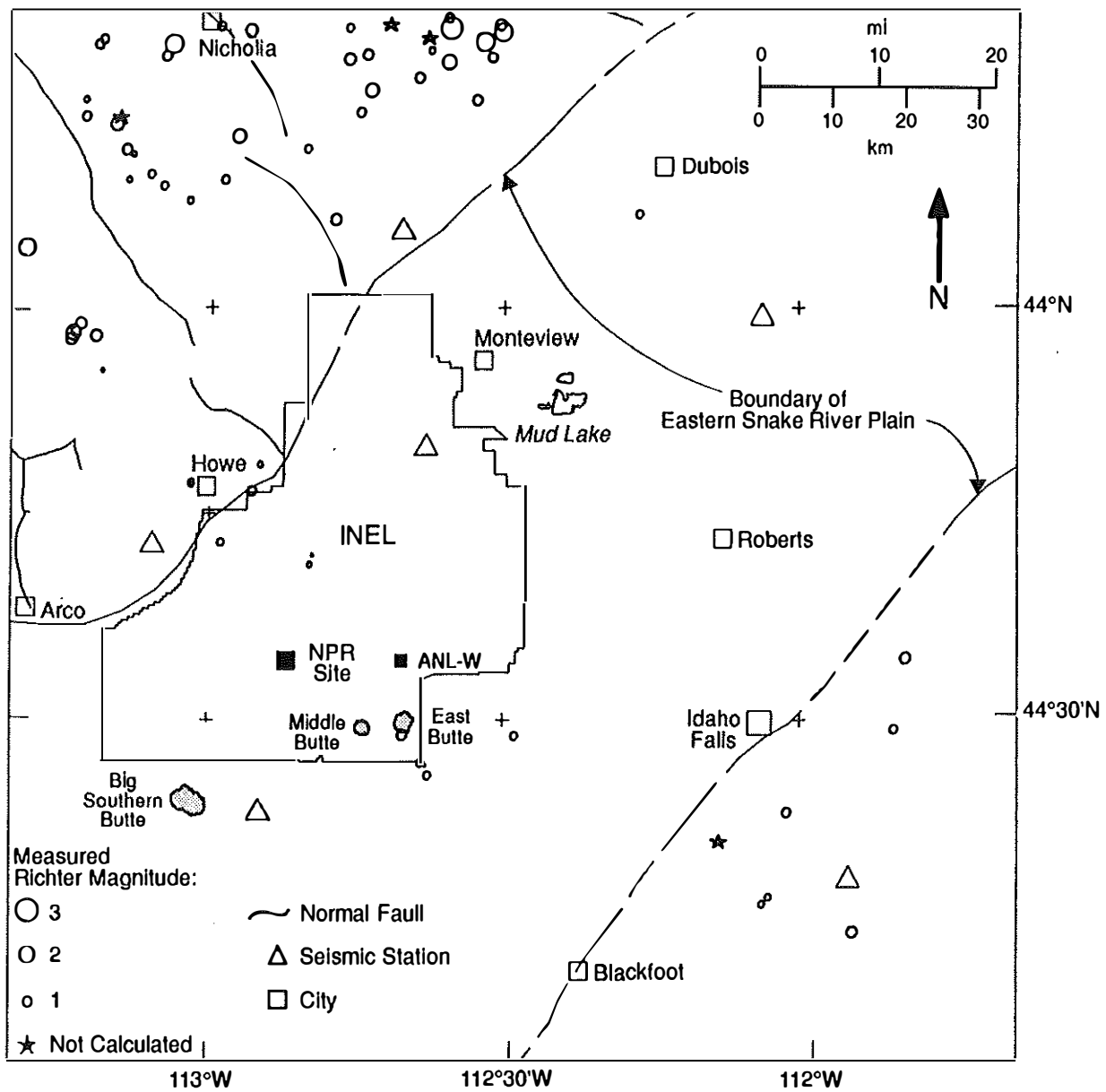


FIGURE 4.2.1-4 Instrumentally Measured Seismicity in the Immediate Vicinity of INEL, 1972-1989 (note relative paucity of earthquakes on the Eastern Snake River Plain relative to the bordering Basin and Range areas) (Source: INEL On-Line Earthquake Catalog Data Base)

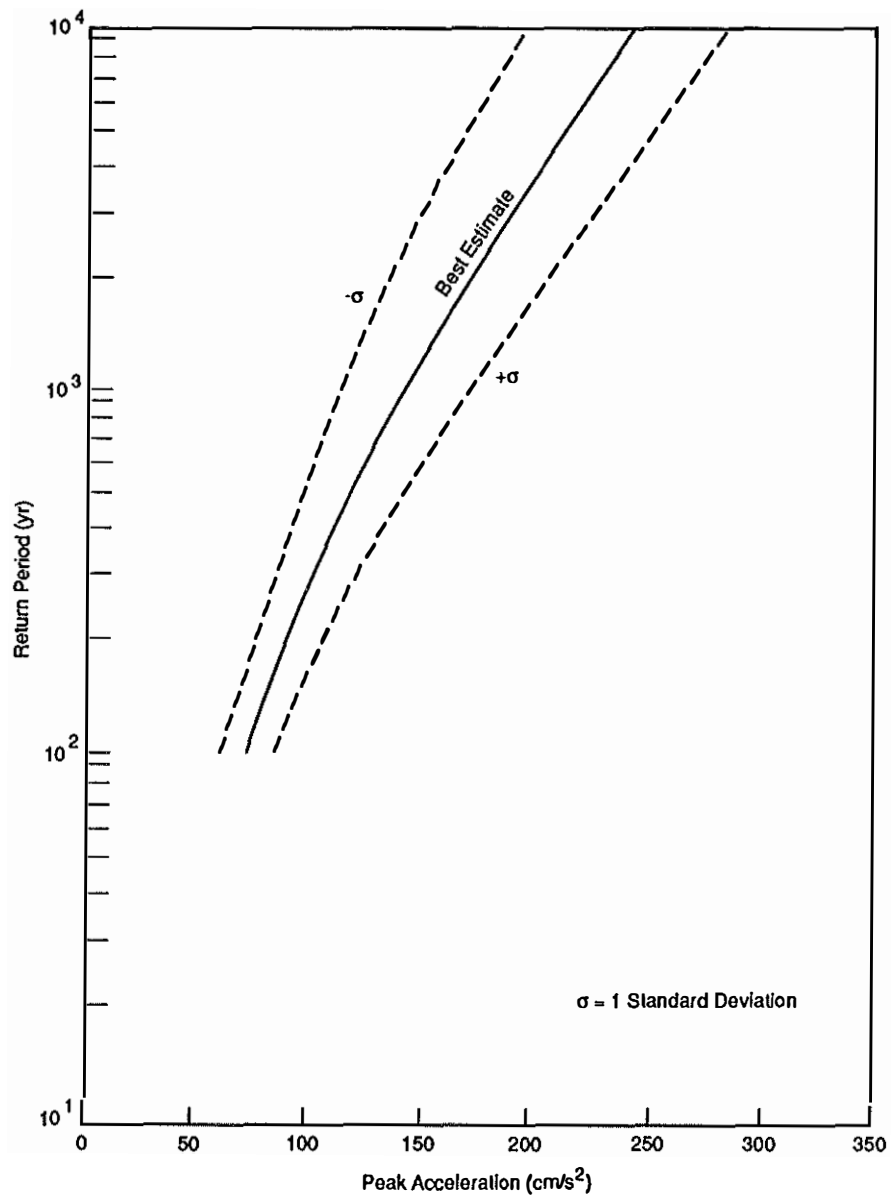


FIGURE 4.2.1-5 Seismic Hazard Curve for the Argonne National Laboratory-West Site at INEL (Source: TERA Corp. 1984)

Wind

Prevailing wind directions at INEL are from the southwest to west-southwest, with a secondary maximum frequency from the north-northeast to northeast. The annual average wind speed measured at the 6-m level at the Central Facilities Area Weather Station is 3.4 m/s. Monthly average wind speeds range from 2.3 m/s in December to 4.2 m/s in April and May.

Temperature and Humidity

The annual average temperature at INEL is 5.6°C; monthly averages range from -8.8°C in January to 20.0°C in July. The annual average relative humidity is 50%, with monthly average values ranging from 30% in July to 70% in February.

Precipitation and Evapotranspiration

The average annual precipitation at INEL is 22.1 cm. The average monthly precipitation ranges from 1.3 cm in October to 3.0 cm in May. A large portion of the precipitation occurs as snow during winter.

Pan evaporation measurements indicate that potential evapotranspiration at INEL is about 104 cm/yr (Farnsworth, Thompson, and Peck 1982), which is considerably more than the average annual precipitation of 22.1 cm. Thus, most of the precipitation is lost through evapotranspiration, except for that portion that percolates through the root zone during the spring thaw or prolonged rainfall. Some percolated water recharges the underlying aquifer (Lewis and Jensen 1984; Pittman, Jensen, and Fischer 1988).

Fog and Visibility

Fog occurs at INEL mainly during winter when wind speeds are low; however, data on fog have not been collected at INEL. The regional background visual range in the vicinity of INEL is estimated to be about 60 to 110 km (Trijonis and Shapland 1978). Statistics on other visibility-reducing phenomena (e.g., dust, blowing dust, and smoke) are not available.

Severe Weather

The maximum instantaneous gust recorded at the Central Facilities Area Weather Station (6-m level) was 35 m/s from the west-southwest, and the maximum hourly average wind speed, also from the west-southwest, was 23 m/s.

On average, two to three thunderstorm days occur during June, July, and August. Hail storms occur occasionally, with the hail usually smaller than 0.64 cm in diameter. Tornadoes are very infrequent in the area. Between 1950 and 1989, a total of five funnel clouds and no tornadoes were sighted within the boundary of INEL. The estimated probability of a tornado striking a point at INEL is 8×10^{-6} /yr (Ramsdell and Andrews 1986).

Atmospheric Dispersion Characteristics

Atmospheric dispersion improves if the wind speed increases, stability conditions become more unstable, and the depth of the mixing layer increases. Annual and seasonal data on the frequency distribution of atmospheric stability classes at the Central Facilities Area Weather Station and the Grid 3 Station are available in EG&G-1.

Data on the monthly average depth of the maximum daily mixing layer at INEL are summarized in Clawson, Start, and Ricks (1989). The approximate annual and seasonal morning and afternoon mixing-layer depths at INEL, as estimated by Holzworth (1972), are listed in Table E.8.

4.2.2.2 Ambient Air Quality

The INEL is located within the Eastern Idaho Intrastate Air Quality Control Region (AQCR). As of 1988, none of the areas within INEL and its surrounding counties was designated as a nonattainment area with respect to any of the National Ambient Air Quality Standards (NAAQS) (40 CFR 50). The applicable NAAQS and Idaho State ambient air quality standards are given in Table E.9.

The major sources of criteria air pollutants at INEL are (1) the calcination of liquid waste, (2) the combustion of coal for steam generation at the Idaho Chemical Processing Plant, and (3) the combustion of fuel oil for heating at various INEL facilities. Other emissions include fugitive particulate emissions from waste-burial activities and coal piles, other process emissions, vehicular emissions, and temporary emissions from various construction activities. Emission estimates for these sources are presented in Table E.10.

Since the promulgation of the Prevention of Significant Deterioration (PSD) regulations (40 CFR 52.21) in 1977, PSD permits were obtained for two major INEL emission sources (i.e., a coal-fired steam-generating plant next to the Idaho Chemical Processing Plant [DOE-24] and the Fuel Processing Restoration Facility [Engineering Sciences 1988]). The maximum increases in the concentrations of sulfur dioxide (SO_2), total suspended particulate (TSP), and nitrogen dioxide (NO_2) at the INEL site boundary and the nearby Craters of the Moon National Monument and Wilderness Area (Class I) due to emissions from these sources were estimated to be small compared with the applicable maximum allowable PSD increments (see Table E.11).

Ambient air quality within and near the INEL site boundary is currently monitored for SO_2 (one location), NO_2 (two locations), and particulate matter (PM) (two locations for TSP) (see Figure E.2 for the locations of these sampling stations). The ambient air quality data collected during the last few years, as summarized in Table E.12, are either very small percentages of the limits set in applicable ambient standards (SO_2 and NO_2) or substantially lower than the limits set in applicable ambient standards (TSP).

The Idaho Department of Health and Welfare (IDHW) no longer monitors ambient ozone (O_3) and NO_2 because previous monitoring indicated that ambient concentrations were very low (IDHW 1988). Monitoring of ambient lead concentrations in Idaho's large cities yielded concentration levels that were only a small fraction of the applicable ambient lead standard (IDHW 1988). These results suggest that the background concentrations of these pollutants are very low.

Toxic air pollutants that would be released from an NPR and its support facilities, and for which ambient concentration limits (to be used by the state as one of the criteria in evaluating construction permit applications for a new source) have been proposed by IDHW (IDHW 1990), include ammonia (NH_3), trichloroethylene (TCE), and nitric acid (HNO_3). The annual emission rates of these pollutants from existing INEL facilities during 1989 and estimates of their maximum 8-hour average ground-level concentrations at the INEL boundary are listed in Table E.26. The concentrations of NH_3 , HNO_3 , and TCE are significantly below their respective ambient concentration limits as proposed by IDHW. These limits are one-hundredth of the recognized occupational exposure levels (e.g., 8-hour time-weighted threshold limit values).

4.2.2.3 Acoustic Conditions

The major noise sources within INEL include various facilities, equipment and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). No INEL environmental noise survey data are available. At the INEL boundary, away from most of these industrial facilities, noise from these sources would be barely distinguishable from background noise levels. Thus, the acoustic environment along the INEL boundary* is assumed to be that of a rural location with typical residual noise levels of 30-35 dBA (Miller 1968; Fidell, Horonjeff, and Green 1981; Bolt, Beranek, and Newman 1984).

The EPA guideline recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA-1). For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.

The Noise Control Act of 1972, together with its subsequent amendments (Quiet Communities Act of 1978, 42 USC 4901-4918), leaves it to the states to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. Except for the prohibition of nuisance noise, neither the state of Idaho nor its local governments have established specific numerical environmental noise standards.

The INEL is remote from population centers; the nearest town is Atomic City, which is just 0.5 km from the southern boundary and about 16 km south of the proposed NPR site. The current resident population of Atomic City is about 30 persons. The next closest town is Howe, which is about 25 km northwest of the proposed NPR site. Its population is similar in size. The residents that could be affected by increased construction-related traffic noise are those living west of Idaho Falls or north of Blackfoot and within 15-20 m of the highway.

*The INEL site boundary nearest to the proposed NPR site is about 14.5 km south.

4.2.3 Water Resources

This section describes water resources at INEL that could be affected by construction and operation of an NPR or by the no-action alternative. The hydrologic feature with the greatest potential to be affected is the Snake River Plain aquifer. Surface water and groundwater resources are described in Sections 4.2.3.1 and 4.2.3.2, respectively; potential impacts to water resources and the significance of those impacts are discussed in Section 5.3.2. Wetlands at INEL are described in Section 4.2.5.2.

4.2.3.1 Surface Water

Description

Most of INEL is located in Pioneer Basin, a closed drainage basin that includes Big Lost River, Little Lost River, and Birch Creek. All three drain mountain watersheds north and west of INEL (Figure 4.2.3-1). Most of the surface water flow in Big Lost River, Little Lost River, and Birch Creek is diverted for irrigation before it reaches the INEL boundary (Barracough, Lewis, and Jensen 1981). This often results in little or no flow in these surface water bodies for many years within the boundaries of INEL (Pittman, Jensen, and Fischer 1988).

The Big Lost River flows southeasterly past the towns of Moore and Arco before crossing the southwestern boundary of INEL. From there, the river turns northward toward its terminus in the Big Lost River sinks. During times of heavy precipitation, the Big Lost River may overflow into flood-spreading areas in the southwestern portion of INEL (Figure 4.2.3-1) and three playas (labeled Playa 1, 2 and 3). In years of unusually high flow, Big Lost River may overflow its own playas and enter the Birch Creek playa (Playa 4). The Birch Creek playa is more commonly fed from the north by discharge from Birch Creek during wet years. The Little Lost River flows southeasterly toward the northwestern INEL boundary. Water from this river flows on-site only during high flow years, infiltrating into the ground or evaporating soon after it reaches the INEL boundary (EG&G-1).

Water flow in the Big Lost River is controlled by the MacKay Dam located approximately 85 km upstream of the proposed NPR site. Average annual discharges for Big Lost River (below MacKay Dam), Little Lost River, and Birch Creek are 8.88 m³/s, 1.97 m³/s, and 2.22 m³/s, respectively. The highest and lowest annual average flows recorded on the Big Lost River below MacKay Dam were 18.7 m³/s (in 1984) and 3.49 m³/s (in 1933), respectively. Other than losses due to evapotranspiration, all surface water that reaches the INEL boundary eventually percolates down into the Snake River Plain aquifer (Pittman, Jensen, and Fischer 1988).

In 1958, a flood diversion system was built in the southwest portion of INEL (Figure 4.2.3-1). This system consists of a small dam to divert flow from the main river channel of the Big Lost River into four flood-spreading areas (EG&G-1). In 1972, the U.S. Geological Survey, evaluating the effectiveness of the INEL flood control system, predicted that the Big Lost River would overflow the INEL diversion dam once every 55 years (Carrigan 1972). In response to those findings, the dikes that surround the flood-spreading areas were raised 2 m to provide a system that could divert a flow of approximately 190 m³/s. The dikes were raised in 1984, and the spreading areas now provide a combined capacity of 72 million m³ (McKinney 1985).

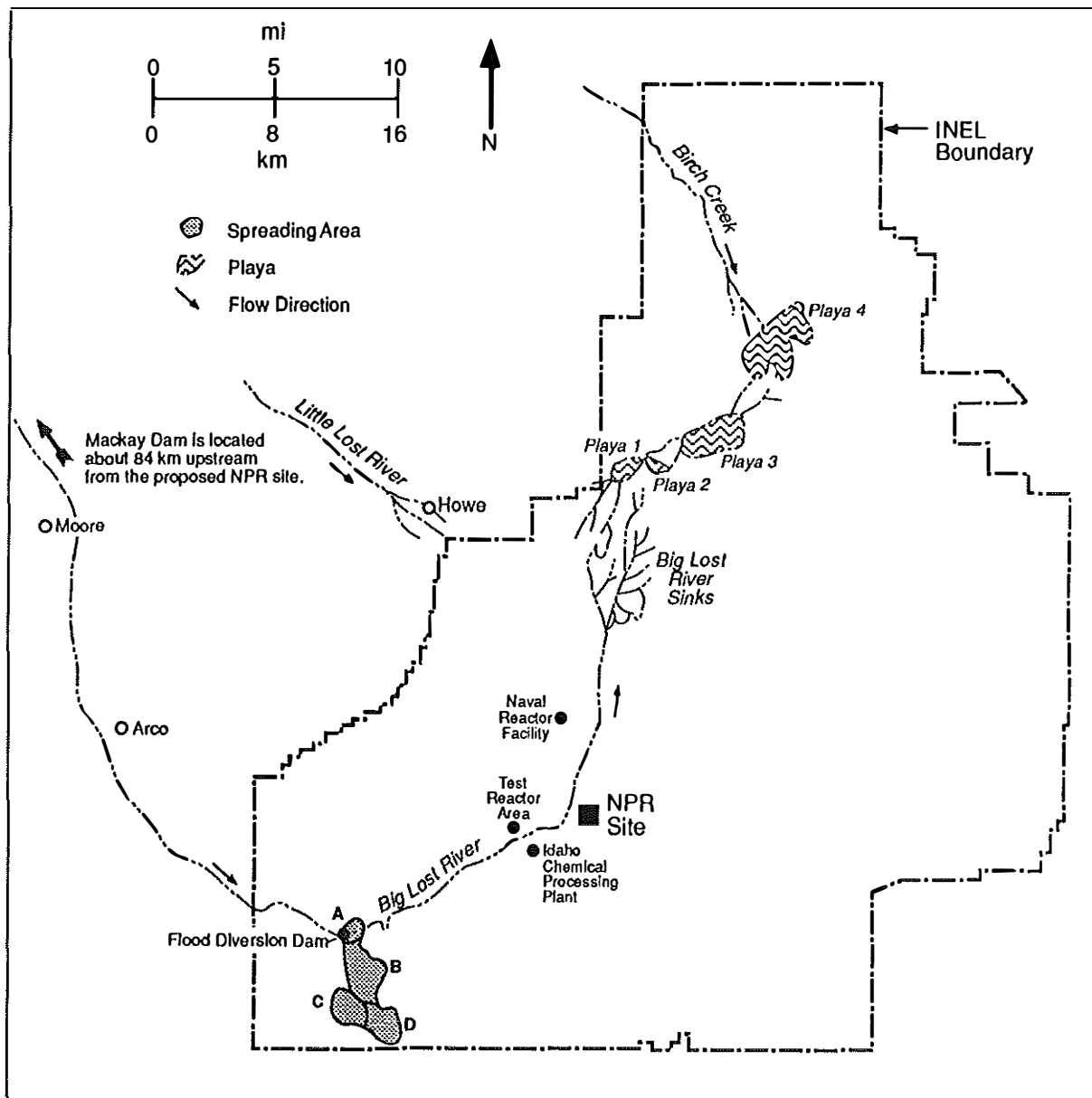


FIGURE 4.2.3-1 Surface Water Features in the Vicinity of INEL (Source: Modified from EG&G-1)

Infiltration rates in these spreading areas average about 0.5 m/d. In addition, the total capacity of Playas 1, 2, and 3 is 9.4 million m³, with the infiltration rates for these playas averaging 0.16 m/d (Barracough et al. 1967).

Man-made wastewater disposal ponds are located at the Test Reactor Area, the Naval Reactor Facility, and the Idaho Chemical Processing Plant. All the disposal ponds currently are unlined to permit the downward infiltration of water, but future plans are to convert these ponds to lined basins. No wastewater is discharged directly into natural surface water features at INEL. Designated wetland areas on INEL are described in Section 4.2.5.

Surface Water Quality

The results of chemical analyses of water samples collected from Big Lost River in 1975 are summarized in Table F.10 (Appendix F). Results of analyses of samples taken in 1963 from Big Lost River, Little Lost River, and Birch Creek are given in Table F.11. More recent samples are not available because of the intermittent nature of these water features. As shown in Appendix F, concentrations of constituents are generally within drinking water standards.

Because all discharges from INEL facilities are to man-made seepage ponds and evaporation ponds, natural surface waters near INEL do not receive direct discharges of effluents.

Floodplain

Detailed analysis of the probable maximum flood combined with a hypothetical failure of MacKay Dam indicates potential flooding of some locations on INEL (Figure F.2). However, the NPR site is located approximately 17 m above the peak level for this flooding event (EG&G-1).

Surface Water Use

No human use of the surface water bodies on INEL has been documented. However, the Big Lost River, Little Lost River, and Birch Creek are major sources of irrigation water for agricultural areas upstream of INEL (EG&G-1; Pittman, Jensen, and Fischer 1988).

The Little Lost River (from its source to the playas) is designated by the Idaho Department of Health and Welfare's Water Quality Standards and Wastewater Treatment Requirements (1988) for the following uses: agricultural water supply, cold-water biota, salmonid spawning, primary contact recreation, and secondary contact recreation. The Big Lost River and Birch Creek (from their sources to their playas) are designated for these same uses and for domestic water supply and special resource waters. Special resource waters are defined as "those specific segments or bodies of water which are recognized as needing intensive protection: (a) to preserve outstanding or unique characteristics; or (b) to maintain current beneficial use."

Surface Water Rights

Surface water rights are not an issue because INEL facilities do not withdraw surface water for use, nor do they discharge effluents directly to natural surface waters.

4.2.3.2 Groundwater

Description

The INEL is located on the Eastern Snake River Plain. The Snake River Plain aquifer lies beneath INEL and covers an area of about 24,900 km² (Figure F.3). The rock through which the groundwater flows is composed of 600 to 3,000 m of basaltic lava flows, rhyolite deposits, and interbedded sediments (Barracough, Lewis, and Jensen 1981). The individual basalt flows generally range from 3 to 15 m thick and cover 130 to 300 km² (Lindholm 1986; Lindholm and Vaccaro 1988). The bulk of the groundwater occurs in the basalt layers which are estimated to contain approximately 2.5×10^{12} m³ of water. It has been estimated that approximately 25% of this water is available for withdrawal by pumping (EG&G-1). All of the water used at INEL is withdrawn from the Snake River Plain aquifer.

The upper surface of the Snake River Plain aquifer is unconfined over most of its extent. However, the aquifer generally behaves as if it were partially confined because of the hydraulic conductivity contrasts between the dense basalt and interbedded sediments and water-bearing fractures. Although the direction of local groundwater movement is complex, the overall flow pattern is to the south and southwest (Figure 4.2.3-2) at velocities of 1.5 to 6.0 m/d (Barracough, Lewis, and Jensen 1981).

Figure 4.2.3-2 shows the potentiometric surface of the aquifer and the generalized groundwater flow direction in the INEL area (Pittman, Jensen, and Fischer 1988). Although the water-carrying properties vary substantially throughout the aquifer, in general, aquifer transmissivities measured beneath INEL are large, as are storativities and effective porosities (Table F.12). The depth to the top of the Snake River Plain aquifer ranges from approximately 60 m in the northeast portion of INEL to 300 m in the southeast corner. The depth to the top of this aquifer at the NPR site is 145 m (EG&G-1). The aquifer is at least 76 m thick.

Recharge to the Snake River Plain aquifer under INEL is primarily by underflow of groundwater from the northeastern part of the Snake River Plain and secondarily from adjacent surface water drainages to the west and north (Big Lost River, Little Lost River, and Birch Creek). Lesser amounts of recharge are derived from local precipitation and snowmelt (Barracough, Lewis, and Jensen 1981).

Perched groundwater occurs beneath the eastern Snake River Plain in areas where infiltrating water is impeded by layers of fine-grained, low-permeability sediments (Robertson 1977). Perched water occurs below a few areas on INEL, including the Big Lost River and the wastewater disposal ponds at the Test Reactor Area and the Idaho Chemical Processing Plant. Small areas of perched water occur in the alluvium at shallow depths beneath the wastewater disposal ponds. A larger zone of perched water, covering at least 3.4 km², also has formed in the interbedded sediment-basalt sequence at a greater depth below the wastewater disposal

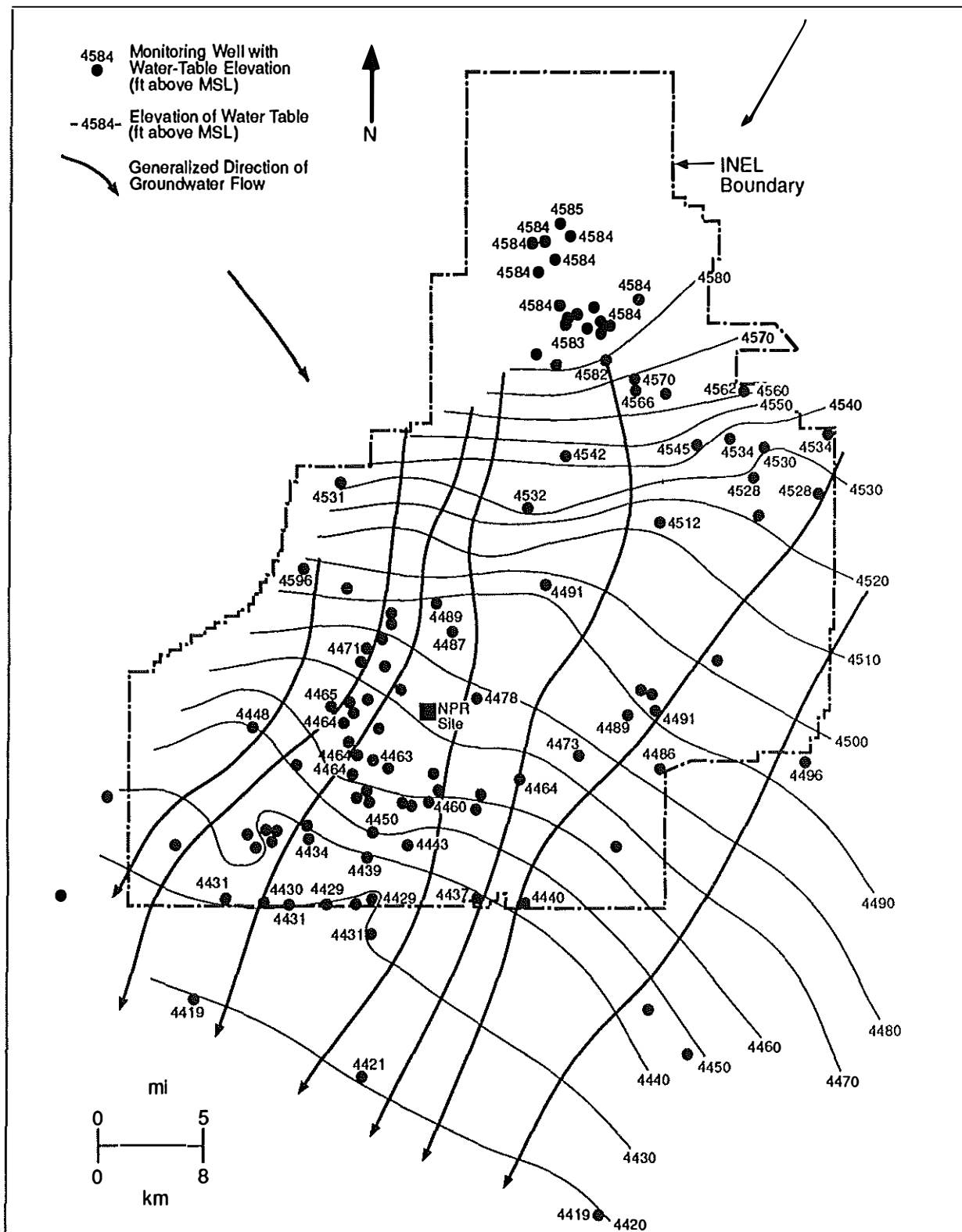


FIGURE 4.2.3-2 Potentiometric Head of the Snake River Plain Aquifer in the INEL Area and General Direction of Groundwater Flow, July 1985 (Source: Modified from Pittman, Jensen, and Fischer 1988)

ponds. This feature is called the deep perched groundwater zone. The base of this deep perched zone is about 90 m above the Snake River Plain aquifer (Pittman, Jensen, and Fischer 1988).

Groundwater Quality

Two groundwater monitoring networks are operated at INEL: one by the U.S. Geological Survey and the other by the Radiological and Environmental Sciences Laboratory.

The USGS network comprises more than 200 wells on and near INEL. Of these, 120 wells sample groundwater in the Snake River Plain aquifer, and 100 sample groundwater in the perched zones (DOE-27). Wells are sampled for both water level and chemical constituents. The wells sampled by the Radiological and Environmental Sciences Laboratory include INEL water supply wells, wells that monitor the migration of constituents from INEL facilities, and off-site water supply wells. These wells are sampled for chemical and radiological constituents.

Analyses of groundwater in the Snake River Group basalt performed by the U.S. Geological Survey (Yee and Souza 1987) indicate that the groundwater quality (based on median and mean values) in the Snake River Plain aquifer in the vicinity of INEL meets drinking water standards (Table F.13). Although more recent analyses of groundwater beneath the NPR site do not exist, groundwater quality is expected to be good because of the site's location upstream from any effluent discharges on INEL.

Radioactive and chemical wastes discharged since 1952 to unlined ponds and deep wells at INEL have affected water quality in localized areas in the perched groundwater zones and in the Snake River Plain aquifer. As a result of effluent disposal into unlined ponds, tritium (a mobile radionuclide) has been detected in the perched zone in the Test Reactor Area (Figure 4.2.3-3) in concentrations above the State of Idaho drinking water standard (20,000 pCi/L) (Pittman, Jensen, and Fischer 1988). Localized plumes of groundwater containing low levels of radionuclides and chemical constituents also occur in the Snake River Plain aquifer from injection of wastes into the ground (Pittman, Jensen, and Fischer 1988; Lewis and Jensen 1984; Robertson 1977). Low-level radioactive and chemical wastes from the Idaho Chemical Processing Plant were discharged directly into the ground through a 180-m-deep well from 1953 until February 1984. Since 1984, wastes from the plant have been disposed of in unlined ponds, although the disposal well was available for use in emergency situations from 1984 to 1986 (Pittman, Jensen, and Fischer 1988).

Plumes of contaminated groundwater containing radioactive waste products (e.g., tritium, strontium-90, iodine-129, cesium-90, plutonium-238 and ruthenium-106) have migrated downgradient (south) from the Idaho Chemical Processing Plant and the Test Reactor Area (Figure 4.2.3-4). The maximum concentration of tritium detected in wells at INEL in 1987 in the Snake River Plain aquifer was 80,600 pCi/L (Knobel and Mann 1988). Tritium, being the most mobile of these radionuclides, has migrated the farthest, followed by iodine and strontium. Cesium, ruthenium, and plutonium have migrated less than 0.8 km. Most other radionuclides are either sorbed on the materials surrounding the disposal areas, decay to low levels before entering the aquifer, or are not discharged in sufficient quantities to be detected in the aquifer. In recent years, the tritium plume near the southern boundary of INEL has receded because of radioactive decay (Pittman, Jensen, and Fischer 1988).

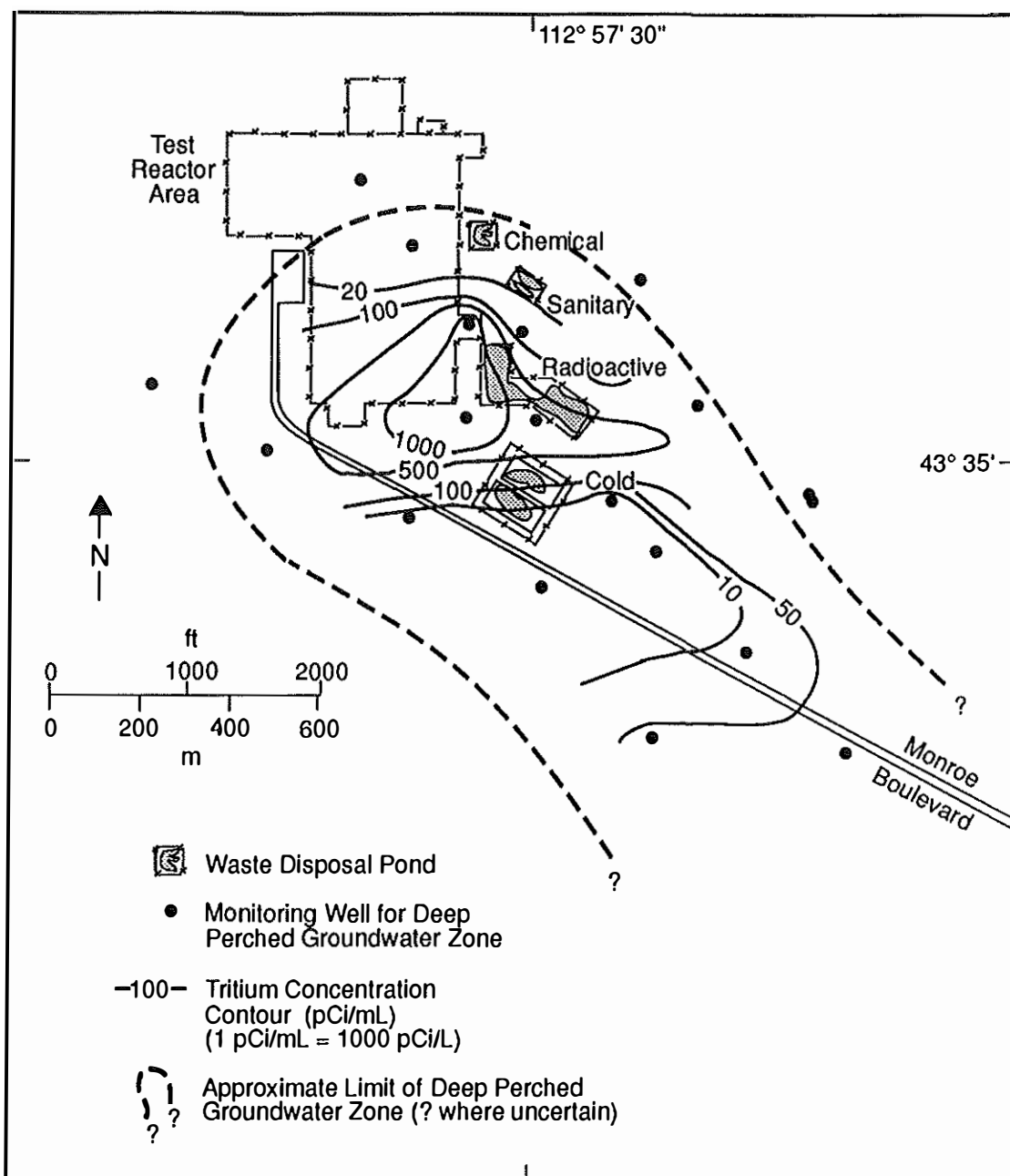


FIGURE 4.2.3-3 Tritium Concentrations in the Deep Perched Groundwater Zone near the Test Reactor Area, October 1985 (Source: Modified from Pittman, Jensen, and Fischer 1988)

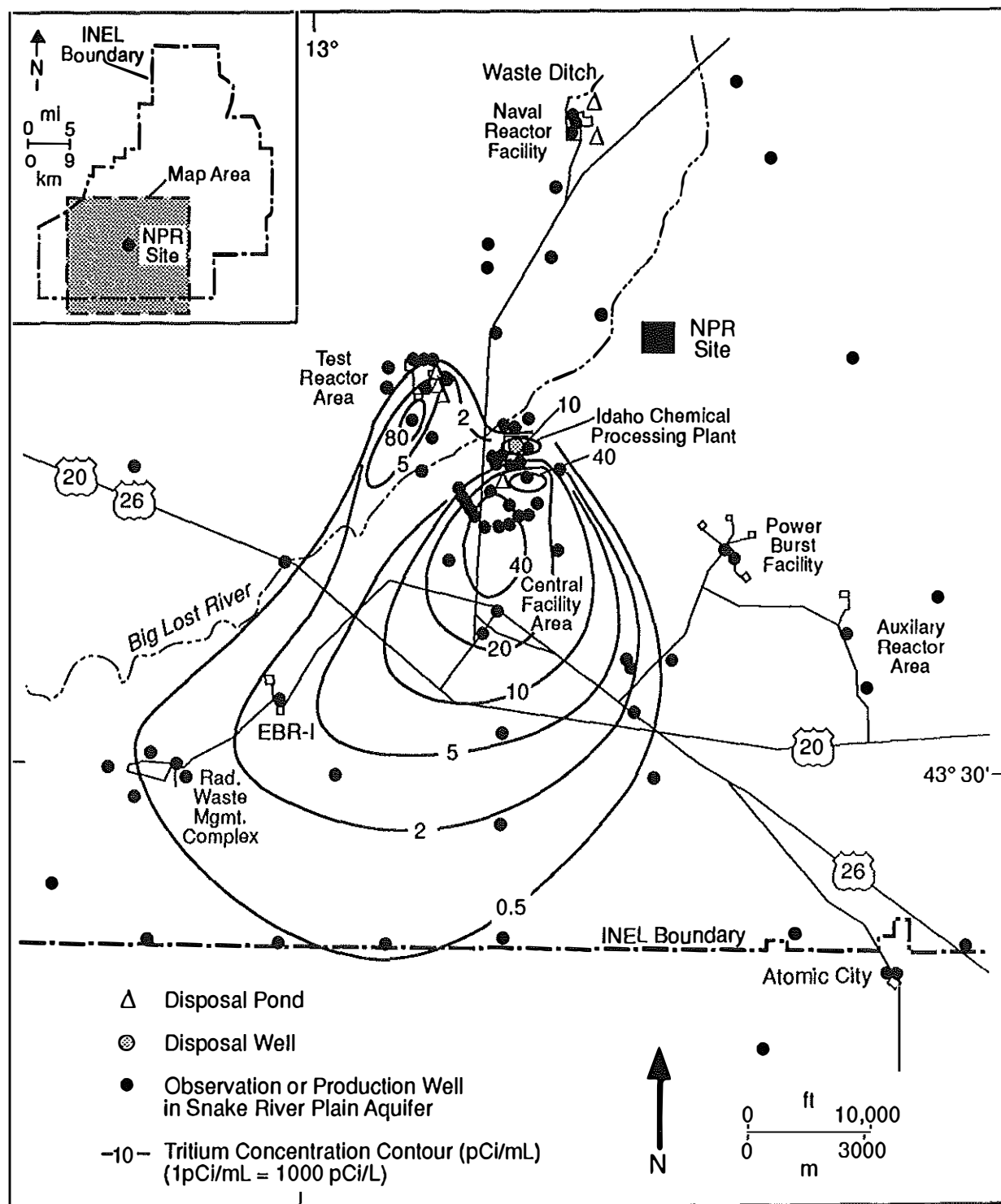


FIGURE 4.2.3-4 Tritium Plume in the Snake River Plain Aquifer in the South-Central Part of INEL, October 1985 (Source: Modified from Pittman, Jensen, and Fischer 1988)

Tables F.14 and F.15 show the maximum concentrations of organic chemical and radioactive constituents in the groundwater beneath INEL. These extreme concentrations tend to be very localized around the sources of contamination. As part of a corrective action unrelated to proposed NPR activities, existing seepage ponds will be fitted with low-permeability liners before construction and operation of an NPR. None of the waste plumes originating at these ponds is in the area of the proposed NPR site.

Groundwater Use

The Snake River Plain aquifer is the source of all water used at INEL. Of the 30 production wells on-site, 27 are routinely in use. The combined pumpage from these wells was approximately $0.25 \text{ m}^3/\text{s}$ (7.9 million m^3/yr) for the period including 1982 through 1985 (Pittman, Jensen, and Fischer 1988). This is 0.40% of the $63 \text{ m}^3/\text{s}$ (2.0 billion m^3/yr) of groundwater withdrawn by all users from the aquifer in the eastern Snake River Plain. Most of the water withdrawn from the aquifer in the eastern Snake River Plain ($57 \text{ m}^3/\text{s}$ [1.8 billion m^3/yr]) is used for agriculture (EG&G-1).

Approximately 63% of the groundwater withdrawn at INEL is disposed of in wells and ponds (nonconsumptive), rather than being consumptively used during site operations (Pittman, Jensen, and Fischer 1988).^{*} The Test Reactor Area is the largest consumptive user at INEL, approximately $0.038 \text{ m}^3/\text{s}$ (1.2 million m^3/yr). This is followed by the Naval Reactors Facility and Argonne National Laboratory which consume 0.019 and $0.0066 \text{ m}^3/\text{s}$ (605,000 and 208,000 m^3/yr), respectively (EG&G-1).

Groundwater Rights

As described in DOE-56, the DOE Idaho Operations Office has negotiated with the Idaho Department of Water Resources regarding a claimed water right for $2.3 \text{ m}^3/\text{s}$ (not to exceed 43 million m^3/yr) withdrawal capacity under the Federal Reserve Doctrine. The State of Idaho has signed a Settlement Agreement and there have been public hearings. Based on these hearings, an Interlocutory Order will be generated. The INEL will abide by this Order as it affects water use until the adjudication process is complete. Currently INEL withdraws an average of $0.25 \text{ m}^3/\text{s}$ (7.9 million m^3/yr) (Pittman, Jensen, and Fischer 1988).

4.2.4 Land Use, Recreation, and Visual Environment

The Idaho National Engineering Laboratory was created between 1949 and 1958 through a series of land withdrawals and purchases of Federal, state, and private lands (PLO No. 318 1946; PLO No. 545 1949; PLO No. 637 1950). The INEL is owned by the Federal government and operated for DOE by EG&G, Idaho, Inc.; Rockwell-INEL; Westinghouse Idaho Nuclear Company, Inc.; Westinghouse Electric Corporation; and Argonne National Laboratory-West. A buffer zone of grazing land for cattle and sheep surrounds the developed areas within INEL and covers

^{*}The amount of water *consumptively used* is the difference between the amount of water originally withdrawn and that ultimately returned to the ground or to surface water bodies. In these cases, consumptive use consists primarily of evaporation to the atmosphere.

almost 1,295 km² (Figure 4.2.4.-1). The grazing land is managed by the Bureau of Land Management.

The Bureau of Land Management has applied visual classifications of III and IV (mixed use and industrial use) to the acreage within INEL boundaries. The use of INEL as a nuclear research, materials, and development facility is consistent with these classifications. The INEL was designated as a National Environmental Research Park in 1975. There are no wildlife refuges within INEL.

Most of the area within INEL consists of open land, with direct line-of-site views frequently interrupted by hilly areas along access roads. Long-distance views are of INEL's rolling hills, buttes, and volcanic outcrops; and of the Lemhi, Lost River, and Bitterroot mountain ranges that border INEL to the north and west. East Butte and Middle Butte are located on INEL and can be seen from most locations on the site. The proposed NPR site consists of open land typical of the undeveloped portions of INEL. The site for the NPR support facilities is in an existing industrial area.

Land use in the region surrounding INEL consists of about 45% agriculture, 45% open land, and 10% urban/built-up area (EG&G-1). Agricultural use includes cropland (e.g., wheat and potatoes) and grazing land for cattle and sheep. The INEL workers live in the urban/built-up portions of the area, which are located east and southeast of INEL. The larger communities in the region are Idaho Falls, Blackfoot, and Pocatello.

The area surrounding INEL offers abundant recreational and tourism opportunities. Outdoor activities include hunting, fishing, and white-water rafting and kayaking. Two world-class ski areas are located within about 161 km at Ketchum, Idaho (Sun Valley), and Jackson Hole, Wyoming. Yellowstone National Park, the Bridger-Teton National Forest, Craters of the Moon National Monument, and other Federal, state, and local parks are easily accessed from Idaho Falls. Yellowstone alone reported more than 800,000 visitors in 1989. Tourism is the third largest industry in Idaho.

The six-county area around INEL has 55 tennis courts (indoor and outdoor), 12 golf courses, 12 bowling centers, public and private swimming pools, numerous ball fields, skating rinks, and several hundred campsites at state and Federal parks. Hardinger (1990) provides a comprehensive description of recreational and tourism resources near INEL.

4.2.5 Biotic Resources

This section describes the biotic resources of INEL, with emphasis on those components that could be affected by construction and operation of an NPR. More detailed descriptions of these resources, as well as lists of plant and animal species occurring there, are presented in Appendix G (Section G.2 and Tables G.3 and G.4). Markham (1983) provides a synopsis of ecological studies that have been conducted at INEL.

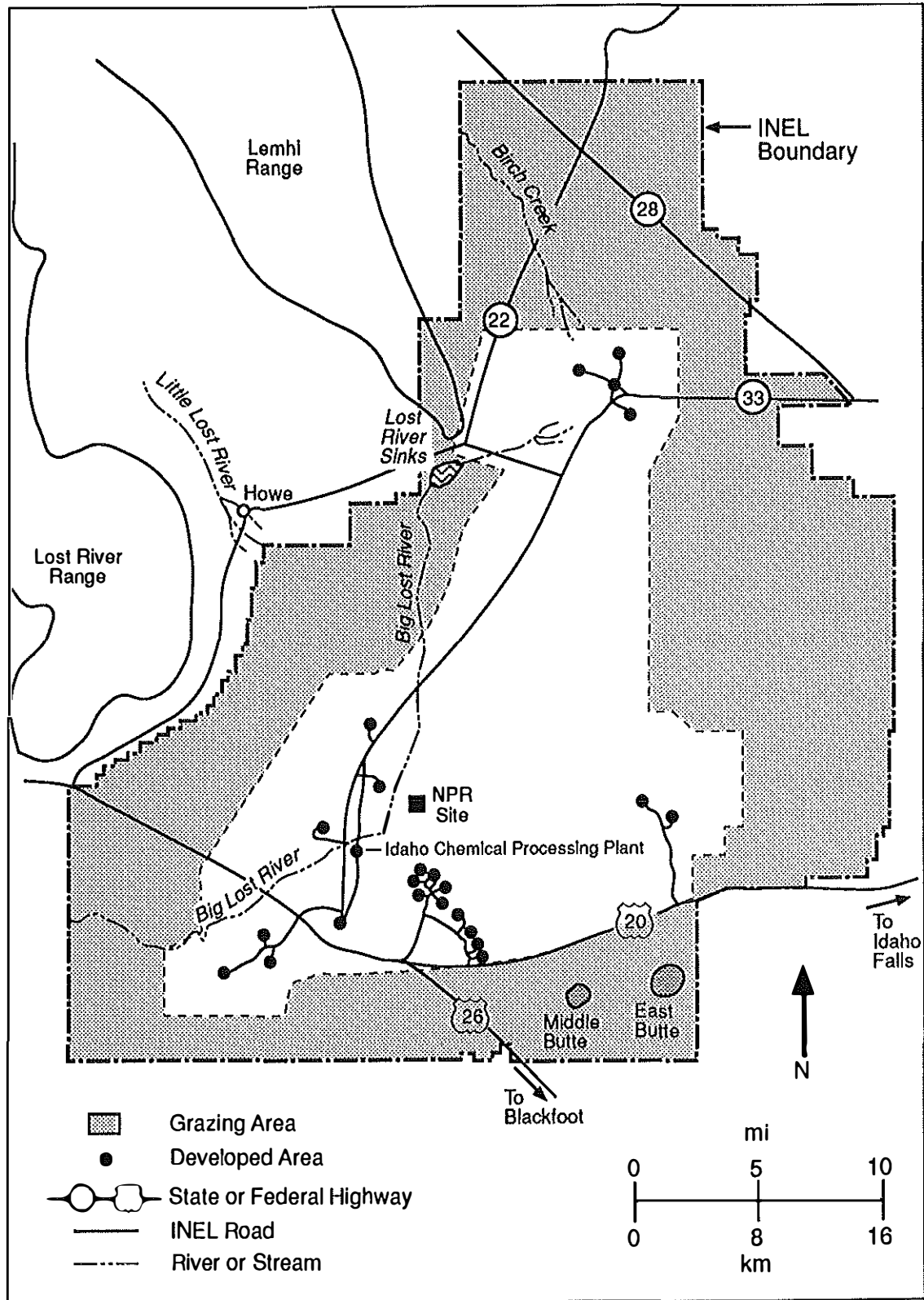


FIGURE 4.2.4-1 Land Use at INEL (Source: Modified from EG&G-1)

4.2.5.1 Terrestrial Resources

Most land within the boundaries of INEL is relatively undisturbed and provides important habitat for species native to the region. Several nuclear production facilities are located on the site, and 60% of the site is grazed by sheep and cattle (McBride et al. 1978). The INEL is within a cool desert ecosystem characterized by shrub-steppe communities. The flora (Table G.3) is typical of the Columbia Plateau province (Atwood 1970). Sagebrush communities occupy the greater part of INEL, but communities dominated by juniper, crested wheatgrass, and Indian ricegrass are also present (Figure 4.2.5-1) (McBride et al. 1978).

The INEL supports numerous animal species, including 1 amphibian, 9 reptile, 184 bird, and 37 mammal species (Table G.3). Common animal species on INEL include the short-horned lizard, gopher snake, horned lark, sage sparrow, Townsend's ground squirrel, and black-tailed jackrabbit. The INEL supports several species of game animals, but DOE allows hunting on the site only near the northern boundary. Important game animals present include several waterfowl species, sage grouse, pronghorn, elk, and mule deer. About 30% of Idaho's total pronghorn population winters on INEL. The INEL is also an important nesting and wintering area for hawks and owls. The juniper communities on the site provide important nesting habitat for these species (Craig 1979).

A preliminary vegetation survey of the NPR site at INEL was conducted in 1990 (Anderson, Glennon, and Houser 1990). The entire site is underlain by basalt lava flows of varying ages, and the dominant vegetation in areas where soils are shallow (over 90% of the site) is big sagebrush (Anderson, Glennon, and Houser 1990). Perennial grasses dominate low-lying depressions where deep, fine soils have accumulated. Common plant species on the NPR site include big sagebrush, rabbitbrush, cheatgrass, bottlebrush squirreltail, thickspike wheatgrass, Indian ricegrass, and needle-and-thread grass. Several isolated stands of juniper also are present on the site. On the whole, the vegetation and habitats on the NPR site appear typical of those developed on lava flows over much of the central portion of INEL (Anderson, Glennon, and Houser 1990).

Although surveys have not been conducted to determine the relative abundance of animal species on the NPR site, the animal habitat present there appears typical of other areas of INEL (Anderson, Glennon, and Houser 1990). Elk use areas in the vicinity of NPR site during the fall, winter, and spring, but pronghorn use of the NPR site is low relative to other areas of INEL. Sage grouse are known to use the NPR site, but not for breeding purposes. The isolated juniper stands located in the southeastern and northeastern portions of the site provide potential nesting habitat for hawks and owls.

Some NPR support facilities would be developed on the Idaho Chemical Processing Plant site. This area is surrounded by a fence, supports ongoing industrial activities associated with INEL operations, and contains little undisturbed habitat.

4.2.5.2 Wetlands

Although most of INEL is desert, more than 800 ha of wetlands exist during periods of high flow in the Big Lost River (Staley 1989), which enters the southwestern corner of INEL and flows north (Figure 4.2.5-1). The Big Lost River spreading areas and Big Lost River sinks

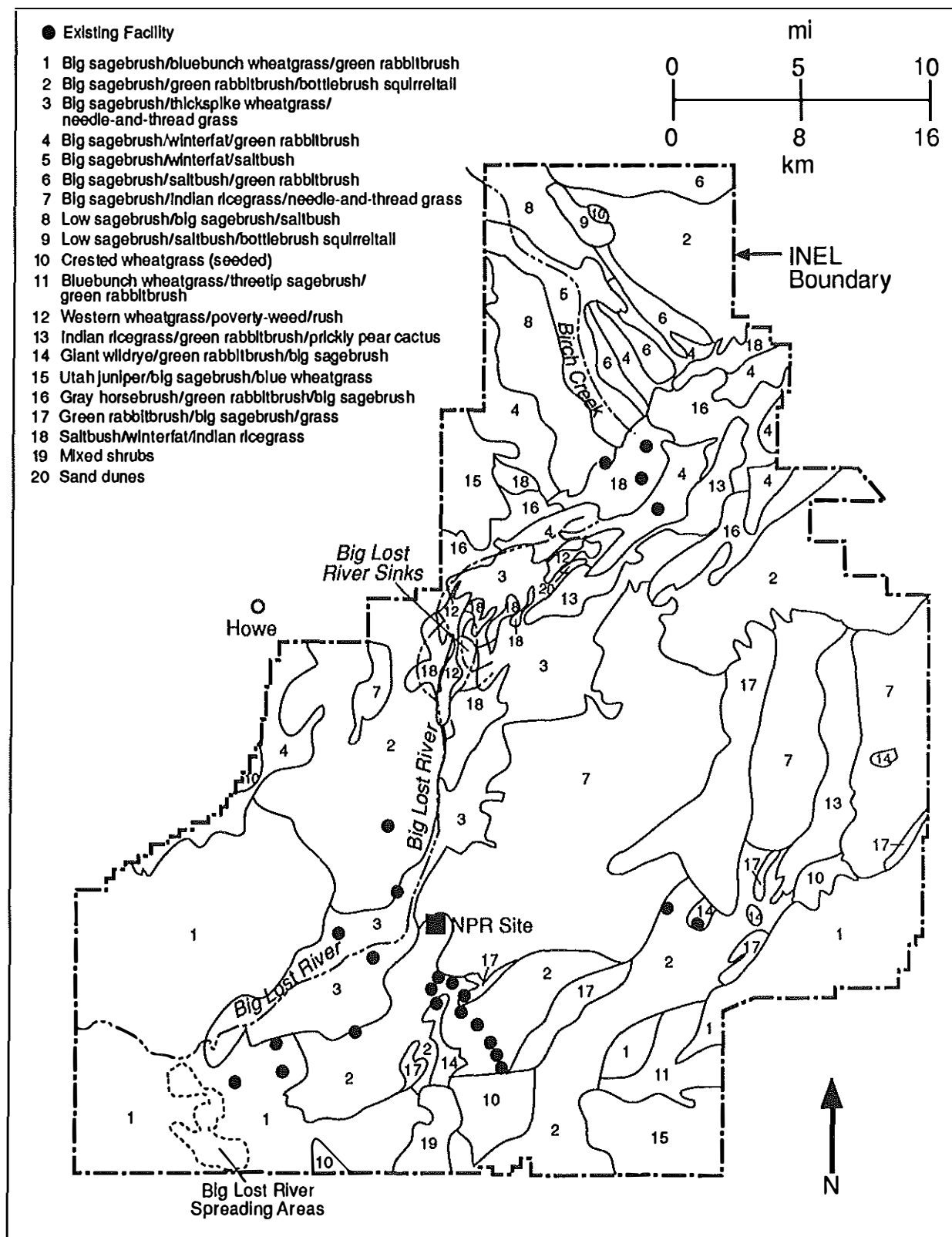


FIGURE 4.2.5-1 Distribution of Major Plant Communities on INEL (Source: McBride et al. 1978)

are major wetlands on INEL and are located, respectively, about 16 km southwest and 20 km north of the proposed NPR site. These areas provide habitat for migratory waterfowl, shorebirds, and other wildlife species during wet years, but they have not held water since 1986. No wetlands are located on the NPR site.

Riparian wetland vegetation (primarily cottonwoods and willows) along the Big Lost River and along Birch Creek (which enters the northern part of INEL and flows south into the sink area) provides nesting habitat for hawks, owls, and numerous songbirds. The riparian vegetation along the Big Lost River, however, currently is in poor condition because irrigation withdrawals and recent drought have caused flows to be intermittent.

4.2.5.3 Aquatic Resources

The Big Lost River flows intermittently across about 50 km of INEL, from southwest to north, before it terminates in the Big Lost River sinks (Figure 4.2.5-1). Drought and upstream diversions have resulted in no spring or summer flows onto INEL since 1986. However, when water is flowing, six species of fish have been observed in the Big Lost River (Table G.3). No aquatic habitat occurs on the NPR site, and the site is about 2.5 km southeast of the Big Lost River.

4.2.5.4 Threatened and Endangered Species

Seventeen Federally and state-listed threatened and endangered species have been identified on and in the vicinity of INEL (Appendix G, Table G.4). Ten of these species occur on or in the vicinity of proposed NPR facilities (Table 4.2.5-1). These species are discussed in greater detail in Appendix G (Section G.2). No critical habitat for threatened or endangered species, as defined in the Endangered Species Act, exists on INEL (50 CFR 17.11 and 17.12).

The bald eagle and the peregrine falcon are the only Federally listed species that occur on INEL (Reynolds et al. 1986). Several bald eagles usually winter in the western and northern portions of INEL, 19 km or more from the NPR site. Peregrine falcons have been observed infrequently on the northern portion of INEL, 45 km from the NPR site. Neither bald eagles nor peregrine falcons have been observed on the NPR site or in areas proposed for associated facilities.

Six species that are candidates for listing by the Federal government (Category 2 species) regularly occur on INEL (Table G.4). Of these, only the ferruginous hawk and Swainson's hawk currently use the NPR site (Table 4.2.5-1). Both species forage over the area, and in 1990, the ferruginous hawk had an active nest in a juniper stand in the northeastern portion of the NPR site. The Townsend's western big-eared bat, which roosts in caves on INEL, has not been observed on the NPR site, but the species could be attracted to aquatic habitats created on the site. Category 2 species do not receive legal protection under the Endangered Species Act, but the FWS recommends that impacts to these species be considered in project planning since these species may become listed at any time.

The state of Idaho does not maintain a list of threatened or endangered species. Plants that are considered rare in Idaho are included in a State Watch List. *Oxytheca* is the only

TABLE 4.2.5-1 Threatened and Endangered Species and Species of Special Concern that Could Be Found in the Vicinity of NPR Facilities on INEL

Species	Status ^a		Known or Potential Location on NPR Site or Affected Areas
	Federal	State	
Plants			
Oxytheca	NL	SC	NPR site ^b
Birds			
Bald eagle	E	SC	Evaporation pond ^c
Peregrine falcon	E	SC	Evaporation pond ^c
Osprey	NL	SC	Evaporation pond ^c
Ferruginous hawk	C2	SC	NPR site ^b
Swainson's hawk	C2	SC	NPR site ^b
Burrowing owl	NL	SC	NPR site ^b
White-faced ibis	NL	SC	Evaporation pond ^c
Mammals			
Townsend's western big-eared bat	C2	NL	Evaporation pond ^c
Bobcat	NL	SC	NPR site ^b

^aStatus: C2 = Category 2 species; E = endangered species; NL = not listed; SC = species of special concern; T = threatened species.

^bKnown to occur on NPR site.

^cPotentially on NPR site or affected area.

Sources: Modified from Cholewa and Henderson 1984; Gleisner 1983; Staley 1989.

species on this list that occurs in the vicinity of the NPR site (Cholewa and Henderson 1984; Anderson, Glennon, and Houser 1990). The Idaho Department of Fish and Game (Gleisner 1983) and the U.S. Bureau of Land Management maintain lists of rare animal species that are of special concern. Nine of the species on these lists are present on INEL (Table G.4), but only the ferruginous hawk, Swainson's hawk, burrowing owl, and bobcat are known to utilize the NPR site. (The burrowing owl and bobcat use the site only occasionally.) The osprey and white-faced ibis currently do not use the NPR site because of the lack of aquatic habitats, but these species could be attracted to any aquatic habitats created on the site for the NPR project. Although these species of special concern do not receive legal protection, they are included here because of their regional importance.

4.2.6 Cultural Resources

A total of 116 archaeological localities were identified during 1983-1984 and 1989 surveys of the NPR site at INEL. The inventory includes prehistoric isolated artifacts, sites, and features representing a time span of about 8,000 years. Although one site contains a historic component, no historic structures are present. Test excavations to determine National Register of Historic Places (NRHP) eligibility were initiated in 1989 and will be completed in 1990-1991. Consultations with potentially affected Native American groups, some of whom consider the area an ancestral homeland, have been initiated by DOE.

4.2.6.1 Regional Prehistory, History, and Ethnography

The earliest known occupants of southeastern Idaho were big game hunters who hunted now-extinct mammals (e.g., mammoth) (ca. 12,000-7,500 years before present [B.P.]). During the middle prehistoric period (7,500-1,300 B.P.), generalized hunter-gatherer groups ranged widely across the region. The late prehistoric period (1,300-300 B.P.) was marked by full-scale adoption of the bow and arrow (Butler 1978, 1986). The first Euro-American settlers found the area inhabited by the Shoshone and Bannock tribes, whose life-styles, augmented by the horse, have been described in detail (Steward 1938; Murphy and Murphy 1986). Winter camps were reportedly scattered along major river drainages, while populations dispersed in the remaining seasons, probably moving across what is now the INEL area as they exploited a wide selection of locally available food resources (Ferris 1940).

The historic period (150-50 B.P.) began with infrequent visits by explorers and fur traders. By the early 1800s, some immigrants moved across the present INEL area as they traveled to the Oregon Territory via a northern spur of the Oregon Trail. In the 1860s, gold strikes in the Lost River Mountains drew many miners into the region. Increased Euro-American settlement during the 1860s led to the conflict with the Shoshone and Bannock tribes, who were eventually confined to the Fort Hall Indian Reservation as a result of treaties signed in the late 1860s and early 1870s. Since 1940 the INEL area has been under control of the U.S. government. Initially used as a test firing range by the U.S. Navy, the area was acquired by the Atomic Energy Commission in 1949. The first reactor built at INEL, and the first to produce electricity by nuclear power (Experimental Breeder Reactor-I), is a registered National Historic Landmark (Brosnan 1948; Conley 1982).

4.2.6.2 Archaeological Sites and Historic Structures

Since 1985 all cultural resource investigations at INEL have been conducted within the framework of a comprehensive research design developed by Reed et al. (1987). To date, approximately 3% of INEL has been subject to field survey.

The proposed NPR site (518 ha in area) is characterized by low undulating topography and sparse shrub-steppe vegetation. The site has been subject to two episodes of archaeological field work, beginning with a survey in 1983-1984 (Miller 1983, 1984; Reed et al. 1987). This survey entailed a pedestrian overview conducted along transects (30- to 50-m intervals) oriented according to natural landforms (e.g., ridge tops). In 1989, six randomly selected 16-ha sample units within the NPR site were intensively resurveyed to evaluate the results of the earlier survey; transect intervals were reduced to 20 m or less (Ringe 1990). All previously recorded

sites were revisited in 1989, and limited test excavations were conducted at ten localities. Subsurface testing involved excavation of 1- to 2-m units at 5- to 10-cm intervals to a depth of 60 cm or less; all excavated sediment was sieved (Ringe 1990).

To date, 116 archaeological localities (prehistoric and historic) have been recorded within the NPR site; no historic structures are present (Ringe 1990). Fifty-one localities consist of isolated surface artifacts or small surface scatters (less than ten artifacts); DOE has assessed these sites as not eligible for the NRHP. Eighteen localities consist of small surface scatters of obsidian (volcanic glass) flakes and one stone circle (Appendix Q); DOE believes that these sites are probably not eligible for the NRHP, but some additional sampling and evaluation will be necessary. The DOE considers the remaining 47 localities as potentially eligible for the NRHP. Most of these sites contain buried remains, including artifacts and, in some cases, features (e.g., former hearths) and faunal remains; four sites in this category consist of stone circles (Appendix Q). These sites will be subject to further testing during 1990-1991 to determine their eligibility status. All recommendations concerning NRHP eligibility must be approved by the Idaho State Historic Preservation Officer.

4.2.6.3 Native American Cultural Resources

The INEL recently initiated consultation with the Shoshone and Bannock tribes (headquartered at the Fort Hall Indian Reservation) regarding a programmatic agreement for cultural concerns (including sacred areas and traditional food resources) protected under the American Indian Religious Freedom Act. The proposed NPR project will be addressed in this agreement. In general, the Shoshone and Bannock tribes consider the INEL area as part of an ancestral homeland and have expressed support for use of scientific methods to preserve cultural resources (Holmer 1986).

4.2.6.4 Paleontological Resources

No paleontological localities have been identified within the NPR site. During archaeological surveys at the NPR site, no tubes, caves, or rock shelters (which might be expected to contain fossil or subfossil remains) were visible on the surface, but several large pack rat middens were noted (Miller 1983, 1984; Ringe 1990).

Near the west and northwest margins of the NPR site, the dominant basaltic terrain of INEL levels out across the Big Lost River floodplain. Pleistocene vertebrate fossils have been discovered in the near-surface and deeply buried riverine sands and gravels. Fossil-bearing lake and river sediments also occur to the north and west in the area of Pleistocene Lake Terretton, the present-day Lost River Sinks and Mud Lake area. The potential for encountering surface or buried paleontological remains on the NPR site (subsurface features and deposits have not been explored) and in the nearby river and lake sediments is characterized as low to moderate against the range of potential for the Snake River Plain as a whole (Ringe et al. 1987).

4.2.7 Environmental Radiation Sources and Exposure

Major sources of radiation exposure to individuals in the vicinity of INEL are presented in Table 4.2.7-1. Routinely encountered sources of background radiation are radon in the

TABLE 4.2.7-1 Major Sources of Radiation Exposure to Individuals in the Vicinity of INEL

Source of Exposure	Dose to Average Individual ^a (rem/yr)
Natural background ^b	
Inhaled radon and radon decay products ^c	0.2
External terrestrial radiation ^d	0.08
Cosmic radiation ^e	0.04
Internal terrestrial radiation	0.04
Fallout radiation ^b	<0.001
Site operations ^f	2.0×10^{-5}
Total ^g	0.4

^aCommitted effective dose equivalent from 1 year of exposure to radiation sources or site operations (see Appendix H, Section H.2, for an explanation of radiation dose units).

^bAverage dose per year of exposure for components, as estimated in NCRP-1.

^cThe inhaled radon and radon decay product dose varies widely with geographic location; the 0.2 rem/yr value represents the U.S. population average.

^dThe external terrestrial component is based upon soil sampling for neutral radionuclides in the vicinity of INEL during 1976 (DOE-27).

^eThe cosmic radiation dose is higher at INEL than at Hanford or SRS because of INEL's higher altitude.

^fCalculated by dividing the 80-km population dose given in DOE-27 by the 80-km population.

^gThe total dose is not exactly 0.4 because the values have been rounded to one significant figure.

environment, terrestrial radiation, cosmic radiation, and naturally occurring terrestrial radiation emitters internal to the body, e.g., potassium-40 -- resulting in a total dose of about 0.4 rem/yr (expressed as committed effective dose equivalent from 1 year of exposure) (NCRP-1). Based on a population of 120,000 within 80 km of INEL (1988 estimate), the total population dose from natural background is estimated to be about 50,000 person-rem/yr. The dose from 1 year of exposure to residual fallout from nuclear weapons testing is less than 0.001 rem/yr, which would add about 100 person-rem to the population dose (NCRP-1).

The dose to the population within 80 km of INEL from site operations in 1988 has been estimated to be 2 person-rem (DOE-27). The dose to the average off-site individual from these operations in 1988 was estimated to be 2×10^{-5} rem. The dose to the maximally exposed off-site individual in 1988 was estimated to be 1×10^{-4} rem (DOE-27).

Applicable regulatory standards for radiological exposure from nuclear facilities are given in Section 5.2.7.1. These standards do not involve background doses; background doses are presented for comparative purposes only. The estimated contribution of the proposed NPR facilities to doses from site operations at INEL are given in Section 5.3.6.1. The INEL environmental monitoring program, which monitors the release of radioactive and nonradioactive hazardous materials to the environment, is identified in Section 3.5. Information on applicable safety criteria that could be used for NPR designs is included under project descriptions in Appendixes A, B, and C.

4.2.8 Socioeconomics

The Socioeconomic Database for Southeastern Idaho (Hardinger 1990) presents a comprehensive description of the socioeconomic and community characteristics (i.e., economic activity, population, housing, community services, fiscal structure, and quality of life) of the INEL area. The following sections summarize portions of the above report. Other relevant material is provided by Idaho State University (ISU 1988), Wells, Hoffman, and Wells (1989), and DOE (DOE-30).

According to surveys performed in 1987, 98% of all INEL employees reside in the Idaho six-county area comprising Bonneville, Bingham, Bannock, Jefferson, Butte, and Madison counties. About 85% of INEL employees reside in the cities of Idaho Falls (6,134 employees, or 58% of the total), Blackfoot (740, or 7%), Pocatello (600, or 6%), Armon (567, or 5%), Rigby (376, or 4%), Shelley (350, or 3%), Arco (208, or 2%), and Chubbuck and Rexburg (each <1%). The residential distribution pattern of employees during construction and operation of NPR facilities is likely to be similar to the existing pattern; therefore, these six counties and seven cities are considered the study area for assessing the potential socioeconomic effects associated with the NPR project. This study area is also referred to as the region of influence (ROI), or simply as the INEL region.

4.2.8.1 Employment and Income

Employment at INEL currently totals about 11,000 (Wells, Hoffman, and Wells 1989), or about 2.6% of total state employment (417,000). About 320 persons are DOE employees, and the rest are employed by private contractors, including Protection Technology of Idaho; Argonne National Laboratory; EG&G Idaho, Inc.; Westinghouse; Westinghouse Idaho, Inc.; and Rockwell

International. In addition, about 700 engineering design and construction workers are employed by Catalytic, MK-Ferguson, and the Ralph M. Parsons Company. Approximately 1,200 Navy personnel are on the site for training at the Naval Reactor Facility. Work force projections to the year 2005 (Table 4.2.8-1) reveal modest growth until 1995 and declining employment from 1995 to 2000.

INEL is the largest single employer in Idaho, accounting for more than \$318 million in wages during 1987. Approximately \$57 million in fringe benefits was paid by contractors on behalf of their employees. In its study, Idaho State University (ISU 1988) estimates that more than 18,000 jobs are directly or indirectly linked to INEL in the six-county region. Employees at INEL make up more than 24% (7,800) of total employment in Bonneville County (32,500) and about 19% (325) in Butte County (1,712).

Table 4.2.8-2 summarizes work force projections by construction occupation for Idaho and for the INEL ROI for 1995. Because the peak construction work force is expected to be larger than the operation work force, the availability of construction craft workers is a key consideration in identifying any potential in-migration and associated socioeconomic impacts arising from NPR activities.

Table 4.2.8-3 compares total personal income and per capita income in the six-county area in 1982 and 1986. Bonneville County had the highest per capita income in the area and Madison County the lowest. Total personal income in the region was \$2.3 billion in 1986. Bonneville County's per capita income was 65% higher than Madison County's in 1982 and 57% higher in 1986.

In 1987, there were more than 4,600 farms in the INEL region. Average farm size ranged from 163 ha in Jefferson County to 390 ha in Bingham County. Most cropland is irrigated. In terms of acreage planted in 1987, wheat (133,000 ha), barley (95,000 ha), and Irish potatoes (68,000 ha) were the most important crops. Livestock and poultry production are also important to the area (Wells, Hoffman, and Wells 1989). In 1986, the agricultural services, supplies, and equipment sector employed several hundred persons. Food processing accounted for an additional 3,500 jobs.

**TABLE 4.2.8-1 Projected INEL Work Force,
1990-2005**

Worker Category	1990	1995	2000	2005
Construction	745	2,100	1,600	1,400
Operation	7,900	6,937	5,387	6,737
Federal	2,200 ^a	2,000	1,200	1,200
Total	10,845	11,037	8,187	9,337

^aIncludes military personnel at the Naval Reactor Facility.

Source: DOE-30.

TABLE 4.2.8-2 Projected State and Regional Work Forces, by Construction Occupation, 1995

Construction Occupation	Idaho	INEL ROI
Pipefitters/welders	2,088	432
Boilermakers	82	22
Carpenters	2,924	514
Equipment operators	3,134	626
Linemen	594	144
Teamsters/laborers	13,532	3,311
Electricians	2,235	491
Ironworkers	214	56
Concrete finishers	629	129
Other crafts	210	49

TABLE 4.2.8-3 Personal and Per Capita Income in the INEL ROI, 1982 and 1987

Location	Total Personal Income (millions of dollars)		Per Capita Income (dollars)	
	1982	1987	1982	1987
Bannock	607	746	8,980	10,960
Bingham	268	358	7,149	9,347
Bonneville	641	863	9,514	12,212
Butte	29	34	8,389	10,786
Jefferson	104	144	6,686	8,755
Madison	120	172	5,766	7,796
INEL ROI	1,769	2,317	8,334	10,500

Source: Wells, Hoffman, and Wells 1989.

Agriculture is an important source of income in the INEL region. In 1988, receipts from the sale of field crops totaled \$373 million, and livestock sales were \$157 million. Total agricultural sales in Idaho in 1988 were about \$1 billion in each category.

4.2.8.2 Population Characteristics

Table 4.2.8-4 summarizes 1980 and 1987 population data in the six-county region. Although the population of Idaho has remained stable since 1985, the INEL region has grown about 10% overall since 1980. Pocatello and Idaho Falls are about the same size (approximately 44,000 persons). Almost 60% of all INEL employees live in Idaho Falls because of its proximity to INEL.

Table 4.2.8-5 presents population projections from 1990 to 2040 for the ROI. Overall, the total population is expected to increase by about one-third from 1990 to 2010. The projections forecast significant out-migration from each county after 1995; however, the population is still expected to increase over the period.

Because INEL dominates local employment, county-level population projections depend on the work force projected for INEL. The total population in the region is projected to nearly double between 1990 and 2040.

4.2.8.3 Housing

In 1988, approximately 1,100 houses were listed for sale in the Idaho Falls area at prices ranging from \$30,000 to \$150,000. Pocatello had nearly 900 houses on the market in the same period. No central agency monitors rental activity in the region; therefore, data on rental rates are not available. However, substantial vacancies are believed to exist for units rented at less than \$350 per month and at more than \$550 month (ISU 1988). Table 4.2.8-6 shows housing permits for the ROI. An average of 547 permits are issued annually, with most of the activity occurring in Idaho Falls.

4.2.8.4 Public and Community Services

This section reviews education, health care, and police and fire protection services. Local jurisdictions providing public and community services in the six-county area include counties, cities, towns, and special districts. The state of Idaho and the Federal government also provide services.

Education

Sixteen school districts provide public education services and facilities in the INEL region. These districts range in enrollment size from almost 100 students in Swan Valley School District No. 92 to almost 14,000 students in Pocatello School District No. 25 (Table 4.2.8-7). With the exception of Pocatello School District No. 25, the larger school districts are operating either near or over capacity; that is, they are experiencing overcrowding or are supplementing facility

TABLE 4.2.8-4 Distribution of Population and INEL Work Force, by Place of Residence for Counties and Selected Communities in the INEL ROI, 1980 and 1987

Location	1980 Population (thousands)	1987		1990 Population Estimate (thousands)
		Population (thousands)	Percentage of INEL Work Force ^a	
Bannock County	65.4	69.8	7	65.8
Chubbuck	7.1	8.0	1	7.5
Pocatello	46.3	44.2	6	41.6
Bingham County	36.5	40.3	14	37.3
Blackfoot	10.1	10.1	7	9.3
Shelley	3.3	3.7	3	3.4
Bonneville County	66.0	73.9	67	71.9
Ammon	4.7	4.9	5	4.8
Idaho Falls	39.6	43.4	58	42.2
Butte County	3.3	3.1	3	NA
Arco	NA ^b	1.1	2	NA
Jefferson County	15.3	16.5	6	16.4
Rigby	2.6	2.6	4	2.6
Madison County	19.5	22.0	1	23.8
Rexburg	11.6	12.2	1	13.2
INEL ROI	206.0	225.6	98	215.2

^aPercentage of INEL work force residing in specified location.

^bNA = not available.

Sources: ISU 1988; Wells, Hoffman, and Wells 1989; 1990 population estimate from U.S. Bureau of the Census, Public Affairs Office, 1991.

TABLE 4.2.8-5 Projected Population for Counties in the INEL ROI, 1990-2040

Location	Population (thousands), by Decade					
	1990	2000	2010	2020	2030	2040
Bannock	65.8	90.8	101.2	112.2	125.7	140.1
Bingham	37.3	50.8	56.8	63.5	71.0	79.4
Bonneville	71.9	98.8	114.9	133.6	155.4	180.7
Butte	5.2	7.1	8.4	9.9	11.8	13.9
Jefferson	16.4	19.4	21.2	23.2	25.3	27.7
Madison	23.8	36.9	40.6	44.7	49.2	54.1
INEL	220	304	343	387	438	496

Sources: The 1990 regional estimates are from the U.S. Bureau of the Census, Public Affairs Office 1991; county-level projections are from Hardinger 1990.

space with modular classrooms. Student/teacher ratios range from 19.4 in Marsh Valley School District No. 21 to 31.3 in Swan Valley School District No. 92. The average ratio for the ROI is 22.0. School districts will likely experience reduced student/teacher ratios and an increase in the number of classrooms in light of a state goal to keep student/teacher ratios below 22.0 for kindergarten through grade 3. Per pupil expenditures in the region range from \$2,590 in Pocatello School District No. 25 to \$5,375 in Swan Valley School District No. 92. The average for the ROI is \$2,932.

Health Care

Ten hospitals serve the six-county area; three provide emergency medical care. Most are operating well below capacity. Additional emergency care is provided by three private health centers. A total of 263 physicians serve the six-county area. Bonneville County has more than half the physicians in the region, while Butte and Jefferson counties have only one physician each. Health care service ratios for counties in the ROI are summarized in Table 4.2.8-8.

Police and Fire Protection

Police Protection in the ROI is provided by 14 county sheriff's offices, city police departments, and the Idaho State Police. Current staffing and levels of service are provided in Table 4.2.8-9 (Hardinger 1990). The largest single police force in the ROI is the Idaho Falls Police Department (69 sworn officers; 1.6 sworn officers per 1,000 people), followed by the Pocatello Police Department, Bonneville County Sheriff's Office, and Bannock County Sheriff's Office. The

TABLE 4.2.8-6 Housing Permits in the INEL ROI, 1980-1990

Location	1980	1981	1982	1983	1984	1985
Bannock County	307	110	60	137	319	186
Chubbuck	81	12	6	27	105	42
Pocatello	197	61	33	68	168	105
Bingham County	156	51	46	70	58	60
Blackfoot	66	5	3	8	5	6
Shelley	13	3	4	4	5	5
Bonneville County	291	234	59	182	262	335
Ammon	11	2	3	12	12	10
Idaho Falls	199	186	26	129	199	275
Butte County	25	1	2	2	1	1
Arco	25	1	2	2	1	1
Jefferson County	57	38	26	24	44	29
Rigby	NR ^a	NR	NR	NR	NR	NR
Madison County	20	8	12	45	27	29
Rexburg	17	6	12	45	27	24
INEL ROI	856	442	205	460	711	640

	1986	1987	1988	1989	1990	1980-89 Average
Bannock County	154	113	114	105	92	160.5
Chubbuck	27	11	12	21	10	34.4
Pocatello	99	76	76	55	68	93.8
Bingham County	40	47	47	47	40	62.8
Blackfoot	6	11	6	6	1	12.2
Shelley	2	1	2	2	NR	14.1
Bonneville County	351	296	292	298	357	260.0
Ammon	16	16	13	11	NR	10.6
Idaho Falls	277	224	215	222	277	195.2
Butte County	1	0	0	0	NR	3.3
Arco	1	0	0	0	NR	3.3
Jefferson County	28	32	19	16	29	31.3
Rigby	NR	NR	NR	NR	NR	NR
Madison County	66	24	44	24	14	29.9
Rexburg	66	24	42	17	14	28.0
INEL ROI	640	512	516	490	NR	547.2

^aNot recorded.

Sources: U.S. Bureau of the Census 1982, 1984, 1986, 1988, 1990.

TABLE 4.2.8-7 Characteristics of School Districts in the INEL ROI

School District	Enrollment	Enrollment Capacity	Student/Teacher Ratio	Per Pupil Expenditure (\$)
Bannock County	15,381			
Marsh Valley No. 21	1,651	1,750	19.4	3,429.00
Pocatello No. 25	13,730	16,000	22.0	2,590.00
Bingham County	11,115			
Snake River No. 52	2,371	2,425	21.9	2,841.00
Blackfoot No. 55	4,572	4,000	20.7	3,113.00
Aberdeen No. 58	815	950	19.0	3,533.00
Firth No. 59	1,005	1,050	21.3	3,238.00
Shelley No. 60	2,352	3,000	22.4	3,203.00
Bonneville County	17,307			
Idaho Falls No. 91	9,833	10,000	22.5	3,018.00
Swan Valley No. 92	95	200	31.3	5,375.00
Bonneville No. 93	7,379	NA ^a	21.5	2,974.00
Butte County	764			
Arco No. 111	764	760	20.5	3,412.00
Jefferson County	5,276			
Jefferson County No. 251	3,849	3,900	23.0	2,763.00
Ririe No. 252	654	650	21.7	2,936.00
West Jefferson No. 253	773	875	21.6	3,436.00
Madison County	5,859			
Madison No. 321	4,359	4,400	24.3	2,937.00
Sugar-Salem No. 322	1,500	1,710	21.2	3,158.00
Total/average	55,702	51,670	22.0	2,932.51

^aNot available.

Sources: Idaho Department of Education 1990a, 1990b.

TABLE 4.2.8-8 Health Care Service Ratios for the INEL ROI

County	Population/ Doctors	Population/ RN/LPN	Population/ Hospital Beds
Bannock	735	169/267	213
Bingham	2,371	363/262	149
Bonneville	564	137/221	258
Butte	3,100	135/344	775
Jefferson	16,500	825/750	NA ^a
Madison	1,222	162/611	415
INEL ROI	858	182/276	NA

^aNot available.

Source: Hardinger 1990.

greatest level of service is provided by the Pocatello Police Department (4.8 sworn officers per 1,000 people); the lowest is provided by the Chubbuck Police Department (1.0 officers per 1,000 people).

Twenty-three fire stations and more than 300 regular and volunteer fire fighters provide fire protection services in the ROI. The principal municipal departments presented in Table 4.2.8-9 include both professional and volunteer staffs (Hardinger 1990). The greatest staffing strength is found in the Idaho Falls and Pocatello fire departments, each of which operates from four stations within each city (Wells, Hoffman, and Wells 1989).

4.2.8.5 Public Finances

Revenues, expenditures, and fund balances of potentially affected cities, counties, and school districts in the ROI are presented in Table 4.2.8-10. The data reflect actual revenues and expenditures of each jurisdiction's general fund, and, as applicable, a jurisdiction's special revenue funds. These funds generally account for all of a jurisdiction's tax-supported expenditures for services provided by the jurisdiction. Examples of other funds maintained by cities and counties include enterprise funds, enterprise funds, special assessment funds, and utility funds. These funds are generally self-supporting through user charges and do not contribute to the general tax burden of a jurisdiction. When the activities of these funds are relatively important in a local community (e.g., revenues and expenditures of utility enterprise funds), the most recent year's revenues and expenditures are reported.

Data are reported for jurisdictions expected to experience the majority of impacts associated with NPR project activities.

TABLE 4.2.8-9 Police and Fire Protection Services in the INEL ROI

Police Protection Services		
County/Agency	Sworn Officers	Officers/ 1,000 People
Bannock County		
Bannock County Sheriff's Office	63	5.1
Chubbuck Police Department	11	1.0
Pocatello Police Department	64	4.8
Bingham County		
Bingham County Sheriff's Office	18	1.1
Blackfoot Police Department	18	1.8
Shelley Police Department	6	1.6
Bonneville County		
Bonneville County Sheriff's Office	64	2.2
Idaho Falls Police Department	69	1.6
Butte County		
Butte County Sheriff's Office	3	1.5
Arco Police Department	1	1.9
Jefferson County		
Jefferson County Sheriff's Office	12	1.4
Rigby Police Department	5	1.8
Madison County		
Madison County Sheriff's Office	NA ^a	NA
Rexburg Police Department	14	1.1

Fire Protection Services ^b		
County/Agency	Fire Fighters	Fire Fighters/ 1,000 People
Bannock County		
Chubbuck Fire Department	34	4.36
Pocatello Fire Department	62	1.35
Bingham County		
Blackfoot Fire Department	19	1.98
Bonneville County		
Amnon Fire Department	25	5.05
Idaho Falls Fire Department	63	1.45

TABLE 4.2.8-9 (Cont'd)

County/Agency	Fire Fighters	Fire Fighters/ 1,000 People
Butte County Arco Fire Department	15	14.52
Jefferson County Rigby Fire Department	15	5.61
Madison County Rexburg Fire Department	6	0.41

^aNot available.

^bTotal fire fighters and level-of-service data include professional and volunteer fire fighters.

Source: Hardinger 1990.

Butte County

Public services provided by Butte County are funded primarily through the county's general fund and special revenue funds. In fiscal year (FY) 1989, revenues and expenditures were approximately \$1.2 and \$1.1 million, respectively. Fund balances were \$80,000, which represents about 7% of operating expenditures in that year. Fund balances were accounted for entirely by special revenue fund monies, with a deficit balance of \$20,000 registered in the general fund account.

City of Arco

Public services provided by Arco are funded primarily through the city's general fund. In FY 1989, revenues and expenditures were approximately \$210,000 and \$200,000, respectively. Fund balances are minimal, representing less than 1% of operating expenditures in that year.

Arco Joint School District No. 111

Services provided by Arco Joint School District No. 111 are funded principally through the district's general fund. In FY 1989, revenues and expenditures were \$2.2 million and \$2.0 million, respectively. Fund balances were \$120,000, which represents about 6% of operating expenditures in that year.

TABLE 4.2.8-10 General and Special Revenue Fund Revenues, Expenditures, and Fund Balances for Selected Jurisdictions for Fiscal Year 1989 in the INEL ROI^a

Jurisdiction	Revenues (\$1,000)	Expenditures (\$1,000)	Fund Balance (\$1,000)
Butte County	1,154	1,126	81
City of Arco	209	202	1
Arco Joint School District No. 111	2,158	1,953	122
Bingham County	8,059	5,280	3,453
City of Blackfoot	3,202	3,104	1,451
City of Shelley	422	387	233
Blackfoot School District No. 55	10,458	10,195	498
Shelley Joint School District No. 60	4,622	3,246	353
Bonneville County	14,169	12,575	5,144
City of Idaho Falls	16,706	16,327	8,496
City of Ammon	455	279	716
Idaho Falls School District No. 91	23,028	22,311	2,291
Bonneville School District No. 93	16,477	15,974	654
Jefferson County (no data)			
City of Rigby	246	485	355

^aFor school districts and the city of Shelley, values represent general fund data.

Sources: Butte County undated; Arco 1990; Draney, Searle, and Townsend 1990; Idaho Falls 1990; Galusha, Higgins, and Galusha 1989; McFadden undated; Idaho Department of Education undated; Draney, Searle, and Townsend 1990; Jones, Yost, and Hatt 1990; T. Layne Vanorder and Associates 1989; Rigby undated.

Bingham County

Public services provided by Bingham County are funded primarily through the county's general and special revenue funds. In FY 1989, revenues and expenditures were \$8.1 million and \$5.3 million, respectively. Fund balances were \$3.5 million in that year, which represents about 65% of operating expenditures. The assessed value of property within Bingham County was \$118.7 million.

City of Blackfoot

Public services provided by Blackfoot are primarily funded through the city's general and special revenue funds. In FY 1989, revenues and expenditures were \$3.2 and \$3.1 million, respectively. Fund balances were \$1.5 million. Local property taxes, intergovernmental revenues, and service charges are the principal revenue sources.

City of Shelley

Public services provided by Shelley are funded principally through the city's general fund. In FY 1990, revenues and expenditures were \$440,000 and \$390,000, respectively. Fund balances were \$230,000, which represents about 60% of operating expenditures in that year. The city has no general obligation bond indebtedness.

Blackfoot School District No. 55

Services provided by Blackfoot School District No. 55 are funded principally through the district's general fund. In FY 1989, revenues and expenditures were \$10.5 million and \$10.2 million, respectively. Fund balances were \$0.5 million, which represents about 5% of operating expenditures in that year.

Shelley Joint School District No. 60

Services provided by Shelley Joint School District No. 60 are funded principally through the district's general fund. In FY 1989, revenues and expenditures were \$4.6 million and \$3.2 million, respectively. Fund balances were \$0.4 million, which represents about 13% of operating expenditures in that year.

Bonneville County

Public services provided by Bonneville County are funded primarily by the county's general and special revenue funds. In FY 1989, revenues and expenditures were \$14.2 million and \$12.6 million, respectively. Fund balances were \$5.1 million, which represents about 40% of operating expenditures in that year. The principal revenue sources of the county are property taxes (approximately 50% of total revenues) and intergovernmental transfers. The assessed value of property within the county was approximately \$1.4 million.

City of Idaho Falls

Public services provided by Idaho Falls are funded primarily through the city's general and special revenue funds. In FY 1989, revenues and expenditures were \$16.7 million and \$16.3 million, respectively. The principal revenue sources of the city are local property taxes and intergovernmental revenues. Fund balances were \$8.5 million, which represents about 50% of operating expenditures in that year. Debt capacity is \$18.8 million less \$2.4 million in current outstanding general obligation bond indebtedness, or \$16.4 million.

City of Ammon

Public services provided by Ammon are funded primarily through the city's general and special revenue funds. In FY 1989, revenues and expenditures were \$460,000 and \$280,000, respectively. Fund balances were \$700,000 in that year. Revenues and expenditures have remained relatively stable over the FY 1987-89 period.

Idaho Falls School District No. 91

Services provided by Idaho Falls School District No. 91 are provided principally through the district's general fund. In FY 1989, revenues and expenditures were \$23.0 million and \$22.3 million, respectively. Fund balances were \$2.3 million, which represents about 10% of operating expenditures in that year.

Bonneville Joint School District No. 93

Services for Bonneville Joint School District No. 93 are funded primarily through the district's general fund. In FY 1989, revenues and expenditures were \$16.5 million and \$16.0 million, respectively. State revenues account for the majority of revenues available to the district. Fund balances were \$0.7 million, which represents about 4% of operating expenditures in that year. General obligation bond indebtedness was \$11.8 million as of June 30, 1989.

City of Rigby

Public services for Rigby (Jefferson County) are funded primarily through the city's general and special revenue funds. In FY 1989, revenues and expenditures were \$250,000 and \$490,000, respectively. Fund balances were \$400,000, which represents about 80% of operating expenditures in that year. Principal revenue sources of the city are local property taxes and intergovernmental revenues. Long-term general obligation bond indebtedness of the city as of September 30, 1989, was \$300,000.

4.2.9 Transportation Systems

This section discusses the existing transportation environment at and around INEL. Roads are the primary mode of transportation to and from the site. Some bulk materials are shipped by rail. Barge transport is not possible, since no navigable waterways exist on or adjacent to INEL. Figures 4.2.9-1 and 4.2.9-2 show the transportation networks serving INEL.

4.2.9.1 Road Transportation

The INEL is served by more than 230 mi* of roadways consisting of principal arterial and major collector routes. There are 139 mi of DOE-owned and -controlled paved roads on-site. In addition, numerous paved intrafacility service roads are within each specific INEL area. Ninety miles of paved Federal and state highways that are open for public use pass through INEL. U.S. Route (US) 20 and US 26 cross the southern portion of INEL, while Idaho State Route (SR) 22, SR 28, and SR 33 cross the northeastern part. Most material shipments on and off INEL are by road (EG&G-4).

*1 mi = 1.609 km.

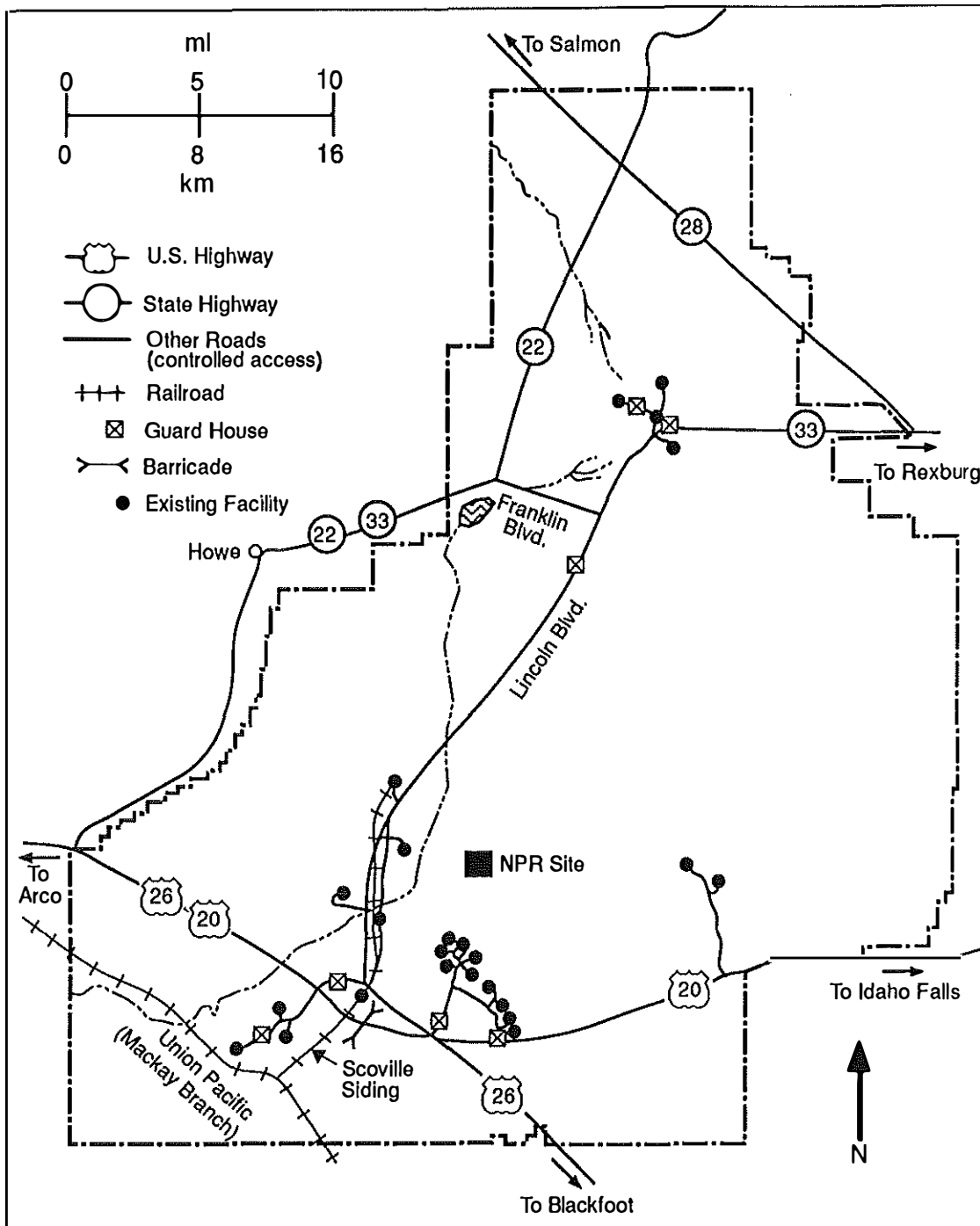


FIGURE 4.2.9-1 Transportation Routes at INEL (Source: Modified from EG&G-4)

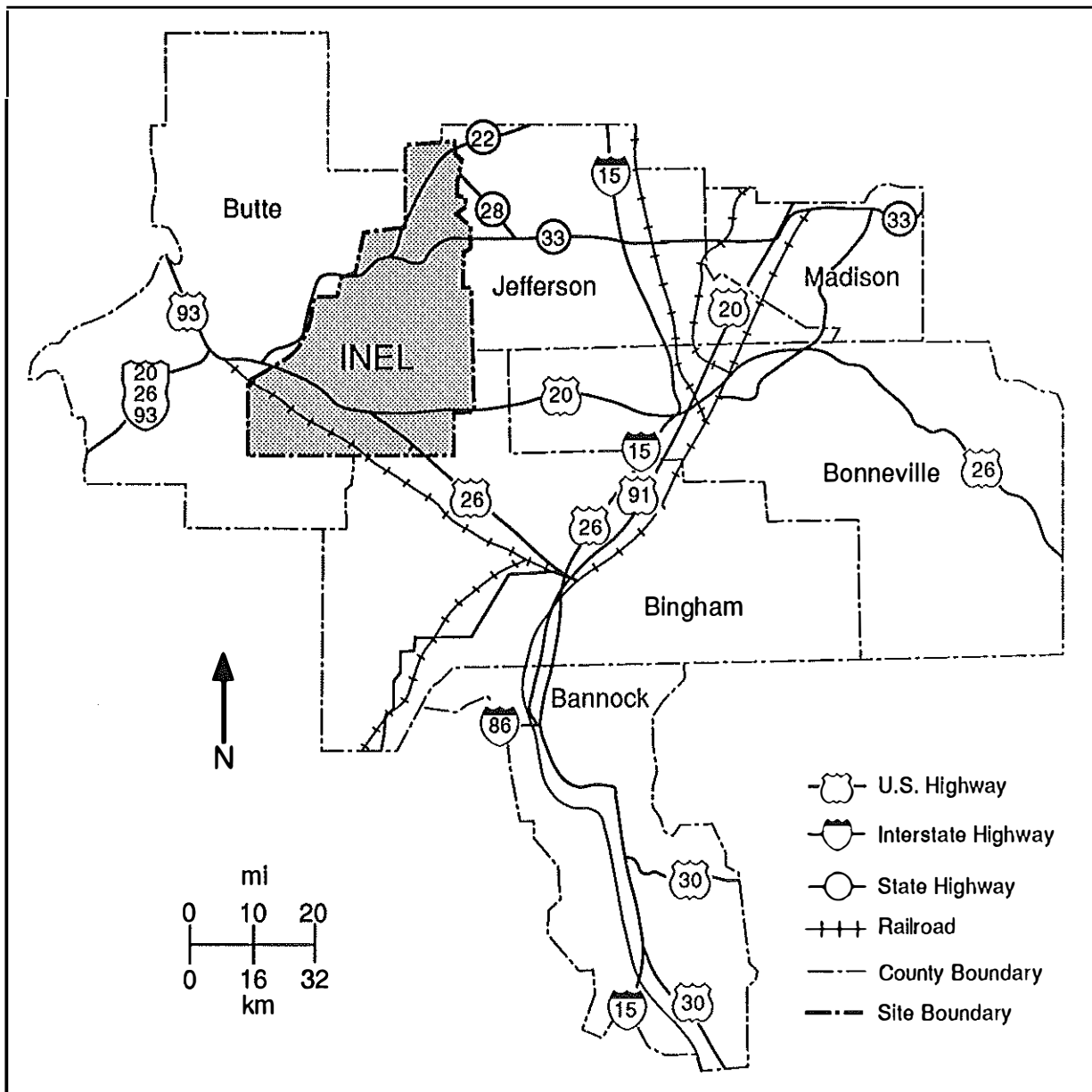


FIGURE 4.2.9-2 Transportation Routes in the INEL Vicinity (Source: Based on DOI-2)

The regional transportation network in the INEL vicinity (Figure 4.2.9-2) serves six Idaho counties (Bannock, Bingham, Bonneville, Butte, Jefferson, and Madison), from which 99% of INEL commuter traffic is generated.

Two interstate highways serve the INEL area. Interstate 15 (I-15), a north-south route that connects several cities along the Snake River, is approximately 15 mi east of INEL. Approximately 35 mi south of INEL, I-15 intersects I-86, only a small portion of which extends within the study area. I-86 provides a primary linkage from I-15 to points west. US 20 and US 26 are the preferred routes connecting INEL with I-15. US 91, located 20 mi east, parallels I-15, connects the cities and towns along the Snake River, and intersects US 30 in Bannock County. These primary highway routes, their associated functional classifications, and 1988 traffic volumes in terms of annual average daily traffic (AADT) and vehicle miles traveled (VMT) are presented in Table 4.2.9-1.

General weight, width, and speed limits have been established for highways in the INEL vicinity. However, no unusual laws or restrictions that have been identified would significantly influence general regional transportation.

Pavement rehabilitation programs are planned for segments of I-15, US 26, and SR 33. Major improvements scheduled include the construction of an interchange along I-15 in northern Jefferson County (Wubker 1989; Meyer 1989).

In 1988 70% of the work force associated with INEL worked at the site, with the remainder at Idaho Falls (Bowman-5). Approximately 81% of the work force resided in Bingham (14%) and Bonneville (67%) Counties. Approximately 4,000 of the employees on the site used bus transportation.

In 1988 nearly 8 million mi were logged by DOE vehicles at INEL. In addition, an estimated 1,620 privately owned vehicles were driven on-site each weekday, and another 590 were driven on-site each weekend day. Assuming a round-trip distance of 30 mi on-site for each of these vehicles, a total of about 20 million mi were driven annually by workers on-site.

The primary highways used by commuters are US 20, US 26, and US 20/US 26. These highways are used by 50, 30, and 20% of the workers, respectively. With these commuting patterns, workers annually travel about 22 million mi off-site. Trucks used for material shipment to INEL compose about 5% of the vehicular traffic on and around the site.

The implementation of staggered work hours and reduced work days has already mitigated some of the congestion along US 20 and US 26, particularly at access points to the INEL facilities (Bowman-6).

From May 1985 through mid-August 1989, 66 accidents involving DOE vehicles occurred at INEL. Of these nonfatal accidents, three involved injuries. Among off-site highway segments of concern, most accidents occurred along I-15. According to available data, the 27 accidents in 1987 involving trucks in the study area resulted in 17 injuries and 2 fatalities (DOT-1).

TABLE 4.2.9-1 Information on Major Transportation Routes around the INEL Site

Road Segment ^a	Functional Classification	AADT ^b (vehicles)	Annual VMT ^c (millions of miles)
I-15 (from northern Bannock County line to northern Jefferson County line)	Interstate	7,140	349
US 20 (from junction with I-15 to US 20/26 in Butte County)	Principal arterial	3,200	50.9
US 20/26 (from US 20 and US 26 junction to junction with US 93)	Principal arterial	1,260	10.8
US 26 (from I-15 in Bingham County to US 20 in Butte County)	Principal arterial	2,100	26.2
US 20/26/93 (from Butte County line to US 20/26 and US 93)	Principal arterial	1,260	11.9
US 93 (from Butte County line to junction with US 20/26)	Principal arterial	1,260	6.34
US 91 (from junction with US 20 in Bonneville County to I-86)	Major collector	928	14.0
SR 22 (from northern Jefferson County line to SR 33)	Major collector	376	2.07
SR 22/33 (from SR 22 and SR 33 junction to junction with US 20/26)	Major collector	245	2.21
SR 28 (from junction with SR 22 to junction with SR 33)	Minor arterial	1,120	5.68
SR 33 (from US 20 in Madison County to junction with SR 22)	Major collector/ Minor collector	1,170	22.9

^aRoute prefixes: I (Interstate), US (United States Route), SR (State Route).

^bAADT = annual average daily traffic.

^cVMT = vehicle miles traveled.

Conversion factor: 1 mi = 1.609 km.

Sources: EG&G-4; Wubker 1989.

4.2.9.2 Rail Transportation

The Union Pacific Railroad's Mackay Branch, 14 mi of which crosses the southern portion of INEL, provides rail transportation. This branch connects with a DOE-owned spur line at Scoville Siding, then links with developed areas within INEL (EG&G-4). Rail shipments to and from INEL are usually limited to radioactive materials. In 1988 INEL had 44 inbound and 43 outbound shipments (EG&G-4). No on-site rail accidents were identified at INEL in 1988.

4.2.9.3 Barge Transportation

No navigable waterways exist at or in the vicinity of INEL; therefore no materials are transported by barge (EG&G-4).

4.2.10 Waste Management

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

The objective of waste management at INEL is to manage and dispose of the existing waste inventory and newly generated waste (EG&G-2). The generation, treatment, storage, transport, and disposal of radioactive waste and other waste at INEL are managed so as to minimize the generation of waste and to protect the health and safety of the public, DOE employees, and the environment. All activities will comply with applicable Federal, state, and local laws and regulations, as well as DOE requirements. Waste types at INEL include HLW, TRU waste, LLW, mixed waste, hazardous waste, and nonradioactive nonhazardous waste (designated for the purposes of this EIS as "other waste"). Waste types and regulatory definitions are described in Appendix M. This section describes the waste management facilities and operations at INEL and identifies those that would be used to process NPR-related waste.

Existing waste handling facilities at INEL are located at the Idaho Chemical Processing Plant, the Radioactive Waste Management Complex, and the Waste Reduction Operations Complex. Located at the Central Facilities Area are a Radioactive Mixed Waste Storage Facility, a Hazardous Waste Shipping Facility, and a sanitary landfill. Waste facilities, existing waste generation rates, and facility capacities at INEL are summarized in Tables 4.2.10-1 and 4.2.10-2. An overview of the INEL waste storage, treatment, and disposal facilities that would support the NPR project is presented in Appendix M, Figure M.2.

TABLE 4.2.10-1 Baseline Waste Quantities as of the Year 2000 at INEL^a

Waste Identification	Annual Disposal Volume from Processing Operations Wastes (m ³ /yr)	Annual Disposal Volume from Processing Stored Wastes (m ³ /yr)	Total Annual Disposal Volume from all Waste Processing (m ³ /yr)	Disposition
High-level waste Solid ^b	500	50	550 ^c	Interim on-site storage ^d
Transuranic waste Solid ^e	2,800	7,400	10,200 ^c	Interim on-site storage ^f
Low-level waste Solid ^g	2,900	0	2,900	On-site disposal
Mixed waste Solid ^g	12	0	12	Interim on-site storage
Hazardous waste Liquid and solid	180	0	180	Off-site disposal
Other waste Nonhazardous				
Liquid	33,000	0	33,000	Liquid effluent
Solid	37,000	0	37,000	On-site disposal
Sewage				
Liquid ^h	230,000	0	230,000	Liquid effluent
Solid ⁱ	5	0	5	On-site disposal

^aBaseline values projected from 1988 data.^bLiquid HLW is held in interim storage and then processed to a solid form for disposal.^cBaseline value taken from 1988 data for planned future activities.^dThese wastes are targeted for disposal at a Federal repository.^eLiquids containing transuranics are processed as HLW.^fThese wastes are targeted for disposal at WIPP.^gSolidified or absorbed-liquid-waste quantities are included in the solid waste quantity.^hLiquid effluents from sewage treatment operations.ⁱSolids from sewage treatment operations.

Source: Bowman-8.

TABLE 4.2.10-2 Baseline Waste Management Facilities as of the Year 2000 at INEL^a

Waste Identification	Facility Description	Facility Function	Facility Input Capacity (m ³ or m ³ /yr) ^b	Percentage of Capacity Used for Processing Operations Wastes	Percentage of Capacity Used for Processing Stored Wastes	Comment
High-level waste						
Liquid	Storage tanks	Storage	15,200	30	2	
Solid	New Waste Calcining Facility	Treatment	4,000	93	6	
	Calcined Solids Storage Facility	Storage	10,000	7	1	
	Waste Immobilization Facility	Treatment	1,300 ^c	60	6	Planned to be operational as of 2011
	Interim storage	Storage	Expandable ^d	Variable ^c	Variable ^c	
Transuranic waste						
Solid ^f	Transuranic Storage Area	Storage	595,000	<1	1	Planned to be operational as of 2000
	Idaho Waste Process Facility ^g	Treatment	Expandable ^d	Variable ^c	Variable ^c	
	Stored Waste Examination Pilot Plant	Storage	Expandable ^d	Variable ^c	Variable ^c	
	Interim storage	Storage	Expandable ^d	Variable ^c	Variable ^c	
Low-level waste						
Liquid	Process Equipment Waste Evaporator	Treatment	15,000	53	0	
Solid ^h	Subsurface Disposal Area	Disposal	100,000	1	0	
	Waste Experimental Reduction Facility:					
	Compactor input	Treatment	1,700	45	0	
	Incinerator input	Treatment	7,500	20	0	
	Noncompacted input	Treatment	Expandable ^d	Variable ^c	0	
	Subsurface Disposal Area	Disposal	100,000	2	0	
Mixed waste						
Solid ^h	Radioactive Mixed Waste Storage Facility	Storage	Full	Variable ^c	0	Operational as of 1994
Hazardous waste						
Liquid and solid	Hazardous Waste Shipping Facility	Storage	Expandable ^d	Variable ^c	0	Waste regularly shipped off-site

TABLE 4.2.10-2 (Cont'd)

Waste Identification	Facility Description	Facility Function	Facility Input Capacity (m ³ or m ³ /yr) ^b	Percentage of Capacity Used for Processing Operations Wastes	Percentage of Capacity Used for Processing Stored Wastes	Comment
Other waste						
Nonhazardous						
Liquid	Evaporation ponds	Treatment	Expandable ^d	Variable ^c	0	
Solid	Central Facilities Area Landfill	Disposal	Expandable ^d	Variable ^c	0	
Sewage						
Liquid ⁱ	Sanitary tile fields	Disposal	Expandable ^d	Variable ^c	0	
Solid ^j	Central landfill	Disposal	Expandable ^d	Variable ^c	0	

^aBaseline values projected from 1988 data.

^bFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^cBaseline value taken from 1988 data for planned future capacity.

^dThere is sufficient space available within the boundaries of the facility to accommodate additional storage/treatment disposal units which can be constructed as needed.

^ePercentage used will vary with additional unit construction schedule.

^fLiquids containing transuranics are processed as HLW.

^gIt is presently planned that the Process Reduction Experimental Pilot Plant will not be operational at NPR start-up but will be replaced by a facility with similar capabilities. The analysis in this document assumes the existence of a facility with similar capabilities.

^hSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

ⁱLiquid effluents from sewage treatment operations.

^jSolids from sewage treatment operations.

Source: Bowman-8.

The baseline quantities of waste at INEL include the inventories of mixed and radioactive waste that are stored on-site and are awaiting final disposal, waste resulting from the processing of naval reactor fuels, and all new waste generated by continued operation of various research reactors and associated facilities at INEL. Most of the baseline HLW, LLW, and hazardous waste are derived from on-going operations at INEL (Table 4.2.10-1). Corresponding NPR-related waste would be treated and disposed of in the same manner as INEL baseline waste (EG&G-2; Bulmahn 1990).

One component of the overall waste management objective at INEL is waste minimization and waste reduction to reduce the output of waste at the source. Waste minimization efforts and reductions in volume are expected to significantly extend the projected 25- to 27-year effective life of the Radioactive Waste Management Complex (EG&G-6).

For LLW, four experimental volume-reduction activities are being conducted at the Waste Experimental Reduction Facility: sizing, compaction, incineration, and melting. Sizing and compaction can reduce the waste volume by a 5:1 (average) ratio. Incineration of combustible waste and solidification (grouting) of the resulting bottom ash and fly ash in Portland cement can reduce the volume by 20:1. Waste processed at the Waste Experimental Reduction Facility is disposed of at the Radioactive Waste Management Complex.

The Buried Waste Program includes a pilot study of the feasibility of retrieving buried radioactive waste and segregating it into LLW and TRU waste, thus reducing the overall volume of TRU waste. The Process Reduction Experimental Pilot Plant was a project for processing TRU waste into a form acceptable for disposal at WIPP. Included in this project were incineration for volume reduction and waste immobilization by cementing. By 2000, the Waste Characterization and Waste Processing Facilities are expected to be operational and designed to process TRU waste at an annual rate of 4,800 m³. HLW reduction can be achieved by coprocessing zirconium-clad fuels from the Naval Fuels Program with fuels from reactors utilizing aluminum-clad elements. The Naval Fuels Program is a long-term contract whereby the Idaho Chemical Processing Plant processes spent fuel from the Department of the Navy's operational and research reactors.

4.2.10.1 High-Level Waste

Most of the HLW generated at INEL results from reprocessing naval reactor fuels. The spent fuel is processed at the Idaho Chemical Processing Plant. Liquid HLW from fuel extraction is sent to the tank farm, which now contains 11 large tanks, each with a capacity of 1,170 m³. Eight new stainless steel tanks, each with a capacity of 1,900 m³, are proposed to be on-line by the mid-1990s. Less-concentrated extraction fluids are first sent to the Process Equipment Waste Evaporator, where they are concentrated and combined with first-cycle HLW extraction liquids at the tank farm. After interim storage at the tank farm, the HLW is converted into metallic oxides in the New Waste Calcining Facility. The metallic oxides (calcine) are placed in retrievable storage in bins at the Calcined Solids Storage Facility. In 1988, 390 m³ of solid radioactive waste was stored in stainless steel calcine storage bins contained in concrete vaults.

Beginning in 2011, the proposed Waste Immobilization Facility is scheduled to convert the calcined solids into a crystalline ceramic waste for disposal in a Federal repository. The NPR-generated HLW calcine would be treated concurrently with the inventory calcine when the vitrification facility becomes operational.

4.2.10.2 Transuranic Waste

TRU waste is packaged at the individual facilities that generate this waste and then is kept in retrievable storage at the 22-ha Transuranic (waste) Storage Area in the Radioactive Waste Management Complex. The Transuranic Storage Area consists of asphalt storage pads for contact-handled TRU waste. Each pad can store 37,200 m³ of waste. The pads are constructed as required. Sufficient room exists inside the current Transuranic Storage Area boundaries for 16 waste storage pads with the potential storage capacity of 595,000 m³. As of 1988, 64,000 m³ of TRU waste was stored at this facility. The TRU waste storage capacity is adequate to store INEL baseline projected waste volumes until shipment to WIPP.

All TRU waste is processed through the Stored Waste Examination Pilot Plant prior to off-site disposal at WIPP. At this plant, each TRU waste container is examined in a three-step process to ensure that the container meets the certification criteria for waste sent to WIPP. The facility has approximately 1,040 m³ of on-site storage space. The NPR-generated TRU waste would be certified and stored at this facility prior to disposal at WIPP.

4.2.10.3 Low-Level Waste

The liquid condensate from the Process Equipment Waste Evaporator (up to 15,000 m³/yr) is combined with the 1.4 to 2.8 × 10⁶ m³/yr of nonradioactive service wastewater from the Idaho Chemical Processing Plant before being discharged to percolation ponds. The use of percolation ponds is scheduled to cease by the time the NPR would become operational. Evaporator condensate would then be processed at the proposed Liquid Effluent Treatment and Disposal Facility, which will recycle the acidic stream back to chemical process activities at the Idaho Chemical Processing Plant.

The Waste Experimental Reduction Facility reduces the volume of primary solid LLW by melting, compaction, and incineration. For example, in 1988, the facility reduced 2,700 m³ of solid LLW to 273 m³, which amounted to a volume reduction of approximately 90%.

Solid LLW is disposed of in the active portion of the fenced Subsurface Disposal Area located in the western part of the Radioactive Waste Management Complex. The Subsurface Disposal Area contains pits, trenches, and vaults excavated into basalt. The total volume of waste disposed of in the Subsurface Disposal Area is about 105,000 m³; about 2,900 m³ of solid LLW is buried annually. NPR-related solid LLW would be disposed of at the Subsurface Disposal Area. An additional 62,300 m³ of LLW mixed with TRU waste with activities of less than 10 nCi/g was buried at the inactive parts of the Radioactive Waste Management Complex prior to 1964. This waste does not affect current INEL waste management facilities and is not expected to affect disposal of NPR-related waste.

4.2.10.4 Mixed Waste and Hazardous Waste

The current rate of mixed waste generation is 12 m³/yr. Mixed waste is stored at the Radioactive Mixed Waste Storage Facility. As of 1988, 37 m³ of mixed waste was stored at that facility, whose total capacity is 77 m³. No commercial waste facilities are currently licensed to accept radioactive mixed waste. In the future, INEL will treat mixed waste at the Waste Experimental Reduction Facility.

More than 30 facilities at INEL generate RCRA-regulated hazardous waste. The amounts generated annually range from less than 0.004 m³ (several facilities) to more than 75 m³ (Idaho Chemical Processing Plant). Nonradioactive hazardous waste, including waste contaminated with polychlorinated biphenyls, is temporarily stored at the Hazardous Waste Shipping Facility located in the Central Facilities Area. This facility currently handles 180 m³/yr of hazardous waste prior to regular off-site shipment for final disposal at licensed RCRA facilities. NPR-related hazardous waste would be disposed of at RCRA-licensed off-site facilities.

4.2.10.5 Other Waste

Nonradioactive, nonhazardous solid waste (Section M.4.2) is disposed of in the Central Facilities Area landfill, which is permitted by the state of Idaho. In 1987, a total of 36,500 m³ of solid other waste was disposed of in INEL sanitary landfills. NPR-related other waste would also be disposed at on-site landfills.

Nonradioactive, nonhazardous liquid effluent streams are discharged into percolation ponds, evaporation ponds, or sewage treatment facilities, depending on the nature and source of the waste. Currently, liquid waste streams from the Idaho Chemical Processing Plant are discharged to percolation ponds. By the time the NPR would be in operation, these service waste will be disposed of in lined evaporation ponds.

4.2.10.6 Remedial Activities

INEL has generated waste regulated as both radioactive and hazardous materials. Several types of remedial activities are either underway or planned. The Buried Waste Program was established to perform studies and to develop a long-term management plan for buried waste. The Retrieval Demonstration Project will study the feasibility of developing large-scale waste retrieval at the Subsurface Disposal Area. As part of this project, previously buried waste would be exhumed, LLW would be reburied, and TRU waste would be segregated, packaged, and stored in the Radioactive Mixed Waste Storage Facility.

4.3 SAVANNAH RIVER SITE

4.3.1 Geology

This section summarizes the geologic setting, including potential geologic hazards, at SRS. Soils of the proposed NPR site are evaluated with respect to the agronomic classifications of Prime Farmland and Unique Farmland. Appendix D contains a more detailed exposition of these topics.

4.3.1.1 Geologic Setting

The SRS is located east of the Fall Line in southeastern South Carolina in the Upper Atlantic Coastal Plain physiographic province. The land surface at SRS ranges from 25.9 to 130 m MSL. The SRS rests on a wedge of coastal plain sediments that averages 280 m thick and dips gently to the east. Beneath the coastal plain sediments are crystalline basement rocks and the Triassic sedimentary formations of the Dunbarton Basin.

4.3.1.2 Geologic Structures

The center of SRS lies 40 km southeast of the Fall Line, a major physiographic and structural feature that separates the Piedmont and the Coastal Plain physiographic provinces. Figures 4.3.1-1 and 4.3.1-2 give the locations of known geologic structures in the region. The Dunbarton Basin is associated with the Dunbarton Fault, a northeast-trending fault zone whose most recent movement occurred in Late Cretaceous time (>63 million years before present). Two faults discovered by geophysical studies extend across SRS and are transverse to the Dunbarton Fault. A third fault, the Pen Branch Fault, lies parallel to it. The Pen Branch Fault is thought to be a growth fault whose displacement occurred after Late Cretaceous time and continued intermittently through the early part of the Late Eocene (~38 million years before present). Evidence of subsequent motion has not been detected; thus, at this time the Pen Branch Fault is not thought to be *capable*. However, it is possible that ongoing studies may identify capable segments of the Pen Branch Fault. Surface mapping, drilling, and geophysical studies at SRS have detected several other surficial faults within Eocene-age strata; however, none of these faults is believed to be *capable* within the definition of 10 CFR 100, Appendix A, because these faults have not been shown to cross cut upper Pleistocene and younger sediments. In addition, the faults exhibit no control over present topography or drainage. There is no conclusive evidence of Recent (Holocene) (<10,000 years before present) displacement along any fault within 300 km of SRS. The only possible exception is the geophysically inferred faults near the 1886 Charleston earthquake, whose epicenter was approximately 145 km (DOE-10) from SRS.

4.3.1.3 Volcanism

There is no volcanic hazard at SRS. The area has not experienced volcanism within the last 230 million years. Future volcanism is not expected because SRS is located along a passive continental margin of the North American plate.

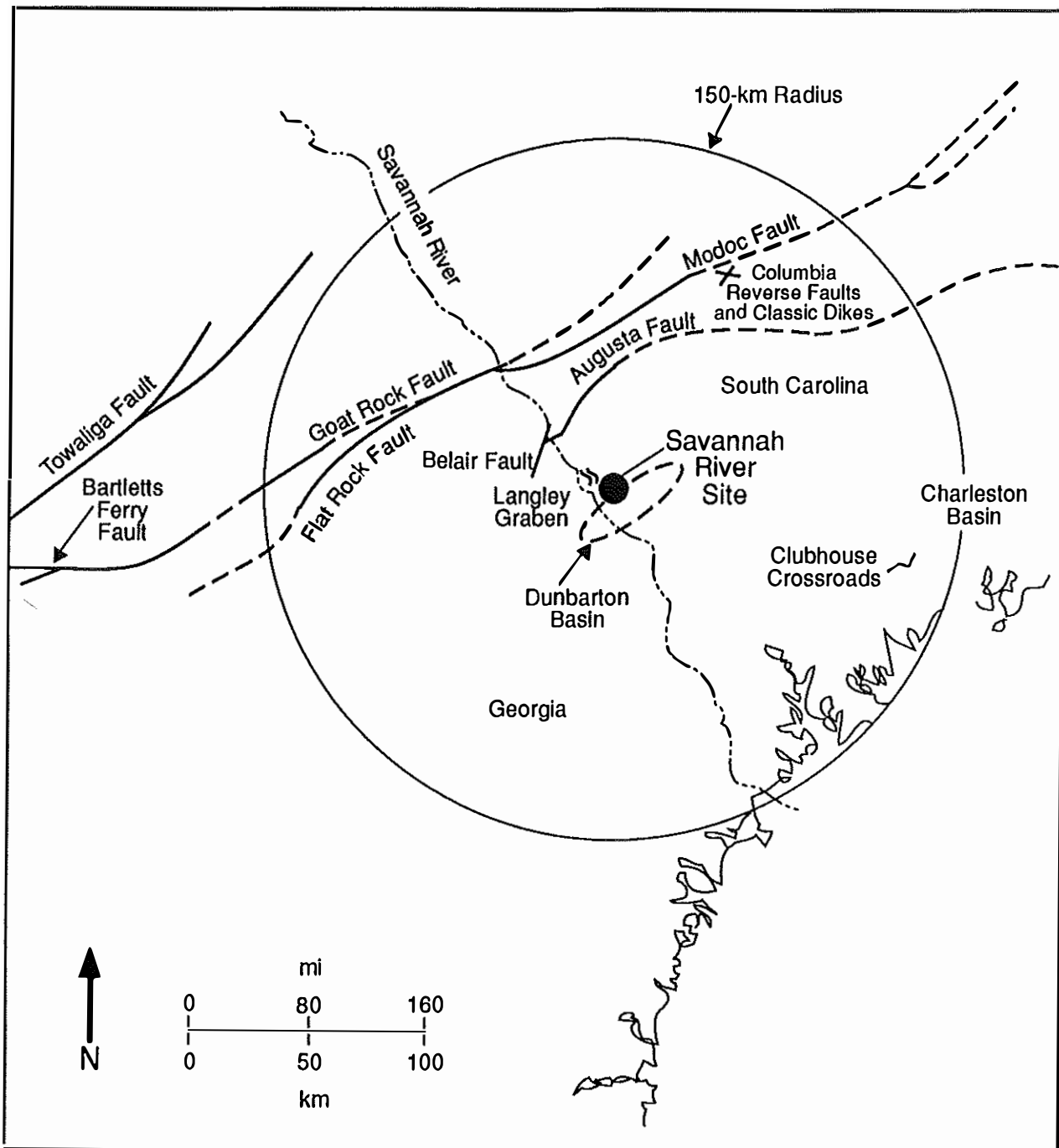


FIGURE 4.3.1-1 Geologic Structures within 150 km of SRS (Source: Modified from WSRC-8)

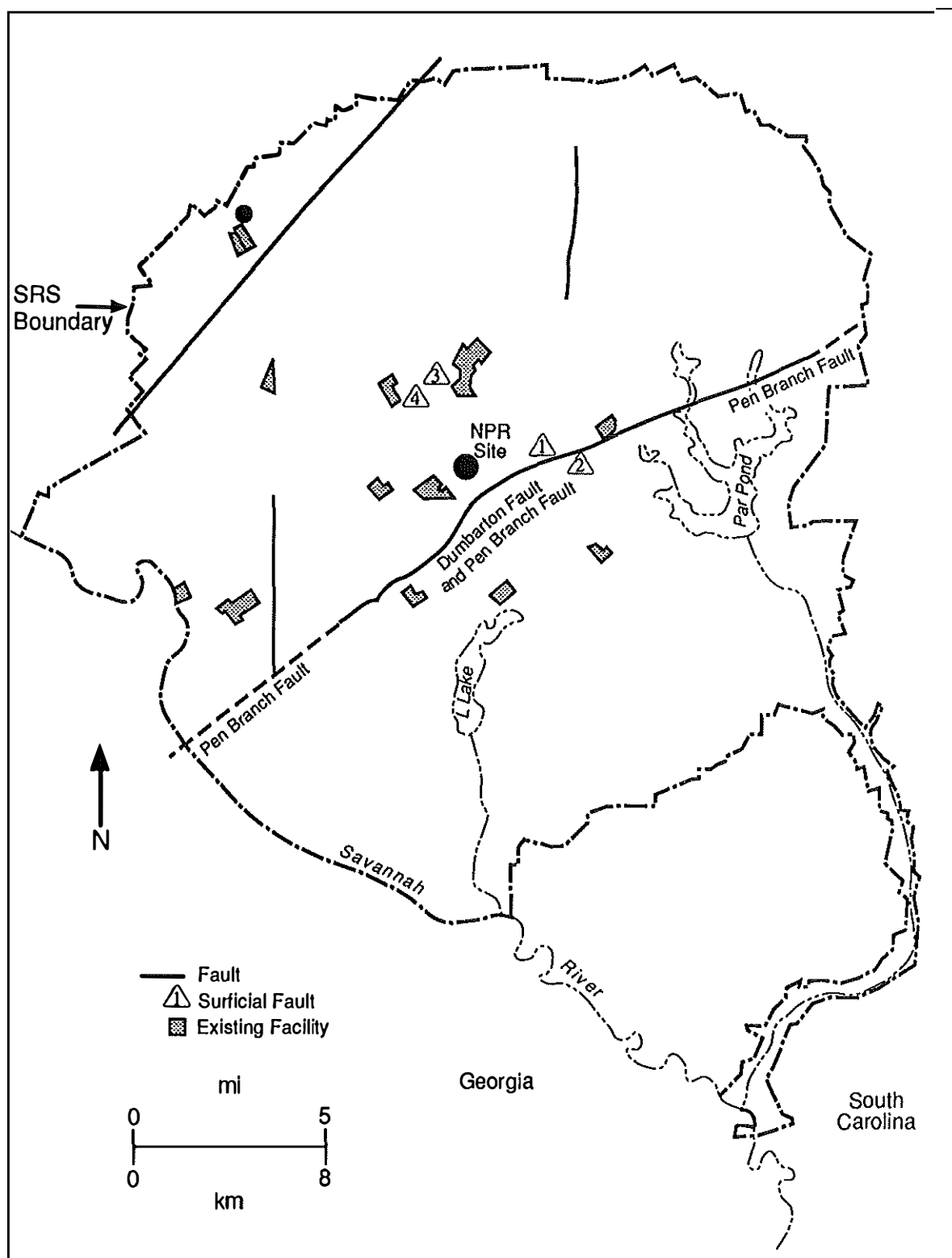


FIGURE 4.3.1-2 Locations of Faults at SRS (Sources: Modified from Chapman and Di Stefano 1989; Snipes, Fallow, and Price 1988)

4.3.1.4 Seismicity

Historical earthquakes are reported as Modified Mercalli Intensities (MMI). As shown in Appendix D, the Modified Mercalli Intensity scale is a measure of the strength of ground motion and as such is partly a function of distance from earthquake source, declining with distance. Instrumental data for the SRS region were reported from coda-length magnitudes, body-wave magnitudes, surface-wave magnitudes, or local magnitudes. Coda-length magnitudes are measured from the concluding part of the seismograph record. Body-wave magnitudes are a function of the ratio of the amplitude to the period of seismic body waves moving through the earth's interior. Surface-wave magnitudes are a function of the amplitude of 20-second-period seismic surface waves. Local magnitude is a measure of the strain energy released by an earthquake at a distance of 100 km from the epicenter.

Two small earthquakes have been instrumentally recorded within the SRS boundary. The first occurred on June 8, 1985, and had a magnitude of 2.6 (MMI of III), an acceleration of 0.002 g, and a hypocentral depth of 0.96 km. The second occurred on August 5, 1988, and had a magnitude of 2.0 (MMI of I to II) and a hypocentral depth of 2.68 km (Figure 4.3.1-3 and Appendix D, Section D.4). Although these earthquakes occurred near the Dunbarton/Pen Branch fault zone, they have not been specifically linked to those faults (Stephenson 1988).

Two large earthquakes have occurred within 300 km of SRS in historical time: the Charleston earthquake of 1886 (epicentral MMI of X) and the Union County, South Carolina, earthquake of 1913 (epicentral MMI of VII to VIII). These events were located 145 and 160 km from SRS, respectively. The peak horizontal ground acceleration at SRS from the 1886 earthquake was calculated to be 0.10 g (URS/Blume 1982). Site intensities, ground accelerations, and available magnitudes for earthquakes of MMI V or larger are listed in Appendix D, Section D.4, and are shown in Figure 4.3.1-4.

Figure 4.3.1-5 is a plot of the earthquake hazard at SRS. Stephenson (1988) cites several recurrence relations developed for the southeastern United States based on different data sets. All of them predict several earthquakes per year of magnitude 2 (and MMI II) in the South Carolina Coastal Plain. The sparseness of data result in decreased confidence in recurrence rates for large-magnitude events.

The results of seismic hazards analyses being conducted by Lawrence Livermore National Laboratory will be considered in the engineering design of NPR facilities at SRS. Hazard curves like the one presented here have been used to project theoretical peak ground accelerations for the development of severe radiological accident scenarios at NPR support facilities. The results of these seismic analyses, which are being conducted by Lawrence Livermore National Laboratory (1990) and Murray and Wesley (1990), are presented in Appendix J.

4.3.1.5 Soils

The soils of the proposed NPR site are mainly sands and sandy loams. One of these soils, the Dothan series, A and B slopes, is classified as Prime Farmland (USDA 1990). There is no Unique Farmland on the proposed NPR site.

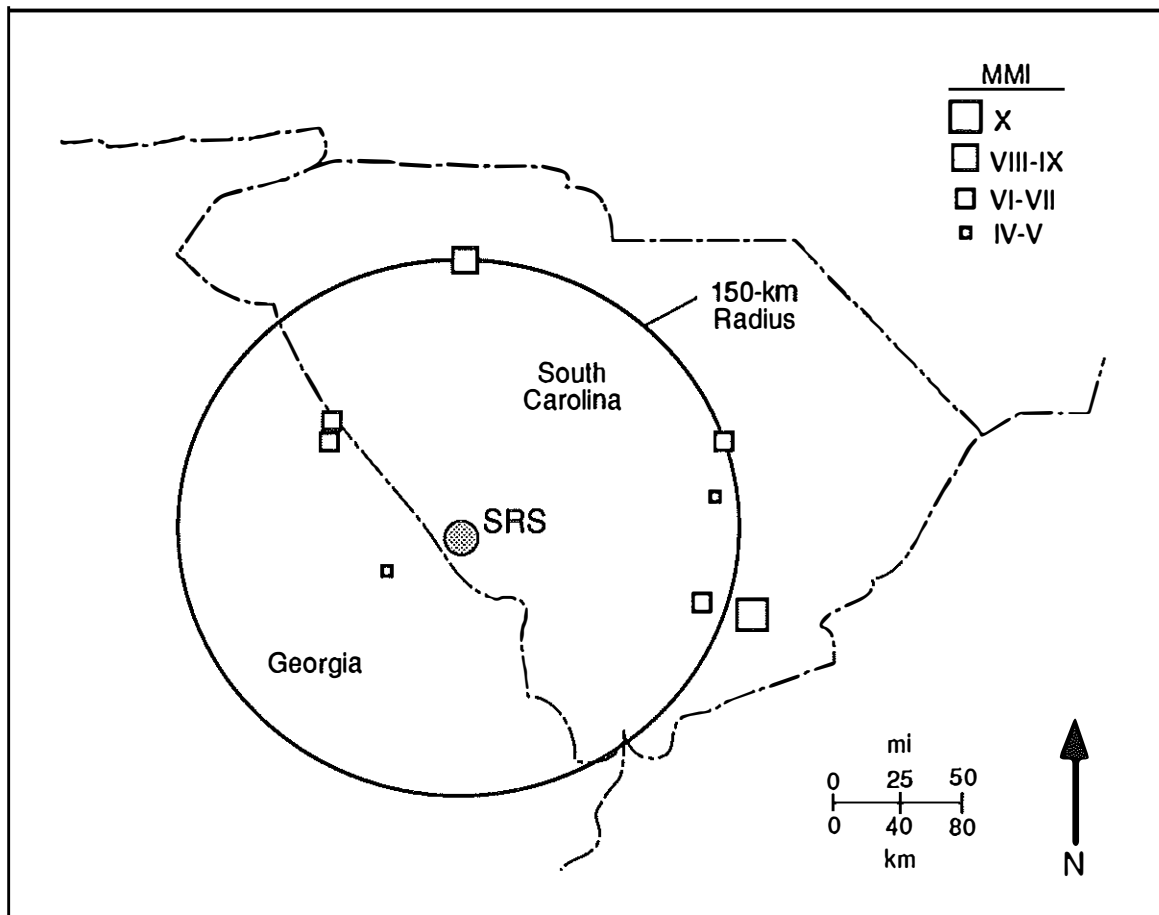


FIGURE 4.3.1-3 Locations of Earthquakes of MMI V or Larger within 150 km of SRS
(Source: Modified from Bollinger 1975)

4.3.2 Air Resources

4.3.2.1 Climate and Meteorology

The SRS region has a temperate climate with short, mild winters and long, humid summers. Throughout the year, it is frequently affected by warm and moist maritime air masses.

Meteorological data from the H-Area tower and the A-Area shelter (Appendix E, Figure E.3) are considered representative of climatic conditions at and near the proposed NPR site. The following climatological and meteorological information is primarily based on data collected from these two locations and summarized in reports prepared by Hoel (1983) and DOE (DOE-25).

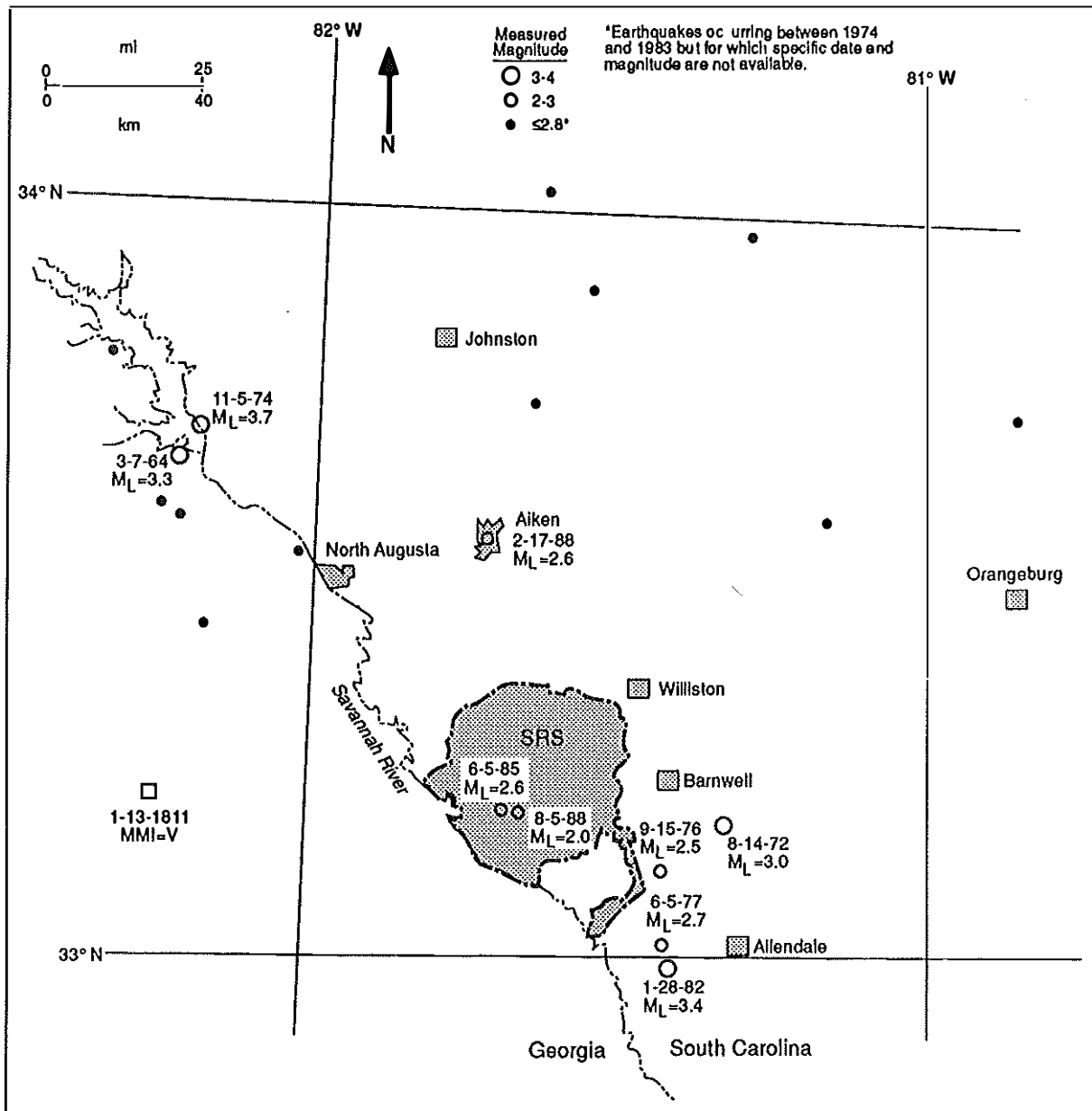


FIGURE 4.3.1-4 Earthquakes in the SRS Region (if no date or magnitude is specified, the event is of magnitude ≤ 2.8 and was instrumentally measured between 1974 and 1983) (Source: Stephenson 1988)

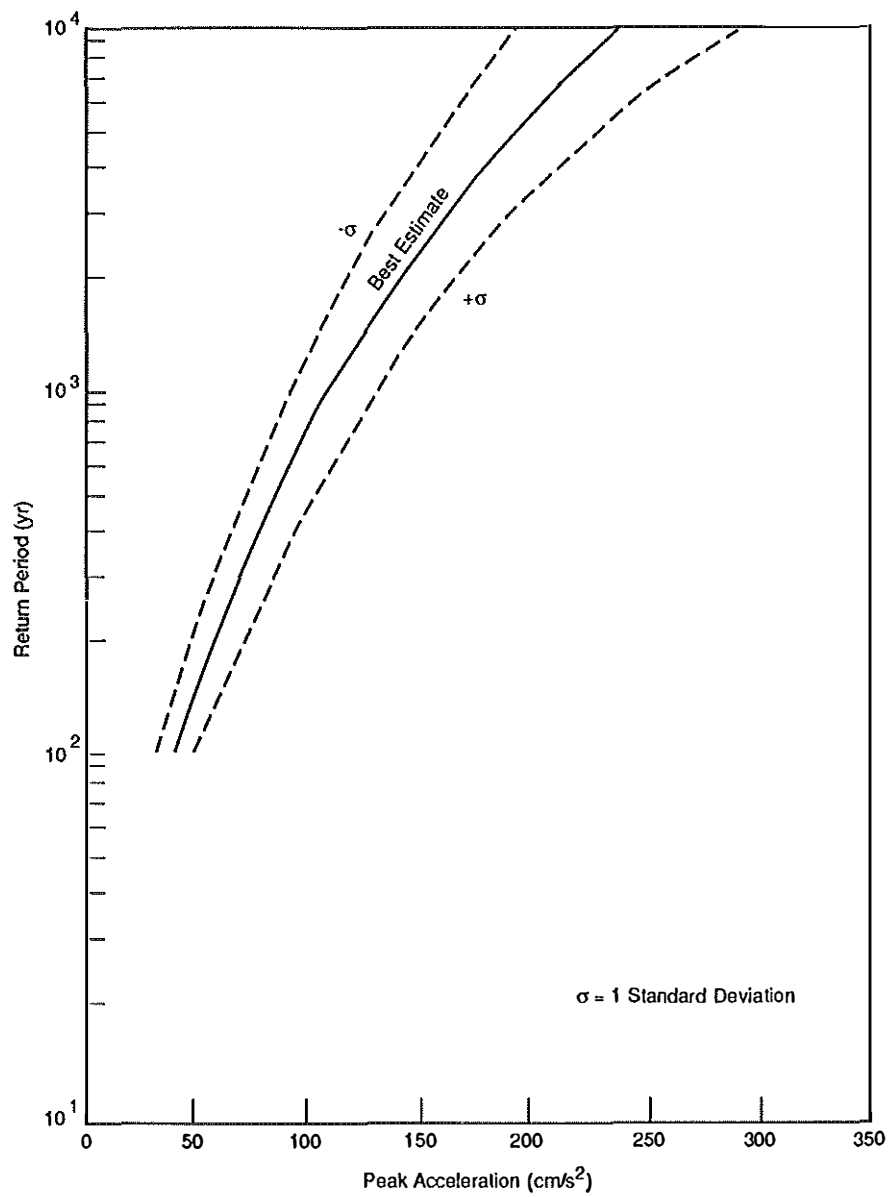


FIGURE 4.3.1-5 Seismic Hazard Curve for SRS (σ represents one standard deviation) (Source: Modified from TERA Corp. 1984)

Wind

The wind data measured at the 6-m level at the H-Area tower for the period 1982-1986 indicate that there is no predominant wind direction at SRS. The maximum directional frequency is from the northeast (about 9% of the time). The annual average wind speed is 3.9 m/s, and monthly average wind speeds range from 3.4 m/s from June through August to 4.6 m/s in February.

Temperature and Humidity

The annual average temperature at SRS is 18°C; monthly averages range from 7°C in January to 27°C in July. The annual average relative humidity is 66%. The lowest monthly average daily minimum (36%) occurs in April, and the highest monthly average daily maximum (98%) occurs in August.

Precipitation and Evapotranspiration

The average annual precipitation at SRS is 122 cm. Precipitation is distributed fairly evenly throughout the year, with the highest precipitation in summer (36.1 cm) and the lowest in fall (22.4 cm). Although snow can fall from October through March, the average annual snowfall is only 3.0 cm; large snowfalls are rare.

Evapotranspiration in the southeastern Coastal Plain physiographic province is approximately 88.9 cm/yr (Wait et al. 1986), which is 73% of the reported average annual precipitation. The remaining precipitation represents the amount available to surface streams for overland flow and to groundwater for recharge.

Fog and Visibility

Heavy fog (visibility ≤ 0.4 km) occurs in Augusta, Georgia, on an average of 28 days each year, averaging 3 days a month during the fall and winter and less than 2 days a month during the spring and summer (NCDC 1988).

The regional background visual range in the SRS area is estimated to be about 25 km (Trijonis and Shapland 1978). Statistics are unavailable for other visibility-reducing phenomena (e.g., smoke, dust, and blowing dust).

Severe Weather

Winter storms in the SRS area occasionally bring strong and gusty surface winds with speeds as high as 32 m/s. Thunderstorms can generate winds with speeds as high as 18 m/s and even stronger gusts. The fastest 1-minute wind speed recorded at Augusta between 1950 and 1986 was 37 m/s.

The average number of thunderstorm days per year at SRS is 56. From 1954 to 1983, 37 tornadoes were reported for a one-degree square of latitude and longitude that includes SRS.

This frequency of occurrence amounts to an average of about one tornado per year. The estimated probability of a tornado striking a point at SRS is 7×10^{-5} /yr (Ramsdell and Andrews 1986). Since operations began at SRS in 1953, six tornadoes have been confirmed in or near SRS. Nothing more than light damage was reported in any of these storms, with the exception of a tornado in October 1989. That tornado caused considerable damage to timber resources in an unpopulated wooded area of SRS (Parker and Kurzeja 1990).

From 1899 to 1980, 13 hurricanes were experienced in South Carolina and Georgia, for an average frequency of about one hurricane every 6 years. Three hurricanes were classified as major. Because SRS is about 160 km inland, the winds associated with hurricanes have usually diminished below hurricane force (greater than or equal to a sustained speed of 33.5 m/s).

Atmospheric Dispersion Characteristics

Atmospheric dispersion improves as wind speed increases, stability conditions become more unstable, and the depth of the mixing layer increases. Annual and seasonal data on the frequency distribution of wind speed by wind direction and atmospheric stability class at SRS are summarized in Hoel (1983).

The approximate annual and seasonal morning and afternoon mixing-layer depths, as estimated by Holzworth (1972) for the SRS region, are listed in Table E.13.

4.3.2.2 Ambient Air Quality

The SRS is located near the center of the Augusta-Aiken Interstate Air Quality Control Region (AQCR). As of 1988, none of the areas within the SRS and its surrounding counties was designated as a nonattainment area with respect to any of the National Ambient Air Quality Standards (NAAQS) (40 CFR 50). The NAAQS and the ambient air quality standards for South Carolina and Georgia are listed in Table E.14. The state standards are identical to the NAAQS, except for the annual average total suspended particulate (TSP) concentration, for which an NAAQS no longer exists. The South Carolina Department of Health and Environmental Control (SCDHEC) also has ambient standards for gaseous fluorides (SCDHEC-3).

The major sources of criteria air pollutants at SRS are (1) the 13 coal-burning boilers for producing steam and electricity (A, D, H, K, and P areas); (2) fuel and target fabrication (M Area) and processing facilities (F and H areas); and (3) continuously operating diesel generators (F, H, K, L, and P areas). Other emissions include fugitive particulate emissions from coal piles and coal processing facilities, vehicular emissions, and temporary emissions from various construction-related activities. Conservative emission estimates for these sources are presented in Table E.15.

Since the promulgation of the Prevention of Significant Deterioration (PSD) regulations (40 CFR 52.21) in 1977, PSD permits have not been required for any of the new SRS emission sources or modifications to existing ones. In South Carolina, the only source in the Augusta-Aiken Interstate AQCR that has been issued a PSD permit is located near Orangeburg, about 65 km northeast of the nearest SRS boundary. Four sources in the Georgia portion of the AQCR have been issued PSD permits. The closest of these is approximately 16 km west of the nearest SRS boundary (Hunter 1989). Because of the substantial distances between these sources

and the SRS boundary, the PSD concentration increments used at the SRS boundary by these sources are expected to be negligible (see Table E.4 for the maximum allowable PSD increments).

In 1988, SRS operated five on-site ambient air quality monitoring stations (Davis, Martin, and Todd 1989). Their locations and the pollutants they monitored are shown in Figure E.3. Additional monitoring of ambient air quality is performed by the state of South Carolina in the SRS vicinity (SCDHEC-3).

The maximum pollutant concentrations measured during 1988 at on-site monitoring stations and at nearby locations outside SRS are listed in Table E.14. All concentrations measured at these stations indicate that ambient concentrations in and near SRS are within the NAAQS and applicable South Carolina ambient air quality standards. Data collected from the on-site monitoring network from 1984 to 1988 indicate that the observed ambient concentrations of sulfur dioxide (SO_2), total suspended particulate (TSP), and nitrogen dioxide (NO_2) were generally less than 50% of the respective limits set in the NAAQS. Quarterly average ambient concentrations of lead were less than one-hundredth of the limit set in the NAAQS. The ozone (O_3) standard was equaled at one monitoring station on one day in 1985 (Hunter 1989). Background concentrations of SO_2 , NO_2 , TSP, and PM_{10} representative of SRS were estimated from the 1985 on-site monitoring network data (Table E.14).

The only toxic air pollutant that would be released from an NPR and its support facilities, and for which an ambient standard has been proposed by the state of South Carolina, is nitric acid (HNO_3). The annual release rate of HNO_3 from existing SRS facilities during 1987 and the maximum 24-hour ground-level concentration at the SRS boundary are listed in Table E.31. For HNO_3 , the estimated concentration level is well below the ambient standard proposed by the South Carolina Department of Health and Environmental Control (SCDHEC-2). No ambient standards have been proposed or established by the state of Georgia.

4.3.2.3 Acoustic Conditions

The major noise sources at SRS, which are primarily located in developed or activity areas, include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). At the SRS boundary, which is at considerable distances from these facilities, noise from these sources would be barely distinguishable from background noise levels. Major noise sources outside these activity areas consist primarily of vehicles and rail operations. These are also the major sources of off-site noise that can be attributed to SRS activities.

A sound-level survey was conducted at SRS in July 1989 and January 1990 to determine background noise levels for major transportation routes near SRS and for a limited number of on-site locations (NUS-3). In both surveys, the sound-level data were collected at seven off-site locations and three on-site locations during daytime and nighttime periods for weekdays and weekends. The L_{dn} values derived from the summer survey data $L_{eq}(1h)$ ranged from 62 to 72 dBA for off-site locations and from 54 to 62 dBA for on-site locations. Winter survey data generally showed noise levels slightly lower than those for the summer survey data. The levels observed were higher than those suggested by EPA as representative of rural, small-town, or quiet suburban areas, except in a few cases where insect, traffic, and industrial-facility noise contributions were all small. Estimated $L_{eq}(24h)$ values at all measurement locations were below

the EPA guideline level of 70 dBA for protection of the public from hearing loss. Further, the levels described are based on data collected at locations adjacent to roads (15 m); therefore, these levels are higher than those that would be expected for general background.

The EPA guideline recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA-1). For protection against hearing loss in the general population from non-impulsive noise, the EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.

The Noise Control Act of 1972, together with its subsequent amendments (Quiet Communities Act of 1978, 42 USC 4901-4918), leaves it to the states to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. The states of Georgia and South Carolina, and the counties in which SRS is located, have not yet established any noise regulations that specify acceptable community noise levels.

The town nearest to the SRS boundary is Jackson, which has a population of 1,800 persons. It is located 1 km from the northwestern boundary of SRS and about 18 km northwest of the proposed NPR site. The next closest town is New Ellenton, which has a population of 2,600 persons. It is located about 20 km north of the proposed NPR site. The residents that could be affected by increased construction-related traffic noise are those living within 15-20 m of the highways leading to Augusta and Aiken from SRS.

4.3.3 Water Resources

This section characterizes water resources at SRS that could be affected by construction and operation of an NPR or by the no-action alternative. Surface water features described here include the Savannah River and its associated swamp, and the two tributaries to the Savannah River that flank the NPR site: Fourmile Branch and Pen Branch (Figure 4.3.3-1). Potential impacts to these water resources and the significance of these impacts are discussed in Section 5.4.2. Wetlands at the SRS are described in Section 4.3.5.2.

4.3.3.1 Surface Water

Description

The Savannah River forms the southwestern border of SRS. The river drains an area of 27,400 km² and ultimately discharges into the Atlantic Ocean. Maximum natural river flows typically occur in winter and spring, and the minimum flows occur in summer and fall (DOE-9). Five large reservoirs -- Thurmond, Russell, Hartwell, Keowee, and Jocassee reservoirs -- upstream of SRS regulate flow in the Savannah River and provide hydroelectric power, flood control, and recreation (DOE-10). The locations of these reservoirs are shown in Appendix F, Figure F.4. The average flow in the vicinity of Augusta, Georgia, based on 82 years (water years* 1884-1891, 1897-1906, 1926-1989) of records is 282 m³/s. In 1989, the mean flow at

*A water year begins October 1 of previous calendar year and ends on September 30 of the current calendar year.

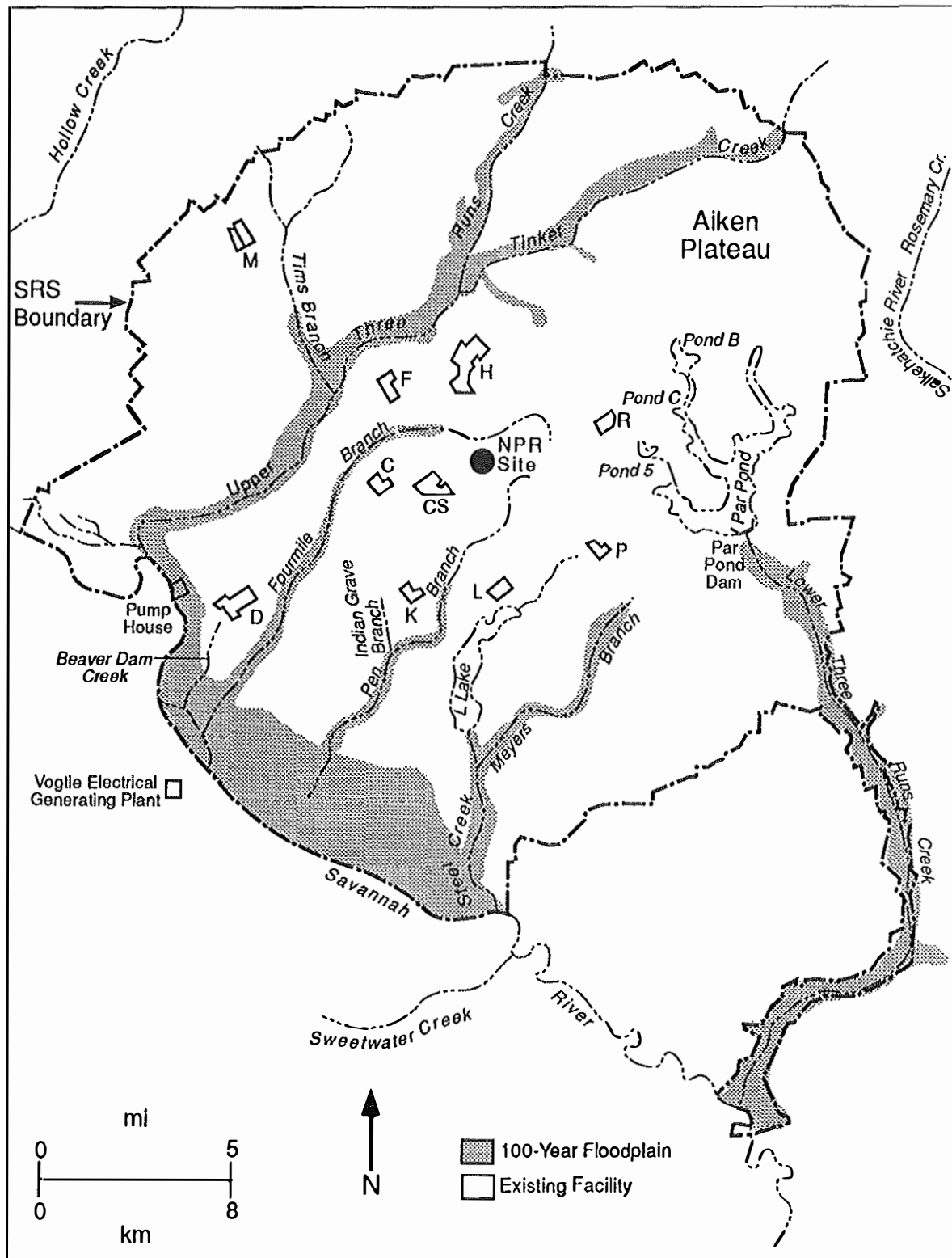


FIGURE 4.3.3-1 Surface Water Features in the Vicinity of SRS (Source: Modified from DOE-10)

Augusta was $152 \text{ m}^3/\text{s}$, about half the long-term average (Bennett et al. 1989). This flow rate reflects the 1985-1989 drought conditions that affected the southeastern portion of the United States. During this drought, the Corps of Engineers maintained minimum flows in the Savannah River by releasing water from the Strom Thurmond Reservoir, which is approximately 105 river kilometers upstream of SRS. Low-flow tests conducted during 1980-1981 by the Corps of Engineers established that the minimum Savannah River flows required at SRS to operate two or three of the existing production reactors are 117 and $140 \text{ m}^3/\text{s}$, respectively. To meet the water requirements for SRS operations, water quality maintenance, and management of fish and wildlife resources, the Corps of Engineers plans to maintain a minimum release of $101 \text{ m}^3/\text{s}$ from the Strom Thurmond Reservoir (DOE-10).

The Savannah River Swamp lies in the floodplain along the Savannah River for a distance of about 16 km on the SRS; the swamp averages about 2.4 km wide. A natural levee has built up along the river adjacent to the swamp. Water discharges to the Savannah River through breaches in the levee during flooding of the swamp.

Surface water draining from the NPR site flows into either Fourmile Branch or Pen Branch. Fourmile Branch is the first perennial stream northwest of the NPR site. It discharges to the Savannah River through the swamp bordering the river. Flow in Fourmile Branch averaged $1.20 \text{ m}^3/\text{s}$ from 1986 through 1989 (Bennett et al. 1986, 1987, 1988, 1989). Groundwater discharges into Fourmile Branch downgradient of seepage basins in F and H areas of SRS. Until June 1985, large volumes of cooling water from C Reactor were discharged to Fourmile Branch through C Canal. Flows during that period were higher than in subsequent years.

Pen Branch is the first perennial stream southeast of the NPR site. Pen Branch discharges to the swamp bordering the Savannah River. The discharge of Pen Branch ranges from 0.10 to $0.3 \text{ m}^3/\text{s}$. During water years 1985-1988, cooling water from K Reactor was released to Pen Branch, and as a result, stream discharge averaged $8.24 \text{ m}^3/\text{s}$ at SRS road A-13.2 (DOE-10).

Surface Water Quality

Water from the Savannah River is routinely analyzed for both radioactive and nonradioactive constituents. The concentrations measured upstream and downstream of SRS in 1988 are listed in Tables F.16 and F.17; sampling locations are shown in Figures F.4 and F.5. Tritium levels were higher downstream of SRS than upstream; however, levels of tritium and gross alpha radioactivity in samples of Savannah River water both upstream and downstream of SRS were below National Drinking Water Standards. The South Carolina Department of Health and Environmental Control (SCDHEC) classified the Savannah River adjacent to SRS as a Class B stream under the South Carolina Water Classifications and Standards (SCDHEC-1). These regulations broadly define Class B waters as suitable for secondary-contact recreation (e.g., fishing, boating, and wading) and as a source of drinking water after conventional treatment in accordance with SCDHEC regulatory requirements.

Many factors affect water quality in the Savannah River, including operation of Thurmond Reservoir, discharge of treated municipal wastewater to the river (which causes nutrient loading and increased oxygen demand), and industrialization of the river basin in the metropolitan Augusta area (DOE-19). In addition, SRS discharges wastewater into the Savannah River via on-site tributaries under NPDES Permit No. SC0000175. These discharges consist

primarily of heated water (thermal effluents) from reactor operations, domestic and industrial wastes, and treated wastewater from groundwater cleanup activities (Lower 1985).

All on-site tributaries of the Savannah River must meet the water quality standards of a Class B Stream according to SCDHEC requirements. Routine analyses of samples taken since 1973 from on-site stream locations indicate that SRS discharges have complied with Class B water classification standards, with the exception of streams receiving thermal discharges. In these streams, temperature and dissolved oxygen standards are sometimes violated (Lower 1985). The concentrations of constituents for Fourmile Branch in 1988 are given in Table F.18. Near the proposed NPR site, Fourmile Branch receives discharges from the Central Shops Area, including storm water, air conditioning condensate, sewage, and auto shop effluents. Before C Reactor was shut down in 1985, Fourmile Branch received effluents from that reactor (Table F.19).

Floodplain

The 100-year floodplain for the Savannah River and its tributaries that drain SRS (Figure 4.3.3-1) was compiled from U.S. Geological Survey quadrangle maps (DOE-10). The proposed NPR site at SRS is outside of the 100-year floodplain of the Savannah River, Fourmile Branch, and Pen Branch.

Surface Water Use

At SRS, Savannah River water is used mainly for reactor cooling. Currently the C, K, L, and P reactors and the D Area powerhouse on SRS are not operating; however, during their past operations, the SRS average withdrawal rate from the Savannah River was approximately 38 m³/s (1.2 billion m³/yr). Most of the water withdrawn is returned to the Savannah River through on-site tributaries. Total consumptive water use was approximately 3.5 m³/s (110 million m³/yr) (Hubbard et al. 1988; DOE-18). Additional Savannah River water users near SRS include Vogtle Electrical Generating Plant (Figure 4.3.3-1) and the Urquhart Steam-Generating Station at Beech Island near Augusta, Georgia. Jointly, these plants withdraw about 10 m³/s (320 million m³/yr) and return about 8.2 m³/s (260 million m³/yr), consuming about 1.9 m³/s (60 million m³/yr) (NRC-4; DOE-18).

Upstream from SRS, the Savannah River supplies municipal water for Augusta, Georgia, and North Augusta, South Carolina (DOE-20). Downstream, the Beaufort-Jasper Water Authority in South Carolina withdraws about 0.23 m³/s (7.2 million m³/yr) to supply a population of about 51,000 persons. By the year 2000, Beaufort-Jasper plans to supply domestic water to 177,000 persons. The Cherokee Hill water treatment plant at Port Wentworth, Georgia, withdraws about 1.3 m³/s (42 million m³/yr) and plans to supply a domestic equivalent of 200,000 persons in the future.

Water Rights

Surface water rights for the Savannah River are determined by the Doctrine of Riparian Rights. Under this doctrine, users of water must not adversely impact the quantity or quality of water available for downstream users.

4.3.3.2 Groundwater

Description

Three groundwater systems underlie SRS and are distinguished by the geologic setting of the systems. Coastal Plain sediments at SRS, consisting of sands, clays, and minor calcareous units, contain the most important regional aquifers. Groundwater systems in crystalline metamorphic rocks beneath the Coastal Plain sediments and in the Triassic sediments in the Dunbarton Basin are not regionally productive (WSRC-8). The following discussion is limited to the aquifers in the Coastal Plain sediments.

In the Coastal Plain sediments, four water-bearing units are designated as Aquifers 1 (deepest) through 4 (shallowest), and two confining units are designated as Aquitards 1 and 2 (Geotrans 1989; Looney-1). Figure F.6 shows the relationship between the hydrologic and stratigraphic units discussed in this document. Aquifer 1 and 2 overlie a non-water-bearing unit, the Basal Confining Unit, consisting of clay layers and semiconsolidated clayey, silty sands. Aquifers 1 and 2 are the principal groundwater sources at SRS. These two sand units have a combined thickness of about 140 m. They are separated by a clay layer referred to as Aquitard 1. Industrial wells in the surrounding area commonly yield more than 0.05 m³/s from these confined aquifers. Aquifers 1 and 2 are recharged in off-site outcrop areas in Aiken County and through the overlying sediments northwest of Upper Three Runs Creek. The natural flow in these aquifers is southwest toward discharge points in the wetlands along the Savannah River.

Aquitard 2 overlies and confines Aquifer 2 and consists of a 15-m-thick section of clay interbedded with sand. Hydrological properties and head differences between subsurface zones indicate that Aquitard 2 may form the principal confining zone beneath SRS. In the central portion of SRS, the hydraulic heads in Aquifers 1 and 2 (below Aquitard 2) are higher than those in Aquifer 3 (head reversal). These potentiometric differences persist in spite of the fact that the deeper aquifers are offset along the Pen Branch fault. The difference in potentiometric surfaces between Aquifers 2 and 3 is shown in Figure 4.3.3-2. In this area, this condition of head reversal prevents water from Aquifer 3 from flowing down into Aquifer 2 and thus prevents any contaminants that may be in the water in Aquifer 3 from getting into Aquifer 2. The location of the no-head-difference boundary varies in response to changes in recharge and pumping conditions.

Aquifer 3 is a sandy unit confined above by a clay layer locally known as the green clay. Aquifer 3 is recharged in off-site outcrop areas and by seepage from overlying on-site formations. Natural flow directions in this aquifer are from recharge areas toward discharge points at the wetlands along Upper Three Runs Creek and the Savannah River.

The green clay separating Aquifers 3 and 4 has a low permeability. Although discontinuous in the northwest part of SRS, it thickens toward the southeast and is continuous over most of SRS. In many areas it supports a head differential between Aquifers 3 and 4.

Aquifer 4 consists of fine to coarse sands and sandy clays in the upper portion and varies from a very fine to medium well-sorted sand to a calcareous unit in the lower portion. Aquifer 4 is unconfined. The depth to the water table varies from 10 to 23 m below the land

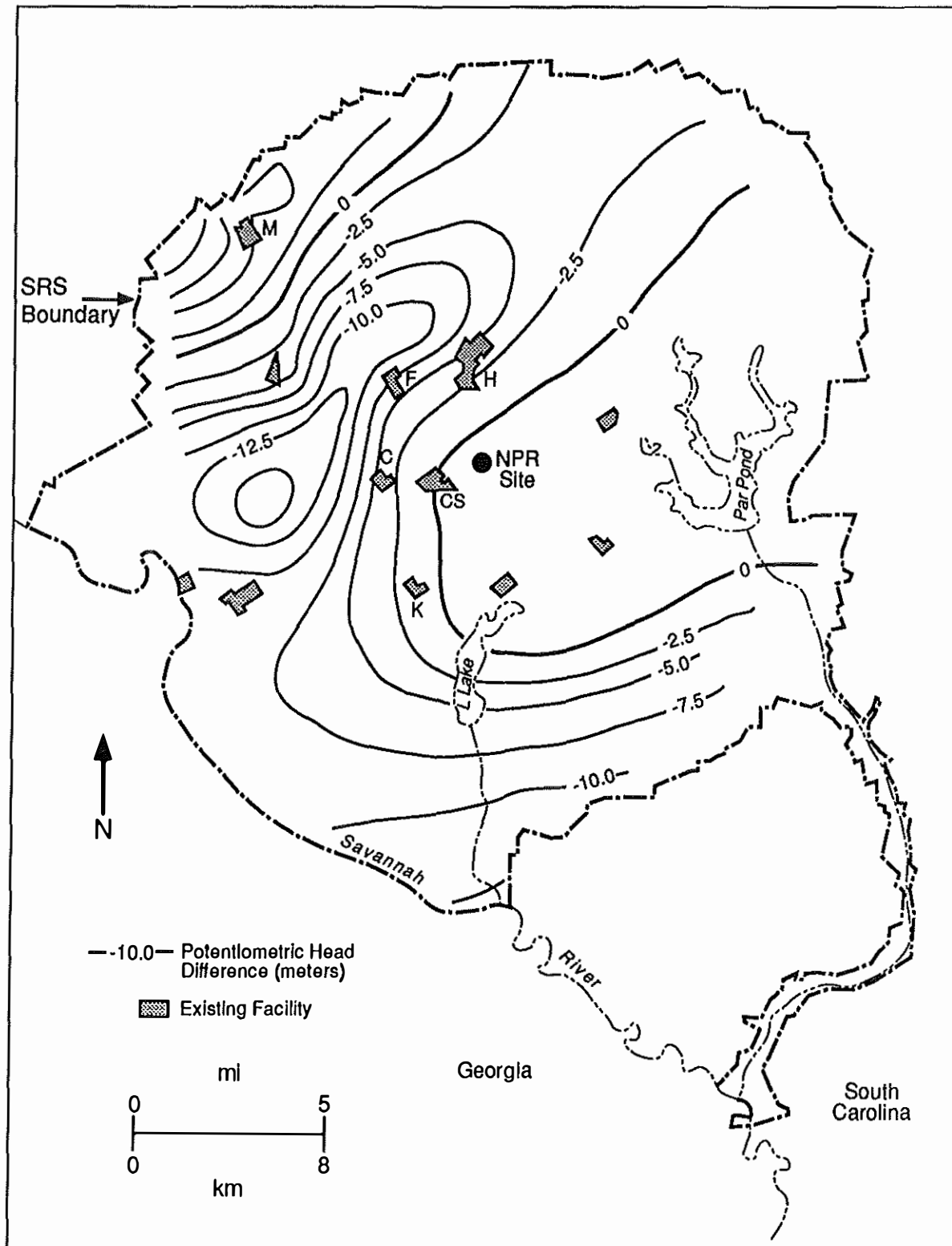


FIGURE 4.3.3-2 Potentiometric Head Difference between Aquifers 2 and 3 at SRS in 1988 (Aquifer 3-Aquifer 2) (Source: Modified from Looney-1)

surface at the NPR site, depending on the well location and climatic conditions (WSRC-9). Perched groundwater was encountered 2 m below the ground surface in one of the six observation wells drilled to characterize the subsurface of the NPR site. Aquifer 4 is recharged by infiltrating precipitation, which moves through the overlying sediments at about 0.9-2.1 m/yr (Haskell and Hawkins 1964). Flow paths are short and locally controlled by small streams. Natural discharge from Aquifer 4 is to perennial streams, such as Pen Branch and Fourmile Branch, and to Aquifer 3. Hubbard and Emslie (1984) estimated that the sitewide annual recharge to Aquifer 4 is about 0.38 m/yr; annual groundwater discharge from Aquifer 4 to surface water streams is about 0.13 m/yr; and annual groundwater seepage to the lower units is 0.25 m/yr.

Aquifers 3 and 4 provide water to much of the rural population surrounding the SRS. Because the high clay content of Aquifer 4 restricts the production capacity of wells, this unit supports only low-production domestic wells (Scott et al.-3; Root 1983; Christensen and Gordon 1983). Wells in these units are capable of yielding 0.02 m³/s.

The hydraulic conductivity values for the Coastal Plain sediments beneath SRS vary through space within a geologic formation and vary with the direction of measurement at any given point in a geologic formation. Table F.21 lists values of hydraulic properties at SRS.

Groundwater Quality

Groundwater data have been obtained from SRS monitoring wells for the past several years (Christensen and Gordon 1983; Zeigler, Lawrimore, and Heath 1986; Zeigler et al. 1987; and DOE-18). Groundwater quality at SRS ranges from good to extremely poor. Aquifer 1 has not been shown to be degraded by SRS operations. On the other hand, water quality in parts of Aquifers 4 and 3 has significantly deteriorated because of infiltration of radioactive and hazardous contaminants from the F, H, and M area seepage basins (DOE-18; WSRC-16). Recent groundwater monitoring data for radioactive constituents for the SRS are summarized in Appendix F, Table F.22. Radionuclide concentrations in SRS groundwater range from below detection limits to 7 billion pCi/L, 140,000 pCi/L, and 2,400 pCi/L for tritium, strontium-89 and -90, and chromium-51, respectively. Results of groundwater quality measurements and comparison with applicable standards or criteria for selected quality parameters are presented in Table F.23. In the vicinity of the proposed NPR site, no groundwater contamination due to SRS activities has been reported.

Groundwater Use

The SRS is one of 56 major municipal, industrial, and agricultural groundwater users identified within 32 km of the center of SRS. The total pumpage for these 56 users averages about 1.56 m³/s (49 million m³/yr) (DOE-10). Table F.24 summarizes groundwater use at SRS and the surrounding communities. Groundwater use at SRS totals 0.48 m³/s (15 million m³/yr), which represents about 31% of the total groundwater used in the area (GeoTrans 1989).

Groundwater Rights

Groundwater rights in South Carolina are traditionally associated with property ownership. The South Carolina Water Resources Commission (SCWRC) requires groundwater users pumping more than 0.0044 m³/s (140,000 m³/yr) to report their withdrawal rates (Hubbard et al. 1988). SRS groundwater use exceeds this value, and SRS reports its withdrawal rates to SCWRC.

4.3.4 Land Use, Recreation, and Visual Environment

The Savannah River Site is owned by the Federal government and operated for DOE by the Westinghouse Savannah River Company in conjunction with Westinghouse/Bechtel Savannah River Company-Construction, the University of Georgia's Savannah River Ecology Laboratory, the U.S. Forest Service, and the University of South Carolina's Savannah River Archaeological Research Program.

Developed areas represent about 5% of the total land area at SRS (Figure 4.3.4-1). The SRS was designated as a National Environmental Research Park in 1972. Most of the land area at SRS is heavily wooded. Except for direct line-of-sight views of industrial facilities, visible when approaching the facilities from SRS access roads, views on SRS are limited by heavily wooded areas bordering the SRS road system and public roads and highways that cross the area.

The proposed NPR site consists of forested land typical of the undeveloped portions of SRS. The support facilities would be sited adjacent to existing industrial areas.

All SRS activities affecting land use are managed and controlled through a formal project review system based on the SRS Site Development and Utilization Plan (SR Order No. 430X.1, 1983), and by the Savannah River Land Use Committee. When appropriate, the South Carolina Department of Wildlife and Marine Resources and the U.S. Forest Service participate in the review process. By interagency agreement with DOE, the U.S. Forest Service's Savannah River Forest Station manages the forested areas of SRS and is responsible for matters related to threatened and endangered species. The forest station projects more than \$2 million in revenues during 1990 from logging operations on SRS. Wetland and floodplain matters are managed through the Site Development and Utilization Plan process.

Land use patterns in the six-county region surrounding SRS are relatively stable, consisting of about 47% forest, 37% agriculture, 3% urban, and 3% wetland/water, with the remaining 10% used by SRS (NUS-1). The urban areas where SRS workers reside include the cities of Augusta, Georgia; Aiken, North Augusta, and Barnwell, South Carolina; and several smaller communities in the immediate area.

The area around SRS has a variety of public and private recreational facilities. Federal outdoor recreational facilities include portions of the Sumter National Forest, the Santee National Wildlife Refuge, and J. Strom Thurmond Lake. The six-county area contains five state parks, all of which offer water-based recreation, camping, hiking, and rental cabins or cottages. Generally, county and local parks are located in or near urban areas; most are associated with neighborhood schools. The area also contains public and private tennis courts, golf courses (including Augusta National), bowling centers, public and private swimming pools, and numerous campsites in state and Federal parks. Aiken County's private recreational facilities include nine golf courses, five polo fields, and three equine training facilities.

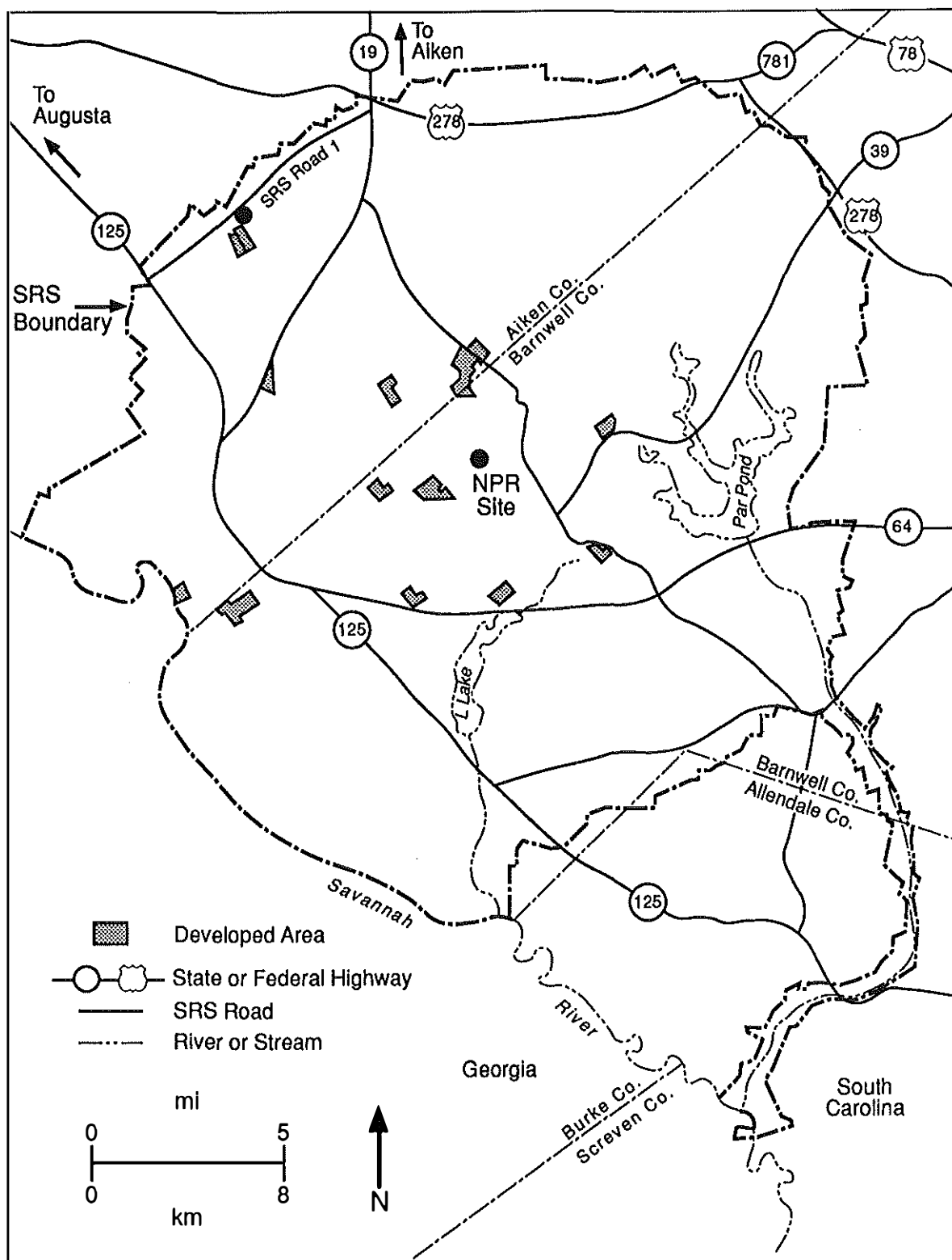


FIGURE 4.3.4-1 Land Use Features at SRS (Source: Modified from NUS-1)

4.3.5 Biotic Resources

This section describes the biotic resources of SRS, with emphasis on those components that could be affected by the construction and operation of an NPR. A more detailed description of these resources and lists of the common and scientific names of plant and animal species occurring there are presented in Appendix G, Section G.3. Additional descriptions of the ecology of SRS are provided by Dukes (1984) and Wike et al. (1989).

4.3.5.1 Terrestrial Resources

The SRS was approximately one-third forested and two-thirds cropland when it was acquired by the Federal government in 1951. Today, about 90% of the site is forested as a result of natural succession and intensive forestry practices, with about 5% occupied by nuclear production and support facilities.

The SRS is in an area that divides two major forest associations -- the oak-hickory-pine forest and the southern mixed forest (Kuchler 1964). Consequently, species typical of both forest types occur on the site (DOE-9), and more than 1,300 species and varieties of vascular plants have been identified (Batson, Angerman, and Jones 1985). Common plant species are listed in Table G.5. Six major plant communities have been described for SRS (Figure 4.3.5-1) (Workman and McLeod 1990). Sandhill and upland hardwood communities dominated by oak and hickory are found in upland areas (Wike et al. 1989). On much of SRS, these communities have been displaced by pine plantations managed by the U.S. Forest Service. Bottomland hardwood forests are common in the moist soils along streams and are characterized by a more diverse plant community dominated by tulip poplar, birch, sweet gum, willow oak, water oak, and loblolly pine.

The diversity and abundance of wildlife on SRS reflect the interspersed and heterogeneity of the plant community of the site. Because of its mild climate and variety of aquatic and terrestrial habitats, SRS supports 43 amphibian, 51 reptile, 213 bird, and 48 mammal species (Wike et al. 1989). Common animal species are listed in Appendix G (Table G.5).

The SRS supports populations of game species, and DOE allows controlled hunts for white-tailed deer and feral hogs. Upland game birds, such as bobwhite and mourning dove, are common permanent residents of the site (Wike et al. 1989). Waterfowl occur mainly as winter migrants, although the wood duck is a common resident during the breeding season, especially within the Savannah River Swamp. From 11,000 to 17,000 ducks and coots winter on SRS; most congregate on Par Pond, L Lake, and on other large ponds and Carolina bays.

Reconnaissance surveys and analysis of aerial photographs indicate that pine plantations account for about 72% of the plant cover on the NPR site. These plantations are dominated by slash pine and loblolly pine ranging in age from new plantings to immature trees. Other vegetation types on the NPR site include old-field (10%), bottomland hardwood forest (5%), upland deciduous forest (7%), and grassland (6%). The NPR site has not been surveyed to determine the relative abundance of plant and animal species within these habitats.

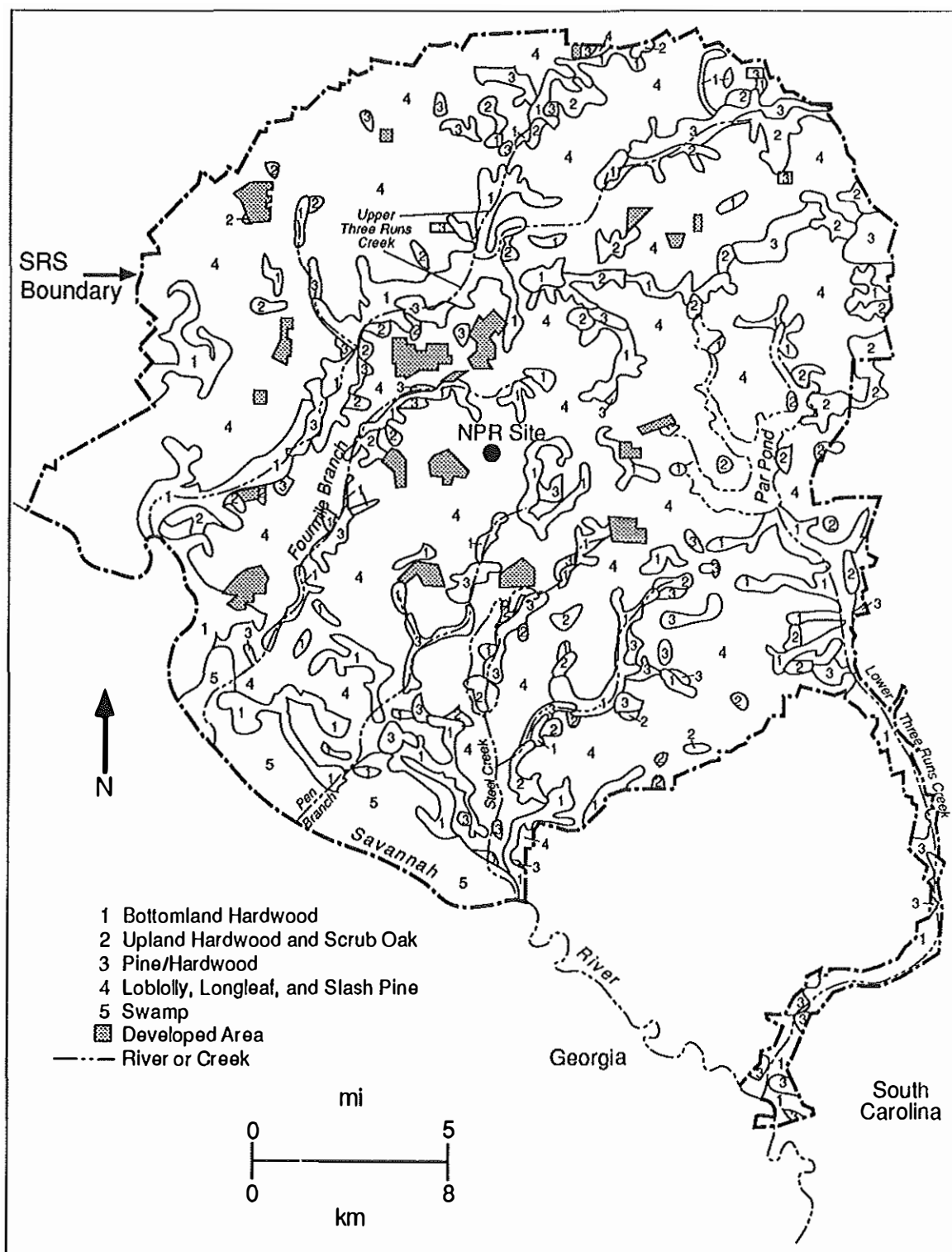


FIGURE 4.3.5-1 Distribution of Major Plant Communities on SRS (Sources: McCort and Wein 1988; Workman and McLeod 1990)

4.3.5.2 Wetlands

The SRS contains approximately 17,400 ha of wetlands, most of which are associated with floodplains, streams, and impoundments (Wike et al. 1989). The most extensive wetland type on SRS is swamp forest associated with the Savannah River floodplain (Figure 4.3.5-1). These wetlands occupy approximately 3,800 ha on SRS and are dominated by bald cypress and water tupelo in areas that have not been affected by past discharges of cooling water effluent (Wike et al. 1989). Releases of cooling water effluent have caused several changes in plant communities of the swamp. These changes are discussed in greater detail in Wike et al. (1989) and are summarized below in Section 4.3.5.3.

Approximately 190 Carolina bays occur on SRS (Shields et al. 1982; Schalles et al. 1989). Carolina bays are unique wetlands of the southeastern United States. These wetlands are natural shallow depressions, generally elliptical in shape, and are not associated with streams (Schalles et al. 1989). At SRS, they are located throughout upland areas, exhibit variable hydrologic regimes, and support a range of plant communities, from marsh to forested wetland (McCort and Wein 1988; Schalles et al. 1989).

Several areas of wetlands that meet Federal jurisdictional requirements (Federal Interagency Committee for Wetland Delineation 1989) exist on or immediately adjacent to the NPR site (Figure 4.3.5-2). Within the site, two areas of forested wetlands (5.9 ha total) are associated with intermittent streams that drain the site. Rainbow Bay, a 2.2-ha wetland, is located just outside of the NPR site boundary toward the northeast. Rainbow Bay supports a variety of amphibian species that have been the subject of a number of ecological studies (Wike et al. 1989). The bay is located within a slash pine/loblolly pine plantation and is fringed with hardwoods such as sweetgum, black gum, and water oak (Semlitsch 1986). Because of drought conditions during recent years, Rainbow Bay has not contained standing water year-round.

About 770 ha of wetlands occur in the floodplain of Fourmile Branch, the stream that would receive cooling water effluent from an NPR via Castor Creek. Most of these wetlands (72%) are bottomland hardwoods (DOE-20). Before 1985, Fourmile Branch received heated water (up to 70°C) from C Reactor operations. This effluent produced water temperatures in excess of 60°C in Fourmile Branch downstream of the outfall. Because of these discharges, open water and marsh have replaced the original bottomland hardwood forest community. Tag alder and wax myrtle currently dominate riparian areas, and thick growths of emergent vegetation, such as sedges and cutgrass, dominate the marshlike area of the stream's delta within the Savannah River Swamp. Overall, approximately 60% of Fourmile Branch wetlands have been destroyed or modified by discharges of liquid effluents from C Reactor. Recovery of wetlands along this stream are being monitored by DOE.

4.3.5.3 Aquatic Resources

Major aquatic habitat types that occur on SRS include small ponds, Carolina bays, reservoirs, streams, and the Savannah River (Figure 4.3.5-1). The surface areas of these waters vary from less than 0.4 ha to about 1,090 ha (Shields et al. 1982). The Savannah River and its associated swamp and tributaries exhibit a diverse fish fauna typical of other southeastern coastal plain rivers and streams (Bennett and McFarlane 1983). Aquatic habitat on the NPR site at SRS is limited to small intermittent streams and Rainbow Bay.

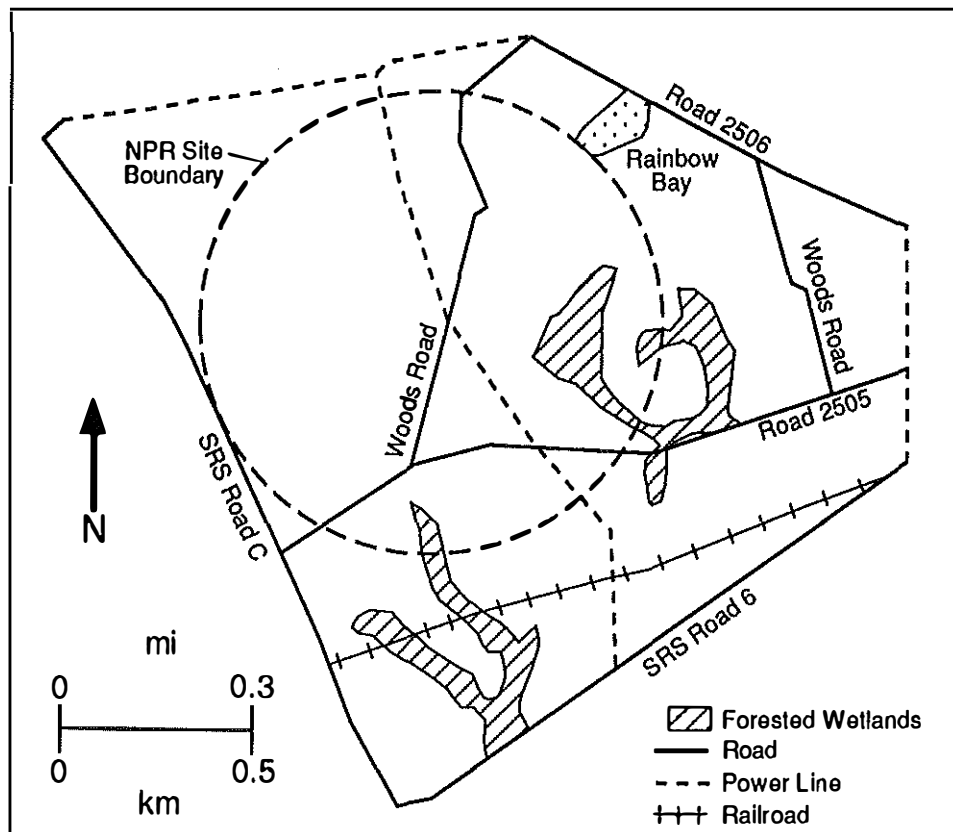


FIGURE 4.3.5-2 Wetlands on and Adjacent to the NPR Site at SRS (Sources: Banker 1989; NUS 1990)

Aquatic vegetation is greatly reduced in SRS streams that have received thermal effluents (du Pont-1) because of the high water flows and elevated temperatures associated with reactor operations. Thermal gradients in these streams have ranged from 70°C (too hot for most organisms) to near ambient temperatures (8°C to 24°C) where the water enters the Savannah River. In the past, reactor effluent increased stream flows to between 10 and 20 times the normal flow. Such flows have broadened and eroded the streambeds, eliminated rooted aquatic plants and most of the trees along the stream, and caused deposition of silt along the bank and in the stream deltas. Streams that received thermal effluent exhibit markedly reduced macroinvertebrate and fish communities (in terms both of the number of species and the abundance of fish).

Fourmile Branch, which would receive effluents from the NPR, is about 24 km long and drains an area of about 89 km². Flows in the stream now average 1.2 m³/s (range of 0.3 to 9.3 m³/s) (Section 4.3.3). In its upper reaches, Fourmile Branch is a small blackwater stream that has been relatively unaffected by past SRS operations (Wike et al. 1989). Below its confluence with Castor Creek, Fourmile Branch is recovering following shutdown of C Reactor in 1985. Before that year, C Reactor discharged cooling water effluent to Fourmile Branch at a rate of 11 m³/s, with temperatures up to 70°C. These discharges changed the creek from a single-channel meandering stream to a wide, multichannel, braided stream system flowing within denuded floodplains (DOE-20). Discharges have reduced habitat diversity, macroinvertebrate

abundance, macroinvertebrate diversity, fish abundance, and fish diversity (DOE-20). Sampling during periods of reactor shutdown indicated that mosquitofish were the most common fish species (97%) in the upper reaches of Fourmile Branch below the C Reactor outfall. Other species in this part of the stream included bowfin, sunfish, and mudminnows (DOE-20). Below the delta of the stream, a more diverse assemblage of fish was collected. That assemblage was dominated by gizzard shad and largemouth bass.

Fish have been entrained and impinged by the withdrawal of Savannah River water for SRS operations (Wike et al. 1989; DOE-20). Because of their presence in the water column, fish species that have planktonic eggs and larvae (ichthyoplankton) are most susceptible to entrainment losses. From 1983 to 1985, the amount of ichthyoplankton entrained by all SRS water intake structures ranged from 7.0% to 12.2% of the total estimated ichthyoplankton present in the portion of the Savannah River adjacent to SRS (DOE-10). Fish larvae entrained during this period were predominantly shad, crappie, and suckers (Wike et al. 1989). Eggs of the American shad and striped bass dominated entrainment samples and represented about 50% and 23% of the total eggs entrained, respectively. Despite these losses, no evidence exists that the species entrained by SRS intakes are declining in the middle reach of the river (Wike et al. 1989).

Larger fish are susceptible to impingement on intake screens during water withdrawals. Impingement losses were monitored from 1983 to 1985 at the three SRS intake structures, and average annual impingement was estimated at 7,600 fish (Wike et al. 1989). Bluespotted sunfish and threadfin shad were the most commonly impinged species. Other commonly impinged species included gizzard shad, redbreast sunfish, and warmouth.

4.3.5.4 Threatened and Endangered Species

Federally and state-listed threatened and endangered species that occur on SRS and vicinity are listed and discussed in Appendix G, Section G.3 and Table G.6. Twenty-two of these species are known to occur in areas that could be affected by an NPR, and 15 more species could occur in these areas (Table 4.3.5-1). The remaining 31 species, including the Federally listed Piedmont bishop-weed, relict trillium, brother spike mussel, red-cockaded woodpecker, and peregrine falcon, have not been observed on the NPR site or affected areas, and, based on habitat requirements, are not likely to occur there. No critical habitat for threatened or endangered species, as defined in the Endangered Species Act, exists on SRS (50 CFR 17.11 and 17.12).

The bald eagle, wood stork, shortnose sturgeon, and American alligator are the only Federally listed species that occur on the NPR site or affected areas (Knox and Sharitz 1988; Wike et al. 1989). Bald eagles (endangered) have been observed at several locations on SRS, particularly in the vicinity of Par Pond and L Lake (Wike et al. 1989). An active bald eagle nest is located about 7 km from the NPR site in an area of Pen Branch, which drains the NPR site. Wood storks (endangered) forage on SRS within the Savannah River Swamp and have been observed near the Fourmile Branch delta approximately 14 km from the NPR site. Effluent from NPR cooling towers would be released to this area (Wike et al. 1989; DOE-20). American alligators (threatened) are common inhabitants of Par Pond, Beaver Dam Creek, and the Savannah River Swamp, all 8 km or more from the NPR site. No self-sustaining reproducing populations of the alligator have been observed in Fourmile Branch or its delta (DOE-20). Shortnose sturgeon spawn upstream of SRS, and four larvae of this species have been collected in or near the water intake canals on the Savannah River, 12 km from the NPR site (Wike et al. 1989). Entrainment or impingement of this species at SRS water intake structures has not been documented (Wike et al. 1989).

TABLE 4.3.5-1 Threatened and Endangered Species that Could Be Found in the Vicinity of NPR Facilities on SRS

Species	Status ^a		Habitat and Status on NPR Site and Other Areas Affected by NPR
	Federal	State	
Plants			
Yellow wild indigo	NL	R	Pine forests and open woods of SRS; potentially suitable habitat present on NPR site
Cypress stump sedge	C2	R	Savannah River Swamp in area that would receive NPR discharge
Elliott’s croton	C2	R	Carolina bays of SRS; potentially suitable habitat at Rainbow Bay adjacent to NPR site
Smooth purple cone-flower	C2	T	Open woodlands and road banks of SRS; potentially suitable habitat present on NPR site
Little bur-head	NL	T	Carolina bays of SRS; potentially suitable habitat at Rainbow Bay adjacent to NPR site
Gaura	NL	R	Streambanks, meadows, and roadsides of SRS; potentially suitable habitat present on NPR site
Swamp lobelia	C2	NL	Carolina bays of SRS; potentially suitable habitat at Rainbow Bay adjacent to NPR site
Florida false loosestrife	NL	R	Carolina bays; known to occur at Rainbow Bay adjacent to NPR site
Nestronia	C2	NL	Upland hardwoods; potentially suitable habitat present on NPR site
Nailwort	NL	R	Pine forests; potentially suitable habitat present on NPR site
Green-fringed orchid	NL	T	Carolina bays and bottomland hardwoods; known to occur at Rainbow Bay adjacent to the NPR site
Awned meadow-beauty	C2	R	Carolina bays; potentially suitable habitat at Rainbow Bay adjacent to the NPR site
Beak-rush (<i>Rhynchospora inundata</i>)	NL	R	Carolina bays; potentially suitable habitat at Rainbow Bay adjacent to the NPR site

TABLE 4.3.5-1 (Cont'd)

Species	Status ^a		Habitat and Status on NPR Site and Other Areas Affected by NPR
	Federal	State	
Plants (Cont'd)			
Beak-rush (<i>Rhynchospora tracyi</i>)	NL	R	Carolina bays; potentially suitable habitat at Rainbow Bay adjacent to the NPR site
Yellow cress	NL	R	Bottomland hardwoods; potentially suitable habitat present on the NPR site
Quill-leaved swamp potato	NL	T	Carolina bays; potentially suitable habitat at Rainbow Bay adjacent to the NPR site
Trecocarpus	NL	R	Bottomland hardwoods; potentially suitable habitat present on the NPR sitels
Fishes			
Shortnose sturgeon	E	E	SRS reach of the Savannah River
Atlantic sturgeon	NL	T	SRS reach of the Savannah River
Bighead redhorse	C2	NL	SRS reach of the Savannah River
Blueback herring	NL	SC	SRS reach of the Savannah River and Savannah River Swamp in area that would receive NPR discharge
Hickory shad	NL	SC	SRS reach of the Savannah River and Savannah River Swamp in area that would receive NPR discharge
American shad	NL	SC	SRS reach of the Savannah River and Savannah River Swamp in area that would receive NPR discharge
Amphibians and Reptiles			
Eastern tiger salamander	NL	SC	Savannah River Swamp in area that would receive NPR discharge; also known to occur at Rainbow Bay adjacent to the NPR site
Carolina crawfish frog	C2	NL	Gopher tortoise and crawfish burrows
Pig frog	NL	SC	Savannah River Swamp in area that would receive NPR discharge
Pickerel frog	NL	SC	Savannah River Swamp in area that would receive NPR discharge

TABLE 4.3.5-1 (Cont'd)

Species	Status ^a		Habitat and Status on NPR Site and Other Areas Affected by NPR
	Federal	State	
American alligator	T	NL	Savannah River Swamp in area that would receive NPR discharge
Eastern slender glass lizard	NL	SC	Savannah River Swamp in area that would receive NPR discharge; also known to occur at Rainbow Bay adjacent to the NPR site
Smooth earth snake	NL	SC	Known to occur at Rainbow Bay adjacent to the NPR site
Birds			
Wood stork	E	E	Savannah River Swamp in area that would receive NPR discharge
Cooper's hawk	NL	T	Known to occur at Rainbow Bay adjacent to the NPR site
Bald eagle	E	E	Active nest on area of Pen Branch that receives runoff from the NPR site
Great-horned owl	NL	SC	Known to occur at Rainbow Bay adjacent to the NPR site
Mammals			
Star-nosed mole	NL	SC	Known to occur at Rainbow Bay adjacent to the NPR site
Bobcat	NL	SC	Savannah River Swamp in area that would receive NPR discharge
River otter	NL	SC	Savannah River Swamp in area that would receive NPR discharge

^aStatus: C2 = Category 2; E = endangered; NL = not listed; R = rare; SC = special concern; T = threatened.

Sources: Modified from McCort and Wein 1988; Wike et al. 1989; Knox and Sharitz 1990.

Cypress stump sedge and bighead redhorse, both candidates for listing by the Federal government (Category 2 species), are known to occur in the Savannah River swamp and the SRS reach of the Savannah River where NPR discharge would be released and, in the latter case, where water would be withdrawn for NPR operations. Six other Category 2 species could occur in areas affected by an NPR, but they have not been documented at these sites (Table 4.3.5-1). Category 2 species do not receive legal protection under the Endangered Species Act, but the FWS recommends that impacts to these species be considered in project planning.

Thirty-two state-listed species could occur in areas that would be affected by an NPR (Table 4.3.5-1). Seven of these species also are listed by the Federal government. Of those state-listed species not listed by the Federal government, 16 are known to occur in project areas, and the remaining 9 species could occur there but have not been documented in those areas. State-listed species do not receive legal protection, but are considered here because of their regional importance.

4.3.6 Cultural Resources

Field studies conducted during the past two decades have documented numerous archaeological and historical resources on SRS. Two surveys have been conducted for cultural resources within the proposed NPR site (Hanson and Brooks 1978; Brooks et al. 1989). The latter study located, recorded, and evaluated 16 archaeological sites, 3 of which have been determined eligible for the National Register of Historic Places (NRHP). Consultations with potentially affected Native American groups have been initiated by DOE.

4.3.6.1 Regional Prehistory, History, and Ethnography

As elsewhere in North America, prehistoric settlement of the region began in the Paleoindian period (12,000-9,000 years before present [B.P.]). The distribution of Early and Middle Archaic sites (9,900-5,000 B.P.) suggests a foraging economy based on a wide range of habitats and resources. The Late Archaic (5,000-3,000 B.P.) and the Early and Middle Woodland periods (3,000-1,500 B.P.) are characterized by the development of various pottery types. The shift to an agricultural economy occurred in the Late Woodland and Mississippian periods (1,500-450 B.P.), but a general abandonment of the Savannah River Valley apparently took place after A.D. 1450 (Anderson and Hanson 1988; Coe 1964; Williams and Stoltman 1965).

The earliest European exploration of the area was undertaken in the mid-1500s by DeSoto, who encountered no native inhabitants (DePratter 1987). By the late 1600s, English traders had penetrated the region, but permanent historic occupation did not begin until the establishment of Fort Moore (ca. 1717) during the Yamasee Indian War (1715-1718). Early historic settlement was dominated by soldiers, traders, and cattlemen. Subsequent historic land use followed a trend from small farm to large farm-plantation to small farm that was common throughout the Southeast from 1750 to 1900. During the early 1800s, remaining Native Americans residing in the middle Savannah River Valley (i.e., Cherokee and Creek) were relocated westward.

4.3.6.2 Archaeological Sites and Historic Structures

An extensive archaeological survey program began at SRS in 1974. This program, which was developed in consultation with the South Carolina State Historic Preservation Officer (SHPO), included inspection of the Statewide Site Inventory Record, a historic literature and document review, and field studies (reconnaissance survey, shovel test transects, and intensive testing within archaeological sites). Approximately 50% of the 800-km² area of SRS has been examined to date (Brooks 1988; Brooks and Hanson 1987; Hanson and Brooks 1978; Hanson, Most, and Anderson 1978). Collectively, these studies identified 852 archaeological sites ranging in age from Clovis Paleoindian (ca. 11,500 B.P.) to 1950s farms. Most structures were demolished during the initial establishment of SRS.

The NPR site at SRS (approximately 214-251 ha) occupies an upland area characterized by limited topographic variability; the vegetation is predominately pine woodland with some open scrub. Archaeological investigations of the NPR site before 1989 consisted of an intensive survey in its eastern portion, associated with a proposed spent fuel storage facility and general surveys of the Fournile Branch and Pen Branch watersheds; four archaeological sites were recorded during these surveys (Hanson and Brooks 1978). During May-August 1989, the South Carolina Institute of Archaeology and Anthropology conducted surveys to inventory and evaluate all archaeological sites within the NPR site and adjacent areas; approximately 210 ha was surveyed (Brooks et al. 1989).

The field investigations included a reconnaissance survey, an intensive survey, and intensive site testing (Brooks et al. 1989). The reconnaissance survey began with relocation of the four previously discovered sites, and location of historic sites indicated on a 1951 aerial photograph. This survey was completed with surface inspection of road cuts, powerline and railroad corridors, and areas of ground surface exposure. The intensive survey entailed excavation of shovel tests (40 × 40 cm) along transects at 30-m intervals; 379 shovel tests were performed in high-probability areas, and 181 shovel tests were performed in low-probability areas. Sediment was excavated to a depth of 80-100 cm or to the sandy clay substrate, and sieved. All sites in the survey area were subjected to intensive site testing, which involved an additional 321 shovel tests and excavation of nine 1-m × 2-m units and two 1-m × 1-m units.

Sixteen archaeological sites, ranging in age from the Middle Archaic period to the twentieth century, are located within the NPR site (Brooks et al. 1989) (Appendix Q). Thirteen sites were determined by the South Carolina SHPO to lack sufficient archaeological content or contextual integrity to warrant eligibility for nomination to the NRHP. The remaining three sites (38BR522, 38BR619, and 38BR629) were determined eligible for the NRHP on the basis of their potential to yield important information on history [36 CFR 60.6(d)]. These sites represent the remains (structural remnants and associated debris) of small historic farmsteads of the nineteenth and twentieth centuries and will yield data about small yeomen and tenant farmers in the region following the Civil War (Brooks et al. 1989; Edmonds 1989).

4.3.6.3 Native American Cultural Resources

The DOE has implemented a comprehensive consultation process with Native American groups that may have historic religious association with SRS (including the NPR site) in accordance with the American Indian Religious Freedom Act. The consultations involve interviews with representatives from various groups affiliated with historical Native American

inhabitants of the Georgia and South Carolina areas. Among the groups that are being contacted are various Creek, Catawba, Cherokee, Shawnee, and Chickasaw entities. The Bureau of Indian Affairs, Branch of Acknowledgment and Research, provided listings of groups that currently are recognized or have petitioned for recognition. Literature reviews provide no evidence that any areas on SRS are of any concern to Native American groups. A summary report will be prepared after consultations with Native American representatives are completed.

4.3.6.4 Paleontological Resources

Invertebrate fossil remains occur within the McBean, Barnwell, and Congaree formations of the Eocene Age (54-39 million years ago) on SRS (Siple 1967). Relatively large quantities of marine invertebrate fossils have been recorded for the McBean (Utley Limestone and Dry Branch) Formation and the Barnwell (Tobacco Road) Formation. At the base of the Tobacco Road and Barnwell formations, researchers (Siple 1967; Dukes 1984) have recorded giant oyster (*Crassostrea gigantissima*) deposits at Shell Bluff (52 m mean sea level [MSL]) and Griffin's Landing (27 m MSL) in Georgia, and near Fourmile Branch (27 m MSL) and at Usserys Bluff on Lower Three Runs Creek (34 m MSL) at SRS. Relative assessment of fossil localities is difficult because the South Carolina Geological Survey has established no criteria for, or registry of, important paleontological locations. Nonetheless, the NPR site is more than 85 m MSL, well above any recorded exposures of paleontological materials at SRS.

4.3.7 Environmental Radiation Sources and Exposure

Major sources of radiation exposure to individuals in the vicinity of SRS are presented in Table 4.3.7-1. Routinely encountered sources of background radiation are radon in the environment, terrestrial radiation, cosmic radiation, and naturally occurring terrestrial radiation emitters internal to the body, e.g., potassium-40 -- resulting in a total dose of about 0.3 rem/yr (expressed as committed effective dose equivalent from 1 year of exposure) (NCRP-1). Based on a population of 560,000 within 80 km of SRS (1988 estimate), the total population dose from natural background is estimated to be about 200,000 person-rem/yr. The dose from 1 year of exposure to residual fallout from nuclear weapons testing is less than 0.001 rem/yr, which would add about 600 person-rem to the population dose (NCRP-1).

The dose to the population in 1988 within 80 km of SRS from site operations, not including operation of K, L, and P reactors but including operation of Georgia Power Company's Vogtle electric generating plant near the site, has been estimated to be 20 person-rem (Davis, Martin, and Todd 1989; DOE-10). The dose to the average off-site individual from these operations in 1988 was estimated to be 4×10^{-5} rem. The dose to the maximally exposed off-site individual dose in 1988 was estimated to be 0.001 rem (Davis, Martin, and Todd 1989; DOE-10).

The 1988 population dose outside of the 80-km area due to Savannah River water usage downstream from SRS has been calculated to be 6 person-rem (Davis, Martin, and Todd 1989). The doses to the average and maximally exposed off-site individuals resulting from this source were estimated to be about 7×10^{-5} rem and 1×10^{-4} rem, respectively, in 1988 (Davis, Martin, and Todd 1989).

TABLE 4.3.7-1 Major Sources of Radiation Exposure to Individuals in the Vicinity of SRS

Source of Exposure	Dose to Average Individual ^a (rem/yr)
Natural background ^b	
Inhaled radon and radon decay products ^c	0.2
External terrestrial radiation	0.03
Cosmic radiation	0.03
Internal terrestrial radiation	0.04
Fallout radiation ^d	<0.001
Site operations ^e	4×10^{-5}
Total ^f	0.3

^aCommitted effective dose equivalent from 1 year of exposure to radiation sources or site operations (see Appendix H, Section H.2, for an explanation of radiation dose units).

^bAverage dose per year of exposure for components, as estimated in NCRP-1.

^cThe inhaled radon and radon decay product dose varies widely with geographic location; the 0.2 rem/yr value represents the U.S. population average.

^dCalculated by dividing the 80-km population dose given by Davis, Martin, and Todel (1989) and DOE (DOE-10) by the 80-km population.

^eThis does not include operation of K, L, and P reactors, but does include Vogtle (see text for contribution from K, L, and P reactors).

^fThe total dose is not exactly 0.3 because the values have been rounded to one significant figure.

If K, L, and P reactors were operating, the doses to the maximally exposed off-site individual and the worst-sector population (in the year 2000) from all routine releases at the site and from the Vogtle electric generating plant near the site are estimated to be 1.3 mrem and 100 person-rem, respectively (DOE-10). The population within 80 km of the site and the populations in Beaufort and Jasper counties, South Carolina, and in Port Wentworth, Georgia -- who consume water from the Savannah River -- have been projected to the year 2020; with the population dose adjusted accordingly, the baseline population dose for the year 2020 is estimated to be 120 person-rem.

Applicable regulatory standards for radiological exposure from nuclear facilities are given in Section 5.2.7.1. These standards do not involve background dose; background doses are presented for comparative purposes only. The estimated contribution of the proposed NPR facilities to doses from site operations at SRS are given in Section 5.4.6.1. The SRS environmental monitoring program, which monitors the release of radioactive and nonradioactive hazardous materials, is identified in Section 3.5. Information on applicable safety criteria that could be used for NPR designs is included under project descriptions in Appendixes A, B, and C.

4.3.8 Socioeconomics

The *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site* (NUS-1) contains a comprehensive description of the socioeconomic and community characteristics (i.e., economic activity, population, housing, community services, fiscal structure, and quality of life) of the SRS area. The following sections summarize portions of that report.

A survey of SRS employees in May 1989 showed that 88% of them reside in the six counties surrounding SRS: Columbia and Richmond counties in Georgia, and Aiken, Allendale, Bamberg, and Barnwell counties in South Carolina. Approximately 62% of the work force lives in five cities in South Carolina (Aiken, Jackson, New Ellenton, North Augusta, and Barnwell) and one in Georgia (Augusta). The residences of the work force during construction and operation of the NPR and its associated facilities would likely be distributed in a pattern similar to the existing one; therefore, the six counties and six cities were chosen as the study area for assessing the potential socioeconomic effects associated with the NPR project. This study area is also referred to as the region of influence (ROI), or simply as the SRS region.

4.3.8.1 Employment and Income

In 1988, the six-county region had 194,000 persons in the work force, with 182,400 actually employed. The unemployment rate averaged about 6%, ranging from 7.2% in Bamberg County to 4.2% in Columbia County. Nonfarm employment in the region is concentrated in the services, government, and manufacturing sectors. Manufacturing constitutes the largest employment category in each of the four South Carolina counties. The government is the largest employer in the two Georgia counties. In 1980, agriculture accounted for 1.8% of total employment in the six-county region.

In May 1988, about 18,600 workers were employed at SRS (NUS-1), which represents almost 10% of total employment in the region. As of April 1989, about 9,200 persons worked at the Vogtle Electrical Generating Plant, and about 300 worked for Chem-Nuclear Systems. Table 4.3.8-1 summarizes SRS work force projections for 1990-2003.

TABLE 4.3.8-1 Projected SRS Work Force, 1990-2003

Employer	1990	1995	2000	2003
DOE-SR operations	584	664	NA ^a	NA
Westinghouse				
Operations	9,951	10,286	9,718	9,744
SR Laboratory	1,491	1,457	1,446	1,446
Construction contractors	6,360	7,700	3,850	3,870
Wackenhut	1,028	1,027	NA	NA
University of Georgia	130	147	165	175
U.S. Forest Service	42	50	50	50
Total	19,586	21,331	NA	NA

^aNot available.

Sources: NUS-1; Bean 1990b.

Table 4.3.8-2 summarizes work force projections by construction occupation for South Carolina, Georgia, and the SRS region for 1995. Since the peak NPR construction work force would be much larger than the operations work force, the availability of construction craft workers is a key consideration in identifying any potential in-migration and associated socioeconomic impacts arising from NPR activities.

In 1988, per capita income in the region was \$13,259, which is 16.6% less than the national average (Table 4.3.8-3). Columbia and Richmond counties had the highest per capita incomes, \$14,384 and \$13,714, respectively. Bamberg County had the lowest, \$8,977. Total regional personal income was \$5.6 billion in 1988; of this total, 75% was earned in Aiken and Richmond counties.

Agriculture is an important source of income in the SRS region. In 1988, receipts from the sale of field crops totaled \$47 million, and livestock sales were \$45 million.

4.3.8.2 Population Characteristics

Table 4.3.8-4 lists the 1980, 1988, and estimated 1990 populations in the ROI. Aiken, Columbia, and Richmond counties compose the Augusta Standard Metropolitan Statistical Area. In 1988, this area had an estimated population of 376,100 people. In 1980, 78% of these people lived in urban areas, compared with 74% in the six-county ROI.

From 1970 through 1988, the entire region experienced population growth at a rate of 1.6% per year. Growth at the county level was steady, with the exception of Allendale and Bamberg counties, where population increased during the 1970s but decreased during the 1980s. The populations of all counties, except Columbia County, decreased in proportion to the total regional population. Aiken County's population maintained the same proportion of the SRS regional total from 1970 to 1988. However, Columbia County's proportion more than doubled over the same period. Populations increased in four of the six selected cities from 1970 to 1988. Only Augusta showed a decline.

TABLE 4.3.8-2 Projected State and Regional Work Forces, by Construction Occupation, 1995

Construction Occupation	South Carolina	Georgia	SRS ROI
Pipefitters/welders	10,135	10,820	1,066
Boilermakers	688	980	73
Carpenters	13,894	32,390	1,797
Equipment operators	11,908	24,720	1,638
Linemen	2,357	3,050	242
Teamsters/laborers	100,058	186,390	12,318
Electricians	11,282	16,630	1,258
Ironworkers	1,520	2,700	175
Concrete finishers	2,127	4,730	264
Other crafts	3,917	1,960	331

TABLE 4.3.8-3 Personal and Per Capita Income in the SRS ROI, 1982 and 1988

Location	Total Personal Income (millions of dollars)		Per Capita Income (dollars)	
	1982	1988 ^a	1982	1988 ^a
South Carolina				
Aiken	1,235	1,618	11,692	13,240
Allendale	85	102	7,943	9,622
Bamberg	133	158	7,312	8,977
Barnwell	186	236	9,316	11,238
Georgia				
Columbia	488	899	12,164	14,384
Richmond	1,966	2,625	10,824	13,714
SRS ROI	4,093	5,638	10,833	13,259

^aValues for 1988 were escalated at 1.3% per year from 1987 values.

Source: Bureau of Economic Analysis 1990.

TABLE 4.3.8-4 Distribution of Population and SRS Work Force by Place of Residence for Counties and Selected Communities in the SRS ROI, 1980, 1988, and 1990

Location	1980 Population (thousands)	1988		1990 Population Estimate ^b (thousands)
		Population (thousands)	Percentage of SRS Work Force ^a	
South Carolina				
Aiken County	105.6	122.2	51.7	117.9
Aiken	15.0	19.6	22.8	18.9
Jackson	1.8	2.1	3.0	2.0
New Ellenton	2.6	3.4	2.7	3.3
North Augusta	13.6	17.3	13.6	16.7
Allendale County	10.7	10.6	1.7	11.4
Bamberg County	18.1	17.6	1.8	19.7
Barnwell County	19.9	21.0	8.7	5.7
Barnwell	5.6	6.1	4.5	64.7
Georgia				
Columbia County	40.1	62.5	6.3	188.1
Richmond County	181.6	191.4	17.3	44.0
Augusta	47.5	44.8	14.9	
SRS ROI	376.0	425.3	87.5	420.2

^aPercentage of SRS work force residing in specified location.

^bEstimates for municipalities are based on 1988 population distributions.

Sources: NUS-1; 1990 population estimate from U.S. Bureau of the Census, Public Affairs Office, 1991.

Table 4.3.8-5 presents population projections for the ROI for 1990-2040. The projections indicate that the total population would continue to increase throughout the period of NPR construction and operation. Columbia County is expected to grow disproportionately faster than other counties in the region. All cities, except Augusta, are expected to increase in total population.

4.3.8.3 Housing

Between 1980 and 1987, the number of housing units, excluding mobile homes, increased at an annual rate of 3.7% for the entire SRS region. For the same period, the annual rate of increase in Columbia County was 10%. The number of mobile homes in the six-county region doubled between 1970 and 1980. The largest growth in mobile dwellings occurred in Allendale County, which experienced a 232% increase during the 10-year period.

TABLE 4.3.8-5 Projected Population for Counties and Selected Cities
in the SRS ROI, 1990-2040

Location	Population (thousands), by Decade					
	1990	2000	2010	2020	2030	2040
South Carolina						
Aiken County	117.9	142.5	159.3	176.1	192.0	205.0
Allendale County	11.4	11.0	10.6	10.2	9.7	9.1
Bamberg County	18.4	17.9	16.9	15.9	14.7	13.2
Barnwell County	19.7	23.9	25.9	27.7	29.2	30.3
Georgia						
Columbia County	64.7	90.9	100.4	130.1	148.1	163.5
Richmond County	188.1	238.1	269.8	301.6	334.0	364.7
SRS ROI ^a	420	524	583	662	728	786

^aTotals are rounded.

Sources: The 1990 regional estimates are from the U.S. Bureau of the Census, Public Affairs Office, 1991; county-level projections are from NUS-1.

In 1987, overall housing vacancy rates in the Augusta Standard Metropolitan Statistical Area were 6.7% in Richmond County, 4.8% in Columbia County, and 4.4% in Aiken County. Vacancy rates for single-family detached homes varied from 2% to 4%. Single-family attached and multifamily units had vacancy rates ranging from 12% to 13%, whereas mobile home vacancy rates ranged from 3% to 11%.

Median property values in 1980 ranged from \$22,400 in Allendale County to \$42,500 in Columbia County. Values in the largest cities in the region ranged from \$23,800 in Augusta to \$40,000 in Aiken. Georgia, South Carolina, and U.S. median property values were \$36,900, \$35,100, and \$47,200, respectively. During the first six months of 1988, the average selling price of housing units in the Augusta area was \$71,700.

In 1980, median monthly rental rates ranged from \$56 in Allendale County to \$168 in Columbia County. Monthly rents in the largest cities in the region ranged from \$84 in New Ellenton to \$168 in North Augusta. Georgia, South Carolina, and the U.S. median rental rates were \$153, \$130, and \$198 per month, respectively. Monthly rental rates for apartments in 1987 in Augusta, North Augusta, and Aiken ranged from \$298 for a one-bedroom apartment in Augusta and North Augusta to \$450 for a three-bedroom apartment in North Augusta.

Table 4.3.8-6 shows housing permits for the ROI; on the average, 2,673 permits have been issued annually in the ROI. Most of this activity has been occurring in Aiken, Columbia, and Richmond counties, with the city of Aiken issuing the highest number.

TABLE 4.3.8-6 Housing Permits in the SRS ROI, 1980-1987

Location	1980	1981	1982	1983	1984
Aiken County	517	453	352	716	1,114
Aiken	42	125	46	94	336
Jackson	NR ^a	NR	NR	NR	NR
New Ellenton	NR	NR	2	NR	NR
North Augusta	28	76	77	192	248
Allendale County	NR	63	9	9	NR
Bamberg County	190	49	99	129	85
Barnwell County	65	14	16	66	33
Barnwell	62	7	11	8	14
Columbia County	439	483	774	1,021	1,361
Richmond County	671	194	477	835	1,006
Augusta	59	45	298	262	247
SRS ROI	1,882	1,256	1,727	2,776	3,599

	1985	1986	1987	1980-87 Average	
Aiken County	849	1,230	755	748	
Aiken	147	440	271	188	
Jackson	NR	NR	NR	NR	
New Ellenton	NR	NR	NR	NR	
North Augusta	217	257	71	148	
Allendale County	36	NR	15	26	
Bamberg County	119	66	63	100	
Barnwell County	71	26	21	39	
Barnwell	61	26	19	26	
Columbia County	1,486	1,501	892	995	
Richmond County	1,063	1,245	709	775	
Augusta	156	121	81	159	
SRS ROI	3,642	4,068	2,455	2,673	

^aNot recorded.

Source: U.S. Bureau of the Census 1982, 1984, 1986, 1988.

4.3.8.4 Public and Community Services

Within the six-county region, public and community services are provided by counties, cities, towns, special districts, government agencies of Georgia and South Carolina, and the Federal government. Descriptions of services are provided for the six counties (Columbia and Richmond counties in Georgia, and Aiken, Allendale, Bamberg, and Barnwell counties in South Carolina) and the nine public school systems in the ROI. Fiscal descriptions are provided for each county, municipality, and school district in the ROI.

Education

Nine school districts (seven in South Carolina and two in Georgia) provide public education services and facilities in the SRS region. The largest of these districts, in terms of enrollment, is Richmond County School System, which has almost 30,000 students. The smallest is Barnwell School District No. 29, which has fewer than 1,000 students (Table 4.3.8-7). The larger school districts in the ROI (Aiken, Columbia, and Richmond) are operating closer to their capacities than the smaller districts. Student/teacher ratios, which range from 13.7 in Allendale County Public School System to 21.9 in Columbia County School System, average 16.9 for the ROI. Per pupil expenditures range from \$3,000 to \$4,000. The average rate for the ROI is \$3,411.

TABLE 4.3.8-7 Characteristics of School Districts in the SRS ROI

School District ^a	Enrollment	Enrollment Capacity	Student/Teacher Ratio	Per Pupil Expenditure (\$)
Aiken County CPSS	22,176	22,325	17.0	3,109.49
Allendale CPSS	2,353	3,515	13.7	3,575.25
Bamberg No. 1	1,810	2,508	15.5	3,547.23
Bamberg No. 2	1,432	2,546	15.4	3,919.06
Barnwell No. 19	1,172	1,463	15.6	3,477.75
Barnwell No. 29	977	1,463	14.0	3,479.02
Barnwell No. 45	2,401	2,850	16.4	3,462.36
Columbia County SS	11,756	9,880	21.9	3,080.67
Richmond County SS	29,972	31,920	16.1	3,710.37
Total/average	74,049	78,470	16.9	3,411.43

^aCPSS = consolidated public school system; SS = school system.

Sources: South Carolina Department of Education 1990; Georgia Department of Education 1990; NUS-1 (SRS school capacities).

Health Care

In 1987, the six-county area had eight general hospitals, for a total capacity of 2,433 beds. Four of the hospitals are in Richmond County and account for the majority of licensed beds. In 1988, the six-county area had 1,295 physicians, 272 dentists, and 3,760 nurses. More than 75% of these health professionals worked in Richmond County. Health care service ratios for counties in the ROI are summarized in Table 4.3.8-8.

Police and Fire Protection

County sheriff's offices, city police departments, and state law enforcement agencies provide police protection in the six-county ROI (Table 4.3.8-9). The largest of these forces are from the more populated cities and counties in the region: Aiken County, city of Aiken, North Augusta, Richmond County, and Augusta. The Richmond County Sheriff's Office has the largest single staff of sworn officers (296) in the ROI; the Augusta Police Department maintains the highest level of service, with 3.57 sworn officers per 1,000 people (NUS-1). The more rural counties maintain smaller forces at levels of service less than the more urban areas of the ROI.

Fifty-six fire departments provide fire protection services in the ROI. Of these, five municipal fire departments are staffed by professional fire fighters (Table 4.3.8-9). The remaining areas are served by volunteer fire protection districts. The Augusta Fire Department is staffed with 122 fire fighters; its level of service is 2.73 fire fighters per 1,000 population. The next-largest departments are the Aiken Fire Department (70 fire fighters; 1.79 fire fighters per 1,000 people) and the North Augusta Fire Department (43 fire fighters; 1.33 fire fighters per 1,000 people).

4.3.8.5 Public Finances

Revenues, expenditures, and fund balances of potentially affected cities, counties, and school districts in the ROI are presented in Table 4.3.8-10. The data reflect actual revenues and expenditures of each jurisdiction's general fund, and, as applicable, a jurisdiction's special

TABLE 4.3.8-8 Health Care Service Ratios for the SRS ROI

County	Population/ Doctors	Population/ RN/LPN	Population/ Hospital Beds
Aiken	1,300	424/698	643
Allendale	1,178	442/815	265
Bamberg	1,173	339/550	298
Barnwell	1,105	404/539	396
Columbia	534	340/477	0
Richmond	184	111/183	246
SRS ROI	328	183/295	175

Source: NUS-1.

TABLE 4.3.8-9 Police and Fire Protection Services in the SRS ROI

County/Agency	Police Protection	
	Sworn Officers	Officers/ 1,000 People
Aiken County		
Aiken County Sheriff's Office	71	0.58
Aiken Department of Public Safety	70	1.79
Jackson Police Department	3	1.42
New Ellenton Police Department	5	1.48
North Augusta Department of Public Safety	40	1.16
Allendale County		
Allendale County Sheriff's Office	6	0.57
Bamberg		
Bamberg County Sheriff's Office	6	0.34
Barnwell County		
Barnwell County Sheriff's Office	9	0.43
Barnwell Police Department	10	1.64
Columbia County		
Columbia County Sheriff's Office	64	1.02
Richmond		
Richmond County Sheriff's Office	296	1.55
Augusta Police Department	160	3.57
County/Agency	Fire Protection	
	Fire Fighters	Fire Fighters/ 1,000 People
Aiken County		
Aiken Fire Department	70	1.79
New Ellenton Fire Department	4	1.19
North Augusta Fire Department	43	1.33
Allendale County	NA ^a	NA
Bamberg County	NA	NA
Barnwell County		
Barnwell Fire Department	3	0.49
Columbia County	NA	NA
Richmond County		
Augusta Fire Department	122	2.73

^aNot available.

Source: NUS-1.

TABLE 4.3.8-10 General and Special Fund Revenues, Expenditures, and Fund Balances for Selected Jurisdictions in the SRS ROI

Jurisdiction	Revenues (\$1,000)	Expenditures (\$1,000)	Fund Balance (\$1,000)	Fiscal Year (\$1,000)
Aiken County	21,017	23,090	(1,791)	1989
City of Aiken	8,885	8,702	6,200	1988
City of North Augusta ^a	4,089	3,876	1,775	1989
City of New Ellenton	326	295	82	1986
Town of Jackson	271	220	159	1988
Aiken County School District	62,962	62,015	1,034	1988
Barnwell County	4,026	4,933	1,382	1988
City of Barnwell	1,191	1,293	417	1989
Barnwell School District No. 45	7,146	7,043	907	1988
City of Augusta	21,043	21,255	8,248	1987
Richmond County School District	109,958	112,510	19,686	1988

^aFor the city of North Augusta, values represent general and special revenue fund data.

Sources: NUS-1; Aiken County 1990; North Augusta 1990.

revenue funds. These funds generally account for all of a jurisdiction's tax-supported expenditures for services provided by the jurisdiction. Examples of other funds maintained by cities and counties include enterprise funds, special assessment funds, and utility funds. These funds are generally self-supporting through user charges and do not contribute to the general tax burden of a jurisdiction. When the activities of these funds are relatively important in a local community (e.g., revenues and expenditures of utility enterprise funds), the most recent year's revenues and expenditures are reported.

Data are reported only for jurisdictions expected to experience the majority of impacts associated with NPR project activities (Table 4.3.8-10).

Aiken County

Public services provided by Aiken County are funded principally through the county's general fund. In FY 1989, revenues and expenditures were \$21.0 million and \$23.1 million, respectively. Fund balances were negative \$1.8 million. Property taxes and state-shared distributions are the principal revenue sources of the county. Outlays for public safety functions (i.e., law enforcement and fire protection), public works, and general administrative services account for the majority of county general fund expenditures.

The county also operates two major enterprise funds: (1) the Aiken County Public Service Authority, which operates a regional wastewater treatment plant for contracted users,

and (2) the Mattie C. Hall Health Care Center. Activities funded through these accounts are generally self-supporting. In FY 1989, the operating revenues and expenditures of these two funds in FY 1989 were approximately \$5.1 million and \$5.5 million, respectively.

Long-term general obligation bond indebtedness was \$8.2 million at the end of FY 1989. The assessed value of property in the county was \$177.5 million in FY 1989, down from the previous year levels. Reserve general obligation bond indebtedness is approximately \$5 million.

City of Aiken

Public services provided by Aiken are funded principally through the city's general fund. In FY 1988, revenues and expenditures were \$8.9 million and \$8.7 million, respectively. Property taxes, service charges, and license and permit revenue were the principal revenue sources of the city. Public safety (i.e., police and fire protection services), public works (i.e., streets and park operation and maintenance), and general government functions (i.e., administration and legal services) accounted for the majority of general fund expenditures. Fund balances were \$6.2 million in FY 1988, up from \$5.5 million in FY 1986 and \$6.0 million in FY 1987. Approximately \$95,000 of the current balance is unreserved and undesignated, with the remainder unreserved but designated principally for capital improvements and equipment replacement.

The assessed valuation in the city is approximately \$43.3 million as of FY 1989. Long-term general obligation bond indebtedness was \$400,000 at the end of FY 1988. Reserve bonding capacity is approximately \$1.3 million as of FY 1989.

Water and wastewater services are accounted for in a separate enterprise fund. In FY 1988, operating revenues of this fund were approximately \$4.6 million, and expenditures were \$4.2 million.

City of North Augusta

Services provided by North Augusta are funded principally through the city's general and special revenue funds. In FY 1989, revenues and expenditures were \$4.1 million and \$3.9 million, respectively. Property taxes, state-shared revenue, licenses and permit revenue, and charges for services are the principal revenue sources of the city. Public safety (i.e., law enforcement and fire protection) and public works account for the majority of general and special revenue fund expenditures. Fund balances were \$1.8 million in FY 1989, up from \$1.7 million in FY 1988 and \$1.6 million in FY 1987. Approximately \$560,000 is designated for future year operational expenditures, and \$190,000 is undesignated and unreserved. The remainder is reserved for the noncurrent portion of loans receivable.

The assessed valuation of property in the city was \$20.9 million, which represents an increase of 2% over the preceding year. The city has no general obligation bond indebtedness. Reserve bonding capacity, which is not subject to voter approval, is approximately \$1.7 million. In FY 1989, the property tax rate was 88 mills for general fund operations and 10 mills for funding the city's Capital Projects Fund.

City of New Ellenton

Public services provided by New Ellenton are funded principally through the city's general fund. In FY 1986, revenues and expenditures were approximately \$326,000 and \$295,000, respectively. Property taxes and revenue from fines and fees are the principal revenue sources of the city. Public safety and general government functions account for the majority of the city's expenditures. The general fund balance at the end of FY 1986 was approximately \$82,000, up from about \$80,000 in the previous year. The balance at the end of FY 1986 represented about 53% of operating expenditures in that year.

Town of Jackson

Services provided by Jackson are funded principally through the town's general fund. In FY 1988, revenues and expenditures were approximately \$270,000 and \$220,000, respectively. Property taxes are the single largest revenue source, accounting for approximately 39% of all revenues in FY 1988. Franchise fees, state shared revenue, and charges for services account for the majority of the remaining revenues. Fund balances amounted to approximately \$160,000 in FY 1988; these monies are undesignated and unreserved. The assessed valuation in the town is approximately \$1.4 million. The town has no general obligation bond indebtedness. Reserve general obligation bond indebtedness is approximately \$110,000.

Consolidated School District of Aiken County

Educational services provided by the Consolidated School District of Aiken County are funded principally through the general and special revenue funds. In FY 1988, revenues and expenditures of these funds were \$63.0 and \$62.0 million, respectively. State educational aid programs account for approximately two-thirds of all of general and special revenue fund revenues, with local source revenues (principally property taxes) accounting for the majority of the remaining sources. Fund balances were \$1.0 million in FY 1988. Balances have increased in recent years; they were approximately \$30,000 in FY 1986 and \$330,000 in FY 1987.

The assessed valuation of property in 1988 was approximately \$195.8 million. General obligation bond indebtedness was \$27.7 million at the end of FY 1988. No further general obligation bond indebtedness may be incurred without voter approval. Mill rates for operations for FY 1989 were 84.0 for property in Aiken County and 73.1 for property in Saluda County.

Barnwell County

Public services provided by Barnwell County are funded principally through the county's general fund. In FY 1988, revenues and expenditures of this fund were \$4.0 million and \$4.9 million, respectively. Property taxes, intergovernmental revenue (principally in the form of state-shared revenue), and various miscellaneous revenues are the principal revenue sources of the county. Fund balances were approximately \$1.4 million in FY 1988, down from the previous year's \$2.1 million. In FY 1988, fund balances represented approximately 29% of operating revenues in that year. These monies are not reserved or designated for any specific use. The county has no general obligation bond indebtedness. The assessed valuation in the county is estimated at approximately \$310 million. The property tax rate is \$0.239 per \$100 of assessed valuation.

City of Barnwell

Services provided by the City of Barnwell are funded principally through the city's general fund. In FY 1989, revenues and expenditures were approximately \$1.2 million and \$1.3 million, respectively. Property taxes and license and permit revenues are the principal revenue sources of the city. Fund balances were approximately \$420,000; these monies were undesignated and unreserved for other uses. This level is down from the approximately \$700,000 recorded in FY 1986.

The city has \$110,000 in general obligation bond indebtedness that is scheduled to be retired by FY 1992. The assessed valuation is approximately \$7.4 million. Reserve general obligation bond indebtedness is approximately \$480,000.

Barnwell School District No. 45

Educational services provided by Barnwell School District No. 45 are funded principally through the district's general and special revenue funds. In FY 1988, revenues and expenditures were \$7.1 million and \$7.0 million, respectively. State education aid programs account for approximately two-thirds of general and special revenue fund revenues. Fund balances amounted to \$900,000. The district has no general obligation bond indebtedness. The assessed valuation in the district was \$17.1 million in FY 1989. Reserve general obligation bond indebtedness is \$1.4 million.

City of Augusta

Services provided by the City of Augusta are funded principally through the city's general and special revenue funds. In FY 1987, revenues and expenditures were approximately \$21.0 million and \$21.3 million, respectively. Property taxes, local option sales taxes, and franchise taxes are the principal tax revenue sources of the city. Public safety, general administrative functions, and public works account for the principal expenditure functions. Fund balances at the end of FY 1987 amounted to \$8.2 million; \$1.4 million was unreserved and undesignated and the remainder was designated for various capital improvement projects. General obligation bond indebtedness was \$4.8 million at the end of FY 1987. In 1989, the net assessed valuation in the city was \$372.2 million.

Richmond County School District

Educational services provided by the Richmond County School District are funded principally through the district's general fund account. In FY 1988, general fund revenues and expenditures were approximately \$110.0 million and \$112.5 million, respectively. Fund balances were \$19.7 million in FY 1988. State source revenues accounted for about two-thirds of all general fund revenue. General obligation bond indebtedness was \$32.0 million at the end of FY 1988. General obligation bond indebtedness is limited to voter-approved amounts.

4.3.9 Transportation Systems

This section discusses the existing transportation environment at and around SRS. Personnel and most materials are transported at and around SRS by road. Rail transportation is used to move irradiated fuel and certain high-level radioactive wastes and to transport coal for steam plants. Although barge transport on the Savannah River is possible, it currently is not used by SRS or commercial shippers. Figures 4.3.9-1 and 4.3.9-2 show the transportation networks serving SRS.

4.3.9.1 Road Transportation

The SRS is served by more than 200 mi* of primary roads and more than 1,000 mi of unpaved secondary roads (WSRC-3). Access to SRS is controlled by barricades, although three routes [U.S. Route (US) 278, State Route (SR) 19, and SR 125] are open to the public (DOE-11). Through traffic along the on-site portion of SR 125 is permitted with a pass obtained at one entrance barricade and returned at the exit barricade, with a time limit for traveling the segment (Snyder 1989).

The regional transportation networks in the SRS vicinity (Figure 4.3.9-2) service four South Carolina counties (Aiken, Allendale, Bamberg, and Barnwell) and two Georgia counties (Columbia and Richmond), from which 88% of SRS commuter traffic is generated.

Two interstate highways serve the SRS area. Interstate 20 (I-20) provides a primary east-west corridor in the region, and I-520 links I-20 with Augusta. US 1 and US 25/SR 121 are principal north-south routes in the region, and US 78 provides east-west connections. Several other highways (US 221, US 301, US 321, and US 601) provide additional transport routes within the study area.

Several routes provide direct access to SRS. From the northwest and north, access is provided by SR 125 and SR 19, respectively, both of which are open to through traffic. From the northeast, SR 39, SR 781, and County Road 54 pass inside the SRS boundary. Access from the east is by SR 64 and from the southeast by SR 125. These are all two-lane roads. The public can use US 278, SR 125, and SR 19, but only SRS employees are permitted access to the site on the other routes. The primary highway routes in the SRS vicinity, their associated functional classifications, and 1988 traffic volumes in terms of annual average daily traffic (AADT) and vehicle miles traveled (VMT) are presented in Table 4.3.9-1.

General weight, width, and speed limits have been established for highways in the SRS vicinity. However, no unusual laws or restrictions that have been identified would significantly influence general regional transportation.

Plans exist to widen segments of I-20, US 25, US 78, US 278, and SR 19 (Skeen 1989; White 1989). The Augusta Regional Transportation Study (ARTS) identified the extension of I-520 to US 1 and I-20 in Aiken County as a central project in its 20-year plan (DOE-11).

*1 mi = 1.609 km.

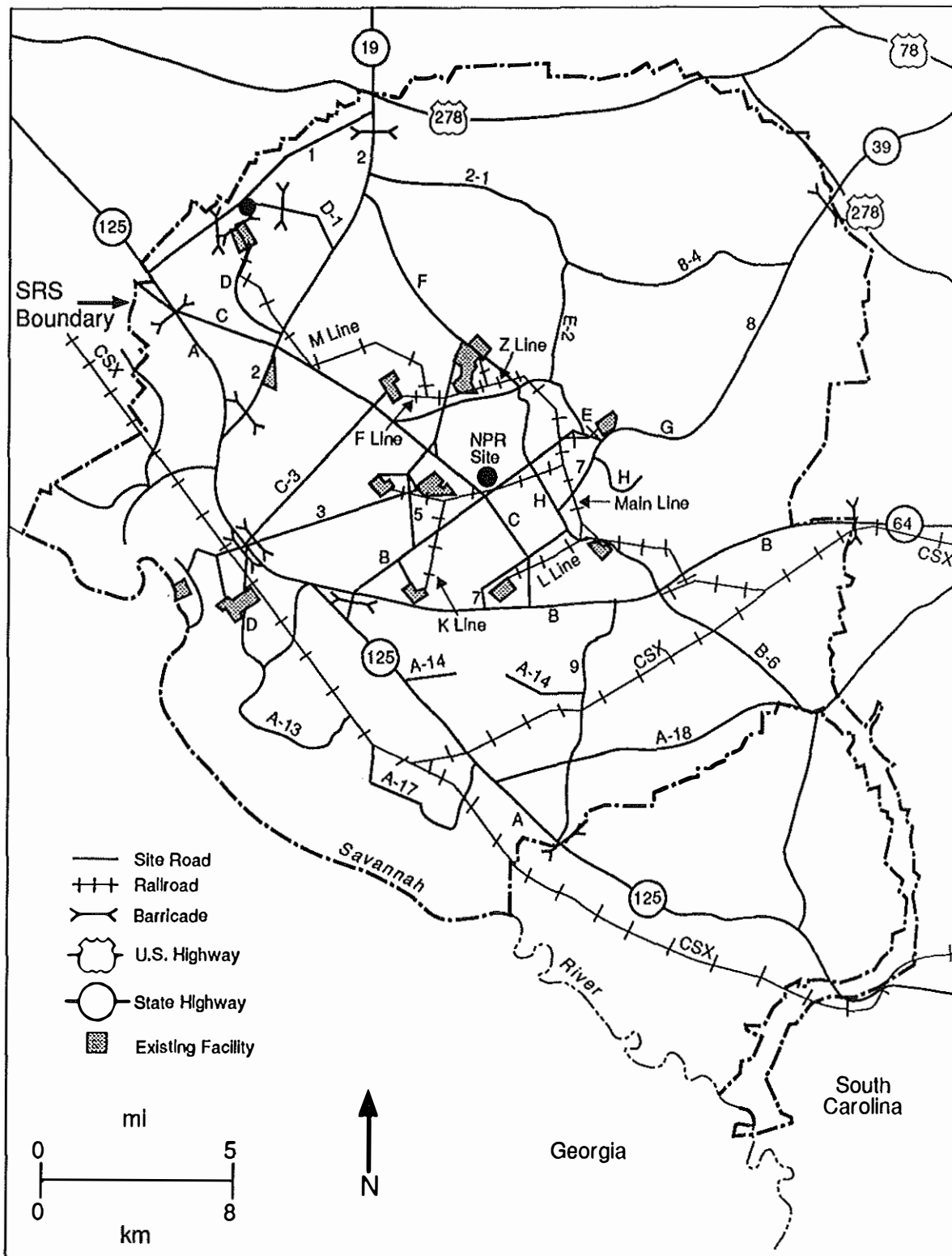


FIGURE 4.3.9-1 Transportation Routes at SRS (Source: Based on data provided by SRS staff)

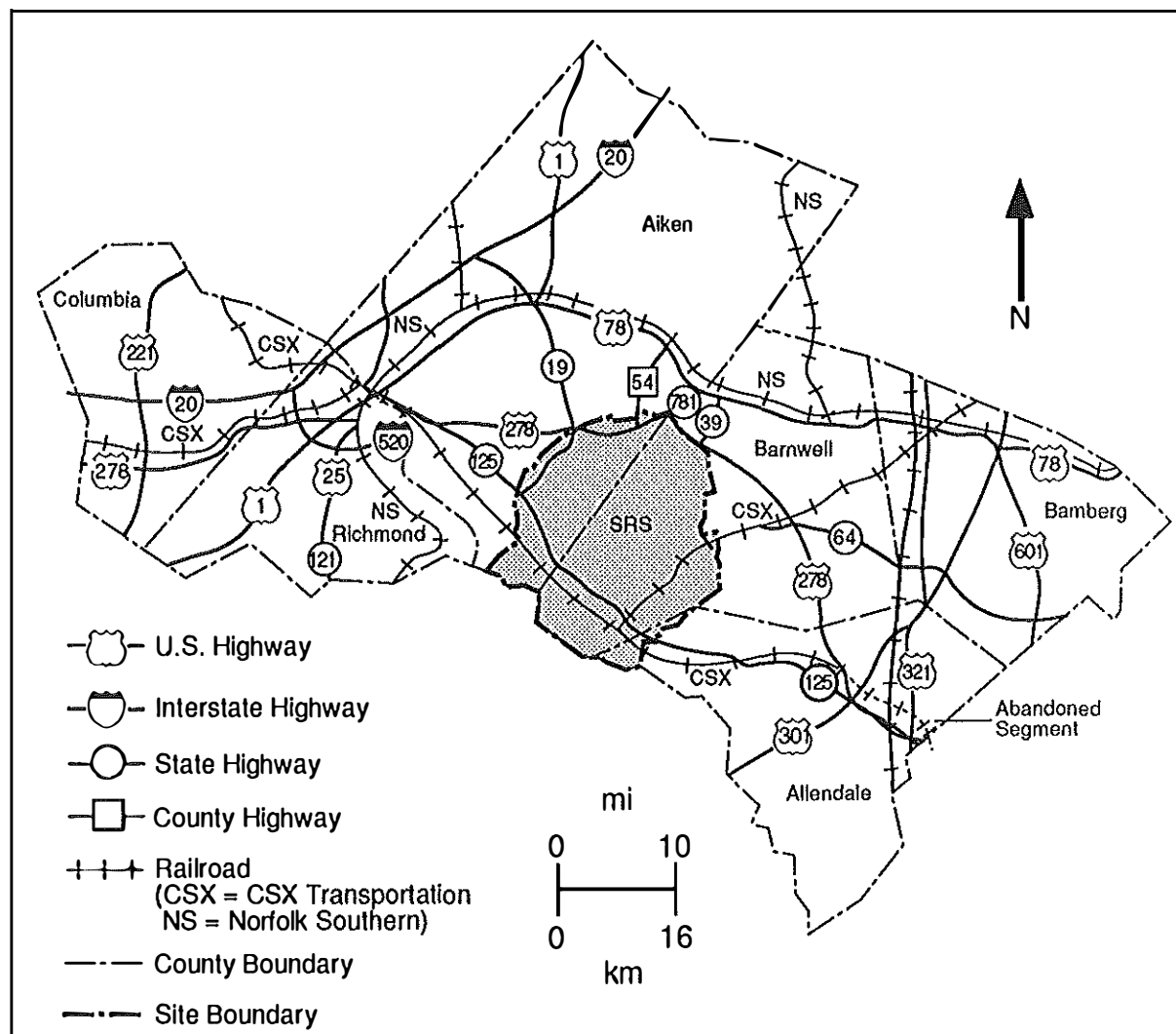


FIGURE 4.3.9-2 Transportation Routes in the SRS Vicinity (Source: Based on DOI-3)

Approximately 84% of the SRS work force resides in Aiken and Barnwell counties in South Carolina and Columbia and Richmond counties in Georgia (52, 9, 6, and 17%, respectively).

In 1988 nearly 16 million mi were logged by DOE vehicles at SRS. In addition, an estimated 11,600 privately owned vehicles were driven on-site each weekday, and another 1,970 were driven on-site each weekend day. Assuming a round-trip distance of 30 mi on-site for each of these vehicles, a total of about 84.5 million mi were driven annually by workers on-site.

The primary highways used by SRS commuters are SR 19, SR 64, and SR 125; 40, 10, and 50% of the workers use these routes, respectively. With these commuting patterns, workers annually travel about 82 million mi off-site. Trucks used for material shipment to SRS compose about 5% of the vehicular traffic on and around the site.

TABLE 4.3.9-1 Information on Major Transportation Routes around the SRS Site

Road Segment ^a	Functional Classification	AADT ^b (vehicles)	Annual VMT ^c (millions of miles)
I-20 (from US 1 in Aiken County to western Columbia County line)	Interstate	21,200	336
US 1 (from southern Richmond County line to I-20)	Principal arterial	18,100	311
US 25/SR 121 (from southern Richmond County line to South Carolina state line)	Principal arterial	15,100	83.5
US 78 (from US 1 to SR 39)	Principal arterial	6,600	48.4
US 278 (from US 125 to SR 64)	Principal arterial	4,010	52.5
SR 19 (from SRS boundary to US 1)	Minor arterial	13,700	58.2
SR 39 (from SRS boundary to US 78)	Collector	2,650	4.74
SR 64 (from SRS boundary to US 278)	Collector	3,450	10.1
SR 125 (from US 1 in Aiken County to US 301)	Principal arterial	5,380	104

^aRoute prefixes: I (Interstate), US (United States Route), SR (State Route).

^bAADT = annual average daily traffic.

^cVMT = vehicle miles traveled.

Conversion factor: 1 mi = 1.609 km.

Sources: DOE-11; Colvin 1989; White 1989; Wilbur Smith Associates 1989; NUS-1.

Significant congestion occurs during peak traffic periods on-site on road 1-A and on SR 19, SR 125, and US 278 at SRS access points (Wilbur Smith Associates 1989). Long delays are also experienced off-site along routes I-20, US-25, and US 1 where they cross the Savannah River (DOE-3). The SRS is currently implementing changes to remedy the congestion at some access points (Huber 1990).

In 1988, 308 accidents involving DOE-owned and private vehicles at SRS, resulted in one fatality and 40 injuries (McClain 1990a). Among off-site segments of concern, most accidents occurred on US 1 and US 25/SR 121. According to available data, the 61 accidents in 1987 involving trucks in the study area resulted in 53 injuries and 11 fatalities (DOT-1).

4.3.9.2 Rail Transportation

Approximately 63 mi of railway are within SRS, all owned by DOE and CSX Transportation (WSRC-3). The SRS is served by a railroad classification yard east of the 100-P Facility. Two major railways with extensive rail networks, CSX Transportation and Norfolk Southern Corporation, serve the SRS vicinity. Movement of coal and casks containing radioactive material constitutes the bulk of rail traffic at SRS. Available data indicate that approximately 95,000 rail miles were logged at SRS in 1985 (WSRC-3). Recent data for on-site rail accidents are unavailable.

4.3.9.3 Barge Transportation

Barge transport of heavy equipment requiring a draft of less than 5 ft (1,200 tons) is possible on the Savannah River (King 1990); however, it currently is not used by SRS or commercial shippers.

4.3.10 Waste Management

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

The objective of the waste management system at SRS is to treat, store, and provide for disposal of all waste generated at this site (DOE-18; WSRC-12). This section describes a baseline for waste management activities at SRS for the year 2000 so that the impact to this system of operating the NPR and its support facilities can be evaluated. In general, these baseline activities consist of (1) treatment, storage, and disposal of newly generated wastes from ongoing activities and (2) treatment, storage, and disposal of inventory waste previously generated at SRS. Baseline estimates do not include the waste resulting from cleaning out or shutting down existing facilities.

The existing baseline for quantities and types of wastes to be managed depend upon whether or not spent fuel is reprocessed and whether or not plutonium is produced, as well as on the extent to which existing reactors continue to operate in the future. Estimates in this section were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium produced. If it is decided not to continue those activities, the impacts upon waste management systems from NPR operations would be less than presented here. In addition, this section was prepared assuming that all three of the existing SRS reactors

would operate at 100% power. On February 11, 1991, the Department of Energy issued a Record of Decision for the RO EIS that determined that P Reactor shall be placed in cold standby and that K and L reactors will remain operational. This would also reduce the amounts of baseline wastes presented in this section.

Six primary waste types are generated at SRS from the operation of its reactors and their support facilities. These waste types include HLW, TRU waste, LLW, mixed waste, hazardous waste, and nonhazardous nonradioactive waste (designated for the purposes of this EIS as "other waste"). Waste types and regulatory definitions of waste are described in Appendix M.

Each waste can exist as a gas, liquid, or solid. Little waste management takes place with gaseous radioactive materials other than interim storage to allow time for partial radioactive decay and filtering to remove radioactive particulate matter. This section does cover the treatment, storage, and disposal of liquid and solid waste generated at SRS. All waste prepared for disposal are ultimately solids. Treated effluents from a waste stream are not considered part of that waste stream. As an example, liquid LLW is treated at an effluent treatment facility. The effluent is considered a nonradioactive, nonhazardous liquid and the treatment media (e.g., resins, filters, and flocculents) are processed as a solid LLW.

Radioactive, mixed, and hazardous waste will be managed in accordance with applicable Federal, state, and local regulations to protect the environment and the health and safety of public and site employees. All activities will comply with Federal, state, and local laws and regulations, as well as DOE requirements. Sitewide waste management plans at SRS include detailed plans for waste minimization and waste reduction (DOE-17).

Waste and contaminated materials are generated from the operation of existing reactors (DOE-10); the processing of inventory waste; and the operation, maintenance, and renovation of support facilities. Wastes are stored, treated, and disposed of at SRS. Waste management facilities, facility capacities, and existing waste generation rates, for both newly generated and stored waste at SRS, are summarized in Tables 4.3.10-1 and 4.3.10-2. An overview of storage, treatment, and disposal facilities that would support the NPR project is presented in Appendix M, Figure M.3.

No radioactive waste is now shipped off-site. Currently, HLW, TRU, and mixed waste are in interim storage at SRS. Other types of waste have already been disposed of at SRS or at appropriate off-site facilities. HLW will be processed in the Defense Waste Processing Facility and shipped off-site to a Federal repository, and TRU waste would be shipped off-site to WIPP. The impact of SRS waste on this latter national facility, the relationship of this waste to the design capacity of WIPP, and the total projected volume of TRU waste to be isolated there are discussed in Section M.1.

One of the primary objectives of the Waste Management Program at SRS is the ongoing Waste Minimization Program (Steven, Lee, and Reynolds 1991) designed to reduce the amount of hazardous, mixed, and radioactive wastes generated at the site (DOE-52). Examples of waste reduction and minimization at SRS include compaction and incineration, both of which result in large volume reductions.

The following sections will cover the generation of each type of waste (Table 4.3.10-1) and the treatment, storage, and disposal of each waste at the various waste management facilities (Table 4.3.10-2). Remedial activities are covered in the last section.

TABLE 4.3.10-1 Baseline Waste Quantities as of the Year 2000 at SRS^a

Waste Identification	Annual Disposal Volume from Processing Operations Wastes (m ³ /yr)	Annual Disposal Volume from Processing Stored Wastes (m ³ /yr)	Total Annual Disposal Volume from all Waste Processing (m ³ /yr)	Disposition
High-level waste Solid ^b	90	210	300 ^c	Interim on-site storage ^d
Transuranic waste Solid ^e	400	250	650 ^c	Interim on-site storage ^f
Low-level waste Solid ^g	59,000	22,000	81,000	On-site disposal
Mixed waste Solid ^g	3,900	0	3,900	On-site disposal
Hazardous waste Liquid and solid	85	0	85	On-site disposal
Other waste Nonhazardous				
Liquid				
Tower blowdown	30,000,000	0	30,000,000	Liquid effluent
All other	140,000	0	140,000	Liquid effluent
Solid	23,000	0	23,000	On-site disposal
Sewage				
Liquid ^h	560,000	0	560,000	Liquid effluent
Solid ⁱ	1,100	0	1,100	On-site disposal

^aBaseline values projected from 1988 data.^bLiquid HLW is held in interim storage and then processed to a solid form for disposal.^cBaseline value taken from 1988 data for planned future activities.^dThese wastes are targeted for disposal at a Federal repository.^eLiquids containing transuranics are processed as HLW.^fThese wastes are targeted for disposal at WIPP.^gSolidified or absorbed-liquid-waste quantities are included in the solid waste quantity.^hLiquid effluents from sewage treatment operations.ⁱSolids from sewage treatment operations.

Source: Williamson 1989.

TABLE 4.3.10-2 Baseline Waste Management Facilities as of the Year 2000 at SRS^a

Waste Identification	Facility Description	Facility Function	Facility Input Capacity (m ³ or m ³ /yr) ^b	Percentage of Capacity Used for Processing Operations Wastes	Percentage of Capacity Used for Processing Stored Wastes	Comment
High-level waste						
Liquid	Storage tanks	Storage	132,000	5	57	Planned to be operational as of 1992
Solid	Defense Waste Processing Facility	Treatment	300 ^c	30	70	
	Interim storage	Storage	1,800	Variable ^d	Variable ^d	
Transuranic waste						
Solid ^e	Transuranic Storage Facility	Treatment	710 ^c	35	64	Planned to be operational as of 1996
	Waste Certification Facility	Storage	1,100	59	41	
	Interim storage	Storage	Expandable ^f	Variable ^d	Variable ^d	
Low-level waste						
Liquid	Tank Farm Evaporator	Treatment	34,000	17	71	Planned to be operational as of 1993 Planned to be operational as of 1991
	F/H-Area Effluent Treatment Facility	Treatment	400,000	35	3	
	Z-Area Saltstone Facility	Treatment	34,000	29	64	
Solid	Saltstone Disposal Vault	Disposal	Expandable ^f	Variable ^d	Variable ^d	
	Consolidated Incineration Facility	Treatment	30,000 ^g	60	0	
	Burial Ground Expansion (LLW area)	Disposal	Expandable ^f	Variable ^d	Variable ^d	
Mixed waste						
Liquid	Waste Solidification and Disposal Facility	Treatment	4,400	68	0	Planned to be operational as of 1995
Solid	Saltstone Disposal Vault	Disposal	Expandable ^f	Variable ^d	Variable ^d	Planned to be operational as of 1993 Planned to be operational as of 1992
	Consolidated Incineration Facility	Treatment	30,000 ^e	2	0	
	Hazardous/Mixed Waste Disposal Facility	Disposal	4,500	Variable ^d	Variable ^d	
Hazardous waste						
Liquid and solid	Processed with mixed waste					

TABLE 4.3.10-2 (Cont'd)

Waste Identification	Facility Description	Facility Function	Facility Input Capacity (m ³ or m ³ /yr) ^b	Percentage of Capacity Used for Processing Operations Wastes	Percentage of Capacity Used for Processing Stored Wastes	Comment
Other waste						
Nonhazardous						
Liquid	Tower blowdown	Disposal	Regulated	Variable ^d	Variable ^d	NPDES ^h -permitted
	All other	Disposal	Regulated	Variable ^d	Variable ^d	NPDES-permitted
Solid	G-Area Central Landfill	Disposal	Expandable ^f	Variable ^d	Variable ^d	
Sewage						
Liquid ⁱ	Sewage treatment plants	Treatment & disposal	Regulated	Variable ^d	Variable ^d	NPDES-permitted
Solid ^j	Land application	Disposal	Expandable ^f	Variable ^d	Variable ^d	

^aBaseline values projected from 1988 data.

^bFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^cBaseline value taken from 1988 data for planned future capacity.

^dPercentage used will vary with additional unit construction schedule.

^eLiquids containing transuramics are processed as HLW.

^fThere is sufficient space available within the boundaries of the facility to accommodate additional storage/treatment disposal units that can be constructed as needed.

^gIncinerator is to be used for several waste types; capacity is for the sum of all waste processed.

^hNPDES is National Pollutant Discharge Elimination System.

ⁱLiquid effluents from sewage treatment operations.

^jSolids from sewage treatment operations.

Source: Williamson 1989.

4.3.10.1 High-Level Waste

Processing of driver fuel and targets from the existing SRS reactors will result in generation of 6,000 m³ of liquid HLW annually from start-up to shutdown. Facilities for liquid HLW storage, treatment, and disposal include storage tanks, tank farm evaporators, cesium removal columns, transfer and processing systems, and salt and sludge processing facilities. By 2000, a combination of treatment, storage, and disposal facilities is scheduled to be in use.

The Defense Waste Processing Facility is planned to be operational in 1992 for immobilizing solid HLW in borosilicate glass. This facility will begin operations with "cold" (nonradioactive) material to show its ability to produce glasslike material. Treatment of the liquid HLW will produce annually 300 m³ of vitrified product, of which 210 m³ is produced from inventory drawdown. This facility will operate near 100% capacity for approximately 15 years until the inventory of liquid HLW is exhausted. These glasslike wastes will eventually be shipped to the Federal repository for disposal when it becomes operational. This material will be stored temporarily at a vault at the facility until the Federal repository begins to accept waste. At its start-up in 1992, the Defense Waste Processing Facility will have about 6 years of storage capacity for these wastes. Additional interim storage capacity for this HLW may be necessary.

Liquid HLW awaiting further treatment is stored in up to 51 storage tanks. The total storage capacity is 189,000 m³, with an existing inventory, as of 1987, of 128,000 m³. There are 24 tanks that will be taken out of service for a variety of reasons, leaving a total storage capacity of 132,000 m³. Thirteen are leaking, and eight have a single-shell design. The HLW storage facilities at SRS are collectively approaching their maximum capacity. Excess capacity has been reduced to the equivalent of one tank (approximately 4,000 m³). Further reduction in this excess capacity must not occur in order to provide a safety margin for the possible malfunction of the equivalent of one "full" tank. An ongoing program of in-tank precipitation separates the high-level waste (precipitate) from the supernate (LLW). The supernate can then be transferred to the Z-Area Saltstone Facility, which allows reuse of that storage space for newly generated evaporator concentrate. The precipitate will eventually undergo additional treatment at the Defense Waste Processing Facility, where the waste will be converted to a vitrified product and shipped to a Federal repository.

The in-tank precipitation process takes time to complete. Potential problems could occur if two in-use tanks were to malfunction in a relatively short time. The small amount of unused capacity would overflow. This potential problem could be alleviated through construction of additional double-shell HLW tanks. If the Defense Waste Processing Facility becomes operational (tentatively scheduled for 1992), this potential problem could be resolved by the time of NPR start-up. Inventories of liquid HLW will have been reduced to 75,000 m³ by the year 2000, resulting in substantial excess capacity for HLW being available at the time of NPR start-up.

4.3.10.2 Transuranic Waste

TRU waste is solid waste that is contaminated primarily with TRU radionuclides (Appendix M). TRU radionuclides enter the waste stream at the fuel reprocessing stage. Liquid waste from fuel reprocessing is handled as HLW even though it contains TRU radionuclides. Before 1965, most TRU waste at SRS was irretrievably buried with other radioactive waste in the Low-Level Waste Burial Ground located between F and H areas. Between 1965 and 1974, TRU

waste containing greater than 0.1 Ci per package was buried in retrievable concrete containers. Since 1974, TRU waste containing greater than 10 nCi/g was stored on storage pads in galvanized drums and concrete containers. The waste can be retrieved intact for at least 20 years. The SRS has a sitewide policy that any material containing more than 10 nCi/g of transuranic radionuclides will be stored as TRU waste. Upon retrieval from the storage pads and repackaging in the Transuranic Waste Facility, waste packages will be classified as (1) 100 nCi/g or greater (disposal at WIPP) or (2) 10 to 100 nCi/g (Burial Ground Expansion).

As of December 1987, 10,400 m³ of stored and buried solid TRU waste had been placed in the Low-Level Waste Burial Ground. About 56% of the waste (5,860 m³) is in interim storage on concrete pads or buried in shallow trenches as retrievable TRU waste. About 44% (4,530 m³) is considered to be nonretrievable and will therefore remain buried in the Low-Level Waste Burial Ground (DOE-17).

Facilities for managing solid TRU waste will consist of a Waste Certification Facility and the Transuranic Waste Facility. Both are scheduled to begin operations in 1998. The Waste Certification Facility will serve to assay and certify that TRU waste meets acceptance criteria for disposal at WIPP. The Transuranic Waste Facility will provide facilities to compact, reduce, and repackage bulky waste and repackage TRU waste retrieved from storage pads and earth-covered trenches. In 1995, SRS is scheduled to begin shipping retrievable TRU waste to WIPP.

The SRS has produced approximately 650 m³ of TRU waste annually. Some of this TRU waste (more than 10 nCi/g of transuranics) is in interim storage (as retrievable TRU waste) awaiting eventual processing at the Transuranic Waste Facility. By 1995, an estimated 12,500 m³ of retrievable TRU waste will have accumulated in interim storage. The processing capacity at SRS for TRU waste destined for WIPP is estimated to be 1,100 m³/yr. In 2000, the Waste Certification Facility is expected to process 650 m³/yr of newly generated TRU waste and 450 m³/yr of retrievable TRU waste drawn from this interim storage inventory. This facility will operate near 100% capacity for about 20 years until the retrievable TRU waste in interim storage has all been processed. The Transuranic Waste Facility will process, compact, and repackage about 700 m³/yr out of the total of 1,100 m³/yr of TRU waste analyzed at the Waste Certification Facility. Ultimately, SRS will ship 650 m³/yr of TRU waste to WIPP, and 310 m³/yr of waste will be redesignated as LLW to be disposed of in the Burial Ground Expansion.

4.3.10.3 Low-Level Waste

Liquid LLW is generated by the operations of reactors and support facilities. Process effluents and accidental radioactive releases to secondary cooling water in the separations area and other nearby facilities are treated in the F- and H-Area Effluent Treatment Facility. Treated effluent is discharged to Upper Three Runs Creek via an NPDES-permitted outfall. The Effluent Treatment Facility is designed to treat 400,000 m³/yr. The treatment media (e.g., resins, filters, and flocculents) are disposed of as LLW.

Solid LLW is produced from facility operations and consists of such materials as equipment pieces, contaminated plastic sheeting, and protective clothing. Annual generation of solid LLW is expected to be approximately 47,000 m³ through 2000. Approximately 523,000 m³ of solid LLW has been placed in the Low-Level Waste Burial Ground. This volume represents about 95% of that facility's capacity. The Low-Level Waste Burial Ground is scheduled to be closed after 1991. The Burial Ground Expansion, a new facility expected to be operational in

1991, will contain below-grade concrete vaults and an above-grade metal building erected on a concrete pad for disposal of LLW.

The Consolidated Incineration Facility, planned to be operational in 1993, will be used for combustible solid and liquid LLW obtained at SRS. The projected volumes for these materials are 18,000 m³/yr, or about 60% of the incinerator facility's annual capacity. A volume reduction of about 20:1 is expected for the processed material. The obtained ash and fly ash will be grouted and disposed of in the underground Saltstone Disposal Vaults.

Substantial volumes of liquid LLW result from the processing of HLW at SRS. A supernate is extracted from this process and sent to the Z-Area Saltstone Facility. This facility is designed as an in-line process that combines cementlike grout solids with liquid LLW. The resultant slurry is pumped into near-surface vaults, where the material is allowed to harden in situ at the Saltstone Disposal Vaults. The baseline input to the Saltstone Facility is 32,000 m³/yr of liquid LLW. This volume represents 94% of the capacity of the Saltstone Facility. Thirty percent of this capacity utilization is attributable to newly generated liquid LLW and 64% to the processing of inventoried liquid HLW held at the Tank Farm. The Saltstone Facility will continue to run at near capacity (94%) until the inventory HLW at the Tank Farms is exhausted around 2010.

4.3.10.4 Mixed Waste and Hazardous Waste

The SRS facilities designed to treat and dispose of mixed waste include an interim storage complex called the Mixed Waste Storage Facility, the Waste Solidification and Disposal Facility (Y Area) (planned for 1995), the Consolidated Incineration Facility (planned for 1993), and the new Hazardous Waste/Mixed Waste Disposal Facility (planned for 1992). Currently, 1,900 m³ of solid and liquid mixed waste is contained in drums and large metal boxes stored at the Mixed Waste Storage Facility. Mixed waste is to be interim stored and permitted on-site at SRS until treatment or disposal facilities are built and permitted (DOE-17).

Future plans are to use the RCRA-permitted Hazardous Waste/Mixed Waste Disposal Facility for disposal when regulatory requirements are defined and met. The Mixed Waste Storage Facility will be closed when the new Hazardous Waste/Mixed Waste Disposal Facility becomes operational. The Waste Solidification and Disposal Facility (Y Area) will treat low-level mixed waste concentrate from the M Area effluent treatment facility and slurry from off-gas treatment. This waste will be grouted and placed in underground Saltstone Disposal Vaults at this facility. The generation rate of solidified mixed waste is projected to be 3000 m³/yr at this facility.

The Consolidated Incineration Facility is designed to treat combustible solid and liquid mixed waste and hazardous waste (except for PCBs) and will become operational for mixed waste when treatment standards are established. The bottom ash and fly ash would be disposed of as grout in disposal vaults at the Hazardous Waste/Mixed Waste Disposal Facility. The disposal volume of mixed waste after start-up of the Defense Waste Processing Facility will be 890 m³/yr at this facility. Current off-site shipments of hazardous, nonradioactive waste amount to about 85 m³/yr. These shipments will continue as necessary until the new Hazardous/Mixed Waste Disposal Facility is approved for treatment and disposal of these wastes.

A facility with RCRA-permitted vaults is planned for the new Hazardous Waste/Mixed Waste Disposal Facility, which is to be used for the permanent disposal of hazardous waste and mixed waste. More than 900 m³ of solid hazardous waste and mixed waste is expected to be generated annually by non-NPR facilities over the next 10 years. Implementation of waste reduction plans, especially chemical control programs, could substantially reduce the generation of hazardous and mixed waste at the site (Steven, Lee, and Reynolds 1991).

4.3.10.5 Other Waste

About 23,000 m³ of nonhazardous, nonradioactive solid waste (e.g., paper, plastics, and some types of rags) are disposed of annually in the Sanitary Landfill in G Area. This conventional landfill facility has ample room for expansion. About 1,100 m³ of sanitary sewage sludge derived from sewage treatment plant operations is disposed of annually in the Sanitary Sewage Sludge Disposal Pit in G Area. Liquid effluents from the sewage treatment plants are discharged to on-site streams and are regulated under NPDES permits. Liquid effluents from the Effluent Treatment Facilities, obtained from process operations, are discharged to on-site streams and are also regulated according to the NPDES permitting process. The sludge from these effluent treatment facilities is treated and disposed of as LLW at the Burial Ground Expansion. Cooling-tower blowdown (30,000,000 m³/yr) from the K reactor is discharged to on-site streams and is also regulated according to the NPDES permitting process.

4.3.10.6 Remedial Activities

Environmental measurement and surveillance programs have been maintained at SRS since 1951. Several types of remedial activities are either underway or are planned for the future (DOE-52; DOE-57). Not every type of remedial activity would impact the waste management facilities to be used in conjunction with NPR operations. At least two proposed remedial actions at SRS could affect the NPR project. Remedial actions to repair nonservicable tanks, which are now used for interim storage of HLW, could affect the site's ability to store these wastes or any newly generated HLW. A remedial action is planned to dig up retrievable TRU waste buried at the Low-Level Waste Burial Ground. This retrievable TRU waste would be transferred to the Transuranic Waste Facility at a rate compatible with the unused capacity of the facility. At that facility, drums would be repackaged, assayed, and certified at the Waste Certification Facility, and then shipped to WIPP. Storing this newly generated TRU waste on a temporary basis might be an acceptable alternative to disposing of it.

5 ENVIRONMENTAL CONSEQUENCES

5.1 INTRODUCTION

The NPR and its support facilities would affect the air, water, land, and people surrounding the site of construction and operations. Section 5 of this EIS describes the environmental consequences of the no-action alternative and those of siting, constructing, and operating the NPR and its support facilities at either Hanford, INEL, or SRS. (The environmental consequences of the programmatic alternatives were discussed in Section 2, and Section 3 describes the proposed NPR location at each site.)

As determined during the scoping period for this EIS, and as presented in the EIS Implementation Plan, the baseline environmental conditions and the no-action alternative for this EIS are based on the EIS for Continued Operation of K, L, and P Reactors at SRS (RO EIS) and assume operations of these reactors at 100% capacity until the year 2040. All the analyses of impacts for this EIS were performed on this basis. This assumption allowed the assessment in the consequences section of the NPR EIS of the greatest potential cumulative impacts of NPR from air emissions, water withdrawal and discharge, radiological releases from normal operations, employment, transportation, and waste management, in the absence of any stated DOE plans as to the operational schedule or lifetime of the existing SRS reactors.

The assumption of 100% operations allowed the establishment of an upper bound of reactor operations impacts at SRS below which the actual impacts of NPR plus existing reactors would fall. This is especially true for the estimation of cumulative impacts, where, for the time frame from 2000 to 2040, the specific number of reactors in production at SRS, the power levels, and the periods of operation to meet national requirements are uncertain.

On February 11, 1991, the Department of Energy issued a Record of Decision for the RO EIS which determined that P Reactor shall be placed in cold standby and K and L reactors remain operational. This decision would change the no-action and baseline assumptions with respect to operation of two reactors at 100% capacity until 2040 at SRS.

Due to the recent issuance of the RO ROD, the no-action alternative and environmental baseline, as well as the cumulative impact of NPR operations, still reflect the assumption of three operating existing SRS reactors. However, it is recognized that this assumption could possibly influence a comparison of impacts with respect to the no-action alternative (continued operation of K, L, and P reactors at SRS). Therefore, where a change in this assumption could lead to a substantially altered conclusion as to impact magnitude or significance, a discussion of these differences has been added.

The EIS assesses the impacts of an NPR complex capable of producing both tritium and weapons-grade plutonium. Assessment of NPR impacts on air quality; hydrology; cultural resources; biotic resources; socioeconomics; land use, recreation, and visual resources; and accidents from hazardous material and nonradiological transportation was based on dual production modes. In these cases, the impacts were bounded by assuming that facilities for both production modes were constructed and operated together. Radiological consequences of NPR operations were calculated separately for tritium and plutonium production modes. Only the radiological consequences and health risks from nonsevere and severe accidents for the tritium production mode are presented in the EIS because these impacts bound potential radiological

consequences and health risks from nonsevere and severe accidents for the plutonium production mode. The waste management consequences of NPR operations were assessed for the mode of operation that resulted in the largest quantity of wastes, mainly the plutonium mode, because the types and quantities of these wastes exceeded those for tritium production. Decontamination and decommissioning consequences were assessed separately for tritium production only, for tritium production with spent fuel processing, and for the combined tritium and plutonium production mode with spent fuel processing.

Detailed designs of alternative NPR technologies and support facilities have not been completed.* The assessments of environmental consequences presented here are based on generic designs and industry experience with similar, existing facilities. In cases where assessment of consequences relies upon detailed design information, reasonable estimates of potential effluents, emissions, and radiation exposures (source terms) were made on the basis of engineering judgment and the many years of experience with reactor operations in the United States. In cases where source terms are uncertain, a conservative approach was taken: the estimates resulting in the largest consequences were used to bound the calculated impacts. Thus, the impacts presented here should be viewed as upper limits on what could be expected if the calculations were based on more detailed designs.

Although this EIS is based on generic designs, the environmental consequences of construction and operation were assessed using detailed site-specific information. The same method was used to calculate any single effect for the alternative sites and technologies. Thus, even though the estimates of a particular type of impact at one site may represent an upper bound, the relative magnitude of that type of impact can be compared among sites and technologies. Where possible, the significance of comparisons of consequences among sites or technologies is discussed in this section. To provide the reader with a background for understanding the detailed consequences presented later, this section summarizes the ways the NPR and its support facilities might affect the environment and how such impacts were assessed.

Presented here for each area of impact assessment are background information, assessment method (including models), assumptions on which the assessment was based, uncertainties affecting the analysis, and interpretations (including those reflecting the regulatory framework) on which assessments of impact significance were based. Sections 5.2-5.4 present the results of the impact assessment.

5.1.1 Geology

Construction and operation of the NPR at any of the three alternative sites would not affect the large-scale geology of that site. Thus, no geologic impacts are presented in Sections 5.2-5.4. (Appendix D discusses the method and assumptions used in the geologic resource assessment.) However, the geologic suitability of the site for construction and foundation support, in terms of potential volcanic eruptions and earthquakes, could affect the cost of the NPR and its support facilities. The latter effects, although believed to be of low probability, might initiate waste tank or basin failures or radiological accidents. The design

*See Section 3 and Appendixes A-C for information concerning construction and operation of the alternative NPR technologies and their support facilities.

criteria for all NPR facilities require that they be able to withstand, with safe shutdown or minimal damage, earthquakes of any magnitude reasonably expected at the proposed sites on the basis of historical and geophysical data.

Sections 4.1.1, 4.2.1, and 4.3.1 discuss the seismic and volcanic conditions present at Hanford, INEL, and SRS, respectively. Sections 5.2-5.4 discuss the impacts of tank or basin failure accidents on groundwater and the radiological impacts of severe accidents at the reactor or its support facilities.

5.1.2 Air Resources and Noise

5.1.2.1 Air Quality

Background

Air pollutants would be emitted during NPR construction and operations. The principal sources of such emissions during construction of the NPR complex would include the following:

- Fugitive dust from land clearing, site preparation, excavation, wind erosion of exposed ground surfaces, and operation of a concrete batch plant.
- Exhaust from and road dust raised by construction equipment, vehicles delivering construction material, and vehicles carrying construction workers.

Air pollutant emission sources associated with NPR operations would include part or all of the following:

- Increased operation of existing boilers to generate additional steam for space heating.
- Operation of certain diesel generators and periodic testing of emergency diesel generators.
- Process operations at NPR support facilities.
- Exhaust from and road dust raised by vehicles delivering supplies and bringing employees to work.

Atmospheric transport and dispersion of air pollutant emissions from NPR facilities would result in increases in ambient concentrations of these pollutants at and in the area surrounding the NPR site.

The purpose of the air quality analysis was to estimate the potential increase in ambient concentrations of nonradiological air pollutants resulting from NPR-related emission sources and to assess any associated effects on human health and welfare. (The methodology used in the

assessment of impacts from radioactive emissions released to the atmosphere is described in Section 5.1.7.)

The air pollutants considered in this analysis include four criteria pollutants: sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), and particulate matter (PM₁₀) (particulate matter with aerodynamic diameter ≤ 10 μm). Total suspended particulate matter (TSP) was also considered. Six toxic air pollutants that would be used and released by NPR support facility processes also were considered: acetone (C₃H₆O), ammonia (NH₃), Freon-113, nitric acid (HNO₃), 1,1,1-trichloroethane (TCA), and trichloroethylene (TCE).

The two remaining criteria pollutants, ozone (O₃) and lead (lead particulate matter, or Pb PM), were not considered in the analysis. Ozone was not considered because high ambient concentrations of ozone are a regional problem primarily associated with areas within and downwind of large metropolitan areas. NPR activities would not contribute a quantitatively measurable level of ozone at any of the sites. Lead was not considered because ambient lead concentrations are no longer a major issue, even in large metropolitan areas (ambient lead concentrations have been declining steadily since 1975, when the use of unleaded gasoline in automobiles was first required). NPR-related vehicles are assumed to use unleaded gasoline; there are no other NPR emissions of lead.

Method and Assumptions

For the analysis of the ambient air quality impacts of emissions stemming from construction and operation of the NPR and its support facilities, inventories of air pollutant emissions were developed for each site for three periods: the baseline preconstruction period, the NPR construction period, and the NPR operational period. Then, air pollutant dispersion models were used to estimate the ambient air pollutant concentrations due to these emissions for each of the three periods. The differences between the baseline period and the construction or operational period would indicate the air quality impacts of the NPR complex.

Emission inventories for stationary sources and mobile construction equipment were developed using two types of sources: the U.S. Environmental Protection Agency's (EPA's) Compilation of Air Pollutant Emission Factors (EPA-7) and the design capacity and/or operating schedule of emission sources such as facilities, equipment, processes and other activities described in the generic and site-specific NPR design documents (EG&G-2; EG&G-6; EG&G-7; WHC-3; WHC-4; WHC-6 through -9; WSRC-2; WSRC-4 through -6; WSRC-13; WSRC-14). When available, site-specific measurement or design emission data were used.

Emission inventories for mobile sources other than construction equipment were developed using the EPA's Mobile 4 emission factors for carbon monoxide, nitrogen oxides, and hydrocarbons (EPA-8); the EPA's size-specific particulate emission factors for mobile sources (EPA-9); the EPA's road dust emission factors (EPA-7); and data on average daily traffic volume derived from the projected vehicle-miles-traveled data for the baseline, construction, and operational periods (the traffic data were based on the estimated population increases given in Sections 5.2.8, 5.3.8 and 5.4.8).

Two computer codes were used for analyzing air quality impacts of the baseline, construction, and operational emissions: the Industrial Source Complex - Short Term (ISCST) model (EPA-3), recommended by EPA for stationary point and area sources, and the CALINE3

model (CASDT 1979), developed for line sources by the California State Department of Transportation for the Federal Highway Administration.

During the construction period, the NPR-related emission rates for air pollutants would vary depending on the construction activities. During the operational period, emission rates would change according to the mode of operation (tritium or plutonium production) and the level of capacity utilization. To be conservative in the air quality impact analysis, the maximum emission rates were assumed: these maximum emission rates were assumed to be those in the peak year of construction and those during full-capacity operations. If emission rates were different for plutonium and tritium production, the higher of the two emission rates was chosen.

Uncertainties

The performance of the ISCST model has not been validated with field data. However, it is an extended version of a single-stack model (CRSTER) that has been examined using field data from four large power plants (EPA-10). The ISCST model predicted the upper percentile of the frequency distribution of 1-hour concentrations and of the corresponding distributions of 24-hour concentrations in acceptably good agreement with the measurements. Concentrations over the remainder of the frequency distributions were significantly underpredicted (see Appendix E).

The CALINE3 model was validated using field data from one location in Michigan and two locations in California (CASDT 1979). The validation study concluded that the model can reliably predict pollutant concentrations for receptors located within 150 m of the roadway, given source strength, meteorology, site geometry, and site characteristics (see Appendix E).

Interpretations and Regulatory Framework

The national primary and secondary ambient air quality standards were established under the Clean Air Act. The primary standards were established to protect the public health with an adequate margin of safety and the secondary standards to protect the public welfare from any known or anticipated adverse effects of a pollutant. National standards have been established for six criteria air pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, particulate matter, and lead (see Appendix E).

Ambient air quality standards also have been established by the individual states, and most are equivalent to the corresponding national standards. However, some state standards are more stringent than the corresponding national standards and others cover additional pollutants. Ambient standards for toxic air pollutants (primarily organic compounds) have been established by Washington state (WDOE-1), and proposed by the states of Idaho (IDHW 1990), and South Carolina (SCDHEC-3). (See Appendix E, Tables E.2, E.26, and E.31 for more information on state standards for toxic pollutants emitted by an NPR.)

The air quality impacts of the NPR and its support facilities would be considered significant if emissions during construction or operation resulted in (1) ambient concentrations of any criteria pollutant exceeding the national or state standard at the site boundary or public-access highways or (2) ambient concentration increases exceeding the Prevention of Significant Deterioration increments (see Appendix E). An impact may also be significant if

concentrations approach a National Ambient Air Quality Standard (NAAQS) or consume a large percentage of an available increment. Air quality impacts from toxic air pollutants would be significant if the ambient concentrations at the site boundary or public-access highways exceeded established or proposed state standards as a result of contributions from NPR process emissions.

5.1.2.2 Cooling Towers

Background

Waste heat generated from NPR operations would be dissipated through the use of mechanical-draft, wet cooling towers for all technologies at all sites. At INEL for the MHTGR technology, dry cooling towers have been proposed as an alternative to reduce potential environmental impacts from constructing and operating one or more blowdown evaporation ponds necessary for wet cooling tower operations. The cooling towers are described in Section 3.

The analysis focused on determining the following environmental impacts of the operation of the NPR cooling towers: visible plume (visual impact), plume-induced fogging and rime icing at ground level (safety impact), drift-related salt* deposition (impact on vegetation), glaze-ice formation during operation of wet cooling towers (safety impact), and cloud formation at high altitudes during operation of dry cooling towers (visual impact).

Method and Assumptions

The potential environmental impacts of the cooling tower emissions of water vapor and drift droplets were analyzed using the Seasonal/Annual Cooling Tower Impacts (SACTI) model licensed by the Electric Power Research Institute (EPRI) (Policastro, Coke, and Wastag 1984; Dunn, Coke, and Policastro 1987). Cooling-tower design and operating parameters and one to five years of hourly meteorological data were used as input data to the model. The meteorological data used were either on-site data or data from a nearby National Weather Service station. For analyzing the potential environmental impacts of thermal discharges, worst-case conditions were assumed: full-power operation of the HWR and full-power operation of the LWR and MHTGR without production of electricity.

Uncertainties

The performance of the ISTST model has been evaluated with field data for its point source submodel (EPA-10; Bowne and Longran 1983, 1985; Murray and Bowne 1988) and for its special features, such as gravitational settling/dry deposition option (Bowers and Anderson 1981; Bowers, Anderson, and Hargraves 1982) and building downwash option (Bowers and Anderson 1981; Schulman and Hanna 1986). The point source model predicted the upper percentile of the

*Salt means the total dissolved solids in the drift droplets, the concentration of which is the same as that for the circulating water flow. The salt composition is similar to that of the makeup water, although several times more concentrated, and may include additional sulfate and chlorine or chloride originating from the sulfuric acid and chlorine used to control scale and biological growth.

frequency distribution of 1-hour concentrations and of the corresponding distributions of 24-hour concentrations in acceptably good agreement with the measurements. Concentrations over the remainder of the frequency distributed were significantly underpredicted (EPA-10) (see Appendix E for further details).

Interpretation

Regulatory standards or limitations related to environmental impacts of cooling tower operations have not been established. Ground fogging and rime icing in the immediate vicinity of the NPR cooling towers would be considered a minor impact. However, any increases in ground fogging and icing along public highways within or beyond the site boundary would be considered a significant impact due to the driving hazards created by these conditions. The significance of visible plume and drift salt deposition is discussed in Sections 5.1.4 and 5.1.5, respectively. Thermal impacts are discussed in Sections 5.2.4 and 5.4.4.

5.1.2.3 Noise

Background

The sources of noise during NPR construction would be heavy-construction equipment, explosives, and increased traffic. Increased traffic would occur at Hanford, INEL, or SRS and along major transportation routes used to bring construction material and workers to the NPR site. During operation of the NPR and its support facilities, the major new sources of noise would include cooling towers, diesel engines, and transformers. Other new noise sources could include some or all of the following: turbines, pumps, fans, motors, steam vents, and paging systems.

Propagation of the noise from these sources could increase environmental noise levels at sensitive locations outside the boundaries of Hanford, INEL, or SRS and near the major transportation routes leading to the proposed NPR sites. Potential impacts of such increases in noise level would range from simple annoyance to speech and sleep interference.

Blasting of basalt for excavation at INEL would generate a stress wave in the surrounding rock, causing vibration of ground and structures on the ground surface. The blasting also would create a compressional wave in the air (airblast overpressure), the audible portion of which would be manifested as noise. Potential impacts of ground vibration include damage to structures such as window breakage. Potential impacts of blast noise include effects on humans and animals. The purpose of the noise analysis was to estimate the potential increases in ambient noise levels, ground vibration, and airblast overpressure and to assess any environmental impacts associated with such increases.

Method and Assumptions

For the analysis of ambient impacts of noise from NPR activities, inventories of noise sources were first developed for the NPR construction and operational periods, and then the ambient increases in noise levels due to these sources were estimated using noise-propagation models.

The noise-source inventories for stationary sources and construction equipment were developed using (1) the noise-source sound-power-level data and formulas from the Edison Electric Institute's Environmental Noise Guide (Bolt, Beranek, and Newman 1984) or the equipment manufacturer's measurement data and (2) the type, number, design capacity, and operating schedule of facilities, machines, equipment, and other activities described in the generic and site-specific NPR design documents (EG&G-2; EG&G-6; EG&G-7; WHC-3; WHC-4; WHC-6 through -9; WSRC-2; WSRC-4 through -6; WSRC-13 and -14). Data on traffic volume along the major roadways leading to the alternative NPR sites, needed for traffic-induced noise modeling, were derived from the projected vehicle-miles-traveled data along these roadways (the traffic data were based on the estimated population increases given in Sections 5.2.8, 5.3.8, and 5.4.8).

Two computer codes were used to estimate the noise-level increases at receptor locations: the Environmental Noise Model (ENM 1.2) for stationary sources and sources such as construction equipment at a construction site (Tonin 1985; RTA 1989) and the Federal Highway Administration's Highway Noise Prediction Model (STAMINA) for highway traffic (FHWA-1 through -3). Noise impact analysis was performed to identify any mitigative measures that might be required to protect human health or welfare as directed by the Noise Control Act of 1972 and as codified in state and local noise standards. To assess the potential impacts of noise-level increases in terms of responses from communities and sensitive receptors, the classification of annoyance provided in the Composite Noise Rating (CNR) model and the Individual Annoyance Prediction (IAP) model were used (see Appendix E).

To be conservative in noise impact analysis, the maximum levels of noise were assumed for both the construction and operational periods, that is, the simultaneous operation of all identified major noise sources at the NPR site, and the traffic noise-emission levels corresponding to the peak construction and normal operational periods.

Analyses of potential impacts of ground vibration and airblast overpressure caused by blasting were made using empirical relationships established among indicators of these phenomena, charge weight per delay,* and the distance between the blast and receptor. The ground vibration was analyzed in terms of peak particle velocity (PPV), or how fast the ground moves, which is generally accepted as the best indicator for the potential for structural damage. A monograph available in Rose (1981) that relates PPV, charge weight per delay and the distance between the blast and receptor was used to estimate potential vibration impacts. Potential impacts of airblast overpressure were estimated using the empirical relationships described by the Construction Engineering Research Laboratory of the U.S. Army Corps of Engineers (Schomer 1973; Schomer et al. 1981), which relate peak overpressure, charge weight per delay, charge depth, time delay, and the distance between the blast and receptor. A range of values

*Blasting is commonly done in sequences using delays, so that for any given delay, only a portion of the total explosive charge is set off so as to limit potential impact to that of the portion rather than the total.

for charge weight and charge depth, and a typical value for delay time were assumed for analyzing the potential impacts (Appendix E). In actual blasting, the charge weight per delay and other parameters would be adjusted to fit observed field conditions to keep peak particle velocity below the levels that cause damage to nearby structures.

5.1.3 Water Resources

Impacts to water resources from construction and operation of NPR facilities would arise from the withdrawal of water from and the discharge of effluents to surface waters and groundwaters. In addition, construction of facilities in the floodplain of a stream or river could potentially modify water flow during flood conditions.

The water quality analysis assessed several impacts to surface waters from NPR construction and operations: changes in river and stream flow from NPR withdrawals and discharges, changes in water quality due to NPR activities, effects of construction on floodplains, and changes in availability of water for other users. Several impacts to groundwaters from NPR construction and operations were also assessed: changes in groundwater level and quality and changes in availability of groundwater for other users. Effects on surface water rights and groundwater rights also were evaluated.

Supporting the NPR operations would be several large water storage or evaporation ponds. If the impermeable barriers lining these ponds were to fail completely or partially during an event such as an earthquake, the release of this water might affect surface waters or groundwaters. Thus, this analysis evaluates the impact of hydrological accidents to determine whether they could have significant impacts on water resources.

5.1.3.1 Surface Water

Potential NPR impacts to surface water flow were analyzed to determine if the combined consumptive use of water (withdrawal minus discharge) would produce a measurable effect on the quantity of water flowing in streams and rivers. This flow may be necessary to support fish and wildlife populations and the requirements of other water users; minimum water flows may be established by regulatory agencies or planning groups to protect water resources and water users. Anticipated changes in flow due to the NPR were expressed as a percentage of minimum flow of the receiving waters. Water use for full-power operations of both the reactor and support facilities was used as the basis for the assessment. The impacts to surface water flow would be considered significant if the predicted changes in flow were perceptible.

Liquid discharges from NPR construction and operations, as well as erosion of construction areas, could affect the water quality of nearby streams and rivers. Water returned from cooling tower operations (called "blowdown") would contain elevated concentrations of chemicals present in the original water withdrawn for cooling; it would also contain any chemicals added to control scaling or biological growth in the towers and trace amounts of radionuclides that had diffused into the cooling water system. If sanitary wastes were treated and released to surface waters, water quality could be affected. In order to assess the water quality impacts of pollutant discharge, estimates were made of the dilution that would occur when the pollutants were mixed with the minimum flow of the receiving water body. Drinking water standards, or other standards derived from classification of surface waters by state

agencies, were used to determine whether the discharges, when diluted, were incompatible with applicable standards.

Construction of NPR facilities on a floodplain, including a streambed, would require permits from the Army Corps of Engineers under the Clean Water Act and, perhaps, the Rivers and Harbors Appropriations Act (see Section 6). In addition, Executive Order 11988 (Floodplain Management) requires assessment of potential effects on flood hazards, floodplain management, and avoidance of impact to floodplains. The floodplain assessment in this EIS determined whether any new NPR facilities would be constructed on floodplains. If so, the potential for these facilities to constrict floodwater flow or create flood hazards was assessed and the required mitigation measures identified.

If consumptive use of water by NPR facilities were to measurably affect surface water flow or impact minimum flow requirements, other downstream water users might be adversely affected. Any case where NPR construction or operations would cause river flow to fall below regulated minimum requirements would be identified as a significant impact.

5.1.3.2 Groundwater

The potential effects on groundwater levels of NPR facilities withdrawing water from or discharging effluents to groundwaters were determined by estimating potential changes in those levels. Because there is some resistance to water movement in an aquifer, water withdrawal creates a "cone of depression" in which water levels are depressed to the greatest extent at the well and to a lesser extent with increasing distance from the well. Likewise, discharge to the groundwater causes groundwater "mounds" in which water levels are elevated at the site of discharge and decrease with increased distance from the discharge site. Because, like at the surface, water in the ground flows from high points to low points, water levels indicate the direction of water flow in the aquifer. In addition, changes in water level not related to a well's pumping are an indication of possible reduced water yields.

The consequences of water withdrawal depend not only on pumping and discharge rates but also on the ease with which water moves through the aquifer (called hydraulic conductivity), the thickness and lateral extent of the aquifer, the ability of the aquifer to store water (called storativity), and the rate at which aquifer water is replaced (called recharge). Because these characteristics may vary greatly from place to place within an aquifer, assessment of consequences required use of a mathematical model that includes this variability. Hanford, INEL, and SRS each have developed such a hydrological model for their sites, and these models were used for the NPR analysis.

The significance of water level impacts was evaluated on the basis of whether water level would change on-site as well as at the boundaries of Hanford, INEL, or SRS, and whether such a change could affect off-site springs or off-site well yields. Discharges of water to the ground might also cause groundwater mounding, and if such mounding was great, change the direction of groundwater flow. Pumping could also change the direction of groundwater flow by removing the effects of mounding. The significance of changes in the direction of groundwater flow depends on the effect of the flow changes on existing groundwater contamination. Decreases in the spread of contaminated groundwater would be a significant beneficial impact, while increases in the spread of contaminated groundwater would be a

significant adverse impact. Changes in the direction of flow that would not affect the spread of contaminated groundwater would not be considered significant.

Groundwater quality was evaluated as well. Under certain conditions, water discharged to the ground from NPR facilities could infiltrate through the unsaturated zone and into the groundwater. It is important to determine whether any contaminants in water discharged to the ground would affect groundwater quality. In this analysis, water was considered to be contaminated, a significant impact, if the discharge could not meet drinking water standards for dissolved substances, including radionuclides. If it would be possible for contaminated discharges to reach the groundwater, then the site-specific hydrological model was used to determine the direction and speed of flow.

Groundwater use could be affected if groundwater levels were significantly decreased beyond the boundaries of Hanford, INEL, or SRS. The significance of groundwater level decreases is assessed by comparing the decreases to the thickness of the aquifer affected.

5.1.3.3 Water Rights

Hanford, INEL, and SRS each maintain Federally reserved water rights with respect to either surface-water or groundwater flow. As a matter of comity, some of these sites negotiate water requirements with the state. The assessment of NPR impacts to water rights determined whether the water requirements for any of the alternative reactor technologies would require new water rights negotiations. If so, the water rights impact would be considered significant.

5.1.3.4 Hydrologic Accidents

The primary concern with hydrologic accidents is whether groundwater or surface water flow or quality would be affected. Thus the method used for these assessments was comparable to that described in Section 5.1.3.2. It was assumed that any leakage or failure of large water storage basins would occur at their bottoms, which would be below grade, and that water would be discharged to the ground. Thus, only impacts to groundwaters were assessed in this analysis.

5.1.4 Land Use, Recreation, and Visual Environment

The purpose of an assessment of land use for construction and operation of a major facility like the NPR complex is to determine if current land uses or land use patterns would be affected. Such a change might constitute a significant environmental impact if existing uses of the land were prevented by the new facility. Land use changes also might be significant if a new use of the land were proposed, such as a change from residential to industrial use.

Potential impacts to recreation associated with NPR construction and normal operations could include conversion of recreational land to other uses or increased use of recreational facilities due to the in-migration of workers. For the purposes of this EIS, impacts to recreation cannot be quantified. However, any impact that would preclude a recreational activity would be considered significant.

Reactors and their associated facilities are significant physical structures. In addition, the plumes of steam from cooling towers could be visible for a considerable distance. If such facilities were built by themselves on an otherwise unobstructed open plain, they would be highly visible. However, the significance of the impact would depend on several factors, including visual classifications by land management agencies; views from parks, highways, and recreation areas; and compatibility with similar views in the area.

5.1.5 Biotic Resources

The assessment of impacts to biotic resources included separate analyses for terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. These divisions are based on similarity of form (terrestrial resources, aquatic resources, and wetlands) and regulatory status (wetlands and threatened and endangered species).

5.1.5.1 Terrestrial Resources

Impacts of NPR construction to terrestrial resources would be largely related to the clearing and grading of land that would occur before actual construction. Such disturbance would destroy plants and some animals (such as invertebrates, amphibians, reptiles, and small mammals) that are present within construction areas. Assessment of the magnitude of construction impacts requires a determination of the land area that would be disturbed, the land area that would be occupied by NPR facilities, the relative availability of habitats that would be disturbed, and the regional importance of the biotic resources within construction areas. These factors were examined to determine if the viability of affected plant and animal populations would be threatened.

Impacts to terrestrial resources from NPR operations would result from facility emissions, including salts deposited from cooling-tower drift (see Section 5.1.2) and radionuclides emitted to the air. Previous studies indicate that the threshold for development of visible stress symptoms on sensitive plant species due to salt deposition is approximately 17.1 kg/ha-mo of sodium chloride (DOE-20), and this threshold value was used to determine if plants would be adversely affected. Terrestrial animals in the vicinity of the NPR complex would receive approximately the same external radiation doses as those calculated for humans (see Section 5.1.7). The analyses for human radiological dose are used for terrestrial organisms because the organisms of concern (wildlife) are reported to have approximately the same sensitivity to radiation as humans (NRC-8).

5.1.5.2 Wetlands

Wetlands receive legal protection under Executive Order 11990 (Protection of Wetlands), which requires that a wetlands assessment be prepared for all projects that have the potential to affect wetlands. Projects affecting wetlands also require a permit from the U.S. Army Corps of Engineers under the Clean Water Act.

In assessing the impacts of NPR construction activities on wetlands, both direct and indirect effects were examined. Direct effects would be limited to physical disturbance of wetlands during construction (such as dredging or filling), whereas indirect effects would occur

if unprotected soils eroded into adjacent wetlands and adversely affected hydrological and ecological conditions there. The significance of these impacts depends on the extent of construction activities within the wetlands, whether or not facilities would be located within wetlands, the proximity and extent of land disturbance adjacent to wetlands, and the effectiveness of erosion control methods.

Impacts to wetlands from NPR operations could result from salt deposition from cooling-tower drift and from radionuclide emissions. The methods used to assess these effects were similar to those described for terrestrial resources (airborne emissions) and aquatic resources (liquid emissions). In addition, riparian wetlands (those located along streams or rivers) could be affected by changes in water flow rates resulting from cooling water withdrawal or discharge. To assess these effects, predicted flow rates during NPR operations were compared to natural flow rates (see Section 5.1.3).

5.1.5.3 Aquatic Resources

Direct and indirect effects of NPR construction on aquatic resources are assessed as they are for wetlands. Direct effects would result from construction within water bodies, whereas indirect effects would result from erosion of unprotected soils on construction areas. Such erosion can cause increased rates of sedimentation within adjacent water bodies as well as increased levels of turbidity. Both of these factors could degrade water quality and adversely affect aquatic organisms. The magnitude of direct and indirect effects on aquatic resources depends on the extent of construction activities within aquatic systems, whether or not structures within these systems would impede natural flows, the proximity and extent of land disturbance adjacent to aquatic resources, and the effectiveness of erosion control methods.

Impacts to aquatic resources from NPR operations could result from the following:

- Salt deposition from cooling-tower drift.
- Alterations in flow due to withdrawal and discharge of cooling water.
- Impingement and entrainment of aquatic organisms during cooling-water withdrawals.
- Increases in water temperature due to the release of relatively warm cooling water.
- Release of radionuclides and other contaminants in cooling water effluents.

Each of these effects was considered separately. The procedure used to assess the effects of salt deposition on terrestrial resources was also applied to aquatic resources. The effects of changes in flow rates were assessed by comparing withdrawal and discharge rates to natural flows.

Impingement (an organism, such as a fish, being pinned against a water intake structure by inflowing current) and entrainment (an organism, such as larvae or fish eggs, being drawn into a water intake structure by inflowing current) could affect aquatic resources if such losses affected the viability of species populations or the structure of ecological communities. The

likelihood of impingement and entrainment of a species is related to a number of factors, including where the species lives in the water column (for example, planktonic or benthic) relative to the location of the intake structure, location of the intake structure relative to areas where organisms concentrate, method of screening the intake structure, intake velocity, and volume of water withdrawn (Rochester, Lloyd, and Farr 1984; Stull et al. 1987; Wike et al. 1989). To determine the importance of potential impingement and entrainment losses due to NPR facilities, estimated values were compared to previously documented rates of impingement and entrainment at similar facilities and their effects on populations of aquatic species (WPPSS-2; Wike et al. 1989).

The discharge of relatively warm water to streams and rivers adjacent to the NPR complex could adversely affect aquatic organisms habituated to the ambient water temperature. The effects of this discharge were assessed by comparing (1) the differential between ambient stream temperatures and effluent temperatures at different seasons, (2) the size or length of the stream that would experience elevated temperatures and the ability of sensitive organisms to avoid affected areas, and (3) the thermal tolerance of fish species in the discharge area.

Some aquatic organisms could be at greater risk than humans to the effects of radionuclides because these organisms would spend some percentage of their time within the discharge area, where radionuclide concentrations would be highest. A conservative approach was used to assess the effects of radionuclide exposure on aquatic organisms. The first step in calculating the dose to a maximally exposed organism (i.e., one that spends all of its time within the contaminated effluent) was to determine the concentration of radionuclides within the discharge area (including existing concentrations of radionuclides). These concentrations then were used to calculate the concentration within the organism by taking into account bioaccumulation within the organism (NRC-9; Till and Meyer 1983). Concentrations were converted to dose using conversion factors presented by ICRP (1983). Total calculated doses were then compared to the dose limit of 1,000 mrad/day established in DOE Order 5400.5 for the protection of native aquatic organisms.

5.1.5.4 Threatened and Endangered Species

Federally listed threatened and endangered species receive legal protection under the Endangered Species Act (see Section 6), which establishes a protocol for consultations between the U.S. Fish and Wildlife Service (FWS), or the National Marine Fisheries Service (NMFS) in the case of listed marine species, and the initiating agency (in this case, DOE). The DOE is required to request a species list and prepare a biological assessment examining impacts to proposed and listed species and critical habitats identified by the FWS or NMFS during initial consultations with the FWS. Formal consultation with the FWS (or NMFS) would be required if such an assessment determined that the proposed action might affect listed species or critical habitat. Using the information gained during formal consultations, the FWS (or NMFS) issues a biological opinion on the effects of the proposed action. Biological assessments that concluded that no significant impacts would occur to Federally listed species have been submitted to the FWS regional offices for the three alternative sites and to NMFS for Hanford and SRS (DOE-68; NUS-6; Reynolds 1990). These biological assessments are currently being evaluated by these agencies and will serve as the basis for the issuance of a Biological Opinion. Results of consultations, including the Biological Opinion, will be included in the final EIS.

In addition to Federally listed species, state-listed species and species that are candidates for listing by the Federal or state governments were considered in this EIS. These species do not receive legal protection under the Endangered Species Act or under state law on Federal property, but they were considered here because of their rarity or regional importance. In addition, changes in the status of these species is conceivable prior to construction of the NPR. If these species were to become listed over this time period, consultations with the FWS (or NMFS) would be required, and thus consideration of these species at this time is a conservative approach.

Impacts to threatened and endangered species from NPR construction and operations were assessed in the same manner as impacts to other terrestrial and aquatic species. Potential impacts considered include disturbance of habitats or resources used by these species, mortality of organisms present within construction areas, effects of impingement and entrainment of organisms at water intake structures, effects of water withdrawal and discharge rates on environments used by these species, and effects of effluents (such as radionuclides, heat, and cooling-tower drift) released to environments used by these species.

5.1.6 Cultural Resources

Cultural resources include any physical relics or remains that may be significant to the history of an area. In general, for a major construction project, the concern begins with ensuring recovery of items ranging from ancient, paleontologically interesting material (such as fossils) to structures dating from early in this century. Generally, before construction can begin, such resources, or the potential for finding them, is identified. Procedures for dealing with any cultural resources that might be affected by construction are discussed with the state historical preservation officer, the (Federal) Advisory Council on Historic Preservation, and Native American tribes, groups, and individuals. Formal agreements are made to ensure that no significant historical resources are destroyed or lost. The present status of site developments along these lines is presented as part of the assessment in Sections 5.2-5.4.

5.1.7 Radiological Impacts

All reactors generate and contain large amounts of radioactivity. The greatest concern of NPR designers is to produce a design that minimizes the release of this radioactivity either during normal operations or during and after any conceivable accident. Accident conditions are, by design, to be made as improbable as is technically feasible. In addition, extensive operator training would be a critical part of plant start-up and operations.

This EIS analyzes the radiological consequences of impacts from normal operations and conceivable accidents. The results of this impact assessment are presented in Sections 5.2.6, 5.3.6, and 5.4.6; the assessment methods are described here.

5.1.7.1 Normal Operations

Background

During normal operations of the NPR and its support facilities, small quantities of radioactive material would be released to the environment in gaseous and liquid effluents. The radioactive materials could consist of fission products (materials resulting from the nuclear fission process) and activation products (materials formed by neutron irradiation of targets, fuel, structural materials, coolants, and the atmosphere within a reactor containment building).

The types and quantities of radionuclides released would depend on the reactor technology, the type of facility, and whether tritium or plutonium were being produced. These radioactive materials would be a source of potential exposure to persons working and living in the area surrounding the facility. In calculating the radiological impacts to the surrounding population from normal operations of NPR facilities, annual releases of radioactive material to the atmosphere or surface water are referred to as normal operation "source terms."

The methods used to estimate projected doses from normal operations of the NPR and its support facilities and their estimated biological impact are discussed here. Appendix H contains additional information about the nature of radiation, its interaction with matter, and methods used to estimate radiation doses and their biological effects.

Method

Radiological impacts from normal operations were estimated for three types of individuals and groups:

- The maximally exposed off-site individual (a hypothetical individual whose location and ingestion and inhalation characteristics would represent an upper bound on an individual's dose).
- The population projected to be within 80 km of an NPR facility in the year 2020.
- The in-plant workers, who are assumed to be working in the building from which the environmental release occurs.

The year 2020 was selected because it is the projected mid-life of NPR facilities and the projected population in that year is considered to be an average for the operating life of these facilities.

Off-site Impacts. Off-site radiological impacts were estimated using the GENII computer code (Napier et al. 1988; Rhoads 1990), which is described in detail in Appendix H. The basic input to GENII is a list of the types and amounts of radionuclides released to the environment. Based on historical meteorological records (for 5 years), GENII then calculates the expected concentrations of radionuclides in 16 directions from the point of emission, in a series of concentric circles, out to a distance of 80 km. The code takes into account the height of the

emission point above ground level as well as structures in the emission area, radioactive decay of the specific radionuclides, and other appropriate factors.

GENII then calculates the quantities of specific radionuclides that would be deposited in each of the 16 sectors and that could result in human exposure by various pathways. It then calculates the radiation doses to the entire population in all 16 sectors (population estimates for each sector are part of the input to GENII) and identifies the dose for the maximally exposed off-site individual.

To convert doses, which are expressed in terms of rem and person-rem, to health effects, the doses were multiplied by risk model factors recommended by the EPA (EPA-4). The incremental lifetime risk of a cancer fatality to an individual, or the number of incremental cancer fatalities in a population, following radiation exposure was estimated by multiplying the appropriate doses by the risk factor of 4.0×10^{-4} cancer fatality/person-rem (the factor recommended by EPA).^{*} The risk of severe genetic effects was estimated by multiplying the appropriate doses by 2.6×10^{-4} genetic effect/person-rem (again, the EPA factor). Severe genetic effects are defined as those resulting in severe physical malformations or mental retardation in the offspring or the ensuing generations of the individuals who are exposed.

The BEIR V report is the fifth in a series of National Research Council committee reports on the biological effects of ionizing radiation (National Research Council 1990). The DOE is evaluating this report and its implications for DOE operations and standards; similar evaluations are being performed by national and international radiation-protection organizations. The mean value given by the BEIR V committee for increased cancer fatalities resulting from an acute whole-body dose of 10 rem to 100,000 individuals (that is, 1,000,000 person-rem) is about 785 fatalities (760 for males and 810 for females), or about 7.9×10^{-4} cancer fatality/person-rem. The BEIR V report also indicates that "for low LET (linear energy transfer) radiation, accumulation of the same dose over weeks or months, however, is expected to reduce the lifetime risk appreciably, possibly by a factor of 2 or more." The risk factor of 4×10^{-4} cancer fatality/person-rem used in this EIS for releases of radioactive materials from normal operations is consistent with the BEIR V findings.

The BEIR V estimate of total genetic risk at equilibrium is 100-200 additional cases/million live births/rem/generation. This is roughly $1-2 \times 10^{-4}$ genetic effect/person-rem/generation. The factor used in this EIS is 2.6×10^{-4} genetic effect/person-rem for all generations. As stated by the BEIR V committee, the genetic risk factors are highly uncertain, and the committee recommends that further studies be conducted. In light of these uncertainties, the genetic risk factors used herein and the BEIR V committee's recommended values are consistent.

Impacts to In-plant Workers. In-plant workers can be exposed to radiation during activities such as operation of the plant, in-service inspection, maintenance, target changeout, and waste handling. In general, dose estimates for in-plant NPR workers were based on (1) experience in operating facilities at Hanford, INEL, and SRS; (2) industry experience in operating facilities equivalent in size and complexity to the NPR and its support facilities;

^{*}Scientific notation is used here to express very small values. In scientific notation, $1.0 \times 10^{-4} = 0.00010$.

(3) standards for protection against radiation; (4) expected NPR facility staffing; and (5) the as-low-as-reasonably-achievable (ALARA) policy. As would be expected under actual conditions, this assumes that most of the in-plant worker doses are due to external exposure with little or no internal exposure due to food ingestion. For the purpose of estimating the radiation exposure of in-plant workers, it is assumed that a reactor design (but not a support facility design) is independent of its potential location. Thus, dose estimates for in-plant workers at an LWR at Hanford, an MHTGR at INEL, and an HWR at SRS are assumed to apply to each alternative site.

Radiological Standards

The radiological impacts of all NPR facilities must be within the limits specified by applicable DOE and EPA standards. The DOE requires that the total exposure to members of the general public from all routine DOE activities not cause an effective dose equivalent from all pathways greater than 0.1 rem/yr (DOE-50). Two EPA standards are applicable to specific exposure pathways. One, a national emission standard for hazardous air pollutants pursuant to the Clean Air Act, requires that radionuclide emissions to the ambient air from DOE facilities not exceed amounts that would cause any member of the public to receive, in any year, an effective dose equivalent of 0.01 rem (EPA-7). The other EPA standard, a maximum contaminant level pursuant to the Safe Drinking Water Act, requires that the average annual concentration of beta particle and photon radioactivity from manmade radionuclides in community drinking water systems not produce an annual dose equivalent to the total body or any internal organ greater than 0.004 rem/yr (EPA-5). The DOE occupational standard requires that no worker be exposed to a dose exceeding 5 rem/yr* (DOE-47).

The Clean Air Act and Safe Drinking Water Act standards are dose rates, expressed as rem per year. The doses calculated for this EIS are estimated doses from 1 year of normal operations, and they include internal committed doses that accrue over 50 years. Therefore, a precise comparison between the calculated doses from 1 year of normal operations and those two standards is not made. However, it is conservative to assume the two quantities are equivalent when comparing the annual standards with the calculated 50-year doses from 1 year of normal NPR operations.

Mitigative Actions

The NPR facilities would be designed to limit radionuclide releases during normal operations to ALARA levels. Thus, additional mitigative actions for normal operations of the proposed facilities would not be necessary. The facility effluents and the site and its vicinity would be closely monitored to ensure that radiation doses to human populations and the environment would be minimized and remain within acceptable limits.

*Based on recommendations of the International Commission on Radiation Protection, regulatory agencies are considering changing this limit to 2 rem/yr.

5.1.7.2 Postulated Nonsevere Accidents

Background

The term "nonsevere accident" is used in this EIS to denote a class of postulated accidents that are traditionally known as design-basis accidents (DBAs), which are the types of accidents that nuclear facilities are designed to withstand. Therefore, the impacts from these accidents, if they were to occur, would be within acceptable limits.

A class of prescriptive DBAs has not yet been established for NPR facilities, pending completion of final designs and safety analyses. Rather, a group of accidents for the three technologies has been specified for both the reactors and support facilities to bound the spectrum of accidents that NPR facilities would be designed to control. These are called nonsevere accidents.

Because of the lack of well-defined designs for the proposed facilities, the accident scenario definitions and calculations of source terms are very conservative. As the designs mature, it will be possible to calculate more precisely the effect of the built-in safety features in these facilities; consequently, the calculated radiological impacts based on detailed designs would likely be lower than the estimates presented in this EIS.

Postulated Nonsevere Accidents at Reactors

During normal reactor operations, radioactive materials would be contained within a system of barriers including the fuel matrix and cladding (for MHTGR, fuel particle coating instead of cladding), the primary cooling system boundary, and the reactor containment building. The primary cooling system boundary includes all piping, the reactor vessel, and the heat exchanger tubing; the total external boundary enclosing the primary coolant. Failure of all barriers would be necessary to produce a substantial release of radionuclides to the environment; if any one of the barriers remained intact, the potential magnitude of a release would be considerably smaller. The probability of a major release would be minimized by stringent construction requirements and engineered safety features such as containment sprays and filters in ventilation systems.

Ordinarily, only a small fraction of the core radionuclide inventory would be available for release from the various containment systems. The majority of the core radioactivity would be bound within the fuel and target elements, with smaller quantities (less than 1% each) in the circulating primary coolant or plated out in the core and the primary system piping. Relatively small amounts of radioactivity would also be fixed within the core structural materials as a result of neutron activation. In most accidents, releases to the environment would consist of radionuclides that are volatile and highly mobile, such as tritium, iodine, noble gases, and, in some cases, cesium.

The environmentally significant radionuclides for nonsevere accidents are listed in Table 5.1-1. The postulated nonsevere NPR accidents with the highest estimated consequences are different for different technologies, but the same at each site; they are listed in Table 5.1-2.

TABLE 5.1-1 Important Radionuclides in Postulated Nonsevere NPR Accidents

Radionuclide	Half-Life ^a (days)	Radionuclide	Half-Life ^a (days)
Tritium	4,500	Iodine-131	8.04
		Iodine-132	0.095
Krypton-85	3,920	Iodine-133	0.867
Krypton-85m	0.187	Iodine-135	0.273
Krypton-87	0.0529		
Krypton-88	0.118	Xenon-133	5.24
		Xenon-135	0.379
Strontium-89	50.5	Xenon-138	0.00979
Strontium-90	10,600		
		Cesium-134	753
Tellurium-129m	33.6	Cesium-137	11,000
Tellurium-131m	1.35		
Tellurium-132	3.26		

^aSource: General Electric Co. 1988.

The consequences of these accidents are provided in Sections 5.2 through 5.4. More detailed description of the postulated NPR nonsevere accidents and their consequences is given in Appendix I.

Method

As for normal NPR operations (Section 5.1.7.1), the GENII computer code was used to calculate the environmental transport of radionuclides and the consequences for the postulated nonsevere accidents. The same meteorological data were used for both sets of calculations, except the nonsevere accident calculations predicted median air concentrations (those experienced 50% of the time) rather than average air concentrations.

Radiation doses and health effects were estimated for three types of individuals and groups:

- A maximally exposed off-site individual who lives an entire year at the place of maximum exposure at the site boundary and consumes only locally grown food.
- The off-site population within an 80-km radius of the facility.
- The maximally exposed colocated worker (a person working on-site at a planned or existing facility other than the one being evaluated).

Because atmospheric transport of material released from a short-term accident is expected to be highly directional, acute population dose is evaluated only in the sector where the release results

TABLE 5.1-2 Postulated Nonsevere NPR Accidents with the Highest Estimated Consequences

Reactor	Accident
HWR ^a	Detritiation System Failure^b The detritiation module in the heavy-water processing facility is assumed to fail, releasing 3×10^5 Ci of elemental tritium gas to the environment, an amount equivalent to the maximum allowed inventory in the module. (HWR1,^c Limiting^d) Charge and Discharge Mishap^e During refueling operations, a fuel assembly is assumed to melt in air in the hot cell refueling canyon due to assumed failure of the crane motive systems and the water-delivery systems that are used to cool the fuel assembly. Initially, the hot cell vents to the environment through filters. After 1 minute, the hot cell is isolated and leaks into the containment, which in turn leaks to the environment at a rate of 0.1% of its volume per day. (HWR4,^c Infrequent^d)
LWR	Waste-Gas Decay Tank Rupture^b The waste-gas decay tanks accept radioactive gases stripped from reactor coolant and provide for holdup to allow for radioactive decay. It is assumed that one of these tanks ruptures, releasing 100% of its normal inventory to the environment. (LWR2A,^c Infrequent^d) Large-Break Loss-of-Coolant Accident^e A large pipe in the primary coolant system is assumed to break, rapidly discharging reactor coolant into the containment. Containment safety equipment is assumed to be operating. (LWR10A,^c Limiting^d)
MHTGR	Depressurized Conduction Cooldown^{b,e} A large pipe in the primary coolant system is assumed to break, rapidly discharging reactor coolant into the containment. This results in the release of the circulating and plateout activity from the primary system into the containment. Fission products, released from the core as the result of a core-heatup transient occurring 80 hours after the start of the accident, are also released into the containment. Containment isolation occurs at the same time as the start of the transient. (GCR6,^c Limiting^d)

^aThe HWR most severe reactor accident is the large-break LOCA and is discussed in Appendix I. It is less severe than those listed here for the HWR.

^bHighest consequences for the maximally exposed colocated worker.

^cAccident identification number used in Appendix I.

^dFrequency class of the postulated accident, which is described in Appendix I, Section I.3.1.

^eHighest consequences for the maximally exposed off-site individual and off-site worst-sector population.

in maximum impact, based on statistical frequencies of atmospheric conditions and the number of people located in the sector. The dose received by the population in this sector is called the worst-sector population dose. It is a conservative estimate of the dose received by the entire population within the 80-km radius (because, if the wind shifted direction and blew into a sector other than the worst sector, the calculated population dose would be reduced).

The calculated doses were converted to health effects using the same risk estimators discussed for normal operations. If the median BEIR V risk factors (see discussion of normal operations) were applied to the acute exposures from nonsevere accidents, the number of cancer fatalities calculated would be about twice those presented in this analysis. In actuality, this factor would be less than 2 because of the difference in time over which an individual would receive the estimated dose from a postulated nonsevere accident and the time period for which the BEIR V recommendations were derived. This factor is not significant considering the overall uncertainty in this type of assessment.

Uncertainties and Conservatism

The goal of this analysis of radiological impacts from nonsevere accidents was to realistically estimate the impacts while providing the assurance that an upper bound has been identified for the total magnitude of the impact. This goal is accomplished by (1) using state-of-the-art computational tools, (2) considering the processes and events that might realistically be expected to occur in the proposed NPR facilities and the environment, and (3) making conservative assumptions.

In most instances, the desire to be realistic has been counterbalanced by the desire to be conservative. In some cases, however, the estimates presented might be very conservative. For example, consider the estimated dose and health effects for the maximally exposed off-site individual. It is not realistic to assume that for all the accidents analyzed such an individual would stay in the worst possible place at the site boundary, unprotected throughout the accident, and continue to live there for an entire year consuming only the locally grown food. On the other hand, since it would be difficult to justify the basis for making a less conservative assumption, the calculations assume that the individual does spend a year in the worst place, unprotected, eating only locally grown food.

For population exposures, it was assumed that the wind blows in the worst possible direction during the entire accident and that people are always under the center line of the radiation plume. It is also assumed that all of these people's food comes from the sector in which they live (which is the worst of the 16 sectors around the facility). Although the meteorological conditions used represent the median conditions, because of the large amount of conservatism assumed in calculating the source terms, environmental transport, and human consumption, the final estimates of population doses and health effects presented in this EIS are conservative.

Mitigative Actions

In the event of an NPR accident that could result in the uncontrolled release of radioactive materials, off-site emergency response authorities would consider actions to protect public health and safety. Their decisions to recommend protective actions would be in

accordance with plans established by Federal, state, and local government authorities (DOE-48; FEMA 1980). These plans call for projections of the doses likely to be received by the public, based on radiological field monitoring data, meteorological conditions, conditions at the facility where the accident occurred, and other relevant information. The projections would then be compared with protective action guides (PAGs), which are levels of projected dose that warrant protective action. A projection that a PAG would be exceeded would be an important factor, but not the sole consideration, in a decision to recommend protective actions. (See Section 3.6 for a description of mitigation, monitoring, and emergency procedure programs at the three candidate sites).

The Federal Emergency Management Agency's (FEMA's) criteria for preparing and evaluating radiological emergency response plans and preparedness for commercial nuclear power plants require that the PAGs be consistent with the EPA's recommendations regarding exposure resulting from the passage of radioactive airborne plumes (EPA-6) and with the Food and Drug Administration's (FDA's) recommendations (FDA 1982) regarding radioactive contamination of human food and animal feeds (FEMA 1980).

The EPA's PAGs for exposure to an airborne plume recommend that for a projected committed effective dose equivalent (CEDE) between 1 and 5 rem or an estimated committed dose equivalent (CDE) to the thyroid between 5 and 25 rem, members of the public be advised to seek shelter as a minimum and evacuation be considered and advised unless constraints make it impractical. For higher projected doses, EPA recommends mandatory evacuation (EPA-6). Plume-exposure protective actions apply within an emergency planning zone that usually encompasses a radius of about 16 km surrounding the facility releasing the radioactive materials. For plume-exposure protective actions to be effective, they must be implemented before or within a few hours after the radioactive plume reaches the off-site environment.

The FDA's PAGs for the ingestion pathway fall into two classes: (1) preventive PAGs, which apply to situations where protective actions causing minimal impact on the food supply are appropriate, and (2) emergency PAGs, which apply to accidents where protective action of great impact on food supply is justified because of the projected health hazard. Removing milk-producing cows from contaminated pastures, moving them indoors, and providing uncontaminated feed that had been stored indoors or covered outdoors is an example of a protective action that could be triggered if preventive PAGs were exceeded. Preventing the introduction of milk or other contaminated human foods into commerce is an example of a protective action that could be triggered if emergency PAGs were exceeded.

The preventive PAGs are 0.5 rem for the CEDE and the CDE to bone marrow and other body organs (except the thyroid) and 1.5 rem to the thyroid. The emergency PAGs are 5 rem for the CEDE and the CDE to bone marrow and other body organs (except the thyroid) and 15 rem to the thyroid (FDA 1982; Shleien et al. 1982). The emergency planning zone for ingestion-pathway protective actions usually encompass a radius of about 80 km surrounding the facility releasing the radioactive materials.

Comparing estimated doses for the maximally exposed off-site individual with plume-exposure and ingestion-pathway PAGs indicates the likelihood that protective actions would be taken in response to a nonsevere accident. If projections of doses from a nonsevere NPR accident based on information available to off-site emergency-response authorities during or after an accident approached a PAG limit, mitigative actions would likely be recommended. For these accidents, most of the estimated dose results from the ingestion pathway. Therefore, in

Sections 5.2-5.4, estimated doses are given both including and excluding the ingestion pathway. If the estimated dose, with the ingestion pathway included, exceeds a preventive or emergency PAG and would be substantiated during an actual emergency, protective actions would likely be recommended, and the doses without the ingestion pathway would be more realistic. However, there would be economic costs in implementing and maintaining the ingestion-pathway protective actions. These costs would be small for preventive protective actions and substantial for emergency protective actions. If plume-exposure PAGs were exceeded and an evacuation of all or part of the plume-exposure emergency planning zone recommended, there could be substantial costs, especially if the evacuated area could not be re-entered in a few days and relocation were necessary.

Each of the three candidate sites considered in this EIS has plans in place that call for evacuation of personnel from the site in less than 2 hours in case of an emergency. The records of occupational doses at the three sites in the past have included only external doses, which constitute most of the occupational dose, since workers normally do not consume food or water that would be exposed to radioactive contamination. Therefore, for the colocated worker, the ingestion pathway was not considered and the worker was assumed to be evacuated from the site 2 hours after the accident began. Because of these assumptions, in some cases the dose to the maximally exposed colocated worker is calculated to be less than the dose to the maximally exposed off-site individual. If the colocated worker lived near the site and went home after the accident, his or her total dose could be calculated conservatively by adding the dose received on-site to the dose received by an individual who had been off-site throughout the accident.

Postulated Nonsevere Accidents at Support Facilities

The same general methodology is used to analyze nonsevere accidents at both the reactors and the support facilities. Therefore, the discussions provided above concerning the methodology, uncertainties, and mitigative actions apply to both the reactors and support facilities. The support facility designs, in general, are not as advanced as the reactor designs. Therefore, the amount of uncertainty and the conservatism are generally greater in support facility nonsevere accident calculations than in reactor calculations. As the designs mature, the uncertainty, the conservatism, and, consequently, the estimated impacts of nonsevere accidents at support facilities are expected to be reduced.

A number of nonsevere accidents that could result in the release of radioactive materials to the environment have been postulated for NPR support facilities at each of the candidate sites. The types of postulated accidents range from inadvertent criticalities, fires, and explosions to procedural errors. The extent to which radioactive materials would be released to the environment in the event of such accidents depends on a number of factors, including the inventory and volatility of the radioactive material, the severity of the accident, and the operating status or efficiency of the systems that filter out the radioactive materials. The postulated nonsevere accidents at support facilities are described in Section I.4 of Appendix I. Sections 5.2.6.3, 5.3.6.3, and 5.4.6.3 provide the radiological impacts from the highest consequence accidents at Hanford, INEL, and SRS, respectively. More detailed discussion of the impacts is given in Appendix I, Section I.4.

5.1.7.3 Postulated Severe Accidents at Reactors

Background

Severe reactor accidents are less likely to occur than the nonsevere accidents described in the previous section since, by definition, severe accidents involve multiple failures of individual redundant safety systems or human actions. However, the radiological impacts of severe accidents could be more serious if actions to reduce the dose were not taken. Postulated severe reactor accidents were evaluated to ensure that NPR operations would not represent an unacceptable risk. The safety criteria set for NPR facilities (DOE-8) are as follows:

- The risk of an early fatality to an average individual within 1.6 km of the facility control perimeter should be less than $5 \times 10^{-7}/\text{yr}$.
- The risk of a cancer fatality to the workers and the general public located within 16 km of the facility control perimeter should be less than $2 \times 10^{-6}/\text{yr}$ per average individual.

The characteristics of severe accidents postulated for the three NPR technologies and the site-specific parameters used for assessing the radiological impacts are described in Appendix J. The radiological impacts of an NPR severe accident were evaluated for both the tritium production mode and the plutonium production mode. These analyses show the activities of radionuclides released to the atmosphere are generally higher for the tritium production mode. This is because the inventories of tritium and significant fission products are higher for the tritium production mode than for plutonium production. Consequently, the resulting impacts are also higher (Hong et al. 1991); only the radiological impacts for the tritium production mode are presented in the impact analysis.

Method

The MELCOR Accident Consequence Code System (MACCS) computer code (Jow et al. 1990) was used to assess the impacts of postulated severe accidents to colocated workers at each of the proposed sites and to the general public in the surrounding area. In contrast to the GENII computer code described in the previous section, the MACCS was developed specifically for the estimation of the consequences of severe reactor accidents. For example, the MACCS includes emergency response models that account for the mitigative actions taken to reduce radiation doses following an accident. The GENII does not include such models. The impacts to in-plant workers are discussed in Appendix J.

For each accidental release, MACCS models the dispersion and deposition of radionuclides released from the reactor containment into the atmosphere and calculates the downwind concentrations of radionuclides up to 800 km away for each of 16 directional sectors around the reactor. It considers a probabilistic model for meteorology that reflects the variability of weather conditions for one representative year at the site. The MACCS code then calculates radiological consequences in terms of population doses and health effects (early fatalities and cancer fatalities), taking into consideration many protective actions for mitigating the consequences.

The MACCS code does not calculate genetic effects resulting from the radiation exposure of a reproductive organ such as a gonad. Because the gonad dose is not dominating and the factor for converting radiation dose to genetic effects is lower than that used for cancer fatalities, the number of genetic effects can be conservatively assumed to be the same as the number of cancer fatalities.

Finally, MACCS produces consequence-probability distribution curves, often called complementary cumulative distribution functions (CCDFs), for the consequence measures for each accidental release. The MACCS results are processed with the RISKIN code (Rollstin and Hong 1990) to incorporate the frequencies of all accidental releases postulated for an NPR and to produce combined CCDFs for given consequence measures. The RISKIN code also estimates average values of risk for given risk measures.

Uncertainties

Overall, the results of these analyses are considered to be conservative. There are uncertainties in the results of the radiological impact analysis for the postulated severe reactor accidents. Many of these uncertainties are associated with the frequency and magnitude of the accidental releases, with the atmospheric dispersion modeling for the radioactive plume transport, and with data for the model parameters. Uncertainty much larger than a factor of 10 but smaller than a factor of 100 is not uncommon for estimated risks due to severe accidents at commercial nuclear power plants (NRC-4; NRC-11). Such uncertainties are based on engineering judgment; the variations reflect a direct result of the scant data available for predicting the very infrequent event. Because the probabilistic risk assessment techniques and consequence analysis models used for the NPR assessment are similar to those used for studies of commercial reactors, it is believed that the uncertainty bounds are similar to those for risks due to severe accidents at commercial nuclear plants.

Mitigative Actions

The accident impacts are effectively lessened by a process used in designing reactors that incorporates features of simplicity, modularity, operability, optimized human-machine interface, operational reliability, ease of maintenance, passive systems that use inherently safe characteristics, and active systems that reduce the frequency and consequences of accidents. The large DOE sites where the NPR might be located would provide extra protection and consequently reduce the impacts to the general public. Impacts could also be mitigated effectively through on-site and off-site emergency planning procedures and real-time emergency management systems currently available at each candidate site (see Section 3.6).

5.1.7.4 Postulated Severe Accidents at Support Facilities

Background

Postulated severe accidents at NPR support facilities were evaluated to ensure that NPR operations would not represent an unacceptable risk. The NPR safety criteria identified in Section 5.1.7.3 (DOE-8) would apply to the support facilities as well as the reactor.

Two NPR support facilities, both associated with tritium production, were considered in the severe accident analysis: the fuel fabrication facility and the tritium-target processing facility. Other facilities, such as the tritium-target fabrication facility and the heavy-water processing facility (for HWR only), were not individually considered. This is because, for example, the tritium-target fabrication facility would contain no radiological source terms at risk, and the tritium source term from the heavy-water processing facility during a severe accident would be much less than that from the tritium-target processing facility.

A range of severe accidents, including internally initiated process-related events and externally induced events, were considered for the NPR support facilities (see Appendix J). In a postulated severe accident for the support facilities, the inventories of radioactivity at risk, as well as the potential energy released, are generally orders of magnitude smaller than those for the reactor. Thus, radiological consequences of a severe accident involving the support facilities would generally be less extensive than would be expected from a severe reactor accident.

Method

Because of the uncertainties in postulating high-consequence but low-probability severe accidents (usually less than 1 accident in 1,000,000 years), a bounding approach was used that established a reasonable upper bound for the potential radioactive releases from such accidents. Such releases were assumed to occur under conditions of multiple component failure and significant structural damage to the NPR facilities, which would be designed to satisfy DOE Order 6430.1A (Nonreactor Safety Class 1 Criteria). External events, such as a severe seismic incident (that is, an earthquake), were assumed to be the causes of such system failures and structural damage. The release inventory estimated for the analysis represents a reasonable upper bound for each of the three reactor technologies.

As in the case of severe reactor accidents, the MACCS computer code (Jow et al. 1990) was used to assess impacts of the postulated severe accidents at support facilities to colocated workers and to the general public. The impacts to in-plant workers are discussed in Appendix J. The MACCS code calculated the radiological consequences in terms of population dose, early fatalities, and latent cancer fatalities. The impacts were further expressed in terms of risks, which weigh the calculated consequences with the estimated probability of the accident events. Appendix J presents a more detailed discussion of the methodology used in this analysis.

Uncertainties

The approach used for this analysis is believed to provide an overall conservative result. Based on engineering judgment, it is estimated that the actual source term release could be as much as a factor of 10 lower than the values given in this EIS. The frequencies of the severe seismic events assumed could be as much as a factor of 10 greater or smaller than the median estimate used in the analysis. Thus, the risk from the severe seismic event could be as much as a factor of 100 smaller, or a factor of 10 greater, than the estimate used in the analysis. Such uncertainties are based on engineering judgment; the variations reflect a direct result of the scant available data for predicting the very infrequent event.

Protective actions for mitigating accident consequences were taken into consideration in computing impacts with MACCS. However, as discussed in Appendix J, the seismic event

adopted for this analysis was hypothetical, and the NPR facilities would most likely withstand the impact of such an event with releases much lower than those postulated.

5.1.7.5 Transportation of Radioactive Material

Background

The impacts of transporting radioactive material to and from NPR facilities would include impacts on-site (within the boundaries of Hanford, INEL, or SRS) and off-site (outside the boundaries of those three sites) for both routine and accident conditions. Radioactive material transported on-site would include uranium fuel, tritium, plutonium, spent fuel, by-product materials, high-level waste, transuranic waste, and low-level waste. This material would be either necessary for or generated by the operation of the NPR and its support facilities.

Radioactive material to be transported off-site would include tritium and plutonium metal as the end products of the NPR operation. The tritium product, regardless of NPR location, would be shipped to SRS, where it would be refined at an existing processing facility. The plutonium metal product would be transported to DOE's Rocky Flats Plant near Denver or another appropriate facility ultimately determined by the DOE reconfiguration study and EIS.

If the HWR technology were selected for either Hanford or INEL, portions of the heavy-water inventory not used for existing operations would be shipped to either site from existing supplies at SRS. High-level and transuranic waste, which would be temporarily stored on-site, would eventually be shipped off-site for disposal at the Waste Isolation Pilot Plant in New Mexico (transuranic waste) or the Federal high-level waste repository or similar facilities; transport of wastes to these locations has been assessed in the national transportation plans and environmental reviews for those facilities (DOE-49; DOE-51). Results of these assessments were used in this EIS for estimating risks associated with transporting high-level and transuranic waste generated by NPR operations.

Method

Radiological impacts from transportation were assessed for the hypothetical maximally exposed individuals and the affected general population. For incident-free transportation, both on-site and off-site, the collective dose equivalents were assessed by the RADTRAN III computer code (Madsen et al. 1986) for transport crew members and the general population adjacent to the transport link. The incident-free maximally exposed individual and collective population doses were based on the exposure from the annual shipments of radioactive materials.

For on-site transport, under accident conditions, the population dose equivalent was calculated by the GENII code (Napier et al. 1988), using site-specific parameters such as site population density and meteorological data. Population doses for off-site transportation, under accident conditions, were calculated using the RADTRAN III code and parameters appropriate for the shipment routes. The collective dose equivalents for accident conditions were weighed by the annual accident probabilities to yield the annual dose risks over all severity categories of transportation accidents, as specified by the Nuclear Regulatory Commission (NRC-7); this approach is consistent with the methodology suggested by the RADTRAN code.

To represent the upper-bound estimates of impacts to individuals, the maximum individual doses for both on-site and off-site transportation were assessed in terms of committed effective dose equivalents, using the GENII computer code. The impacts were further expressed as health effects in cancer fatalities as well as genetic effects for offspring of the exposed population. The health risk conversion factors used are those suggested by the EPA: 4×10^{-4} cancer fatality/person-rem and 2.6×10^{-4} genetic effect/person-rem (EPA-4).

Uncertainties

The method used in the radiological transportation analysis, either by the RADTRAN code or the GENII code, has been demonstrated to be conservative. Furthermore, the parameters and assumptions used for the analysis were also conservative. The aim was thus to establish upper-bound risk values.

Some uncertainties in this approach have been identified. For incident-free conditions, for instance, the impacts were found to be generally dominated by the shipment of low-level waste on-site and the shipment of high-level waste off-site. These impacts are directly related to the estimated waste volume and can vary by a factor of 4 for low-level waste and by a factor of 10 for high-level waste, between the plutonium and tritium operation modes of the NPR. Parameters such as vehicle speed, loading capacity, waste packaging method, exposed population density, source-to-receptor distance, and total shipping distance contribute to the overall uncertainties of the analysis.

For accident analysis, in addition to the uncertainty in the estimated waste volumes, the largest uncertainty is in the estimated accident data (accident frequency per travel distance), especially for the on-site analysis. Such accident data are based on either limited accident statistics or data supporting an accident rate of 10^{-1} to 10^{-6} accident per kilometer traveled. These data can vary by a factor of more than 10. Other factors, such as accident release fractions, are based on conservative estimates from currently available data for which the level of uncertainty has yet to be ascertained.

5.1.8 Postulated Accidents Involving Nonradioactive Hazardous Materials

5.1.8.1 Background

The purpose of assessing impacts from accidents involving nonradioactive hazardous materials was to characterize the source and magnitude of the human health risks related to accidental releases of these materials to the atmosphere. The NPR assessment did not consider releases to other environmental media (such as surface water or groundwater) because the materials of concern are primarily gaseous upon release. Liquid chemicals or diesel fuel could be spilled during storage or transport, but such spills would not constitute a significant hydrologic threat because of engineered barriers, catchments, and other mitigation contingency plans (Tomasko and Tilbrook 1990).

5.1.8.2 Method

The storage and use of hazardous materials related to NPR operations would be typical of many chemical or industrial facilities. Therefore, the potential impacts from NPR operations are comparable to those in other U.S. industries. A screening of the chemicals to be used in NPR operations identified three with high hazard potential -- ammonia, chlorine, and hydrogen -- for which detailed assessments were performed. These chemicals are believed to pose the greatest potential hazard. The assessment examined effects of acute inhalation (single exposures for up to 1 hour), thermal radiation from fireballs, and explosions.

The screening process used to select the chemicals of concern, the models used for air dispersion analysis, and the health criteria used to assess impacts of accidents are described in Appendix L. Details of the method used to assess accidents involving nonradioactive hazardous materials are presented in a separate report (NUS-5).

Two accident scenarios were evaluated: (1) rupture and complete release of chemicals from storage vessels at the NPR site and (2) rupture and complete release of chemicals from a shipment vessel damaged by a transportation accident. No routine tank failures (due, for example, to corrosion or split seams) have been reported at Hanford, INEL, or SRS over their operating history. Discussions with tank vendors indicated there have been very few of these cases reported elsewhere (Heacock 1990b). Although externally induced tank failures resulting in chemical releases to the atmosphere have been reported, the design of NPR facilities would reduce the likelihood of such accidents. These scenarios and their underlying assumptions represent the bounding accidents associated with NPR operations.

Transportation-related accidents, especially those off-site, represent a much larger hazard potential because the likelihood of occurrence is greater, the exposed population is much closer to the release point, and fewer well-trained emergency response personnel would be immediately available than at a stationary site.

Environmental transport and diffusion of chemicals released into the air were simulated using the SLAB model (Ermak 1988, 1989). The object of the SLAB modeling analyses for ammonia and chlorine was to determine the distance (impact radius) at which various health-based exposure criteria would be exceeded.

The purpose of the SLAB analyses for hydrogen was somewhat different: because of hydrogen's explosive nature, the SLAB model was used to determine the greatest downwind distance from the release point at which the concentration could exceed the lower explosive limit (about 5% by volume). Subsequently, the Chemical Hazard Evaluation Methodologies, CHEMS-PLUS (A.D. Little 1988b), were used to estimate fire and explosion impacts resulting from the hydrogen release.

Meteorological conditions (wind speed and Pasquill stability class) were selected that would give the largest impact radius for each chemical. The atmosphere's capability to disperse pollutants depends, in part, on the thermal stability of the atmosphere and the wind speed. Stability classes, ranging from A (extremely unstable) through F (moderately stable) indicate the turbulent nature of the atmosphere. Extremely unstable conditions enhance diffusion (generally reducing pollutant concentrations) while moderately stable conditions inhibit diffusion and pollutant dispersion. Also, pollutant dispersion is generally enhanced with increasing wind

speed. Thus, bounding accident meteorological conditions would include low wind speeds and a slightly to moderately stable atmosphere.

5.1.8.3 Interpretations and Regulatory Framework

The impacts from inhalation of ammonia and chlorine as a result of releases from fixed on-site storage vessels are presented in terms of the size of the off-site populations that would be exposed to concentrations of these chemicals above emergency response planning guidelines (ERPGs) (AIHA 1989b). The affected population size is given as a range to reflect differences in the populations within each of the 16 angular wind-direction sectors modeled.

Impacts from on-site and off-site transportation vessel releases, however, are presented differently. Because transportation vessels are not fixed, it is impossible to predict the exact location of a transportation accident. Therefore, the size of the population at risk of exposure cannot be determined with any certainty (there are an infinite number of highway locations where accidents could happen). Thus, the impacts are presented in terms of a range of distances (critical impact radii) from the point of release at which the ERPGs would be exceeded. Similarly, impacts from fire and explosions resulting from a hydrogen release are presented as distances from the point of release at which criteria for exposure to thermal radiation from fireballs or explosive overpressure are exceeded.

The ERPGs are estimates of the maximum airborne concentrations of chemicals above which nearly all individuals exposed for up to 1 hour could experience different degrees of health effects. Three levels of ERPGs are used:

- ERPG-1 defines the level above which individuals could experience mild, transient adverse health effects or perceive a clearly defined objectionable odor (ammonia, 25 ppm, and chlorine, 1 ppm).
- ERPG-2 defines the level above which individuals could experience or develop irreversible or other serious health effects or symptoms that could impair their ability to take protective action (ammonia, 200 ppm, and chlorine, 3 ppm).
- ERPG-3 defines the level above which individuals could experience or develop life-threatening health effects (ammonia, 1,000 ppm, and chlorine, 20 ppm).

The projected impacts exceeding the ERPG-2 and ERPG-3 levels are considered significant impacts in the discussion given in Sections 5.2.7, 5.3.7, and 5.4.7. The ERPGs for ammonia and chlorine are taken from AIHA 1988b and AIHA 1988a, respectively.

The impacts from thermal radiation and explosive overpressure resulting from a hydrogen release and ignition are presented for a range of distances from the point of release at which various criteria are exceeded. For impacts from fireball thermal radiation, two criteria were selected: a heat flux that is fatal to humans due to irreversible skin tissue damage and a heat flux that induces pain or mild second-degree burns (A.D. Little 1988a). For impacts from explosive overpressure, three criteria were selected: an overpressure that kills humans due to

direct blast effects, ruptures eardrums, and causes some damage to house ceilings and 10% glass breakage (A.D. Little 1988a).

5.1.9 Socioeconomics

5.1.9.1 Background

The socioeconomic assessment evaluated the potential social and economic impacts of the in-migration of NPR workers and their families to the areas surrounding the alternative sites, during both construction and operation (these impacts are called direct economic effects). It also evaluated impacts from increased spending for materials and services associated with the NPR (these impacts are called indirect and induced effects).

In general, the socioeconomic impacts of large projects like the NPR can be positive or adverse, depending on conditions in the affected areas. In an area of high unemployment, surplus housing availability, and underutilization of schools and public services, in-migration would likely have positive socioeconomic impacts. Conversely, in an area of high employment, low housing availability, and full use or over use of schools and public services, in-migration could have adverse impacts. In fact, the situation is seldom as clear-cut as the two extremes cited above: almost all communities have excess capacity in some of these areas and shortages in others.

For the NPR socioeconomic assessment, each affected area -- also called the region of influence (ROI) or simply the region -- was defined on the basis of proximity to one of the alternative NPR sites, the existence of population centers within commuting distance of the site, the locations of current site employees' homes, and the locations where temporary NPR construction workers would be expected to reside. These regions are typically multicounty areas immediately surrounding Hanford, INEL, and SRS.

The socioeconomic analysis examined changes in the following:

- Economic characteristics: employment, unemployment, and income.
- Housing characteristics.
- Community service characteristics: school capacities and student enrollment, health facilities, and police and fire protection.
- Common measures of quality of life.
- Local government fiscal structure.

In addition, availability within each ROI of skilled construction and operations workers was considered to determine if necessary NPR workers would be available locally. The results of the socioeconomic assessment are presented in Sections 5.2-5.4.*

*Impacts to Native Americans are discussed as part of the cultural resource assessments in Sections 5.2-5.4.

5.1.9.2 Method

Manpower requirements and schedules for NPR construction and operations were provided by Hanford, INEL, and SRS (see Appendix N). Local worker availability was compared to NPR work force projections to determine if in-migration to the ROI would be required. The analysis included consideration of a multiplier effect: in-migration of NPR workers could create a need for additional workers in wholesale and retail trade and in community services. In addition, some workers would bring families with them. Therefore, an in-migrating worker would normally result, on average, in the addition of more than one person to the community.

The socioeconomic assessment compared NPR-related in-migration to existing housing availability and community services to determine if additional personnel or facilities would be needed to accommodate any expected growth. Increased housing requirements associated with each NPR alternative were estimated separately to account for the needs of families as well as individuals. The analysis of community services investigated potential impacts to public education, health services, and police and fire protection. The impacts were estimated by evaluating the increased NPR-related demand and determining the corresponding increases in community services that would be needed to maintain the existing level of service, above and beyond projected non-NPR increases in baseline population.

No impacts to the community services of water supply, wastewater collection and treatment, or electrical services were identified. Therefore, no analysis is presented in Sections 5.2-5.4.

Different levels of political jurisdictions were used in the impact analysis, depending on the socioeconomic factor being analyzed. Different levels of political jurisdictions were used for different analyses for one of two reasons. In some cases, data were available at specific levels for specific analyses (for instance, employment data were available at the county level but not at the school-district level). In other cases, analyses were performed at a specific level based on the level of impact anticipated (thus, a more detailed level was used for impact analysis in critical areas such as education).

5.1.9.3 Assumptions and Models

Estimates of the socioeconomic impacts of NPR construction and operation were based on generic descriptions of reactor facilities, schedules, work force sizes, and site adaptations. Peak work force requirements and expenditures were calculated using typical "loading curves" for nuclear facilities. The impact projections, which were based on in-migration using the Leistritz-Murdock model (Wieland, Leistritz, and Murdock 1977), account for (1) total work force requirements, (2) the size of the peak construction work force, and (3) the number of craft workers and other workers expected to in-migrate to each location. Although this model is believed to be more reliable for rural areas than urban areas, it is the only model of in-migration in the literature that generated consistent results among NPR technology and site alternatives.

Infrastructure and housing added for temporary NPR construction workers would be sufficient, in most cases, for the later operations phase. Thus, the operations work force would be expected to create fewer socioeconomic impacts than the peak construction work force.

Direct and indirect effects from worker and material purchases were calculated using the Regional Input-Output Modeling System (RIMS), developed by the Department (Bureau of Economic Analysis 1986). Aggregate multipliers for each ROI were constructed from county-level data by the Bureau of Economic Analysis specifically for this assessment. This approach accounts for the round-by-round effects of spending by supplying industries and wage-earners throughout the regional economies. It should be noted that the RIMS multipliers generate impact estimates that are likely to be higher than actual impacts.

The residence locations of in-migrating workers and their families were assumed to mirror the distribution of current residences of workers at the three sites. Therefore, project impacts were distributed based on this worker housing distribution.

5.1.9.4 Uncertainties

Cost estimates prepared by Oak Ridge National Laboratory (see Appendix N) were used as the basis for calculating indirect labor requirements and income effects of NPR construction and operation. Most of the methodological and data limitations of this analysis would lead to an overstatement of projected socioeconomic impacts. The costs supplied by Oak Ridge were subdivided by Standard Industrial Classification (SIC) code. All materials purchases were included as expenditures in the ROI, except for major components (such as the reactor vessel) and electrical equipment. This approach resulted in the inclusion of many purchases that might come from outside the ROI and thereby led to an overstatement of socioeconomic impact. This provides a measure of conservatism to the analysis. Offsetting these overstatements is a systematic understatement of costs. The costs of plutonium facilities, cooling towers at INEL, and a heavy-water processing facility for the HWR alternative were not included in the Oak Ridge estimates.

Estimates of peak work force requirements by year that were used as a basis for the socioeconomic analysis are given in Tables 3.3-1 through 3.3-6 for the various alternatives. (No work force projections were available for decontamination and decommissioning; therefore, no socioeconomic analysis was performed for that NPR activity.) The project design for each alternative is ongoing; hence, it is quite likely that the work force estimates will be revised in the near future, as well as later when funding profiles by fiscal years are established. It is possible that design changes or any changes in the work force estimates would affect socioeconomic analyses. Updated socioeconomic analyses incorporating the most recent work force requirement estimates will be included in the final EIS.

The uncertainties outlined above are traditionally addressed by monitoring actual impacts.

5.1.9.5 Interpretations and Regulatory Framework

Socioeconomic impacts at SRS and Hanford must be considered in view of the recent construction of the Vogtle nuclear power plant near SRS and the peak construction work force requirements at Hanford during the early 1980s. In both cases, peak work forces exceeded 10,000 workers. A peak work force for any of the three NPR alternatives would not exceed about 5,000 workers. With some experience in adapting to large, temporary construction work

forces, the regions around Hanford and SRS thus might more readily adapt to a project as large as the NPR than would the region around INEL, which has had rather stable employment.

The Secretary of Energy's notice of February 5, 1990 (SEN-15-90), states the DOE must prepare a Mitigation Action Plan (MAP) for any commitments to mitigation made in the EIS Record of Decision.

5.1.10 Transportation Systems

The transportation by road of the direct labor force required to build and operate NPR facilities at any of the three alternative sites could impact traffic flows and result in increased risks of death, injury, and property damage accidents. In the analysis for this EIS, these increases in fatalities were determined for the three sites using the changes in the baseline vehicle-miles-traveled (VMT) for the peak year of construction and the peak year of operation. The changes in VMT were determined both for the roads on the three sites and for the roads used by commuters to travel to the sites. The 1988 data were used as a baseline since they represented the most complete data available on recent conditions at and near each of the three sites. Estimates were made of the extent to which increases in traffic resulting from NPR construction and operations would add to congestion, particularly on roadways already experiencing congested conditions. These changes in level of service of roadways were assessed according to the definitions in Table 5.1-3. The number of daily trips for construction vehicles was estimated, as was the extent of possible road damage due to heavy construction traffic. Increases in barge and rail traffic associated with NPR construction and operations were also estimated.

At all sites, 17% of the commuters were assumed to be at their respective sites each weekend day. To allow for people absent from the site due to business travel, vacation, or sickness, a factor of 6% was used to reduce the number of commuters traveling to each site on weekdays. Similar ratios were used to determine the VMT for the baseline work forces in the peak years of construction and operation. A vehicle occupancy of two persons was used. To estimate the upper-bound effects, no increases in bus usage were assumed for any of the sites. The VMT of the site personnel was also adjusted proportionally to the changes in the work force on the sites for the peak years of construction and operation.

The distribution of commuter vehicles along the roads in the vicinity of the three sites was made on the basis of 1988 traffic flows and work-force residence statistics. A constant accident rate based on 1988 statistics for the respective states was assumed to determine the total number of accidents and the associated fatalities, injuries, and level of property damage. The sites are in the process of implementing measures such as increased ride-sharing (car pooling, van pooling, or bus pooling), increased use of staggered work hours, and a four-day work week. Such measures would serve to improve the traffic flow and further reduce any risks associated with NPR construction and operation.

TABLE 5.1-3 Definitions of Level of Service Used for Transportation System Assessments

Level of Service	Definition
Free flow	Operation of vehicles is virtually unaffected by the presence of other vehicles, and operations are constrained only by the geometric features of the highway and driver preferences. Minor disruptions to flow are easily absorbed at this level without causing significant delays or queuing.
Stable flow (upper speed limit)	Indicative of free flow, although the presence of other vehicles begins to be noticeable. Average travel speeds are generally over 53 mph on sections with 70 mph design speed. Minor disruptions are easily absorbed at this level, though local deterioration in the level of service will be more obvious.
Stable flow	A range where the influence of traffic density becomes marked. Ability to maneuver within the traffic stream, and to select an operating speed is clearly influenced by the presence of other vehicles. Average travel speeds are reduced to about 50 mph on 70 mph design speed sections. Minor disruptions may be expected to cause serious local deterioration in service, and queues may form behind any significant travel disruptions. Severe or long term disruptions may result in deterioration of service to forced flow conditions.
Approaching unstable flow	Speeds and ability to maneuver are severely restricted because of traffic congestion. Average travel speeds are approximately 40 mph on 70 mph design speed sections. Only the most minor disruptions can be absorbed without the formation of extensive queues and deterioration of levels of service to forced flow conditions.
Unstable flow	Operations at or near capacity. Disruptions cannot be dampened or dissipated and any disruption, however minor, will cause queues to form and the level of service to deteriorate to forced flow conditions. Average speeds at capacity are approximately 30 mph.
Forced flow ^a	Occurs at a point where vehicles arrive either at a rate greater than that at which they are discharged, or at a point in a planned facility where forecasted demand exceeds the computed capacity. While operations at such points and on immediately downstream sections will appear to be at capacity or better, queues will form behind these breakdowns. Operations within queues are highly unstable, with vehicles experiencing short spurts of movement followed by stoppages. Average travel speeds within the queues are generally below 30 mph.

^aAlso called breakdown flow.

5.1.11 Waste Management

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

5.1.11.1 Background

The construction and operation of the NPR and its support facilities would generate measurable quantities of waste. Construction wastes would be similar to those generated by any construction project of similar scope. Wastes generated during NPR operations would consist of typical nonhazardous wastes as well as six primary types of hazardous and radioactive wastes: high-level waste (HLW), transuranic waste (TRU),* low-level waste (LLW), mixed waste, hazardous waste, and nonhazardous nonradioactive waste. These waste types are described and regulatory definitions are given in Appendix M.

The quantities and types of wastes to be managed depend upon whether or not spent fuel is reprocessed and whether or not plutonium is produced. Estimates in this section were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium produced. If it is decided not to continue those activities, the impacts upon waste management systems from NPR operations would be less than presented in this section.

The radioactive wastes generated by the NPR and its support facilities would be disposed of in an environmentally acceptable manner. At each of the proposed sites, existing facilities for radioactive waste management have well-developed methods for dealing with radioactive waste, methods that have been tested over many years of operation. The existing waste management facilities and methods were not assessed here for their effectiveness in dealing with radioactive wastes. The DOE has generated a report that delineates the activities and responsibilities for review of waste management facilities, operations, and systems used at each of the sites (DOE-57). In addition, DOE is preparing a waste management programmatic EIS (see Section 2).

This NPR EIS assesses the quantities of waste materials generated by the NPR and its support facilities and compares them to the existing non-NPR waste quantities and input

*In this EIS "transuranic waste" refers only to retrievable TRU waste and does not distinguish between contact and noncontact TRU waste.

capacities of waste management facilities at each of the alternative sites. This comparison was made to identify potential impacts to waste management operations.

Because of different waste management procedures, the quantities of waste generated during NPR operations may vary considerably at the different sites. Generation of a large amount of a particular radioactive waste at one site may not, in itself, constitute a significant environmental impact. However, if a site's waste facilities were already at or near capacity for handling a given waste type, any additional demand placed on the waste facility by NPR could be significant. This EIS identifies as adverse impacts those instances where the input of NPR waste might significantly impact the capacity of a waste management facility.

Hazardous and radioactive NPR wastes could occur in gaseous, liquid, or solid form. The environmental impacts of gaseous releases are discussed in Appendix H. The waste management analysis covers the treatment, storage, and disposal of liquid and solid wastes generated by the operation of the NPR and its support facilities. For each of the sites, numerous studies are ongoing to review and evaluate the environmental consequences of current waste management operations.

5.1.11.2 Assumptions

A number of assumptions made in the waste management analyses affect the results presented in Sections 5.2-5.4. The waste management data as presented represent input capacities for the waste management facilities listed in Sections 5.2-5.4, which are either those that would be impacted by the NPR and its supporting operations or those that might impact the handling of NPR waste. Those lists do not represent the total waste management capabilities for a given site. Baseline quantities and projections were derived from 1988 information provided by each of the three sites. It was assumed that appropriate off-site Federal facilities for the final disposal of high-level waste (such as the Federal repository) and transuranic wastes (such as the Waste Isolation Pilot Plant) would become operational before or during the lifetime of the NPR. Thus, only interim storage for these two waste types would be necessary at each of the proposed sites. Off-site shipment of these two wastes would commence when the Federal disposal facilities became operational. (Consequences of any failure of these Federal waste disposal facilities to become operational were not considered in this EIS.) Sufficient interim storage can be provided at the sites.

It was further assumed that the waste management facilities, the reactor, and its various support facilities would be continually upgraded, at each of the proposed sites, to meet the more stringent regulatory climate for waste management expected toward the end of NPR operations. It was assumed that the capacity of storage-type facilities could be expanded as the need arose. All waste management systems are presented as having the ability to operate over time at 100% of design capacity.

Mixed waste at each of the proposed sites is currently placed in interim storage. Treatment standards for the many varieties of mixed waste are not yet fully developed. For this EIS, it was assumed that treatment standards for these mixed wastes would be fully developed and receive regulatory approval prior to the start-up of NPR operations (the consequences of failure to achieve these goals were not considered in this EIS). The projected volumes of mixed and hazardous waste from NPR operations at the different sites vary widely. To some extent, differences in the quantities of both hazardous and mixed waste represent differences in site

practices. The sites are at varying stages of implementing strict waste-minimization programs to restrict the use of hazardous materials and, whenever possible, replace the original hazardous materials with alternative nonhazardous materials.

5.1.11.3 Uncertainties

Where there may be uncertainty in the assessment of waste management capabilities, conservative "upper bounds" were used from the data or projections provided. The information providing waste volumes was developed from the most current data available during the preparation of the NPR DEIS. The data are continually being updated. Data are provided for NPR impacts on waste stream volumes throughout each site's waste management system. These data include information on each waste type and each technology, for both tritium and weapons-grade plutonium production modes. (See Appendix M for flowcharts showing the waste management systems and information on waste stream quantities.)

Uncertainties associated with NPR waste data stem from several factors. For example, designs for facilities and systems are not final and each site has ongoing programs to upgrade waste treatment procedures and volume capabilities. It was estimated that each waste stream quantity is uncertain by a factor of 2 or more.

As an example of one type of uncertainty, a wide range of apparent volumes of TRU waste was projected at the different sites (see Sections 5.2-5.4). These results appear to arise from differing TRU classification and processing procedures at the sites. The TRU radionuclides enter the waste stream at the fuel reprocessing stage. In general, the liquid waste from this reprocessing is handled as high-level waste, even though TRU radionuclides are contained within the waste material. Transuranic waste should be waste that is contaminated primarily with TRU radionuclides. It appears, however, that some sites might be including a larger portion of low-level waste within their TRU waste stream while other sites are including a larger portion of their TRU waste within the high-level waste stream. This approach of classifying a waste as belonging to the most restrictive type is a common "conservative" approach, but does lead to large uncertainties in this type of waste stream data. However, in all cases, all waste is accounted for.

The quantities of any type of waste generated would vary among the three reactor technologies, for each of the three different sites. Also, the volume of waste generated would differ for the tritium and plutonium production modes. Assessment of NPR impacts on the waste management system was based on an "upper-bound" estimate of waste volumes, which was the larger of the waste volumes for each stream generated for full-time tritium production or full-time plutonium production. Thus, all estimated waste quantities can be considered the maximum for a given waste stream.

5.1.11.4 Interpretations and Regulatory Framework

All three candidate NPR sites are governed by an extensive system of standards and requirements set forth in DOE orders and other applicable Federal and state regulations to protect health and minimize the dangers to life and property (see Section 6). Through these DOE orders, safe operation of all site facilities is ensured pursuant to the Atomic Energy Act of

1954, as amended. In accordance with the Energy Reorganization Act of 1974, DOE defense-related operations are not subject to licensing by the U.S. Nuclear Regulatory Commission.

The Resource Conservation and Recovery Act (RCRA) authorizes EPA to regulate current and future waste management practices for the use, handling, treatment, storage, and disposal of solid and hazardous materials and waste. It has also been determined that the hazardous portion of mixed wastes is regulated under RCRA. (For information on individual state and Federal administrations and enforcements, see Section 6.)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as reauthorized, provides the statutory basis for the identification, evaluation, and remediation of sites where hazardous substances were released or pose a substantial threat of release. The principal objectives of CERCLA are as follows:

- Identify sites from which releases of hazardous substances into the environment might occur or have occurred.
- Establish a mechanism of response for the immediate cleanup of hazardous substance contamination from accidental spills or for the remediation of chronic environmental damage associated with abandoned hazardous waste sites.
- Develop a system for the determination of leachability at such sites and mechanisms for the compensation for costs incurred in the remediation of these sites.

All three NPR candidate sites are currently included on the National Priorities List for remedial action under CERCLA. The NPR and its support facilities would not negatively impact these activities. For specific information on DOE's current commitments, see Section 6. Detailed interactions between NPR operations and remedial activities would be reviewed in the NPR mitigation action plan, which would be issued after the record of decision for the NPR.

5.1.12 Decontamination and Decommissioning

5.1.12.1 Background

Decontamination and decommissioning (D&D) activities are carried out at the end of a nuclear facility's life to permit that facility to be removed safely from service. The D&D activities can vary greatly in scope, from performing a simple radiological survey to safe caretaking activities and either decontamination for reuse, complete dismantling and removal, or in-place stabilization and isolation. The objectives of D&D are to reduce contamination of facilities to levels of radioactivity that comply with approved health and safety standards, and to decommission all surplus facilities in accordance with DOE requirements.

The D&D analysis presented in Sections 5.2-5.4 and Appendix O evaluates the consequences of one set of D&D alternatives; these alternatives are not necessarily those that might be selected for NPR facilities. The analysis was performed to determine if D&D of all three NPR technologies would be reasonably achievable and to determine if there are any major

discriminating differences in D&D for any of the reactor technologies at any of the alternative sites. Three impacts are analyzed: dose to workers, volume of wastes generated, and cost.

The impacts associated with the D&D of the NPR and its supporting facilities would be reevaluated twice during the life of the NPR. Plans for D&D would be prepared during the detailed design of the facilities and near the end of the NPR's useful life. The second plan would present the D&D plans using then-current technology and addressing any waste disposal requirements and regulations; it would also address, compare, and update issues discussed in the design-stage plan. The final D&D plan would be subject to NEPA review.

5.1.12.2 Method and Assumptions

It was assumed that all NPR facilities would be designed for eventual D&D as required by DOE Order 5820.2A (Radioactive Waste Management) and DOE Order 6430.1A (General Design Criteria). The NPR project would be managed in accordance with a waste reduction program that covers the entire project life from conceptual engineering design to decommissioning. The program will define the specific steps in which the contractor plans to minimize all wastes (including hazardous and nonhazardous wastes) generated during construction, operations, and decommissioning. To achieve an effective waste reduction program, primary emphasis will be given to source reduction and, alternatively, recycling to minimize the quantities and toxicities of materials and substances before they enter the waste streams for treatment or disposal. For waste that is generated, waste reduction will include treatment to reduce the volume, toxicity, or mobility of such waste prior to storage or disposal. Following the direction of the NPR requirements document (DOE-8), DOE developed a method (Blond 1989) for estimating occupational exposure, volume of waste generated, and cost of D&D based on overall facility volume. Facility volume was selected since it is the only consistent engineering information available for all the reactor and support facilities at this stage of NPR design.

The D&D impact analysis for the NPR was based on the results of an EIS on decommissioning prepared by the Nuclear Regulatory Commission (NRC-3), which provides D&D information for several facility types based on a consistent set of assumptions. Factors were generated that provide, on a per-unit-volume basis, estimates of the occupational doses, waste volumes, and costs associated with D&D. To calculate the consequences of D&D of NPR facilities, these volume-normalized estimation factors were applied to the volume of each facility making up the NPR complex or used by NPR. The volumes used were obtained from the external dimensions of each facility. For facilities in which radioactive materials were not handled, the least costly estimation factors were used, and the occupational dose and radioactive waste volume were assumed to be zero.

5.1.12.3 Uncertainties

Uncertainties in the estimation of D&D impacts arise from two sources: uncertainties in the volume estimation factors and uncertainties resulting from applying the volume-normalized estimation factors to the entire building volume. The DOE study stated that the D&D cost estimates, when compared to actual costs, indicate an uncertainty of a factor of 2 (Blond 1989). There is no basis for determining the uncertainty of the estimation factors for occupational dose and waste volume. The uncertainty arising from the assumption that an entire

building can be represented by one type of factor is unclear, but probably results in an overestimation of impacts.

5.2 HANFORD SITE

5.2.1 Air Resources and Noise

This section describes the potential environmental impacts associated with constructing and operating an NPR and its support facilities at the Hanford Site that relate to air pollutants, cooling towers, and noise. The air quality assessments are based on analyses performed by Pacific Northwest Laboratory (PNL-6), unless otherwise noted. The assessments of cooling tower and noise impacts are based on analyses performed by Argonne National Laboratory (Chun and Coke 1991; Chun and Rabchuk 1991).

5.2.1.1 Air Quality

The potential air quality (nonradiological) impacts of constructing and operating the NPR and its support facilities at Hanford, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts are discussed in this section. Radiological air quality impacts are discussed in Section 5.2.6.

Impacts of No Action

Under the no-action alternative, the NPR and its support facilities would not be constructed, and the air pollutant emissions that would be associated with NPR construction and operation would not occur. In addition, no major changes in existing emission levels are expected at Hanford during the projected NPR construction period. Therefore, the ambient air quality at Hanford would be expected to remain essentially the same for the no-action alternative as for the baseline period.

Impacts of NPR Construction and Operation

The results of a detailed analysis of potential air quality impacts from constructing and operating an NPR and support facilities at Hanford (PNL-6) are summarized in Appendix E, Section E.2.1.1, for the three reactor technologies. The results indicate that the estimated ambient concentrations of sulfur dioxide (SO₂), nitrogendioxide (NO₂), carbon monoxide (CO), and PM₁₀ would remain below applicable national and state ambient air quality standards during both the NPR construction and operation periods (Table E.20). Although short-term (24-hour) ambient total suspended particulate (TSP) concentrations are expected to be in compliance with the state's ambient standards during the NPR operation period, the TSP concentrations are projected occasionally to exceed the state's 24-hour ambient TSP standard during the peak construction period (Table E.20). These occurrences would be during very dry and windy conditions. The increments of the criteria pollutant concentrations attributable to emissions from new operational sources would all be less than applicable maximum allowable Prevention of Significant Deterioration (PSD) increments (Table E.20).

The results of the analysis also show that the estimated ambient concentrations of acetone (C₃H₆O), ammonia (NH₃), nitric acid (HNO₃), 1,1,1-trichloroethane (TCA), and

trichloroethylene (TCE) would remain well below the Washington state ambient standards for these toxic pollutants during the NPR operation period (Table E.21).

Mitigation and Conclusions

The only significant air quality impact anticipated from the construction and operation of the NPR and its support facilities at Hanford will be short-term (24-hour) ambient TSP concentrations exceeding the state's ambient air quality standard (AAQS) during the peak construction period. Fugitive dust emissions from construction areas (e.g., during site preparation and excavation) and from unpaved roads would be reduced by periodic spraying of water. The frequency of spraying would be increased as necessary during very dry and windy conditions.

All new emission sources of criteria pollutants would comply with applicable new source performance standards. The new emission sources with pollutant emission rates that exceed the PSD significant emission rates (Table E.19) would be equipped with "best available control technology." "Maximum available control technology" would be applied to the NPR toxic air pollutant emission sources, if required by the Clean Air Act Amendments of 1990.

With the mitigation measures described above, no significant air quality impacts are expected at Hanford from constructing or operating an NPR and its support facilities.

5.2.1.2 Cooling Towers

This section describes the potential environmental impacts of operating circular, mechanical-draft, wet cooling towers for the three NPR technologies at Hanford, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts.

Impacts of No Action

Under the no-action alternative, the NPR and the cooling towers for NPR facilities would not be constructed, and the potential environmental impacts from constructing and operating the cooling towers would not occur.

Impacts of Cooling Tower Operation

The results of a detailed analysis of the potential environmental impacts of operating mechanical-draft cooling towers for the three NPR technologies at Hanford (Chun and Coke 1991) are summarized in Section E.2.2.1. The results indicate that under the conditions modeled, operation of the mechanical-draft cooling towers would not cause ground fogging or rime icing (Chun and Coke 1991). However, under the rare conditions of high wind speed, which might cause tower structure downwash effects, and high relative humidity, such phenomena could possibly occur within a few hundred meters of the cooling towers. Formation of glaze ice on surfaces, including facility roads within a few hundred meters of the cooling towers, could occur as a result of freezing of deposited drift droplets during an extended period when the ground is freezing. However, no impacts are anticipated from ground fogging, rime

icing, or glaze icing at the nearest public highway (SR 240), which, at its closest points, is located about 6 and 12 km southwest of the proposed NPR site for an HWR or MHTGR and the WNP-1 site, respectively.

The potential impacts on visual resources due to visible plumes and on terrestrial vegetation due to salt deposition are discussed in Sections 5.2.3 and 5.2.4, respectively.

Mitigation and Conclusions

The potential environmental impacts of operating the mechanical-draft, wet cooling towers for the three NPR technologies at Hanford are described in the previous section.

Any hazards to the safety of workers due to potential, but infrequent, buildup of glaze ice on facility roads in the immediate vicinity of the cooling towers would be mitigated by applying deicing materials, such as salt, as needed.

The potential impacts of salt deposition on terrestrial vegetation would be mitigated by minimizing emission of salt-containing drift from the cooling towers through regular maintenance of the tower's mist eliminators. A modern mist eliminator system could reduce the drift emission rate to less than one-half the design rate for the NPR cooling towers (0.02% of the circulating water flow rate). With the reduced drift emissions, any potential for glaze ice buildup and salt deposition would be substantially reduced.

With the mitigation measures described above, any environmental impacts due to salt deposition and visual plumes from the mechanical-draft cooling towers for the three NPR technologies at Hanford would be substantially reduced (Sections 5.2.3 and 5.2.4).

5.2.1.3 Noise

This section describes the potential noise impacts from constructing and operating the NPR and its support facilities at Hanford, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts.

Impacts of No Action

Under the no-action alternative, the NPR and its support facilities would not be constructed, and the noise associated with NPR construction and operation activities would not occur. Because no major changes in existing noise-emitting sources are expected at Hanford during the projected NPR construction period, the ambient noise levels at Hanford would be expected to remain essentially the same for the no-action alternative as during the baseline period.

Impacts of NPR Construction and Operation

The results of a detailed analysis of the potential noise impacts from constructing and operating an NPR and its support facilities at Hanford (Chun and Rabchuk 1991) are

summarized in Section E.2.3.1. The analysis indicates that noise from NPR construction equipment and machines, and from operational facilities, equipment, and machines, would not cause ambient noise levels to exceed the limits set by the Washington noise control regulations (Table E.7) or EPA guidelines. The latter are set to protect the public from the effect of broadband environmental noise and to protect the public against hearing loss (Tables E.39 and E.40). The results also indicate that increases in noise levels from constructing and operating the NPR and its support facilities, including increased traffic along the major roadways, would result in little or no increase in the annoyance level experienced by communities or individuals (Tables E.39 through E.41).

Mitigation and Conclusions

No significant noise impacts from activities associated with NPR construction and operation are expected at sensitive receptor locations outside the Hanford boundary or at residences along the major highways leading to the proposed NPR site at Hanford.

Construction workers and other personnel working in noisy environments during NPR construction or operation would be provided with earmuffs or earplugs approved by the Occupational Safety and Health Administration. In areas where workers would be exposed to equipment noise so severe that hearing loss could occur, noise levels would be monitored, according to DOE Order 5480.4 (DOE-31), to assure conformance with the threshold limit values (Tables E.50 and E.51) established by the American Conference of Governmental Industrial Hygienists (ACGIH 1990).

5.2.2 Water Resources

This section evaluates the potential impacts to surface water and groundwater resources from construction and operation of an NPR (HWR, LWR, or MHTGR) and associated support facilities at the Hanford Site and from hypothetical NPR-related hydrologic accidents. Evaluated are potential impacts to water flows, water quality, floodplain, water use, and water rights. The significance of these impacts is evaluated, and mitigative measures that would be implemented to reduce impacts are identified and assessed. Potential impacts associated with the no-action alternative also are discussed. Potential impacts of sanitary and nonhazardous, nonradioactive wastes on water quality are assessed. Potential impacts of radioactive, hazardous, and mixed wastes are assessed in Section 5.2.10.

5.2.2.1 Impacts of No Action

If an NPR were not constructed and operated at the Hanford Site, water resources would remain as described in Section 4.1.3, except for the effects that the possible future closure of the Plutonium-Uranium Extraction (PUREX) facility in the 200-East Area would have on the existing conditions at Hanford. The possibility of closing PUREX in 1995 is independent of NPR, and the potential impacts of that possibility are not the subject of this EIS. Anticipated changes in the hydrological conditions from the closure of the PUREX facility are discussed here only to compare the future baseline environment at Hanford with potential impacts from the construction and operation of an NPR.

Surface Water

Liquid effluent from PUREX operations currently are discharged to wastewater ponds and facilities in which contaminants ultimately infiltrate to the unconfined groundwater aquifer. In the absence of discharges from PUREX, the sizes of B Pond and the Fast Flux Test Facility (FFTF) Pond will decrease until the ponds no longer exist as surface water features. The quality of water in the ponds will progressively decrease as the ponds dry up and contaminants become more concentrated. The contaminants will eventually infiltrate to the groundwater in the unconfined aquifer or become trapped in the pond sediments. Once B Pond and FFTF Pond dry up, they will be backfilled, and grasses will be planted to stabilize the surface soil. However, before the backfilling occurs, contaminants in the dried sediments may be picked up by the wind and become a source of airborne pollutants.

West Lake is a naturally occurring surface water feature at the Hanford Site that is recharged from groundwater. As effluent discharges to the waste ponds and ultimately to groundwater decrease, West Lake will receive less recharge from the groundwater and eventually will again become a seasonal surface water feature. (The lake was seasonal before Hanford operations began in the 1940s.)

Groundwater

Groundwater withdrawals for the PUREX operations do not significantly affect the level of the unconfined aquifer beneath the Hanford Site. Effluents from PUREX operations currently are discharged to wastewater ponds and facilities in which contaminants ultimately infiltrate to the unconfined aquifer. In May 1989, DOE, EPA, and the Washington State Department of Ecology reached an agreement (called the Hanford Federal Facility Agreement and Consent Order, or the Tri-Party Agreement) concerning discharges and cleanup at the Hanford Site. The agreement provides for cleanup of past-practice units, which include existing discharge ponds and other untreated wastewater discharge facilities where the discharge infiltrates to the unconfined aquifer. The no-action alternative, including the cessation of PUREX operations in 1995 and changes made pursuant to the Tri-Party Agreement would generally reduce effluent discharges that would infiltrate to the unconfined aquifer.

The reduction of discharges would lower the water table elevation of the unconfined aquifer beneath the Hanford Site and lower the groundwater mound under B Pond. Lowering the groundwater mound in the B Pond area would decrease the hydraulic gradient of the groundwater and ultimately reduce the rate at which the groundwater flows toward the Columbia River. Reduced flow rate in the unconfined aquifer would, in turn, increase contaminant travel times to the river, and thus concentrations of radioactive contaminants in the groundwater would decrease through radioactive decay. Concentrations of nonradioactive contaminants, such as nitrate, that do not decay would remain the same. The net effect of these changes would be a slight improvement in the quality of groundwater discharges to the Columbia River at the Hanford Site.

Reducing the groundwater mounds in the B Pond area also would change the groundwater flow direction in the 200-E Area from northerly to easterly. The direction of the tritium plume migration in the 200-W Area would change accordingly (Figures 4.1.3-4 and 4.1.3-5).

5.2.2.2 Impacts of NPR Construction and Operation

This section assesses the potential impacts of the NPR project. Water withdrawals for construction and operation of an NPR at the Hanford Site are summarized in Appendix F, Tables F.25 and F.26. Construction of an LWR at Hanford would include completion of the partially constructed reactor at WNP-1. An HWR or MHTGR would be located at the NPR site.

Surface Water

Surface Water Flows. Surface water required for construction and operation of NPR support facilities in the 200 East Area would be taken from the existing water supply system, which obtains water from the Columbia River. Construction of the support facilities for an NPR would require approximately 0.00057-0.00063 m³/s (18,000-20,000 m³/yr) of surface water for dust suppression and concrete production (Table F.25). The withdrawal would be about 0.00006% of the minimum regulated flow of the Columbia River in the Hanford Reach (1,010 m³/s) for 5-10 years (depending on the reactor alternative). This level of withdrawal would have no measurable effect and no significant impact on the flow of the Columbia River in the Hanford Reach.

Surface water requirements for the operation of an NPR are shown in Table F.25. The water supply system for reactor operations would be separate from the system for support facilities in the 200-East Area. Operation of an NPR and support facilities would require approximately 1.1-1.4 m³/s (36-45 million m³/yr) of surface water. These surface water withdrawals would represent about 0.1% of the regulated minimum flow of the Columbia River in the Hanford Reach. This volume of withdrawal would not be measurable using conventional flow meters, which could have an error of approximately 5%, and would not significantly affect the flow or water level of the Columbia River.

During construction of an NPR and support facilities, no liquid effluents would be discharged directly to the Columbia River and, thus, there would be no significant impact to the river flow. Any runoff from the NPR site or WNP-1 site would either evaporate or infiltrate to the ground before reaching the Columbia River.

The primary discharge to the Columbia River during operation of an NPR would be reactor cooling tower blowdown. The blowdown would be discharged to the river through either an existing blowdown line (LWR) or a new line (HWR or MHTGR). The blowdown discharge structures would be placed in the river adjacent to, but downstream of, the NPR intake structure. Blowdown discharges to the Columbia River during operation of an NPR would total about 0.27 m³/s (8.5 million m³/yr) for an HWR, 0.25 m³/s (7.9 million m³/yr) for an LWR, and 0.22 m³/s (6.9 million m³/yr) for an MHTGR (Tables A.1, B.1, and C.2 in Appendixes A, B, and C). These volumes would be approximately 0.02% or less of the minimum regulated flow of the Columbia River in the Hanford Reach and would not constitute a significant impact to surface water flow.

Surface Water Quality. During NPR construction, no effluents would be discharged directly to the Columbia River, and thus no significant surface water quality impacts would be anticipated from this source. However, construction of new intake and discharge structures

would be necessary for the HWR or MHTGR, and construction activities would have the potential to impact water quality. Intake and discharge structures for the LWR at the WNP-1 site already are in place. For the purposes of this EIS it is assumed that the design of the structures for the HWR or MHTGR would be similar to those of WNP-1 and that best-technology-available and construction practices similar to those used for WNP-1 would be employed. Potential impacts of WNP-1 cooling water system operation were assessed by the NRC in 1975 and were found to be insignificant with respect to impacts on water quality for municipal water supplies and for aquatic systems (NRC-1). Excavation and dredging for the buried intake and discharge lines for an HWR or MHTGR would temporarily increase turbidity immediately downstream of the construction site. Appropriate erosion control techniques would be used to limit the extent of these effects. These techniques would include, but not be limited to, riprapping the area of the intake and discharge structures, riprapping the disturbed banks of the river, and reseeded areas disturbed by construction.

Cooling tower blowdown, the primary effluent discharge to the Columbia River from NPR operation, would contain chemical and radioactive contaminants (including tritium). The annual tritium releases in liquid blowdown from an LWR at Hanford for normal plant operations without detritiation (prior removal of tritium) would be the largest among the three reactor alternatives, at approximately 12,000 Ci per year (Table H.2 in Appendix H). With a planned detritiation system removing 90% of the tritium, the LWR tritium release would be 1,200 Ci/yr, and the corresponding tritium concentration in blowdown water would be approximately 156,000 pCi/L. Under conditions of minimum regulated flow in the Columbia River (1,010 m³/s), blowdown would be diluted by the Columbia River by a factor of approximately 4,200. At this dilution factor, the tritium concentration increase in the river at the Richland, Washington, monitoring site would be approximately 37 pCi/L, which would be well below the EPA Drinking Water Standard limit of 20,000 pCi/L. The concentrations of all other radionuclides in the cooling tower blowdown would be less than the effluent release concentrations set by the Nuclear Regulatory Commission in 10 CFR 20. The combined total of the effluent concentrations was estimated to be only about 3% of the NRC concentration limits for all radionuclides other than tritium (WHC-8).

Chemical components in the blowdown discharge (Tables P.1 and P.2 in Appendix P) would also be diluted by Columbia River water. For assessing the potential impacts of the blowdown on water quality, the concentrations of chemical constituents in the blowdown are compared with the EPA drinking water standards. Although concentrations of some constituents would exceed the standards (Tables P.1 through P.3), the water quality effect on the Columbia River would be unmeasurable once the blowdown was mixed with the river water. The effects of dissolved contaminants and thermal discharge on water quality also can be inferred from monitoring data for WNP-2 operations (WPPSS-2), which are similar in types and quantity of blowdown discharge to those shown in Table P.1. The chemical and thermal character of the Columbia River in the vicinity of the WNP-2 has been monitored since 1983. Data for 1988 indicate that no significant differences in the chemical and thermal character of the river 90 m downstream from the WNP-2 discharge could be detected (WPPSS-2). This comparison indicates that impacts to Columbia River water quality from chemical contaminants and thermal energy from NPR cooling water blowdown would be insignificant.

Floodplain. Both the WNP-1 site and the NPR site at Hanford are located outside the Columbia River floodplain, as defined by the probable maximum flood (Figure 4.1.3-1). No new structures for an LWR at the WNP-1 site would be located within the Columbia River floodplain.

Operation of an HWR or an MHTGR at Hanford would require construction of new intake and discharge pipes in the floodplain and in the bed of the Columbia River. These pipes, however, would be buried and would not be flow impediments in the event of a flood. Therefore, no significant impacts to the Columbia River floodplain are expected. This construction activity would require a permit from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act (Section 6).

Surface Water Use. Neither construction nor operation of an NPR at Hanford would have a significant impact on the water flow or water quality of the Columbia River. Therefore, the availability of Columbia River water would not be affected for domestic, industrial, or agricultural water users downstream of the Hanford Site, including the Portland, Oregon, area. Because an NPR at Hanford would not have any significant and unmitigable impacts to the flow or quality of the Columbia River, construction and operation of an NPR would not preclude the Columbia River's receiving status under the Wild and Scenic River Act (Section 6).

Surface Water Rights. Because the DOE has asserted a Federally reserved water right, water rights issues would not be affected.

Groundwater

Groundwater Levels. Groundwater required for the construction of an NPR and its support facilities would be withdrawn from the unconfined aquifer either from existing wells in the 400 Area or from new wells at the NPR site or WNP-1 site. Construction of an LWR (WNP-1) at Hanford is about 60% complete. For this reason, groundwater needed to complete the LWR is expected to be less than the generic annual requirement of 0.012 m³/s (380,000 m³/yr) and for a shorter construction period of 5 years. Construction of an HWR at Hanford would require approximately 0.013 m³/s (410,000 m³/yr) of groundwater for 8.5 years, and the MHTGR would require approximately 0.013 m³/s (420,000 m³/yr) of groundwater for 10 years (Table F.25).

Potential impacts from water withdrawal on groundwater level were evaluated for construction of that facility. The computations indicate that the drawdown produced by a single well pumping continuously from the unconfined aquifer at the NPR site at a rate doubling the MHTGR requirement (0.013 m³/s) would be 0.5 m at a distance of 300 m from the well. This drawdown would not significantly affect groundwater flow. At the Columbia River, 12 km from the NPR site, the drawdown from pumping for NPR construction would not be distinguishable from the annual water level variations in groundwater produced by fluctuations in groundwater recharge (Tomasko and Durham 1990). These impacts to groundwater flow from construction of an NPR and support facilities would not be significant.

Operation of NPR support facilities would require groundwater either from new or existing wells at the NPR site and the 400 Area. For an HWR, groundwater withdrawal would be about 0.035 m³/s (1.1 million m³/yr) for either the tritium mode or the plutonium mode (almost all for the heavy-water processing facility) (Table F.26). Based on the drawdown discussed in the preceding paragraph for construction withdrawal, the drawdown would be about 0.7 m at a distance of 300 m from the well. This drawdown would not significantly affect

groundwater flow. For the LWR and MHTGR, groundwater withdrawals would total about 0.00063-0.00076 m³/s (20,000-24,000 m³/yr) for the tritium mode and 0-0.0057 m³/s (0-180,000 m³/yr) for the plutonium mode (Table F.26). The drawdown from obtaining these quantities of water by pumping at a single well would be significantly less than the drawdown for construction purposes and, as discussed above, would not cause a significant impact to groundwater levels and flows at the Columbia River.

Construction and operations of an NPR and support facilities would result in the discharge of sanitary and other wastes to either existing treatment facilities near the WNP-1 site or to sanitary tile fields in the 200-East Area and the 400 Area. Sanitary wastes from construction and operation of an LWR at the WNP-1 site would be directed to an existing treatment facility originally designed to accommodate discharges from three reactor complexes (WNP-1, WNP-2, and WNP-4). This facility has the capacity to treat 0.0076 m³/s (240,000 m³/yr) of sewage and then discharge it to a sanitary tile field. About 0.0016 m³/s (50,000 m³/yr) or less would be discharged to new 0.6-ha drain fields in any area (Heacock 1990c). The resultant mounding of groundwater would be less than 1 m (Tomasko and Durham 1990). While this mounding might cause some localized changes in groundwater flow rates, the effects would not be measurable at the Columbia River. Thus groundwater flow to the Columbia River would not be significantly affected. Groundwater mounding of less than 1 m in the 200-East Area would not be sufficient to drive groundwater flows in a northerly direction toward West Lake. Thus, West Lake would remain as described above under the no-action alternative.

Groundwater Quality. The concentrations of constituents in effluents from the drain fields are expected to be similar to those of treatment plant effluent. The amount of nonhazardous liquid waste generated during operation would be about 0.00057-0.0027 m³/s (18,000-107,000 m³/yr) for the tritium production mode and 0.0057-0.0092 m³/s (180,000-290,000 m³/yr) for the plutonium production mode (Tables 5.2.10-2 and 5.2.10-3 in Section 5.2.10). Nonhazardous liquid waste would be disposed of in evaporation ponds, which would be lined to minimize infiltration into the ground. The NPR is not expected to have significant impacts to groundwater quality.

Groundwater Use. Because the construction and operation of an NPR would not significantly affect the level, flow, or quality of groundwater, no significant impacts to groundwater uses are expected.

Groundwater Rights. Because the DOE has asserted a Federally reserved water right, water rights issues could not be affected.

5.2.2.3 Impacts of Hydrologic Accidents

At the Hanford Site, large volumes of water containing contaminants such as tritium would be contained in the secondary cooling water intake basin (95,000 m³) for the HWR and the spray pond for the LWR (49,000 m³). Failure of these basins could impact the hydrological system. However, these containing basins would be designed to meet Category I seismic criteria; their failure is not credible and will not be further evaluated (Tomasko and Tilbrook 1990).

Failures of other liquid-containing systems (e.g., cooling system water for the MHTGR, other water systems for the HWR or LWR, chemical or diesel fuel storage or treatment systems, etc.) would not significantly impact the Hanford hydrological system for a number of reasons. These reasons include small associated fluid volumes, location within radiological control structures without liquid release paths, and the large number of potential mitigation methodologies that could be implemented (Tomasko and Tilbrook 1990). These methodologies include engineered barriers (dams and dikes), catchments, and other on-site mitigation contingency plans.

5.2.2.4 Mitigation and Conclusions

Surface Water

Construction and operation of an NPR and support facilities at the Hanford Site would not have any significant effects on existing surface water resources. Downstream changes in the flow or water levels in the Columbia River would not be measurable using standard measuring devices.

To ensure that water quality of the Columbia River would not be affected during the construction of an NPR and support facilities, best management practices for erosion and sedimentation control would be implemented in accordance with applicable state of Washington requirements. Best available technology and construction techniques also would be used to protect water quality during construction of the intake and discharge pipes in the Columbia River. These techniques would include, but are not limited to, placing riprap around the intake and discharge structures along the disturbed river banks and revegetating disturbed land areas. Water quality in the Columbia River at the Richland, Washington, monitoring site during construction and operation of an NPR would remain within EPA Drinking Water Standards and the state of Washington's Water Quality Standards.

Groundwater

Construction and operation of an NPR and support facilities at the Hanford Site would not have any significant effects on existing groundwater resources. Changes in the levels and quality of groundwater in the unconfined aquifer would not be measurable at the site boundary. Construction or operation of an NPR would require the use of groundwater from new or existing wells in the 400 Area or NPR site. Groundwater in the unconfined aquifer in these areas is contaminated with plumes of radioactive and chemical constituents, as shown in Figures 4.1.3-5 and 4.1.3-6. To mitigate the impacts of using and subsequently discharging contaminated groundwater, alternative sources of clean water would be found. Such sources might include groundwater in different locations or water from the Columbia River. Withdrawal of the additional water from the river would have no significant impact on the flow or level of the Columbia River, because the amount of withdrawal would be small relative to the river flow.

No credible significant hydrologic accidents were identified for the site; any structures containing large volumes of contaminated water either would be isolated from the environment or contained in structures designed to meet Category I seismic criteria. Failures of other liquid-containing systems would not be important because of the small volumes of liquids involved, a lack of release paths, and easily implemented mitigation strategies.

5.2.3 Land Use, Recreation, and Visual Environment

5.2.3.1 Impacts of No Action

If an NPR were not constructed and operated at the Hanford Site, land use patterns, use of recreational resources, and the visual environment would remain as described in Section 4.1.4. The Hanford Site would remain a Federal facility dedicated to nuclear research and development, isotope production, and electricity generation. Other continuing activities would include waste management, commercial power production, ecological research, and wildlife management.

5.2.3.2 Impacts of NPR Construction and Operation

Historically, the Hanford Site has been used for nuclear materials production. The construction and operation of an NPR would be consistent with this historical use. Off-site land use would not be affected by construction and operations of an NPR, except to the extent that some undeveloped lands probably would be developed for worker housing (Section 5.2.7). Such development would be subject to local land use and zoning controls, which vary by jurisdiction. No project facilities would be located off-site.

No direct or indirect effects would occur to wildlife refuges on the Hanford Site because NPR activities would not be close to these areas. Although construction at the NPR site would disturb native vegetation (Section 5.2.4), the 805 ha (maximum) involved would constitute only a small part of the existing natural environment at Hanford, about 34,000 ha. Therefore, the use of Hanford as a National Environmental Research Park would not be significantly affected.

The cooling water intake and discharge pipeline, to be constructed between the NPR site and the Columbia River, would cross land that, if irrigated, might be suitable for agriculture. To date, this land has not been designated as either prime or unique farmland.

Population increases resulting both from construction and operation of an NPR would increase use of recreational facilities and parks in the area. However, potential impacts to recreation from any of the three NPR alternative technologies are not quantifiable.

Adverse publicity might result from any controversy that arose over development of an NPR at the Hanford Site or in the unlikely event of an accident at the reactor or support facilities; thus, it is conceivable that the number of visitors to the Tri-Cities could decrease slightly. However, historical use of the Hanford Site for materials production and radioactive waste management has already been widely publicized. It is expected that the incremental impacts to tourism associated with adverse publicity due to construction and operation of an NPR would not be discernible.

Changes caused by construction and operation of an NPR would be consistent with the existing overall visual environment of the Hanford Site. The WNP-1 reactor facility and support facilities for the LWR alternative would be partially obstructed from view from population centers. Construction of WNP-1 is nearly completed, and the facility is adjacent to the existing WNP-2 facility, which includes buildings, containment structure, and cooling towers. Topographic features obstruct the NPR site (the proposed location for the HWR and MHTGR

alternatives) from view from populated areas. Both the WNP-1 site and NPR site could be seen from the farmland bluffs that overlook the Columbia River on the east. However, these lands are on private property not readily accessible to the public. Landowners would likely grant access permission only during the hunting season, if at all.

Cooling tower plumes from the proposed facilities at either NPR location would be visible at times from public access highways and from the Columbia River. Three plumes from an LWR operating at the WNP-1 location would be adjacent to those from the WNP-2 reactor and would impact the current visual environment at the WNP-1 site. Two plumes from the MHTGR or three plumes from the HWR at the NPR site would be partially obstructed from view from the Tri-Cities by topography and by distance. These plumes would constitute new visual elements in the vicinity of the NPR site, but they would be consistent with the expectation of cooling tower plumes within the Hanford Site. The method used to assess the impacts of NPR cooling towers in the visual environment is discussed in Section 5.2.1.2. The HWR and MHTGR would create no visible plume beyond the site boundaries, although plumes often would be visible to motorists from Highway 240. The LWR plumes would be visible beyond the Hanford boundaries less than 0.1% of time. Fogging is extremely unlikely for any of the alternatives.

5.2.3.3 Mitigation and Conclusions

No impacts requiring mitigation would occur to land use, recreation, or the visual environment as a result of construction or operation of an NPR at the Hanford Site.

5.2.4 Biotic Resources

This section evaluates the impacts to biotic resources that would result from the construction and normal operations of an HWR, LWR, or MHTGR at the Hanford Site. Descriptions of these reactor alternatives and their associated facilities are presented in Section 3.4

5.2.4.1 Terrestrial Resources

Impacts of No Action

If an NPR were not developed, no changes to terrestrial resources would be expected on the Hanford Site beyond those resulting from natural processes of succession and the impacts of ongoing Hanford operations (see Section 4.1.5). These two factors would be unaffected by the lack of new production capacity.

Impacts of NPR Construction and Operation

Construction of an HWR or MHTGR at Hanford would disturb about 805 ha or 463 ha of land, respectively, representing about 0.6% or 0.4% of the total area of the Hanford Site. Approximately 277 ha or 267 ha, respectively, would be occupied by facilities, access roads, or

rights-of-way and, therefore, would remain developed for the life of the project. The remaining land would be revegetated with native grasses and shrubs upon completion of construction.

Because the existing WNP-1 facility would be used for an LWR at Hanford, development of this alternative and associated support facilities would disturb only about 118 ha, or 0.1% of the Hanford Site. About 51 ha of this land would remain developed for the life of the project; as with the HWR and MHTGR alternatives, the remaining land would be revegetated with native species.

Vegetation within construction areas would be destroyed during land-clearing activities. Plant species that are dominant on the Hanford NPR site, and thus would be most affected, include big sagebrush, cheatgrass, Sandberg's bluegrass, antelope bitterbrush, and needle-and-thread grass. Although the plant communities to be disturbed are well-represented on the Hanford Site, they are relatively uncommon regionally because of the widespread conversion of shrub-steppe habitats to agriculture (Rickard and Poole 1989). Disturbed areas are generally recolonized by cheatgrass, a nonnative species, at the expense of native plants (Rickard and Poole 1989). Mitigation of these impacts would include minimizing the area of disturbance and revegetating with native species, including shrubs. Adverse impacts to vegetation on Hanford are expected to be limited to the project area and vicinity and are not expected to affect the viability of any plant populations on the Hanford Site.

Construction of an NPR and support facilities would have some adverse affect on animal populations. Less mobile animals such as invertebrates, reptiles, and small mammals within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to adjacent suitable habitat (Moore and Mills 1977), and these individual animals might not survive and reproduce. Project facilities would displace about 277 ha or 267 ha, respectively, of animal habitat for the life of an HWR or MHTGR; LWR facilities would displace about 51 ha of currently undisturbed animal habitat. Revegetated areas (e.g., construction laydown areas and buried pipeline routes) would be reinvaded by animal species from surrounding, undisturbed habitats. The adverse impacts of construction are expected to be limited to the project area and vicinity and should not affect the viability of any animal populations on the Hanford Site because similar suitable habitat would remain abundant on the site.

Cooling tower drift would result in salt deposition on surrounding land areas and vegetation. For an HWR, LWR, or MHTGR, respectively, areas of approximately 7.1 ha, 12.7 ha and 34.2 ha in the immediate vicinity of the cooling towers would be affected by salt deposition. These areas would experience salt deposition rates above the threshold value of 17.1 kg/ha-mo at which salt stress symptoms can become visible on sensitive plant species (DOE-20). Part of the locations affected by drift would include developed portions of the facility; thus, the actual total areas of vegetation affected would be less than the values cited above. Maximum distance from the cooling towers at which threshold values would be exceeded also would vary according to reactor technology -- 350 m, 400 m, and 850 m for an HWR, LWR, and MHTGR, respectively. All areas affected by drift would be within the Hanford Site boundary and would be relatively small compared with the total land area of the Hanford Site. Studies conducted in 1987 for the operating WNP-2 reactor indicated that no changes to vegetation could be attributed to drift effects and that chemical characteristics of soil and vegetation in areas of deposition were either within previously measured ranges or were below levels measured in preoperational studies (WPPSS-4).

Very small concentrations of radionuclides (several orders of magnitude lower than natural background levels) would be released to the atmosphere during NPR operations. No organisms studied to date are reported to be more sensitive than man to radiation (NRC-8). Therefore, as concluded for humans (see Section 5.2.6), the effects of these releases on terrestrial organisms are expected to be minor.

Mitigation and Conclusions

Impacts to terrestrial resources from construction of an NPR at Hanford would include (1) disturbance and alteration of plant communities and (2) displacement of animals present on construction areas. These disturbances would occur on a relatively small percentage of the Hanford land area and would be considerably less for an LWR than for an HWR or MHTGR. Those impacts would be mitigated by minimizing the amount of land disturbed during construction, employing soil erosion control measures during construction activities, and revegetating disturbed areas with native species. These mitigation measures would limit the amount of direct and indirect disturbance to the construction area and surrounding habitats and would speed the recovery process for disturbed lands.

Operational impacts to terrestrial biotic resources would include (1) deposition of salts from cooling tower drift on nearby terrestrial vegetation and (2) exposure of plants and animals to small amounts of radionuclides released during operation of the NPR. The area affected by salt deposition would be less than 35 ha, and the levels of radionuclide exposure would be below those levels that produce adverse effects.

Mitigation of operational impacts are related to design features of the NPR and associated facilities as described in Section 3.4. Rates of salt deposition due to cooling tower drift could be reduced to approximately one-half of those discussed by using a modern mist eliminator system (see Section 5.2.1). Additional mitigation would not be required to bring effluents within acceptable levels.

5.2.4.2 Wetlands

Impacts of No Action

If an NPR were not developed, no changes to wetlands on the Hanford Site would be expected beyond those changes resulting from natural processes and the impacts of ongoing Hanford operations (see Section 4.1.5).

Impacts of NPR Construction and Operation

No wetlands occur on the NPR site; however, some riparian wetlands (less than 0.25 ha) along the Columbia River would be disturbed temporarily during construction of the water intake and discharge pipelines for an HWR or MHTGR. No impacts to wetlands are expected for the LWR alternative at Hanford because the WNP-1 site is not located near wetlands and the intake and discharge lines for this facility are already built.

No impacts to wetlands are expected to result from operation of an HWR, LWR, or MHTGR at Hanford because water intake and discharge rates would not affect the flow of the Columbia River and, therefore, would not affect riparian wetlands along the river (see Section 5.2.2). No wetlands are within the area that would be affected by cooling tower drift.

Mitigation and Conclusions

Detailed mitigation plans would be developed in consultations with the Corps of Engineers as part of the permitting process for construction activities within riparian areas associated with development of intake and discharge structures for an HWR or MHTGR. Disturbed areas would be revegetated with native grasses and shrubs immediately upon completion of construction so as to minimize erosion and runoff. Therefore, impacts should be temporary. Since no new intake or discharge facilities are needed for an LWR at Hanford, no wetland impacts are expected for this alternative and no mitigation is required. No NPR operational impacts to wetlands are expected at Hanford.

5.2.4.3 Aquatic Resources

Impacts of No Action

If an NPR were not developed, no changes would be expected to aquatic resources on the Hanford Site other than those changes resulting from natural processes and the impacts of ongoing Hanford operations (see Section 4.1.5). These two factors would be unaffected by the lack of new production capacity.

Impacts of NPR Construction and Operation

Although no aquatic habitats occur on the NPR site or the WNP-1 site, construction of the water intake and discharge structures for the HWR or MHTGR and operation of any of the three reactor types could affect aquatic organisms and habitats in the Columbia River.

Construction of the water intake and discharge pipelines for the HWR or MHTGR would cause some disruption of the shore and bed of the Columbia River. The benthic communities of plants and invertebrates would be destroyed where ditches were dug within the river bed for pipelines. These organisms are expected to recolonize these areas shortly after burial of the pipelines. Sedimentation and turbidity would increase downstream of construction sites, but these conditions also would be relatively temporary. The use of standard erosion control measures on the shore and banks of the river, including revegetation shortly after construction, would minimize erosion and subsequent increases in turbidity in the river. In addition, work in the river would not be conducted during the fall spawning period of salmon. The intake and discharge pipelines for the LWR have already been constructed; therefore, no additional impacts to aquatic organisms and habitats are expected for LWR construction.

During operations, an HWR, LWR, or MHTGR would withdraw cooling water from the Columbia River at a rate representing less than 0.1% of the river's flow at the lowest regulated

level (Section 5.2.2). Such removal would not significantly affect river flows or the aquatic organisms dependent on them.

Removal of cooling water from the Columbia River would cause the entrainment and subsequent mortality of planktonic organisms, including the eggs and larvae of certain fish species. Fish species in the Hanford Reach of the Columbia River that have planktonic egg and larval stages, and thus would be most affected by entrainment, include minnows, suckers, and mountain whitefish (NRC-1). Eggs and larvae of salmonid species are less likely to be entrained because they are not planktonic (Scott and Crossman 1973). Free-swimming salmon fry (young fish) are not expected to be entrained because they typically occupy shallow, gravel areas near the stream bank (Scott and Crossman 1973; Dauble, Page, and Hanf 1989), away from the intake structure, which would be located more than 100 m from the shore at low water. Because a relatively small percentage of the total water volume passing the site (0.1% of the minimum flow) would enter the NPR intake, entrainment losses are not expected to affect the viability of any populations of aquatic organisms in the Hanford Reach.

Larger fish in the immediate vicinity of the intake structure could be impinged and killed on the water intake screens, but monitoring associated with operation of WNP-2 at Hanford has detected only minimal loss of fish due to impingement. No impingement losses were detected in 1987 (WPPSS-4). Impingement losses due to an HWR or MHTGR would be minimized by the location of the intake structure (away from areas of fish concentration) and the low velocity (less than 15.2 cm/s) of water entering the structure. Intake structures for an HWR or MHTGR would be situated perpendicular to the river current, which flows at a minimum rate of 70.7 cm/s. Thus, fish and debris would tend to be washed away from the intake. The existing WNP-1 intake structure, which would be used for an LWR, consists of a perforated outer sleeve that would prevent fish from entering the system. The low intake velocity (12.2 cm/s) would reduce the likelihood of impingement losses (NRC-1).

An HWR, LWR, or MHTGR would discharge cooling-tower blowdown water into the Columbia River. The DOE is committed to meeting all water quality standards at the point of discharge of this effluent. The released blowdown water would be approximately 9.4 to 10.9°C warmer than the ambient water temperature in the river, which averages 11.4°C. However, because of the large dilution factor in the river (4,200:1; see Section 5.2.2), the thermal plume caused by this effluent would not extend beyond 91 m downstream of the outfall. In addition, the concentration of water-treatment chemicals (e.g., chlorine) in the blowdown water would not be significantly above ambient levels beyond this mixing zone. Monitoring associated with WNP-2 operations did not detect differences in water temperature or other water quality parameters between sampling areas above and below the point of effluent discharge for that facility (WPPSS-1; WPPSS-4). Impacts to aquatic organisms from NPR effluents would be limited to those organisms within the thermal plume. Because this plume would be so small, only a very small percentage of the biota in the Hanford Reach would be affected. Relatively sessile organisms, such as benthic macroinvertebrates, are expected to be most affected (NRC-1). Fish, including salmonids, easily swim around limited thermal plumes to avoid adverse conditions (Romberg et al. 1974).

The cooling-tower blowdown and other process effluents released to the Columbia River would contain radionuclides. The most abundant radionuclide in this effluent would be tritium (at concentrations of 56,500 pCi/L, 1.56 million pCi/L, or 812,000 pCi/L for an HWR, LWR, or MHTGR, respectively). Other radionuclides would be present in very small concentrations but would make a greater contribution to the total dose. The total dose from all radionuclides to an

aquatic organism (e.g., a fish) living within undiluted effluent is estimated to be 1.2 mrad/d (405 mrad/yr) or less (Table 5.2.4-1). This value is well below the dose limit of 1,000 mrad/d established in DOE Order 5400.5 for the protection of native aquatic organisms. The calculated dose is conservative because it is unlikely that an organism would spend a substantial portion of its life within the effluent plume, and the concentration of radionuclides would be diluted by a factor of 4,200 upon release to the Columbia River (Section 5.2.2). Therefore, the amount of radiation to which most river organisms would be exposed is expected to be lower than this estimated dose, and, thus, impacts due to release of radionuclides to the river should not adversely affect aquatic biota.

TABLE 5.2.4-1 Calculated Dose to an Aquatic Organism Living in Undiluted Effluent from an NPR at Hanford^a

Source	Dose (mrad/d)	
	Contributed Dose	Total Dose (Existing + NPR)
Existing	0.006	NA
HWR	0.48	0.49
LWR	1.19	1.20
MHTGR	0.21	0.22

^aMethod of calculation is presented in Section 5.1.5.

Mitigation and Conclusions

Detailed mitigation plans would be developed in consultation with the Corps of Engineers as part of the permitting process for construction of HWR or MHTGR intake and discharge structures in the Columbia River. Standard erosion control practices on the shores and banks of the river, including revegetation with native species, would be implemented to minimize sediment runoff. In addition, construction activities would not be conducted within the river during the autumn, when salmon spawn in the Hanford Reach. The use of the existing WNP-1 structures for an LWR would preclude the need to develop mitigation for this alternative.

Mitigation of operational impacts are related to design features of the NPR and associated facilities, as described in Section 3.4. This includes a commitment by DOE to meet all water quality standards at the point of discharge of blowdown effluents. The intake structures have been designed to limit the potential for significant loss of aquatic organisms through entrainment or impingement. Such design characteristics include placement of intake structures away from areas of fish concentration, screening of the structure, and limiting the intake velocity to less than 15 cm/s. Concentrations of tritium in the blowdown water from an LWR could be reduced by 90% with the employment of detritiation.

Impacts to aquatic resources from construction of an NPR at Hanford would be limited to disturbance of the shoreline and bed of the Columbia River during construction of the intake and discharge facilities for an HWR or MHTGR. With mitigation, construction impacts to aquatic resources would be temporary and limited to the immediate area of construction. No such impacts would result from construction of an LWR, since this alternative would utilize existing structures. Operational impacts of an HWR, LWR, or MHTGR would include (1) exposure of aquatic organisms to increases in temperature and concentrations of radionuclides and other contaminants within a limited area near the discharge outfall in the river and (2) loss of organisms as a result of impingement and entrainment. Given the design characteristics of the facility, these impacts should not reach adverse levels.

5.2.4.4 Threatened and Endangered Species

Impacts of No Action

If an NPR were not developed, no change to threatened and endangered species on the Hanford Site would be expected to occur beyond those effects resulting from natural processes and the impacts of ongoing Hanford operations (see Section 5.1.5).

Impacts of NPR Construction and Operation

The bald eagle is the only Federally listed species that is likely to be affected by construction of an NPR at Hanford. Impacts would result from construction of the HWR or MHTGR water intake and discharge facilities at the historic Hanford Townsite along the Columbia River, where eagles perch and forage during the winter. Eagles at this location would be disturbed during periods of construction and are expected to avoid this area until construction is complete. Completion of the WNP-1 facility for the LWR alternative is not expected to affect the bald eagle. Eagles do not use areas where the remaining construction for this facility would occur. The bald eagle is not expected to be affected by NPR operations. As an occasional migrant through the Hanford area, the peregrine falcon should not be affected by construction or operation of an NPR.

Several other species that do not receive Federal protection under the Endangered Species Act, but that are candidates for listing (Category 2) and would be affected by NPR construction, include the long-billed curlew, Swainson's hawk, ferruginous hawk, giant Columbia River limpet, giant Columbia River spire snail, and Columbia yellow cress. Long-billed curlew nesting and foraging habitat on the NPR site would be destroyed during land-clearing operations before construction. Construction and operations also would disturb curlews in areas immediately adjacent to the site, causing the curlews to avoid these areas. Completion of the WNP-1 facility for an LWR would not affect long-billed curlew habitat. Impacts from development of an NPR are not expected to affect the viability of the long-billed curlew population on the Hanford Site because similar habitat is relatively common there.

Both the Swainson's hawk and ferruginous hawk would lose some foraging habitat as a result of construction of an NPR at Hanford. However, since these species forage over a relatively large area and this type of habitat is abundant on the Hanford Site, loss of foraging habitat on the NPR site is not expected to affect the viability of populations of either species at Hanford. Disturbance of nesting birds of both species is also expected to occur. Human activities associated with construction and operations of an HWR or MHTGR on the NPR site could disturb ferruginous hawks nesting on transmission towers 1 km from the NPR site. This disturbance could cause hawks to abandon their nests.

Construction of HWR or MHTGR water intake and discharge facilities at the Hanford Townsite could disturb Swainson's hawks nesting there and result in the destruction of several nests of this species. Impacts to nesting Swainson's hawks, however, would be restricted to periods of construction.

Giant Columbia River limpets and giant Columbia River spire snails present within construction areas of the river bed would be destroyed, but limpets and snails from adjacent

areas would recolonize the site following construction. In a similar fashion, Columbia yellow cress plants within the riparian zone of the Hanford Townsite could be crushed during construction of water lines, but would reinvade from adjacent areas after construction was complete. No long-term effects are expected on populations of these species.

State-listed species would be affected by construction of an HWR or MHTGR. Sandhill cranes, white pelicans, and common loons in the vicinity of the intake and discharge facilities along the river would be disturbed by human activities and would move to other areas along the river. In addition, sandhill cranes could be affected by habitat disturbance on the NPR site. Impacts to all these state-listed species should not effect the viability of their populations in the Hanford area.

Mitigation and Conclusions

A biological assessment that describes the impacts to Federally listed species has been developed and submitted to the FWS for evaluation (DOE-68). If deemed necessary by the FWS, a detailed plan to mitigate impacts to Federally listed threatened and endangered species would be developed in consultation with that agency. Potential mitigation of impacts to the bald eagle (Federal threatened) includes (1) avoidance of construction in the vicinity of the historic Hanford Townsite during the winter, when eagles frequent the area, and (2) construction of artificial perch sites to replace any trees at the Hanford Townsite destroyed during construction. Mitigation of impacts to the long-billed curlew, Swainson's hawk, and ferruginous hawk (Federal Category 2 species) would include (1) minimizing the amount of land disturbed during construction, (2) avoiding land-clearing activities during nesting season of these species (April to August), (3) minimizing the number of trees removed during construction, and (4) constructing artificial nesting platforms to replace nest sites of the Swainson's hawk or ferruginous hawk that are lost or abandoned during the construction period. Impacts to the giant Columbia River limpet and giant Columbia River spire snail (Federal Category 2 species) could be mitigated by limiting the amount of disturbance to the river bed during construction of the intake and discharge facilities. Mitigation of impacts to Columbia yellow cress (Federal Category 2) and the sandhill crane (state endangered) would be limited to minimizing the area of disturbance.

Impacts to threatened and endangered species at Hanford that would result from construction of an HWR or MHTGR include (1) disturbance of bald eagle perch sites, (2) disturbance of nesting long-billed curlews, Swainson's hawks, and ferruginous hawks, (3) disturbance of foraging areas for long-billed curlews, Swainson's hawks, and ferruginous hawks, (4) disturbance of areas of the river occupied by giant Columbia River limpets and giant Columbia River spire snails, and (5) disturbance of habitats occupied or used by Columbia yellowcress, white pelicans, common loons, and sandhill cranes. With the mitigation outlined above, these impacts should not affect the viability of these populations. No such impacts would result from development of an LWR at Hanford, since the nearly complete WNP-1 facility would be used for this alternative. In addition, operation of any NPR alternative at Hanford is not expected to have any impacts on threatened and endangered species.

5.2.5 Cultural Resources

The construction of a light water reactor at the WNP-1 site and the no-action alternative would not affect archaeological, historical, or cultural resources at Hanford. Construction of an HWR or an MHTGR at the Hanford NPR site could have adverse effects on one historic property. The construction corridor for the water intake and discharge facilities for the HWR and MHTGR would cross two potentially significant sites, and one of these sites (45BN305) could be adversely affected. Operational impacts are not expected. Mitigation alternatives, which will be worked out in consultation with the Washington State Historic Preservation Officer (SHPO), Advisory Council for Historic Preservation, and area tribes, may include avoidance or data recovery.

5.2.5.1 Impacts of No Action

The no-action alternative would not adversely affect the archaeological, historical, or cultural resources at Hanford. These would remain as described in Section 4.2.6.

5.2.5.2 Impacts of NPR Construction and Operation

Affected Archaeological Sites and Historic Structures

The LWR alternative would use an existing, partially completed reactor (including water intake and discharge) and existing fuel and target fabrication facilities. Spent fuel processing would require construction of a new building in the 200-East Area, where Manhattan Project facilities (currently under evaluation for National Register of Historic Places [NRHP] eligibility) are located. However, because no archaeological sites are listed in the area that would be affected by the LWR and because construction would not affect the Manhattan Project facilities in any way, this alternative would have no direct effect on archaeological or historic sites. No indirect effects would occur either because no archaeological sites are known to occur within at least 3.2 km of any of the locations proposed for LWR facilities. Fuel processing facilities would be constructed in an industrialized area and would not alter the feeling or association of the Manhattan Project facilities located nearby.

Known archaeological or historical resources on the NPR site proposed for the HWR and MHTGR facilities are confined to two isolated artifacts. Two potential historical properties have been identified in the corridor for the water intake and discharge facilities: the Hanford Townsite and archaeological site 45BN305 (Section 4.2.6; ERTEC 1982). It would be necessary to conduct findings of effect for these two properties if either alternative were chosen for development at Hanford. A preliminary assessment by DOE suggests that the corridor would not significantly alter the historical potential of the extensive townsite, but could have adverse effects on the archaeological site. Construction in the 200-East Area would not adversely affect archaeological sites or historic structures. Options for mitigation include moving the corridor a short distance north or south to avoid the site or conducting data recovery excavations in the construction corridor.

Two new buildings for the fuel processing facility would be constructed in the 200-East Area, where Manhattan Project facilities (which are potentially eligible for the NRHP) are

located. Because no archaeological sites occur in the proposed area for this facility and because construction would not affect the Manhattan Project facilities in any way, there would be no effects from this part of the undertaking.

Construction of the water intake and discharge structures would bring workers close to historic and archaeological sites, and this could cause indirect effects because of unauthorized artifact collection. These effects would be mitigated through a worker education program, which would use posters to inform workers of applicable laws, and briefing sessions for all persons expected to work along the corridor. The briefing sessions would stress the importance of cultural resources and specifications of the laws and regulations that exist for their protection.

Native American Cultural Resources

None of the alternatives appears to entail direct or indirect impacts to any areas of known cultural or religious significance to members of the Yakima Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, or the Wanapum Band. This conclusion is based on the proposed locations of facilities relative to sacred and culturally important areas identified through ethnohistorical research and interviews with elders of bands that formerly used the Hanford Site (Chatters 1989).

Paleontological Resources

Proposed sites of all three alternative reactor designs and their water intake and support facilities are located on sand and gravel deposits of the Late Pleistocene Hanford Formation. Because this formation lacks concentrations of paleontological materials, none of the alternatives would adversely affect paleontological resources of the Hanford Site.

5.2.5.3 Mitigation and Conclusions

Implementation of either the HWR or MHTGR alternative could adversely affect archaeological site 45BN305; if this site is determined to be eligible for the NRHP, such effects would require mitigative measures (36 CFR 800). If avoidance is not possible, DOE would undertake data recovery through excavation. A mitigation plan would be developed in consultation with the Washington SHPO, the Advisory Council on Historic Preservation, and local Native American groups pursuant to policies established in the Hanford Cultural Resources Management Plan (Chatters 1989).

Although adverse effects to Native American cultural resources protected under the American Indian Religious Freedom Act have not been identified, if such impacts are documented, DOE would attempt to mitigate impacts through consultation with the affected tribes. No mitigative measures for paleontological resources are necessary.

5.2.6 Radiological Impacts

Radiological impacts were estimated for the three reactor technologies (HWR, LWR, and MHTGR) and their support facilities at Hanford. Potential impacts from no action, normal

operations, nonsevere accidents, and severe accidents are discussed in Sections 5.2.6.1, 5.2.6.2, 5.2.6.3, and 5.2.6.4, respectively. Impacts from transportation of radioactive materials are discussed in Section 5.2.6.5. The conclusions of the assessment and potential mitigative actions for reduction of significant impacts are discussed in Section 5.2.6.6.

5.2.6.1 Impacts of No Action

If a decision were made not to construct and operate an NPR at the Hanford Site, the radiological environment at Hanford would remain as described in Section 4.1.7.

5.2.6.2 Impacts of Normal Operations

Baseline Radiological Conditions

Baseline radiological conditions are defined as the sources and resulting radiological impacts from current operations at a particular site prior to the start-up of NPR operations. The baseline radiological conditions are added to the incremental radiological impacts from NPR activities to obtain the total radiological impacts at a site. Baseline radiological conditions at Hanford are presented in Section 4.1.7. Based on U.S. Bureau of the Census statistics, the population within 80 km of the site is estimated to be 30% higher in the year 2020 than in 1988. Therefore, the baseline population dose used for this assessment was increased by 30%.

Estimated Doses and Health Effects

Estimated doses to a hypothetical maximally exposed off-site individual, 80-km population, and in-plant worker from 1 year of exposure to releases from normal operations of NPRs and their support facilities are given in Table 5.2.6-1. The doses to the hypothetical maximally exposed off-site individual are the sums of doses from individual facilities to various receptors at the off-site location of maximum impact for each facility. The estimated dose listed in Table 5.2.6-1 for each technology/mode is therefore greater than the combined dose from all facilities to an actual individual at any single location. Radiological impacts from individual facilities are given in Appendix H.

The estimated annual CEDEs to the hypothetical maximally exposed off-site individual range from 6.8×10^{-5} to 3.6×10^{-4} rem, and the estimated collective doses to the 80-km population range from 3.0 to 7.7 person-rem. These doses are several orders of magnitude lower than the estimated doses from 1 year of exposure to natural background radiation, i.e., 0.3 rem and 1×10^5 person-rem, respectively. When the estimated doses to the hypothetical maximally exposed off-site individual from NPR facilities are added to the baseline doses, the resulting sums are smaller (by factors of more than 10) than the dose rate limits for compliance with the Clean Air Act and Safe Drinking Water Act and the DOE standard for normal operations of DOE facilities. The estimates presented herein are based on conservative assumptions; actual impacts are expected to be even smaller.

The health effects associated with 1 year of normal operations would be correspondingly small (see Appendix H, Sections H.4.2 and H.5.2). For the hypothetical maximally exposed

TABLE 5.2.6-1 Estimated CEDEs from 1 Year of Exposure to Releases during Normal Operations of Reactors and Support Facilities at Hanford

Technology/Mode	Maximally Exposed Off-site Individual ^a (rem)	80-km Population ^b (person-rem)	In-Plant Worker ^c (person-rem)
HWR			
Tritium mode	1.6×10^{-4}	6.9	180
Plutonium mode	1.1×10^{-4}	4.5	360
LWR			
Tritium mode	3.6×10^{-4}	7.7	640
Plutonium mode	3.1×10^{-4}	5.8	700
MHTGR			
Tritium mode	6.8×10^{-5}	3.0	130
Plutonium mode	7.5×10^{-5}	4.4	360
Baseline conditions ^d	3×10^{-4}	7	-
Natural background	0.3 ^e	1×10^5	-

^aEach dose is the sum of doses to the maximally exposed off-site individual from releases from individual facilities; actually, the location of the maximally exposed off-site individual would probably differ from facility to facility.

^bEach dose is the sum of doses to the 80-km population from releases from individual facilities; actually, different facilities have different 80-km populations.

^cSources for in-plant worker doses: WSRC-4 (HWR); Heacock 1990b (LWR); Bowman-3 (MHTGR); WSRC-2 (HWR support facilities); Pajunen 1990a (LWR support facilities); and Bowman-4 (MHTGR support facilities).

^dSee Section 4.1.7 for baseline conditions. The 80-km population dose has been increased by 30% to account for projected population increases to the year 2020. A number of DOE facilities were not operating during 1988.

^eThe value of 0.3 rem for natural background is average, not maximum (see Section 4.1.7).

off-site individual, the incremental lifetime fatal cancer risk from 1 year of exposure is estimated to range from 3×10^{-8} to 1×10^{-7} . For the 80-km population, the incremental number of cancer deaths is estimated to range from 0.001 to 0.003 and the incremental number of genetic effects from 8×10^{-4} to 0.002. These estimates are sufficiently small that no cancer deaths or genetic effects would be expected from routine releases during the operating lifetimes of NPR facilities at Hanford. For comparison with these estimates, about 40 cancer fatalities/yr would be expected among the 80-km population around the site as a result of exposure to natural background radiation (calculated using the EPA risk estimator of 4×10^{-4} cancer fatalities/person-rem), and about 790 cancer fatalities/yr would be expected among the same population from all causes combined (U.S. Bureau of the Census 1987).

Collective doses to in-plant workers from 1 year of normal operations of NPR facilities are estimated to range from 130 to 640 person-rem in the tritium production mode and from 360 to 700 person-rem in the plutonium production mode. These doses would be predominantly to workers in the reactor, fuel processing, and plutonium-target processing facilities. For Hanford, the doses to HWR support facility workers are taken to be the same as those to HWR support facility workers at SRS (WSRC-2); the doses to LWR support facility workers are those estimated for the facilities at Hanford (Pajunen 1990a), and the doses to MHTGR support facility workers are taken to be the same as those to MHTGR support facility workers at INEL (Bowman-4).

Through work planning and personnel monitoring, no worker would be allowed to accumulate an annual dose that is greater than a fraction of the DOE occupational limits. The estimated collective in-plant occupational doses for NPR facilities at Hanford are much smaller than these limiting doses.

The estimated number of cancer fatalities among in-plant workers due to radiation exposure per year of operations would be between 0.05 and 0.3 for the tritium production mode and between 0.1 and 0.3 for the plutonium production mode (calculated using the EPA risk factor of 4×10^{-4} cancer fatalities/person-rem). Assuming that the same number of workers would be employed at these facilities continuously, one cancer fatality would be expected in 3 to 20 years of operations for the tritium production mode and one fatality in 3 to 10 years of operations for the plutonium production mode.

5.2.6.3 Impacts of Postulated Nonsevere Accidents

Nonsevere Accidents at Reactors

The methodology used to estimate radiological impacts of postulated nonsevere accidents at the proposed NPRs at Hanford is discussed in Section 5.1.7.2. Appendix I provides a more complete discussion of the methodology and potential impacts, as well as descriptions of the accidents analyzed. In Appendix I, estimated doses and health effects are presented for a range of postulated nonsevere accidents in the proposed NPRs at Hanford. In this section, only bounding estimates are given -- i.e., the highest consequences from any nonsevere accident at the HWR, LWR, and MHTGR for each of the three receptors (maximally exposed off-site individual, 80-km off-site population, and maximally exposed colocated worker). The accidents that result in the highest consequences are listed in Table 5.1-2; the estimated doses for these accidents are given in Table 5.2.6-2. For the HWR and LWR, the accident with the highest consequences is different for off-site individuals than for the on-site colocated worker.

TABLE 5.2.6-2 Estimated Doses for Accident with Highest Consequences from Postulated NPR Nonsevere Accidents at Hanford

Reactor ^a	Ingestion Pathway Included	Committed Effective Dose Equivalent ^b		
		Maximally Exposed Off-site Individual (rem)	80-km Worst-Sector Population (person-rem)	Maximally Exposed Colocated Worker (rem)
HWR	No	0.0069	210	0.15
	Yes	0.37	7,800	NA ^c
LWR	No	0.041	540	0.035
	Yes	3.1	25,000	NA
MHTGR	No	0.021	670	0.037
	Yes	0.67	14,000	NA

^aFor the HWR and MHTGR, the maximally exposed off-site individual would be 15,600 m east-southeast; the maximally exposed sector would be south-southeast with a population of 104,000; and the maximally exposed colocated worker would be 700 m west-southwest.

For the LWR, the maximally exposed off-site individual would be 5,000 m east; the maximally exposed sector would be south-southeast with a population of 96,000; and the maximally exposed colocated worker would be 500 m south-southwest.

^bEstimated doses from the highest consequence accident in the unlikely event that the accident occurred; see Table 5.1-2 for accident descriptions and frequency classes; see Appendix I for a description of the calculations and for more details of these estimates.

^cNA means not applicable.

In Table 5.2.6-2, the doses listed with the "ingestion pathway included" were estimated assuming that no mitigative or emergency action was taken following the accident. That is, it was assumed that the maximally exposed off-site individual and persons within 80 km of the affected facility continued their activities as usual after the accident. The values listed with the "ingestion pathway not included" were estimated assuming that some action was taken that would eliminate the dose due to the ingestion pathway.

The accidents with the highest consequences (Table 5.1-2) are different for each technology. Because of the different designs and inherent technology differences, the progression and therefore the quantity and timing of radioactive releases to the environment during these accidents are also different. The source terms for the bounding postulated accidents are listed in Appendix I.

The location proposed for the HWR and MHTGR at Hanford is different than the WNP-1 location for the LWR. The LWR location is considerably closer to the site boundary, and the maximally exposed off-site individual is therefore much closer to the LWR than to the HWR and MHTGR (5,000 m vs. 15,600 m). Because of this, the CEDEs and organ CDEs to the maximally exposed off-site individual are generally higher for the LWR. The differences between the HWR and the MHTGR are due solely to differences in source terms.

The estimated health effects resulting from the doses listed in Table 5.2.6-2 are given in Table 5.2.6-3. The effects for the maximally exposed off-site individual and the colocated worker are given in terms of incremental risk of contracting a fatal cancer. The effects for the worst-sector population are given in terms of additional fatal cancers and severe genetic effects.

From an examination of the estimated doses due to postulated NPR nonsevere accidents at Hanford (Table 5.2.6-2 and Appendix I), it is apparent that the large-break loss-of-coolant accident in the LWR is the only accident at Hanford that is likely to trigger emergency action for the hypothetical maximally exposed off-site individual. (See Section 5.1.7.2 for a discussion of mitigative actions and the use of PAGs.) This person's estimated thyroid CDE with the ingestion pathway included is 21 rem (see Appendix I, Table I.7), which is above the FDA recommended PAG limit for emergency action (15 rem). With the ingestion pathway not included, this individual's estimated doses (0.041 rem CEDE and about 0.2 rem thyroid CDE) would be considerably below the PAG limits of the EPA (5 rem CEDE and 25 rem thyroid CDE).

For the highest consequence accidents at the HWR and MHTGR, some protective actions would probably be taken, such as washing food to remove surface contamination or temporarily putting animals on stored feed. Taking emergency action or protective measures would be recommended on a case-by-case basis by the emergency response personnel from Federal, state, and local governments around the site.

A more detailed assessment of the results presented in this section and a discussion of occupational exposures to in-plant workers during and after (i.e., cleanup phase) the postulated nonsevere accidents are provided in Appendix I. Based on this information, it is estimated that with proper protective or emergency action, no cancer fatalities or genetic effects would occur at or near the site as a result of a postulated nonsevere accident in any of the proposed NPRs at Hanford. This compares with approximately 790 cancer fatalities/yr expected among the 80-km population around the site from all causes combined (U.S. Bureau of the Census 1987).

The designs for the proposed NPR program facilities are still under development. As the designs mature, some of the conservative assumptions made in the calculations regarding the operation of various safety features can be relaxed. Consequently, once the final designs are available, the estimated releases of radionuclides from these facilities and the associated doses and health effects will probably be lower.

Nonsevere Accidents at Support Facilities

The types of postulated nonsevere accidents at Hanford NPR support facilities that could result in atmospheric releases of radioactive materials to the environment are described briefly in Section I.4.1.2 of Appendix I. The extent to which radioactivity would be released to

TABLE 5.2.6-3 Estimated Incremental Health Effects per Accident^a for Postulated NPR Nonsevere Accidents with the Highest Consequences at Hanford

Reactor	Ingestion Pathway Included	Maximally Exposed Off-site Individual Fatal Cancer Risk	80-km Worst-Sector Population		Maximally Exposed Colocated Worker Fatal Cancer Risk
			Fatal Cancers	Genetic Effects	
HWR	No	3×10^{-6}	None ^b	None	6×10^{-5}
	Yes	2×10^{-4}	3	1	NA ^c
LWR	No	2×10^{-5}	None	None	1×10^{-5}
	Yes	0.001	10	6	NA
MHTGR	No	8×10^{-6}	None	None	2×10^{-5}
	Yes	3×10^{-4}	6	4	NA

^aIn the unlikely event that the accident occurred; see Table 5.1-2 for accident descriptions and frequency classes; see Appendix I for a description of the calculations and for more details of these estimates.

^b"None" means the calculated value is less than 0.5.

^cNA means not applicable.

the environment in the event of such accidents would depend on a number of factors, including the inventory and volatility of the radioactive materials and the operating status or efficiency of systems that filter out these materials. Not all types of accidents are possible at each type of support facility. For example, criticality accidents (accidents involving an unintended nuclear chain reaction) are not possible at tritium-target processing facilities because of the absence of fissile material (material that can sustain a chain reaction). Also, some types of accidents are restricted to only one reactor technology; for example, accidents involving combustion of Zircaloy-4 chips are restricted to the LWR technology (Zircaloy-4 is used to clad LWR fuel).

Because detailed facility designs and safety analyses were not available, Safety Analysis Reports and other reports addressing the hazards of operations similar to those to be utilized at NPR support facilities were reviewed in order to compile a list of postulated accidents. A subset of these accidents that could provide a reasonable and credible upper bound estimate of the maximum radionuclide release to the environment was chosen for analysis for each type of support facility for each reactor technology at each site. Appendix I describes the accidents chosen and presents the source terms and estimated impacts for bounding (highest consequence) accidents in each type of support facility for each technology at each site. The presentation here is limited to the bounding postulated accidents for each reactor technology at Hanford.

The highest CEDEs to the maximally exposed off-site individual, off-site worst-sector population, and maximally exposed colocated worker from any of the postulated nonsevere accidents at Hanford support facilities are given in Table 5.2.6-4. The doses listed with and

TABLE 5.2.6-4 Estimated Doses for Accident with Highest Consequences^a from Postulated Nonsevere Accidents at Hanford Support Facilities

Reactor	Ingestion Pathway Included	Committed Effective Dose Equivalent		
		Maximally Exposed Off-site Individual ^b (rem)	80-km Worst-Sector Population ^b (person-rem)	Maximally Exposed Colocated Worker ^c (rem)
HWR	No	0.05	1,400	2.4
	Yes	4.3	6.7×10^4	NA ^d
LWR	No	0.05	1,400	0.36
	Yes	4.3	6.7×10^4	NA
MHTGR	No	0.05	1,400	2.4
	Yes	4.3	6.7×10^4	NA

^aIn the unlikely event that the accident occurred; see Appendix I for a description of the accidents and for more details of these estimates.

^bThe highest consequence postulated accident for the maximally exposed off-site individual and worst-sector population for each reactor technology is the tritium deflagration accident at the tritium-target processing facility (accidents HH6D1, HL6D1, HM6D1 in Appendix I).

^cThe highest consequence postulated accident for the maximally exposed colocated worker for the HWR and LWR is a criticality at the fuel fabrication facility (accidents HH1C1 and HM1C1); the highest consequence postulated accident for the maximally exposed colocated worker for the LWR is the tritium deflagration accident (HL6D1).

^dNA means not applicable.

without the ingestion pathway included were obtained using the same assumptions that were used to estimate impacts from postulated accidents at reactors (see above).

Overall, the postulated nonsevere accident at Hanford support facilities that could result in the highest doses to off-site individuals is estimated to be a tritium deflagration (fire and explosion) accident at the tritium-target processing facility for all reactor technologies. The tritium release from this accident is assumed to be the same for each reactor technology and, because the proposed location for this facility is also the same, the estimated doses are the same for all technologies (4.3 rem to the maximally exposed off-site individual, 6.7×10^4 person-rem to the worst-sector population, and 0.36 rem to the maximally exposed colocated worker). For the HWR and MHTGR, the postulated nonsevere accident with the highest dose to a colocated

worker would be a criticality at the fuel fabrication facility (2.4 rem). For the LWR, because the location proposed for the fuel fabrication facility is different than for the other reactor technologies, the highest dose to a colocated worker (0.36 rem) would result from a tritium deflagration accident in the tritium-target processing facility. Thus, the highest dose to the maximally exposed colocated worker from any support facility at Hanford would be 2.4 rem, which is below the DOE occupational standard of 5 rem.

From an examination of the estimated doses (with the ingestion pathway included) due to postulated support facility nonsevere accidents at Hanford (Table 5.2.6-4 and Appendix I), it is apparent that neither the EPA PAGs nor the FDA emergency PAGs are exceeded for any of the postulated accidents. (See Section 5.1.7.2 for a discussion of mitigative actions and the use of PAGs.) However, the estimated CEDEs and organ doses to the maximally exposed off-site individual do exceed FDA preventive PAGs for a few postulated accidents (see Appendix I, Section I.4). Therefore, if these accidents were to occur, some low-impact protective actions would probably be taken, such as washing food to remove surface contamination or temporarily putting animals on stored feed. Taking protective actions would be recommended on a case-by-case basis by the emergency response personnel from Federal, state, and local governments around the site.

The estimated health effects resulting from the doses listed in Table 5.2.6-4 are given in Table 5.2.6-5. If mitigative measures were taken to eliminate the ingestion pathway, at most one cancer fatality and no genetic effects would be expected among the population around Hanford from an occurrence of any of the postulated support facility nonsevere accidents. This compares with approximately 790 cancer fatalities/yr expected among the 80-km population around the site from all causes combined (U.S. Bureau of the Census 1987).

The doses and health effects presented in Tables 5.2.6-4 and 5.2.6-5 are based on very conservative assumptions and on the assumption that an accident will occur. As discussed for nonsevere reactor accidents (see above), the estimated releases of radionuclides from these facilities and the associated doses and health effects will probably be lower once the final NPR program facility designs are available.

5.2.6.4 Impacts of Postulated Severe Accidents

Radiological impacts of postulated severe accidents at Hanford new production reactors and their support facilities are estimated for the off-site general public (population within an 800-km radius of the site) and for colocated workers (on-site workers excluding those in the facility at risk). For the severe reactor accident analysis, calculated impacts are further summarized in the form of complementary cumulative distribution functions (CCDFs) or expressed as average risk values for three consequence measures: early fatalities, cancer fatalities, and population doses.

Severe Accidents at Reactors

Early Fatalities. Mitigative actions such as evacuation and relocation are considered in calculations of early fatalities. Calculations predict that no early fatalities would occur off-site

TABLE 5.2.6-5 Estimated Incremental Health Effects per Accident^a from Postulated Nonsevere Accidents with the Highest Consequences at Hanford Support Facilities

Reactor	Ingestion Pathway Included	Maximally Exposed Off-site Individual Fatal Cancer Risk ^b	80-km Worst-Sector Population ^b		Maximally Exposed Colocated Worker Fatal Cancer Risk ^c
			Fatal Cancers	Genetic Effects	
HWR	No	2×10^{-5}	1	None ^d	0.001
	Yes	0.002	30	20	NA ^e
LWR	No	2×10^{-5}	1	None	1×10^{-4}
	Yes	0.002	30	20	NA
MHTGR	No	2×10^{-5}	1	None	0.001
	Yes	0.002	30	20	NA

^aIn the unlikely event that the accident occurred; see Appendix I for a description of the calculations and for more details of these estimates.

^bThe highest consequence postulated accident for the maximally exposed off-site individual and worst-sector population for each reactor technology is the tritium deflagration accident at the tritium-target processing facility (accidents HH6D1, HL6D1, HM6D1 in Appendix I).

^cThe highest consequence postulated accident for the maximally exposed colocated worker for the HWR and MHTGR would be a criticality at the fuel fabrication facility (accidents HH1C1 and HM1C1); the highest consequence postulated accident for the maximally exposed colocated worker for the LWR would be the tritium deflagration accident (HL6D1).

^d"None" means the estimated number of cancer deaths or genetic effects is less than 0.5.

^eNA means not applicable.

among the general public surrounding the Hanford Site as a result of any of the postulated NPR severe accidents. The major factors contributing to this result are the large size of the Hanford Site and the low population density in the area near the site where most of the exposures would be expected to occur. Calculations predict that no early fatalities would occur among the colocated on-site workers at the Hanford Site from any postulated severe accident at an HWR or an MHTGR. At most, one early fatality among colocated workers might occur following an LWR accident.

Cancer Fatalities. The CCDFs for cancer fatalities calculated for off-site and on-site populations at Hanford are given in Figure 5.2.6-1. The estimated cancer fatalities at various

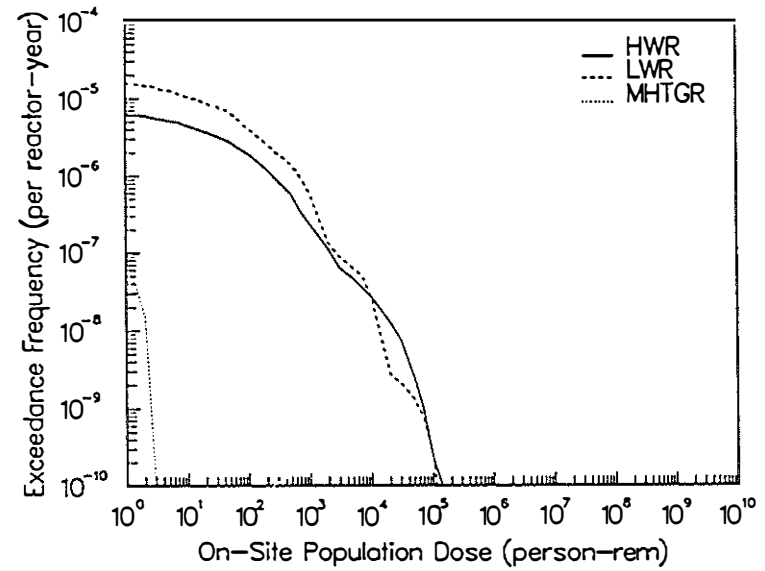
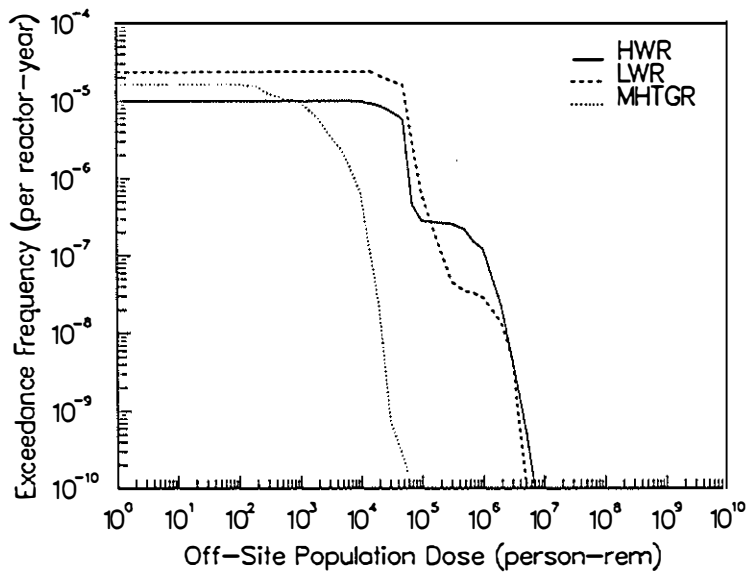
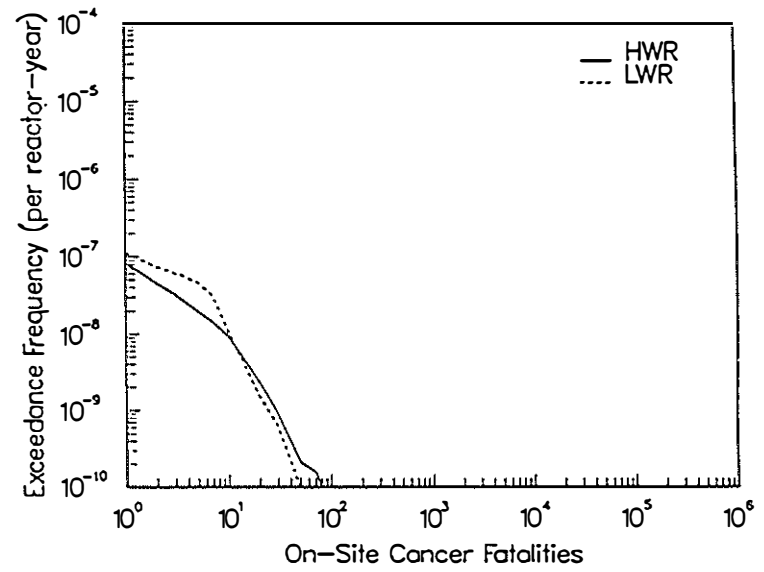
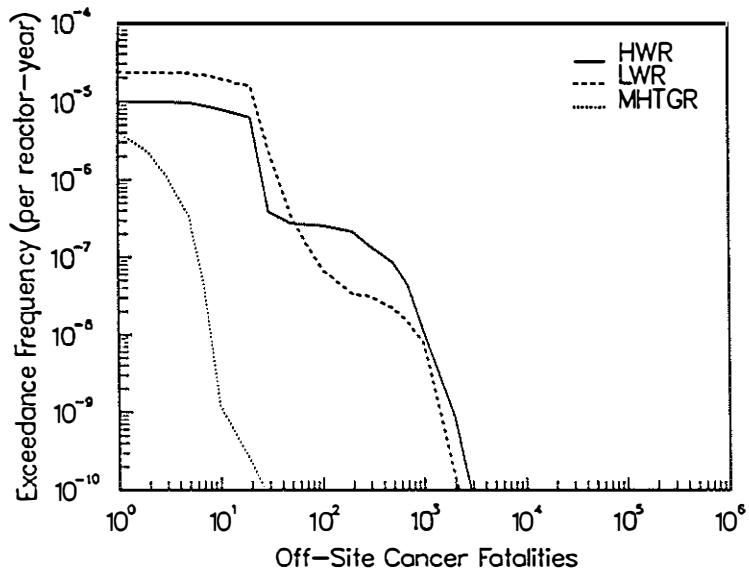


FIGURE 5.2.6-1 Frequency Distributions of Off-site and On-site Consequences of Severe Reactor Accidents at Hanford (on-site cancer fatalities are negligible for the MHTGR at the exceedance frequencies shown)

exceedance frequencies account for the short-term and long-term dose mitigative actions discussed in Appendix J.

The estimated impacts to the general public due to either HWR or LWR severe accidents at Hanford are comparable to each other but are both higher than the impacts due to MHTGR severe accidents. This is also true for colocated workers. The radionuclide release associated with the postulated MHTGR severe accidents is assumed to occur in two phases. The first release would be followed by a significantly larger second release, which would occur between 50 and 80 hours later. Because of the long delay between the two releases, evacuation or relocation of colocated workers would likely be completed before the second release occurred. Therefore, the radiological consequences to colocated workers are significantly lower for MHTGR accidents than for HWR and LWR accidents.

The likelihood of causing one or more cancer fatalities among colocated workers at Hanford due to severe accidents is estimated to be about 1×10^{-7} per reactor-year for an LWR and less than 8×10^{-8} for an HWR (see Figure 5.2.6-1). The likelihood of producing the same cancer fatalities for an MHTGR is estimated to be less than 1×10^{-10} per reactor-year. Because of this low exceedance frequency, the on-site CCDF for an MHTGR is not shown in Figure 5.2.6-1.

Population Doses. The CCDFs for off-site and on-site population doses at Hanford are also shown in Figure 5.2.6-1. The estimated population dose accounts for the dose mitigative actions that would take place immediately after the accident and in the long term. The CCDFs indicate that variations in population doses at equal exceedance frequency levels are similar to those of cancer fatalities.

Risks. Estimated risks resulting from postulated NPR severe accidents are presented in terms of societal risks and individual risks for the consequence measures under consideration. In contrast to individual risks, societal risks are risks to all members of the general public within an 800-km radius around the reactor or to all colocated workers at the Hanford Site.

All estimated average values of societal early fatality risk are on the order of 1×10^{-10} per reactor-year or lower, except that the risk for the colocated worker is 5×10^{-8} per 1 year of LWR operations at Hanford (Hong et al. 1991). For perspective in understanding the meaning of early fatality risk, the risk from a postulated severe reactor accident at Hanford can be compared with other risks for a population of similar size. The total number of colocated workers at Hanford is about 15,000. Accidental fatalities per year for a population of this size, based upon an overall average for the United States, are approximately 3 from motor vehicle accidents, 1 from falls, 0.5 from burns, and 0.2 from firearms (CONAES 1979). Therefore, the estimated early fatality risk from reactor accidents is an extremely small fraction of the total risk from other kinds of accidents. The average societal risk values for cancer fatality and population dose for the three technologies at Hanford are presented in Table 5.2.6-6. The radiological risks for HWR and LWR accidents are comparable, but the risk is lower for MHTGR accidents because of a relatively small release of radioactive material.

Individual risks of early fatality and cancer fatality in the immediate vicinity of the reactor were also estimated for the purpose of comparison to NPR safety goals (DOE-8). All individual risks resulting from potential severe accidents at an HWR, LWR, or MHTGR at Hanford are several orders of magnitude below the NPR safety goal values (Hong et al. 1991).

TABLE 5.2.6-6 Estimated Values of Societal Risks Resulting from Postulated Severe Reactor Accidents at Hanford

Reactor	Population Dose Risk (person-rem/ reactor-year)		Cancer Fatality Risk (fatalities/ reactor-year)	
	General Public	Colocated Worker	General Public	Colocated Worker
HWR	0.7	0.002	3×10^{-4}	7×10^{-7}
LWR	1	0.003	5×10^{-4}	1×10^{-6}
MHTGR	0.04	6×10^{-7}	2×10^{-5}	2×10^{-10}

Severe Accidents at Support Facilities

The estimated releases from postulated severe accidents at the fuel fabrication or tritium-target processing facilities at Hanford would not result in early fatalities. The estimated individual risks of cancer fatality are very small, i.e., less than 10^{-10} fatalities/yr. The estimated total radiological impacts to colocated workers and the general public from the postulated accidents are summarized in Table 5.2.6-7. The population doses and corresponding latent cancer effects represent the direct consequences of the accident; the risk values represent the consequences weighed by the frequency of the accident, which is estimated to be 1×10^{-8} /yr at Hanford (see Appendix J).

5.2.6.5 Impacts of Transportation

The radiological impacts from transportation of radioactive materials for the Hanford Site include on-site and off-site activities. For on-site transportation, the radioactive materials from NPR operations are generally categorized as (1) irradiated driver-fuel assemblies, (2) irradiated target rods, (3) low-level waste, and (4) transuranic waste. The low-level waste would be disposed of on-site. Off-site transportation would include shipment of tritium to SRS and might include shipment of plutonium metal for processing to the Rocky Flats Plant or another site as determined by the DOE Reconfiguration Study and PEIS. In addition, if the HWR technology were chosen for Hanford, the existing tritium-contaminated heavy-water inventory would be shipped from SRS for use at Hanford. The proposed NPR at Hanford would have its own on-site fuel processing, waste processing, and waste storage facilities and a heavy-water processing facility for the HWR. Off-site transportation of high-level waste and transuranic waste to the Federal repository or Waste Isolation Pilot Plant, respectively, has been assessed in the existing environmental reviews for these facilities (DOE-49; DOE-51). The results of these assessments were used to estimate the risks associated with wastes from NPR operations in this EIS. More details regarding radiological impacts from transportation of radioactive materials are presented in Appendix K.

TABLE 5.2.6-7 Estimated Total Radiological Impacts of Postulated Severe Accidents at Hanford Support Facilities^a

Impact	Tritium Fuel Fabrication Facility	Tritium-Target Processing Facility
Population dose	14 person-rem	6,100 person-rem
Latent cancer effects	0.005 fatalities	3 fatalities
Population dose risk	1×10^{-7} person-rem/yr	6×10^{-5} person-rem/yr
Population health risk	$< 10^{-10}$ fatalities/yr	3×10^{-8} fatalities/yr

^aEach value given in this table is the sum of impacts to the colocated workers and the general public; see Appendix J for details.

Incident-Free Transportation

The estimated radiological impacts from incident-free transportation are summarized in Table 5.2.6-8. The maximum individual doses are estimated to be 1.5 rem/yr to a transport vehicle crew member (occupational worker) and 0.005 rem/yr to a member of the public near the transport route. These doses are within the DOE limits of 5 rem/yr for occupational workers (DOE Order 5480.11) and 0.1 rem/yr for the general public (DOE Order 5400.5). The total annual transportation doses from incident-free transportation, both on-site and off-site, are estimated to range from 28 to 72 person-rem, which would result in no more than 0.03 cancer fatalities and no more than 0.02 genetic effects.

Transportation Accidents

The estimated radiological impacts from transportation accidents are summarized in Table 5.2.6-9; associated nonradiological impacts are also presented. The total annual population dose risks from transportation accidents (considering the probability of occurrence and consequences) are estimated to range from 0.026 to 0.15 person-rem. These estimated dose risks would result in annual health risks of no more than 6×10^{-5} cancer fatalities and 6×10^{-5} genetic effects. By comparison, the nonradiological accident impacts from the same transportation activities are estimated to range from 0.03 to 0.05 accident fatalities. The highest radiological risk is associated with the HWR and would result mainly from transportation of tritiated heavy water from SRS to Hanford for reuse.

The maximum individual doses from on-site transportation accidents are estimated to be 4.7 rem for an on-site worker and 0.14 rem for a member of the general public at the site boundary. These doses would result in about 2×10^{-3} and 5×10^{-5} lifetime cancer risks to exposed on-site and off-site individuals, respectively. Such maximum doses have been calculated for a severe rail accident involving a shipment of irradiated driver fuel assemblies, for which the accident frequency is estimated to be about 1×10^{-6} /yr. For off-site transportation, the maximum individual dose is estimated to be 24 rem to a member of the public from a severe transportation accident involving tritiated heavy water for the HWR, for which the estimated accident frequency ranges from 0.001 to 0.0001/yr. Much of the maximum individual dose estimated for a member of the general public is related to ingestion of contaminated foodstuffs,

TABLE 5.2.6-8 Impacts from Incident-Free Transportation of Radioactive Materials for NPR Operations at Hanford

Reactor	Transportation Mode	Maximum Individual Dose ^a (rem/yr)	Maximum Individual Health Risk (health effects/yr)	Population Dose Risk (person-rem/yr)	Population Health Risk (health effects/yr)	Population Genetic Risk (effects/yr)
HWR	On-site	0.21	8×10^{-5}	1.5	6×10^{-4}	4×10^{-4}
	Off-site	1.5	6×10^{-4}	58	0.02	0.02
	Total			60	0.02	0.02
LWR	On-site	0.15	6×10^{-5}	1.2	5×10^{-4}	3×10^{-4}
	Off-site	1.5	6×10^{-4}	71	0.03	0.02
	Total			72	0.03	0.02
MHTGR	On-site	0.33	1×10^{-4}	3.4	0.001	8×10^{-4}
	Off-site	1.5	6×10^{-4}	25	0.01	0.01
	Total			28	0.01	0.1

^aThe maximum individual doses shown here are the doses to occupational personnel. For nonoccupational personnel, the maximum individual dose is estimated to be 0.005 rem/yr (DOE-49).

TABLE 5.2.6-9 Impacts from Transportation of Radioactive Materials for NPR Operations at Hanford under Accident Conditions

Reactor	Transportation Mode	Maximum Individual Dose ^a (rem/yr)	Maximum Individual Health Risk ^a (health effects/yr)	Population Dose Risk (person-rem/yr)	Population Health Risk (health effects/yr)	Population Genetic Risk ^b (effects/yr)	Nonradiological Risk ^c (effects/yr)
HWR	On-site	0.14	5×10^{-5}	0.0025	1×10^{-6}	2×10^{-7}	0.003
		4.7	0.002				
	Off-site	24	0.01	0.15	6×10^{-5}	4×10^{-5d}	0.05
	Total			0.15	6×10^{-5}	4×10^{-5}	0.05
LWR	On-site	0.14	5×10^{-5}	0.011	4×10^{-6}	2×10^{-6}	0.003
		4.7	0.002				
	Off-site	22	0.01	0.053	2×10^{-5}	4×10^{-8d}	0.04
	Total			0.064	2×10^{-5}	2×10^{-6}	0.04
MHTGR	On-site	0.14	5×10^{-5}	0.0045	2×10^{-6}	3×10^{-7}	0.009
		4.7	0.002				
	Off-site	22	0.01	0.021	8×10^{-6}	4×10^{-8d}	0.02
	Total			0.026	1×10^{-5}	3×10^{-7}	0.03

^aFor each reactor technology, two values are given for the on-site transportation mode. The value on the first line is for a member of the public located at the site boundary; the value on the second line is for a transportation worker located 100 m away from the accident.

^bFor on-site transportation, calculated risks are based on GENII methodology, for which the worst-sector population risks are estimated; for off-site transportation, calculated risks are based on RADTRAN methodology, for which a uniform population density is assumed.

^cThe nonradiological risks are the traffic accident fatalities associated with transportation.

^dData to not include shipment of transuranic waste and high-level waste because genetic risk data are not available from existing environmental reviews (DOE-49; DOE-51).

which can be interdicted by appropriate government agencies according to Federal remedial action guidelines. If such interdiction occurred, the resulting doses would be lower than those estimated in this EIS.

5.2.6.6 Conclusions and Mitigation

Conclusions

The radiological impacts to off-site individuals and on-site workers because of the proposed NPR program facilities at Hanford are summarized below. For perspective in understanding the significance of these impacts, statistics of the U.S. Bureau of the Census (1987) indicate that among the population within 80 km of the site (approximately 440,000 persons), the expected number of deaths due to accidents and adverse effects is about 170 per year and the expected number of cancer deaths from all causes combined is about 790 per year. The natural background radiation dose for the same population is estimated to be about 100,000 person-rem per year, which is calculated to result in approximately 40 cancer deaths per year (calculated using the health risk factor of 4×10^{-4} cancer deaths per person-rem). The results presented below show that the radiological impacts of the proposed NPR program facilities would be small in comparison to the impacts from other causes.

Normal Operations. Under normal operations, annual radioactive releases from an NPR and its support facilities would result in a dose of no more than 3.6×10^{-4} rem to the maximally exposed off-site individual. This estimated individual dose, combined with the existing baseline dose at the Hanford Site, is well within regulatory limits, which are 0.01 rem/yr for airborne releases (Clean Air Act) and 0.004 rem/yr for releases to drinking water (Safe Drinking Water Act). The estimated annual population doses, including the off-site 80-km population and in-plant workers, are no more than 700 person-rem. This equates statistically to less than 1 additional cancer fatality among the 80-km population in the Hanford area. All estimated impacts from normal operations deviate by no more than a factor of 2 among the three reactor technologies.

Nonsevere Accidents. For postulated nonsevere accidents at reactors, the highest consequence event is estimated to result in no early fatalities and in a total population dose of about 25,000 person-rem. This equates statistically to 10 cancer fatalities. The highest consequence estimated from the postulated nonsevere accidents would result from a loss-of-coolant accident in the LWR due to a large pipe break; such an accident would result in an estimated maximum off-site individual dose of 3.1 rem. Other estimated impacts for the highest consequence scenarios for either the HWR or MHTGR would be lower than the estimated impacts for the LWR by a factor of about 2 to 3 for population risks and a factor of 5 to 10 for maximum individual risks.

For postulated nonsevere accidents at support facilities, the highest consequence accident is estimated to result in no early fatalities and a total population dose of about 67,000 person-rem. This equates statistically to 30 cancer fatalities. The highest consequence estimated from the postulated support facility nonsevere accidents would result from a tritium deflagration accident in a tritium-target processing facility; such an event would result in an

estimated maximum off-site individual dose of 4.3 rem. These consequences would equally apply to all three technologies.

Severe Accidents. For postulated severe accidents at reactors, a broad spectrum of possible accidental releases has been considered, with frequencies ranging from 10^{-6} to 10^{-9} /yr. The estimated health risks (frequencies times health consequences) are no more than 5×10^{-4} cancer fatalities/yr and no more than 5×10^{-8} early fatalities/yr for both colocated workers and the general public. For postulated severe accidents at support facilities, an upper bound radioactive release has been established for all three reactor technologies. Such an event is estimated to result in no early fatalities and in a risk of 3×10^{-8} cancer fatalities/yr for a severe seismic event with an estimated frequency of about 1×10^{-8} /yr.

Transportation. Impacts from transportation of radioactive materials were assessed for incident-free and accident conditions for all shipments transported on-site and off-site. The estimated maximum individual doses are no more than 1.5 rem/yr to an occupational worker (identified as a transport vehicle crew member) and no more than 0.005 rem/yr to a member of the general public. These maximum doses are below the DOE limits of 5 rem/yr for occupational workers and 0.1 rem/yr for the general public. The estimated total incident-free population doses are no more than 72 person-rem/yr, which corresponds to 0.03 cancer fatalities/yr. Most of the impact results from shipment of high-level waste off-site to the Federal repository. The estimated accident dose risks are no more than 0.15 person-rem/yr, which corresponds to a risk of 6×10^{-5} cancer fatalities/yr. The HWR has been estimated to have the highest transportation accident risk, much of which is associated with shipment of the existing tritiated heavy water inventory from SRS to Hanford. The total estimated radiological risk from transportation, including incident-free and accident conditions, is about the same as the nonradiological risk of 0.03 fatalities/yr resulting from highway accidents for similar transportation activities involving nonradioactive materials.

Mitigation

In conclusion, all radiological impacts from normal (incident-free) operations of an NPR and its associated activities at Hanford have been determined to be within Federal guidelines and standards. Furthermore, all activities are required to be practiced under the ALARA policy, as stipulated under DOE Orders 5480.11 and 5400.5, to further reduce exposures to both workers and the general public. In the event of an accident, potential radiological impacts would be reduced by implementation of effective short-term mitigative measures according to emergency preparedness procedures (see Section 3.6). Implementation of long-term mitigative measures, such as land decontamination and crop interdiction, would be conducted by appropriate government authorities according to Federal guidelines. If these mitigative actions were implemented, it is estimated that accident impacts could be reduced by as much as 90% or more below those presented in this EIS.

5.2.7 Accidents Involving Nonradioactive Hazardous Material

The purpose of this section is to assess the potential human health risks from accidental releases of nonradioactive hazardous materials that would be used during operation of an NPR

and associated support facilities at Hanford. Risks have been assessed for ammonia, chlorine, and hydrogen -- the three chemicals believed to pose the highest hazard potentials. The assessment examines (1) effects of acute inhalation for single exposures of up to 1 hour, (2) thermal radiation from fireballs, and (3) explosion hazards. Two accident scenarios were modeled: (1) rupture and complete release from on-site storage vessels and (2) rupture and complete release from a shipment vessel damaged by a transportation accident.

Environmental fate and atmospheric transport were simulated using the SLAB model (Ermak 1988, 1989). The modeling simulations were based on meteorological conditions that, on the basis of Hanford meteorological data collected for the period 1983 through 1987, occur about 25%-35% of the time. Furthermore, the meteorological data indicate that the selected conditions can, in most cases, persist long enough for the toxic plume to reach the maximum distance where exposure criteria would be exceeded (the exception being migration of hydrogen chloride out to 50 km). The impacts from inhalation of ammonia and chlorine are presented in terms of (1) the size of off-site populations that would be exposed to concentrations above the Emergency Response Planning Guidelines (ERPGs), as defined in Section 5.1.7, for on-site storage vessel accidents and (2) impact radii for transportation accidents. For fire and explosion hazards, the results are presented in terms of distances from the point of release at which various thermal and overpressure criteria would be exceeded.

The results of the hazard assessment for the HWR, LWR, and MHTGR technologies at Hanford are summarized below. Additional details are presented in Appendix L. Details of the nonradioactive hazardous material accident assessment methodology are presented in a separate report (NUS-5).

5.2.7.1 Impacts of No Action

If an NPR were not constructed and operated at Hanford, current site conditions would continue. Since chemical storage and usage would remain unchanged, the risk of accidents involving nonradioactive hazardous materials would not change.

5.2.7.2 Impacts of NPR Operation

The following discussion addresses, for each reactor type, the chemical release scenario that would affect the greatest number of people.

Acute Inhalation

Acute inhalation impacts for the three reactor technologies were assessed for chlorine and ammonia releases.

HWR. During operation of an HWR, on-site storage accidents involving a chlorine release would affect the largest number of people (among the scenarios investigated). For off-site populations, no individuals would be exposed to life-threatening conditions (ERPG-3); from 0 to 20 individuals might suffer impaired ability to take protective action (ERPG-2); and

from 0 to 200 individuals might perceive an objectional odor or experience mild transient health effects (ERPG-1).

Transportation accidents producing the largest impact radii also would be associated with chlorine releases. Distances at which ERPGs would be exceeded are 3 km for ERPG-3, 8 km for ERPG-2, and 14 km for ERPG-1.

The times required for plumes to reach its critical impact radii for on-site storage and transportation accidents involving chlorine releases would range from about 1 to 4 hours. Hanford meteorological data indicate that the conditions modeled for the chlorine release (1 m/s wind speed and Pasquill stability class F) occur about 15% of the time and can persist for 8 hours.

LWR. At an LWR, on-site storage accidents and transportation accidents involving release of chlorine would affect the largest number of people. Since the storage and transportation conditions for an LWR would be the same as for an HWR, the impacts would be the same as discussed in the previous subsection.

MHTGR. At an MHTGR, on-site storage accidents involving an ammonia release would affect the largest number of people. For off-site populations, no individuals should be exposed to life-threatening conditions (ERPG-3). From 40 to 24,000 or more individuals might perceive an odor, experience mild transient health effects, or be exposed to conditions that might impair their ability to take protective action.

Transportation accidents resulting in the largest impact radii also would be from ammonia releases. Distances at which ERPGs would be exceeded are 3 km for ERPG-3, 7 km for ERPG-2, and 15 km for ERPG-1.

Times required for release plumes to reach their critical impact radii for on-site storage and transportation accidents involving ammonia releases would range from about 1 to 7 hours. The meteorological conditions modeled for the ammonia release were the same as for the chlorine release (1 m/s and F stability). Hanford meteorological data indicate that the conditions modeled for ammonia (1 m/s wind speed and Pasquill stability class F) occur about 15% of the time and can persist for 8 hours.

In addition to the off-site population exposures discussed above for the three reactor technologies, occupational exposures also could occur. Accidental on-site releases of ammonia or chlorine could kill or injure workers. An off-site transportation accident might kill or injure transportation workers and members of the public.

Fire and Explosion

Fire and explosion impacts for the three reactor technologies were assessed for hydrogen releases.

HWR. Thermal radiation (heat) and explosive overpressure impacts from on-site storage and transportation accidents associated with the HWR technology would occur within 0.1 km from the point of release.

LWR. Thermal radiation and explosive overpressure impacts from on-site storage accidents associated with the LWR technology would occur within 0.1 km from the point of release.

For transportation accidents, thermal radiation impacts and some explosive overpressure impacts (fatalities and eardrum rupture) would occur within 0.1 km. However, some building damage from explosive overpressure might occur as far away as 0.4 km.

MHTGR. Fatalities and injuries due to thermal radiation exposure from MHTGR on-site storage accidents could occur as far away as 0.5 km and 1 km, respectively. Explosive overpressure impacts could be experienced up to 1.9 km away for building damage, 0.4 km for eardrum rupture, and 0.1 km for fatalities.

For transportation accidents, thermal radiation fatalities and injuries could occur as far away as 0.1 km and 0.2 km, respectively. Some building damage from explosive overpressure might occur as far away as 0.6 km, while fatalities and eardrum rupture would be confined to an area within 0.1 km.

5.2.7.3 Mitigation and Conclusions

The preceding analysis identifies a series of conditions that have potential for causing significant impacts both on-site and off-site. The maximum number of off-site individuals significantly affected by accidental releases of ammonia or chlorine from an on-site storage vessel is estimated to be from 0 to 20 for all three technologies. On-site personnel also could be significantly affected by these releases and hydrogen releases, and both on-site and off-site individuals could be significantly affected by transportation accidents resulting in releases of these materials.

This analysis indicates that at Hanford, the operation of an MHTGR would represent the greatest hazard potential of the three reactor technologies considered. A hazard analysis would be carried out at the design stage. A safety analysis report (SAR) would be prepared for each facility to evaluate the consequences and risks of accidents and to demonstrate that the facility has been constructed and will be operated to meet appropriate standards.

Some mitigation possibilities include (1) development and implementation of detailed emergency response plans that fit into the site's overall emergency response plan, (2) reduction of inventories, (3) modification of process or storage conditions, (4) reduction of storage vessel size, (5) substitution of hazardous material with something less hazardous, (6) improvement of secondary containment, and (7) training of plant operators.

One of the most important aspects in the mitigation strategy is emergency preparedness. If an accident did occur, DOE would take emergency action in accordance with EPA guidelines and applicable DOE orders (DOE-48). Such actions would ensure that the exposures to off-site

individuals and to occupational workers would be kept at a minimum. Mitigation could reduce the significance of the impacts.

5.2.8 Socioeconomics

The following section describes the socioeconomic impacts of NPR construction and operation at Hanford. Requirements for additional housing, classrooms, teachers, police officers, and fire fighters are examined. Health care impacts are also described. Impacts are expressed as a percentage increase in population(s) or as an increase in the level of community services required to accommodate an in-migrating NPR work force. The assumptions, methods, and uncertainties used in the analysis are described in Section 5.1.9.

Hanford work force requirements are shown in Tables 3.3-1 and 3.3-2. Initial preconstruction activities would occur in 1993 for all alternatives. Initial reactor operations could occur in 1997 for the LWR and in or about 2000 for the HWR and MHTGR. Impacts are examined for the period 1993-2040, although impacts are shown only for the peak year of construction (when the maximum impact would occur) and the first year of operation. The impacts of operation would recur each year until 2040. The remainder of this section discusses (1) impacts of the no-action alternative, construction, and operation, and (2) mitigation and conclusions.

5.2.8.1 Impacts of No Action

If an NPR were not constructed and operated at the Hanford Site, socioeconomic conditions would continue as described in Section 4.1.8. Employment at Hanford under these conditions is described in Cluett and Clark (1990). The Hanford Site would remain a Federal facility dedicated to nuclear research and development, isotope production, electricity generation, waste management, and ecological research.

5.2.8.2 Impacts of NPR Construction

Employment and Income

Estimates of construction work force requirements for each alternative technology at the Hanford Site are listed in Table 5.2.8-1. An HWR or LWR would require a peak labor force of 2,400 or 5,800 persons, respectively. An MHTGR would require a peak work force of about 2,000 persons. As scheduled, HWR employment would peak in or about 1999, LWR employment in or about 1995, and MHTGR employment in or about 1996.

Total regional employment would increase by 13%, 32%, and 11% over the 1988 baseline for the HWR, LWR, and MHTGR, respectively. In all instances an increase in employment would benefit the Hanford Region economically. However, the increase in regional employment for an LWR would be sufficiently large to require socioeconomic monitoring.

TABLE 5.2.8-1 Estimated NPR Construction-Related Changes in Employment and Population in the Hanford ROI, by NPR Technology

Employment/In-Migration	HWR	LWR	MHTGR
Peak-year employment			
Direct employment	2,400	5,800	2,000
Indirect employment	6,000	14,500	5,000
Total increase in employment	8,400	20,300	7,000
Increase in employment (%)	13	32	11
Peak-year in-migration			
Direct NPR worker	3,540	10,585	2,700
in-migrating population			
Indirect worker	946	1,505	884
in-migrating population			
Total in-migrants	4,486	12,090	3,584
Increase in population (%)	3	8	2

The effect on earnings of HWR construction and preoperation activities is estimated at about \$1.87 billion. An LWR would increase regional earnings by about \$562 million. The effect on earnings of construction and preoperation activity would be about \$1.89 billion. An MHTGR or HWR would add about one additional year's personal income to the Hanford economy. This addition would provide some cushion in the event of an economic slowdown in the Hanford region. Income effects of the LWR would be insignificant.

Because no farmland would be removed from agriculture for construction of any of the NPR alternatives, no direct impacts on agriculture would occur during construction for any alternative.

Population Characteristics

Construction of an NPR would increase the regional population over baseline projections by 4,500 (3%), 12,000 (8%), and 3,600 (2%) persons for an HWR, LWR, and MHTGR, respectively. During the years leading to the construction peak, NPR staffing could double projected rates of population growth in the Hanford area for an HWR or MHTGR and could triple these rates for an LWR. Although the LWR and HWR would require about the same total person-years of effort, the shorter construction schedule and resultant higher peak in worker requirements for the LWR would cause its socioeconomic impacts to be more than twice as large as those of the other alternatives.

Housing

The greatest housing impacts as a consequence of NPR construction at the Hanford Site are anticipated to accompany the LWR alternative (Table 5.2.8-2). The greatest increase in

TABLE 5.2.8-2 Estimated In-Migrant Housing Demand for NPR Peak Construction Year in the Hanford ROI, by NPR Technology

Location	HWR	LWR	MHTGR
Benton County	1,425	3,840	1,138
Kennewick	466	1,256	372
Richland	764	2,058	610
Franklin County	126	340	101
Pasco	123	331	98
Hanford ROI	1,551	4,180	1,239

housing demand under the LWR alternative is expected to occur in Benton County, where nearly 3,850 housing units would be required. The community of Kennewick alone would require about 1,250 housing units to accommodate projected in-migrants. These increases in demand would be noteworthy in both areas, particularly given the historic capabilities of the local housing construction industries and the relatively low vacancy rates that have characterized the area in recent years. Anticipated housing impacts to Franklin County and the community of Pasco are estimated to be much smaller in absolute terms, though increased LWR-related demand would significantly exceed housing construction for any year during the 1980s.

Anticipated housing impacts of the HWR would be the second largest of the three alternatives considered, roughly 35% of those projected for the LWR (Table 5.2.8-2). The MHTGR-related housing impacts would be smallest. For both the HWR and MHTGR, housing impacts to Benton County would be the largest and would greatly exceed the housing construction for any year during the 1980s. Similarly, though they would be much smaller than needs for the LWR, projected housing demands for the HWR and MHTGR in Franklin County would significantly exceed construction in the 1980s.

Public and Community Services

Education. Public education impacts arising from NPR construction are presented in Table 5.2.8-3. Impacts would be greatest under the LWR alternative at the peak of construction, with a total of more than 2,000 additional students in the region of interest (ROI). To maintain existing student/teacher ratios, 116 additional teachers would be needed in the region. For the HWR and MHTGR, impacts would be somewhat less, with enrollment increases of 774 and 619 students, respectively; corresponding increases in instructional staffs would be 43 and 35 teachers, respectively, for the ROI.

These impacts to public education services would be concentrated in the Benton County school districts of Richland and Kennewick. Richland School District would experience an enrollment increase of 1,025 students and would require an additional 60 teachers to maintain the current student/teacher ratio at the peak of construction. In Kennewick School District,

TABLE 5.2.8-3 Estimated NPR Construction-Related Impacts to Public Education in the Hanford ROI, by NPR Technology

County/ School District	Enrollment Impacts			Teacher Impacts		
	HWR	LWR	MHTGR	HWR	LWR	MHTGR
Benton County	711	1,913	569	40	107	32
Finley	22	59	18	1	3	1
Kennewick	233	626	186	13	35	10
Kiona-Benton	24	64	19	1	3	1
Paterson	1	3	1	0	0	0
Prosser	50	135	40	2	6	2
Richland	381	1,025	305	22	60	18
Franklin County	63	169	50	3	9	3
Kahlotus	0	0	0	0	0	0
North Franklin	2	5	1	0	0	0
Pasco	61	164	49	3	9	3
Star	0	0	0	0	0	0
Hanford ROI	774	2,082	619	43	116	35

enrollment increases in excess of 600 students under the LWR alternative would require an additional 35 teachers to maintain the current student/teacher ratio. Kennewick School District is rapidly approaching enrollment capacity; baseline enrollment increases combined with NPR-generated increases would exacerbate its crowded classroom conditions. Impacts under the HWR and MHTGR alternatives would also be greatest in these two school districts, although the impact would be less than under the LWR alternative (Table 5.2.8-3).

Although enrollment impacts to Finley and Prosser school districts would not be as great as those to Richland and Kennewick school districts, these former impacts probably would be more acute because of existing crowded conditions reported by these districts. Finley School District, which is operating at its capacity of 1,015 students, would experience an enrollment increase of 59 students under the LWR alternative, 22 students under the HWR, and 18 students under the MHTGR. Reports from Prosser School District indicate that it currently is operating over its capacity of 2,000 students, housing its enrollment of 2,297 students by using 16 portable classrooms; this district anticipates a 5% growth in enrollment by the fall of 1991. Construction of the NPR would exacerbate already crowded conditions at Prosser School District, which would experience enrollment growth of 135 students under the LWR alternative, 50 students for the HWR, and 40 students for the MHTGR.

Health Care. Analysis of health care impacts related to the NPR construction was based on the LWR alternative as the bounding (most conservative) condition. Although more doctors and nurses would be needed (Table 5.2.8-4), current capacity at area hospitals would be sufficient to handle the growth.

TABLE 5.2.8-4 Estimated NPR Construction-Related Impacts to Health Services in the Hanford ROI

County	Doctors	RN/LPN	Hospital Beds
Benton	15	77/28	21
Franklin	1	4/2	NA ^a

^aNot available.

Police and Fire Protection. Potential impacts to police protection at the peak of NPR construction under all three alternatives are presented in Table 5.2.8-5. These impacts follow the distribution of NPR-generated population impacts and reflect the increased demand for local public services arising from NPR-related in-migration during construction. Under all three alternatives, impacts would be experienced by all police departments except the Franklin County Sheriff's Office. The remaining police departments would have to increase their staff sizes (by up to seven additional sworn officers at the Richland Police Department under the LWR alternative) to meet the increased demand at the peak of NPR construction while maintaining existing levels of police protection.

The projected peak impacts to fire protection services during construction under all three NPR alternatives are presented in Table 5.2.8-5. As with police protection, these impacts follow the distribution of population impacts and reflect the increased demand for public services arising from peak construction phase in-migration. The Richland Fire Department would experience the greatest impacts and would need six additional fire fighters during the peak of construction under the LWR alternative. The Richland and Kennewick fire departments would experience impacts under all three alternatives; the Pasco Fire Department would experience increased demand only during the peak construction of the LWR alternative. Projections for the rural fire departments were not made because they rely on volunteers.

Public Finance

As the above analyses show, fiscal impacts related to the NPR would be determined by factors such as the location of in-migrant workers, the size and timing of purchases, and the number of school age children. In taxing jurisdictions where service capabilities would be severely strained (especially where new classrooms would be added), additional sources of revenue might be required. Fiscal impact analysis is an integral part of a Socioeconomic Monitoring and Mitigation Plan. If a final site is selected for the NPR, fiscal assessments will be conducted for all impacted taxing districts as an ongoing part of such a plan.

TABLE 5.2.8-5 Estimated NPR Construction-Related Impacts to Police and Fire Protection Services (additional professionals needed) in the Hanford ROI, by NPR Technology

County/Agency	HWR	LWR	MHTGR
Police Protection			
Benton County			
Benton County Sheriff's Office	1	3	1
Kennewick Police Department	1	4	1
Richland Police Department	3	7	2
Franklin County			
Franklin County Sheriff's Office	0	0	0
Pasco Police Department	1	2	0
Fire Protection			
Benton County			
Benton County Rural Fire Dept. #1	NA ^a	NA	NA
Benton County Rural Fire Dept. #2	NA	NA	NA
Benton County Rural Fire Dept. #4	NA	NA	NA
Kennewick Fire Department	1	3	1
Richland Fire Department	2	6	2
Franklin County			
Pasco Fire Department	0	1	0

^aNot available.

5.2.8.3 Impacts of NPR Operation

Employment and Income

A summary of operational work force requirements is presented in Table 5.2.8-6. Estimates range from 1,254 (HWR) to 1,881 (MHTGR) persons. These estimates reflect maximum operational work force requirements for the reactor and facilities.

The effect of HWR operation on annual earnings is estimated to be the same as for the LWR -- about \$130 million in additional earnings each year. The effect on annual earnings of MHTGR operation is estimated to be \$145 million above baseline earnings. This effect would increase personal income by 7% over the 1987 level. Direct, indirect, and secondary effects of operation for all alternatives would result in employment of more than 6,100 people per year, an increase of 11% from the 1988 regional employment level. Under all alternatives, an NPR would substantially benefit the Hanford area's economy.

Impacts to agriculture during NPR operation could occur because of reactor or support facility accidents; however, such incidents are highly unlikely during the lifetime of an NPR, with a probability of occurrence of about 10^{-4} to 10^{-6} (see Section 5.2.6). Potential nonsevere

**TABLE 5.2.8-6 Estimated NPR Operations-Related Changes
in Employment and Population in the Hanford ROI,
by NPR Technology**

Employment/In-Migration	HWR	LWR	MHTGR
Annual employment			
Direct employment	1,254	1,808	1,881
Indirect employment	3,762	5,424	5,643
Increase in employment	5,016	7,232	7,524
Increase in employment (%)	6	9	9
In-migration			
Direct NPR worker	2,446	3,525	3,668
in-migrating population			
Indirect worker	860	1,241	1,290
in-migrating population			
Total in-migrants	3,306	4,766	4,958
Increase in population (%)	2	3	3

accidental releases might lead to impoundment of some portion of area field crops, vegetables, or livestock (which had a combined value of \$352 million in 1988 in Benton and Franklin counties). Appendix I identifies the highly unlikely accidents that might result in impoundment of food crops to protect human health. Publicity of such an event might adversely affect the sale of branded categories of food unaffected by the accident, such as Washington State apples and wines. Impacts to tourism are discussed in Section 5.2.3.

Population Characteristics

The greatest socioeconomic effects would occur for MHTGR operation, which would lead to a 3% increase (4,600 persons) in regional population (Table 5.2.8-6). Impacts of LWR operation would be nearly as great as those of MHTGR operation, but the large infrastructure requirements during LWR construction would probably negate any additional needs during LWR operation.

Housing

The greatest housing impacts as a consequence of NPR operation at the Hanford Site are anticipated to accompany the MHTGR alternative (Table 5.2.8-7), with the greatest increase in housing demand (more than 1,000 housing units) expected in Benton County. The community of Richland alone would require almost 550 housing units to accommodate projected in-migrants. These increases in demand would be noticeable in both Benton County and Richland, in each case exceeding the decade average for annual housing permits issued (though exceeded by the permits issued in at least one year for both cases). Anticipated housing impacts to Franklin

TABLE 5.2.8-7 Estimated In-Migrant Housing Demand for NPR Peak Operations Year in the Hanford ROI, by NPR Technology

Location	HWR	LWR	MHTGR
Benton County	1,023	1,475	1,534
Kennewick	335	482	502
Richland	548	790	822
Franklin County	91	131	136
Pasco	88	127	132
Hanford ROI	1,114	1,605	1,670

County and the community of Pasco are estimated to be much smaller in absolute terms, though increased LWR-related demand would exceed the average annual number of housing construction permits issued during the 1980s.

Anticipated housing impacts of the LWR alternative are slightly less than the projected MHTGR impacts (Table 5.2.8-7). The HWR-related housing impacts would be substantially less than those associated with either of the other alternatives. For both the LWR and HWR, housing impacts would be the greatest in Benton County, greatly exceeding the annual average number of housing construction permits issued during the 1980s. Similarly, though much lower than impacts of the MHTGR alternative, housing impacts to Franklin County projected to accompany the HWR or LWR would be much greater than the annual average number of building permits issued between 1980 and 1990.

Public and Community Services

Education. Impacts to public education during NPR operation at the Hanford Site are presented in Table 5.2.8-8. Public enrollment impacts would be greatest under the MHTGR alternative, with more than 850 additional students in the ROI; 48 additional teachers would be needed to maintain current student/teacher ratios. Impacts under the LWR alternative would be only slightly less (820 students and 46 teachers); impacts under the HWR alternative would amount to 569 students and 32 teachers in the ROI.

As during the construction phase, impacts to public education would be numerically greatest in the Richland and Kennewick school districts. Operation of the MHTGR would result in the greatest enrollment impacts (420 students in Richland School District and 257 students in Kennewick School District). Kennewick School District is rapidly approaching enrollment capacity; baseline enrollment increases combined with NPR-generated increases would exacerbate its crowded classroom conditions. Increases in instructional staff needed to maintain existing student/teacher ratios would be 25 teachers in Richland School District and 14 teachers in Kennewick School District. Under the LWR alternative, enrollment impacts would be slightly less, and impacts to teaching staffs would be the same. Under the HWR alternative, impacts to both enrollments and teachers would be less than under the MHTGR and LWR alternatives.

TABLE 5.2.8-8 Estimated NPR Operations-Related Impacts to Public Education in the Hanford ROI, by NPR Technology

County/ School District	Enrollment Impacts			Teacher Impacts		
	HWR	LWR	MHTGR	HWR	LWR	MHTGR
Benton County	523	753	784	29	42	44
Finley	16	23	24	1	1	1
Kennewick	171	247	257	10	14	14
Kiona-Benton	18	25	26	1	1	1
Paterson	1	1	1	0	0	0
Prosser	37	53	55	2	2	2
Richland	280	404	420	16	24	25
Franklin County	46	67	69	2	3	4
Kahlotus	0	0	0	0	0	0
North Franklin	1	2	2	0	0	0
Pasco	45	65	67	2	3	3
Star	0	0	0	0	0	0
Hanford ROI	569	820	853	31	45	48

During NPR operation, as during construction, enrollment impacts to Finley and Prosser school districts would be numerically smaller, but they would probably be more acute because of the current crowded conditions. Finley School District, operating at its capacity of 1,015 students, would experience an enrollment increase of 24 students under the MHTGR alternative, 23 students under the LWR alternative, and 16 students under the HWR alternative. Prosser School District, with a capacity of 2,000 students, currently serves an enrollment of 2,297 students by using mobile classrooms; in addition, this district anticipates a 5% growth in enrollment by the fall of 1991. Operation of the NPR would add 55 students to the already crowded conditions in Prosser School District under the MHTGR alternative, 53 students under the LWR alternative, and 37 students under the HWR alternative.

Health Care. Health care impacts were considered for the construction of the NPR as a worst case scenario. Operational impacts would not be expected to adversely affect health care facilities.

Police and Fire Protection. Potential impacts to police protection resulting from NPR operation under all three alternatives are presented in Table 5.2.8-9. As with peak construction impacts, these projections reflect the distribution of NPR-generated population impacts and the increased demand for local public services arising from in-migration during NPR operation. Under all three alternatives, impacts would be experienced by all police departments except the Franklin County Sheriff's Office and the Pasco Police Department. The Pasco Police Department would require only one additional officer during operation of the LWR and MHTGR alternatives. The remaining police departments would have to increase their staff sizes (by up to three

TABLE 5.2.8-9 Estimated NPR Operations-Related Impacts to Police and Fire Protection Services (additional professionals needed) in the Hanford ROI, by NPR Technology

County/Agency	HWR	LWR	MHTGR
Police Protection			
Benton County			
Benton County Sheriff's Office	1	1	1
Kennewick Police Department	1	2	2
Richland Police Department	2	3	3
Franklin County			
Franklin County Sheriff's Office	0	0	0
Pasco Police Department	0	1	1
Fire Protection			
Benton County			
Benton County Rural Fire Department #1	NA ^a	NA	NA
Benton County Rural Fire Department #2	NA	NA	NA
Benton County Rural Fire Department #4	NA	NA	NA
Kennewick Fire Department	1	1	1
Richland Fire Department	2	3	3
Franklin County			
Pasco Fire Department	0	0	0

^aNot available.

additional sworn officers at the Richland Police Department during operation of the LWR and MHTGR) to meet increased demands during NPR operation while maintaining existing levels of police protection.

Projected operational impacts to fire protection services under all three NPR alternatives are presented in Table 5.2.8-9. As with police protection, these impacts would follow the distribution of population impacts and would reflect the increased demand for public services arising from operations phase in-migration during NPR operation. Only the Richland and Kennewick fire departments would experience increased demand during NPR operation. The Richland Fire Department, with the greatest impact, would need three additional fire fighters under both the LWR and MHTGR alternatives; Kennewick Fire Department would need only one additional fire fighter to meet increased demand and maintain current levels of service.

Public Finance

See the discussion of NPR-related fiscal impacts in Section 5.2.8.2.

5.2.8.4 Mitigation and Conclusions

Among the alternatives considered, an LWR would have the largest socioeconomic impacts and an MHTGR the smallest during construction. Housing impacts and impacts to local schools are predicted to be substantial during construction of an LWR. Payments in lieu of taxes or grants equivalent to taxes might be necessary to offset these impacts.

Uncertainties associated with (1) the timing, number, and composition of an in-migrating work force and (2) the probable settlement patterns of in-migrants preclude precise estimation of socioeconomic, especially fiscal, impacts. Hence, a Socioeconomic Monitoring and Mitigation Plan would be developed. This plan would provide for (1) periodic surveys of employees and affected communities and (2) a claim process to systematically identify, review, negotiate, and resolve issues related to local area socioeconomic impacts.

5.2.9 Transportation Systems

This section addresses the impacts of increased requirements for transportation of workers and nonradioactive materials to the Hanford Site and the surrounding area. Transportation of radioactive materials is addressed in Section 5.2.6. The changes in the vehicle miles traveled (VMT)* associated with increases in baseline population and activity during construction and operation of the three reactor technologies are provided in Figure 5.2.9-1.

5.2.9.1 Impacts of No Action

If an NPR were not constructed and operated at the Hanford Site, the existing transportation environment would remain as described in Section 4.1.9. Changes in population due to non-NPR activities at the Hanford Site and in the surrounding communities would affect transportation. Any increases in the general population of the region would cause corresponding increases in traffic congestion, truck traffic, and vehicular accidents. Projected population changes in the Hanford area are identified in Section 4.1.8. Improvements to existing roadways that might be initiated in response to increased regional population are discussed in Section 4.1.9.

5.2.9.2 Impacts of NPR Construction

The construction of NPR facilities would require additions to the Hanford work force (Section 5.2.8). In addition, construction materials, wastes, and excavated materials would be transported both on-site and off-site. These activities would result in increases in operation of personal-use vehicles by commuting construction workers, in commercial truck traffic, and in traffic associated with daily operations of the Hanford Site.

This analysis addresses traffic congestion, increased truck traffic and associated fatalities and injuries, and potential road damage during construction for the three NPR technologies. Impacts are summarized in Tables 5.2.9-1 and 5.2.9-2 and are discussed in the following paragraphs.

*1 vehicle mile traveled = 1.609 vehicle kilometers traveled.

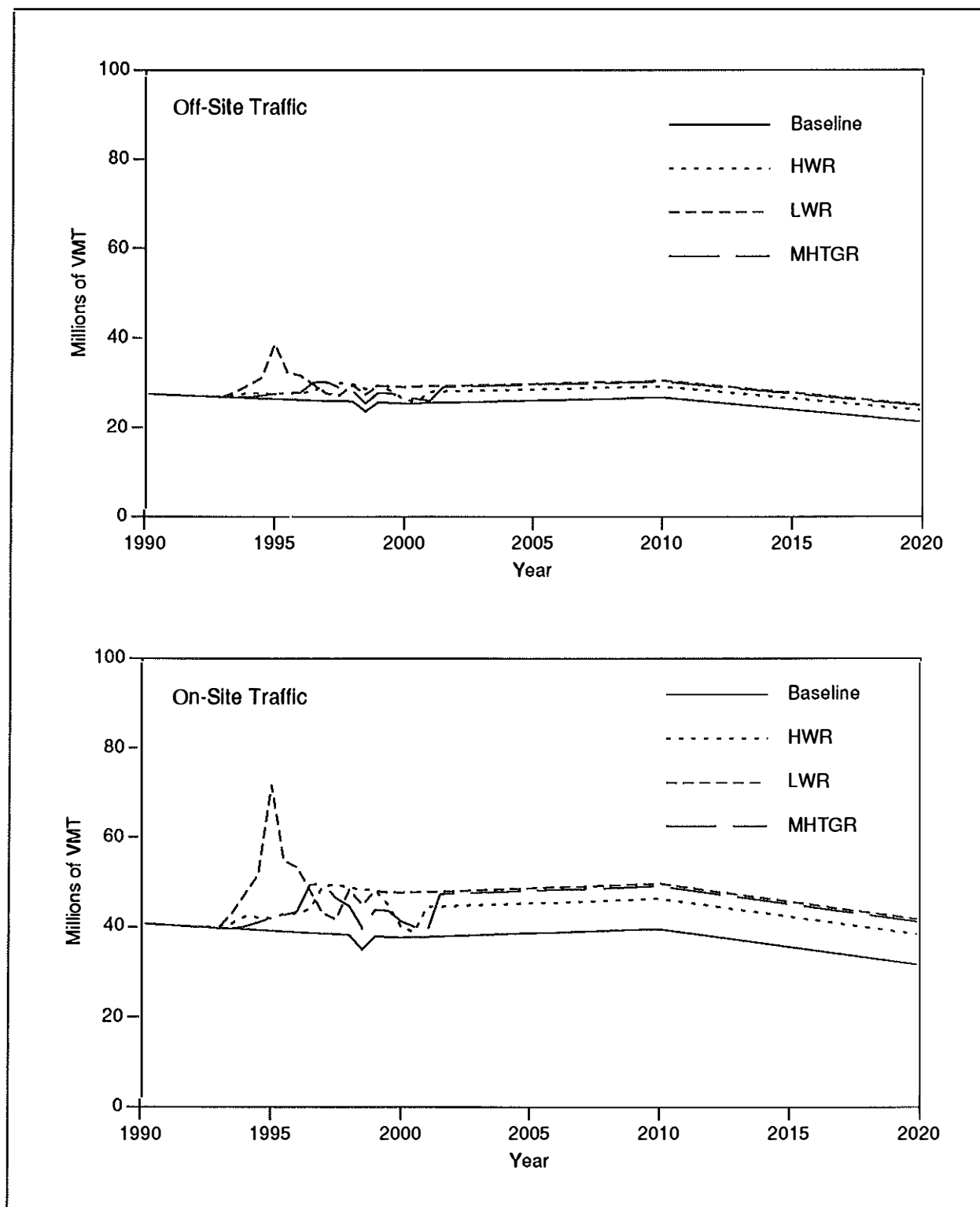


FIGURE 5.2.9-1 On-site and Off-site Traffic at Hanford

TABLE 5.2.9-1 Potential Impacts on Peak Travel Period Performance of Off-site Transportation Routes due to Transportation of Workers and Nonradioactive Materials in the Hanford Site Vicinity

Reactor	Typical Route ^a	Impact (Level of Service) ^b		
		1988 Baseline	Construction	Operation
HWR	SR 24	Free flow	Free flow	Free flow
	SR 240	Approaching unstable flow to unstable flow	Approaching unstable flow to unstable flow	Forced flow
	I-182	Free flow	Free flow to stable flow (upper speed limit)	Stable flow (upper speed limit)
LWR	SR 24	Free flow	Free flow	Free flow
	SR 240	Approaching unstable flow to unstable flow	Approaching unstable flow to unstable flow	Forced flow
	I-182	Free flow	Free flow to stable flow (upper speed limit)	Stable flow (upper speed limit)
MHTGR	SR 24	Free flow	Free flow	Free flow
	SR 240	Approaching unstable flow to unstable flow	Approaching unstable flow to unstable flow	Forced flow
	I-182	Free flow	Free flow to stable flow (upper speed limit)	Stable flow (upper speed limit)

^aSR = State Route; I = Interstate. The amount of NPR-related traffic on these routes would not represent a significant degree of nuisance.

^bEstimated levels of service based on NUS-1 (Table 7.2); see Section 5.1.10 for definitions.

TABLE 5.2.9-2 Potential Fatalities from Transportation of Workers and Nonradioactive Materials at Hanford and Vicinity

Reactor	NPR Activity	Applicable Time Period (years)	Fatality Rate ^a (per year)	
			On-site	Off-site
HWR	Construction	9	0.08	0.03
	Operation	39	0.11	0.04
LWR	Construction	5	0.08	0.03
	Operation	42	0.11	0.04
MHTGR	Construction	7	0.10	0.04
	Operation	39	0.11	0.04
Baseline population		50	0.38	0.58

^aFatalities based on state rates for all vehicles.

Traffic Congestion

An estimate of the level of service indicated that growth in the local population and the NPR work force would probably cause overloading and delays during peak traffic periods on sections of SR 240. Significant traffic congestion could cause delays by reducing the overall speed along the highway.

Truck Traffic

The number of trucks required to transport the construction materials and excavated earth has been estimated on the basis of a 40,000-lb load per truck. The daily number of trips by trucks transporting excavation materials, gravel, and sand on the site during the construction period would be 186 for the MHTGR, 117 for the HWR, and 7 for the LWR. Transportation of other construction materials would add 6 truck trips daily on the site and on off-site highways for the HWR, 2 trips for the LWR, and 25 trips for the MHTGR. Such truck traffic would not be a nuisance. Given compliance with state and Federal loading and speed regulations, truck traffic would not significantly damage the roadbed.

Vehicular Accidents

The expected increase in fatal accidents during the construction of the NPR was estimated from the statewide statistics for 1988. The estimated total number of additional annual fatalities at Hanford during construction would be 0.08 for the HWR and LWR and 0.1 for the MHTGR. Additional annual off-site traffic fatalities would number 0.03 for the HWR and LWR and 0.04 for the MHTGR. The baseline rates during this period are 0.38 and 0.58 for on-site and

off-site fatalities, respectively. Therefore, the increases caused by the NPR would not be significant.

Barge and Rail Transportation

The limited use of barge and rail during NPR construction for heavy equipment and coal transport to the Hanford Site would have no significant impact to the Hanford Site or its vicinity.

5.2.9.3 Impacts of NPR Operation

Traffic Congestion

During NPR operations, congestion along SR 240 could cause delays during peak traffic hours for all reactor technologies.

Truck Traffic

The amount of truck traffic would be considerably less during NPR operation than during construction. If the nonhazardous operational material were transported by truck, the total number of trucks transporting operational material on-site and off-site per day would be about 1 for the HWR, 2 for the LWR, and 12 for the MHTGR.

Vehicular Accidents

The additional annual on-site and off-site fatalities estimated during operation of the NPR would be 0.11 and 0.04 for each of the three technologies. In comparison with the annual baseline fatality rates of 0.38 and 0.58 (on-site and off-site, respectively), no significant impacts would be expected.

Barge and Rail Transportation

The limited use of barge and rail traffic, primarily for the transport of heavy equipment, hazardous material, and coal, would have no significant impact to the Hanford Site or its vicinity.

5.2.9.4 Mitigation and Conclusions

The Hanford Site is attempting to reduce traffic congestion by implementing flexible and staggered working hours. Reducing congestion during peak traffic times for transportation of the baseline population may require further analysis of highway design, which is outside the scope of this document.

5.2.10 Waste Management

This section describes the impacts to site waste management facilities from the construction and operation of the three NPR technologies at Hanford. The impacts of the no-action alternative are also discussed. The analysis is organized by major activity: no-action alternative, construction, and operation. The section on the impacts of NPR operations is subdivided by waste type. Where applicable, differences in impacts between the candidate technologies are also presented. The last section presents conclusions and mitigation requirements.

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

The quantities and types of wastes to be managed depend upon whether or not spent fuel is reprocessed and whether or not plutonium is produced, as well as on the extent to which existing reactors continue to operate in the future. Estimates in this section were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium produced. If it is decided not to continue those activities, the impacts upon waste management systems from NPR operations would be less than presented in this section. This could also reduce the amounts of cumulative wastes presented in this section.

5.2.10.1 Impacts of No Action

The no-action alternative at Hanford would result in no new production capacity at the site, and waste management operations would continue as described in Section 4.1.10. The primary focus of waste management at the site would be treatment and disposal of the HLW and LLW now stored in tanks at Hanford. The HLW would be immobilized in glass at the planned Waste Vitrification Plant before being shipped to a Federal repository for final disposal. The mixed waste inventory would be processed at the proposed Waste Reduction and Process Facility. TRU waste would be packaged and certified for off-site disposal at WIPP. Liquid LLW would continue to be solidified at the Grout Treatment Facility and disposed of on-site. Hazardous and other waste would continue to be handled in a manner necessary to meet regulatory requirements.

5.2.10.2 Impacts of NPR Construction

Construction of NPR facilities at Hanford would generate wastewater, nonhazardous solid waste, and hazardous waste. Construction waste are described in Appendix M. Construction waste would be managed by Hanford's existing waste management system for wastewater, other waste, and hazardous waste as outlined in Section 4.1.10. These wastes would be handled in a manner similar to the wastes generated by on-going construction projects. No significant impacts to the waste management system at Hanford are expected from the generation of NPR-related construction waste. Those waste input volumes could be handled by existing waste treatment and disposal facilities. No new facilities would be required. The waste volumes associated with construction of the three NPR technologies are presented in Table 5.2.10-1.

5.2.10.3 Impacts of NPR Operation

Normal operation of the NPR and its support facilities at Hanford would generate waste that requires environmentally sound treatment, storage, and disposal procedures that comply with applicable regulations. This waste would be similar to the solid and liquid waste generated by non-NPR facilities at Hanford (Section 4.2.10) (WHC-3, -4, -6, -7, -8, -9). The various waste types are described in Appendix M.

The environmental effects of NPR-generated waste would depend on the ability of Hanford waste management facilities to effectively treat and dispose of waste from both NPR and non-NPR sources. For this EIS, it was assumed that Hanford waste management facilities would be capable of operating at design capacities throughout the active life of the NPR project. Potential adverse impacts are noted for situations in which NPR-related waste would exceed by 80% or more the available capacity of a site facility to process or store waste streams containing NPR and non-NPR waste.

The "available capacity" of a site waste management facility refers to the difference between the design capacity of that facility and the input of waste from active non-NPR operations at Hanford. This approach was taken to maintain consistency in the assessments of the impacts of NPR-related waste to waste management facilities across all three sites. Inputs from inventoried waste awaiting treatment are not included in the quantification of non-NPR operations waste inputs or in the determination of available capacity.

During the operational period of the NPR and its support facilities (2000-2040), more than half of the non-NPR waste processed at the site would be from the inventory of HLW, TRU waste, and LLW accumulated during previous production operations at Hanford. (See Table 4.1.10-1 for volume estimates.) The treatment and disposal of inventory waste would remain flexible, being accomplished by processing the waste at a rate compatible with the capacity of the specific treatment facility and the input of NPR-related waste. In most instances, from 15 to 30 years would be required to completely process and dispose of inventory waste. Because the inventory waste is already stored at existing facilities in double- and single-shell tanks, no additional storage space would be required to hold inventory waste while NPR waste was processed on-site.

**TABLE 5.2.10-1 Construction Waste Volumes at Hanford,
by NPR Technology (m³/yr)**

Waste Type	HWR	LWR	MHTGR
Wastewater ^a	35,000	40,000	4,000 ^b
Nonhazardous solid waste ^c	31,000	25,000	9,000
Hazardous waste ^c	22	25	25

^aWastewater volumes based on total peak-year use for system flushing.

^bWastewater volume for MHTGR based on a flush of secondary system ten times, and no primary system flush.

^cNonhazardous solid waste and hazardous waste are yearly average over the construction period.

Sources: Values derived from data in WHC-3, -4, -6, -7, -9.

The NPR-related HLW and LLW streams generated during spent fuel and target processing would first be processed at the NPR Spent Fuel Processing Complex. Radioactive NPR waste would then be processed together with baseline waste through the Waste Vitrification Plant, Transuranic Waste Storage and Assay Facility, Low-Level Radioactive Waste Disposal Facility, Grout Treatment Facility, and Waste Receiving and Processing Facility, as discussed in Section 4.1.10. Nonradioactive solid waste would be disposed of at the Hanford Central Landfill, and nonradioactive liquid waste would be discharged to solar ponds or treated as sanitary waste and discharged to the ground, drain fields, or the Columbia River, depending on the specific waste. Diagrams depicting NPR waste management at Hanford are presented in Figures M.4 through M.21. The capacity to handle HLW, LLW, and TRU waste at Hanford would be sufficient to accommodate the expected additional loading of waste from NPR facilities during operation (2000-2040). The 1990 plans for treating and disposing of mixed waste at Hanford do not provide for handling the additional mixed waste load from NPR operations. Hazardous and other waste operations and facilities would be sufficient to dispose of added waste input from NPR operations.

The quantities of waste generated would vary among the three reactor technologies. Also, the volume of waste generated would be different for the tritium and plutonium production modes. The waste management assessments in this EIS are based on upper-bound estimates of waste volumes, that is, on the larger of the waste volumes for each waste stream generated by full-time tritium production or full-time plutonium production.

Effects of NPR-Related Waste on Hanford Waste Management Facilities

The quantities and types of waste that would be generated by NPR operations at Hanford are summarized in Tables 5.2.10-2 and 5.2.10-3. The NPR-related waste data are derived from the references cited in Section 5.2.10.2. The non-NPR Hanford operations waste

TABLE 5.2.10-2 Comparison of Annual Waste Management Facility Inputs from NPR Operations in the Tritium Production Mode and Non-NPR Operations at Hanford between 2000 and 2040

Waste Identification	Facility Description	Facility Input Capacity ^a (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^b (m ³ /yr)
			HWR	LWR	MHTGR	
High-level waste						
Liquid	Storage tanks	120,000	91	42	51	0
	Waste Vitrification Plant	240	91	42	51	0
Solid	Interim storage	Expandable	15	18	33	0
Transuranic waste						
Solid ^c	Transuranic Waste Storage and Assay Facility	4,400	40	70	50	0
	Interim storage	Expandable	40	70	50	0
Low-level waste						
Liquid	242-A Evaporator	38,000	5,200	4,500	1,000	1,900
	Grout Treatment Facility	25,000	2,600	2,600	120	300
Solid ^d	Near-surface vaults	Expandable	3,600	3,800	500	400
	Low-Level Waste Disposal Facility	Expandable	4,800	3,600	3,800	13,000
	Special disposal vaults ^e	Expandable	0	0	560	0
Mixed waste						
Solid ^d	Mixed waste storage facilities	Expandable	880	800	120	300
	Waste Receiving and Processing Facility	560	870	790	220	300
Hazardous waste						
Liquid and solid	Nonradioactive Dangerous Waste Storage Facility	100	37	290	42	100
Other waste						
Nonhazardous						
Liquid	Discharge canal	Expandable	7,100,000	4,200,000	6,900,000	0
	Evaporation ponds	Expandable	38,000	85,000	18,000	2,000,000
Solid	Central landfill	Expandable	2,100	3,100	2,300	38,000
Sewage						
Liquid ^f	Sewage treatment plant	Expandable	19,000	27,000	20,000	0
	Sanitary tile fields	Expandable	23,000	33,000	26,000	210,000
Solid ^g	Central landfill	Expandable	38	21	0	4

^aFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^bNon-NPR operations values projected from 1988 data; values do not include processing of stored waste.

^cLiquids containing transuranics are processed as HLW.

^dSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^eFinal holding capacity to be established if NPR is to be located at Hanford.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

Sources: Evans 1990; Merrick 1989; WHC-3, -4, -6, -7.

TABLE 5.2.10-3 Comparison of Annual Waste Management Facility Inputs from NPR Operations in the Plutonium Production Mode and Non-NPR Operations at Hanford between 2000 and 2040

Waste Identification	Facility Description	Facility Input Capacity ^a (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^b (m ³ /yr)
			HWR	LWR	MHTGR	
High-level waste						
Liquid	Storage tanks	Expandable	71	67	60	0
	Waste Vitrification Plant	240	71	67	60	0
Solid	Interim storage	Expandable	10	12	38	0
Transuranic waste						
Solid ^c	Transuranic Waste Storage and Assay Facility	4,400	87	250	130	0
	Interim storage	Expandable	87	250	130	0
Low-level waste						
Liquid	242-A Evaporator	38,000	8,200	4,900	6,400	1,900
	Grout Treatment Facility	25,000	5,000	5,500	680	300
Solid ^d	Near-surface vaults	Expandable	6,700	7,300	1,100	400
	Low-Level Waste Disposal Facility	Expandable	3,600	3,200	7,800	13,000
	Special disposal vaults ^e	Expandable	0	0	19,000	0
Mixed waste						
Solid ^d	Mixed waste storage facilities	Expandable	880	810	130	300
	Waste Receiving and Processing Facility ^e	560	860	790	240	300
Hazardous waste						
Liquid and solid	Nonradioactive Dangerous Waste Storage Facility	100	37	290	57	100
Other waste						
Nonhazardous						
Liquid	Discharge canal	Expandable	7,100,000	4,200,000	6,900,000	0
	Evaporation ponds	Expandable	200,000	180,000	290,000	2,000,000
Solid	Central landfill	Expandable	1,900	2,500	2,800	38,000
Sewage						
Liquid ^f	Sewage treatment plant	Expandable	19,000	27,000	26,000	0
	Sanitary tile fields	Expandable	19,000	22,000	30,000	210,000
Solid ^g	Central landfill	Expandable	38	21	0	4

^aFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^bNon-NPR operations values projected from 1988 data; values do not include processing of stored waste.

^cLiquids containing transuranics are processed as HLW.

^dSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^eFinal holding capacity to be established if NPR is to be located at Hanford.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

Sources: Evans 1990; Merrick 1989; WHC-3, -4, -6, -7.

inputs and the capacities of the affected Hanford waste management facilities are also given in the tables. The utilization of site waste management capacities resulting from NPR waste inputs is given in Tables 5.2.10-4 and 5.2.10-5. The discussions of the percentage of available capacity are based on the data in these tables. The drawdown and processing of inventory waste would be integrated with the processing of NPR-related waste to allow for full processing capacity utilization of waste management facilities.

High-Level Waste

The various interim and final volumes of HLW generated by NPR operations would represent a minor portion of the Hanford capacities for HLW treatment and tank storage before vitrification. The NPR-related waste processed at the Waste Vitrification Plant would amount to less than 40% of the plant's vitrification capacity. No new facilities or expansion of existing capacity would be required to process NPR-generated HLW.

The available storage space in the double-shell tanks (Section 4.1.10.2) would be sufficient to accept NPR-generated HLW liquids. The available storage capacity in the double-shell tank farm assumes that at least one complete tank volume (approximately 4,300 m³) of unused capacity would remain empty throughout the tank farm of 28 tanks to allow for effective transfer of material throughout the tank system in the event of a failure or leakage of the equivalent of one full tank. However, if under some circumstance (e.g., multiple tank failure) more than the equivalent of one tank volume of radioactive liquid would require transfer, a tank system overload could result, causing a backlog of liquid waste at NPR production facilities. This situation could affect NPR production of tritium or plutonium. At present, the service record of the double-shell tanks at Hanford is good, and the probability of an overload in liquid radioactive storage appears to be low. The Waste Management PEIS in preparation by DOE will address waste storage facilities.

Transuranic Waste

Current operations at Hanford do not generate TRU waste. The largest potential NPR-related impact would result from the LWR technology. This operation would account for 6% of the throughput of the Transuranic Waste Storage and Assay Facility. No new facilities or expansion of existing capacity would be required to certify NPR-generated TRU waste.

Low-Level Waste

The largest potential input of liquid LLW to the 242-A Evaporator from NPR operations would be 8,200 m³/yr from the HWR technology in the plutonium production mode. This input would represent 23% of the evaporator unit's capacity. This input would not significantly affect the processing of Hanford operations LLW to the evaporator because at least 75% of 242-A Evaporator capacity would remain available to process baseline operations as well as the stored inventory of LLW at Hanford. The solidification of NPR-related liquid LLW would require less than 25% of the grouting process capacity at the Grout Treatment Facility. The input of solid LLW grout from either HWR or LWR technology operations between 2000 and 2040 to the near-surface Grout Disposal Vaults would require constructing as many as 50 vaults in addition to

TABLE 5.2.10-4 Impacts to Hanford Waste Management Facilities Resulting from NPR Operation in the Tritium Production Mode between 2000 and 2040

Waste Identification	Facility Description	Percent Use of Available Capacity Used ^a			Comment
		HWR Input	LWR Input	MHTGR Input	
High-level waste					
Liquid	Storage tanks	b	b	b	
	Waste Vitrification Plant	38	18	21	
Solid	Interim storage	b	b	b	
Transuranic waste					
Solid ^c	Transuranic Waste Storage and Assay Facility	1	2	1	
	Interim storage	b	b	b	
Low-level waste					
Liquid	242-A Evaporator	14	12	3	
	Group Treatment Facility	11	11	<1	
Solid ^d	Near-surface vaults	b	b	b	
	Low-Level Waste Disposal Facility	b	b	b	
	Special disposal vaults	b	b	b	
Mixed waste					
Solid ^d	Mixed waste storage facilities	b	b	b	
	Waste Receiving and Processing Facility ^e	340	300	85	Percentages over 100% indicate waste generation rates that exceed the processing capacity
Hazardous waste					
Liquid and solid	Nonradioactive Dangerous Waste Storage Facility	b	b	b	
Other waste					
Nonhazardous					
Liquid	Discharge canal	b	b	b	
	Evaporation ponds	b	b	b	
Solid	Central landfill	b	b	b	
Sewage					
Liquid ^f	Sewage treatment plant	b	b	b	
	Sanitary tile fields	b	b	b	
Solid ^g	Central landfill	b	b	b	

^aAvailable capacity is the facility capacity reduced by the amount needed for non-NPR operations; non-NPR operations do not include the processing of stored waste.

^bPercentage of available capacity used is not applicable because sufficient space is available to accommodate additional storage/treatment/disposal units, which can be constructed as needed within the boundaries of the facility; DOE's Waste Management PEIS will review expansions in waste management facility capacities.

^cLiquids containing transuranics are processed as HLW.

^dSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^eFinal holding capacity to be established if NPR is to be located at Hanford.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

TABLE 5.2.10-5 Impacts to Hanford Waste Management Facilities Resulting from NPR Operation in the Plutonium Production Mode between 2000 and 2040

Waste Identification	Facility Description	Percent Use of Available Capacity Used ^a			Comment
		HWR Input	LWR Input	MHTGR Input	
High-level waste					
Liquid	Storage tanks	b	b	b	
	Waste Vittrification Plant	30	28	25	
Solid	Interim storage	b	b	b	
Transuranic waste					
Solid ^c	Transuranic Waste Storage and Assay Facility	2	6	3	
	Interim storage	b	b	b	
Low-level waste					
Liquid	242-A Evaporator	23	14	18	
	Group Treatment Facility	20	22	3	
Solid ^d	Near-surface vaults	b	b	b	
	Low-Level Waste Disposal Facility	b	b	b	
	Special disposal vaults	b	b	b	
Mixed waste					
Solid ^d	Mixed waste storage facilities	b	b	b	
	Waste Receiving and Processing Facility ^e	330	300	92	Percentages over 100% indicate waste generation rates that exceed the processing capacity
Hazardous waste					
Liquid and solid	Nonradioactive Dangerous Waste Storage Facility	b	b	b	
Other wastes					
Nonhazardous					
Liquid	Discharge canal	b	b	b	
	Evaporation ponds	b	b	b	
Solid	Central landfill	b	b	b	
Sewage					
Liquid ^f	Sewage treatment plant	b	b	b	
	Sanitary tile fields	b	b	b	
Solid ^g	Central landfill	b	b	b	

^aAvailable capacity is the facility capacity reduced by the amount needed for non-NPR operations; non-NPR operations do not include the processing of stored waste.

^bPercentage of available capacity used is not applicable because the facility capacity is expandable. A separate EIS will review expansions in waste management facility capacities.

^cLiquids containing transuranics are processed as HLW.

^dSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^eFinal holding capacity to be established if NPR is to be located at Hanford.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

the planned 44 vaults to accept the inventory waste at Hanford. Sufficient space exists in the area of the grout facilities to accommodate the additional vaults needed for grouted LLW resulting from NPR operations. The DOE is preparing a programmatic EIS on waste management that addresses strategies and policies for future operations of the department's waste management complex. Special decisions on new waste management facilities for NPR may not be made until after the ROD for the Waste Management PEIS, and these facilities would have their own NEPA documentation. The NPR-generated solid LLW to be disposed of at the Low-Level Radioactive Waste Disposal Facility would not exceed 60% of the annual non-NPR input of 13,000 m³ to the facility. When active disposal capacity is consumed, the total disposal capacity at the facility would be expanded to accept NPR-related and baseline LLW input.

The manufacture of fuel and targets for the MHTGR technology would generate a liquid sodium chloride waste contaminated with small amounts of radioactive materials. According to the Washington Department of Ecology, this LLW stream would require a disposal protocol different from that suitable for other LLW at the site. The 19,000 m³/yr of LLW that would be generated by MHTGR operations and regulated by the Washington Department of Ecology would be analyzed and sent to newly constructed on-site vaults dedicated to storing this sodium-chloride/uranium waste. The capacity of the vaults would be sufficient to contain the waste generated during 40 years of NPR operations.

Mixed Waste and Hazardous Waste

The proposed HWR technology would generate the largest volume of unprocessed mixed waste (i.e., 870 m³/yr in both the tritium and plutonium production modes) that would be treated at the planned Waste Receiving and Processing Facility. The mixed waste input from the HWR technology would represent approximately 160% of the currently planned capacity and 340% of available capacity of the Waste Receiving and Processing Facility. The LWR technology would represent approximately 140% of planned capacity and 300% of available capacity. Approximately 43% of planned capacity and 92% of available capacity would be required by the MHTGR technology.

The final design of this facility is not complete. If the NPR and its support facilities were to be built at Hanford, the effective processing capacity of the Waste Receiving and Processing Facility would have to be at least doubled to allow for the additional loading of mixed waste generated by NPR operations. The environmental impact of such facility expansion will be discussed as part of the programmatic environmental restoration and waste management EIS that is currently being prepared.

The 880 m³/yr of HWR-generated unprocessed mixed waste would be the largest mixed waste input from NPR activities and could be three times the total non-NPR Hanford mixed waste input to the Radioactive Mixed Waste Storage Facility. The planned on-site storage capacity (to be operational in 1994) would be 12,000 m³ of mixed waste. Given the current mixed waste inventory (1,800 m³ in 1988) and the annual baseline input of mixed waste at Hanford (Table 4.1.10-1), the total available storage capacity would be 6,200 m³ in 2000. The input of NPR and baseline mixed waste after 2000 would overload the storage capacity of the unit after approximately 5 years of NPR operation. The years of operation after 2000 are approximately 6 years for the LWR and 4 years for the MHTGR technologies. If the disposal of mixed waste, which is based on as-yet-undeveloped technology and unspecified regulatory requirements, has not begun by 2005 for the HWR, 2006 for the LWR, and 2004 for the MHTGR

technologies, additional storage capacity would be required to accommodate the mixed waste generated by NPR and non-NPR operations. The environmental impact of such facility expansion will be discussed as part of the programmatic environmental restoration and waste management EIS that is currently being prepared. According to Hanford waste management guidelines, the Waste Receiving and Processing Facility would be designed and permitted to comply with hazardous waste and radioactive waste regulations affecting the storage of mixed waste. The waste would be stored until disposal capacity would become available.

Hazardous waste from each of the alternative technologies would result in an increased input to the Hanford Nonradioactive Dangerous Waste Storage Facility. The increased input due to the NPR would be accommodated by increasing the frequency of waste shipments to off-site disposal facilities or by allowing for a larger volume of waste to be transported per shipment. No expansion of the Hanford Nonradioactive Dangerous Waste Storage Facility would be required to handle NPR-related waste.

Other Waste

The other NPR-related wastes (e.g., nonradioactive wastes, nonhazardous solid wastes, settled solids from evaporation ponds, nonradioactive wastewater, and sanitary wastewater) would not overload or adversely affect any Hanford waste management facility designated to accept these waste types. All such wastes would be disposed of in accordance with applicable rules and regulations.

5.2.10.4 Mitigation and Conclusions

The NPR project would be managed in accordance with a waste reduction program that covers the entire project life from conceptual engineering design to decommissioning. The program will define the specific steps in which the contractor plans to minimize all wastes (including hazardous and nonhazardous wastes) generated during construction, operations, and decommissioning. To achieve an effective waste reduction program, primary emphasis will be given to source reduction and, alternatively, recycling to minimize the quantities and toxicities of materials and substances before they enter the waste streams for treatment or disposal. For waste that is generated, waste reduction will include treatment to reduce the volume, toxicity, or mobility of such waste prior to storage or disposal.

The adverse impacts to Hanford waste management facilities resulting from NPR operations are summarized in Table 5.2.10-6. Mitigation of the adverse impacts would require development of additional storage, treatment or disposal capacity. After mitigation, there would be no adverse impacts to site waste management facilities.

The analysis of the environmental impacts associated with expanding waste management facilities would be completed as part of the design of each of the facilities.

TABLE 5.2.10-6 Cumulative Impacts that May Require Additional Waste Management Facilities at Hanford^a

Waste Type/Facility	HWR	LWR	MHTGR	Mitigation
Low-level waste Near-surface grout vaults	About 140,000 m ³ (T) to 270,000 m ³ (P) of disposal capacity needed for grouted waste	About 145,000 m ³ (T) to 290,000 m ³ (P) of disposal capacity needed for grouted waste	About 44,000 m ³ (P) to 140,000 m ³ (T) of disposal capacity needed for grouted waste	Plan for and provide needed disposal capacity
Low-level waste Special disposal vaults	Not required	Not required	About 23,000 m ³ (T) to 760,000 m ³ (P) disposed of on-site in facilities regulated by Washington State	Plan for and provide needed disposal capacity
Mixed waste Waste Receiving and Processing Facility	Expected waste generation rate exceeds facility capacity	Expected waste generation rate exceeds facility capacity	Expected waste generation rate does not exceed facility capacity	Increase total facility capacity; or provide additional on-site storage capacity
Mixed waste On-site permitted disposal facility	About 47,000 m ³ (T or P) of disposal capacity needed for mixed waste	About 44,000 m ³ (T or P) of disposal capacity needed for mixed waste	About 17,000 m ³ (T or P) of disposal capacity needed for mixed waste	Plan for and provide needed disposal capacity

^aT indicates values for NPR operations in 100% tritium production mode between the years 2000 and 2040;

P indicates values for NPR operations in 100% plutonium-239 production mode between the years 2000 and 2040.

5.2.11 Institutional Issues

5.2.11.1 Salmon Escapement and Enhancement

The U.S.-Canadian Pacific Salmon Interception Treaty of 1985 established the Pacific Salmon Commission, which is composed of panels with authorities and responsibilities codified in 16 USC 3631, et seq. Article VII of the treaty authorizes the panels to establish spawning escapement and enhancement programs for certain transboundary rivers, including the Columbia River. To date, no agreements have been reached regarding the Columbia River; however, the treaty states that these issues would be addressed in a manner to avoid interference with present and future Federal, tribal, and state salmon management programs. Therefore, the Columbia River does not have specific regulation or management of salmon stock through the Pacific Salmon Commission pursuant to the U.S.-Canadian Pacific Salmon Interception Treaty.

Construction and operation of an NPR at Hanford would require withdrawal of water from the Columbia River, and the HWR or MHTGR alternative would require construction of water intake and discharge structures in the bed of the river. These activities would be subject to state and Federal review and regulation for the protection of Columbia River salmon stocks. Because construction and operation of NPR facilities would have no adverse impact on migrating

salmon, future programs for salmon escapements and enhancements developed under the U.S.-Canadian Pacific Salmon Interception Treaty would not be affected by an NPR at Hanford.

5.2.11.2 Use of WNP-1 for Nuclear Materials Production

The Hart-Simpson amendment to the Atomic Energy Act of 1954 provides that special nuclear material produced in reactors licensed by the NRC may not be "transferred, reprocessed, used or otherwise made available by any instrumentality of the United States or any other person for nuclear explosive purposes." The WNP-1 facility was designed as a commercial reactor, and the NRC granted a permit to the Washington Public Power Supply System to construct the facility. However, the WNP-1 facility was not completed; it was not subjected to an NRC operating license; and no nuclear materials were ever present or produced by the facility. Thus, conversion of the partially completed WNP-1 facility to an NPR would not be prevented by law. Civilian facilities have not been operated for defense purposes in the United States in the past, and, for the reason stated above, conversion of WNP-1 to use as an NPR would not compromise the national policy that civilian nuclear reactors not be used for defense production purposes.

The Treaty on Nonproliferation of Nuclear Weapons and the corresponding law, the Nuclear Nonproliferation Act of 1978, provide that nonnuclear weapons states (countries) may not receive nuclear materials or technology without a pledge that there will be no diversion of nuclear energy from peaceful uses to nuclear weapons. As a nuclear weapons state, the United States has no such prohibition under either the treaty or law, but the United States does support and promote the concept of nonproliferation. Since WNP-1 was never licensed or operated as a commercial nuclear power reactor, conversion of that facility to an NPR would not be a change in use. Conversion would not have significant implications for international acceptance of nuclear weapons safeguards or for the U.S. nonproliferation policy (Fox 1987).

5.2.12 Decontamination and Decommissioning

Decontamination and decommissioning (D&D) activities are carried out at the end of a nuclear facility's life to permit the facility to be removed safely from service and to enable the property to be used for other purposes. D&D activities can range from performing a simple radiological survey to confirm that contamination of a facility is within acceptable limits to completely dismantling and removing a contaminated facility. An analysis of D&D impacts is included in the EIS to demonstrate whether D&D of the alternative NPRs is reasonably achievable and to determine if there are any major differences in the D&D of the alternative reactor technologies at any of the alternative sites. The methodology and details of the D&D analysis are presented below and in Appendix O.

5.2.12.1 Impacts of No Action

If it were decided not to site, construct, and operate an NPR at Hanford, no additional D&D requirements would arise. Existing facilities proposed for NPR use (Figures 3.4.3-1, 3.4.4-1, and 3.4.5-1), such as the Fuels and Materials Examination Facility, would become available for D&D within the original time frame. At the present time, the Fuels and Materials Examination Facility has not been used for processes involving nuclear materials.

5.2.12.2 Impacts of Decontamination and Decommissioning

Three broadly defined D&D options for the NPR would be considered (Appendix O, Section O.2):

- *DECON* -- decontamination (removal of radioactive materials so that levels of radioactivity would be within acceptable limits),
- *SAFSTOR* -- storage for as long as 60 to 100 years, followed by decontamination, and
- *ENTOMB* -- encasement or entombment of the radioactive facilities in a long-lived material such as concrete to allow the radioactive material to decay to safe levels.

The objective of D&D is to reduce contamination of facilities to "acceptable levels of radioactivity" so that facilities can be released for "unrestricted use." Levels of radioactivity remaining at a facility would be low enough that the facility and its surroundings could be used by the general public without any radiologically related restrictions on the type of use or duration of occupancy.

The EIS analysis evaluates the following D&D options recommended by NRC for commercial facilities: DECON for all nonreactor support facilities and SAFSTOR for reactor facilities. An analysis and comparison of various D&D options are presented in the NRC final generic decommissioning document (NRC-3).

Three D&D impacts to NPR facilities are analyzed: dose to workers, volume of waste generated, and cost. For each reactor technology, three cases are analyzed: (1) D&D of the reactor and its support facilities for the tritium production mode, (2) case 1 plus the support facilities for spent fuel processing, and (3) case 2 plus the support facilities for the plutonium production mode. More than one process might be used within a facility. Therefore, for some reactor technologies, producing both tritium and plutonium would not increase the number of facilities or their volumes for D&D. The methodology used to estimate D&D costs, doses to workers, and volume of waste generated is described briefly in Section 5.1.11 and in greater detail in Section O.3.

The impacts associated with the decontamination and decommissioning of the NPR and its support facilities would be reevaluated twice during the life of the NPR. The first evaluation would occur during the detailed design phase, when a D&D plan would be prepared. The design-phase D&D plan would address regulatory compliance, decommissioning options, controls and limits on procedures and equipment to protect occupational and public health and safety, a final radiation survey, quality assurance, safeguards, mitigation of environmental impacts, volumes of radioactive and other hazardous wastes generated, disposal sites, occupational and public radiation exposure, costs, and schedule. The plan would specifically address the disposal of low-level waste (LLW), high-level waste (HLW), and transuranic (TRU) waste; hazardous waste storage requirements; and compliance with RCRA and CERCLA. The plan would include the transportation impacts for off-site waste disposal.

Near the end of the useful life of NPR, a final D&D plan would be prepared. The final plan would present the D&D procedures, using then-current technology and addressing any

waste disposal requirements and regulations. The final plan would also address, compare, and update all the issues discussed in the design-phase plan. The final D&D plan would be subject to NEPA review.

All D&D activities would be regulated by DOE orders limiting the exposure to the general public. The exposures to the general public from airborne radioactive contaminants are expected to be less than the exposures from normal operations (Sections 5.2.6, 5.3.6, and 5.4.6). Table 5.2.12-1 presents an evaluation of the D&D impacts of the NPR and its support facilities at Hanford. The occupational doses from D&D at Hanford would range from 610 to 940 person-rem for the tritium production mode, and from 2,000 to 2,400 person-rem for the combined tritium and plutonium production mode with spent fuel processing. The occupational doses represent between 0.02 and 0.9 cancer fatalities to D&D workers and can be compared with the normal operating dose of 100 to 700 person-rem/yr during the 5 to 6 years of D&D activities. Radioactive exposures to any individual performing D&D would also be limited by DOE orders regulating occupational exposures in effect at the time of D&D. Currently, DOE Order 5480.11, Radiation Protection for Occupational Workers, limits occupational exposure to 5 rem/yr from existing facilities and to 100 mrem/yr from operations in new facilities.

The total radioactive waste volume generated by D&D at Hanford would range from 26,000 to 38,000 m³ for the tritium production mode, and from 51,000 to 64,000 m³ for the combined tritium and plutonium production mode with spent fuel processing. For the tritium production mode, about 4,200 m³ of the waste would be HLW or TRU waste; 17,000 m³ of HLW and TRU waste would result from the combined tritium and plutonium production mode with spent fuel processing. From this analysis, the HLW or TRU waste would represent between 11% and 16% of the total radioactive D&D waste for the tritium production mode, and between 27% and 33% for the combined tritium and plutonium production mode with spent fuel processing. The HLW would be shipped off-site to a Federal repository; TRU waste would be shipped to the Waste Isolation Pilot Plant or another appropriate facility. The HLW and TRU disposal sites will comply with all applicable Federal, state, and local regulations in effect at the time of disposal. The requirements for HLW and TRU disposal would be assessed in the initial and final D&D plans. Impacts of shipping the HLW and TRU D&D wastes would be similar to the impacts of transporting operational wastes (Section 5.2.6). The low-level waste (LLW) generated by NPR D&D would be buried on-site (22,000 to 47,000 m³ during a 6-yr period). On an average annual basis, low-level waste volumes generated by D&D would be less than (and not materially different from) annual waste volumes generated by operation of an NPR and by other sitewide activities.

As indicated in Table 5.2.12-1, the D&D costs for the three reactor technologies in the tritium production mode would vary from \$210 million to \$320 million. The D&D costs for operating in the combined tritium and plutonium production mode with spent fuel processing would vary from \$700 million to \$830 million. In all three tritium and plutonium production options, the HWR technology would have the lowest D&D costs, although the difference in cost among the reactor technologies would not be significant. The D&D costs represent about 15% of the capital cost, except for the LWR where the D&D costs represent about 50% of the capital cost. Because the LWR option at Hanford is partly constructed, the capital costs for this technology are relatively low compared with other technologies.

TABLE 5.2.12-1 D&D Impacts at Hanford for HWR, LWR, and MHTGR Technologies

D&D Impact	HWR	LWR	MHTGR
Facility volume (m ³)			
Tritium production only	350,000	620,000	700,000
Tritium production with spent fuel processing	760,000	1 × 10 ⁶	1.1 × 10 ⁶
Tritium and plutonium production with spent fuel processing	790,000	1 × 10 ⁶	1.2 × 10 ⁶
Cost (millions of 1989 dollars)			
Tritium production only	210	310	320
Tritium production with spent fuel processing	700	800	830
Tritium and plutonium production with spent fuel processing	700	800	830
Occupational dose (person-rem)			
Tritium production only	610	900	940
Tritium production with spent fuel processing	2,000	2,300	2,400
Tritium and plutonium production with spent fuel processing	2,000	2,300	2,400
Waste volume (m ³)			
Tritium production only	26,000	31,000	38,000
Tritium production with spent fuel processing	47,000	51,000	59,000
Tritium and plutonium production with spent fuel processing	53,000	51,000	64,000

5.2.12.3 Mitigation and Conclusions

The first action to mitigate the impacts of D&D is required by DOE Order 5820.2A, *Radioactive Waste Management* and DOE Order 6430.1A, *General Design Criteria*. These orders require that DOE facility designs minimize the impacts of D&D. These design features are presented in Table O.1.

This analysis shows that the HWR technology would have the lowest impact, but would not be significantly (about 50%) lower than the LWR or MHTGR impact for either the tritium production mode or the combined tritium and plutonium production mode with spent fuel processing. For the tritium and plutonium production mode with spent fuel processing, the D&D cost and occupational dose impacts and their associated health effects would be triple those for the tritium production mode only, and the waste volumes would be double.

The NPR project would be managed in accordance with a waste reduction program that covers the entire project life from conceptual engineering design to decommissioning. The program will define the specific steps in which the contractor plans to minimize all wastes (including hazardous and nonhazardous wastes) generated during construction, operations, and decommissioning. To achieve an effective waste reduction program, primary emphasis will be given to source reduction and, alternatively, recycling to minimize the quantities and toxicities of materials and substances before they enter the waste streams for treatment or disposal. For waste that is generated, waste reduction will include treatment to reduce the volume, toxicity, or mobility of such waste prior to storage or disposal.

The impacts would be different if other D&D options were selected. For example, if SAFSTOR for 100 years were selected for D&D of spent fuel processing, the estimated D&D cost would increase from \$1,200 to \$2,000/m³ of facility volume. The resultant D&D costs would increase about 60%. However, the corresponding occupational doses and their associated health effects and waste volumes would decrease. The option used for the reactor facilities in this analysis -- SAFSTOR for 30 years -- results in higher D&D costs, higher occupational doses and their associated health effects, and higher waste volumes than the 60-yr SAFSTOR option recommended by NRC.

As discussed in Section O.5, the decontamination activities at Hanford would occur in two distinct time frames: DECON, from 1 year before reactor shutdown to 5 years after reactor shutdown; and SAFSTOR, from 30 to 36 years after reactor shutdown. The three alternative technologies would show no significant differences in schedules because the controlling effect is the time projected for SAFSTOR of the reactors, which is assumed to be 30 years for this analysis.

5.3 IDAHO NATIONAL ENGINEERING LABORATORY

5.3.1 Air Resources and Noise

The potential environmental impacts associated with constructing and operating an NPR and its support facilities at INEL that relate to air pollutants, cooling towers, and noise are described in this section. The air quality impact assessments are based on analyses conducted by EG&G Idaho, Inc. (EG&G-9), unless otherwise noted. The assessments of cooling tower and noise impacts are based on analyses performed by Argonne National Laboratory (Chun and Coke 1991; Chun and Rabchuk 1991).

5.3.1.1 Air Quality

This section describes the potential air quality (nonradiological) impacts of constructing and operating the NPR and its support facilities at INEL, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts. Radiological air quality impacts are discussed in Section 5.3.6.

Impacts of No Action

Under the no-action alternative, the NPR and its support facilities would not be constructed, and the air pollutant emissions that would be associated with NPR construction and operation would not occur. In addition, no major changes in existing emission levels are expected at INEL during the projected NPR construction period. Therefore, the ambient air quality at INEL would be expected to remain essentially the same for the no-action alternative as for the baseline period.

Impacts of NPR Construction and Operation

The results of a detailed analysis of potential air quality impacts from constructing and operating an NPR and support facilities at INEL (EG&G-9) are summarized in Appendix E, Section E.2.1.2 for the three reactor technologies. The results indicate that the ambient concentrations of sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), and PM₁₀* would remain below applicable national and state ambient air quality standards during both the NPR construction and operation periods (Table E.25). Although short-term (24-hour) ambient total suspended particulate (TSP) concentrations are expected to be in compliance with the state's ambient standards during the NPR operation period, the TSP concentrations are expected occasionally to exceed the state's 24-hour ambient TSP standard during the peak construction period (Table E.25). These occurrences would be during very dry and windy conditions. The increments of the criteria pollutant concentrations attributable to emissions from new operational sources would all be less than applicable maximum allowable Prevention of Significant Deterioration (PSD) increments (Table E.25).

*PM₁₀ is particulate matter with a diameter ≤10 μm.

The stack effluents from process operations of the NPR support facilities containing nitrogen oxide (NO_x) would not cause visibility impairment at the Craters of the Moon National Monument and Wilderness Area (Class I visual area) located about 48 km west-southwest of the proposed NPR site (Appendix E).

The analysis also shows that the estimated ambient concentrations of ammonia (NH_3), nitric acid (HNO_3), and trichloroethylene (TCE) would remain well below the proposed state ambient concentration limits for these toxic pollutants (to be used by the State of Idaho) as one of the criteria in evaluating construction permit applications for new emission sources) during the NPR operation period (Table E.26).

Mitigation and Conclusions

The only significant air quality impact anticipated from construction and operation of the NPR and its support facilities at INEL will be short-term (24-hour) ambient TSP concentrations exceeding the state's ambient air quality standard (AAQS) during the peak construction period. Fugitive dust emissions from construction areas (e.g., during site preparation and excavation) and from unpaved roads would be reduced by periodic spraying of water. The frequency of spraying would be increased as necessary during extremely dry and windy conditions.

All new emission sources of criteria pollutants would comply with applicable new source performance standards. The new emission sources with pollutant emission rates that exceed the PSD significant emission rate (Table E.19) would be equipped with "best available control technology." "Maximum available control technology" would be applied to the NPR toxic air pollutant emission sources, if required by the Clean Air Act Amendments of 1990.

With the mitigation measures described above, no significant air quality impacts are expected at INEL from constructing or operating an NPR and its support facilities.

5.3.1.2 Cooling Towers

This section describes the potential environmental impacts of operating circular, mechanical-draft, wet cooling towers for the three NPR technologies at INEL, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts.

Impacts of No Action

Under the no-action alternative, the NPR and the cooling towers for NPR facilities would not be constructed, and the potential environmental impacts from construction and operation of the cooling towers would not occur.

Impacts of Cooling Tower Operation

The results of a detailed analysis of potential environmental impacts of operating mechanical-draft cooling towers for the three NPR technologies at INEL (Chun and Coke 1991)

are summarized in Section E.2.2.2. The analysis indicates that under the conditions modeled, operation of mechanical-draft cooling towers would not cause ground fogging or rime icing (Chun and Coke 1991). However, under the rare condition of high wind speed, which might cause tower structure downwash effects, and high relative humidity, such phenomena could possibly occur within a few hundred meters of the cooling towers. Formation of glaze ice on surfaces, including facility roads, within a few hundred meters of the cooling towers could occur as a result of freezing of deposited drift droplets during an extended period when the ground is freezing. However, no impacts are anticipated from ground fogging, rime icing, or glaze icing at the public highways that traverse the INEL site (i.e., US 20, 26, and 26/20). At their closest points, these highways are about 8 km south to southwest of the proposed NPR site.

The potential impacts on visual resources due to visible plumes and on terrestrial vegetation due to salt deposition are discussed in Sections 5.3.3 and 5.3.4, respectively.

Mitigation and Conclusions

The potential environmental impacts of operating the mechanical-draft, wet cooling towers at INEL for the three NPR technologies are described in the previous section.

Any hazards to the safety of workers due to potential, but infrequent, buildup of glaze ice on facility roads in the immediate vicinity of the cooling towers would be mitigated by applying deicing materials, such as salt, as needed.

The potential impacts of salt deposition on terrestrial vegetation would be mitigated by minimizing emission of salt-containing drift from the cooling towers through regular maintenance of the tower's mist eliminators. A modern mist eliminator system could reduce the drift emission rate to less than one-half the design rate for the NPR cooling towers (0.02% of the circulating water flow rate). With the reduced drift emissions, any potential for glaze ice buildup and salt deposition would be substantially reduced.

As a mitigation alternative to reduce the potential environmental impacts of constructing and operating the secondary cooling system at INEL, including wet cooling towers and a large evaporation pond, dry cooling towers are proposed for the MHTGR technology. Water vapor and drift droplets would not be emitted from dry cooling towers, and, therefore, no environmental impacts associated with such emissions would occur. However, visible clouds could form at high altitudes under certain meteorological conditions when the warm buoyant parcel of air rising from the dry towers was cooled under the lower ambient temperatures at high altitudes. The appearance of such clouds would not be significantly different from that of naturally occurring clouds.

With the mitigation measures described above, any environmental impacts due to salt deposition and visual plumes from the mechanical-draft cooling towers for the three NPR technologies at INEL would be substantially reduced (Sections 5.3.3 and 5.3.4). No significant environmental impacts are expected from operating dry cooling towers for the MHTGR technology at INEL.

5.3.1.3 Noise

This section describes the potential noise impacts from constructing and operating the NPR and its support facilities at INEL, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts.

Impacts of No Action

Under the no-action alternative, the NPR and its support facilities would not be constructed, and the noise associated with NPR construction and operation would not occur. Because no major changes in existing noise-emitting sources are expected at INEL during the projected NPR construction period, the ambient noise levels at INEL would be expected to remain essentially the same for the no-action alternative as during the baseline period.

Impacts of NPR Construction and Operation

The results of a detailed analysis of the potential noise impacts from constructing and operating the NPR and its support facilities at INEL (Chun and Rabchuk 1991) are summarized in Section E.2.3.2. The analysis shows that noise emissions from NPR construction equipment and machines and from operational facilities, equipment, and machines, would not cause ambient noise levels to exceed the EPA guidelines set to protect the public from the effect of broadband environmental noise and to protect the public against hearing loss (Tables E.42 and E.43). The increased noise levels from construction and operational activities for the NPR and its support facilities, including increased traffic along the major roadway, would cause little or no increase in the annoyance level experienced by communities or individuals (Tables E.42-E.44). The blasting of basalt for excavation at the NPR construction site is not expected to cause any significant ground vibration or air blast overpressure (noise) impacts at the nearby INEL facilities (see Appendix E, Section E.2.3.2).

Mitigation and Conclusions

No significant noise impacts from activities associated with NPR construction and operation are expected at sensitive receptor locations outside the INEL boundary or at residences along the major highways leading to the proposed NPR site at INEL.

Construction workers and other personnel working in noisy environments during NPR construction or operation would be provided with earmuffs or earplugs approved by the Occupational Safety and Health Administration. In areas where workers would be exposed to equipment noise so severe that hearing loss could occur, noise levels will be monitored, according to DOE Order 5480.4, to assure conformance with the threshold limit values (Tables E.50 and E.51) established by the American Conference of Governmental Industrial Hygienists (ACGIH 1990).

5.3.2 Water Resources

This section evaluates potential impacts to surface water and groundwater resources for the no-action alternative and for construction, normal operation, and accident conditions of an NPR (HWR, LWR, or MHTGR) and associated support facilities at INEL. The significance of these impacts is assessed, and mitigative measures that would be implemented are identified and discussed. Potential impacts of sanitary and nonradioactive, nonhazardous wastes on water quality are assessed. Potential impacts of radioactive, hazardous, and mixed wastes are assessed in Section 5.3.10.

5.3.2.1 Impacts of No Action

The no-action alternative consists of continuing current INEL operations through the year 2040 without the construction and operation of an NPR. The current conditions of no surface water withdrawals and no discharges of wastewater directly to natural surface waters at INEL would continue, and surface waters would remain as described in Section 4.2.3.

Under the no-action alternative, groundwater withdrawals are expected to remain the same as current withdrawals; however, wastewater discharges from existing INEL facilities have decreased in recent years and may decrease further as a result of continued efforts to reduce waste generation and improve waste treatment. Since the effects of these efforts, which depend partially on future technology development, are uncertain, it is assumed that the characteristics (including effluent quantity and quality) of the waste streams would remain the same under the no-action alternative as in the recent past.

Currently, wastewater is discharged to unlined disposal ponds at the Test Reactor Area and the Idaho Chemical Processing Plant. Water in these ponds either evaporates or infiltrates into the ground, eventually reaching the Snake River Plain aquifer. Before operation of NPR support facilities in these areas (but independent of the NPR project), the ponds will be lined to prevent infiltration of the wastes into the underlying ground. Lining of the disposal ponds will cause groundwater levels beneath the disposal areas to drop in response to the cessation of artificial recharge from the ponds. Also, the water quality of the Snake River Plain aquifer affected by INEL operations is expected to improve in response to reductions in waste seepage.

Existing radioactive and chemical contaminant plumes in the groundwater will continue to migrate southwestward, and the concentrations of the contaminants will continue to decrease with time due to the combined effect of source reduction, decay, and sorption. The future migration of tritium under current conditions was modeled by Arnett, Martineau, and Lehto (1990a). Their results indicate that between 1985 and 1988, the tritium plume was in a transition from an advancing to a receding plume. This transitional phase was confirmed by field measurements in 1985 and 1988 (Arnett, Martineau, and Lehto 1990a). Modeling results indicate the tritium plume should continue to recede. Areas of the plume where concentrations of tritium would be above the state of Idaho drinking water maximum contaminant level (MCL) of 20,000 pCi/L are predicted to stay well within the INEL boundaries.

5.3.2.2 Impacts of NPR Construction and Operation

Surface Water

Although no surface water withdrawals or planned discharges would occur during NPR construction or operation, construction of an NPR would disturb significant areas of the land surface, creating the potential for erosion and runoff. Construction of large cooling water evaporation ponds, assuming heated ponds, required for NPR operations would encompass up to approximately 820 ha, 860 ha, and 680 ha for the HWR, LWR, and MHTGR technologies, respectively (Table F.27 in Appendix F). Additional land would be disturbed for construction of the reactor and support facilities (approximately 740 ha, 270 ha, and 530 ha for the HWR, LWR, and MHTGR technologies, respectively) (Roman 1991).

Surface Water Flows. Since no surface water would be withdrawn and no effluents directly discharged to surface water bodies during construction and operation of an NPR and its support facilities, flows in natural surface water bodies would not be impacted.

Surface Water Quality. The disturbance of surface soils during construction might result in soil erosion by surface water runoff. However, soil erosion should be minimal because of sparse rainfall, thin soils, and presence of basalt at shallow depth.

Since no wastewater would be discharged to surface waters during operation of an NPR and support facilities, there would be no impacts to surface water quality from these types of activities. Runoff from building roofs and parking lots might carry some contaminants into the intermittent surface water stream channels. These contaminants are expected to be primarily oil and grease. Runoff from these areas will be monitored and, if necessary, treated to meet all applicable Federal, State and local requirements.

Floodplain. As described in Section 4.2.3.1, the NPR site is located about 17 m above the peak flood level produced by the probable maximum flood combined with a hypothetical failure of MacKay Dam (Figure F.2). Therefore, construction and operation of an NPR and most support facilities at INEL are not expected to affect the floodplain area at INEL. Some NPR support facilities at the Idaho Chemical Processing Plant would be located in the floodplain as defined above. Floodplain studies will be performed during the facility design stage to assess potential floodplain impacts.

Surface Water Use. Since no surface water would be withdrawn during construction and operation of an NPR and support facilities, the amount of surface water available from any of the natural surface water bodies would not be affected.

Surface Water Rights. Surface water rights would not be affected by the NPR project.

Groundwater

Construction and normal operations of an NPR and support facilities would require groundwater withdrawals from the Snake River Plain aquifer, and during operation, sanitary wastewater would be disposed of in a leach field.

The resulting potential impacts to groundwater levels, water quality, water use, and water rights are assessed for the three reactor technologies. Mitigation of adverse effects is also described.

Groundwater Levels. Construction of an NPR and support facilities at INEL would require water withdrawals from the Snake River Plain aquifer. Water would be withdrawn from wells located within the proposed NPR site. The water requirements for construction of the three alternative reactor technologies are given in Table F.28. Construction of an HWR and support facilities would require approximately $0.011 \text{ m}^3/\text{s}$ ($360,000 \text{ m}^3/\text{yr}$) for a period of 10 years; an LWR and support facilities would require approximately $0.0092 \text{ m}^3/\text{s}$ ($290,000 \text{ m}^3/\text{yr}$) of water for 11 years. A lesser amount of water, $0.0027 \text{ m}^3/\text{s}$ ($84,000 \text{ m}^3/\text{yr}$), would be required for construction of an MHTGR and support facilities for 11 years (Arnett, Martineau, and Lehto 1990b).

Impacts to the Snake River Plain aquifer due to this withdrawal of construction water were quantified by Arnett, Martineau, and Lehto (1990b). For a single continuously pumping well at the rate required for constructing an HWR ($0.011 \text{ m}^3/\text{s}$), drawdowns in the unconfined aquifer would be on the order of 1 m near the well. Near the INEL boundary, drawdowns for this withdrawal rate would not be measurable. Uncertainties in the calculation are mainly associated with the aquifer's hydraulic conductivity, storativity, and thickness. Because the Snake River Plain aquifer is highly conductive, has a high storativity, and is thick, the associated uncertainties would be small, less than 0.1 m. Water level drawdown due to pumping of construction water for an LWR or MHTGR would be less because of the smaller water withdrawals required -- $0.0092 \text{ m}^3/\text{s}$ and $0.0027 \text{ m}^3/\text{s}$, respectively.

Operation of an NPR and support facilities would require withdrawal of water from the Snake River Plain aquifer for secondary cooling system makeup, support facilities, sanitary water, and potable water. Water would be obtained from wells within the proposed NPR site. Potential maximum water requirements for the operation of the three reactor technologies are given in Table F.29. Operation of an LWR and support facilities would require the most water, $1.43 \text{ m}^3/\text{s}$ (45 million m^3/s) for the tritium mode and $1.46 \text{ m}^3/\text{s}$ (46 million m^3/yr) for the plutonium mode. Operation of an HWR and support facilities would require about $1.40\text{-}1.43 \text{ m}^3/\text{s}$ (44-45 million m^3/yr), depending on the production mode. Operation of an MHTGR would require the least amount of water -- about $1.11 \text{ m}^3/\text{s}$ (35 million m^3/yr) for the tritium mode and $1.27 \text{ m}^3/\text{s}$ (40 million m^3/yr) for the plutonium mode.

The potential effect of groundwater pumping required for normal operation of an LWR at INEL have been calculated by Arnett, Martineau, and Lehto (1990b) for periods of low precipitation (no recharge to the aquifer from infiltration from the Big Lost River or the spreading area) using a steady-state model. Potentiometric heads near the pumping area would be significantly lowered, and the water table elevation would decrease by up to 7 m. In the pumping area, this drop in head would be slightly less than 10% of the thickness of the most transmissive portion of the aquifer. At a distance of 300 m from the pumping area, drawdowns

would be approximately 6.5 m. At the INEL boundary, drawdown due to LWR withdrawal would be approximately 1 m, or about 1% of the aquifer's high-permeability thickness. Recharge studies by Barraclough (1984) indicate that about 10 years would be required for any effects of pumping to reach off-site springs near Hagerman, Idaho (Figure F.3). Calculations indicate that pumping at a rate of 1.40 m³/s (44 million m³/yr) (approximately 96% of the LWR water requirement) for 50 years would cause a decline in the water table near the springs (Figure F.3) of less than 0.1 m, assuming no induced seepage from the Snake River.

While the drawdowns created by water withdrawal for LWR operation would be measurable at the INEL site boundary, the significance of the drawdown would be small due to the thickness of the Snake River Plain aquifer and the amount of recoverable water in the flow systems. At more distant locations (e.g., off-site springs near Hagerman) drawdown impacts would be insignificant and less than the seasonal variations in local water levels. Because of lower required rates of withdrawal for the HWR and MHTGR technologies, the potential impacts to the Snake River Plain aquifer would be correspondingly less. Of the three technologies, the MHTGR would produce the least impacts because of its smallest water requirements.

During operation of an NPR, sanitary wastewater and potentially some water from the demineralizer system would be disposed of in a leach field. This disposal during operation of any of the reactor technologies would have no measurable effect on groundwater levels at the INEL site boundary. This is due to the combined effects of distance (approximately 16 km in the direction of groundwater flow), low associated discharge volumes, and high evaporation rates at the INEL site.

Groundwater Quality. The only liquid waste that would have a potential to reach the Snake River Plain aquifer under normal operating conditions would be the sanitary wastewater disposed to the leach field. Water withdrawn for reactor cooling would be passed through mechanical draft cooling towers (three towers for the LWR or HWR and two towers for the MHTGR) operating at five cycles of concentration. During this process, chemicals present in the cooling water or added during water treatment would be concentrated, and tritium would diffuse across cooling system barriers into the cooling water. The cooling water evaporation ponds would be capable of containing the annual volume of cooling tower blowdown and small amounts of other liquid waste streams at a depth equal to the estimated annual evaporation depth at INEL (approximately 0.86 m). The ponds would be lined to inhibit the release of radionuclides to the groundwater. The sludge from the evaporation ponds and all other wastes, including radioactive and hazardous wastes, would be managed at appropriate waste management facilities. Wastewater disposed at the leach field during operation of any reactor technology is not expected to have a measurable effect on groundwater quality at INEL because of the combined effects of the great depth to the water table, low discharge volumes, high evaporation rates at the INEL site, and a composition and concentration consistent with treated sanitary wastewater.

A limited increase in activity at the Idaho Chemical Processing Plant attributable to NPR operations would correspondingly increase the plant's wastewater discharge. This would not result in additional contamination of the groundwater, since the wastewater ponds would be lined.

The potential effects of groundwater pumping on the migration of the existing contaminant plumes at INEL were studied by Arnett, Martineau, and Lehto (1990b). The

direction of groundwater flow near the Test Reactor Area and Idaho Chemical Processing Plant would be somewhat changed, shifting the tritium plume to the east. The study predicts that the plume would not be drawn into the NPR pumping area.

Groundwater Use. The total demands for raw water for construction of HWR, LWR, and MHTGR technologies are estimated to be 0.011 m³/s, 0.0092 m³/s, and 0.0027 m³/s (360,000 m³/yr, 290,000 m³/yr, and 84,000 m³/yr), respectively (Table F.28). Compared with the pumpage from all other INEL facilities (0.25 m³/s) (Pittman, Jensen, and Fischer 1988), the amount of pumpage from construction of an NPR at INEL is insignificant (less than 5% of total for the HWR technology). The amount of pumpage for NPR construction (HWR technology) at INEL would be less than 0.02% of the total pumpage from the Snake River Plain aquifer (63 m³/s) (EG&G-1).

The potential maximum demand for raw water for operation of the HWR, LWR, and MHTGR technologies in the tritium production mode are estimated to be 1.40, 1.43, and 1.11 m³/s (44 million, 45 million, and 35 million m³/yr), respectively (Table F.29). Compared with current estimated pumpage by all INEL facilities (0.25 m³/s), the amount of pumpage for NPR operation would be significant (for the HWR, LWR, and MHTGR technologies, approximately 5.6, 5.7, and 4.4 times the current withdrawals, respectively). Combined with current INEL pumpage, the total withdrawals would be 1.65 m³/s with an HWR, 1.68 m³/s with an LWR, and 1.36 m³/s with an MHTGR. Total INEL withdrawals with the operation of the HWR, LWR, and MHTGR are estimated to be 2.6%, 2.7%, and 2.2%, respectively, of the total amount of water withdrawn from the Snake River Plain aquifer (63 m³/s) (EG&G-1).

In the plutonium production mode, the potential maximum groundwater demand for operating the HWR, LWR, and MHTGR would be about 1.43, 1.46, and 1.27 m³/s (45 million, 46 million, and 40 million m³/yr), respectively (Table F.29). Combined with current INEL pumpage, the total withdrawals would be about 1.68, 1.71, and 1.52 m³/s (53 million, 54 million, and 48 million m³/yr) with HWR, LWR, and MHTGR, respectively.

Groundwater Rights. As described in Section 4.2.3.2, DOE-Idaho has negotiated with the Idaho Department of Water Resources regarding a claimed water right for 2.3 m³/s (not to exceed 43 million m³/yr) withdrawal capacity under the Federal Reserve Doctrine. Total INEL withdrawals during the construction of the NPR are estimated to be about 19% of the total amount of water allocated to INEL (43 million m³/yr) (DOE-56).

Total INEL withdrawals with the operation of the HWR, LWR, and MHTGR technologies with wet cooling towers in the tritium production mode are estimated to be 121%, 123%, and 100%, respectively, of the total amount of water allocated to INEL. The Interlocutory Order would need to be renegotiated for the HWR and LWR alternatives. In the plutonium production mode, total INEL withdrawals with the operation of the HWR, LWR, and MHTGR with wet cooling towers would be about 123%, 126%, and 112%, respectively, of the total allocated to INEL. The Interlocutory Order would need to be renegotiated for all three reactor alternatives. As a result of informal discussions with the State of Idaho, DOE anticipates that the needed increase in water rights would be granted from water right reserves available to the state to support industrial and commercial development. Any need to renegotiate the Interlocutory Order would be eliminated by adoption of dry cooling towers for the LWR or MHTGR.

5.3.2.3 Impacts of Hydrologic Accidents

Potential impacts on water resources are evaluated for accident scenarios for all three reactor technologies at INEL. An accident that severely damages the lining of the evaporation ponds could, in a relatively short time, release a large amount of wastewater into the subsurface and eventually the aquifer (Arnett, Martineau, and Lehto 1990b). No other accident scenarios are considered as significant to water resources as the failure of the evaporation pond liner (Tomasko and Tilbrook 1990).

Detailed design of the evaporation pond system has not been completed. For purposes of evaluating the potential hydrologic impacts, the system is assumed to consist of a series of eight interconnected ponds located in the northwest portion of the NPR site. It is assumed that the ponds would be designed so that wastewater would overflow from one pond to the next. The main differences between the reactor technologies for the accident scenarios are the size of the evaporation ponds and the concentration of tritium in the ponds. The pond sizes are determined by the blowdown rates. Annual blowdown rates and estimated pond surface areas required for the three technologies are presented in Table F.27. With a planned detritiation system removing 90% of the tritium from the blowdown discharges, the annual amounts of tritium discharged to evaporation ponds would be 210 Ci for the HWR, 640 Ci for the LWR, and 95 Ci for the MHTGR (Arnett, Martineau, and Lehto 1990b). The estimated concentrations of contaminants in the blowdown released to the evaporation ponds are shown in Table P.4 in Appendix P.

Two limiting-case accident scenarios were evaluated for the LWR evaporation pond by Arnett, Martineau, and Lehto (1990b): (1) a small hole failure (0.09 m²) in the liner and (2) failure of the entire liner. For the small hole scenario, a slow, continuous release of tritium was assumed. For the complete liner failure scenario, the pond furthest downstream was assumed to fail, quickly releasing the contents of the entire pond complex to the Snake River Plain aquifer. For both cases, the addition of makeup water to the ponds was ignored. In addition, for the small hole case, the infiltration rate was assumed to be equal to the saturated hydraulic conductivity of the least permeable layer in the unsaturated zone below the ponds (Tomasko and Tilbrook 1990).

The impacts of the small leak accident scenario would be negligible in terms of groundwater mounding (Arnett, Martineau, and Lehto 1990b). The rate of aquifer recharge due to this accident would be four orders of magnitude smaller than the withdrawal rates required for construction of the NPR. Predicted aquifer drawdowns from construction water pumping would be on the order of 1 m at the pumping well. Mounding caused by recharge from the pond leak would not be measurable.

Impacts of the small leak accident on groundwater quality also would be negligible in terms of tritium concentration (Arnett, Martineau, and Lehto 1990b). The tritium released to the aquifer from the pond for the LWR case, which would have the greatest tritium content in the evaporation pond, was estimated to be 0.0013 Ci/yr. The tritium concentration in the plume created by the small leak would decrease to the tritium detection limit of 200 pCi/L within a few hundred meters of the source.

The second accident scenario consisted of a complete failure of the pond liner, releasing the entire content of tritium, with no actions taken to limit the release. After 5 years, tritium concentrations in excess of 20,000 pCi/L (drinking water limit for tritium) would barely extend

beyond the NPR site boundary and would be well within the boundary of INEL (Arnett, Martineau, and Lehto 1990b). By the 24th year after the pond failure, peak concentration in the plume would decline to 6,000 pCi/L, and the plume would have mixed with the existing tritium plume from the Test Reactor Area and the Idaho Chemical Processing Plant. After 40 years, the peak tritium concentration would be less than 2,000 pCi/L. Based on these predicted concentrations, the hypothetical accident scenarios would have insignificant impacts to areas outside of the INEL boundary.

On-site water supply wells that tap the Snake River Plain aquifer could be affected by the liner failure accidents. Failure of a 0.09-m² area of the liner would be expected to produce tritium concentrations less than the tritium detection limit of 200 pCi/L in a water supply well, less than 1% of the drinking water limit (20,000 pCi/L) for tritium. Complete failure of the liner might cause tritium concentrations in water supply wells on the NPR site to exceed the drinking water limit. Alternative water supply sources would be used to mitigate the impact in the event of such an accident.

The consequences of a failure in the cooling water evaporation pond liner would be the greatest for the LWR technology, because this technology results in the largest concentration of tritium into the cooling water evaporation ponds. Consequences for the other technologies would be correspondingly less; the smallest consequences would be associated with the MHTGR.

5.3.2.4 Mitigation and Conclusions

Surface Water

No surface water would be withdrawn and no wastewater would be discharged directly to natural surface water bodies during construction and operation of an NPR at INEL. Therefore, the NPR would have no impact on surface water flow, water quality, water use, and water rights.

Potential erosion and sedimentation during construction of the NPR could be controlled by use of proper erosion control methods. Best management practices for erosion and sedimentation control would be implemented in accordance with applicable state and local requirements. Surface erosion and sedimentation during construction would be lessened by the recommended changes in cooling tower design described in Section 5.3.4. These cooling tower designs would eliminate the need to construct large cooling water evaporation ponds, thus reducing the total area of disturbance.

Groundwater

Potential maximum water requirements for the HWR, LWR, and MHTGR operation in the tritium production mode would be about 5.6, 5.7, and 4.4 times, respectively, the current INEL pumpage from the Snake River Plain aquifer. However, groundwater drawdown at the INEL site boundary (approximately 1 m) due to NPR pumping would be small compared with the total thickness of the aquifer (greater than 76 m). Thus, the impacts of NPR operations on off-site water uses would be insignificant. In the plutonium production mode, the drawdown at the INEL site boundary due to NPR pumping also would be insignificant.

Total INEL withdrawals with the operation of the MHTGR in the tritium production mode would be equal to or less than the total water currently allocated to INEL (43 million m³/yr). However, the HWR and LWR operational water requirements, when added to other INEL water requirements, are estimated to be 121% and 123%, respectively, of the total amount of water currently allocated to INEL. The renegotiation of water rights and allocations to permit either the HWR or LWR technology would be a significant water right issue. In the plutonium production mode, water right would be a significant issue for all three reactor technology alternatives. Water withdrawals could be lessened by operating the cooling towers at a greater concentration factor to reduce the blowdown requirement. Use of dry cooling towers instead of wet cooling towers would essentially eliminate the need for a large volume of makeup water.

Failure of the cooling water evaporation pond liners could cause the release of water contaminated with tritium to the Snake River Plain aquifer. Modeling by Arnett, Martineau, and Lehto (1990b) indicates that this contamination would not migrate beyond the INEL boundary at levels above the Idaho drinking water standard for tritium (20,000 pCi/L). Water supply wells at INEL are periodically monitored for contamination. If failure of the cooling water evaporation pond liner resulted in contamination of an on-site water supply well, appropriate mitigative measures would be taken. These measures might include drilling new water supply wells or supplying bottled drinking water.

The blowdown evaporation ponds could be greatly reduced or eliminated by using dry cooling towers or combining wet cooling towers with forced evaporation in enclosed evaporators.

5.3.3 Land Use, Recreation, and Visual Environment

5.3.3.1 Impacts of No Action

If an NPR were not constructed and operated at INEL, land use patterns, use of recreational resources, and visual resources would remain as described in Section 4.2.4. The INEL would remain a Federal facility dedicated to nuclear research and development and isotope production. Other continuing activities would include fuel processing, ecological research, and livestock grazing.

5.3.3.2 Impacts of NPR Construction and Operation

Construction and operation of any of the three alternative NPR technologies would be consistent with the current and historical uses of INEL for basic research, nuclear materials testing, and nuclear systems development. Grazing areas at INEL would not be affected by NPR construction. The soils at the NPR site do not satisfy criteria for prime or unique farmlands, so no prime or unique soils would be affected. Although construction at the NPR site would disturb native vegetation, the area disturbed would be only a small part of the existing natural environment at INEL, 1,200-1,560 ha of the 230,000 ha. Therefore, the use of INEL as a National Environmental Research Park would not be affected.

Off-site land use would be affected by construction of housing for in-migrating NPR construction workers. Some rangeland or cropland would likely be converted to housing

developments. Such development would be subject to local land use and zoning controls, which vary by jurisdiction.

Potential impacts to area recreation facilities and features from construction and normal operations of any of the three NPR alternatives are not quantifiable. In-migration of workers during the construction period would slightly increase, temporarily, the use of recreational facilities and parks.

Any controversy that arose over development of an NPR at INEL or in the unlikely event of an accident at the reactor or support facilities might result in adverse publicity that would slightly decrease the number of visitors to the INEL area. However, INEL's use for nuclear reactor development; temporary storage of hazardous, mixed, TRU, and high-level waste; and disposal of low-level waste has already been widely publicized. The addition of NPR facilities would not substantially alter this perception. It is expected that incremental impacts to recreation and tourism from adverse publicity or increased population associated with construction and operation of an NPR would not be discernible.

Changes caused by construction and operation of an NPR would be consistent with the existing overall visual environment of INEL. The proposed NPR site is several kilometers from the nearest public access highways (US 20 and US 26) that cross INEL. Because of distance and topography, the NPR facilities would not be directly visible from these highways, except if viewed briefly while looking north from the East and Middle buttes. The proposed NPR site is not visible from any population centers. Cooling tower plumes (three for the HWR and LWR and two for the MHTGR) would be visible from public access highways (US 20 and US 26) on INEL and perhaps from as far away as Craters of the Moon National Monument. Such visual impacts would vary significantly, depending on the temperature and weather conditions, season of the year, and level of activity at the NPR. Icing, fogging, and other features of a cooling tower plume are discussed in air resources evaluation (Section 5.3.1). Currently, plumes from existing cooling towers and from the Idaho Chemical Processing Plant main stack are often visible.

The method used to assess the impacts of NPR cooling towers on the visual environment is discussed in Section 5.3.1.2. The plume for the HWR could extend up to 20 km, which is beyond the site boundary (principally south), and would also be visible from US 20/26. Cooling towers for the LWR and MHTGR would not be visible from beyond the INEL boundaries.

The BLM has applied mixed use and industrial use visual classifications to INEL, and development of an NPR would be consistent with these visual resource classifications.

5.3.3.3 Mitigation and Conclusions

No impacts requiring mitigation would occur to land use, recreation, or the visual environment as a result of construction and operation of an NPR at INEL. Under some conditions, plumes from cooling towers would be visible from off-site, perhaps even at Craters of the Moon National Monument. Use of dry cooling for the MHTGR alternative (as suggested in Section 5.3.4 for mitigation of impacts to biotic resources) would eliminate the plume. Alternative wet cooling systems for the LWR and HWR technologies would not eliminate cooling tower plumes (Section 5.2.1).

5.3.4 Biotic Resources

This section evaluates the impacts to biotic resources that would result from the construction and normal operations of an HWR, LWR, or MHTGR at INEL. Descriptions of these reactors and their associated facilities at INEL are presented in Section 3.

5.3.4.1 Terrestrial Resources

Impacts of No Action

If an NPR were not developed, no changes to biotic resources would be expected on INEL other than those changes resulting from natural processes of succession and the impacts of ongoing INEL operations (see Section 4.2.5). These two factors would not be affected by the lack of new production capacity.

Impacts of NPR Construction and Operation

Construction of an NPR and support facilities at INEL would disturb approximately 1,570 ha, 1,120 ha, or 1,220 ha of land for an HWR, LWR, or MHTGR, respectively. For these three alternatives, approximately 1,150 ha, 1,040 ha, or 804 ha, respectively, would be occupied by facilities (e.g., reactor, support facilities, evaporation pond, utility rights-of-way, access roads) and would remain developed for the life of the project. The evaporation pond would cause a major portion of this land disturbance -- 829 ha, 855 ha, or 673 ha for an HWR, LWR, or MHTGR, respectively. The remaining disturbed land for each alternative would be revegetated following construction.

Vegetation within construction areas would be destroyed during land-clearing activities. Plant species that are dominant on the NPR site at INEL include big sagebrush, rabbitbrush, and Indian ricegrass. The plant communities to be disturbed by development of an NPR are well represented on INEL, but they are relatively uncommon regionally because of the widespread conversion of shrub-steppe habitats to agriculture (Gates 1983). Disturbed areas in shrub-steppe communities are generally recolonized by cheatgrass, a nonnative species, at the expense of native plants (Rickard and Poole 1989; Anderson, Glennon, and Houser 1990). Mitigation of these impacts include minimizing the area of disturbance and revegetating with native species, including shrubs, shortly after construction is complete. Adverse impacts to vegetation from construction of NPR facilities on INEL are expected to be limited to the project area and vicinity and are not expected to affect the viability of any plant populations.

Construction of an NPR would have some adverse effect on animal populations. Less mobile animals (such as invertebrates, reptiles, and small mammals) within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to adjacent suitable habitat (Moore and Mills 1977). Project facilities would displace 1,150 ha, 1,040 ha, or 804 ha of wildlife habitat for the life of an HWR, LWR, or MHTGR, respectively. Other disturbed areas (e.g., construction laydown areas, rights-of-way, and buried pipeline routes) would be revegetated upon completion of construction and would be reinvaded by animal species present in surrounding, undisturbed habitats. The adverse impacts of construction are

expected to be limited to the project area and immediate vicinity and should not affect the viability of any animal populations on INEL because similar suitable habitat would remain abundant on the INEL site.

Cooling tower drift would result in salt deposition on surrounding land areas and vegetation. For an HWR, LWR, or MHTGR, respectively, areas of approximately 81 ha, 123 ha, and 85 ha in the immediate vicinity of the cooling towers would be affected by salt deposition. These areas would experience salt deposition rates above the threshold value of 17.1 kg/ha·mo at which salt stress symptoms can become visible on sensitive plant species (DOE-20). Part of the locations affected by drift would include developed portions of the facility; thus, the actual total area of vegetation affected would be less than the values cited above. Maximum distance from the cooling towers at which threshold values would be exceeded also would vary according to reactor technology -- 750 m, 950 m, and 950 m for an HWR, LWR, and MHTGR, respectively. All areas affected by drift would be within the INEL boundary and would be relatively small compared with the total land area of INEL.

Very small concentrations of radionuclides (several orders of magnitude lower than natural background levels) would be released to the atmosphere during NPR operations. Studies have indicated that no other organisms are more sensitive than man to radiation (NRC-8). Therefore, as concluded for humans (see Section 5.3.6), the effects of these radionuclides on terrestrial organisms are expected to be very minor.

The completed evaporation pond would represent the largest perennial body of water on INEL. Because water is scarce in the arid INEL environment, the evaporation pond would attract many animal species (EG&G-3). The heated pond would be an important source of water throughout the year, since most water in this region is frozen during the winter. Mammals and songbirds seeking drinking water would be attracted to the pond. In addition, it is expected that large numbers of waterfowl would be attracted to the pond, especially during migration, because the pond would provide drinking water and an area for foraging and resting. Two areas on INEL -- the Test Reactor Area pond and the Big Lost River spreading areas -- are currently used extensively by waterfowl and other wildlife and indicate the type of use that could occur at the NPR evaporation pond (EG&G-3).

Tritium and other radionuclides, and various chemicals added to the cooling water to prevent corrosion and fouling, would be present in the blowdown water released to the evaporation pond. Animals using the pond would be exposed to these radionuclides and chemicals, primarily by ingestion of contaminated water, vegetation, and prey. Uptake by animals would provide pathways for these materials to be spread beyond the pond and site boundary (EG&G-3).

Mitigation and Conclusions

Impacts to terrestrial plant and animal communities at INEL would be mitigated by minimizing the amount of land disturbed during construction, employing soil erosion control measures during construction activities, and revegetating disturbed areas with native species. These mitigation measures would limit the amount of direct and indirect disturbance to the construction area and surrounding habitats and would speed the recovery process for disturbed lands. The most important adverse impacts would result from the use of an evaporation pond to receive cooling water blowdown. Several options exist to mitigate the effects of the

evaporation pond on wildlife at INEL. The evaporation pond could be fenced to minimize access by larger animals, such as elk, antelope, and coyotes, but exclusion of smaller animals and birds, including waterfowl, would most likely be impossible. Because of the pond's large size, netting of the pond to prevent use by these species would be impractical. Alternatively, dry cooling towers or wet towers with forced evaporation could be used in place of the proposed wet cooling tower with passive evaporation. These alternative cooling technologies would eliminate the need for an evaporation pond and would, therefore, reduce the adverse impacts of an NPR at INEL. Without an evaporation pond, the amount of land occupied by facilities would be reduced to 323 ha, 183 ha, or 131 ha for an HWR, LWR, or MHTGR, respectively, and exposure to radionuclides and other contaminants in the cooling water would be reduced substantially because the NPR facility would no longer attract waterfowl and other wildlife. Mitigation of other operational impacts is related to design features of the NPR and associated facilities as described in Section 3.4. Rates of salt deposition due to cooling tower drift could be reduced to approximately one-half of those discussed by using a modern mist eliminator system (see Section 5.3.1).

Impacts to terrestrial resources that would result from construction of an NPR at INEL if alternative cooling systems were used rather than an evaporation pond include (1) disturbance and alteration of plant communities and (2) displacement of animals present on construction areas. These disturbances would take place on a relatively small percentage of the INEL land area. Operational impacts would include (1) deposition of salts from cooling tower drift on nearby terrestrial vegetation and (2) exposure of plants and animals to small amounts of radionuclides released during operation of the NPR. Levels of radionuclide exposure are expected to be less than the levels at which adverse effects would occur. Areas affected by salt deposition are expected to total less than 125 ha.

5.3.4.2 Wetlands

Impacts of No Action

If an NPR were not developed, no changes to wetlands on INEL would be expected beyond those resulting from natural processes and the impacts of ongoing INEL operations (see Section 4.1.5). These two factors would not be affected by the lack of new production capacity.

Impacts of NPR Construction and Operation

Construction of the reactor and support facilities at INEL would not directly affect wetlands, because no wetlands are located on the NPR site or in areas where NPR facilities would be located. The Big Lost River spreading areas and sinks are more than 15 km from the NPR site and should not be affected by construction or operation of the proposed facilities. The proposed evaporation pond, support facilities, rights-of-way, and access roads would not be located near either of these important wetlands. Riparian habitat along the Big Lost River would not be affected by construction because the river is 2.5 km from the NPR site. In addition, these wetlands are outside of the area that would be affected by cooling tower drift.

Mitigation and Conclusions

Because wetlands on INEL would be too far away to be impacted by construction or operation of NPR facilities, no mitigation would be required.

5.3.4.3 Aquatic Resources

Impacts of No Action

If an NPR were not developed at INEL, no changes to aquatic resources on INEL would be expected other than those changes resulting from natural processes and the impacts of ongoing INEL operations (see Section 4.1.5).

Impacts of NPR Construction and Operation

Construction of the reactor facilities would not directly affect aquatic habitats, since such habitats do not occur on the NPR site. Indirect effects, such as construction runoff, are not expected because the NPR site is located 2.5 km from the nearest aquatic habitat -- the Big Lost River. The rates of salt deposition due to cooling tower drift are not expected to have any adverse effects on aquatic resources because these resources (located 2.5 km away from the NPR site) are outside areas where significant deposition would occur (see Section 5.3.4.1). Unlike alternatives at the Hanford Site and SRS, cooling-tower blowdown water would not be released to any natural body of water on INEL, but instead would be released to the evaporation pond or evaporated at the reactor facility. Thus, any impacts to existing aquatic resources associated with release of this water would be avoided at INEL.

Mitigation and Conclusions

The distance between aquatic resources on INEL and the proposed NPR facilities would preclude the possibility of impacts to these resources and thus eliminate the need for mitigation.

5.3.4.4 Threatened and Endangered Species

Impacts of No Action

If an NPR were not developed, no changes to terrestrial resources would be expected on INEL other than those resulting from natural processes and the impacts of ongoing INEL operations (see Section 4.2.5). These two factors would be unaffected by the lack of new production capacity.

Impacts of NPR Construction and Operation

No Federally listed species would be affected by construction of an NPR at the proposed site on INEL. However, the Swainson's hawk and ferruginous hawk, both candidates for Federal listing (Category 2 species that currently do not receive Federal protection under the Endangered Species Act), would be affected by NPR construction. Both of these hawks would lose some foraging habitat as a result of NPR construction. Because these species forage over a relatively large area and because this type of habitat is abundant on INEL, loss of foraging habitat is not expected to affect the viability of populations of either species on the site. Because suitable nesting sites for these two species are relatively rare on INEL, disturbance of nesting areas on the NPR site has a greater potential for adverse impact. If construction occurred in the vicinity of these nesting areas, mitigation would be developed in consultation with the FWS.

Species of special concern to the State of Idaho also would be affected by construction of an NPR. *Oxytheca* has been found on the NPR site, and individual plants of this species could be killed during land-clearing activities. This species has been collected at seven other sites on INEL and only at two other sites in Idaho. Habitat of the burrowing owl and bobcat on the NPR site would be disturbed during construction, but because of the relative abundance of this type of habitat on the site, this impact would not affect the viability of the populations of these species on INEL.

Operation of an NPR at INEL could adversely affect threatened and endangered species as a result of creation of the proposed evaporation pond. Federally listed species that would be affected by the evaporation pond are the peregrine falcon and the bald eagle, both listed as endangered. Both species feed on waterfowl (Bent 1961), and individuals wintering in the area are expected to be attracted to the waterfowl that would congregate on the pond (see Section 5.3.4.1). Other species that do not receive legal protection, but that would be attracted to the pond, include the Townsend's western big-eared bat (Federal Category 2) and two species of special concern -- the osprey and white-faced ibis. Bats are typically attracted to water bodies to forage for insects and obtain drinking water (Humphrey 1982; Cross 1986). This attraction would be particularly strong in the arid INEL environment. The white-faced ibis and osprey both forage in aquatic environments. The ibis typically eats invertebrates, amphibians, and fish; whereas the osprey eats fish only. Ibises are summer vagrants on INEL and would be expected to forage on the invertebrates and amphibians that would colonize the evaporation pond. Ospreys initially would be attracted to the pond, but the lack of fish in the pond would prevent them from staying.

Attraction of threatened and endangered species to the area would expose them to potentially adverse impacts. As discussed in Section 5.3.4.1, the pond would contain such contaminants as radionuclides (mostly tritium) and chemicals used to treat cooling water. Individual animals foraging at the pond would be exposed to these contaminants through their food supplies. In addition to the potential effects of exposure to chemical hazards, species attracted to the pond would be exposed to potential harassment during operation of the facility.

Mitigation and Conclusions

Impacts to threatened and endangered species at INEL that would result from construction of an NPR and its associated facilities include (1) disturbance of foraging habitat for Swainson's hawks, ferruginous hawks, bobcat, and burrowing owl; (2) potential disturbance

of some nesting habitat for the Swainson's hawk, ferruginous hawk, and burrowing owl; and (3) disturbance of habitats occupied by oxytheca. With the proposed mitigation, these impacts should not affect the viability of any of these populations. Operational impacts to the bald eagle, peregrine falcon, Townsend's western big-eared bat, osprey, and white-faced ibis would result from use of a large evaporation pond to receive cooling-tower blowdown water. Impacts to these species are potentially significant but could be avoided with the use of an alternative cooling system.

A biological assessment that describes the impacts to Federally listed species has been developed and submitted to the FWS for evaluation by the FWS (Reynolds 1990). If deemed necessary by the FWS, a detailed plan to mitigate impacts to Federally listed threatened and endangered species would be developed in consultation with that agency. Impacts to these species resulting from construction of an NPR at INEL would be mitigated by employing those measures described in Section 5.3.4.1. In addition, impacts to nesting Swainson's hawks and ferruginous hawks would be mitigated by avoiding nesting sites and replacing lost nesting sites. Mitigation of impacts to oxytheca would include avoiding areas where this species is found and developing a habitat restoration/reseeding program when habitat disturbance is unavoidable. Operational impacts of an NPR would be limited largely to those resulting from use of an evaporation pond. Fencing the pond to prevent its use by wildlife would not be effective in protecting birds or bats. Dry cooling towers or wet cooling towers with forced evaporation could be used as alternatives to the proposed wet cooling tower with passive evaporation. These alternative cooling systems would eliminate the adverse impacts of the proposed evaporation pond to threatened and endangered species.

5.3.5 Cultural Resources

Construction and operation of an NPR may adversely affect cultural resources at INEL both directly and indirectly. Direct effects may result from construction of facility features, access roads, and utility lines, while indirect effects may result from increased activity in the area. Direct impacts to cultural resources that possess potential for inclusion in the National Register of Historic Places (NRHP) would be mitigated either by avoidance or by additional data collection through excavation or monitoring during construction. Indirect impacts would be mitigated by conducting an education program for INEL employees and construction workers. Mitigation planning would be developed in consultation with the Idaho State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation.

5.3.5.1 Impacts of No Action

The no-action alternative would not affect the archaeological, historical, or cultural resources at INEL. These would remain as described in Section 4.2.6.

5.3.5.2 Impacts of NPR Construction and Operation

Affected Archaeological Sites and Historic Structures

Archaeological sites within the area of the proposed NPR and associated facilities would be subject to direct adverse effects. Impacts would be caused by clearing and leveling the ground surface and by excavating foundations for the reactor and associated facilities. Sites affected by these activities would be subject to disturbance, damage, and destruction of artifacts and features. Although the size and specific location of the reactor complex at the NPR site have not been determined, the known distribution and preliminary evaluation of archaeological sites in this part of INEL (Section 4.2.6.2) permit some probabilistic statements. The results of a survey and limited testing (Henrikson 1990; Ringe 1990) indicate that the NPR is likely to affect approximately two archaeological localities (isolated artifacts and sites) per hectare. The affected group, in turn, is likely to include sites that are eligible for the NRHP; ongoing testing to determine eligibility must be completed to reliably estimate the proportion of affected eligible properties. On the basis of the most recent survey of sample units, DOE estimates that 0.050 eligible archaeological sites per hectare would be affected (Henrikson 1990). If the proposed NPR site occupies a 100-ha area, approximately 200 localities, including five sites eligible for the NRHP, are likely to be adversely affected. Only the eligible properties require mitigative action; if avoidance is not possible, adverse effects would be mitigated through data recovery (i.e., mapping and collection or excavation).

Additional direct impacts could be caused by construction of the associated utility and transportation corridors. It is not possible to predict the adverse effects of these project features even in probabilistic terms. However, it is usually possible to avoid utility and transportation corridor impacts to archaeological sites through minor design modifications.

Indirect impacts are expected to be confined to areas near the facility perimeter and any roads that pass through the general area. Indirect impact zones could extend 200 m beyond the facility perimeter and 100 m on either side of access roads. (The width of these zones is somewhat arbitrary, and the potential for indirect impacts exists at all locations within the NPR site.)

Construction of the blowdown water evaporation pond, which would be located near the NPR site (possibly overlapping a portion of the site), would likely impact additional significant archaeological sites, given the known distribution and contents of such sites in the area. However, specific impacts cannot be assessed until the location of the pond is identified and the affected areas are inventoried and evaluated for cultural resources. Impacts would probably be greater for the LWR and HWR alternatives, which would have a larger evaporation pond (829-855 ha) than that proposed for the MHTGR alternative (673 ha).

Native American Cultural Resources

No cultural resources of obvious religious or ceremonial significance to Native American groups have been identified on the NPR site. However, ongoing consultation by DOE with the Shoshone and Bannock tribes may document Native American religious or cultural concerns related to the proposed project.

Paleontological Resources

Construction would not adversely affect paleontological resources on the ground surface within the NPR site. However, the area may contain deeply buried lava blisters with plant and animal remains (Ringe et al. 1987), which could be disturbed by deep trenching or excavation activity.

5.3.5.3 Mitigation and Conclusions

Adverse effects to archaeological sites eligible for the NRHP require mitigative measures (36 CFR 800). In cases where avoidance to such sites is not possible, direct impacts would be mitigated through data recovery. At a minimum, this would entail detailed mapping and collection of artifacts from affected sites. At sites containing buried remains, excavations would be conducted. Data recovery would be pursued within the framework of issues and problems in regional prehistory (Ringe 1990). Indirect impacts would be mitigated through education of employees on cultural resources and the laws that protect those resources. All mitigative measures would be undertaken within the context of a comprehensive mitigation plan developed by DOE in consultation with the Idaho SHPO and the Advisory Council on Historic Preservation.

Although adverse effects to Native American cultural resources protected under the American Indian Religious Freedom Act have not been identified, if such impacts are documented, DOE would attempt to mitigate impacts through consultation with the affected tribes.

During the construction phase, deep trenching and excavation activities would be monitored by a professional cultural resources specialist. Should any deeply buried paleontological materials be encountered, a qualified paleontologist would evaluate and, if necessary, recover and analyze the materials.

5.3.6 Radiological Impacts

Radiological impacts were estimated for the three reactor technologies (HWR, LWR, and MHTGR) and their support facilities at INEL. Potential impacts from no action, normal operations, nonsevere accidents, and severe accidents are discussed in Sections 5.3.6.1, 5.3.6.2, 5.3.6.3, and 5.3.6.4, respectively. Impacts from transportation of radioactive materials are discussed in Section 5.3.6.5. The conclusions of the assessment and potential mitigative actions for reduction of significant impacts are discussed in Section 5.3.6.6.

5.3.6.1 Impacts of No Action

If a decision were made not to construct and operate an NPR at INEL, the radiological environment at INEL would remain as described in Section 4.2.7.

5.3.6.2 Impacts of Normal Operations

Baseline Radiological Conditions

Baseline radiological conditions at INEL are presented in Section 4.2.7. Based on U.S. Bureau of the Census statistics, the population within 80 km of the site is estimated to be 70% higher in the year 2020 than in 1988. Therefore, the baseline population dose used for this assessment was increased by 70%.

Estimated Doses and Health Effects

Estimated doses to a hypothetical maximally exposed off-site individual, 80-km population, and in-plant worker from 1 year of exposure to releases from normal operations of NPRs and their support facilities are given in Table 5.3.6-1. The doses to the hypothetical maximally exposed off-site individual are the sums of doses from individual facilities to various receptors at the off-site location of maximum impact for each facility. The estimated dose listed in Table 5.3.6-1 for each technology/mode is therefore greater than the combined dose from all facilities to an actual individual at any single location. Radiological impacts from individual facilities are given in Appendix H. For each NPR facility at INEL, there would be no surface or subsurface water pathways by which routine liquid releases would reach the off-site environment.

The estimated annual CEDEs to the maximally exposed off-site individual range from 1.3×10^{-4} to 3.2×10^{-4} rem, and the estimated collective doses to the 80-km population range from 1.8 to 5.0 person-rem. These doses are several orders of magnitude lower than the estimated doses from 1 year of exposure to natural background radiation, i.e., 0.4 rem and 8×10^4 person-rem, respectively. When the estimated doses to the hypothetical maximally exposed off-site individual from NPR facilities are added to the baseline doses, the resulting sums are smaller (by factors of more than 20) than the dose rate limits for compliance with the Clean Air Act and Safe Drinking Water Act and the DOE standard for normal operations of DOE facilities. The estimates presented herein are based on conservative assumptions; actual impacts are expected to be even smaller.

The health effects associated with 1 year of normal operations would be correspondingly small (see Appendix H, Sections H.4.3 and H.5.3). For the maximally exposed off-site individual, the incremental lifetime fatal cancer risk is estimated to range from 5×10^{-8} to 1×10^{-7} . For the 80-km population, the incremental number of cancer deaths is estimated to range from 7×10^{-4} to 0.002 and the incremental number of genetic effects from 5×10^{-4} to 0.001. These estimates are sufficiently small that no cancer deaths or genetic effects would be expected from routine releases during the operating lifetimes of NPR facilities at INEL. For comparison with these estimates, about 30 cancer fatalities/yr would be expected among the 80-km population around the site as a result of exposure to natural background radiation (calculated using the EPA risk estimator of 4×10^{-4} cancer fatalities/person-rem), and about 290 cancer fatalities would be expected among the same population from all causes combined (U.S. Bureau of the Census 1987).

Collective doses to in-plant workers from 1 year of normal operations of NPR facilities are estimated to range from 85 to 440 person-rem in the tritium production mode and from

TABLE 5.3.6-1 Estimated CEDEs from 1 Year of Exposure to Releases during Normal Operations of Reactors and Support Facilities at INEL

Technology/Mode	Maximally Exposed Off-site Individual ^a (rem)	80-km Population ^b (person-rem)	In-Plant Worker ^c (person-rem)
HWR			
Tritium mode	1.4×10^{-4}	2.0	85
Plutonium mode	1.3×10^{-4}	1.8	300
LWR			
Tritium mode	3.2×10^{-4}	5.0	440
Plutonium mode	3.2×10^{-4}	4.8	740
MHTGR			
Tritium mode	1.6×10^{-4}	2.4	130
Plutonium mode	1.5×10^{-4}	2.3	360
Baseline conditions ^d	1×10^{-4}	3	-
Natural background	0.4 ^e	8×10^4	-

^aEach dose is the sum of doses to the maximally exposed off-site individual from releases from individual facilities; actually, the location of the maximally exposed off-site individual would probably differ from facility to facility.

^bEach dose is the sum of doses to the 80-km population from releases from individual facilities; actually, different facilities have different 80-km populations.

^cSources for in-plant worker doses: HWR (WSRC-4); LWR (Heacock 1990b); MHTGR (Bowman-3); and all support facilities (Bowman-4).

^dSee Section 4.2.7 for baseline conditions. The 80-km population dose has been increased by 70% to account for projected population increases to the year 2020.

^eThe value of 0.4 rem for natural background is average, not maximum (see Section 4.2.7).

300 to 740 person-rem in the plutonium production mode. These doses would be predominantly to workers in the reactor, fuel processing, and plutonium-target processing facilities. The estimated doses to workers at support facilities for each reactor technology are based on those facilities being at INEL (Bowman-4).

Through work planning and personnel monitoring, no worker would be allowed to accumulate an annual dose that is greater than a fraction of the DOE occupational limits. The estimated collective in-plant occupational doses for NPR facilities at INEL are much smaller than these limiting doses.

The estimated number of cancer fatalities among in-plant workers due to radiation exposure per year of operations would be between 0.03 and 0.2 in the tritium production mode and between 0.1 and 0.3 in the plutonium production mode (calculated using the EPA risk factor of 4×10^4 cancers fatalities/person-rem). Assuming that the same number of workers would be employed at these facilities continuously, one cancer fatality would be expected among the workers for every 5 to 30 years of operations in the tritium production mode and one fatality for every 3 to 10 years of operations in the plutonium production mode.

5.3.6.3 Impacts of Postulated Nonsevere Accidents

Nonsevere Accidents at Reactors

The methodology used to estimate radiological impacts of postulated nonsevere accidents at the proposed NPRs at INEL is discussed in Section 5.1.7.2. Appendix I provides a more complete discussion of the methodology and potential impacts, as well as descriptions of the accidents analyzed. In Appendix I, estimated doses and health effects are presented for a range of postulated nonsevere accidents in the proposed NPRs at INEL. In this section, only bounding estimates are given -- i.e., the highest consequences from any nonsevere accident at the HWR, LWR, and MHTGR for each of the three receptors (maximally exposed off-site individual, 80-km off-site population, and maximally exposed colocated worker). The accidents that result in the highest consequences are listed in Table 5.1-2; the estimated doses for these accidents are given in Table 5.3.6-2. For the HWR and LWR, the accident with the highest consequences is different for off-site individuals than for the on-site colocated worker.

In Table 5.3.6-2, the doses listed with the "ingestion pathway included" were estimated assuming that no mitigative or emergency action was taken following the accident. That is, it was assumed that the maximally exposed off-site individual and persons within 80 km of the affected facility continued their activities as usual after the accident. The values listed with the "ingestion pathway not included" were estimated assuming that some action was taken that would eliminate the dose due to the ingestion pathway.

The accidents with the highest consequences (Table 5.1-2) are different for each technology. Because of the different designs and inherent technology differences, the progression and therefore the quantity and timing of radioactive releases to the environment during these accidents are also different. The source terms for the bounding postulated accidents are listed in Appendix I.

TABLE 5.3.6-2 Estimated Doses for Accident with Highest Consequences^a from Postulated NPR Nonsevere Accidents at INEL

Reactor	Ingestion Pathway Included	Committed Effective Dose Equivalent		
		Maximally Exposed Off-site Individual ^b (rem)	80-km Worst-Sector Population ^b (person-rem)	Maximally Exposed Colocated Worker ^b (rem)
HWR	No	0.011	110	0.019
	Yes	0.55	4,100	NA ^c
LWR	No	0.028	310	0.0071
	Yes	1.9	16,000	NA
MHTGR	No	0.034	370	0.0044
	Yes	1.0	8,600	NA

^aEstimated doses from the highest consequence accident in the unlikely event that the accident occurred; see Table 5.1-2 for accident descriptions and frequency classes; see Appendix I for a description of the calculations and for more details of these estimates.

^bThe maximally exposed off-site individual would be 14,800 m south-southeast; the maximally exposed sector would be east with a population of 113,000; and the maximally exposed colocated worker would be 2,900 m south.

^cNA means not applicable.

The estimated health effects resulting from the doses listed in Table 5.3.6-2 are given in Table 5.3.6-3. The effects for the maximally exposed off-site individual and the colocated worker are given in terms of incremental risk of contracting a fatal cancer. The effects for the worst-sector population are given in terms of additional fatal cancers and severe genetic effects.

From an examination of the estimated doses due to postulated NPR nonsevere accidents at INEL (Table 5.3.6-2 and Appendix I), it is apparent that, even with the highly conservative estimates provided in this EIS, no emergency action would be required for the maximally exposed off-site individual or for the population around the site if any of these accidents were to occur. However, for the highest consequence accidents, some protective actions would probably be taken, such as washing food to remove surface contamination or temporarily putting animals on stored feed. Taking protective actions would be recommended on a case-by-case basis by the emergency response personnel from Federal, state, and local governments around the site. (See Section 5.1.7.2 for a discussion of mitigative actions.)

A more detailed assessment of the results presented in this section and a discussion of occupational exposures to in-plant workers during and after (i.e., cleanup phase) the postulated nonsevere accidents are provided in Appendix I. Based on this information, it is estimated that

**TABLE 5.3.6-3 Estimated Incremental Health Effects per Accident^a
for Postulated NPR Nonsevere Accidents with the Highest Consequences
at INEL**

Reactor	Ingestion Pathway Included	Maximally Exposed Off-site Individual Fatal Cancer Risk	80-km Worst-Sector Population		Maximally Exposed Colocated Worker Fatal Cancer Risk
			Fatal Cancers	Genetic Effects	
HWR	No	4×10^{-7}	None ^b	None	8×10^{-6}
	Yes	2×10^{-4}	2	1	NA ^c
LWR	No	1×10^{-5}	None	None	3×10^{-6}
	Yes	8×10^{-4}	6	4	NA
MHTGR	No	1×10^{-5}	None	None	2×10^{-6}
	Yes	4×10^{-4}	3	2	NA

^aIn the unlikely event that the accident occurred; see Table 5.1-2 for accident descriptions and frequency classes; see Appendix I for a description of the calculations and for more details of these estimates.

^b"None" means the calculated value is less than 0.5.

^cNA means not applicable.

with proper protective action, no cancer fatalities or genetic effects would occur at or near the site as a result of a postulated nonsevere accident in any of the proposed NPRs at INEL. This compares with approximately 290 cancer fatalities/yr expected among the 80-km population around the site from all causes combined (U.S. Bureau of the Census 1987).

The designs for the proposed NPR program facilities are still under development. As the designs mature, some of the conservative assumptions made in the calculations regarding the operation of various safety features can be relaxed. Consequently, once the final designs are available, the estimated releases of radionuclides from these facilities and the associated doses and health effects will probably be lower.

Nonsevere Accidents at Support Facilities

The types of postulated nonsevere accidents at INEL new production reactor support facilities that could result in atmospheric releases of radioactive materials to the environment are described briefly in Section I.4.1.2 of Appendix I. The extent to which radioactivity would be released to the environment in the event of such accidents would depend on a number of factors, including the inventory and volatility of the radioactive materials and the operating status or efficiency of systems that filter out these materials. Not all types of accidents are possible at each type of support facility. For example, criticality accidents (accidents involving an unintended nuclear chain reaction) are not possible at tritium-target processing facilities because

of the absence of fissile material (material that can sustain a chain reaction). Also, some types of accidents are restricted to only one reactor technology; for example, accidents involving combustion of Zircaloy-4 chips are restricted to the LWR technology (Zircaloy-4 is used to clad LWR fuel).

Because detailed facility designs and safety analyses were not available, Safety Analysis Reports and other reports addressing the hazards of operations similar to those to be utilized at NPR support facilities were reviewed in order to compile a list of postulated accidents. A subset of these accidents that could provide a reasonable and credible upper bound estimate of the maximum radionuclide release to the environment was chosen for analysis for each type of support facility for each reactor technology at each site. Appendix I describes the accidents chosen and presents the source terms and estimated impacts for bounding (highest consequence) accidents in each type of support facility for each technology at each site. The presentation here is limited to the bounding postulated accidents for each reactor technology at INEL.

The highest CEDEs to the maximally exposed off-site individual, off-site worst-sector population, and maximally exposed colocated worker from any of the postulated nonsevere accidents at INEL support facilities are given in Table 5.3.6-4. The doses listed with and without the ingestion pathway included were obtained using the same assumptions that were used to estimate impacts from postulated accidents at reactors (see above).

Overall, the postulated nonsevere accident at INEL support facilities that could result in the highest doses to off-site individuals and the maximally exposed colocated workers is estimated to be a tritium deflagration (fire and explosion) accident at the tritium-target processing facility for all reactor technologies. The tritium release from this accident is assumed to be the same for each reactor technology and, because the proposed location for this facility is also the same, the estimated doses are the same for all technologies (2.1 rem to the maximally exposed off-site individual, 3,800 person-rem to the worst-sector population, and 0.078 rem to the maximally exposed colocated worker). Thus, the highest dose to the maximally exposed colocated worker from any support facility at INEL would be 0.078 rem, which is well below the DOE occupational standard of 5 rem.

From an examination of the estimated doses (with the ingestion pathway included) due to postulated support facility nonsevere accidents at INEL (Table 5.3.6-4 and Appendix I), it is apparent that neither the EPA PAGs nor the FDA emergency PAGs are exceeded for any of the postulated accidents. (See Section 5.1.7.2 for a discussion of mitigative actions and the use of PAGs.) However, the estimated CEDEs and organ doses to the maximally exposed off-site individual do exceed FDA preventive PAGs for the tritium deflagration accident in the tritium-target processing facility (see Appendix I, Section I.4). Therefore, if this accident were to occur, some low-impact protective actions would probably be taken, such as washing food to remove surface contamination or temporarily putting animals on stored feed. Taking protective actions would be recommended on a case-by-case basis by the emergency response personnel from Federal, state, and local governments around the site.

The estimated health effects resulting from the doses listed in Table 5.3.6-4 are given in Table 5.3.6-5. If mitigative actions were taken to eliminate the ingestion pathway, no cancer fatalities or genetic effects would be expected among the population around INEL from an occurrence of any of the postulated support facility nonsevere accidents. This compares with approximately 290 cancer fatalities/yr expected among the 80-km population around the site from all causes combined (U.S. Bureau of the Census 1987).

TABLE 5.3.6-4 Estimated Doses for Accident with Highest Consequences^a from Postulated Nonsevere Accidents at INEL Support Facilities

Reactor	Ingestion Pathway Included	Committed Effective Dose Equivalent		
		Maximally Exposed Off-site Individual ^b (rem)	80-km Worst-Sector Population ^b (person-rem)	Maximally Exposed Colocated Worker ^b (rem)
HWR	No	0.028	540	0.078
	Yes	2.1	3,800	NA ^c
LWR	No	0.028	540	0.078
	Yes	2.1	3,800	NA
MHTGR	No	0.028	540	0.078
	Yes	2.1	3,800	NA

^aIn the unlikely event that the accident occurred; see Appendix I for a description of the calculations and for more details of these estimates.

^bThe highest consequence postulated accident for the maximally exposed off-site individual, worst-sector population, and maximally exposed colocated worker for each reactor technology is estimated to be a tritium deflagration accident at the tritium-target processing facility (accidents IH6D1, IL6D1, IM6D1 in Appendix I).

^cNA means not applicable.

The doses and health effects presented in Tables 5.3.6-4 and 5.3.6-5 are based on very conservative assumptions and on the assumption that an accident will occur. As discussed for nonsevere reactor accidents (see above), the estimated releases of radionuclides from these facilities and the associated doses and health effects will probably be lower once the final NPR program facility designs are available.

5.3.6.4 Impacts of Postulated Severe Accidents

Radiological impacts of postulated severe accidents at INEL new production reactors and their support facilities are estimated for the off-site general public (population within an 80-km radius of the site) and for colocated workers (on-site workers excluding those in the facility at risk). For the severe reactor accident analysis, calculated impacts are further summarized in the form of CCDFs or expressed as average risk values for three consequence measures: early fatalities, cancer fatalities, and population doses.

**TABLE 5.3.6-5 Estimated Incremental Health Effects per Accident^a
 for Postulated Nonsevere Accidents with the Highest Consequences
 at INEL Support Facilities**

Reactor	Ingestion Pathway Included	Maximally Exposed Off-site Individual Fatal Cancer Risk	80-km Worst-Sector Population ^b		Maximally Exposed Colocated Worker Fatal Cancer Risk
			Fatal Cancers	Genetic Effects	
HWR	No	1×10^{-5}	None ^c	None	3×10^{-5}
	Yes	8×10^{-4}	2	1	NA ^d
LWR	No	1×10^{-5}	None	None	3×10^{-5}
	Yes	8×10^{-4}	2	1	NA
MHTGR	No	1×10^{-5}	None	None	3×10^{-5}
	Yes	8×10^{-4}	2	1	NA

^aIn the unlikely event that the accident occurred; see Appendix I for a description of the calculations and for more details of these estimates.

^bThe highest consequence postulated accident for the maximally exposed off-site individual, worst-sector population, and maximally exposed colocated worker for each reactor technology is estimated to be a tritium deflagration accident at the tritium-target processing facility (accidents IH6D1, IL6D1, IM6D1 in Appendix I).

^c"None" means the estimated number of cancer deaths or genetic effects is less than 0.5.

^dNA means not applicable.

Severe Accidents at Reactors

Early Fatalities. Mitigative actions such as evacuation and relocation are considered in calculations of early fatalities. Calculations predict that no early fatalities would occur off-site among the general public surrounding INEL as a result of any of the postulated NPR severe accidents. The major factors contributing to this result are the large size of the INEL site and the low population density in the area near the site where most of the exposures would be expected to occur. There would be no early fatalities for colocated workers at the site.

Cancer Fatalities. The CCDFs for cancer fatalities calculated for off-site and on-site populations at INEL are presented in Figure 5.3.6-1. The estimated cancer fatalities at various exceedance frequencies account for the short-term and long-term dose mitigative actions discussed in Appendix J.

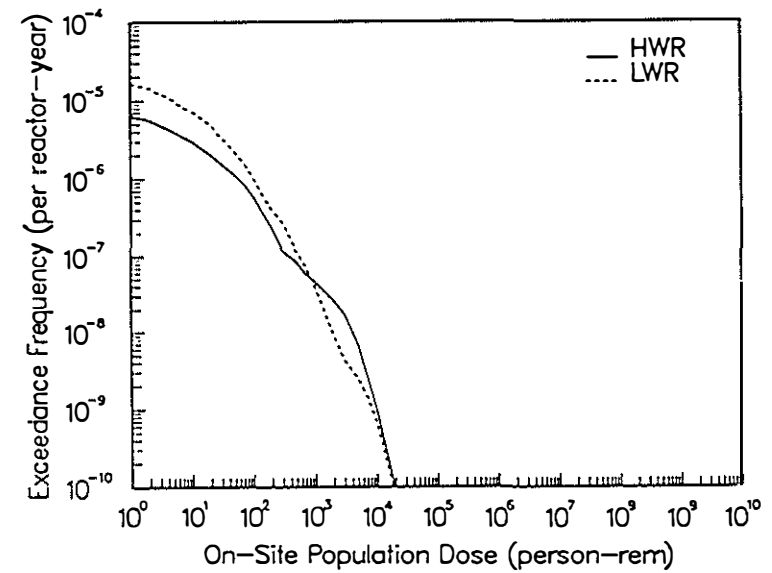
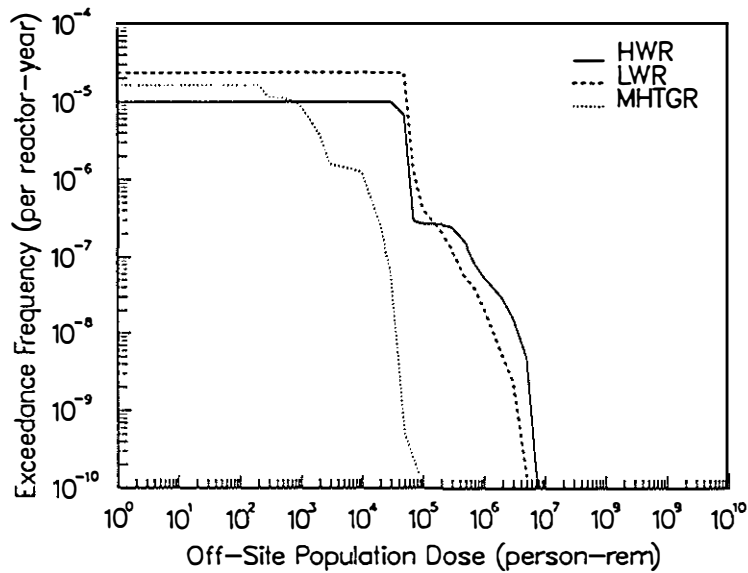
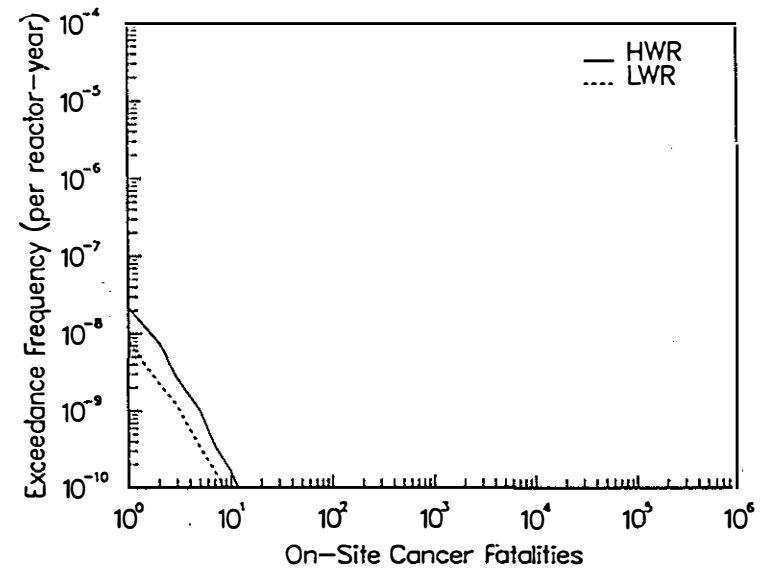
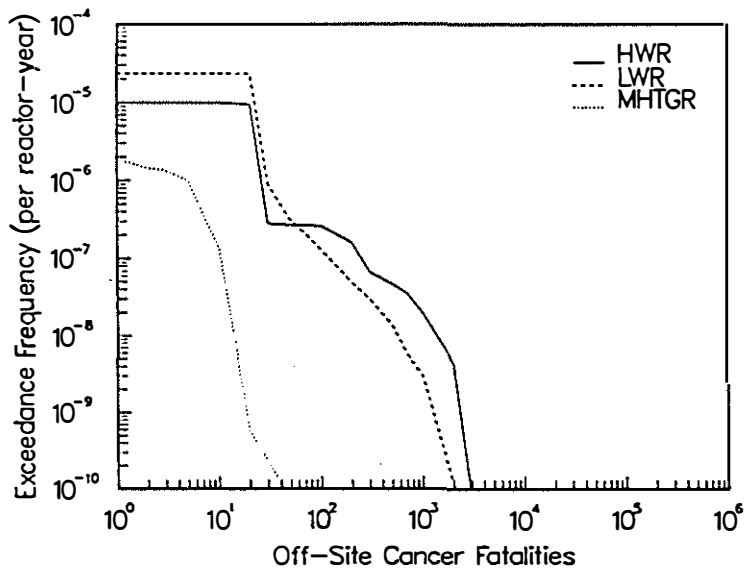


FIGURE 5.3.6-1 Frequency Distributions of Off-site and On-site Consequences of Severe Reactor Accidents at INEL (on-site cancer fatalities and population doses are negligible for the MHTGR at the exceedance frequencies shown)

The estimated impacts to the general public due to either HWR or LWR severe accidents at INEL are comparable to each other but are both higher than the impacts due to MHTGR severe accidents. This is also true for colocated workers. The radionuclide release associated with the postulated MHTGR severe accidents is assumed to occur in two phases. The first release would be followed by a significantly larger second release, which would occur between 50 and 80 hours later. Because of the long delay between the two releases, evacuation or relocation of colocated workers would likely be completed before the second release occurred. Therefore, the radiological consequences to colocated workers are significantly lower for MHTGR accidents than for HWR and LWR accidents.

The likelihood of causing one or more cancer fatalities among colocated workers at INEL due to severe accidents is estimated to be about 8×10^9 per reactor-year for an LWR and 2×10^8 for an HWR (see Figure 5.3.6-1). The likelihood of producing the same cancer fatalities for an MHTGR is estimated to be less than 1×10^{10} per reactor-year. Because of this low exceedance frequency, the on-site CCDF for an MHTGR is not shown in Figure 5.3.6-1.

Population Doses. The CCDFs for off-site and on-site population doses at INEL are also presented in Figure 5.3.6-1. The estimated population dose accounts for the dose mitigative actions that would take place immediately after the accident and in the long term. The CCDFs indicate that variations in population doses at equal exceedance frequency levels are similar to those of cancer fatalities.

Risks. Estimated risks resulting from postulated NPR severe accidents are presented in terms of societal risks and individual risks for the consequence measures under consideration. In contrast to individual risks, societal risks are risks to all members of the general public within an 800-km radius around the reactor or to all colocated workers at the INEL site.

All estimated average values of societal early fatality risk are lower than 1×10^{10} per 1 year of NPR operations at INEL (Hong et al. 1991). This risk is extremely small when compared to other kinds of accidents (see discussion of "Risks" in Section 5.2.6.4). The average societal risk values for cancer fatality and population dose for the three technologies at INEL are presented in Table 5.3.6-6. The radiological risks for HWR and LWR accidents are comparable, but the risk is lower for MHTGR accidents because of a relatively small release of radioactive material.

Individual risks of early fatality and cancer fatality in the immediate vicinity of the reactor were also estimated for the purpose of comparison to NPR safety goals (DOE-8). All individual risks resulting from postulated severe accidents at an HWR, LWR, or MHTGR at INEL are several orders of magnitude below the NPR safety goal values (Hong et al. 1991).

Severe Accidents at Support Facilities

The estimated releases from postulated severe accidents at the fuel fabrication or tritium-target processing facilities at INEL would not result in early fatalities. The estimated individual risks of cancer fatality are very small, i.e., less than 10^{10} fatalities/yr. The estimated total radiological impacts to colocated workers and the general public from the postulated accidents are summarized in Table 5.3.6-7. The population doses and corresponding cancer effects

TABLE 5.3.6-6 Estimated Values of Societal Risks Resulting from Postulated Severe Reactor Accidents at INEL

Reactor	Population Dose Risk (person-rem/ reactor-year)		Cancer Fatality Risk (fatalities/ reactor-year)	
	General Public	Colocated Worker	General Public	Colocated Worker
HWR	0.7	4×10^{-4}	3×10^{-4}	2×10^{-7}
LWR	2	6×10^{-4}	6×10^{-4}	2×10^{-7}
MHTGR	0.04	2×10^{-7}	1×10^{-5}	$< 10^{-10}$

TABLE 5.3.6-7 Estimated Total Radiological Impacts of Postulated Severe Accidents at INEL Support Facilities^a

Impact	Tritium Fuel Fabrication Facility	Tritium-Target Processing Facility
Population dose	7 person-rem	7,000 person-rem
Latent cancer effects	0.001 fatalities	3 fatalities
Population dose risk	7×10^{-8} person-rem/yr	7×10^{-5} person-rem/yr
Population health risk	$< 10^{-10}$ fatalities/yr	3×10^{-8} fatalities/yr

^aEach value given in this table is the sum of impacts to the colocated workers and the general public. See Appendix J for details.

represent the direct consequences of the accident; the risk values represent the consequences weighed by the frequency of the accident, which is estimated to be 1×10^{-8} /yr at INEL (see Appendix J).

5.3.6.5 Impacts of Transportation

The radiological impacts from transportation of radioactive materials for INEL include on-site and off-site activities. For on-site transportation, the radioactive materials from NPR operations are generally categorized as (1) irradiated driver-fuel assemblies, (2) irradiated target rods, (3) low-level waste, and (4) transuranic waste. The low-level waste would be disposed of on-site. Off-site transportation would include shipment of tritium to SRS and might include shipment of plutonium metal to the Rocky Flats Plant for processing. In addition, if the HWR technology were chosen for INEL, the existing tritium-contaminated heavy-water inventory would be shipped from SRS for use at INEL. A potential NPR at INEL would have its own on-site fuel processing, waste processing, and waste storage facilities and a heavy-water

processing facility for the HWR. Off-site transportation of high-level waste and transuranic waste to the Federal repository or Waste Isolation Pilot Plant, respectively, has been assessed in the existing environmental reviews for these facilities (DOE-49; DOE-51). The results of these assessments were used to estimate the risks associated with wastes from NPR operations in this EIS. More details regarding radiological impacts from transportation of radioactive materials are presented in Appendix K.

Incident-Free Transportation

The estimated radiological impacts from incident-free transportation are summarized in Table 5.3.6-8. The maximum individual doses are estimated to be 1.5 rem/yr to a transport vehicle crew member (occupational worker) and 0.005 rem/yr to a member of the public near the transport route. These doses are within the DOE limits of 5 rem/yr for occupational workers (DOE Order 5480.11) and 0.1 rem/yr for the general public (DOE Order 5400.5). The total annual transportation doses from incident-free transportation, both on-site and off-site, are estimated to range from 7.8 to 22 person-rem, which would result in no more than 0.009 cancer fatalities and no more than 0.006 genetic effects.

Transportation Accidents

The estimated radiological impacts from transportation accidents are summarized in Table 5.3.6-9; associated nonradiological impacts are also presented. The total annual population dose risks from transportation accidents (considering probability of occurrence and consequences) are estimated to range from 0.018 to 0.13 person-rem. These estimated dose risks would result in annual health risks of no more than 5×10^{-5} cancer fatalities and 4×10^{-5} genetic effects. By comparison, the nonradiological accident impacts from the same transportation activities are estimated to be 0.03 accident fatalities. The highest radiological risk is associated with the HWR and would result mainly from transportation of tritiated heavy water from SRS to INEL for reuse.

The maximum individual doses from on-site transportation accidents are estimated to be 21 rem for an on-site worker and 0.01 rem for a member of the general public at the site boundary. These doses would result in about 0.009 and 4×10^{-5} lifetime cancer risks to the exposed on-site and off-site individuals, respectively. Such maximum doses have been calculated for a severe rail accident involving a shipment of LLW in a liquid tank truck, for which the accident frequency is estimated to be about 1×10^{-6} /yr. For off-site transportation, the maximum individual dose is estimated to be 24 rem to a member of the public from a severe transportation accident involving tritiated heavy water for the HWR, for which the estimated accident frequency ranges from 0.001 to 0.0001/yr. Much of the maximum individual dose estimated for a member of the general public is related to ingestion of contaminated foodstuffs, which can be interdicted by appropriate government agencies according to Federal remedial actions guidelines. If such interdiction occurred, the resulting doses would be lower than those estimated in this EIS.

TABLE 5.3.6-8 Impacts from Incident-Free Transportation of Radioactive Materials for NPR Operations at INEL

Reactor	Transportation Mode	Maximum Individual Dose ^a (rem/yr)	Maximum Individual Health Risk (health effects/yr)	Population Dose Risk (person-rem/yr)	Population Health Risk (health effects/yr)	Population Genetic Risk (effects/yr)
HWR	On-site	0.0024	1×10^{-6}	0.11	4×10^{-5}	3×10^{-5}
	Off-site	0.51	2×10^{-4}	7.7	0.003	0.002
	Total			7.8	0.003	0.002
LWR	On-site	0.0022	9×10^{-7}	7.5×10^{-2}	3×10^{-5}	2×10^{-5}
	Off-site	1.5	6×10^{-4}	22	0.009	0.006
	Total			22	0.009	0.006
MHTGR	On-site	0.01	2×10^{-4}	0.54	2×10^{-4}	0.001
	Off-site	0.60	2×10^{-4}	11	0.004	0.003
	Total			12	0.004	0.004

^aThe maximum individual doses shown here are the doses to occupational personnel. For nonoccupational personnel, the maximum individual dose is estimated to be 0.005 rem/yr (DOE-49).

TABLE 5.3.6-9 Impacts from Transportation of Radioactive Materials for NPR Operations at INEL under Accident Conditions

Reactor	Transportation Mode	Maximum Individual Dose ^a (rem/yr)	Maximum Individual Health Risk ^a (health effects/yr)	Population Dose Risk ^b (person-rem/yr)	Population Health Risk ^b (health effects/yr)	Population Genetic Risk ^b (effects/yr)	Nonradio-logical Risk ^c (effects/yr)
HWR	On-site	0.01	4×10^{-5}	5.3×10^{-4}	2×10^{-7}	1×10^{-8}	3×10^{-4}
		21	0.008				
	Off-site	24	0.01	0.13	5×10^{-5}	4×10^{-5d}	0.03
	Total			0.13	5×10^{-5}	4×10^{-5}	0.03
LWR	On-site	0.01	4×10^{-5}	5.4×10^{-4}	2×10^{-7}	1×10^{-8}	3×10^{-4}
		21	0.008				
	Off-site	22	0.01	0.018	7×10^{-6}	4×10^{-8d}	0.03
	Total			0.018	7×10^{-6}	5×10^{-8}	0.03
MHTGR	On-site	0.01	4×10^{-5}	8.5×10^{-4}	3×10^{-7}	4×10^{-8}	0.004
		21	0.008				
	Off-site	22	0.01	0.031	1×10^{-5}	4×10^{-8d}	0.3
	Total			0.031	1×10^{-5}	8×10^{-8}	0.3

^aFor each reactor technology, two values are given for the on-site transportation mode. The value on the first line is for a member of the public located at the site boundary; the value on the second line is for a transportation worker located 100 m away from the accident.

^bFor on-site transportation, calculated risks are based on GENII methodology, for which the worst-sector population risks are estimated; for off-site transportation, calculated risks are based on RADTRAN methodology, for which a uniform population density is assumed.

TABLE 5.3.6-9 (Cont'd)

^cThe nonradiological risks are the traffic accident fatalities associated with transportation.

^dData do not include shipment of transuranic waste and high-level waste because genetic dose data are not available from existing environmental reviews (DOE-49; DOE-51).

5.3.6.6 Conclusions and Mitigation

Conclusions

The radiological impacts to off-site individuals and on-site workers because of the proposed NPR program facilities at INEL are summarized below. For perspective in understanding the significance of these impacts, statistics of the U.S. Bureau of the Census (1987) indicate that among the population within 80 km of the site (approximately 205,000 persons), the expected number of deaths due to accidents and adverse effects is about 100 per year and the expected number of cancer deaths from all causes combined is about 290 per year. The natural background radiation dose for the same population is estimated to be about 80,000 person-rem per year, which is calculated to result in approximately 30 cancer deaths per year (calculated using the health risk factor of 4×10^{-4} cancer deaths per person-rem). The results presented below show that the radiological impacts of the proposed NPR program facilities would be small in comparison to the impacts from other causes.

Normal Operations. Under normal operations, annual radioactive releases from an NPR and its support facilities would result in a dose of no more than 3.2×10^{-4} rem to the maximally exposed off-site individual. This estimated individual dose, combined with the existing baseline dose at INEL, is well within regulatory limits, which are 0.01 rem/yr for airborne releases (Clean Air Act) and 0.004 rem/yr for releases to drinking water (Safe Drinking Water Act). The estimated annual population doses, including the off-site population and in-plant workers, are no more than 740 person-rem. This equates statistically to less than 1 additional cancer fatality among the 80-km population in the INEL area. All estimated impacts from normal operations deviate by no more than a factor of about 5 among the three reactor technologies.

Nonsevere Accidents. For postulated nonsevere accidents at reactors, the highest consequence event is estimated to result in no early fatalities and in a total population dose of about 16,000 person-rem. This equates statistically to 6 cancer fatalities. The highest consequence estimated from the postulated nonsevere accidents would result from a loss-of-coolant accident in the LWR due to a large pipe break; such an accident would result in an estimated maximum off-site individual dose of 1.9 rem. Other estimated impacts for the highest consequence scenarios for either the HWR or MHTGR would deviate from the estimated impacts for the LWR by a factor of about 2 to 4 for both population risks and maximum individual risks.

For postulated nonsevere accidents at support facilities, the highest consequence accident is estimated to result in no early fatalities and a total population dose of about 3,800 person-rem. This equates statistically to 2 cancer fatalities. The highest consequence estimated from the postulated support facility nonsevere accidents would result from a tritium deflagration accident in a tritium-target processing facility; such an event would result in an estimated maximum off-site individual dose of 2.1 rem. These consequences would equally apply to all three technologies.

Severe Accidents. For postulated severe accidents at reactors, a broad spectrum of possible accidental releases has been considered, with frequencies ranging from 10^{-6} to 10^{-9} /yr.

The estimated health risks (frequencies times health consequences) are no more than 6×10^{-4} cancer fatalities/yr and no more than 1×10^{-10} early fatalities/yr for both colocated workers and the general public. For postulated severe accidents at support facilities, an upper bound radioactive release has been established for all three reactor technologies. Such an event is estimated to result in no early fatalities and in a risk of 3×10^{-8} cancer fatalities/yr for a severe seismic event with an estimated frequency of about 1×10^{-8} /yr.

Transportation. Impacts from transportation of radioactive materials were assessed for incident-free and accident conditions for all shipments transported on-site and off-site. The estimated maximum individual doses are no more than 1.5 rem/yr to an occupational worker (identified as a transport vehicle crew member) and no more than 0.005 rem/yr to a member of the general public. These maximum doses are below the DOE limits of 5 rem/yr for occupational workers and 0.1 rem/yr for the general public. The estimated total incident-free population doses are no more than 22 person-rem/yr, which corresponds to 0.009 cancer fatalities/yr. Most of the impact results from shipment of high-level waste off-site to the Federal repository. The estimated accident dose risks are no more than 0.13 person-rem/yr, which corresponds to a risk of 5×10^{-5} cancer fatalities/yr. The HWR has been estimated to have the highest transportation accident risk, much of which is associated with shipment of the existing tritiated heavy water inventory from SRS to INEL. The total estimated radiological risk from transportation, including incident-free and accident conditions, is about three times lower than the nonradiological risk of 0.03 fatalities/yr resulting from highway accidents for similar transportation activities involving nonradioactive materials.

Mitigation

In conclusion, all radiological impacts from normal (incident-free) operations of an NPR and its associated activities at INEL have been determined to be within Federal guidelines and standards. Furthermore, all activities are required to be practiced under the ALARA policy, as stipulated under DOE Orders 5480.11 and 5400.5, to further reduce exposures to both workers and the general public. In the event of an accident, potential radiological impacts would be reduced by implementation of effective short-term mitigative measures according to emergency preparedness procedures (see Section 3.6). Implementation of long-term mitigative measures, such as land decontamination and crop interdiction, would be conducted by appropriate government authorities according to Federal guidelines. If these mitigative actions were implemented, it is estimated that accident impacts could be reduced by as much as 90% or more below those presented in this EIS.

5.3.7 Accidents Involving Nonradioactive Hazardous Materials

The purpose of this section is to assess the potential human health risks from accidental releases of nonradioactive hazardous materials that would be used during operation of an NPR and associated support facilities at INEL. Risks have been assessed for ammonia, chlorine, and hydrogen – the three chemicals believed to pose the highest hazard potentials. The assessment examines (1) effects of acute inhalation for single exposures of up to 1 hour, (2) thermal radiation from fireballs, and (3) explosion hazards. Two accident scenarios were modeled: (1) rupture and complete release from on-site storage vessels and (2) rupture and complete release from a shipment vessel damaged by a transportation accident.

Environmental fate and atmospheric transport were simulated using the SLAB model (Ermak 1988, 1989). The simulations were based on meteorological conditions that, on the basis of modeling at INEL for 1983 and 1986, occur about 15%-20% of the time. Furthermore, the meteorological data indicate that the selected conditions can persist long enough for the toxic plume to reach the maximum distance where exposure criteria would be exceeded. The impacts from inhalation of ammonia and chlorine are presented in terms of (1) the size of off-site populations that would be exposed to concentrations above the Emergency Response Planning Guides (ERPGs), as defined in Section 5.1.7, for on-site storage vessel accidents and (2) impact radii for transportation accidents. For fire and explosion hazards, the results are presented in terms of distances from the point of release at which various thermal and overpressure criteria would be exceeded.

The results of the hazard assessment for the HWR, LWR, and MHTGR technologies at INEL are summarized below. More detailed discussions are presented in Appendix L. Details of the nonradioactive hazardous material accident assessment methodology are presented in a separate report (NUS-5).

5.3.7.1 Impacts of No Action

If an NPR were not constructed and operated at INEL, current site conditions would continue. Since chemical storage and usage would remain unchanged, the risk of accidents involving nonradioactive hazardous materials would not change.

5.3.7.2 Impacts of NPR Operation

The following discussion for each reactor type addresses the chemical release scenarios that would affect the greatest number of people.

Acute Inhalation

Acute inhalation impacts for the three reactor technologies were assessed for chlorine and ammonia releases.

HWR. During operation of an HWR, on-site storage accidents involving chlorine release would affect the largest number of people (among the scenarios investigated). For off-site populations, no individuals would be exposed to life-threatening conditions (ERPG-3); from 0 to 10 individuals might suffer impaired ability to take protective action (ERPG-2); and from 0 to 10 individuals might perceive an objectional odor or experience mild transient health effects (ERPG-1).

Transportation accidents that resulted in the largest impact radii also would involve chlorine releases. Distances at which ERPGs would be exceeded are 3 km for ERPG-3, 8 km for ERPG-2, and 14 km for ERPG-1.

The times required for toxic plumes to reach their critical impact radii for on-site storage and transportation accidents involving chlorine releases would range from about 1-4 hours.

Meteorological data collected at INEL indicate that the conditions modeled for chlorine release (1 m/s wind speed and Pasquill stability class F) occur about 10% of the time and can persist for 12 hours.

LWR. For LWR operations, on-site storage accidents and transportation accidents involving release of chlorine would affect the largest number of people. Since the storage and transportation conditions for an LWR would be the same as for an HWR, the impacts would be the same as discussed in the previous subsection.

MHTGR. At an MHTGR, on-site storage accidents involving an ammonia release would affect the largest number of people. For off-site populations, no individuals should be exposed to life-threatening conditions (ERPG-3). From 0 to 150 or more individuals might perceive an odor, experience mild transient health effects, or be exposed to conditions that might impair their ability to take protective action.

Transportation accidents resulting in the largest impact radii also would involve ammonia releases. Distances at which ERPGs would be exceeded are 1 km for ERPG-3, 2 km for ERPG-2, and 6 km for ERPG-1.

The times required for toxic plumes to reach their critical impact radii for on-site storage and transportation accidents involving ammonia releases would range from about 1/2 to 7 hours. The meteorological conditions used in modeling releases of ammonia (1 m/s and F stability) occur about 10% of the time and persist for up to 12 hours, which long enough for the toxic plume to reach the maximum travel distances.

In addition to the off-site population exposures discussed above for the three reactor technologies, occupational exposures also could occur. Accidental on-site releases of ammonia or chlorine could kill or injure workers. An off-site transportation accident might kill or injure transportation workers and members of the public.

Fire and Explosion

Fire and explosion impacts for the three technologies were assessed for hydrogen release.

HWR. Thermal radiation (heat) and explosive overpressure impacts from on-site storage and transportation accidents associated with the HWR technology would occur within 0.1 km from the point of release.

LWR. Thermal radiation and explosive overpressure impacts from on-site storage accidents associated with the LWR technology would occur within 0.1 km from the point of release. For transportation accidents, thermal radiation impacts and some explosive overpressure impacts (fatalities and eardrum rupture) would occur within 0.1 km. However, some building damage from explosive overpressure might occur as far away as 0.4 km.

MHTGR. Fatalities and injuries due to thermal radiation exposure from MHTGR on-site storage accidents could occur as far away as 0.5 km and 1 km, respectively. Explosive overpressure impacts could be experienced up to 1.9 km away for building damage, 0.4 km for eardrum rupture, and 0.1 km for fatalities.

For transportation accidents, thermal radiation fatalities and injuries could be observed within 0.1 km. Some building damage from explosive overpressure might occur as far away as 3 km, while fatalities and eardrum rupture would be confined to an area within 0.1 km.

5.3.7.3 Mitigation and Conclusions

The preceding analysis identifies a series of conditions that have potential for causing significant impacts both on- and off-site. The maximum number of off-site individuals significantly affected by accidental releases of ammonia or chlorine from an on-site storage vessel is estimated to be from 0 to 10 for the HWR and LWR technologies and from 0 to 150 for the MHTGR technology. On-site personnel also could be significantly affected by these releases and hydrogen releases, and both on-site and off-site individuals could be significantly affected by transportation accidents resulting in releases of these materials.

This analysis indicates that at INEL, the operation of an MHTGR would represent the greatest hazard potential of the three reactor technologies. A hazard analysis would be carried out at the design stage. A safety analysis report (SAR) would be prepared for each facility to evaluate the consequences and risks of accidents and to demonstrate that the facility has been constructed and will be operated to meet appropriate standards.

Some mitigation possibilities include (1) development and implementation of detailed emergency response plans that fit into the site's overall emergency response plans, (2) reduction of inventories, (3) modification of process or storage conditions, (4) reduction of the storage vessel size, (5) substitution of hazardous material with something less hazardous, (6) improvement of secondary containment, and (7) training of plant operators.

One of the most important aspects in the mitigation strategy is emergency preparedness. If an accident did occur, DOE would take emergency action in accordance with EPA guidelines and applicable DOE orders (DOE-48). Such actions would ensure that the exposures to off-site individuals and to occupational workers would be kept at a minimum. Mitigation could reduce the significance of the impacts.

5.3.8 Socioeconomics

The following section describes the socioeconomic impacts of NPR construction and operation at INEL. Requirements for additional housing, classrooms, teachers, police officers and fire fighters are examined. Health care impacts are also described. Impacts are expressed as a percentage increase in population(s) or as an increase in the level of community services required to accommodate an in-migrating NPR work force. The assumptions, methods, and uncertainties used in the analysis are described in Section 5.1.9.

The INEL work force data are shown in Table 3.3-3. Initial preconstruction activities would occur in 1993 for all alternatives. Initial reactor operations would occur in or about 2001

for the LWR and in or about 2002 for the HWR and MHTGR. Impacts are examined for the period 1993-2040, although impacts are shown only for the peak year of construction (when the maximum impact would occur) and the first year of operation. The impacts of operation would recur each year through 2040. The remainder of this section discusses (1) impacts of the no-action alternative, NPR construction, and NPR operations and (2) mitigation and conclusions.

5.3.8.1 Impacts of No Action

If an NPR were not constructed and operated at INEL, socioeconomic conditions would continue as described in Section 4.2.8. Employment at INEL under these conditions is described in DOE-30 and Table 4.2.8-1.

5.3.8.2 Impacts of NPR Construction

Employment and Income

Estimates of construction work force requirements for each alternative technology at INEL are listed in Table 5.3.8-1. An HWR would require a peak labor force of about 2,600 persons. An LWR would require a peak work force of about 4,100, and an MHTGR about 1,100 persons. As scheduled, HWR employment would peak in or about 1997, LWR employment in or about 1998, and MHTGR employment in or about 1998, during facilities construction. Total regional employment would increase by 4%, 7%, and 2% for the HWR, LWR, and MHTGR, respectively. In all instances, an increase in employment would benefit the INEL area.

The effect on earnings of HWR construction and preoperation activities is estimated at about \$1.84 billion. An LWR would increase regional earnings by about \$1.7 billion. The effect on earnings of MHTGR construction and preoperation activity would be about \$2.0 billion. In all cases, an NPR would inject about one year's additional income into the INEL economy. This addition would provide some cushion in the event of an economic slowdown in the INEL region.

Since no grazing land at INEL would be converted for the NPR, no impacts to agriculture are projected during construction for any NPR alternative.

Population Characteristics

Construction of an NPR would increase the regional population by 5,300 (2%), 9,000 (3%), and 2,200 (1%) persons for an HWR, LWR, and MHTGR, respectively (Table 5.3.8-1). During the years leading to the construction peak, NPR staffing could double projected rates of population growth for an HWR or LWR. Population growth rates during construction of an MHTGR would not be substantially different from baseline projections. Socioeconomic impacts for the LWR would be about twice those for the other alternatives. Total population growth would exceed baseline projections in the peak year by 3%.

TABLE 5.3.8-1 Estimated NPR Construction-Related Changes in Employment and Population in the INEL ROI, by NPR Technology

Employment/In-Migration	HWR	LWR	MHTGR
Peak-year employment			
Direct employment	2,600	4,100	1,100
Indirect employment	6,500	10,250	2,750
Total increase in employment	9,100	14,350	3,850
Increase in employment (%)	4	7	2
Peak-year in-migration			
Direct NPR worker	4,615	8,200	1,842
in-migrating population			
Indirect worker	725	788	350
in-migrating population			
Total in-migrants	9,340	8,988	2,192
Increase in population (%)	2	3	1

Housing

The greatest housing impacts as a consequence of NPR construction at INEL would be anticipated to accompany the LWR alternative (Table 5.3.8-2). The greatest increase in housing demand under the LWR alternative would occur in Bonneville County, where nearly 2,260 housing units would be required. The community of Idaho Falls alone would require more than 1,950 housing units to accommodate projected in-migrants. These increases in demand are significant in both areas, particularly given the historic capabilities of the local housing construction industries and the relatively low vacancy rates that have characterized the ROI in recent years. Anticipated housing impacts to Bingham and Jefferson counties would also be noteworthy, because increased LWR-related demand would significantly exceed housing construction for any year during the 1980s.

Anticipated housing impacts of the HWR would be the second largest of the three alternatives considered at INEL (Table 5.3.8-2). The MHTGR-related housing impacts would be smallest. For both the HWR and MHTGR, housing impacts to Bonneville County would be the largest and would exceed the housing construction for any year during the 1980s. Similarly, though they would be much smaller than needs for the LWR, projected housing demands for the HWR and MHTGR in Bingham and Jefferson counties would significantly exceed the average annual construction in each county during the 1980s.

Public and Community Services

Education. Impacts to public education arising from NPR construction at INEL are presented in Table 5.3.8-3. The greatest impacts would occur under the LWR alternative at the peak of construction, with a total of more than 2,100 additional students in the ROI. To maintain

TABLE 5.3.8-2 Estimated In-Migrant Housing
Demand for NPR Peak Construction Year in the
INEL ROI, by NPR Technology

Location	HWR	LWR	MHTGR
Bannock County	140	236	58
Chubbuck	20	34	8
Pocatello	120	202	49
Bingham County	280	472	115
Blackfoot	140	236	58
Shelley	60	101	25
Bonneville County	1,342	2,259	551
Ammon	100	169	41
Idaho Falls	1,162	1,955	477
Butte County	60	101	25
Arco	40	67	16
Jefferson County	120	202	49
Rigby	80	135	33
Madison County	20	34	8
Rexburg	20	34	8
INEL ROI	1,962	3,304	806

current student/teacher ratios of component school districts, 97 additional teachers would be needed in the region. For the HWR and MHTGR, impacts would be significantly less, with enrollment increases of 1,264 and 854 students, respectively; corresponding increases in instructional staffs would be 57 and 39 teachers, respectively, for the ROI at the peak of construction.

The greatest impacts to public education services would occur in school districts in Bonneville County. Idaho Falls School District #91 would experience an enrollment increase of 827 students and would require 37 additional teachers to maintain the current student/teacher ratio at the peak of construction. This school district is currently operating at its capacity of 10,000 students. However, by the fall of 1991, new construction of one junior high school (capacity 900 students) and two grade schools (each with a capacity of 400 students) is expected to be completed. With baseline enrollment anticipated to continue increasing over the next few years, the increased capacity provided by these new schools combined with NPR-generated enrollments would cause district operations to be near capacity once again. In Bonneville School District #93, enrollment increases under the LWR alternative would reach 620 students and would require 29 additional teachers to maintain current student/teacher ratios. Impacts under the HWR and MHTGR alternatives would also be largest in these school districts, but the impact would be less than under the LWR alternative (Table 5.3.8-3).

TABLE 5.3.8-3 Estimated NPR Construction-Related Impacts to Public Education in the INEL ROI, by NPR Technology

County/ School District	Enrollment Impacts			Teacher Impacts		
	HWR	LWR	MHTGR	HWR	LWR	MHTGR
Bannock County	90	152	372	4	7	17
Marsh Valley No. 21	0	0	0	0	0	0
Pocatello No. 25	90	152	372	4	7	17
Bingham County	181	304	74	9	14	3
Snake River No. 52	29	49	12	1	2	1
Blackfoot No. 55	91	152	37	4	7	2
Aberdeen No. 58	10	17	4	1	1	0
Firth No. 59	12	21	5	1	1	0
Shelley No. 60	39	65	16	2	3	1
Bonneville County	864	1,455	355	39	66	16
Idaho Falls No. 91	491	827	202	22	37	9
Swan Valley No. 92	5	8	2	0	0	0
Bonneville No. 93	368	620	151	17	29	7
Butte County	39	65	16	2	3	1
Arco No. 111	39	65	16	2	3	1
Jefferson County	77	130	32	3	6	1
Jefferson No. 251	56	95	23	2	4	1
Ririe No. 252	10	16	4	0	1	0
West Jefferson No. 253	11	19	5	1	1	0
Madison County	13	22	5	1	1	0
Madison No. 321	13	22	5	1	1	0
Sugar-Salem No. 322	0	0	0	0	0	0
INEL ROI	1,264	2,128	854	58	97	38

In addition to Idaho Falls School District #91, the following seven school districts in the ROI currently operating at capacity would receive the indicated numbers of additional students under the LWR alternative: Blackfoot School District #55, 152; Jefferson County School District #251, 95; Arco School District #111, 65; Snake River School District #52, 49; Madison School District #321, 22; Firth School District #59, 21; and Ririe School District #252, 16. Crowded conditions at each of these districts would become intensified with construction of the NPR.

Health Care. Analysis of health care impacts related to the NPR construction at INEL was based on the LWR alternative as the bounding (most conservative) condition. Although more doctors and nurses would be needed (Table 5.3.8-4), current capacity at area hospitals would be sufficient to handle the growth. Most hospitals are operating well below capacity.

TABLE 5.3.8-4 Estimated NPR Construction-Related Impacts to Health Services in the INEL ROI

County	Doctors	RN/LPN	Hospital Beds
Bannock	1	4/2	3
Bingham	1	4/5	8
Bonneville	11	44/27	23
Butte	0	2/1	0
Madison	0	0	0

Police and Fire Protection. Potential impacts to police protection at the peak of NPR construction under all three alternatives are presented in Table 5.3.8-5. These impacts would follow the distribution of NPR-generated population impacts and would reflect the increased demand for local public services arising from NPR-related in-migration during construction. Under all three alternatives, the greatest impacts would be experienced by the Bonneville County Sheriff's Office, the greatest demand being for 13 additional officers during peak construction of the LWR. Of the remaining 13 police departments, 7 would have to increase their staff sizes under at least one alternative to meet the increased demand at the peak of NPR construction while maintaining existing levels of police protection.

The projected peak impacts to fire protection services during construction under all three NPR alternatives are presented in Table 5.3.8-5. As with police protection, these impacts follow the distribution of population impacts and reflect the increased demand for public services arising from peak construction phase in-migration. The Idaho Falls Fire Department would experience the greatest impacts and would need eight additional fire fighters during the peak of construction under the LWR alternative. All fire departments except the Rexburg and Chubbuck fire departments would experience impacts under at least one NPR alternative.

Public Finances

As the above analyses show, fiscal impacts related to the NPR would be determined by factors such as the location of in-migrant workers, the size and timing of purchases, and the number of school age children. In taxing jurisdictions where service capabilities would be severely strained (especially where new classrooms would be needed), additional sources of revenue might be required. Fiscal impact analysis is an integral component of a Socioeconomic Monitoring and Mitigation Plan. If a final site is selected for the NPR, fiscal assessments would be conducted for all impacted taxing districts as an ongoing part of such a plan.

TABLE 5.3.8-5 Estimated NPR Construction-Related Impacts to Police and Fire Protection Services (additional professionals needed) in the INEL ROI, by NPR Technology

County/Agency	HWR	LWR	MHTGR
Police Protection			
Bannock County			
Bannock County Sheriff's Office	2	3	1
Chubbuck Police Department	0	0	0
Pocatello Police Department	2	3	1
Bingham County			
Bingham County Sheriff's Office	1	1	0
Blackfoot Police Department	1	1	0
Shelley Police Department	0	0	0
Bonneville County			
Bonneville County Sheriff's Office	8	13	3
Idaho Falls Police Department	5	8	2
Butte County			
Butte County Sheriff's Office	0	0	0
Arco Police Department	0	0	0
Jefferson County			
Jefferson County Sheriff's Office	0	1	0
Rigby Police Department	0	1	0
Madison County			
Madison County Sheriff's Office	NA ^a	NA	NA
Rexburg Police Department	0	0	0
Fire Protection			
Bannock County			
Chubbuck Fire Department	0	0	0
Pocatello Fire Department	0	1	0
Bingham County			
Blackfoot Fire Department	1	1	0
Bonneville County			
Ammon Fire Department	1	2	1
Idaho Falls Fire Department	4	8	2
Butte County			
Arco Fire Department	2	3	1
Jefferson County			
Rigby Fire Department	1	2	0
Madison County			
Rexburg Fire Department	0	0	0

^aNot available.

5.3.8.3 Impacts of NPR Operation

Employment and Income

A summary of operational work force requirements is presented in Table 5.3.8-6. Estimates range from 1,662 (HWR) to 2,334 (MHTGR) persons. These estimates reflect maximum operational work force requirements for the reactor and facilities.

The effect of HWR operation on annual earnings is estimated to be the same as for the LWR -- about \$155 million in additional earnings each year. Operation of an MHTGR is expected to increase annual earnings by \$186 million. This effect would increase personal income by 8% over the 1986 level. Direct, indirect, and secondary effects of operation for all alternatives would result in employment of more than 9,660 people per year, an increase of 7% from the 1988 regional employment level. Under all alternatives, an NPR would substantially benefit the INEL area's economy through higher regional employment and higher personal income.

Impacts to agriculture during NPR operation could occur as a result of reactor or support facility accidents (Section 5.3.6) if releases exceeded protective action guidelines and resulted in impoundment of area field crops, vegetables, or livestock. (These commodities had a combined value of \$531 million in 1988 in the ROI counties). These accidents are highly unlikely to occur during the lifetime of the NPR, with a probability of occurrence of about 10^{-4} to 10^{-6} . Such impacts might carry over to branded categories of food products including Idaho potatoes. Appendix I identifies the highly unlikely accidents that might result in the impoundment of food crops to protect human health. Impacts on tourism are discussed in Section 5.8.3.

Population Characteristics

The NPR operation would increase regional population by about 2% for all alternatives. Since construction precedes operation, a minimal increment to regional population growth is projected for all alternatives. The greatest socioeconomic effects, for MHTGR operation, would lead to a 2% increase (6,000 persons) in regional population. Impacts of LWR operation would be nearly equivalent to those of HWR operation, but the infrastructure added during HWR construction would probably negate any additional needs for HWR operation.

Housing

The greatest housing impacts as a consequence of NPR operation at INEL are anticipated to accompany the MHTGR alternative (Table 5.3.8-7). The greatest increase in housing demand under the MHTGR alternative (1,505 housing units) would occur in Bonneville County. The community of Idaho Falls would require more than 1,300 housing units to accommodate projected in-migrants. These increases in demand would be noticeable in both Bonneville County and Idaho Falls, in each case exceeding the number of housing permits issued for any year during the 1980s. Anticipated housing impacts to Bingham and Jefferson counties, though estimated to be much smaller in absolute terms than those to Bonneville County, nevertheless would exceed the number of housing construction permits issued for any year during the 1980s.

**TABLE 5.3.8-6 Estimated NPR Operations-Related
 Changes in Employment and Population in the INEL ROI,
 by NPR Technology**

Employment/In-Migration	HWR	LWR	MHTGR
Annual employment			
Direct employment	1,662	1,808	2,334
Indirect employment	4,986	5,424	7,002
Increase in employment	6,648	7,232	9,336
Increase in employment (%)	3	3	4
In-migration			
Direct NPR worker	3,242	3,525	4,552
in-migrating population			
Indirect worker	1,138	1,241	1,598
in-migrating population			
Total in-migrants	4,380	4,766	6,150
Increase in population (%)	2	2	2

**TABLE 5.3.8-7 Estimated In-Migrant Housing
 Demand for NPR Peak Operations Year in the
 INEL ROI, by NPR Technology**

Location	HWR	LWR	MHTGR
Bannock County	112	122	157
Chubbuck	16	17	22
Pocatello	96	104	135
Bingham County	224	244	315
Blackfoot	112	122	157
Shelley	48	52	67
Bonneville County	1,072	1,166	1,505
Ammon	80	87	112
Idaho Falls	928	1,010	1,303
Butte County	48	52	67
Arco	32	35	45
Jefferson County	96	104	135
Rigby	64	70	90
Madison County	16	17	22
Rexburg	16	17	22
INEL ROI	1,568	1,705	2,201

Anticipated housing impacts of the LWR alternative would be less than those of the MHTGR; HWR-related impacts would be slightly less than those of the LWR (Table 5.3.8-7). For both the LWR and HWR, housing impacts would be the greatest in Bonneville County, greatly exceeding the number of housing construction permits issued there for any year during the 1980s. Similarly, though much lower than the MHTGR alternative, housing impacts projected to accompany the HWR or LWR in Bingham and Jefferson counties would be greater than the annual number of building permits issued between 1980 and 1990.

Public and Community Services

Education. Impacts to public education arising from NPR operation at INEL are presented in Table 5.3.8-8. Enrollment impacts in the ROI would be greatest under the MHTGR alternative, with more than 1,450 additional students; 66 additional teachers would be needed to maintain existing student/teacher ratios. Impacts under the HWR and LWR alternatives would be smaller: 1,037 students and 47 teachers for the HWR alternative and 1,129 students and 51 teachers for the LWR alternative.

As during construction, impacts to public education would be greatest in the Bonneville County school districts of Idaho Falls #91 and Bonneville #93. Operation of the MHTGR would result in enrollment impacts of 565 students in the already overcrowded Idaho Falls School District #91 and 424 students in Bonneville School District #93. Instructional staff required to maintain existing student/teacher ratios would be 25 additional teachers in Idaho Falls School District #91 and 20 additional teachers in Bonneville School District #93. Enrollment and teaching staff impacts would be less under the HWR and LWR alternatives (Table 5.3.8-8).

In addition to Idaho Falls School District #91, the seven other school districts in the ROI operating at capacity --Blackfoot School District #55, Jefferson County School District #251, Arco School District #111, Snake River School District #52, Madison School District #321, Firth School District #59, and Ririe School District #252 -- would experience further crowding during operation of any NPR alternative.

Health Care. Health care impacts were considered for the construction of the NPR as a worst case scenario. Operational impacts would not be expected to adversely affect health care facilities.

Police and Fire Protection. Potential impacts to police protection resulting from NPR operation under all three alternatives are presented in Table 5.3.8-9. As with peak construction impacts, these projections reflect the distribution of NPR-generated population impacts and the increased demand for local public services arising from in-migration during NPR operation. Under all three alternatives, impacts would be experienced by at least 6 of the 14 police departments in the ROI. The Bonneville County Sheriff's Office would experience the greatest demand, with 9 additional officers during operation of the MHTGR alternative, 7 officers for the LWR, and 6 officers for the HWR. The Bannock County Sheriff's Office, Pocatello Police Department, Bingham County Sheriff's Office, Blackfoot Police Department, and Idaho Falls Police Department would have to increase their staff sizes (by up to 6 additional sworn officers

TABLE 5.3.8-8 Estimated NPR Operations-Related Impacts to Public Education in the INEL ROI, by NPR Technology

County/ School District	Enrollment Impacts			Teacher Impacts		
	HWR	LWR	MHTGR	HWR	LWR	MHTGR
Bannock County	74	81	104	3	4	5
Marsh Valley No. 21	0	0	0	0	0	0
Pocatello No. 25	74	81	104	3	4	5
Bingham County	148	161	208	7	8	10
Snake River No. 52	24	26	34	1	1	2
Blackfoot No. 55	74	81	104	4	4	5
Aberdeen No. 58	8	9	12	0	0	0
Firth No. 59	10	11	14	0	1	1
Shelley No. 60	32	35	45	1	2	2
Bonneville County	709	771	995	32	35	45
Idaho Falls No. 91	403	438	565	18	19	25
Swan Valley No. 92	4	4	5	0	0	0
Bonneville No. 93	302	329	424	14	15	20
Butte County	32	35	45	2	2	2
Arco No. 111	32	35	45	2	2	2
Jefferson County	63	69	89	3	3	4
Jefferson No. 251	46	50	65	2	2	3
Ririe No. 252	8	9	11	0	0	1
West Jefferson No. 253	9	10	13	0	0	1
Madison County	11	12	15	0	0	1
Madison No. 321	11	12	15	0	0	1
Sugar-Salem No. 322	0	0	0	0	0	0
INEL ROI	1,037	1,129	1,456	47	52	67

at the Idaho Falls Police Department during operation of the MHTGR alternative) to meet increased demand arising during NPR operation while maintaining existing levels of police protection.

Projected operational impacts to fire protection services under all three NPR alternatives are presented in Table 5.3.8-9. As with police protection, these impacts would follow the distribution of population impacts and would reflect the increased demand for public services arising from in-migration during NPR operation. Five of the eight fire departments in the ROI would experience increased demand during NPR operation under all three alternatives (the Blackfoot, Ammon, Idaho Falls, Arco, and Rigby fire departments). The Idaho Falls Fire Department would experience the greatest impacts, needing five additional fire fighters for MHTGR and four for HWR or LWR operation.

TABLE 5.3.8-9 Estimated NPR Operations-Related Impacts to Police and Fire Protection Services (additional professionals needed) in the INEL ROI, by NPR Technology

County/Agency	HWR	LWR	MHTGR
Police Protection			
Bannock County			
Bannock County Sheriff's Office	2	2	2
Chubbuck Police Department	0	0	0
Pocatello Police Department	1	1	2
Bingham County			
Bingham County Sheriff's Office	1	1	1
Blackfoot Police Department	1	1	1
Shelley Police Department	0	0	0
Bonneville County			
Bonneville County Sheriff's Office	6	7	9
Idaho Falls Police Department	4	4	6
Butte County			
Butte County Sheriff's Office	0	0	1
Arco Police Department	0	0	0
Jefferson County			
Jefferson County Sheriff's Office	0	0	1
Rigby Police Department	0	0	0
Madison County			
Madison County Sheriff's Office	0	0	0
Rexburg Police Department	0	0	0
Fire Protection			
Bannock County			
Chubbuck Fire Department	0	0	0
Pocatello Fire Department	0	0	0
Bingham County			
Blackfoot Fire Department	1	1	1
Bonneville County			
Ammon Fire Department	1	1	2
Idaho Falls Fire Department	4	4	5
Butte County			
Arco Fire Department	1	1	2
Jefferson County			
Rigby Fire Department	1	1	1
Madison County			
Rexburg Fire Department	0	0	0

Public Finances

See the discussion of NPR-related fiscal impacts in Section 5.3.8.2.

5.3.8.4 Mitigation and Conclusions

Among the alternatives considered, an LWR would have the largest socioeconomic impacts and an MHTGR the smallest during construction. The MHTGR alternative would have the greatest impacts during operation. The LWR alternative would impact both housing and schools. Although some new schools are under construction, increased enrollments related to the LWR would expand the system nearly to its capacity. Payments in lieu of taxes or grants equivalent to taxes might be necessary to offset these impacts.

Uncertainties associated with (1) the timing, numbers, and composition of an in-migrating work force and (2) the probable settlement patterns of in-migrants preclude precise estimation of socioeconomic impacts. Hence, a Socioeconomic Monitoring and Mitigation Plan would be developed. This plan would provide for (1) periodic surveys of employees and affected communities and (2) a claims process to systematically identify, review, negotiate, and resolve issues related to local area impacts.

5.3.9 Transportation Systems

This section addresses the impacts of increased requirements for transportation of workers and nonradioactive materials to INEL and the surrounding area. Transportation of radioactive materials is addressed in Section 5.3.6. The changes in the vehicle miles traveled (VMT)* associated with increases in baseline population and activity during construction and operation of the three reactor technologies are provided in Figure 5.3.9-1.

5.3.9.1 Impacts of No Action

If an NPR were not constructed and operated at INEL, the existing transportation environment would remain as described in Section 4.2.9. Changes in population due to non-NPR activities at INEL and in the surrounding communities would affect transportation. Any increases in the general population of the region would cause corresponding increases in traffic congestion, truck traffic, and vehicular accidents. Projected population changes in the INEL area are identified in Section 4.2.8. Improvements to existing roadways that might be initiated in response to increased regional population are discussed in Section 4.3.9.

5.3.9.2 Impacts of NPR Construction

The construction of NPR facilities would require additions to the INEL work force (Section 5.3.8). In addition, construction materials, wastes, and excavated materials would be transported both on-site and off-site. These activities would result in increases in operation of

*1 vehicle mile traveled = 1.609 vehicle kilometers traveled.

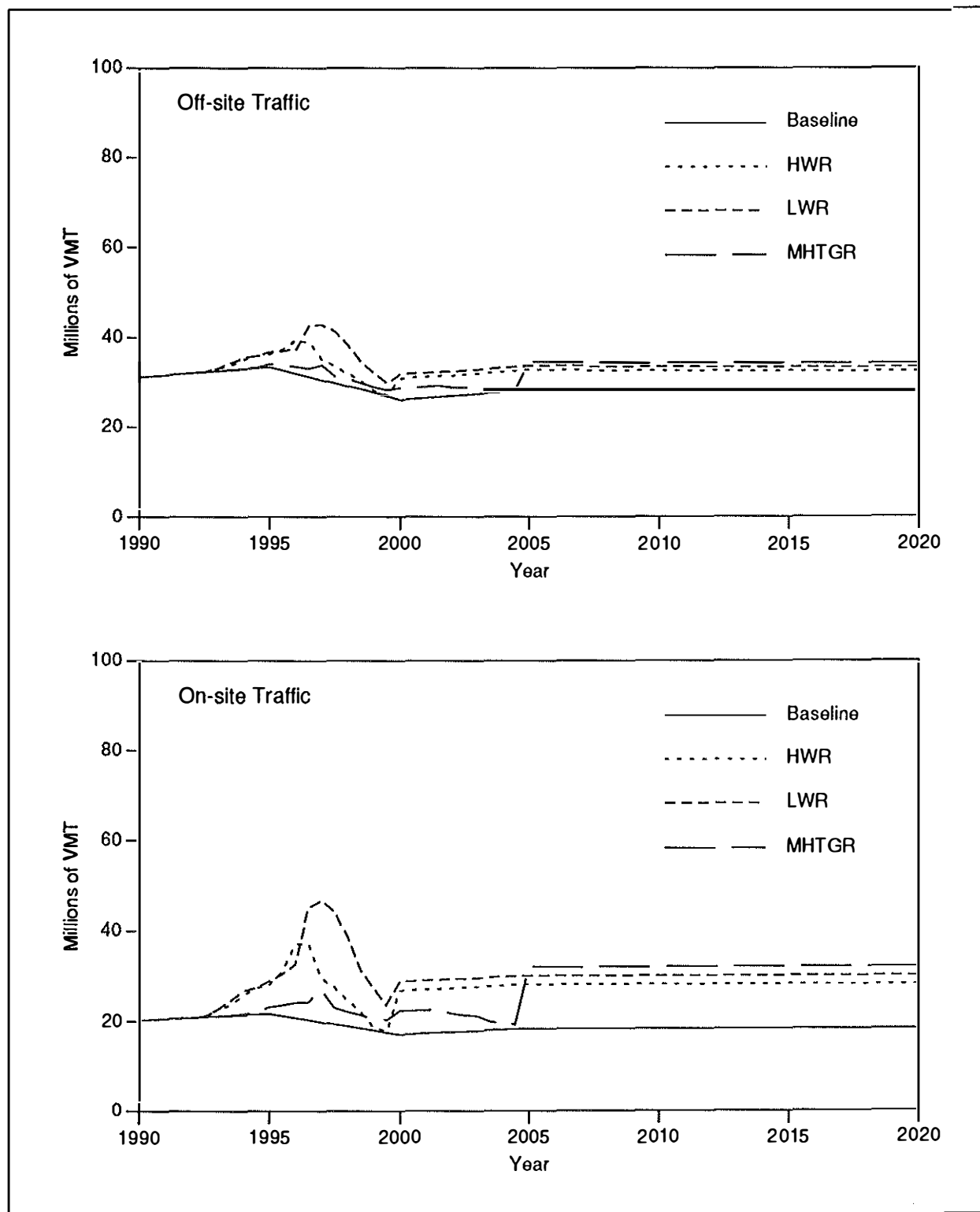


FIGURE 5.3.9-1 On-site and Off-site Traffic at INEL

personal-use vehicles by commuting construction workers, in commercial truck traffic, and in traffic associated with daily operations of INEL.

This analysis addresses traffic congestion, increased truck traffic and associated fatalities and injuries, and potential road damage during construction for the three NPR technologies. Impacts are summarized in Tables 5.3.9-1 and 5.3.9-2 and are discussed in the following paragraphs.

Traffic Congestion

An estimate of the level of service indicated that growth in the local population and the NPR work force would probably cause no additional overloading and delays during peak traffic periods on roadways in the INEL vicinity. Traffic congestion would not be a significant problem.

Truck Traffic

The number of trucks required to transport the construction materials and excavated earth has been estimated on the basis of a 40,000-lb load per truck. The daily number of trips by trucks transporting excavation materials, gravel, and sand on the site during the construction period would be 132 for the HWR, 71 for the LWR, and 183 for the MHTGR. Transportation of other construction materials would add 12 truck trips daily on the site and on off-site highways for the HWR, 12 trips for the LWR, and 21 trips for the MHTGR. Such truck traffic would not be a nuisance. Given compliance with state and Federal loading and speed regulations, truck traffic would not significantly damage the roadbed.

Vehicular Accidents

The expected increase in fatal accidents during the construction of the NPR was estimated from the statewide statistics for 1988. The estimated total number of additional annual fatalities at INEL during construction would be 0.18 for the HWR, 0.37 for the LWR, and 0.08 for the MHTGR. Additional annual off-site traffic fatalities would number 0.08 for the HWR, 0.17 for the LWR, and 0.04 for the MHTGR. The baseline rates during this period are 0.56 and 0.87, for on-site and off-site fatalities, respectively. Therefore, the increases caused by the NPR would not be significant.

Barge and Rail Transportation

The limited use of rail transport to INEL during NPR construction, primarily for heavy equipment and coal, would cause no significant impact. No navigable waterways exist in the vicinity of INEL to permit direct barge transport.

TABLE 5.3.9-1 Potential Impacts on Peak Period Performance of Off-site Transportation Routes due to Transportation of Workers and Nonradioactive Materials in the INEL Vicinity

Reactor	Typical Route ^a	Impact (Level of Service) ^b		
		1988 Baseline	Construction	Operation
HWR	US 20	Free flow	Free flow	Free flow
	US 26	Free flow	Free flow	Free flow
	US 20/26	Free flow	Free flow	Free flow
LWR	US 20	Free flow	Free flow	Free flow
	US 26	Free flow	Free flow	Free flow
	US 20/26	Free flow	Free flow	Free flow
MHTGR	US 20	Free flow	Free flow	Free flow
	US 26	Free flow	Free flow	Free flow
	US 20/26	Free flow	Free flow	Free flow

^aUS = Federal (U.S.) route. The amount of NPR-related traffic on these routes would not represent a significant degree of nuisance.

^bEstimated levels of service based on NUS-1 (Table 7-2). See Section 5.1.10 for definitions.

TABLE 5.3.9-2 Potential Fatalities from Transportation of Workers and Nonradioactive Materials at INEL and Vicinity

Reactor	NPR Activity	Applicable Time Period (years)	Fatality Rate ^a (per year)	
			On-site	Off-site
HWR	Construction	8	0.18	0.08
	Operation	40	0.29	0.13
LWR	Construction	7	0.37	0.17
	Operation	40	0.35	0.16
MHTGR	Construction	12	0.08	0.04
	Operation	35	0.41	0.19
Baseline population		50	0.56	0.87

^aFatalities based on state rates for all vehicles.

5.3.9.3 Impacts of NPR Operation

Traffic Congestion

During NPR operations, no traffic congestion would be anticipated for any reactor technology.

Truck Traffic

The amount of truck traffic would be considerably less during NPR operations than during construction. If the nonhazardous operational material were transported by truck, the total number of trucks per day transporting operational material would be about 2 for the HWR and LWR and about 12 for the MHTGR.

Vehicular Accidents

The additional annual on-site fatalities estimated during operation of the NPR would be 0.29 for the HWR, 0.35 for the LWR, and 0.4 for the MHTGR. Additional annual fatalities off-site would number 0.13, 0.16, and 0.19 for the three technologies, respectively. In comparison with the annual baseline fatality rates of 0.56 and 0.87 (on-site and off-site, respectively), no significant impacts would be expected.

Barge and Rail Transportation

During NPR operations, only limited rail transport of materials would occur, and thus no significant impacts would be expected. No barge transport would occur.

5.3.9.4 Mitigation and Conclusions

No mitigative steps would be required at INEL.

5.3.10 Waste Management

This section describes the impacts to site waste management facilities from the construction and operation of the three NPR technologies at INEL. The impacts of the no-action alternative are also discussed. The analysis is organized by major activity: no-action alternative, construction, and operation. The section on the impacts of NPR operations is subdivided by waste type. Where applicable, differences in impacts between the candidate technologies are also presented. The last section presents conclusions and mitigation requirements.

The quantities and types of wastes to be managed depend upon whether or not spent fuel is reprocessed and whether or not plutonium is produced, as well as on the extent to which existing reactors continue to operate in the future. Estimates in this section were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium

produced. If it is decided not to continue those activities, the impacts upon waste management systems from NPR operations would be less than presented in this section. This could also reduce the amounts of cumulative wastes presented in this section.

5.3.10.1 Impacts of No Action

The no-action alternative at INEL would result in no new production capacity at the site. The processing of spent fuel and waste from the Naval Fuels Program and the various research reactors at the site would continue at the waste management facilities outlined in Section 4.2.10. The existing and proposed waste management facilities would process the existing inventory and any newly generated high-level calcine waste into a glass ceramic after 2011 for off-site disposal at a Federal repository. The inventory of stored TRU waste would be packaged and certified and then shipped off-site for disposal at WIPP when that facility becomes operational. Low-level waste and mixed waste would be treated at the Waste Experimental Reduction Facility. Low-level waste would be disposed of on-site; mixed waste would be disposed of off-site per future DOE and EPA regulations for this waste type. Hazardous and other waste would continue to be handled in a manner necessary to meet regulatory requirements.

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

5.3.10.2 Impacts of NPR Construction

Construction of NPR facilities at INEL would generate wastewater, nonhazardous solid waste, and hazardous waste. Construction wastes are described in Appendix M. Construction waste would be managed by INEL's existing waste management system for wastewater, other waste, and hazardous waste as outlined in Section 4.2.10. No significant impacts to the waste management system at INEL are expected from the generation of NPR-related construction waste. Those waste input volumes could be handled by existing waste treatment and disposal facilities. No new facilities would be required. The waste volumes associated with construction of the three NPR technologies are presented in Table 5.3.10-1.

TABLE 5.3.10-1 Construction Waste Volumes at INEL,
 by NPR Technology (m³/yr)

Waste Type	HWR	LWR	MHTGR
Wastewater ^a	35,000	40,000	4,000 ^b
Nonhazardous solid waste ^c	9,000	20,000	9,000
Hazardous waste ^c	22	46	25

^aWastewater volumes based on total peak-year use for system flushing.

^bWastewater volume for MHTGR based on a flush of secondary system ten times, and no primary system flush.

^cNonhazardous solid waste and hazardous waste are yearly average over the construction period.

Sources: Values derived from data in EG&G-2, -6, -7.

5.3.10.3 Impacts of NPR Operation

Normal operation of the NPR and its support facilities at INEL would generate waste that requires environmentally sound treatment, storage, and disposal procedures that comply with applicable regulations. This waste would be similar to the solid and liquid waste generated by non-NPR facilities at INEL (Section 4.2.10) (EG&G-6; EG&G-7). The various waste types are described in Appendix M.

The environmental effects of NPR-generated waste would depend on the ability of INEL waste management facilities to effectively treat and dispose of waste from both NPR and non-NPR sources. For this EIS, it was assumed that INEL waste management facilities would be capable of operating at original design capacity throughout the active life of the NPR project. Potential adverse impacts are noted for situations in which NPR-related waste would exceed by 80% or more the available capacity of a site facility to process or store waste streams containing NPR and non-NPR waste.

The "available capacity" of a site waste management facility refers to the difference between the design capacity of that facility and the input of waste from active non-NPR operations at INEL. At INEL, operations waste represent most of the non-NPR waste input to waste management facilities. Inputs from inventory waste awaiting treatment are not included in the quantification of non-NPR operations waste inputs or in the determination of available capacity. (See Table 4.2.10-1 for volume estimates.)

Because the quantity of stored high-level waste at INEL is relatively small, the processing of this inventory waste can easily be merged with the processing of NPR operations waste. Therefore, the placement of NPR facilities at INEL would have little impact on the capability of continued inventory waste processing.

The processing and disposal of NPR-related waste would be integrated into INEL's existing waste management system. Radioactive waste would be processed at the Idaho Chemical Processing Plant, Radioactive Waste Management Complex, Waste Experimental Reduction Facility, and other facilities mentioned in Section 4.2.10. Nonradioactive other waste would be handled at the Central Facilities Area, and nonradioactive liquid waste would be treated as service waste and disposed of via evaporation ponds. Schematics describing the routing of NPR-related waste at INEL are presented in Figures M.22 through M.39. Section M.4 discusses the storage, treatment, and disposal of NPR-related waste at INEL. Individual NPR facilities would process waste, as necessary, to provide a material acceptable for input to the appropriate INEL waste handling facility (EG&G-2; EG&G-6; EG&G-7).

The quantities of waste generated would vary among the three reactor technologies. Also, the volume of waste generated would differ for the tritium and plutonium production modes. The waste management assessments in this EIS are based on upper-bound estimates of waste volumes, that is, on the larger of the waste volumes for each waste stream generated by full-time tritium production or full-time plutonium production.

Effects of NPR-Related Waste on INEL Waste Management Facilities

The quantities and types of waste that would be generated by NPR operations at INEL are summarized in Tables 5.3.10-2 and 5.3.10-3. The NPR-related waste data are derived from the references cited in Section 5.3.10.2. The non-NPR INEL operations waste inputs and the capacities of the affected INEL waste management facilities are also given in the tables. The utilization of site waste management capacities resulting from NPR waste inputs is given in Tables 5.3.10-4 and 5.3.10-5. The discussions of the percentage of available capacity are based on the data in these tables. Overall, the input of TRU waste, hazardous waste, and other nonradioactive waste from NPR operations would not adversely affect waste management facilities at INEL. The addition of NPR-generated HLW, mixed waste, and some LLW might adversely affect specific INEL waste management facilities.

High-Level Waste

Inputs of HLW from NPR operations to the New Waste Calcining Facility would range from a high of 8% of the total facility capacity for the MHTGR technology to less than 1% for the HWR technology. However, the addition of NPR-related waste from HWR would require 20% of the available processing capacity of the calcining facility. The waste from LWR would require 70% and from MHTGR 100% of available capacity. Expansion of calcination capacity would be required to adequately accommodate the NPR and baseline operations. The environmental impact of such facility expansion will be discussed as part of the programmatic environmental restoration and waste management EIS that is currently being prepared. The input of NPR-generated calcined HLW to the Calcined Solids Storage Facility would represent less than 3% of the non-NPR operations input of calcine to storage. Given the removal of calcine for processing into vitrified ceramic at the planned Waste Immobilization Facility beginning in 2011, the available capacity at the Calcined Solids Storage Facility would be sufficient to contain both the NPR and non-NPR operations calcine generated prior to 2011. The drawdown of calcine from storage would open up sufficient storage to contain all calcine generated at INEL after 2011.

TABLE 5.3.10-2 Comparison of Annual Waste Management Facility Inputs from NPR Operations in the Tritium Production Mode and Non-NPR Operations at INEL between 2000 and 2040

Waste Identification	Facility Description	Facility Input Capacity ^a (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^b (m ³ /yr)
			HWR	LWR	MHTGR	
High-level waste						
Liquid	Storage tanks	15,200	43	140	140	3,700
Solid	New Waste Calcining Facility	4,000	43	140	140	3,700
	Calcined Solids Storage Facility	10,000	5	23	1	740
	Waste Immobilization Facility	1,300	5	23	1	740
	Interim storage	Expandable	3	15	1	500
Transuranic waste						
Solid ^c	Transuranic Storage Area	595,000	2	100	8	2,800
	Process Reduction Experimental Pilot Plant ^d	Expandable	0	80	0	Variable
	Stored Waste Examination Pilot Plant	Expandable	2	35	8	2,800
	Interim storage	Expandable	2	20	8	2,800
Low-level waste						
Liquid	Process Equipment	15,000	560	6,800	200	8,000
Solid ^e	Waste Evaporator					
	Subsurface Disposal Area	100,000	70	800	150	1,000
	Waste Experimental Reduction Facility					
	Compactor input	1,700	650	400	320	760
	Incinerator input	7,500	1,100	500	280	1,500
	Noncompacted input	Expandable	1,800	2,200	1,200	2,700
	Subsurface Disposal Area	100,000	2,000	2,200	1,300	2,900
Mixed waste						
Solid ^c	Radioactive Mixed Waste Storage Facility	Full	85	160	3	12
Hazardous waste						
Liquid and solid	Hazardous Waste Shipping Facility	Expandable	22	1,100	25	180
Other waste						
Nonhazardous						
Liquid	Cooling Tower Blowdown Evaporation Pond	Expandable	7,600,000	4,200,000	6,800,000	0
Solid	Evaporation ponds	Expandable	190,000	48,000	260,000	33,000
	Central Facilities Area Landfill	Expandable	5,200	9,000	6,100	37,000

TABLE 5.3.10-2 (Cont'd)

Waste Identification	Facility Description	Facility Input Capacity ^a (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^b (m ³ /yr)
			HWR	LWR	MHTGR	
Sewage Liquid ^d	Sanitary tile field-NPR	Expandable	23,000	38,000	26,000	0
	Sanitary tile fields	Expandable	12,000	22,000	14,000	230,000
Solid ^e	Central Facilities Area landfill	Expandable	1	1	1	5

^aFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^bNon-NPR operations values projected from 1988 data; values do not include processing of stored waste.

^cLiquids containing transuranics are processed as HLW.

^dAlthough the Process Reduction Experimental Pilot Plant will not be operational at NPR startup, the analysis in this document assumes the existence of a facility with similar capabilities.

^eSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

Sources: Bowman-7, -8; Bulmahn 1990; EG&G-2, -6, -7.

The input of NPR-related calcined solids to the Waste Immobilization Facility (vitrification) would represent less than 1% of the available facility capacity for the HWR and MHTGR technologies and 6% for the LWR technology. Non-NPR inputs to that facility would represent less than 60% of capacity. No increase in vitrification capacity would be required.

At INEL, the volume of NPR-related HLW needing to be disposed of is projected to be significantly lower than the volumes projected for the other two sites (Section 5.6).

Two factors account for the low volume of NPR-generated HLW at INEL. The first is the coprocessing of spent fuel from the Naval Fuel Program with spent fuel from the NPR. Such coprocessing is an effective volume reduction technique that takes advantage of certain chemical and material requirements. Specifically, dissolution of the zirconium-clad naval fuel produces solutions with high concentrations of fluoride ion. Because fluoride compounds tend to be highly soluble, direct conversion of such solutions into a ceramic-like solid at the Waste Immobilization Facility would produce a product with undesirable leachability characteristics (see Appendix M for a general description of vitrification).

The negative effects of the fluoride ion upon vitrified solids can be eliminated by adding aluminum to the process. The aluminum ion strongly binds the fluoride ions, resulting in a solid product with low leachability. In coprocessing of NPR-related HWR spent fuel, a significant portion of the needed aluminum is supplied by the HWR fuel cladding. The coprocessing of the aluminum-rich, high-level waste from NPR spent fuel dissolution with the Naval Fuel Program

TABLE 5.3.10-3 Comparison of Annual Waste Management Facility Inputs from NPR Operations in the Plutonium Production Mode and Non-NPR Operations at INEL between 2000 and 2040

Waste Identification	Facility Description	Facility Input Capacity ^a (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^b (m ³ /yr)
			HWR	LWR	MHTGR	
High-level waste						
Liquid	Storage tanks	15,200	60	210	310	3,700
Solid	New Waste Calcining Facility	4,000	60	210	310	3,700
	Calcined Solids Storage Facility	10,000	7	33	4	740
	Waste Immobilization Facility	1,300	7	33	4	740
	Interim storage	Expandable	4	21	3	500
Transuranic waste						
Solid ^c	Transuranic Storage Area	595,000	190	280	240	2,800
	Process Reduction Experimental Pilot Plant ^d	Expandable	74	260	31	Variable
	Stored Waste Examination Pilot Plant	Expandable	120	70	210	2,800
	Interim storage	Expandable	110	20	200	2,800
Low-level waste						
Liquid	Process Equipment	15,000	560	9,900	200	8,000
	Waste Evaporator					
	Subsurface Disposal Area	100,000	70	1,200	150	1,000
Solid ^e	Waste Experimental Reduction Facility					
	Compactor input	1,700	780	300	1,400	760
	Incinerator input	7,500	720	400	1,000	1,500
	Noncompacted input	Expandable	2,000	2,300	4,900	2,700
	Subsurface Disposal Area	100,000	2,200	2,400	5,300	2,900
Mixed waste						
Solid ^e	Radioactive Mixed Waste Storage Facility	Full	420	160	6	12
Hazardous waste						
Liquid and solid	Hazardous Waste Shipping Facility	Expandable	43	300	59	180
Other waste						
Nonhazardous						
Liquid	Cooling Tower Blowdown Evaporation Pond	Expandable	7,200,000	4,200,000	6,800,000	0
	Evaporation ponds	Expandable	500,000	72,000	690,000	33,000
Solid	Central Facilities Area Landfill	Expandable	7,700	7,300	10,000	37,000

TABLE 5.3.10-3 (Cont'd)

Waste Identification	Facility Description	Facility Input Capacity ^a (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^b (m ³ /yr)
			HWR	LWR	MHTGR	
Sewage Liquid ^f	Sanitary tile field-NPR	Expandable	19,000	27,000	34,000	0
	Sanitary tile fields	Expandable	32,000	22,000	35,000	230,000
Solid ^g	Central Facilities Area Landfill	Expandable	1	1	1	5

^aFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^bNon-NPR operations values projected from 1988 data; values do not include processing of stored waste.

^cLiquids containing transuranics are processed as HLW.

^dAlthough the Process Reduction Experimental Pilot Plant will not be operational at NPR startup, the analysis in this document assumes the existence of a facility with similar capabilities.

^eSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

Sources: Bowman-7, -8; Bulmahn 1990; EG&G-2, -6, -7.

high-level waste would result in less solid HLW than would be produced by separate processing of the two fuels.

Although for a different reason, a similar benefit would be derived from blending high-level liquid waste from MHTGR spent fuel dissolution with the high-level waste from processing of naval reactor fuels. In this case, it would be the high concentration of uranium in the MHTGR spent fuel that provided the overall waste volume reduction.

Because the LWR alternative fuel is both zirconium-clad and low in uranium enrichment, neither coprocessing nor blending could be effectively applied as a volume reduction technique.

The second factor contributing to the low amount of high-level waste generated at INEL is related to the nature of the solidified product. At INEL, the Waste Immobilization Facility will produce a crystalline ceramic product capable of sustaining a waste loading that is about 2.5 times greater than that possible with alternative glass-like products. This higher loading capability results in a smaller final product volume.

TABLE 5.3,10-4 Impacts to INEL Waste Management Facilities Resulting from NPR Operations in the Tritium Production Mode between 2000 and 2040

Waste Identification	Facility Description	Percentage of Available Capacity ^a Used		
		HWR Input	LWR Input	MHTGR Input
High-level waste				
Liquid	Storage tanks	<1	2	2
Solid	New Waste Calcining Facility	14	47	47
	Calcined Solids Storage Facility	<1	<1	<1
	Waste Immobilization Facility	1	4	<1
	Interim storage	b	b	b
Transuranic waste				
Solid ^c	Transuranic Storage Area	<1	<1	<1
	Process Reduction Experimental Pilot Plant ^d	b	b	b
	Stored Waste Examination Pilot Plant	b	b	b
	Interim storage	b	b	b
Low-level waste				
Liquid	Process Equipment Waste Evaporator	8	97	3
	Subsurface Disposal Area	<1	1	<1
Solid ^e	Waste Experimental Reduction Facility			
	Compactor input	69	43	34
	Incinerator input	18	8	5
	Noncompacted input	b	b	b
	Subsurface Disposal Area	2	2	1
Mixed waste				
Solid ^e	Radioactive Mixed Waste Storage Facility	b	b	b
Hazardous waste				
Liquid and solid	Hazardous Waste Shipping Facility	b	b	b
Other waste				
Nonhazardous				
Liquid	Cooling Tower Blowdown Evaporation Pond	b	b	b
	Evaporation ponds	b	b	b
Solid	Central Facilities Area Landfill	b	b	b
Sewage				
Liquid ^f	Sanitary tile field-NPR	b	b	b
	Sanitary tile fields	b	b	b
Solid ^g	Off-site disposal	b	b	b

TABLE 5.3.10-4 (Cont'd)

^aAvailable capacity is the facility capacity reduced by the amount needed for non-NPR operations; non-NPR operations do not include the processing of stored waste.

^bPercentage of available capacity used is not applicable because the facility capacity is expandable.

A separate EIS will review expansions in waste management facility capacities.

^cLiquids containing transuranics are processed as HLW.

^dAlthough the Process Reduction Experimental Pilot Plant will not be operational at NPR startup, the analysis in this document assumes the existence of a facility with similar capabilities.

^eSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

Transuranic Waste

The TRU waste generated by NPR operations would represent 10% or less of the TRU waste generated by INEL non-NPR operations (2,800 m³/yr). The TRU waste would be certified at the Stored Waste Examination Pilot Plant to meet WIPP disposal criteria. The largest NPR input would be the 210 m³/yr of TRU waste generated by the MHTGR technology. The capacity to examine and certify packaged TRU would remain flexible and would depend primarily on staff scheduling at the Stored Waste Examination Pilot Plant. No expansion of the assay facilities at this plant would be required to handle the additional NPR-related TRU waste. The NPR input of unprocessed TRU waste to a facility with capabilities similar to those of the original Process Reduction Experimental Pilot Plant would represent a small amount of its available capacity. The drawdown of the non-NPR TRU waste inventory at INEL would utilize the remaining capacity. No increase in the capacity of the Process Reduction Experimental Pilot Plant would be required to accommodate the additional NPR-related TRU waste.

Low-Level Waste

Liquid low-level radioactive waste is concentrated to a high-activity stream at the Process Equipment Waste Evaporator. The resultant high-activity concentrate is added to the high-level liquid waste stream for processing. The low-activity condensate is sent to the Liquid Effluent Treatment and Disposal Facility for further processing.

For the LWR technology, the NPR liquid LLW going to the Process Equipment Waste Evaporator would require 76% of available capacity. The HWR and MHTGR technologies would require 4% and 2%, respectively. The facility would not have to be expanded to accommodate the additional LLW generated by NPR operations.

Adding NPR-generated LLW to the load now handled at the Waste Experimental Reduction Facility would overload the waste compaction capacity of the facility by 150% for the MHTGR technology. The HWR and LWR technologies would require 83% and 43%,

TABLE 5.3.10-5 Impact to INEL Waste Management Facilities Resulting from NPR Operations in the Plutonium Production Mode between 2000 and 2040

Waste Identification	Facility Description	Percentage of Available Capacity ^a Used			Comment
		HWR Input	LWR Input	MHTGR Input	
High-level waste					
Liquid	Storage tanks	1	2	4	
Solid	New Waste Calcining Facility	20	70	100	High percentages limit the capacity available for processing stored waste
	Calcined Solids Storage Facility	<1	<1	<1	
	Waste Immobilization Facility	1	6	1	
	Interim storage	b	b	b	
Transuranic waste					
Solid ^c	Transuranic Storage Area	<1	<1	<1	
	Process Reduction Experimental Pilot Plant ^d	b	b	b	
	Stored Waste Examination Pilot Plant	b	b	b	
	Interim storage	b	b	b	
Low-level waste					
Liquid	Process Equipment Waste Evaporator	8	141	3	
	Subsurface Disposal Area	<1	1	<1	
Solid ^e	Waste Experimental Reduction Facility				
	Compactor input	83	32	150	Percentages higher than 100% indicate waste generation rates that exceed the processing capacity
	Incinerator input	12	7	17	
	Noncompacted input	b	b	b	
	Subsurface Disposal Area	2	2	5	
Mixed waste					
Solid ^e	Radioactive Mixed Waste Storage Facility	b	b	b	
Hazardous waste					
Liquid and solid	Hazardous Waste Shipping Facility	b	b	b	
Other waste					
Nonhazardous					
Liquid	Cooling Tower Blowdown Evaporation Pond	b	b	b	
	Evaporation ponds	b	b	b	
Solid	Central Facilities Area Landfill	b	b	b	

TABLE 5.3.10-5 (Cont'd)

Waste Identification	Facility Description	Percentage of Available Capacity ^a Used			Comment
		HWR Input	LWR Input	MHTGR Input	
Sewage Liquid ^f	Sanitary tile field-NPR	b	b	b	
	Sanitary tile fields	b	b	b	
Solid ^g	Off-site disposal	b	b	b	

^aAvailable capacity is the facility capacity reduced by the amount needed for non-NPR operations; non-NPR operations do not include the processing of stored waste.

^bPercentage of available capacity used is not applicable because the facility capacity is expandable. A separate EIS will review expansions in waste management facility capacities.

^cLiquids containing transuranics are processed as IHLW.

^dAlthough the Process Reduction Experimental Pilot Plant will not be operational at NPR startup, the analysis in this document assumes the existence of a facility with similar capabilities.

^eSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

respectively. An increase in compaction capacity would be required to accommodate the added load from the MHTGR technology. The environmental impact of such facility expansion will be discussed as part of the programmatic environmental restoration and waste management EIS that is currently being prepared.

An increase in the disposal capacity at the Subsurface Disposal Area would be required during the NPR operation period to handle baseline and NPR-related LLW. The environmental impact of such facility expansion will be discussed as part of the programmatic environmental restoration and waste management EIS that is currently being prepared. The available capacity at the Subsurface Disposal Area is estimated to be 100,000 m³ in the year 2000. Additional disposal capacity would be required in 2015 for the HWR, in 2013 for the LWR, and in 2011 for the MHTGR technologies. Sufficient unused space exists at the Subsurface Disposal Area to allow for such expansion.

Mixed Waste and Hazardous Waste

The inputs of unprocessed mixed waste from NPR operations would greatly exceed those from non-NPR operations. The HWR technology would require a storage area of 17,000 m³ over the 40-year life of the NPR project. The LWR technology would require 6,400 m³ and the MHTGR technology 240 m³. In addition, non-NPR operations would require 480 m³ of storage capacity. Therefore, the Radioactive Mixed Waste Storage Facility is expected to be filled to capacity by the year 2000 (Section 4.2.10.4). New storage capacity would have to be constructed to handle NPR-related mixed waste. The environmental impact of such facility expansion will be discussed as part of the programmatic environmental restoration and waste

management EIS that is currently being prepared. Pending regulatory approval by DOE and EPA, the Waste Experimental Reduction Facility would process mixed waste at INEL. The development of guidelines for treatment and disposal of mixed waste by DOE and EPA would probably affect the capacity of INEL to store mixed waste.

The largest expected increase in hazardous waste input related to NPR operations would be from the LWR technology. The hazardous waste load from the LWR technology would be six times greater than that of non-NPR operations. The increased input due to the NPR would be accommodated by increasing the frequency of waste shipments to off-site disposal facilities or by allowing for a larger volume of waste to be transported per shipment. No expansion of the INEL Hazardous Waste Shipping Facility would be required to handle NPR-related waste.

Other Waste

The other NPR-related waste (e.g., nonradioactive waste, nonhazardous solid waste, settled solids from evaporation ponds, nonradioactive wastewater, and sanitary waste waters) would not overload or adversely affect any INEL waste management facility destined to accept these waste types. All such wastes would be disposed of in accordance with applicable rules and regulations.

5.3.10.4 Mitigation and Conclusions

The NPR project would be managed in accordance with a waste reduction program that covers the entire project life from conceptual engineering design to decommissioning. The program will define the specific steps in which the contractor plans to minimize all wastes (including hazardous and nonhazardous wastes) generated during construction, operations, and decommissioning. To achieve an effective waste reduction program, primary emphasis will be given to source reduction and, alternatively, recycling to minimize the quantities and toxicities of materials and substances before they enter the waste streams for treatment or disposal. For waste that is generated, waste reduction will include treatment to reduce the volume, toxicity, or mobility of such waste prior to storage or disposal.

Table 5.3.10-6 summarizes the adverse impacts of NPR operations waste. Mitigation of the adverse impacts would require development of additional storage, treatment, or disposal capacity. After mitigation, there would be no adverse impacts to site waste management facilities. The analysis of the environmental impacts associated with expanding waste management facilities would be completed as part of the design of each of the facilities.

5.3.11 Institutional Issues

Construction and operation of NPR facilities at INEL would not affect any institutional issues related to U.S. national or international policy regarding fisheries or nuclear nonproliferation.

TABLE 5.3.10-6 Cumulative Impacts on Waste Management Facilities^a

Waste Type/Facility	HWR	LWR	MHTGR	Mitigation
High-level waste New Waste Calcine Facility	About 14% (T) to 20% (P) of available facility capacity needed for waste processing	About 47% (T) to 70% (P) of available facility capacity needed for waste processing	About 47% (T) to 100% (P) of available facility capacity needed for waste processing	Increase total facility capacity for MHTGR technology
Low-level waste Process Equipment Waste Evaporator	About 8% (T,P) of available facility capacity needed for waste processing	About 97% (T) to 141% (P) of available facility capacity needed for waste processing	About 3% (T,P) of available facility capacity needed for waste processing	Increase total facility capacity for LWR technology
Waste Experimental Reduction Facility Compactor	About 69% (T) to 83% (P) of available facility capacity needed for waste processing	About 32% (P) to 43% (T) of available facility capacity needed for waste processing	About 34% (T) to 150% (P) of available facility capacity needed for waste processing	Increase total facility capacity for LWR and MHTGR technologies
Low-level waste Subsurface Disposal Area	Expected waste generation exceeds planned facility capacity by year 2015	Expected waste generation exceeds planned facility capacity by year 2013	Expected waste generation exceeds planned facility capacity by year 2011	Plan for and provide needed disposal capacity
Mixed waste Radioactive Mixed Waste Storage Facility	Interim storage capacity would be exceeded prior to NPR operations	Interim storage capacity would be exceeded prior to NPR operations	Interim storage capacity would be exceeded prior to NPR operations	Plan for and provide additional on-site storage capacity

^aT indicates values for NPR operations in 100% tritium production mode between the years 2000 and 2040;

P indicates values for NPR operations in 100% plutonium-239 production mode between the years 2000 and 2040.

5.3.12 Decontamination and Decommissioning

Decontamination and decommissioning (D&D) activities are carried out at the end of a nuclear facility's life to permit the facility to be removed safely from service and to enable the property to be used for other purposes. D&D activities can range from performing a simple radiological survey to confirm that contamination of a facility is within acceptable limits to completely dismantling and removing a contaminated facility. An analysis of D&D impacts is included in the EIS to demonstrate whether D&D of the alternative NPRs is reasonably achievable and to determine if there are any major differences in the D&D of the alternative reactor technologies at any of the alternative sites. The methodology and details of the D&D analysis are presented below and in Appendix O.

5.3.12.1 Impacts of No Action

If it were decided not to site, construct, and operate an NPR at INEL, no additional D&D requirements would arise. Existing facilities proposed for NPR use (Figures 3.4.3-2, 3.4.4-2, and 3.4.5-2), such as the Fuel Processing Facility at the Idaho Chemical Processing Plant, would become available for D&D within the original time frame.

5.3.12.2 Impacts of Decontamination and Decommissioning

Three broadly defined D&D options for the NPR would be considered (Appendix O, Section O.2):

- *DECON* -- decontamination (removal of radioactive materials so that levels of radioactivity would be within acceptable limits),
- *SAFSTOR* -- storage for as long as 60 to 100 years, followed by decontamination, and
- *ENTOMB* -- encasement or entombment of the radioactive facilities in a long-lived material such as concrete to allow the radioactive material to decay to safe levels.

The objective of D&D is to reduce contamination of facilities to "acceptable levels of radioactivity" so that facilities can be released for "unrestricted use." Levels of radioactivity remaining at a facility would be low enough that the facility and its surroundings could be used by the general public without any radiologically related restrictions on the type of use or duration of occupancy.

The EIS analysis evaluates the following D&D options recommended by NRC for commercial facilities: *DECON* for all nonreactor support facilities and *SAFSTOR* for reactor facilities. An analysis and comparison of various D&D options are presented in the NRC final generic decommissioning document (NRC-3).

Three D&D impacts to NPR facilities are analyzed: dose to workers, volume of waste generated, and cost. For each reactor technology, three cases are analyzed: (1) D&D of the reactor and its support facilities for the tritium production mode, (2) case 1 plus the support facilities for spent fuel processing, and (3) case 2 plus the support facilities for the plutonium production mode. More than one process might be used within a facility. Therefore, for some reactor technologies, producing both tritium and plutonium would not increase the number of facilities or their volumes for D&D. The methodology used to estimate D&D costs, doses to workers, and volume of waste generated is described briefly in Section 5.1.11 and in greater detail in Section O.3.

The impacts associated with the decontamination and decommissioning of the NPR and its support facilities would be reevaluated twice during the life of the NPR. The first evaluation would occur during the detailed design phase, when a D&D plan would be prepared. The design-phase D&D plan would address regulatory compliance, decommissioning options, controls and limits on procedures and equipment to protect occupational and public health and safety, a final radiation survey, quality assurance, safeguards, mitigation of environmental impacts, volumes of radioactive and other hazardous wastes generated, disposal sites, occupational and public radiation exposure, costs, and schedule. The plan would specifically address the disposal of low-level waste (LLW), high-level waste (HLW), and transuranic (TRU) waste; hazardous waste storage requirements; and compliance with RCRA and CERCLA. The plan would include the transportation impacts for off-site waste disposal.

Near the end of the useful life of NPR, a final D&D plan would be prepared. The final plan would present the D&D procedures, using then-current technology and addressing any

waste disposal requirements and regulations. The final plan would also address, compare, and update all the issues discussed in the design-phase plan. The final D&D plan would be subject to NEPA review.

All D&D activities would be regulated by DOE orders limiting the exposure to the general public. The exposures to the general public from airborne radioactive contaminants are expected to be less than the exposures from normal operations (Sections 5.2.6, 5.3.6, and 5.4.6). Table 5.3.12-1 presents an evaluation of the D&D impacts to the NPR and its support facilities at INEL. The occupational doses from D&D at INEL would range from 160 to 640 person-rem for the tritium production mode, and from 960 to 2,000 person-rem for the combined tritium and plutonium production mode with spent fuel processing. The occupational doses represent between 0.6 and 0.8 cancer fatalities to D&D workers and can be compared with the normal operating dose of 80 to 740 person-rem/yr during the 5 to 6 years of D&D activities. Radioactive exposures to any individual performing D&D would also be limited by DOE orders regulating occupational exposures in effect at the time of D&D. Currently, DOE Order 5480.11, *Radiation Protection for Occupational Workers*, limits occupational exposure to 5 rem/yr from existing facilities and to 100 mrem/yr from operations in new facilities.

The total radioactive waste volume generated by D&D at INEL would range from 22,000 to 36,000 m³ for the tritium production mode, and from 42,000 to 57,000 m³ for the combined tritium and plutonium production mode with spent fuel processing. For the tritium production mode, between 240 and 1,800 m³ of waste would be HLW or TRU waste; 7,200 to 14,000 m³ of HLW or TRU waste would result from the combined tritium and plutonium production mode with spent fuel processing. From this analysis, the HLW or TRU waste would represent between 1% and 5% of the total radioactive D&D waste for the tritium production mode, and between 17% and 25% of the radioactive D&D waste for the combined tritium and plutonium production mode with spent fuel processing. The HLW would be shipped off-site to a Federal repository; TRU waste would be shipped to the Waste Isolation Pilot Plant or another appropriate facility. The HLW and TRU disposal sites will comply with all applicable Federal, state, and local regulations in effect at the time of disposal. The requirements for HLW and TRU disposal would be assessed in the initial and final D&D plans. Impacts of shipping the HLW and TRU D&D wastes would be similar to the impacts of transporting operational wastes (Section 5.2.6). The low-level waste generated by NPR D&D would be buried on-site (22,000 to 57,000 m³ during a 6-yr period). On an average annual basis, low-level waste volumes generated by D&D would be up to 1 1/2 times greater than (and not materially different from) annual waste volumes generated by operation of an NPR and by other sitewide activities. These additional wastes could be accommodated by extending the D&D inventory in future years or by expanding the throughput capacity of the INEL waste management system. The requirement for, and desirability of, any of the options will depend on the results of the DOE waste management PEIS and the effect the PEIS will have on the site's waste management system beyond the year 2040.

As indicated in Table 5.3.12-1, the D&D costs for the three reactor technologies in the tritium production mode would vary from \$56 million to \$220 million. The D&D costs for facilities operating in the combined tritium and plutonium production mode with spent fuel processing would vary from \$340 million to \$710 million. In all three tritium and plutonium production options, the HWR technology would have the lowest D&D costs. The D&D costs would represent about 8% to 18% of the capital cost. The D&D costs normally represent about 15% to 20% of capital costs for D&D of commercial facilities, so this fraction compares favorably with projected costs.

TABLE 5.3.12-1 D&D Impacts at INEL for HWR, LWR, and MHTGR Technologies

D&D Impact	HWR	LWR	MHTGR
Facility volume (m ³)			
Tritium production only	240,000	600,000	590,000
Tritium production with spent fuel processing	440,000	1 × 10 ⁶	800,000
Tritium and plutonium production with spent fuel processing	520,000	1 × 10 ⁶	880,000
Cost (millions of 1989 dollars)			
Tritium production only	56	220	190
Tritium production with spent fuel processing	300	710	440
Tritium and plutonium production with spent fuel processing	340	710	500
Occupational dose (person-rem)			
Tritium production only	170	640	560
Tritium production with spent fuel processing	860	2,000	1,300
Tritium and plutonium production with spent fuel processing	970	2,000	1,400
Waste volume (m ³)			
Tritium production only	22,000	36,000	32,000
Tritium production with spent fuel processing	32,000	57,000	42,000
Tritium and plutonium production with spent fuel processing	42,000	57,000	50,000

5.3.12.3 Mitigation and Conclusions

The first action to mitigate the impacts of D&D is required by DOE Order 5820.2A, *Radioactive Waste Management*, and DOE Order 6430.1A, *General Design Criteria*. These orders require that DOE facility designs minimize the impacts of D&D. These design features are presented in Table O.1.

This analysis shows that the HWR technology would result in the lowest impacts. The impacts of the HWR technology would be significantly (about 400%) less than the impacts of the LWR or MHTGR technology in the tritium production mode. For the combined tritium and plutonium production mode with spent fuel processing, the cost of D&D for the HWR would be lower by about 33% to 200%. For spent fuel processing, the D&D cost and occupational dose impacts and their associated health effects would be more than double those for the tritium production mode only, and the waste volumes would be nearly double.

The NPR project would be managed in accordance with a waste reduction program that covers the entire project life from conceptual engineering design to decommissioning. The program will define the specific steps in which the contractor plans to minimize all wastes (including hazardous and nonhazardous wastes) generated during construction, operations, and decommissioning. To achieve an effective waste reduction program, primary emphasis will be given to source reduction and, alternatively, recycling to minimize the quantities and toxicities of materials and substances before they enter the waste streams for treatment or disposal. For waste that is generated, waste reduction will include treatment to reduce the volume, toxicity, or mobility of such waste prior to storage or disposal.

The impacts would be different if other D&D options were selected. For example, if SAFSTOR for 100 years were selected for D&D of spent fuel processing, the estimated D&D cost would increase from \$1,200 to \$2,000/m³ of facility volume. Therefore, the D&D costs would increase between 11% and 70%, depending on the reactor technology and whether plutonium production and spent fuel processing are included. However, the corresponding occupational doses and associated health effects and waste volumes would decrease. The option used for the reactor facilities in this analysis -- SAFSTOR for 30 years -- would result in higher D&D costs, higher occupational doses and their associated health effects, and higher waste volumes than the 60-yr SAFSTOR option recommended by NRC.

As discussed in Section O.5, the decontamination activities at INEL would occur in two distinct time frames: DECON, from 1 year before reactor shutdown to 5 years after reactor shutdown; and SAFSTOR, from 30 to 36 years after reactor shutdown. The three alternative technologies would show no significant differences in schedules because the controlling effect is the time projected for SAFSTOR of the reactors, which is assumed to be 30 years in this analysis.

5.4 SAVANNAH RIVER SITE

5.4.1 Air Resources and Noise

The potential environmental impacts associated with constructing and operating an NPR and its support facilities at SRS that relate to air pollutants, cooling towers, and noise are described in this section. The air quality and cooling tower impact assessments are based on analyses conducted by NUS Corp. (NUS-2), unless otherwise noted. The assessments of noise impacts are based on analyses performed by Argonne National Laboratory (Chun and Rabchuk 1991).

5.4.1.1 Air Quality

This section describes the potential air quality (nonradiological) impacts of constructing and operating the NPR and its support facilities at SRS, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts. Radiological air quality impacts are discussed in Section 5.4.6.

Impacts of No Action

Under the no-action alternative, the NPR and its support facilities would not be constructed, and the air pollutant emissions that would be associated with NPR construction and operation would not occur. In addition, no major changes in existing emission levels are expected at SRS during the projected NPR construction period. Therefore, the ambient air quality at SRS would be expected to remain essentially the same for the no-action alternative as for the baseline period.

Impacts of NPR Construction and Operation

The results of a detailed analysis of potential air quality impacts from constructing and operating an NPR and its support facilities at SRS (NUS-2) are summarized in Appendix E, Section E.2.1.3 for the three reactor technologies. The results indicate that the ambient concentrations of sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), and PM₁₀* would remain below applicable national and state ambient air quality standards during the construction and operation periods (Table E.30). Although short-term (24-hour) ambient PM₁₀ concentrations are expected to be in compliance with the national and state ambient standards during the NPR construction and operation periods, the PM₁₀ concentrations are expected occasionally to be quite close to the 24-hour ambient PM₁₀ standard during the peak construction period (Table E.30). These elevated concentration levels are expected to occur during very dry and windy conditions. The increments of the criteria pollutant concentrations attributable to emissions from new operational sources would all be less than applicable maximum allowable Prevention of Significant Deterioration (PSD) increments (Table E.30).

*PM₁₀ is particulate matter with a diameter ≤10 μm.

The analysis also shows that the estimated ambient concentration of nitric acid (HNO₃) would remain well below the proposed South Carolina state ambient standard for the toxic pollutant during the NPR operational period (Table E.31).

Mitigation and Conclusions

No significant air quality impacts are expected from construction and operation of an NPR and its support facilities at SRS. Fugitive dust emissions from construction areas (e.g., during site preparation and excavation) and from unpaved roads would be reduced by periodic spraying of water. The frequency of spraying would be increased as necessary during extremely dry, windy conditions.

All new emission sources of criteria pollutants would comply with applicable new source performance standards. The new emission sources with pollutant emission rates that exceed the PSD significant emission rate (Table E.19) would be equipped with "best available control technology." "Maximum available control technology" would be applied to the NPR toxic air pollutant emission sources, if necessary to meet the requirements of the Clean Air Act Amendments of 1990.

With the mitigation measures described above, no significant air quality impacts are expected at SRS from constructing or operating an NPR and its support facilities.

5.4.1.2 Cooling Towers

This section describes the potential environmental impacts of operating circular, mechanical- and natural-draft wet cooling towers for the three NPR technologies at SRS, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts.

Impacts of No Action

Under the no-action alternative, the NPR and the cooling towers for NPR facilities would not be constructed, and the potential environmental impacts from construction and operation of the cooling towers would not occur.

Impacts of Cooling Tower Operation

The results of a detailed analysis of potential environmental impacts of operating mechanical-draft cooling towers and the alternative natural-draft cooling towers for the three NPR technologies at SRS (NUS-2) are summarized in Section E.2.2.3. The analyses indicate that under the conditions modeled, operation of the mechanical- or natural-draft cooling towers would not cause ground fogging or rime icing (NUS-2). However, under the rare condition of high wind speed, which might cause tower structure downwash effects, and high relative humidity, such phenomena could possibly occur within a few hundred meters of the mechanical-draft cooling towers. Formation of glaze ice on the surfaces, including facility roads, within a few hundred meters of the mechanical-draft cooling towers could occur as a result of freezing of deposited drift droplets during an extended period when the ground is freezing. However,

for the case of the mechanical-draft towers, no impacts are anticipated from ground fogging, rime icing, or glaze icing involving the highways where public access is not limited (i.e., SR 125, 19, 39, and 64). Ground fogging, rime icing, and glaze ice formation would not be expected in the vicinity of natural-draft cooling towers.

The potential impacts on visual resources due to visible plumes and on terrestrial vegetation due to salt deposition are discussed in Sections 5.4.3 and 5.4.4, respectively.

Mitigation and Conclusions

The potential environmental impacts of operating the mechanical- and natural-draft wet cooling towers at SRS for the three NPR technologies at SRS are described in the previous section.

For the case of the mechanical-draft towers, any hazards to the safety of workers due to potential, but infrequent, buildup of glaze ice on facility roads in the immediate vicinity of the cooling towers would be mitigated by incorporating ice-reduction procedures such as sanding, salting, or deicing. Warning signs would be posted along roadways to alert motorists of the potential hazard.

The potential impacts of salt deposition on terrestrial vegetation would be mitigated by minimizing emission of salt-containing drift from the cooling towers through regular maintenance of the tower's mist eliminators. A modern mist eliminator system could reduce the drift emission rate to less than one-half the design rate for the NPR cooling towers (0.02% of the circulating water flow rate). With the reduced drift emissions, any potential for glaze ice buildup and salt deposition would be substantially reduced.

The mitigation measures described above could substantially reduce any environmental impacts due to salt deposition and visual plumes from the mechanical- or natural-draft cooling towers for the three NPR technologies at SRS.

5.4.1.3 Noise

This section describes the potential noise impacts from constructing and operating an NPR and its support facilities at SRS, the impacts of the no-action alternative, and the measures proposed for mitigating those impacts.

Impacts of No Action

Under the no-action alternative, the NPR and its support facilities would not be constructed, and the noise associated with NPR construction and operation would not occur. Because no major changes in existing noise-emitting sources are expected at SRS during the projected NPR construction period, the ambient noise levels at SRS for the no-action alternative would be expected to remain essentially the same as the baseline period.

Impacts of NPR Construction and Operation

The results of a detailed analysis of the potential noise impacts from constructing and operating an NPR and its support facilities at SRS (Chun and Rabchuk 1991) are summarized in Section E.2.3.3. The analysis shows that noise emissions from NPR construction equipment and machines and from operational facilities, equipment, and machines, would not cause ambient noise levels to exceed the EPA guidelines set to protect the public from the effect of broadband environmental noise and to protect the public against hearing loss (Tables E.45 and E.46). The increased noise levels from constructing and operating the NPR and its support facilities and from increased traffic along the major roadway would cause little or no increase in the annoyance level experienced by communities or individuals (Tables E.45 through E.47).

Mitigation and Conclusions

No significant noise impacts from activities associated with NPR construction and operation are expected at sensitive receptor locations outside the SRS boundary or at residences along the major highways leading to the proposed NPR site at SRS.

Construction workers and other personnel working in noisy environments during NPR construction or operation would be provided with earmuffs or earplugs approved by the Occupational Safety and Health Administration. In areas where workers would be exposed to equipment noise so severe that hearing loss could occur, noise levels would be monitored, according to DOE Order 5480.4, to ensure conformance with the threshold limit values (Tables E.50 and E.51) established by the American Conference of Governmental Industrial Hygienists (ACGIH 1990).

5.4.2 Water Resources

The potential impacts on surface water and groundwater resources at SRS from construction and operation of an NPR, as well as from hypothetical NPR-related hydrologic accidents, are assessed in this section. The significance of these impacts is evaluated, and mitigative measures that would be implemented are identified and assessed. The no-action alternative is presented as a baseline case for comparison with the effects of operation of HWR, LWR, and MHTGR.

Potential impacts of sanitary and nonradioactive, nonhazardous wastes on water quality are assessed. Potential impacts of radioactive, hazardous, and mixed wastes are assessed in Section 5.4.10.

5.4.2.1 Impacts of No Action

Surface Water

The no-action alternative evaluated in this EIS assumed that K, L, and P reactors and their associated support facilities would continue to provide the tritium production capacity for U.S. defense needs. Withdrawals of Savannah River water to support operation of the three

reactors at full capacity would total about 18 m³/s, about 18% of the minimum flow to be maintained from Thurmond Dam (101 m³/s). This withdrawal assumes that the K Reactor cooling tower under construction would be operating. Most of this water would be returned via surface flow to the river -- consumptive use (3.5 m³/s) would be about 3.4% of the minimum river flow. If only K and L reactors operated at full power, as stated in the RO EIS ROD, water withdrawal and consumptive use would be 13.1 m³/s and 2.1 m³/s, respectively.

Surface water discharges from the K, L, and P reactors and support facilities historically have gone into the Savannah River via on-site streams. These discharges to on-site streams are regulated under NPDES permit SC0000175. Compliance with chemical permit limitations for operating years 1985 through 1988 was above 99%. Continued operations of K, L, and P reactors would have insignificant effects on the chemical quality of on-site streams (DOE-10), which are Class B streams within the guidelines of SCDHEC. Thermal discharge limitations from reactor operations have been established by the NPDES permit process; where thermal limitations are exceeded, Section 316a demonstration studies must prove the maintenance of a balanced biological community. Such a study has been performed for P Reactor discharges (DOE-10). The Savannah River below SRS, which receives the flow from these streams, has elevated tritium levels. In addition, the Savannah River water remains within applicable drinking water standards and within the Class B stream guidelines of the SCDHEC for the Savannah River. The impact of SRS operations on existing water quality of site streams and the Savannah River is further discussed in Section 4.3.3.1.

Groundwater

About 0.44 m³/s of groundwater would be withdrawn for operation of the existing K, L, and P reactors and their associated support facilities under the no-action alternative (DOE-10). This level of groundwater withdrawal would have no lasting effects on SRS regional groundwater levels (DOE-10).

Contaminants from past operations are present in the groundwater aquifers beneath basins in the F, H, and M areas of SRS. The regionally important Aquifers 1 and 2 have not been contaminated, and detectable limits of contaminants have not migrated beyond SRS boundaries via groundwater aquifers (Davis, Martin, and Todd 1989). This is partly because hydraulic heads in the central part of SRS are higher in Aquifer 2 than in Aquifer 3, a condition known as head reversal (Section 4.3.3). Because of this condition, water does not flow from Aquifer 3 to Aquifer 2 in this area. Currently, the eastern boundary of the area of head reversal is just east of H Area on SRS (Figure 4.3.3-2). Mitigative efforts underway at SRS include closure of the three basins in F, H, and M areas, and air stripping of volatile contaminants out of groundwater from M Area. The current quality of groundwater at SRS is further discussed in Section 4.3.3.

5.4.2.2 Impacts of NPR Construction and Operation

Surface Water

Surface Water Flows. The estimated average water requirements for construction of an NPR would be about 0.012 to 0.014 m³/s (390,000 to 440,000 m³/yr) (Table F.30, Appendix F). This water would be withdrawn either from the Savannah River or from groundwater wells in Aquifer 1. If water for construction of NPR were obtained from the Savannah River, the withdrawal would be less than 0.1% of the low flow from Thurmond Dam maintained by the Corps of Engineers and would have no measurable effect on Savannah River flow.

Construction of an MHTGR at SRS would require excavation to a depth of 31 m below the water table. The area of excavation would be isolated from the surrounding soils and rock by freezing, using a recirculating freezing brine technology. The engineering details of the design of this system are insufficient to precisely evaluate the effectiveness of this technology at SRS, but preliminary calculations for a range of hydrologic and engineering conditions indicate that discharges of water from the excavation for one of the eight MHTGR modules would range from negligible to a peak rate of 0.95 m³/s. Since several modules would be constructed simultaneously, the maximum dewatering discharge could amount to a few cubic meters per second. Currently it is proposed that this water be discharged to Fournile Branch. The rate of discharge would be several times current average flow in Fournile Branch. The maximum dewatering discharge is not likely to further erode Fournile Branch, although it could impede the stream's continuing recovery from the past impact of the C Reactor discharge. The dewatering discharge would eventually reach the Savannah River, but would probably have no measurable effect on the river flow.

Construction of an HWR and LWR would require much less groundwater dewatering and the resulting discharge would have no significant impact on Fournile Branch and the Savannah River.

The potential maximum water requirements for operating an NPR are listed in Table F.31. Water for cooling tower makeup and for blowdown temperature control would be withdrawn from the Savannah River at a maximum rate of about 3.2 m³/s (101 million m³/yr) for an LWR. Maximum consumptive use of Savannah River water would be about 1.2 m³/s (38 million m³/yr) for an LWR. Consumptive water use for the other reactors would be 0.89 m³/s (28 million m³/yr) for an MHTGR and 1.1 m³/s (34 million m³/yr) for an HWR (Table F.32). The maximum surface water withdrawal rate for operation of an NPR would increase the total withdrawals of Savannah River water for SRS facilities including three existing reactors by about 17%. Maximum consumptive use would increase about 35%. For operation of K, L, and P reactors, NPR could increase total withdrawal of Savannah River water by about 24%, and maximum consumptive use would increase about 50%.

Discharges of cooling tower blowdown and blowdown temperature control water from an NPR would return to the Savannah River through Fournile Branch. The return flow would be equal to the total withdrawal from the Savannah River less the consumptive use (Tables F.31 and F.32). An LWR would return the most water, 2.0 m³/s (63 million m³/yr), resulting in a 170% increase above current average flow in Fournile Branch. As discussed previously concerning discharge of construction dewatering, discharge from NPR operation is not likely to

further erode Fourmile Branch, although it could impede the stream's recovery from the past impact of the C Reactor discharge.

Surface Water Quality. During NPR construction, sanitary wastes would be disposed of off-site and would not impact the SRS hydrologic environment. Dewatering of the excavations for an MHTGR would result in the release of groundwater to surface water streams. There has been no historical activity which could contaminate groundwater at the NPR site, and discharge of this groundwater would not degrade surface water quality.

During operations, the multicycle cooling process would concentrate chemicals present in the cooling water, and tritium would diffuse into the cooling water. Estimated chemical composition of blowdown water for a 2.5-cycle cooling system is given in Appendix P, Table P.6 (HWR) and Table P.7 (MHTGR). Before being discharged to the Savannah River via Fourmile Branch, this water would be physically and chemically treated and diluted to meet NPDES requirements and South Carolina Class B stream standards. The annual tritium releases in liquid blowdown from an LWR without detritiation would be the largest among the three reactor alternatives at 12,000 Ci/yr (Table H.5 in Appendix H). With a planned detritiation system removing 90% of the tritium, the LWR tritium release would be 1,200 Ci/yr, and the corresponding tritium concentration in the liquid discharge would be 19,000 pCi/L after mixing with the water released for blowdown temperature control (Table F.30). Tritium in the blowdown water would be diluted by water in Fourmile Branch, and when blowdown water reached the Savannah River, dilution of 56:1 or greater would increase Savannah River tritium activity by 340 pCi/L or less. This would not raise the tritium concentration in the river above the drinking water standard of 20,000 pCi/L because the tritium concentrations now average about 3,400 pCi/L downstream from SRS (Table F.17).

To meet South Carolina Class B stream standard for temperature, it is proposed that cooling tower blowdown would be blended at the discharge point with water withdrawn from the Savannah River so that maximum temperature rise above ambient conditions would not exceed 2.8°C and the stream temperature would not exceed 32.2°C at any time. However, a study (NUS-4) has shown that it is not possible to meet the 2.8°C rise criteria all the time because of high temperatures in the Savannah River. Potential mitigations for temperature impact include direct discharge of cooling tower blowdown to the Savannah River, blending with cooler groundwater when necessary, and holding the blowdown in cooling ponds before releasing to Fourmile Branch.

Floodplain. The NPR site is located near the headwaters of Fourmile Branch and Pen Branch and at the watershed divide of these two streams. No NPR facilities would be constructed in the 100-year floodplain (Section 4.3.3.1 and Figure 4.3.3-1).

Discharge of NPR cooling tower blowdown and temperature control water up to 2.0 m³/s (LWR alternative) to Fourmile Branch could increase the stream's 100-year flood discharge if the NPR is operating during the flood. However, the stream channel has been widened due to the discharge of C Reactor cooling water. The effect of NPR discharge on the floodplain width, if any, would not be significant.

Surface Water Use. On-site streams are not used for recreation, transportation, or as sources of drinking water. Use of the Savannah River would not be significantly affected by consumptive use associated with NPR. Maximum consumptive use for NPR operation would be about 1.2 m³/s, which is about 1.2% of the low flow from Thurmond Dam.

Surface Water Rights. Operation of NPR under the flow conditions previously described would not violate the Doctrine of Riparian Rights (Section 4.3.3.1).

Groundwater

Groundwater Levels. Estimates of NPR construction water requirements range from about 0.012 m³/s (390,000 m³/yr) for an HWR to about 0.014 m³/s (440,000 m³/yr) for an LWR (Table F.30). This water may be withdrawn from groundwater wells in Aquifer 1. To evaluate the impacts of pumpage on the groundwater aquifers, numerical simulations of groundwater withdrawals of 0.063 m³/s (2 million m³/yr) from Aquifer 1 were conducted (Looney-1). That evaluation bounded construction water requirements for all three reactor technologies. The results indicated that although simulated drawdown in Aquifer 1 was as much as 2.1 m at the well head, drawdowns were smaller in overlying aquifers and did not extend beyond SRS boundaries in any aquifer. It can be concluded from this simulation that Aquifer 1 could supply sufficient quantities of water to support construction requirements without adversely impacting regional water levels.

As mentioned above, construction of an MHTGR would require installation of below-grade reactor vessels. These would extend to a depth of approximately 40 m, which is approximately 31 m below the water table at the NPR site. The vessels would not extend below the base of Aquifer 4, the water table aquifer. Use of a recirculating freezing brine slurry technology to prevent groundwater from flooding the excavation has been proposed (WSRC-6). As discussed earlier, the worst-case dewatering rate could amount to a few cubic meters per second if several reactor vessels were excavated simultaneously. During construction, the effect of dewatering on groundwater level would be monitored and, if necessary, impact mitigative measures would be implemented. Potential mitigative measures include excavating one reactor vessel at a time, recharging the water-table aquifer at locations where existing wells are affected, and providing alternative water supply for affected users.

To analyze groundwater requirements for NPR operations, the assumption was made that all process water, potable water, and water for operation of NPR support facilities would be withdrawn from Aquifer 1. In the tritium production mode, groundwater use would be 0.13 m³/s (4 million m³/yr) for an HWR, 0.0092 m³/s (290,000 m³/yr) for an LWR, and 0.024 m³/s (750,000 m³/yr) for an MHTGR. In the plutonium production mode, groundwater use would be 0.089 m³/s (2.8 million m³/yr) for an HWR, 0.016 m³/s (500,000 m³/yr) for an LWR, and 0.19 m³/s (5.9 million m³/yr) for an MHTGR (Table F.31). To evaluate the impacts of these pumpages on the groundwater aquifers, numerical simulations of groundwater withdrawals of 0.13 m³/s (4 million m³/yr) from Aquifer 1 were conducted (Looney-3). This level of withdrawal bounded water requirements for an HWR or LWR, but not for an MHTGR in the plutonium mode. Based on the results of the simulation study, drawdown in Aquifer 1 from the largest pumping rate required for the MHTGR operation in the plutonium mode would be about 6.2 m at the well head; drawdown would decrease to 0.9 m at 11.4 km from the

pumping center. In the overlying Aquifer 2, drawdown would be about 4.4 m near the pumping center, decreasing to 0.9 m within about 11.4 km. Drawdowns would be less in overlying aquifers and would be confined to a smaller area. Pumpage from Aquifer 1 would not adversely impact regional water levels outside the SRS boundary.

Groundwater Quality. Currently, groundwater under the NPR site is not contaminated from past SRS activities. Construction of an HWR or LWR would not result in significant degradation of groundwater quality, since liquid discharges would be to surface waters. The freezing brine slurry technology proposed for constructing an MHTGR would not have a significant impact on groundwater quality because the brine slurry would be in a closed piping system. However, the groundwater quality would be monitored during construction to ensure protection of the aquifers.

Normal operation of an NPR would not result in liquid effluent discharges to groundwater, and thus groundwater quality would not be directly affected by waste discharges. However, withdrawal of groundwater from Aquifer 1 would cause the western boundary of the area of head reversal to move east and the eastern boundary to move west. A groundwater withdrawal rate of $0.063 \text{ m}^3/\text{s}$ (2 million m^3/yr) would eventually cause the eastern line to migrate approximately 480 m west, but would cause no appreciable change in the western line. At a pumping rate of $0.13 \text{ m}^3/\text{s}$ (4 million m^3/yr), the eastern line would eventually migrate about 600 m west, and the western line would eventually migrate about 300 m east (Looney-1 and Looney-3). Higher pumping rates would cause further shrinkage of the area of head reversal. Operational use of groundwater would be managed to avoid shrinking the area of head reversal (Figure 4.3.3-2) that is protecting regional groundwater resources in Aquifers 1 and 2 from contaminants in Aquifers 3 and 4 in the vicinity of the F and H area seepage basins.

Groundwater Use. All potable water and water for operation of support facilities would be groundwater obtained from Aquifer 1. A maximum of about $0.19 \text{ m}^3/\text{s}$ (5.9 million m^3/yr) of groundwater would be needed for MHTGR operation in the plutonium production mode. It is SRS policy that all new groundwater pumpage be from Aquifer 1. Pumpage of Aquifer 1 at rates sufficient to support an HWR, LWR, or MHTGR would have only minor impacts on SRS groundwater production. For the HWR and LWR technologies, off-site users would not be affected. The largest pumpage associated with an MHTGR might cause a slight lowering of water levels in off-site wells (no more than 1 m), but production from those wells would not be significantly affected.

Groundwater Rights. SRS would continue to notify the SCWRC when groundwater pumping exceeds $0.0044 \text{ m}^3/\text{s}$ (140,000 m^3/yr).

5.4.2.3 Impacts of Hydrologic Accidents

At SRS, large volumes of water containing tritium and other contaminants would be stored in the secondary cooling water intake basin (capacity of 95,000 m^3) for the HWR or in the spray pond (capacity of 49,000 m^3) for the LWR. Failure of these basins could impact the hydrological system. However, these containing basins would be designed to meet Category I

seismic criteria, and their failure is judged to be incredible. Therefore, such failure will not be further evaluated (Tomasko and Tillbrook 1990).

Although potentially credible, failures of other liquid-containing systems (e.g., cooling system water for the MHTGR, other water systems for the HWR or LWR, chemical or diesel fuel spills during transport or storage) would not significantly impact the SRS hydrological system because of small fluid volumes, occurrence within radiological control structures without liquid release paths, and the large number of potential remediation technologies that could be implemented (Tomasko and Tillbrook 1990).

5.4.2.4 Mitigation and Conclusions

Surface Water

Construction of an HWR or LWR would not adversely affect surface water resources at SRS. Construction of an MHTGR is likely to impede Fourmile Branch's recovery from past impact of the C Reactor discharge (because of dewatering discharges) but would not adversely affect the Savannah River.

Of the three reactor technologies being evaluated, operation of an LWR would result in the greatest consumptive use of the Savannah River water, and operation of an MHTGR the least. The consumptive use for the LWR would be less than 2% of the minimum release of Thurmond Reservoir (Section 4.3.3.1). None of the proposed technologies would significantly affect the quantity or quality of Savannah River water. Discharge of cooling water to Fourmile Branch is not likely to further erode the channel but is likely to impede the stream's recovery from the previous impact of the C Reactor discharge. To meet South Carolina Class B stream standard for temperature, it would be necessary to consider alternatives to blending Savannah River water with cooling tower blowdown for discharge to Fourmile Branch. To reduce or eliminate impacts to surface water at SRS, cooling-tower blowdown water could be discharged to Par Pond. Other potential alternatives include direct discharge of the blowdown to the Savannah River, blending with cooler groundwater when necessary, and holding the blowdown in cooling ponds before releasing to Fourmile Branch.

Groundwater

The productivity of Aquifer 1 is sufficient to support construction and operation of any of the three proposed technologies. Use of the freezing slurry wall technique during construction of the MHTGR might degrade the groundwater quality at the NPR site. The groundwater would be monitored during construction, and appropriate mitigative measures would be implemented if necessary.

At the highest pumping rates associated with MHTGR operations, additional drawdown would be expected to occur outside of the SRS boundaries. However, impacts on regional wells producing from Aquifer 1 would be small. To protect groundwater quality in Aquifers 1 and 2, groundwater pumping from Aquifer 1 would be managed to avoid shrinking the area of head reversal. If necessary, surface water instead of groundwater would be used for potable water and operating support facilities.

5.4.3 Land Use, Recreation, and Visual Environment

5.4.3.1 Impacts of No Action

If an NPR were not constructed and operated at SRS, land use patterns, use of recreational resources, and the visual environment would remain as described in Section 4.3.4. The SRS would remain a Federal facility dedicated to nuclear research and development and isotope production. Other continuing activities would include waste management, ecological research, and forestry.

5.4.3.2 Impacts of NPR Construction and Operation

Construction and operation of any of the three alternative NPR technologies would be consistent with the historical use of SRS for nuclear materials production. No NPR facilities would be constructed off-site, and off-site land use would not be impacted except to the extent that some currently undeveloped land would likely be converted to residential developments to house workers. Such development would be subject to local land use and zoning controls, which vary by jurisdiction.

Construction at the NPR site would disturb 251 ha (maximum) of undeveloped areas; however, this disturbance would affect only a small part of the existing natural environment, approximately 77,000 ha. Ecological studies of Rainbow Bay, an extensively researched Carolina bay adjacent to the NPR site, might be affected either directly or indirectly by construction. Otherwise, the use of SRS as a National Environmental Research Park would not be affected.

Some soils on the NPR site are classified as prime farmland. Although this land is precluded from agricultural use by inclusion in SRS, areas occupied by new buildings and ancillary facilities for an NPR would be removed from potential future agricultural use during the life of the project. No unique soils are on SRS; thus, none would be impacted by NPR construction.

Potential impacts to area recreational facilities from construction and normal operations of any of the three NPR alternatives are not quantifiable. In-migrating construction workers might temporarily increase local demand for recreational opportunities. However, the Vogtle Nuclear Power Plant, located across the Savannah River from SRS, had a peak construction work force of 10,000 people, far greater than the peak work force expected for an NPR. Local officials indicated that Vogtle did not create any excessive burden on recreational facilities. Hence, an NPR would not be expected to affect recreation in the SRS region. The area around SRS does not support a tourism industry that would be expected to be affected by potential adverse publicity from NPR operations or in the unlikely event of an accident, and nuclear production activities of the site have already been publicized.

Changes from construction and operation of an NPR would be consistent with the existing visual environment at SRS. Views of the proposed NPR facilities would be obstructed by the heavily wooded zones that buffer all developed areas of SRS. The NPR facilities would not be visible from public access highways off SRS or from population centers. The NPR facilities would not be distinguishable from existing facilities if they could be viewed from high ground in areas remote from SRS.

The method used to assess the impacts of NPR cooling towers on the visual environment is discussed in Section 5.4.1.2. A plume from the HWR would be visible for 8-10 km but only 0.5% of the time (40 hours per year). Plumes for the LWR and MHTGR would not be visible at 10 km. Natural-draft cooling towers would create a plume that would be visible more than 10 km away, but it would be visible beyond SRS boundaries only a few times a year. However, because a plume would already be visible from the cooling towers currently under construction for K Reactor, the new plumes from an NPR would be consistent with the existing visual environment at SRS. The cooling tower for K Reactor will be more than 150 m tall and will be noticeable for several kilometers beyond the site boundary.

5.4.3.3 Mitigation and Conclusions

No impacts requiring mitigation would occur to land use, recreation, or the visual environment as a result of construction and operations of an NPR at SRS. Plumes from cooling towers would be visible from public access roads and public roads external to SRS.

5.4.4 Biotic Resources

This section evaluates the impacts to biotic resources that would result from the construction and normal operations of an HWR, LWR, or MHTGR and associated support facilities at SRS. Descriptions of these reactor alternatives and their associated facilities at SRS are presented in Section 3.4.

5.4.4.1 Terrestrial Resources

Impacts of No Action

If an NPR were not developed, no changes to terrestrial resources would be expected to occur on SRS beyond those resulting from natural processes of succession and the impacts of ongoing SRS operations (see Section 4.3.5). No impacts to terrestrial resources are expected to occur due to the operation for tritium production of existing P, K, and L reactors at SRS (DOE-10).

Impacts of NPR Construction and Operation

Construction of an NPR and support facilities at SRS would disturb about 214 ha for an HWR, 242 ha for an LWR, or 251 ha for an MHTGR. Each of these areas represents about 0.3% of the total land area of SRS. About 148 ha, 170 ha, or 163 ha for an HWR, LWR, or MHTGR, respectively, would be occupied by reactor facilities, access roads, rights-of-way, or other associated facilities and, therefore, would remain developed for the life of the project. The remaining land would be revegetated with native species after construction was completed.

Vegetation within construction areas would be destroyed during land-clearing activities. The plant communities to be disturbed by development of an NPR (mostly pine plantation) are common on SRS. Because only 50 ha of the 125-ha NPR site would be occupied by NPR

facilities, opportunity would exist to avoid less abundant habitats. Bottomland hardwood forest and deciduous forest would be avoided. Mitigation of impacts to plant communities would include minimizing the area of disturbance, and disturbed areas would be revegetated following completion of construction activities. Adverse impacts to vegetation related to the construction of NPR facilities on SRS are expected to be limited to the project area and vicinity and are not expected to affect the viability of any plant species on SRS.

Construction of an NPR would have some adverse effect on animal populations on SRS. Less mobile animals, such as invertebrates, reptiles, and small mammals, within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to adjacent suitable habitat (Moore and Mills 1977). Project facilities would displace 148-170 ha of wildlife habitat for the life of the project; 13 ha of this area would be maintained as mowed right-of-way, which would have some limited value for wildlife. Other disturbed areas (e.g., construction laydown areas and rights-of-way) would be revegetated upon completion of construction and would be reinvaded by animal species present in surrounding, undisturbed habitats. The adverse impacts of construction are expected to be limited to the project area and immediate vicinity and should not affect the viability of any animal populations on SRS because similar suitable habitat would remain abundant at SRS.

Cooling tower drift would result in salt deposition on surrounding land areas and vegetation. The calculated sodium chloride deposition rates for an HWR, LWR, or MHTGR at SRS do not exceed the threshold value of 17.1 kg/ha-mo at which visible salt stress can occur in sensitive plant species (DOE-20) (see Section 4.3.2). As a consequence, salt deposition from cooling tower drift is not expected to have any significant effect on vegetation. No cumulative effect from salt deposition by K Reactor and NPR are expected because of the distance separating these facilities.

Very small concentrations of radionuclides (several orders of magnitude lower than natural background levels) would be released to the atmosphere from NPR operations. Studies have indicated that no other organisms are more sensitive than man to radiation (NRC-8). Therefore, as concluded for humans (Section 5.4.6), the effects of these releases on terrestrial organisms are expected to be minor.

Mitigation and Conclusions

Impacts to terrestrial plant and animal communities at SRS would be mitigated by minimizing the amount of land disturbed during construction, implementing soil erosion control measures during construction activities, and revegetating disturbed areas with native species. These mitigation measures would limit the amount of direct and indirect disturbance to the construction area and surrounding habitats and would speed the recovery process for disturbed lands. Mitigation of operational impacts is related to design features of the NPR and associated facilities, as described in Section 3.4. Additional mitigation would not be needed to bring effluents within acceptable levels.

Impacts to terrestrial resources that would result from construction and operation of an NPR at SRS include (1) disturbance and alteration of plant communities and (2) destruction or displacement of animals present on construction areas. These disturbances would take place on a relatively small percentage of the SRS land area. Operational impacts would include

(1) deposition of salts due to cooling tower drift on nearby terrestrial vegetation and (2) exposure of plants and animals to small amounts of radionuclides released during operation of the NPR. Levels of salt deposition and radionuclide exposure would be below the levels that produce adverse effects.

5.4.4.2 Wetlands

Impacts of No Action

If an NPR were not developed, no changes to wetlands would be expected to occur on SRS other than those changes resulting from natural processes of succession and the impacts of ongoing SRS operations (see Section 4.3.5.3). However, if the existing K and L reactors at SRS were operated for tritium production, impacts to wetlands would occur (DOE-10). Operation of K Reactor with a recirculating cooling tower, and operation of L Reactor with once-through cooling water discharged to L Lake would eliminate impacts on wetlands.

Impacts of NPR Construction and Operation

Wetlands on SRS would be affected by construction and operation of an NPR. Construction activities within wetlands would require a permit from the U.S. Army Corps of Engineers (COE), and consultations with the COE have been initiated to identify wetland areas on the NPR site (Banker 1989).

Construction of an NPR at SRS has the potential to impact wetlands both directly and indirectly and the magnitude of these impacts would depend upon final design. Wetlands most at risk would include the bottomland hardwood forest (5.9 ha) on the NPR site and the 2.2-ha Rainbow Bay adjacent to the NPR site. These impacts would be minimized by avoiding construction within these areas and by employing erosion control techniques to prevent the run off of sediment to these wetlands from construction areas. In order to comply with DOE's policy of no net loss of wetlands, any wetlands that are disturbed during construction would be replaced. Any such wetland mitigation plan would be developed in consultation with the COE.

Operation of an NPR at SRS also has the potential to affect wetlands. Wetland impacts can occur through (1) the deposition of salts from cooling tower drift on wetland vegetation, (2) the release of relatively warm cooling water blowdown to Fourmile Branch, and (3) the increase in flow rates within Fourmile Branch resulting from discharge of blowdown water. As discussed in Section 5.4.4.1, the deposition of salts through NPR cooling tower drift is not expected to affect vegetation, even in areas of maximum deposition. This conclusion also applies to the effects of drift on wetland vegetation.

The predicted maximum water temperature in the immediate discharge area of Fourmile Branch (end of C-Area discharge canal) is 28°C (NUS-4). The water temperature would be at ambient levels within 2.5 km of the discharge point at all times of the year (NUS-4). No thermal impacts to wetlands along Fourmile Branch are expected because predicted temperatures are within the range of normal water temperatures in each season, and the predicted maximum temperature has been shown to have no adverse effect on production or survival of plants typical of SRS wetlands (duPont-1).

Discharges of cooling tower blowdown effluent during periods of reactor operations would increase the instream flow of Fourmile Branch from an average of 1.2 m³/s to approximately 3.0 m³/s (see Section 5.4.2) for an HWR, 3.2 m³/s for an LWR, or 2.7 m³/s for an MHTGR. These values are considerably less than the instream flows in Fourmile Branch that occurred during operation of C Reactor (11 m³/s) prior to 1985 (DOE-20) and are within the range of normal flows that have occurred since (0.3 to 9.3 m³/s) (see Section 4.3.3). Therefore, the succession of wetland vegetation that began following shutdown of C Reactor is expected to continue over much of the Fourmile Branch floodplain. Succession would proceed toward bottomland hardwoods along Fourmile Branch and toward a bald cypress/water tupelo community within the Savannah River swamp.

Mitigation and Conclusions

In keeping with DOE's policy of no net loss of wetlands, all wetlands on the NPR site would be avoided if possible. Detailed mitigation would be developed in consultation with the COE as part of the permitting process if construction activities could not be avoided within wetlands. Potential mitigation for lost wetlands includes replacement in kind. Standard erosion control practices, including revegetation of disturbed areas, would minimize the run off of sediments to wetlands in the vicinity of construction areas. Mitigation of operational impacts to wetlands is related to design features of the NPR and associated facilities, as described in Section 3.4. Estimated water discharge rates reflect the addition of Savannah River water to reduce temperature. Water discharge rates could be reduced by increasing the cycles of concentration within the cooling tower. Alternatively, cooling tower blowdown water could be discharged to Par Pond to achieve additional cooling. Either alternative would reduce or eliminate the impacts to Fourmile Branch resulting from increased flows.

With mitigation, construction impacts to wetlands could be avoided. Some salt deposition on wetland areas would occur, but this deposition would not exceed acceptable levels. Release of relatively warm cooling-tower blowdown effluent would not adversely affect the wetland vegetation along Fourmile Branch, but increased flow rates in the stream would prevent complete succession along the Fourmile Branch floodplain.

5.4.4.3 Aquatic Resources

Impacts of No Action

If an NPR were not developed, no changes to aquatic resources would be expected to occur on SRS beyond those resulting from natural processes of succession and the impacts of ongoing SRS operations (see Section 4.3.5). However, if the lack of new production capacity resulted in operation of existing SRS reactors for tritium production at SRS, impacts to aquatic resources would occur (DOE-10). Projected impacts of continued operation of K Reactor, with a recirculating cooling tower, and of P and L reactors with once-through cooling water discharges to Par Pond and L Lake, respectively, include (1) impingement and entrainment losses of fish (4,250 fish) and ichthyoplankton (2.11×10^8 fish larvae and 6.9×10^6 fish eggs) at intake structures at L Lake and Savannah River; (2) fish kills in upper L Lake and Pond C at the periodic start-up of reactors due to thermal discharge; (3) formation of an anoxic zone within

L Lake and Par Pond; and (4) some streambed erosion in Indian Branch, Pen Branch, and Steel Creek.

Impacts of NPR Construction and Operation

Construction of an NPR at SRS could affect aquatic resources both directly and indirectly. The resources at risk include the two intermittent, unnamed streams with headwaters on the NPR site and the upper reaches of Fourmile Branch and Pen Branch that flow near the site. Construction on the NPR site could, however, avoid these intermittent streams, and erosion control techniques would be implemented to prevent the run off of sediment to these streams and Fourmile and Pen Branches. Any construction activities within streams would require a permit from the COE pursuant to Section 404b of the Clean Water Act. Mitigation of impacts associated with this construction (e.g., restoration of drainage patterns) would be developed during consultations with the COE and would be a requirement of any permit granted.

Operation of an NPR at SRS also has the potential to affect aquatic resources. Impacts to these resources could occur through (1) the deposition of salts on aquatic ecosystems from cooling-tower drift, (2) withdrawal of water from the Savannah River, and (3) discharge of cooling-tower blowdown water and other effluents to Fourmile Branch. As discussed in Section 5.4.4.1, the deposition of salts through NPR cooling tower drift is not expected to affect vegetation. This finding also applies to the effects of drift on aquatic resources.

An HWR, LWR, or MHTGR at SRS would withdraw cooling water from the Savannah River at rates equivalent to about 2.8%, 3.2%, and 2.3%, respectively, of the minimum regulated flow rate of the river (101 m³/s). Discharge of cooling-tower blowdown into Fourmile Branch, a tributary of the Savannah River, would compensate for some of this withdrawal. The net rate of withdrawal would not significantly affect river flow and therefore is not expected to adversely affect the river ecosystem.

Withdrawal of water from the Savannah River would cause the entrainment and subsequent mortality of planktonic organisms, including the eggs and larvae of certain fish species (ichthyoplankton). Entrainment losses have been shown to be directly proportional to the amount of water withdrawn at SRS (DOE-10; DOE-20). Based on the relationship between entrainment and water withdrawal it is estimated that NPR operations would result in annual entrainment losses of fish larvae totalling 2.1×10^6 (MHTGR), 2.7×10^6 (HWR), and 2.8×10^6 (LWR). Annual losses of fish eggs would be 1.1×10^6 (MHTGR), 1.4×10^6 (HWR), and 1.5×10^6 (LWR). These losses represent about 1.1% to 1.5% of the total ichthyoplankton passing SRS (Wike et al. 1989). Species entrained should be the same as those entrained in the past; thus, entrained larvae should be dominated by shad, crappie, and suckers, and entrained eggs should be predominantly those of the American shad and striped bass. As previously determined during monitoring of past SRS operations (Wike et al. 1989), fish populations should not be adversely affected by these losses.

Some larger fish would be impinged on the intake screen during water withdrawal. Bluespotted sunfish, threadfin shad, and gizzard shad, as in the past (Wike et al. 1989), are expected to be the most common species impinged. Impingement losses are proportional to water withdrawal rates at SRS (DOE-10; DOE-20); thus, an estimated 840 (MHTGR), 1,070 (HWR), and 1,140 (LWR) fish are expected to be impinged annually as a result of NPR

operations. This rate of impingement is considered low relative to documented impingement rates for power plants in the southeastern United States (Wike et al. 1989).

Discharges of cooling-tower blowdown effluent to Fourmile Branch during periods of reactor operations would increase the instream flow by a factor of 2 to 3 (see Section 5.4.4.2). The flows associated with an NPR are not of sufficient magnitude to prevent the habitation of the stream by native aquatic species. During initial startup of an NPR, some resuspension of sediment would occur, resulting in increased turbidity in the stream and some remobilization of Cs-137. However, this condition would cease within a few weeks of continued operation and should not adversely affect aquatic biota (duPont-1). The succession of wetland vegetation that is expected to occur along Fourmile Branch (see Section 5.4.4.2) would also increase habitat diversity in the stream and thus favor diversity in the aquatic community.

The predicted maximum water temperature in the immediate discharge area of Fourmile Branch (end of C-Area discharge canal) is 28°C (NUS-4), which is below the maximum of 32.2°C required for Class B waters of the state. However, if cooling tower blowdown effluent were not blended with Savannah River water for temperature control, the other temperature criterion for Class B waters (maximum temperature differential of 2.8°C between effluent and the stream) would be exceeded at the discharge point for up to 196 days during cooler months of the year (October to May). The exceedance would be in violation of the SRS NPDES permit and would require a Section 316(a) demonstration of a balanced biotic community after the NPR became operational. Without the mixing of blowdown effluent with Savannah River water prior to release, the mean monthly maximum temperature differential would be 7°C during January, and the water temperature would be at ambient levels within 2.5 km of the discharge point in Fourmile Branch at all times of the year (NUS-4). If, as proposed, cooling tower blowdown effluent were blended with Savannah River water for temperature control, the exceedance of the 2.8°C temperature differential criterion could be reduced up to an average of 49 days per year, with no monthly average differential exceeding 2.8°C. However, since Savannah River water is 2.8°C warmer than Fourmile Branch water for an average of 29 days per year, mixing would not be able to completely eliminate exceedance of the temperature differential criterion for Class B waters, and a Section 316(a) demonstration of a balanced biotic community would be necessary.

Water temperatures, even at the point of discharge, would be well below the thermal tolerance limits (mid to upper 30s°C) of native warmwater fish species, such as largemouth bass, bluegill, and channel catfish (Block et al 1984; Chutham et al. 1976; DOE-20). In addition, in each season, the temperature of the blowdown effluent would be within the range of normal water temperatures in that season and is not expected to affect the distribution or abundance of macroinvertebrates or other aquatic organisms within the stream. Therefore, recolonization of the Fourmile Branch system by native fish species and other aquatic organisms is expected to continue, and these species would eventually replace the thermally tolerant species that became prevalent during operation of C Reactor. The rapid changes in temperature that could occur when the reactor is started up should not exceed the tolerance of fish species present in Fourmile Branch (DOE-20; Cincotta, Stanffer, and Hocutt 1984). No thermal effects on aquatic biota in the Savannah River are expected because the temperature of Fourmile Branch would be at ambient levels at the confluence of the stream with the river (NUS-4).

The cooling-tower blowdown and other process effluents released to Fourmile Branch would contain radionuclides. The most abundant radionuclide in this effluent would be tritium (at concentrations of 11,600 pCi/L, 190,000 pCi/L, or 50,000 pCi/L for an HWR, LWR, or MHTGR, respectively). Other radionuclides would be present in very small concentrations but would make a greater contribution to total dose. The total dose from all radionuclides to an aquatic organism (e.g., a fish) living within undiluted effluent is estimated to be 0.22 mrad/d (80.3 mrad/yr) or less (Table 5.4.4-1). This value is well below the dose limit of 1,000 mrad/d established in DOE Order 5400.5 for the protection of native aquatic organisms. The calculated dose is conservative because it is unlikely that an organism would spend a substantial portion of its life within the effluent plume, and the concentration of radionuclides would be diluted upon release to Fourmile Branch. Therefore, exposure of most organisms within the stream to radiation is expected to be lower than this estimated dose.

TABLE 5.4.4-1. Calculated Dose to an Aquatic Organism Living in Undiluted Effluent from an NPR at SRS^a

Source	Dose (mrad/d)	
	Contributed Dose	Total Dose (Existing + NPR)
Existing	0.07	NA
HWR	0.11	0.18
LWR	0.15	0.22
MHTGR	0.01	0.09

^aMethod of calculation is presented in Section 5.1.5.

Mitigation and Conclusions

A detailed mitigation plan to minimize construction impacts to aquatic resources would be developed in consultation with the COE as part of the permitting process if construction activities within intermittent streams on the NPR site could not be avoided. Standard erosion control practices, including revegetation of disturbed areas, would minimize the runoff of sediments to these and adjacent streams in the vicinity of construction areas. Mitigation of operational impacts to aquatic resources are related to design features of the NPR and associated facilities, as described in Section 3.4. For the most part, additional mitigation would not be necessary to bring effluents within acceptable levels. Water discharge rates could be reduced by increasing the cycles of concentration within the cooling tower. To achieve additional cooling, blowdown water could be released to Par Pond rather than to Fourmile Branch. Both alternatives would reduce the impacts of flow rate changes. The latter alternative would also result in elimination of thermal impacts. For an LWR, concentrations of tritium in the blowdown water could be reduced by 90% with the employment of detritiation. Mitigation to reduce impingement and entrainment losses at SRS water intake structures have been examined by the DOE, but further mitigation is not deemed warranted, because fish populations do not appear to be adversely affected by SRS operations (DOE-53).

With mitigation, construction impacts to aquatic resources would be avoided. Some salt deposition on aquatic resources would occur, but this deposition would not exceed acceptable levels. With the implementation of alternative cooling systems discussed in the preceding paragraph, impacts to aquatic resources due to thermal effects or changes in stream flows could be reduced or eliminated in Fourmile Branch, and a Section 316(a) demonstration would not be necessary. Radionuclide doses to aquatic organisms within Fourmile Branch and the Savannah River would be well below established limits and would not require additional mitigation.

5.4.4.4 Threatened and Endangered Species

Impacts of No Action

If an NPR were not developed, no impacts to threatened and endangered species would be expected to occur on SRS other than those resulting from natural processes of succession and the impacts of ongoing SRS operations (see Section 4.3.5). No impacts to threatened and endangered species are expected to occur if the lack of new production capacity resulted in the restart and operation of existing P, K, and L reactors at SRS (DOE-10).

Impacts of NPR Construction and Operation

The bald eagle, wood stork, shortnose sturgeon, and American alligator are the only Federally listed species that could be affected by construction or operation of an NPR. Construction activities are not expected to have direct impacts on any of these species because they have not been observed in the areas to be disturbed by construction. However, indirect effects could result from the runoff of sediment from construction areas and the disturbance of individual animals in the vicinity of construction. Only the bald eagle has been observed sufficiently close to the NPR site to be affected by runoff from the site. An active bald eagle nest is located about 7 km from the NPR site in an area of Pen Branch that drains the NPR site. If erosion was of sufficient magnitude, it could result in the build up of sediment within the beaver pond on which the nest is located, and thus prompt the abandonment of the site by the eagles. This would be prevented by the implementation of standard erosion control methods during construction and the revegetation of disturbed sites upon completion of construction. Bald eagles are not expected to be disturbed by construction activities. The NPR site is well outside (about 5.5 km) the buffer zone established by DOE to protect the bald eagle nest (Walker 1990).

NPR operations are the most likely source of impacts to the other Federally listed species -- the wood stork, American alligator, and shortnose sturgeon. All of these species are associated with aquatic systems of SRS and have been observed in Fourmile Branch (wood stork, alligator), which would receive cooling-tower blowdown water from an NPR, or the Savannah River (shortnose sturgeon), where cooling water would be withdrawn. As discussed in Sections 5.4.4.2 and 5.4.4.3, discharge of blowdown water to Fourmile Branch is not expected to have significant adverse effects on wetlands or aquatic resources. These findings apply as well to the wood stork and alligator which utilize these resources. Increased use of the Fourmile Branch delta by both species is expected as reduced instream flow and decreased water temperatures allow the area to recover from the effects of past C Reactor operations (DOE-20). After an initial increase, use of the Fourmile Branch system by wood storks is expected to decline over the next several decades as wetlands proceed through natural succession and less open water becomes available for foraging (DOE-20). Use of the area by alligators, however, is not expected to decline.

The shortnose sturgeon would not be affected by thermal discharge because cooling-tower blowdown water would be at the ambient temperature by the time it reached the Savannah River (NUS-4), where this species occurs. The finding of four shortnose sturgeon larvae in SRS water intake canals and the impingement of one Atlantic sturgeon (not a Federally listed species) raise the possibility that some entrainment and impingement loss of the shortnose sturgeon could occur as a result of NPR water withdrawals (Wike et al. 1989). Sturgeon eggs

are not at risk of entrainment because they tend to sink and are strongly adhesive and gelatinous. These characteristics limit the downstream transport of eggs and dispersion through the water column (Wike et al. 1989; DOE-10; DOE-20). The low numbers of larvae in the vicinity of intake structures and the preference of these larvae for benthic habitats limits the possibility of entrainment at this life stage (Wike et al. 1989; DOE-10). The lack of evidence of past impingement or occupation of the intake canals by nonlarval forms of this species and the attainable swimming speeds of healthy juvenile and adult sturgeon relative to the velocity of water entering the intake structures, makes it unlikely that impingement losses could occur (Wike et al. 1989; DOE-20).

Several other species that do not receive Federal protection, but that are candidates for listing (Category 2), occur on SRS and have the potential to be affected by NPR construction. These include a number of plant species (cypress stump sedge, Elliott's croton, smooth purple coneflower, swamp lobelia, nestronia, and awned meadow-beauty), one fish (bighead redhorse), and one amphibian (Carolina crawfish frog).

Adverse impacts to Elliott's croton, awned meadow-beauty, smooth purple coneflower, swamp lobelia, nestronia, and the Carolina crayfish frog would occur if these species were located within or adjacent to construction areas. Although none of these species is known to occur on the NPR site and potentially affected areas, their habitat preferences raise the possibility of occurrence in these or nearby areas. Detailed surveys would be conducted prior to construction to determine if any of these species occurred in areas to be disturbed. If individuals of these species were found, mitigation would be developed in consultation with the FWS to avoid impacts. Erosion control practices would prevent indirect impacts from runoff and sedimentation of adjacent habitats.

Operation of an NPR has the potential to affect the remaining Category 2 species, cypress stump sedge and the bighead redhorse. Cypress stump sedge, present within the Savannah River Swamp, should not be significantly affected by operations because effluent discharge, the most likely source of impacts, is not expected to have significant effects on biota (see Sections 5.4.4.2 and 5.4.4.3). The bighead redhorse could be affected by entrainment or impingement. Although this species has been documented to occur in the Savannah River near the mouth of Upper Three Runs Creek, where one of the SRS intake structures is located, this species has not been found to be entrained or impinged at any of the SRS water intakes (Wike et al. 1989). On the basis of this information, it is unlikely that the bighead redhorse would be adversely affected by NPR withdrawals.

Several state-listed species that are not also listed by the Federal government could be affected by construction of an NPR. None of these species has been documented on the NPR site, but suitable habitat for five state-listed species does occur there (see Table 4.3.5-1). Before construction, project areas would be surveyed for these species, areas where they occurred would be avoided if possible, and mitigation plans would be developed. Construction impacts to state-listed plant, amphibian, reptile, and mammal species that occur at Rainbow Bay adjacent to the NPR site would be minimized by controlling soil erosion and runoff from the site. Individuals of the two state-listed bird species that occur at Rainbow Bay (Cooper's hawk, great-horned owl) would be disturbed during construction. These birds would likely move to suitable habitat elsewhere on-site during periods of intensive human activity.

Operation of an NPR at SRS could also affect state-listed species, including species of special concern to the state. Plant species that occur at adjacent Rainbow Bay would be exposed

to cooling-tower drift, but the impacts of this drift on vegetation are not expected to be significant (see Section 5.4.4.2). Several state-listed animal species occur in the Savannah River Swamp and the SRS reach of the Savannah River, where cooling water effluent discharge and water intake would occur during NPR operations. Thermal impacts to state-listed aquatic species within these areas are expected to be minor because, during periods of reactor operation, instream water temperatures in these areas would be at ambient levels (see Section 5.4.4.3). The expected flows within Fourmile Branch from NPR discharges should not adversely affect these species (see Section 5.4.4.3). No operational impacts to state-listed terrestrial species in the Savannah River Swamp are expected because the discharge of water will not cause a noticeable decrease in terrestrial habitats.

The state-listed Atlantic sturgeon, blueback herring, hickory shad, and American shad found in the SRS Reach of the Savannah River have been impinged or entrained during past SRS reactor operations (Wike et al. 1989). Impingement and entrainment of these species are expected to result from water intake associated with NPR operations as well. Previous studies of these and other fish species in the SRS reach during periods of reactor operations have determined that viable populations of these species were being maintained (Wike et al. 1989). No evidence suggested that SRS operations had any adverse impacts on these species (Wike et al. 1989). Any adverse effects resulting from NPR operations should be small and localized.

Mitigation and Conclusions

A biological assessment that describes the impacts to Federally listed species has been developed and submitted to the FWS for evaluation (NUS-6). If deemed necessary by the FWS, a detailed plan to mitigate impacts to Federally listed threatened and endangered species at SRS would be developed in consultation with that agency. Impacts to the bald eagle (Federal endangered) would be mitigated by implementation of soil erosion control practices, including revegetation, on the NPR site. Such practices would prevent sedimentation of Pen Branch, where a bald eagle nest has been established downstream of the site. Erosion control on the NPR site also would prevent erosion-related impacts to protected species at Rainbow Bay, adjacent to the NPR site. Detailed surveys would be conducted on the NPR site to determine if any Federally or state-listed threatened or endangered species occur there. Disturbance to these species would be avoided or a mitigation plan would be developed if such avoidance was not possible. Mitigation of operational impacts is related to design features of the NPR and associated facilities, as described in Section 3.4. Additional mitigation to reduce effluents (e.g., deposition of salt due to drift, release of radionuclides, thermal releases) would not be needed to bring effluents within acceptable levels.

With mitigation, construction impacts to threatened and endangered species would be avoided. Some salt deposition on threatened and endangered plant species found within Rainbow Bay adjacent to the NPR site would occur, but this deposition would not exceed acceptable levels. Release of cooling-tower blowdown effluent would not adversely affect the thermal regime of Fourmile Branch, and increased flow rates within the stream would be within the range of normal flows. In addition, the concentration of radionuclides released to Fourmile Branch and the Savannah River would be well below established limits. As a consequence, no appreciable impacts are anticipated to threatened or endangered species that utilize these areas of SRS. Past studies indicate that impingement and entrainment of the endangered shortnose sturgeon at SRS water intake structures is unlikely.

5.4.5 Cultural Resources

Impacts to cultural resources at SRS (including up to three archaeological sites determined eligible for the National Register of Historic Places [NRHP]) would occur during the initial clearing and leveling of the NPR site for construction of project facilities. Additional impacts could result from construction of new utility and transportation corridors. Operational impacts are not expected. Adverse effects to significant cultural resources associated with each of the alternative technologies would be identical. The DOE would implement appropriate measures (avoidance or data recovery) to mitigate adverse effects to these resources before construction begins.

5.4.5.1 Impacts of No Action

The no-action alternative would not adversely affect the archaeological, historical, or cultural resources at SRS. These would remain as described in Section 4.3.6.

5.4.5.2 Impacts of NPR Construction and Operation

Affected Archaeological Sites and Historic Structures

Construction of an NPR would disturb 214-251 ha; archaeological sites and historic structures within this area would be subject to direct adverse effects. Impacts would be caused by clearing and leveling the land and by excavating foundations for the reactor and associated support facilities. Sites affected by these activities would be subject to disturbance, damage, and destruction of artifacts and features (including structural remains). Although the specific location within the SRS NPR site has not been determined, the known distribution and evaluation of archaeological sites in this part of SRS (Section 4.3.6.2) permit some probabilistic statements. The results of a survey and testing (Brooks et al. 1989) suggest that the NPR is likely to affect approximately nine sites, including one or two of the three sites eligible for the NRHP as determined by the South Carolina SHPO (Section 4.3.6.2). Only the latter sites would require mitigative measures; if avoidance is not possible, adverse effects would be mitigated through data recovery (i.e., excavation) in consultation with the South Carolina SHPO (Edmonds 1989). Eligible properties that could be affected are listed in Table 5.4.5-1 (see also Appendix Q). These sites represent the remains (structural remnants and associated debris) of small historic farmsteads of the nineteenth and twentieth centuries.

Additional impacts to sites could be caused by construction of the associated utility and transportation corridors. It is not possible to predict the adverse effects of these project features even in probabilistic terms. However, it is usually possible to avoid utility and transportation corridor impacts to archaeological sites through minor design modifications.

Indirect impacts associated with the construction and operation of the NPR would be minimal. Sites are protected from vandalism and inadvertent destruction by SRS's security contractor and by restricted access to SRS. All associated activities with potential indirect impacts would be reviewed and permitted through the Site Use Review System, which includes a comprehensive archaeological resources review. Any indirect impacts to significant

TABLE 5.4.5-1 Sites Eligible for the National Register of Historic Places that Could Be Affected by Construction of an NPR at SRS

Site	Cultural Period	Adverse Effects	Mitigation Options
38BR522	Twentieth century	Direct -- facility construction	Avoidance, protection, or data recovery
38BR619	Late nineteenth century, twentieth century	Direct -- facility construction	Avoidance, protection, or data recovery
38BR629	Late nineteenth century, twentieth century	Direct -- facility construction	Avoidance, protection, or data recovery

Source: Brooks et al. 1989.

archaeological resources would be evaluated and mitigated by DOE through consultation with the South Carolina State Historic Preservation Officer (SHPO).

Native American Cultural Resources

The DOE has initiated consultations with Native American groups and individuals to identify significant religious, ceremonial, and cultural resources that exist within SRS, including the NPR site. The DOE guidelines for compliance with the American Indian Religious Freedom Act are being followed (Sharples and Salk 1988). If Native American religious, ceremonial, or cultural resources are determined to exist within the NPR site, DOE will conduct subsequent consultations with the concerned Native American groups to determine mitigative measures.

Paleontological Resources

The potential for direct and indirect impacts to significant paleontological resources within the NPR site is minor. If significant paleontological resources were discovered during construction, DOE would undertake appropriate recovery of the fossil remains.

5.4.5.3 Mitigation and Conclusions

Adverse effects to archaeological sites and historic structures eligible for the NRHP require mitigative measures (36 CFR 800). Up to three historic archaeological sites could be damaged or destroyed by the proposed action. Unavoidable impacts to these sites would be mitigated through data recovery, which would entail background document research, excavation of sample units, mapping, and analysis of excavated and recorded artifacts and features; data recovery would be undertaken within the framework of issues and problems in the regional history of post-Civil War tenant farming (Edmonds 1989; Brooks et al. 1989). Mitigation of impacts to any sites and structures located along the right-of-way of proposed utility and transportation corridors cannot be specified at this time, but is likely to be limited to avoidance. A comprehensive mitigation plan incorporating the features listed above has been developed by DOE in consultation with the South Carolina SHPO and the Advisory Council on Historic

Preservation (Brooks et al. 1989). This plan has been reviewed by the South Carolina SHPO (Edmonds 1989). No mitigative measures appear to be warranted at this time for Native American cultural resources or paleontological resources.

5.4.6 Radiological Impacts

Radiological impacts were estimated for the three reactor technologies (HWR, LWR, and MHTGR) and their support facilities at SRS. Potential impacts from no action, normal operations, nonsevere accidents, and severe accidents are discussed in Sections 5.4.6.1, 5.4.6.2, 5.4.6.3, and 5.4.6.4, respectively. Impacts from transportation of radioactive materials are discussed in Section 5.4.6.5. The conclusions of the assessment and potential mitigative actions for reduction of significant impacts are discussed in Section 5.4.6.6.

5.4.6.1 Impacts of No Action

If no action were taken, no NPR would be constructed at SRS. Under such circumstances, the mission of tritium production is assumed to be undertaken by continued operations of the existing reactors at SRS, the potential impacts would be associated with the operations of these reactors. The radiological impacts from continued operations of the existing facilities have been assessed in a separate EIS document (DOE-10).

5.4.6.2 Impacts of Normal Operations

Baseline Radiological Conditions

Baseline radiological conditions at SRS are presented in Section 4.3.7. These conditions are specific to 1988 when the existing reactors at SRS were not operating.

Estimated Doses and Health Effects

Estimated CEDEs to a hypothetical maximally exposed off-site individual, 80-km population (augmented by the Beaufort-Jasper and Port Wentworth population groups for liquid releases), and in-plant workers from 1 year of exposure to releases from normal operations of NPRs and their support facilities at SRS are given in Table 5.4.6-1. The doses to the hypothetical maximally exposed off-site individual are the sums of doses from individual facilities to various receptors at the off-site location of maximum impact for each facility. The estimated dose listed in Table 5.4.6-1 for each technology/mode is therefore greater than the combined dose from all facilities to an actual individual at any single location. Radiological impacts from individual facilities are given in Appendix H.

The estimated annual CEDEs to the maximally exposed off-site individual range from 1.2×10^{-4} to 3.5×10^{-4} rem, and the estimated collective doses to the augmented 80-km population range from 8.5 to 24 person-rem. These doses are several orders of magnitude lower than the estimated doses from 1 year of exposure to natural background radiation, 0.3 rem and

TABLE 5.4.6-1 Estimated CEDEs from 1 Year of Exposure to Releases during Normal Operations of Reactors and Support Facilities at SRS

Technology/Mode	Maximally Exposed Off-site Individual ^a (rem)	80-km Population (person-rem)	In-Plant Worker ^b (person-rem)
HWR			
Tritium mode	1.5×10^{-4}	8.5	180
Plutonium mode	1.7×10^{-4}	12	360
LWR			
Tritium mode	1.2×10^{-4}	16	640
Plutonium mode	1.2×10^{-4}	16	700
MHTGR			
Tritium mode	1.9×10^{-4}	14	130
Plutonium mode	3.5×10^{-4}	24	360
Baseline conditions ^c	1.3×10^{-3}	120	-
Natural background	0.3 ^d	3×10^5	-

^aEach dose is the sum of doses to the maximally exposed off-site individual from releases from individual facilities; actually, the location of the maximally exposed off-site individual would probably differ from facility to facility.

^bSources for in-plant worker doses: HWR (WSRC-4); LWR (Heacock 1990b); MHTGR (Bowman-3); HWR support facilities (WSRC-2); LWR support facilities (Pajunen 1990); and MHTGR support facilities (Bowman-4).

^cThese values include doses from operation of K, L, and P reactors, assumed to be at full power, and from Vogtle. These values are 1.1×10^{-3} and 110 person-rem, respectively, without P Reactor operating.

^dThe value of 0.3 rem for natural background is average, not maximum (see Section 4.3.7).

3×10^5 person-rem, respectively. When the estimated doses to the hypothetical maximally exposed off-site individual from NPR facilities are added to the baseline doses, the resulting sums are smaller (by factors of more than 6) than the dose rate limits for compliance with the Clean Air Act and Safe Drinking Water Act and the DOE standard for normal operations of DOE facilities. The estimates presented herein are based on conservative assumptions; actual impacts are expected to be even smaller.

The health effects associated with 1 year of normal operations would be correspondingly small (see Appendix H, Sections H.4.4 and H.5.4). For the hypothetical maximally exposed off-site individual, the incremental lifetime fatal cancer risk is estimated to range from 5×10^{-8} to 1×10^{-7} . For the augmented 80-km population, the incremental number of cancer deaths is estimated to range from 0.003 to 0.009 and the incremental number of genetic effects from 0.001 to 0.004. These estimates are sufficiently small that no cancer deaths or genetic effects would be expected from routine releases during the operating lifetimes of NPR facilities at SRS. For comparison with these estimates, about 100 cancer fatalities/yr would be expected among the 80-km population around the site as a result of exposure to natural background radiation (calculated using the EPA risk estimator of 4×10^{-4} cancer fatalities/person-rem), and about 1,600 cancer fatalities/yr would be expected among the same population from all causes combined (U.S. Bureau of the Census 1987).

Collective doses to in-plant workers from 1 year of normal operations of NPR facilities are estimated to range from 130 to 640 person-rem in the tritium production mode and from 360 to 700 person-rem in the plutonium production mode. These doses would be predominantly to workers in the reactor, fuel processing, and plutonium-target processing facilities. For SRS, the doses to HWR support facility workers are assumed to be all in support of the NPR (WSRC-2). If the existing reactors at SRS are operating at the same time, some of the doses to workers would be received while working in the facilities supporting those reactors. The doses to LWR support facility workers are taken to be the same as those to LWR support facility workers at Hanford (Pajunen 1990), and the doses to MHTGR support facility workers are taken to be the same as those to MHTGR support facility workers at INEL (Bowman-4).

Through work planning and personnel monitoring, no worker would be allowed to accumulate an annual dose that is greater than a fraction of the DOE occupational limits. The estimated collective in-plant occupational doses for NPR facilities at SRS are much smaller than these limiting doses.

The estimated number of cancer fatalities among in-plant workers due to radiation exposure per year of operations would be between 0.05 and 0.03 in the tritium production mode and between 0.1 and 0.3 in the plutonium production mode (calculated using the EPA risk factor of 4×10^{-4} cancer fatalities/person-rem). Assuming that the same number of workers would be employed at these facilities continuously, one cancer fatality would be expected among the workers for every 3 to 20 years of operations in the tritium production mode and one fatality for every 3 to 10 years of operations in the plutonium production mode.

5.4.6.3 Impacts of Postulated Nonsevere Accidents

Nonsevere Accidents at Reactors

The methodology used to estimate radiological impacts of postulated nonsevere accidents at the proposed NPRs at SRS is discussed in Section 5.1.7.2. Appendix I provides a more complete discussion of the methodology and potential impacts, as well as descriptions of the accidents analyzed. In Appendix I, estimated doses and health effects are presented for a range of postulated nonsevere accidents in the proposed NPRs at SRS. In this section, only bounding estimates are given -- i.e., the highest consequences from any nonsevere accident at the HWR, LWR, and MHTGR for each of the three receptors (maximally exposed off-site individual, 80-km off-site population, and maximally exposed colocated worker). The accidents that result in the highest consequences are listed in Table 5.1-2; the estimated doses for these accidents are given in Table 5.4.6-2. For the HWR and LWR, the accident with the highest consequences is different for off-site individuals than for the on-site colocated worker.

In Table 5.4.6-2, the doses listed with the "ingestion pathway included" were estimated assuming that no mitigative or emergency action was taken following the accident. That is, it was assumed that the maximally exposed off-site individual and persons within 80 km of the affected facility continued their activities as usual after the accident. The values listed with the "ingestion pathway not included" were estimated assuming that some action was taken that would eliminate the dose due to the ingestion pathway.

The accidents with the highest consequences (Table 5.1-2) are different for each technology. Because of the different designs and inherent technology differences, the progression and therefore the quantity and timing of radioactive releases to the environment during these accidents are also different. The source terms for the bounding postulated accidents are listed in Appendix I.

The estimated health effects resulting from the doses listed in Table 5.4.6-2 are given in Table 5.4.6-3. The effects for the maximally exposed off-site individual and the colocated worker are given in terms of incremental risk of contracting a fatal cancer. The effects for the worst-sector population are given in terms of additional fatal cancers and severe genetic effects.

From an examination of the estimated doses due to postulated NPR nonsevere accidents at SRS (Table 5.4.6-2 and Appendix I), it is apparent that, even with the highly conservative estimates provided in this EIS, no emergency action would be required for the maximally exposed off-site individual or for the population around the site if any of these accidents were to occur. However, for the highest consequence accidents, some protective actions would probably be taken, such as washing food to remove surface contamination or temporarily putting animals on stored feed. Taking protective actions would be recommended on a case-by-case basis by the emergency response personnel from Federal, state, and local governments around the site. (See Section 5.1.7.2 for a discussion of mitigative actions.)

A more detailed assessment of the results presented in this section and a discussion of occupational exposures to in-plant workers during and after (i.e., cleanup phase) the postulated nonsevere accidents are provided in Appendix I. Based on this information, it is estimated that with proper protective action, no cancer fatalities or genetic effects would occur at or near the

TABLE 5.4.6-2 Estimated Doses for Accident with Highest Consequences from Postulated NPR Nonsevere Accidents at SRS

Reactor ^a	Ingestion Pathway Included	Committed Effective Dose Equivalent ^b		
		Maximally Exposed Off-site Individual (rem)	80-km Worst-Sector Population (person-rem)	Maximally Exposed Colocated Worker (rem)
HWR	No	0.0030	89	0.010
	Yes	0.18	2,300	NA ^c
LWR	No	0.0071	250	0.0052
	Yes	0.39	5,500	NA
MHTGR	No	0.0089	300	0.0023
	Yes	0.24	3,800	NA

^aThe maximally exposed off-site individual would be 14,500 m north-northwest; the maximally exposed sector would be west-northwest with a population of 254,000; and the maximally exposed colocated worker would be 2,100 m west-southwest.

^bEstimated doses from the highest consequence accident in the unlikely event that the accident occurred; see Table 5.1-2 for accident descriptions and frequency classes; see Appendix I for a description of the calculations and for more details of these estimates.

^cNA means not applicable.

site as a result of a postulated nonsevere accident in any of the proposed NPRs at SRS. This compares with approximately 1,600 cancer fatalities/yr expected among the 80-km population around the site from all causes combined (U.S. Bureau of the Census 1987).

The designs for the proposed NPR program facilities are still under development. As the designs mature, some of the conservative assumptions made in the calculations regarding the operation of various safety features can be relaxed. Consequently, once the final designs are available, the estimated releases of radionuclides from these facilities and the associated doses and health effects will probably be lower.

Nonsevere Accidents at Support Facilities

The types of postulated nonsevere accidents at SRS new production reactor support facilities that could result in atmospheric releases of radioactive materials to the environment are described briefly in Section I.4.1.2 of Appendix I. The extent to which radioactivity would be

TABLE 5.4.6-3 Estimated Incremental Health Effects per Accident^a for Postulated NPR Nonsevere Accidents with the Highest Consequences at SRS

Reactor	Ingestion Pathway Included	Maximally Exposed Off-site Individual Fatal Cancer Risk	80-km Worst-Sector Population		Maximally Exposed Colocated Worker Fatal Cancer Risk
			Fatal Cancers	Genetic Effects	
HWR	No	1×10^{-6}	None ^b	None	4×10^{-6}
	Yes	7×10^{-5}	1	None	NA ^c
LWR	No	3×10^{-6}	None	None	2×10^{-6}
	Yes	2×10^{-4}	2	1	NA
MHTGR	No	4×10^{-6}	None	None	9×10^{-7}
	Yes	1×10^{-4}	2	1	NA

^aIn the unlikely event that the accident occurred; see Table 5.1-2 for accident descriptions and frequency classes; see Appendix I for a description of the calculations and for more details of these estimates.

^b"None" means the calculated value is less than 0.5.

^cNA means not applicable.

released to the environment in the event of such accidents would depend on a number of factors, including the inventory and volatility of the radioactive materials and the operating status or efficiency of systems that filter out these materials. Not all types of accidents are possible at each type of support facility. For example, criticality accidents (accidents involving an unintended nuclear chain reaction) are not possible at tritium-target processing facilities because of the absence of fissile material (material that can sustain a chain reaction). Also, some types of accidents are restricted to only one reactor technology; for example, accidents involving combustion of Zircaloy-4 chips are restricted to the LWR technology (Zircaloy-4 is used to clad LWR fuel).

Because detailed facility designs and safety analyses were not available, Safety Analysis Reports and other reports addressing the hazards of operations similar to those to be utilized at NPR support facilities were reviewed in order to compile a list of postulated accidents. A subset of these accidents that could provide a reasonable and credible upper bound estimate of the maximum radionuclide release to the environment was chosen for analysis for each type of support facility for each reactor technology at each site. Appendix I describes the accidents chosen and presents the source terms and the estimated impacts for bounding (highest consequence) accidents in each type of support facility for each technology at each site. The presentation here is limited to the bounding postulated accidents for each reactor technology at SRS.

The highest CEDEs to the maximally exposed off-site individual, off-site worst-sector population, and maximally exposed colocated worker from any of the postulated nonsevere accidents at SRS support facilities are given in Table 5.4.6-4. The doses listed with and without the ingestion pathway included were obtained using the same assumptions that were used to estimate impacts from postulated accidents at reactors (see above).

Overall, the postulated nonsevere accident at SRS support facilities that could result in the highest doses to off-site individuals is estimated to be a tritium deflagration (fire and explosion) accident at the tritium-target processing facility for all reactor technologies. The tritium release from this accident is assumed to be the same for each reactor technology and, because the proposed location for this facility is also the same, the estimated doses are the same for all technologies (1.2 rem to the maximally exposed off-site individual, 1.6×10^4 person-rem to the worst-sector population, and 0.086 rem to the maximally exposed colocated worker). The postulated nonsevere accident with the highest dose (0.18 rem) to a colocated worker would be a criticality at the fuel fabrication facility for all technologies. The source terms for this accident are assumed to be the same for each reactor technology and, because the proposed location for this facility is also the same, the estimated doses are the same for all technologies. Thus, the highest dose to the maximally exposed colocated worker from any support facility at SRS would be 0.18 rem, which is well below the DOE occupational standard of 5 rem.

From an examination of the estimated doses (with the ingestion pathway included) due to postulated support facility nonsevere accidents at SRS (Table 5.4.6-4 and Appendix I), it is apparent that the EPA PAGs are not exceeded for any of the postulated accidents. (See Section 5.1.7.2 for a discussion of mitigative actions and the use of PAGs.) However, the estimated thyroid dose of 23 rem to the maximally exposed off-site individual for one of the postulated accidents (30-day cooled fuel processing accident at the HWR technology fuel processing facility, accident SH2N1; see Table I.45 in Appendix I) exceeds the FDA emergency PAG of 15 rem for the thyroid. In addition, the estimated CEDEs and organ doses to the maximally exposed off-site individual exceed FDA preventive PAGs for a few postulated accidents (see Appendix I, Section I.4). Therefore, if the accident having the highest estimated thyroid dose to the maximally exposed off-site individual occurred, some protective actions might be taken to significantly reduce the dose from the ingestion pathway. If those postulated accidents having estimated doses below the FDA emergency PAGs but above the preventive PAGs were to occur, some low-impact protective actions would probably be taken, such as washing food to remove surface contamination or temporarily putting animals on stored feed. Taking protective actions would be recommended on a case-by-case basis by the emergency response personnel from Federal, state and local governments around the site.

The estimated health effects resulting from the doses listed in Table 5.4.6-4 are given in Table 5.4.6-5. If mitigative actions were taken to eliminate the ingestion pathway, no cancer fatalities or genetic effects would be expected among the population around SRS from an occurrence of any of the postulated support facility nonsevere accidents. This compares with approximately 1,600 cancer fatalities/yr expected among the 80-km population around the site from all causes combined (U.S. Bureau of the Census 1987).

The doses and health effects presented in Tables 5.4.6-4 and 5.4.6-5 are based on very conservative assumptions and on the assumption that an accident will occur. As discussed for nonsevere reactor accidents (see above), the estimated releases of radionuclides from these

TABLE 5.4.6-4 Estimated Doses for Accident with Highest Consequences^a from Postulated Nonsevere Accidents at SRS Support Facilities

Reactor	Ingestion Pathway Included	Committed Effective Dose Equivalent		
		Maximally Exposed Off-site Individual ^b (rem)	80-km Worst-Sector Population ^b (person-rem)	Maximally Exposed Colocated Worker ^c (rem)
HWR	No	0.022	640	0.18
	Yes	1.2	1.6×10^4	NA ^d
LWR	No	0.022	640	0.18
	Yes	1.2	1.6×10^4	NA
MHTGR	No	0.022	640	0.18
	Yes	1.2	1.6×10^4	NA

^aIn the unlikely event that the accident occurred; see Appendix I for a description of the calculations and for more details of these estimates.

^bThe highest consequence postulated accident for the maximally exposed off-site individual and worst-sector population for each reactor technology is the tritium deflagration accident at the tritium-target processing facility (accidents SH6D1, SL6D1 in Appendix I).

^cThe highest consequence postulated accident for the maximally exposed colocated worker for each reactor technology is a criticality at the fuel fabrication facility (accidents SH1C1, SL1C1 in Appendix I).

^dNA means not applicable.

facilities and the associated doses and health effects will probably be lower once the final NPR program facility designs are available.

5.4.6.4 Impacts of Postulated Severe Accidents

Radiological impacts of postulated severe accidents at SRS new production reactors and their support facilities are estimated for the off-site general public (population within an 80-km radius of the site) and for colocated workers (on-site workers excluding those in the facility at risk). For the severe reactor accident analysis, calculated impacts are further summarized in the form of CCDFs or expressed as average risk values for three consequence measures: early fatalities, cancer fatalities, and population doses.

TABLE 5.4.6-5 Estimated Incremental Health Effects per Accident^a for Postulated Nonsevere Accidents with the Highest Consequences at SRS Support Facilities

Reactor	Ingestion Pathway Included	Maximally Exposed Off-site Individual Fatal Cancer Risk ^b	80-km Worst-Sector ^b Population		Maximally Exposed Colocated Worker Fatal Cancer Risk ^c
			Fatal Cancers	Genetic Effects	
HWR	No	9×10^{-6}	None ^d	None	7×10^{-5}
	Yes	5×10^{-4}	6	4	NA ^e
LWR	No	9×10^{-6}	None	None	7×10^{-5}
	Yes	5×10^{-4}	6	4	NA
MHTGR	No	9×10^{-6}	None	None	7×10^{-5}
	Yes	5×10^{-4}	6	4	NA

^aIn the unlikely event that the accident occurred; see Appendix I for a description of the calculations and for more details of these estimates.

^bThe highest consequence postulated accident for the maximally exposed off-site individual and worst-sector population for each reactor technology is the tritium deflagration accident at the tritium-target processing facility (accidents SH6D1, SL6D1, SM6D1 in Appendix I).

^cThe highest consequence postulated accident for the maximally exposed colocated worker for each reactor technology would be a criticality at the fuel fabrication facility (accidents SH1C1, SL1C1, SM1C1 in Appendix I).

^d"None" means the estimated number of cancer deaths or genetic effects is less than 0.5.

^eNA means not applicable.

Severe Accidents at Reactors

Early Fatalities. Mitigative actions such as evacuation and relocation are considered in calculations of early fatalities. Calculations predict that no early fatalities would occur off-site among the general public surrounding the SRS as a result of any of the postulated NPR severe accidents. The major factors contributing to this result are the large size of SRS and the low population density in the area near the site where most of the exposures would be expected to occur. There would be no early fatalities among colocated workers at the site.

Cancer Fatalities. The CCDFs for cancer fatalities calculated for off-site and on-site populations at SRS are presented in Figure 5.4.6-1. The estimated cancer fatalities at various exceedance frequencies account for the short-term and long-term dose mitigative actions discussed in Appendix J.

The estimated impacts to the general public due to either HWR or LWR severe accidents at SRS are comparable to each other but are both higher than the impacts due to MHTGR severe accidents. This is also true for colocated workers. The radionuclide release associated with the postulated MHTGR severe accidents is assumed to occur in two phases. The first release would be followed by a significantly larger second release, which would occur between 50 and 80 hours later. Because of the long delay between the two releases, evacuation or relocation of colocated workers would likely be completed before the second release occurred. Therefore, the radiological consequences to colocated workers are significantly lower for MHTGR accidents than for HWR and LWR accidents.

The likelihood of causing one or more cancer fatalities among colocated workers at SRS due to severe accidents is estimated to be about 5×10^{-8} per reactor-year for an LWR and 3×10^{-8} for an HWR (see Figure 5.4.6-1). The likelihood of producing the same cancer fatalities for an MHTGR is estimated to be less than 1×10^{-10} per reactor-year. Because of this low exceedance frequency, the on-site CCDF for an MHTGR is not shown in Figure 5.4.6-1.

Population Doses. The CCDFs for off-site and on-site population doses at SRS are also presented in Figure 5.4.6-1. The estimated population dose accounts for the dose mitigative actions that would take place immediately after the accident and in the long term. The CCDFs indicate that variations in population doses at equal exceedance frequency levels are similar to those of cancer fatalities.

Risks. Estimated risks resulting from postulated NPR severe accidents are presented in terms of societal risks and individual risks for the consequence measures under consideration. In contrast to individual risks, societal risks are risks to all members of the general public within an 80-km radius around the reactor or to all colocated workers at SRS.

All estimated average values of societal early fatality risk are lower than 2×10^{-10} per 1 year of NPR operations at SRS (Hong et al. 1991). This risk is extremely small when compared with other kinds of accidents (see discussion of "Risks" in Section 5.2.6.4). The average societal risk value for cancer fatality and population dose for the three technologies at SRS are presented in Table 5.4.6-6. The radiological risks for HWR and LWR accidents are comparable, but the risk is lower for MHTGR accidents because of a relatively small release of radioactive material.

Individual risks of early fatality and cancer fatality in the immediate vicinity of the reactor were also estimated for the purpose of comparison to NPR safety goals (DOE-8). All individual risks resulting from postulated severe accidents at an HWR, LWR, or MHTGR at SRS are several orders of magnitude below the NPR safety goal values (Hong et al. 1991).

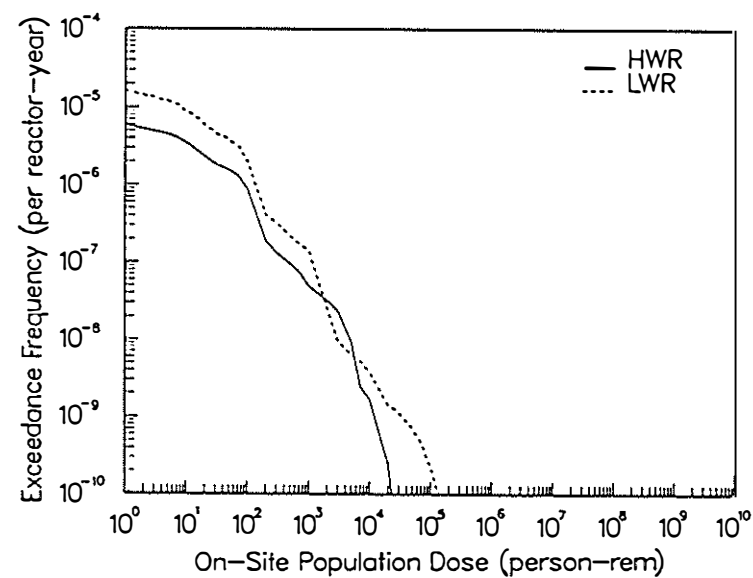
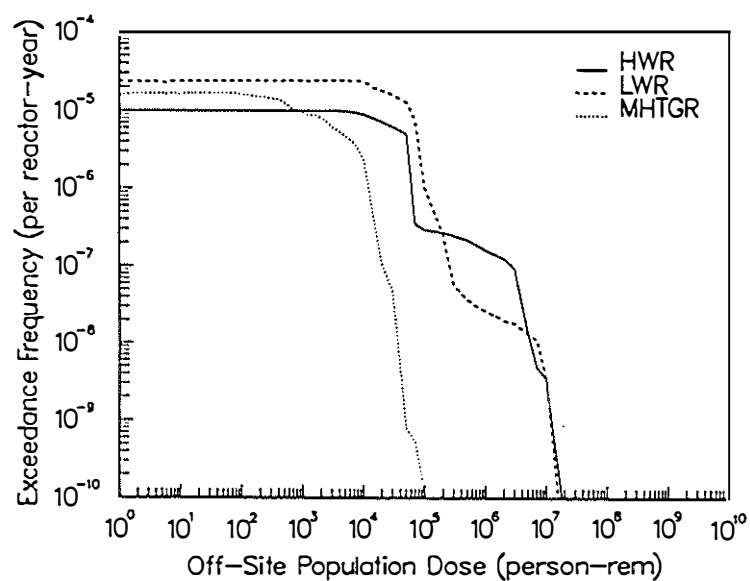
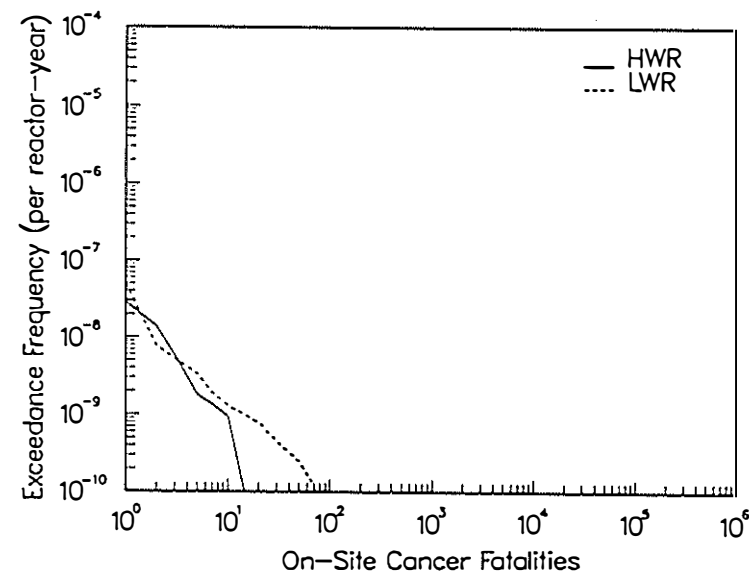
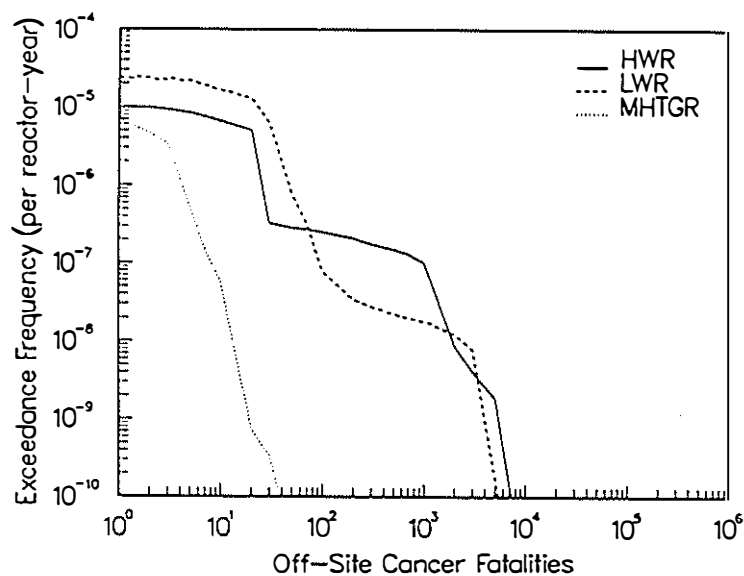


FIGURE 5.4.6-1 Frequency Distributions of Off-site and On-site Consequences of Severe Reactor Accidents at SRS (on-site cancer fatalities and population doses are negligible for the MHTGR at the exceedance frequencies shown)

TABLE 5.4.6-6 Estimated Values of Societal Risks Resulting from Postulated Severe Reactor Accidents at SRS

Reactor	Population Dose Risk (person-rem/ reactor-year)		Cancer Fatality Risk (fatalities/ reactor-year)	
	General Public	Colocated Worker	General Public	Colocated Worker
HWR	1	4×10^{-4}	4×10^{-4}	2×10^{-7}
LWR	1	9×10^{-4}	6×10^{-4}	4×10^{-7}
MHTGR	0.06	2×10^{-7}	2×10^{-5}	$<10^{-10}$

Severe Accidents at Support Facilities

The estimated releases from postulated severe accidents at the fuel fabrication or tritium-target processing facilities at SRS would not result in early fatalities. The estimated individual risks of cancer fatality are very small, i.e., less than 10^{-10} fatalities/yr. The estimated total radiological impacts to colocated workers and the general public from the postulated accidents are summarized in Table 5.4.6-7. The population doses and corresponding cancer effects represent the direct consequences of the accident; the risk values represent the consequences weighed by the frequency of the accident, which is estimated to be 4×10^{-7} /yr at SRS (see Appendix J).

5.4.6.5 Impacts of Transportation

The radiological impacts from transportation of radioactive materials for SRS include on-site and off-site activities. For on-site transportation, the radioactive materials from NPR operations are generally categorized as (1) irradiated driver-fuel assemblies, (2) irradiated target rods, (3) low-level waste, and (4) transuranic waste. The low-level waste would be disposed of on-site. Off-site transportation might include shipment of plutonium metal to the Rocky Flats Plant for processing. The proposed NPR at SRS would have its own on-site fuel processing, waste processing, and waste storage facilities and a heavy-water processing facility for the HWR. Off-site transportation of high-level waste and transuranic waste to the Federal repository or Waste Isolation Pilot Plant, respectively, has been discussed in the existing reviews for these facilities (DOE-49; DOE-51). The results of these assessments were used to estimate the risks associated with wastes from NPR operations in this EIS. More details regarding radiological impacts from transportation of radioactive materials are presented in Appendix K.

Incident-Free Transportation

The estimated radiological impacts from incident-free transportation are summarized in Table 5.4.6-8. The maximum individual doses are estimated to be 1.2 rem/yr to a transport

TABLE 5.4.6-7 Estimated Total Radiological Impacts of Postulated Severe Accidents at SRS Support Facilities^a

Impact	Tritium Fuel Fabrication Facility	Tritium-Target Processing Facility
Population dose	46 person-rem	6,400 person-rem
Latent cancer effects	0.02 fatalities	2 fatalities
Population dose risk	2×10^{-5} person-rem/yr	2×10^{-3} person-rem/yr
Population health risk	7×10^{-9} fatalities/yr	1×10^{-6} fatalities/yr

^aEach value given in this table is the sum of impacts to the colocated workers and the general public. See Appendix J for details.

TABLE 5.4.6-8 Impacts from Incident-Free Transportation of Radioactive Materials for NPR Operations at SRS

Reactor	Transportation Mode	Maximum Individual Dose ^a (rem/yr)	Maximum Individual Health Risk (health effects/yr)	Population Dose Risk (person-rem/yr)	Population Health Risk (health effects/yr)	Population Genetic Risk (effects/yr)
HWR	On-site	0.47	2×10^{-4}	5.2	0.002	0.001
	Off-site	1.2	5×10^{-4}	18	0.007	0.005
	Total			23	0.009	0.006
LWR	On-site	0.77	3×10^{-4}	8.5	0.003	0.002
	Off-site	1.2	5×10^{-4}	34	0.02	0.009
	Total			43	0.02	0.01
MHTGR	On-site	0.54	2×10^{-4}	6.0	0.002	0.002
	Off-site	1.2	5×10^{-4}	35	0.01	0.009
	Total			41	0.01	0.01

^aThe maximum individual doses shown here are the doses to occupational personnel. For nonoccupational personnel, the maximum individual dose is estimated to be 0.005 rem/yr (DOE-49).

vehicle crew member (occupational worker) and 0.005 rem/yr to a member of the public near the transport route. These doses are within the DOE limits of 5 rem/yr for occupational workers (DOE Order 5480.11) and 0.1 rem/yr for the general public (DOE Order 5400.5). The total annual transportation doses from incident-free transportation, both on-site and off-site, are estimated to range from 23 to 43 person-rem, which would result in no more than 0.02 cancer fatalities and no more than 0.01 genetic effects.

Transportation Accidents

The estimated radiological impacts from transportation accidents are summarized in Table 5.4.6-9; associated nonradiological impacts are also presented. The total annual population dose risks from transportation accidents (considering the probability of occurrence and consequences) are estimated to range from 0.56 to 1.0 person-rem. These estimated dose risks would result in annual health risks of no more than 4×10^{-4} cancer fatalities and 6×10^{-5} genetic effects. By comparison, the nonradiological accident impacts from the same transportation activities are estimated to range from 0.01 to 0.04 accident fatalities. The highest radiological risk is associated with the MHTGR and would result mainly from transportation of TRU waste to the WIPP for disposal.

The maximum individual doses from on-site transportation accidents are estimated to be 0.26 rem for an on-site worker and 0.14 rem for a member of the general public at the site boundary. These doses would result in about 1×10^{-4} and 2×10^{-5} lifetime cancer risks to the exposed on-site and off-site individuals, respectively. Such maximum doses have been calculated for a severe rail accident involving a shipment of irradiated driver-fuel assemblies, for which the accident frequency is estimated to be about 1×10^{-5} /yr. For off-site transportation, the maximum individual dose is estimated to be 0.29 rem to a member of the public from a severe transportation accident involving shipment of plutonium product to the Rocky Flats Plant, for which the estimated accident frequency is about 1×10^{-7} /yr. Much of the maximum individual dose estimated for a member of the general public is related to ingestion of contaminated foodstuffs, which can be interdicted by appropriate government agencies according to Federal remedial action guidelines. If such interdiction occurred, the resulting doses would be lower than those estimated in this EIS.

5.4.6.6 Conclusions and Mitigation

Conclusions

The radiological impacts to off-site individuals and on-site workers because of the proposed NPR program facilities at SRS are summarized below. For perspective in understanding the significance of these impacts, statistics of the U.S. Bureau of the Census (1987) indicate that among the population within 80 km of the site (approximately 954,000 persons), the expected number of deaths due to accidents and adverse effects is about 470 per year and the expected number of cancer deaths from all causes combined is about 1,600 per year. The natural background radiation dose for the same population is estimated to be about 300,000 person-rem per year, which is calculated to result in approximately 100 cancer deaths per year (calculated using the health risk factor of 4×10^{-4} cancer deaths per person-rem). The results presented

TABLE 5.4.6-9 Impacts from Transportation of Radioactive Materials for NPR Operations at SRS under Accident Conditions

Reactor	Transportation Mode	Maximum Individual Dose ^a (rem/yr)	Maximum Individual Health Risk ^b (health effects/yr)	Population Dose Risk ^b (person-rem/yr)	Population Health Risk ^b (health effects/yr)	Population Genetic Risk ^b (effects/yr)	Nonradiological Risk ^c (effects/yr)
HWR	On-site	0.043	2×10^{-5}	0.0015	6×10^{-7}	4×10^{-7}	0.005
		0.26	1×10^{-4}				
	Off-site	0.29	1×10^{-4}	0.56	2×10^{-4}	2×10^{-9d}	0.009
	Total			0.56	4×10^{-7}	4×10^{-7}	0.01
LWR	On-site	0.043	2×10^{-5}	0.091	4×10^{-5}	2×10^{-5}	0.01
		0.26	1×10^{-4}				
	Off-site	0.29	1×10^{-4}	0.58	2×10^{-4}	1×10^{-10d}	0.02
	Total			0.67	2×10^{-4}	2×10^{-5}	0.03
MHTGR	On-site	0.043	2×10^{-5}	0.25	1×10^{-4}	6×10^{-5}	0.006
		0.26	1×10^{-4}				
	Off-site	0.29	1×10^{-4}	0.73	3×10^{-4}	1×10^{-10d}	0.03
	Total			1.0	4×10^{-4}	6×10^{-5}	0.04

^aFor each reactor technology, two values are given for the on-site transportation mode. The value on the first line is for a member of the public located at the site boundary; the value on the second line is for a transportation worker located 100 m away from the accident.

^bFor on-site transportation, calculated risks are based on GENII methodology, for which the worst-sector population risks are estimated; for off-site transportation, calculated risks are based on RADTRAN methodology, for which uniform population density is assumed.

^cThe nonradiological risks are the traffic accident fatalities associated with transportation.

^dData do not include shipment of transuranic waste and high-level waste because genetic dose data are not available from existing environmental reviews (DOE-49; DOE-51).

below show that the radiological impacts of the proposed NPR program facilities would be small in comparison to the impacts from other causes.

Normal Operations. Under normal operations, annual radioactive releases from an NPR and its support facilities would result in a dose of no more than 3.5×10^{-4} rem to the maximally exposed off-site individual. This estimated individual doses combined with the existing baseline dose at SRS, is well within regulatory limits, which are 0.01 rem/yr for airborne releases (Clean Air Act) and 0.004 rem/yr for releases to drinking water (Safe Drinking Water Act). The estimated annual population doses, including the off-site population and in-plant workers, are no more than 700 person-rem. This equates statistically to less than 1 additional cancer fatality among about 100 cancer fatalities/yr estimated for the 80-km population in the SRS area. All estimated impacts from normal operations deviate by no more than a factor of 4 among the three reactor technologies.

Nonsevere Accidents. For nonsevere accidents at reactors, the highest consequence event is estimated to result in no early fatalities and in a total population dose of about 5,500 person-rem. This equates statistically to 2 cancer fatalities. The highest consequence estimated for the postulated nonsevere accidents would result from a loss-of-coolant accident in the LWR due to a large pipe break; such an accident would result in an estimated maximum off-site individual dose of 0.39 rem. Other estimated impacts for the highest consequence scenarios for either the HWR or MHTGR would be lower than the estimated impacts for the LWR by a factor of about 2 to 3 for population risks and for maximum individual risks.

For postulated nonsevere accidents at support facilities, the highest consequence event is estimated to result in no early fatalities and a total population dose of about 16,000 person-rem. This equates statistically to 6 cancer fatalities. The highest consequence estimated from the postulated support facility nonsevere accidents would result from a tritium deflagration accident in a tritium-target processing facility; such an event would result in an estimated maximum off-site individual dose of 1.2 rem. These consequences would equally apply to all three technologies.

Severe Accidents. For postulated severe accidents at reactors, a broad spectrum of possible accidental releases has been considered, with frequencies ranging from 10^{-6} to 10^{-9} /yr. The estimated health risks (frequencies times health consequences) are no more than 6×10^{-4} cancer fatalities/yr and no more than 2×10^{-10} early fatalities/yr for both colocated workers and the general public. For postulated severe accidents at NPR support facilities, an upper bound radioactive release has been established for all three reactor technologies. Such an event is estimated to result in no early fatalities and in a risk of 1×10^{-6} cancer fatalities/yr for a severe seismic event with an estimated frequency of about 4×10^{-7} /yr.

Transportation. Impacts from transportation of radioactive materials were assessed for incident-free and accident conditions for all shipments transported on-site and off-site. The estimated maximum individual doses are no more than 1.2 rem/yr to an occupational worker (identified as a transport vehicle crew member) and no more than 0.005 rem/yr to a member of the general public. These maximum doses are below the DOE limits of 5 rem/yr for occupational workers and 0.1 rem/yr for the general public. The estimated total incident-free

population doses are no more than 43 person-rem/yr, which corresponds to 0.02 cancer fatalities/yr. Most of the impact results from shipment of high-level waste off-site to the Federal repository. The estimated accident dose risks are no more than 1.0 person-rem/yr, which corresponds to a risk of 4×10^{-4} cancer fatalities/yr. Much of the accident risk results from shipment of transuranic waste from SRS to the Waste Isolation Pilot Plant for disposal. The total estimated radiological risk from transportation, including incident-free and accident conditions, is about the same as the nonradiological accident risk of 0.03 fatalities/yr resulting from highway accidents for similar transportation activities involving nonradioactive materials.

Mitigation

In conclusion, all radiological impacts from normal (incident-free) operations of an NPR and its associated activities at SRS have been determined to be within Federal guidelines and standards. Furthermore, all activities are required to be practiced under the ALARA policy, as stipulated under DOE Orders 5480.11 and 5400.5, to further reduce exposures to both workers and the general public. In the event of an accident, potential radiological impacts would be reduced by implementation of effective short-term mitigative actions according to emergency preparedness procedures (see Section 3.6). Implementation of long-term mitigative measures, such as land decontamination and crop interdiction, would be conducted by appropriate government authorities according to Federal guidelines. If these mitigative actions were implemented, it is estimated that accident impacts could be reduced by as much as 90% or more below those estimated in this EIS.

5.4.7 Accidents Involving Nonradioactive Hazardous Materials

The purpose of this section is to assess the potential human health risks from accidental releases of nonradioactive hazardous materials that would be used during operation of an NPR and associated support facilities at SRS. Risks have been assessed for ammonia, chlorine, and hydrogen -- the three chemicals believed to pose the highest hazard potentials. The assessment examines (1) effects of acute inhalation for single exposures for up to 1 hour, (2) thermal radiation from fireballs, and (3) explosion hazards. Two accident scenarios were modeled: (1) rupture and complete release from on-site storage vessels and (2) rupture and complete release from a shipment vessel damaged by a transportation accident.

Environmental fate and atmospheric transport were simulated using the SLAB model (Ermak 1988, 1989). The modeling simulations were based on meteorological conditions that, on the basis of data collected at SRS for the period from 1982 through 1986, occur about 15% of the time. Furthermore, the meteorological data indicate that in most cases the selected conditions can persist long enough for the toxic plume to reach the maximum distance where exposure criteria would be exceeded (the exception being hydrogen chloride migration out to 50 km). The impacts from inhalation of ammonia and chlorine are presented in terms of (1) the size of off-site populations that would be exposed to concentrations above the Emergency Response Planning Guides (ERPGs), as defined in Section 5.1.7, for on-site storage vessel accidents and (2) impact radii for transportation accidents. For fire and explosion hazards, the results are presented in terms of distances from the point of release at which various thermal and overpressure criteria would be exceeded.

The results of the hazard assessment for the HWR, LWR, and MHTGR technologies at SRS are summarized below, and more details are presented in Appendix L. Details of the nonradioactive hazardous material accident assessment methodology are presented in a separate report (NUS-5).

5.4.7.1 Impacts of No Action

If an NPR were not constructed and operated at SRS, current site conditions would continue. Since chemical storage and usage would remain unchanged, the risk of accidents involving nonradioactive hazardous materials would not change.

5.4.7.2 Impacts of NPR Operation

The following discussion for each reactor type addresses the chemical release scenarios that would affect the greatest number of people.

Acute Inhalation

Acute inhalation impacts for the three reactor technologies were assessed for chlorine and ammonia releases.

HWR. During operation of an HWR, on-site storage accidents involving chlorine release would affect the largest number of people (among the scenarios investigated). For off-site populations, no individuals would be exposed to life-threatening conditions (ERPG-3) or suffer impaired ability to take protective action (ERPG-2); from 0 to 300 individuals might perceive an objectionable odor or experience mild transient health effects (ERPG-1).

Transportation accidents that resulted in the largest impact radii also would involve chlorine releases. Distances at which ERPGs would be exceeded are 3 km for ERPG-3, 8 km for ERPG-2, and 14 km for ERPG-1.

The times required for toxic plumes to reach their critical impact radii for on-site storage and transportation accidents involving chlorine releases would range from about 1 to 4 hours. The meteorological data indicate that the conditions modeled for chlorine release (1 m/s wind speed and Pasquill stability class F) occur about 10% of the time and can persist long enough for the toxic plume to reach the maximum travel distance.

LWR. For LWR operations, on-site storage accidents and transportation accidents involving release of chlorine would affect the largest number of people. Since the storage and transportation conditions for an LWR would be the same as for an HWR, the impacts would be the same as discussed in the previous subsection.

MHTGR. For an MHTGR, on-site storage accidents involving an ammonia release would affect the largest number of people. For off-site populations, no individuals should be

exposed to life-threatening conditions. From 300-7,000 or more individuals might perceive an odor, experience mild transient health effects, or be exposed to conditions that might impair their ability to take protective action.

Transportation accidents resulting in the largest impact radii also would involve ammonia releases. Distances at which ERPGs would be exceeded are 1 km for ERPG-3, 3 km for ERPG-2, and greater than 12 km for ERPG-1.

The times required for toxic plumes to reach impact radii for on-site storage and transportation accidents resulting in ammonia releases would range from about 1/2 to 3 hours. The meteorological conditions modeled for the hydrogen chloride release were the same as for the chlorine release (1 m/s and F stability). SRS meteorological data indicate that the conditions modeled for ammonia (1 m/s windspeed and Pasquill stability class F) occur about 15% of the time and can persist for 8 hours.

In addition to the off-site population exposures discussed above for the three technologies, occupational exposures also could occur. Accidental on-site releases of ammonia or chlorine could kill or injure workers. An off-site transportation accident might kill or injure transportation workers and members of the public.

Fire and Explosion

Fire and explosion impacts for the three reactor technologies were assessed for hydrogen release.

HWR. Thermal radiation (heat) and explosive overpressure impacts from on-site storage and transportation accidents associated with the HWR technology would be confined to an area within 0.1 km from the point of release.

LWR. Thermal radiation and explosive overpressure impacts from on-site storage accidents associated with the LWR technology would occur within 0.1 km from the point of release. For transportation accidents, thermal radiation impacts and some explosive overpressure impacts (eardrum rupture and fatalities) would occur within 0.1 km. However, some building damage from explosive overpressure might occur as far away as 0.4 km.

MHTGR. Fatalities and injuries due to thermal radiation exposure from MHTGR on-site storage accidents could occur as far away as 0.5 km and 1 km, respectively. Explosive overpressure impacts could be experienced up to 1.9 km away for building damage, 0.4 km for eardrum rupture, and 0.1 km for fatalities.

For transportation accidents, thermal radiation fatalities and injuries would be confined to an area within 0.1 km. Some building damage from explosive overpressure might occur as far away as 0.3 km, while fatalities and eardrum rupture would be confined to an area within 0.1 km.

5.4.7.3 Mitigation and Conclusions

The preceding analysis identifies a series of conditions that have potential for causing significant impacts both on- and off-site. The maximum number of off-site individuals significantly affected by accidental releases of ammonia or chlorine from an on-site storage vessel is estimated to be from 0 to 300 for the HWR and LWR technologies and from 0 to 40 for the MHTGR technology. On-site personnel also could be significantly affected by these releases and by hydrogen releases, and both on-site and off-site individuals could be significantly affected by transportation accidents resulting in releases of these materials.

This analysis indicates that at SRS, the operation of an MHTGR would represent the greatest hazard potential of the three reactor technologies considered. A hazard analysis would be carried out at the design stage. A safety analysis report (SAR) would be prepared for each facility to evaluate the consequences and risks of accidents and to demonstrate that the facility has been constructed and will be operated to meet appropriate standards. Some mitigation possibilities include (1) development and implementation of detailed emergency response plans that will fit into the site's overall emergency response plan, (2) reduction of inventories, (3) modification of process or storage conditions, (4) reduction of the storage vessel size, (5) substitution of hazardous material with something less hazardous, (6) improvement of secondary containment, and (7) training of plant operators.

One of the most important aspects in the mitigation strategy is emergency preparedness. If an accident did occur, DOE would take emergency action in accordance with EPA guidelines and applicable DOE orders (DOE-48). Such actions would ensure that the exposures to off-site individuals and occupational workers would be kept at a minimum. Mitigation could reduce the significance of the impacts.

5.4.8 Socioeconomics

The following section describes the socioeconomic impacts of NPR construction and operation at SRS. Requirements for additional housing, classrooms, teachers, police officers, and fire fighters are examined. Health care impacts are also described. Impacts are expressed as a percentage increase in population(s) or as an increase in the level of community services required to accommodate an in-migrating NPR work force. The assumptions, methods, and uncertainties used in the analysis are described in Section 5.1.9.

The SRS work force data are shown in Tables 3.3-5 and 3.3-6. Initial preconstruction activities would occur in 1992, 1994, and 1993 for the HWR, LWR, and MHTGR, respectively. Reactor operations would commence in 2000 and 2002, respectively. Impacts are examined for the period 1993-2040, although impacts are shown only for the peak year of construction (when maximum impacts would occur) and the first year of operation. The impacts of operation would recur each year through 2040. The remainder of this section discusses (1) impacts of the no-action alternative, NPR construction, and NPR operation, and (2) mitigation and conclusions.

5.4.8.1 Impacts of No Action

If an NPR were not constructed and operated at SRS, socioeconomic conditions would continue as described in Section 4.3.8. Employment at SRS under these conditions is described in NUS-1 (Table 4.3.8-1).

5.4.8.2 Impacts of NPR Construction

Employment and Income

Estimates of construction work force requirements for each alternative technology at SRS are presented in Table 5.4.8-1. An LWR would require a peak labor force of 4,000 persons. An HWR or MHTGR would require a peak work force of about 2,400 or 900 persons, respectively. HWR employment would peak in or about 1997, LWR employment in or about 1998, and MHTGR employment in or about 1997, during facilities construction. An NPR would increase the total regional employment by 4%, 6%, or 1% for an HWR, LWR, or MHTGR, respectively. An HWR or LWR would substantially benefit the economy of the SRS area. Impacts of the MHTGR would be insignificant.

The effect on earnings of HWR construction and preoperation activities is estimated at about \$1.5 billion. An LWR would increase regional earnings by about \$1.7 billion. The effect on earnings of MHTGR construction and preoperation activities would be about \$2.0 billion. Under all alternatives, an NPR would benefit the SRS area's economy, but no benefit would be sufficiently large to create substantial differences over baseline conditions.

Because no farmland would be converted by NPR construction, no impact to agriculture would occur during construction for any NPR alternative.

Population Characteristics

Construction of an NPR would increase the regional population by 2,400 (<1%), 4,000 (1%), and 900 (<1%) persons for the HWR, LWR, and MHTGR, respectively. In all instances, these increments to population would be virtually indistinguishable from baseline population projections. An LWR would have socioeconomic impacts more than twice as large as an HWR or MHTGR.

Housing

The greatest housing impacts as a consequence of NPR construction at SRS are anticipated to accompany the LWR alternative (Table 5.4.8-2). The greatest increase in housing demand under the LWR alternative is expected to occur in Aiken County, where 1,330 housing units would be required. The community of Aiken would require almost 590 housing units to accommodate projected in-migrants. Although they are not excessive, these increases in demand deserve some attention, particularly given the historic capabilities of the local housing construction industries. Projected Aiken County housing needs exceed annual building permit

TABLE 5.4.8-1 Estimated NPR Construction-Related Changes in Employment and Population in the SRS ROI, by NPR Technology

Employment/In-Migration	HWR	LWR	MHTGR
Peak-year employment			
Direct employment	2,400	4,000	900
Indirect employment	6,000	10,000	2,250
Total increase in employment	8,400	14,000	3,150
Increase in employment (%)	4	6	1
Peak-year in-migration			
Direct NPR work	1,500	4,900	0
in-migrating population			
Indirect worker	1,730	1,962	866
in-migrating population			
Total in-migrants	3,230	6,862	866
Increase in population (%)	1	1	1

TABLE 5.4.8-2 Estimated In-Migrant Housing Demand for NPR Peak Construction Year in the Hanford ROI, by NPR Technology

Location	HWR	LWR	MHTGR
Aiken County	626	1,330	168
Aiken	276	587	74
Jackson	36	77	10
New Ellenton	33	69	9
North Augusta	165	350	44
Allendale County	21	44	6
Bamberg County	22	46	6
Barnwell County	105	224	28
Barnwell	54	116	15
Columbia County	76	162	20
Richmond County	210	445	56
Augusta	180	383	48
SRS ROI	1,060	2,251	284

issuances for 1980 through 1987 for every year, as is the case for the city of Aiken. Anticipated housing impacts to the other counties and communities examined within the SRS region are substantially lower, both in absolute and relative terms.

Anticipated housing impacts of the HWR would be the second largest of the three alternative considered at SRS (Table 5.4.8-2). The MHTGR-related housing impacts would be smallest. For both the HWR and MHTGR, housing impacts would be the greatest in Aiken County, though the demands would be less than the average number of annual housing permits issued during the first eight years of the 1980s. Housing impacts to the city of Aiken would exceed the annual average of housing permits issued for 1980 through 1987 under the HWR alternative but would be less than the average under the MHTGR alternative.

Public and Community Services

Education. Impacts to public education services arising from NPR construction at SRS are presented in Table 5.4.8-3. Impacts would be greatest under the LWR alternative at the peak of construction, with a total of more than 1,200 additional students in the ROI. To maintain existing student/teacher ratios, 71 additional teachers would be needed in the region. Under the HWR and MHTGR alternatives, impacts would be less, with enrollment increases of 567 and 152 students, respectively; corresponding increases in instructional staffs would be 34 and 9 teachers, respectively, for the ROI.

Enrollment and teaching staff impacts would be greatest in the Aiken County Public School System and the Richmond County School System. The Aiken County Public School System would experience an enrollment increase of 711 students and would require 42 additional teachers to maintain the current student/teacher ratio at the peak of construction. This school system is currently operating near capacity, and impacts under the LWR alternative would push the district's enrollment above its capacity and contribute to overcrowding. In the Richmond County School System, also operating near capacity, enrollment increases of 238 students under the LWR alternative would require 15 additional teachers to maintain the current student/teacher ratio. Impacts under the HWR and MHTGR alternatives would also be greatest to these school districts, but the degree of impact would be substantially less than under the LWR alternative (Table 5.4.8-3).

In addition to these two school systems, the Columbia County School System is operating far above capacity. Construction of any NPR alternative, whatever its degree of impact, could only contribute to and intensify already crowded school and classroom conditions in this system.

Health Care. Analysis of health care impacts related to NPR construction at SRS was based on the LWR alternative as the bounding (most conservative) condition. Although more doctors and nurses would be needed (Table 5.4.8-4), no impact to area hospitals is anticipated because the percentage increase in population related to the project would be small.

TABLE 5.4.8-3 Estimated NPR Construction-Related Impacts to Public Education in the SRS ROI, by NPR Technology

County/ School District	Enrollment Impacts			Instructor Impacts		
	HWR	LWR	MHTGR	HWR	LWR	MHTGR
Aiken County	335	711	90	20	42	5
Aiken Consolidated	335	711	90	20	42	5
Allendale County	11	23	3	1	2	0
Allendale Consolidated	11	23	3	1	2	0
Bamberg County	12	25	3	1	2	0
Bamberg No. 1	7	14	2	0	1	0
Bamberg No. 2	5	11	1	0	1	0
Barnwell County	56	120	15	4	8	1
Barnwell No. 19	14	31	4	1	2	0
Barnwell No. 29	12	26	3	1	2	0
Barnwell No. 45	30	63	8	2	4	0
Columbia County	41	87	11	2	4	1
Columbia	41	87	11	2	4	1
Richmond County	112	238	30	7	15	2
Richmond	112	238	30	7	15	2
SRS ROI	567	1,204	152	35	73	9

TABLE 5.4.8-4 Estimated NPR Construction-Related Impacts to Health Services in the SRS ROI

County	Doctors	RN/LPN	Hospital Beds
Aiken	3	8/5	6
Allendale	0	0/0	0
Bamberg	0	0/0	0
Barnwell	1	2/1	2
Columbia	1	1/1	0
Richmond	7	11/7	5

TABLE 5.4.8-5 Estimated NPR Construction-Related Impacts to Police and Fire Protection Services (additional professionals needed) in the SRS ROI, by NPR Technology

County/Agency	HWR	LWR	MHTGR
Police Protection Agency			
Aiken County			
Aiken County Sheriff's Office	1	2	0
Aiken Department of Public Safety	1	3	0
Jackson Police Department	0	0	0
New Ellenton Police Department	0	0	0
North Augusta Department of Public Safety	1	1	0
Allendale County			
Allendale County Sheriff's Office	0	0	0
Bamberg County			
Bamberg County Sheriff's Office	0	0	0
Barnwell County			
Barnwell County Sheriff's Office	0	0	0
Barnwell Police Department	0	1	0
Columbia County			
Columbia County Sheriff's Office	0	0	0
Richmond County			
Richmond County Sheriff's Office	1	2	0
Augusta Police Department	2	4	0
Fire Protection			
Aiken County			
Aiken Fire Department	1	3	0
New Ellenton Fire Department	0	0	0
North Augusta Fire Department	1	1	0
Barnwell County			
Barnwell Fire Department	0	0	0
Richmond County			
Augusta Fire Department	1	3	0

Police and Fire Protection. Potential impacts to police protection at the peak of NPR construction under all three alternatives are presented in Table 5.4.8-5. These impacts follow the distribution of NPR-generated population impacts and reflect the increased demand for local public services arising from NPR-related in-migration during construction. Under all three alternatives, the greatest impacts would be experienced by the Augusta Police Department, the greatest demand being for 4 additional officers during the construction peak of the LWR. Of the remaining 11 police departments, 5 would have to increase their staff sizes under at least one alternative to meet the increased demand at the peak of NPR construction while maintaining existing levels of police protection.

The projected peak impacts to fire protection services during construction under all three NPR alternatives are presented in Table 5.4.8-5. As with police protection, these impacts follow the distribution of population impacts and reflect the increased demand for public services arising from in-migration during the construction peak. The Aiken and Augusta fire departments would need three additional fire fighters during the peak of construction under the LWR alternative; the North Augusta Fire Department would require one additional fire fighter under that alternative.

Public Finances

As the above analyses show, fiscal impacts related to the NPR would be determined by factors such as the location of in-migrant workers, the size and timing of purchases, and the number of school age children. In taxing jurisdictions where service capabilities would be severely strained (especially where new classrooms would be needed), additional sources of revenue might be required. Fiscal impact analysis is an integral part of a Socioeconomic Monitoring and Mitigation Plan. If a final site is selected for the NPR, fiscal assessments will be conducted for all impacted taxing districts as an ongoing part of such a plan.

5.4.8.3 Impacts of NPR Operation

A summary of operational work force requirements is presented in Table 5.4.8-6. Estimates range from 938 (HWR) to 1,826 (LWR) persons. These estimates reflect maximum operational work force requirements for the reactor and facilities.

The effect of HWR operation on annual earnings is estimated to be the same as for the LWR -- about \$155 million in additional earnings each year. The effect on annual earnings of MHTGR operation is estimated to be \$182 million over baseline earnings. In all instances, these impacts are of small benefit to the SRS economy.

The direct, indirect, and secondary effects of NPR operation under all alternatives would result in the employment of about 8,000-9,000 people per year, an increase in regional employment of more than 3% over the 1988 level. In all instances, these economic impacts are of small benefit to the SRS region.

Impacts to agriculture during NPR operation could occur in the highly unlikely event that a reactor or support facility accident required impoundment of foodstuffs to limit public radiological exposures (Section 5.4.6 and Appendix I). These accidents are highly unlikely to occur during the lifetime of the NPR, with a probability of occurrence of about 10^{-4} to 10^{-6} . Some

**TABLE 5.4.8-6 Estimated NPR Operations-Related
Changes in Employment and Population in the SRS
ROI, by NPR Technology**

Employment/In-Migration	HWR	LWR	MHTGR
Annual employment			
Direct employment	938	1,826	1,319
Indirect employment	2,814	5,478	3,957
Increase in employment	3,752	7,304	5,276
Increase in employment (%)	2	3	2
In-Migration			
Direct NPR worker	1,830	3,562	2,571
in-migrating population			
Indirect worker	641	1,249	906
in-migrating population			
Total in-migrants	2,471	4,811	3,477
Increase in population (%)	1	1	1

small proportion of field crops, vegetables, or livestock might be impounded. These commodities had a combined value of \$92 million in 1988 in the six-county SRS area.

Population Characteristics

The NPR operation would increase regional population by about 1% under all alternatives. Since construction precedes operation, a minimal increment to regional population growth is projected under all alternatives. The greatest socioeconomic effects, for LWR operation, would lead to a 1% increase (4,200 persons) in the regional population. Infrastructure requirements during LWR construction would probably negate any additional needs during LWR operation. Impacts on tourism are discussed in Section 5.4.3.

Housing

As during construction of the NPR at SRS, the greatest housing impacts during NPR operation would accompany the LWR alternative (Table 5.4.8-7). The greatest increase in housing demand under the LWR alternative (more than 900 housing units) is expected to occur in Aiken County. The community of Aiken alone would require about 400 housing units to accommodate projected in-migrants. These needs should not be excessive at the county level, being below the 1980 through 1987 average in annual building permit issuance. However, in the city of Aiken, LWR impacts alone would exceed the annual average number of building permits issued and would be noteworthy. Anticipated housing impacts to other counties and communities in the SRS region would be minimal.

Anticipated housing impacts of the MHTGR alternative are slightly less than those of the LWR (Table 5.4.8-7). The HWR-related housing impacts would be less than those of either

TABLE 5.4.8-7 Estimated In-Migrant Housing Demand for NPR Peak Operations Year in the SRS ROI, by NPR Technology

Location	HWR	LWR	MHTGR
Aiken County	467	909	657
Aiken	206	401	290
Jackson	27	53	38
New Ellenton	24	47	34
North Augusta	123	239	173
Allendale County	15	30	22
Bamberg County	16	32	23
Barnwell County	79	153	110
Barnwell	41	79	57
Columbia County	57	111	80
Richmond County	156	304	220
Augusta	135	262	189
SRS ROI	790	1,539	1,112

the MHTGR or LWR. For both the MHTGR and HWR, housing impacts would be the greatest to Aiken County, but for neither would needs exceed the annual average number of housing construction permits issued for 1980 through 1987. Though much lower than for the LWR, projected housing demands in the city of Aiken for the MHTGR alternative would exceed the annual average number of building permits issued in 1980-1987. Housing needs under the HWR alternative would be less than the annual average building permits issued over the same period.

Public and Community Services

Education. Impacts to public education during NPR operation at SRS are presented in Table 5.4.8-8. As during the construction peak, impacts to public school enrollment would be greatest under the LWR alternative, with nearly 850 additional students in the ROI; 50 additional teachers would be needed to maintain current student/teacher ratios. Impacts for the MHTGR (611 students and 36 teachers) and the HWR (433 students and 26 teachers) would be smaller.

Impacts to public education at the local level would be greatest in the Aiken County Public School System and the Richmond County School System, both of which are operating at or near enrollment capacity. Operation of the LWR would increase enrollments by 498 students in the Aiken County Public School System and 167 students in the Richmond County School System. These estimated increases would contribute to the already crowded conditions in these

TABLE 5.4.8-8 Estimated NPR Operations-Related Impacts to Public Education in the SRS ROI, by NPR Technology

County/ School District	Enrollment Impacts			Instructor Impacts		
	HWR	LWR	MHTGR	HWR	LWR	MHTGR
Aiken County	256	498	360	15	29	21
Aiken Consolidated	256	498	360	15	29	21
Allendale County	8	16	12	1	1	1
Allendale Consolidated	8	16	12	1	1	1
Bamberg County	9	17	13	1	1	1
Bamberg No. 1	5	9	7	0	1	0
Bamberg No. 2	4	8	6	0	0	0
Barnwell County	43	84	61	3	5	4
Barnwell No. 19	11	22	16	1	1	1
Barnwell No. 29	9	18	13	1	1	1
Barnwell No. 45	23	44	32	1	3	2
Columbia County	31	61	44	1	3	2
Columbia	31	61	44	1	3	2
Richmond County	86	167	121	5	10	8
Richmond	86	167	121	5	10	8
SRS ROI	433	843	611	26	49	37

school systems. Accompanying increases in instructional staff necessary to maintain existing student/teacher ratios would be 29 teachers in Aiken and 10 teachers in Richmond. Enrollment and teaching staff impacts would be smaller under both the HWR and MHTGR alternatives.

Although enrollment impacts are estimated to be substantially less in the Columbia County School System than in Aiken County and Richmond County, the Columbia County School System currently is operating far above its enrollment capacity. Any increases in enrollment attributable to NPR operation would exacerbate already crowded school and classroom conditions.

Health Care. Health care impacts were considered for the construction of the NPR as the most conservative scenario. Operation of the NPR would not be expected to impact health care facilities.

Police and Fire Protection. Potential impacts to police protection resulting from NPR operation under all three alternatives are presented in Table 5.4.8-9. As with peak construction impacts, these projections reflect the distribution of NPR-generated population impacts and the increased demand for local public services arising from in-migration during NPR operations.

TABLE 5.4.8-9 Estimated NPR Operations-Related Impacts to Police and Fire Protection Services (additional professionals needed) in the SRS ROI, by NPR Technology

County/Agency	HWR	LWR	MHTGR
Police Protection Agency			
Aiken County			
Aiken County Sheriff's Office	1	1	1
Aiken Department of Public Safety	1	2	1
Jackson Police Department	0	0	0
New Ellenton Police Department	0	0	0
North Augusta Department of Public Safety	0	1	1
Allendale County			
Allendale County Sheriff's Office	0	0	0
Bamberg County			
Bamberg County Sheriff's Office	0	0	0
Barnwell County			
Barnwell County Sheriff's Office	0	0	0
Barnwell Police Department	0	0	0
Columbia County			
Columbia County Sheriff's Office	0	0	0
Richmond County			
Richmond County Sheriff's Office	1	1	1
Augusta Police Department	1	3	2
Fire Protection			
Aiken County			
Aiken Fire Department	1	2	1
New Ellenton Fire Department	0	0	0
North Augusta Fire Department	0	1	1
Barnwell County			
Barnwell Fire Department	0	0	0
Richmond County			
Augusta Fire Department	1	2	1

Under all three alternatives, impacts would be experienced by at least 4 of the 12 police departments in the ROI. The Augusta Police Department would experience the greatest demand, for 3 additional officers during operation of the LWR alternative, 2 officers for the MHTGR, and 1 officer for the HWR. The Aiken County Sheriff's Office, Aiken Department of Public Safety, North Augusta Department of Public Safety, and Richmond County Sheriff's Office would have to increase their staff sizes (by up to 2 additional sworn officers at the Aiken Department of Public Safety during operation of the LWR alternative) to meet the increased demand arising during NPR operation while maintaining existing levels of police protection.

Projected operational impacts to fire protection services under all three NPR alternatives are presented in Table 5.4.8-9. As with police protection, these impacts would follow the distribution of population impacts and would reflect the increased demand for public services arising from in-migration during NPR operation. Three of the five fire departments in the ROI would experience increased demand during NPR operation under at least two alternatives (Aiken, North Augusta, and Augusta fire departments). The Aiken and Augusta fire departments would experience the greatest impacts, needing two additional fire fighters each during NPR operation under the LWR alternative and one fire fighter each under the HWR and MHTGR alternatives.

Public Finances

See the discussion of NPR-related fiscal impacts in Section 5.4.8.2.

5.4.8.4 Mitigation and Conclusions

Among the alternatives considered, an LWR would have the greatest socioeconomic impacts. However, in-migration for any reactor alternative would increase the regional population by about 1%. Educational systems already at or near capacity would be impacted by all three alternatives. Payments in lieu of taxes or grants equivalent to taxes might be necessary to offset these impacts.

Uncertainties associated with (1) the timing, numbers, and composition of an in-migrating work force and (2) the probable settlement patterns of in-migrants preclude precise estimation of socioeconomic impacts. Hence, a Socioeconomic Monitoring and Mitigation Plan would be developed. This plan would provide for (1) periodic surveys of employees and affected communities and (2) a claim process to systematically identify, review, negotiate, and resolve issues related to local area impacts.

5.4.9 Transportation Systems

This section addresses the impacts of increased requirements for transportation of workers and nonradioactive materials to SRS and the surrounding area. Transportation of radioactive materials is addressed in Section 5.4.6. The changes in the vehicle miles traveled

(VMT)* associated with increases in baseline population and activity during construction and operation for the three reactor technologies are provided in Figure 5.4.9-1.

5.4.9.1 Impacts of No Action

If an NPR were not constructed and operated at SRS, the existing transportation environment would remain as described in Section 4.3.9. Changes in population due to non-NPR activities at SRS and in the surrounding communities would affect transportation. Any increases in the general population of the region would cause corresponding increases in traffic congestion, truck traffic, and vehicular accidents. Projected population changes in the SRS area are identified in Section 5.4.8. Improvements to existing roadways that might be initiated in response to increased regional population are discussed in Section 4.3.9.

5.4.9.2 Impacts of NPR Construction

The construction of NPR facilities would require additions to the SRS work force (Section 5.4.8). In addition, construction materials, wastes, and excavated materials would be transported both on-site and off-site. These activities would result in increases in operation of personal-use vehicles by commuting construction workers, in commercial truck traffic, and in traffic associated with daily operations of SRS.

This analysis addresses traffic congestion, increased truck traffic and associated fatalities and injuries, and potential road damage during construction for the three NPR technologies. The impacts are summarized in Tables 5.4.9-1 and 5.4.9-2 and are discussed in the following paragraphs.

Traffic Congestion

An estimate of the level of service indicated that growth in the local population and the NPR work force would probably cause overloading and delays during peak traffic periods on sections of several routes that already experience some delays during peak hours. Significant traffic congestion could cause delays by reducing the overall speed along the highways. Several segments of concern, including SR 125, have been identified in NUS-1.

Truck Traffic

The number of trucks required to transport the construction materials and excavated earth has been estimated on the basis of a 40,000-lb load per truck. The daily number of trips by trucks transporting excavation materials, gravel, and sand on the site during the construction period would be 109 for the HWR, 67 for the LWR, and 183 for the MHTGR. Transportation of other construction materials would add 7 truck trips daily on the site and on off-site highways

*1 vehicle mile traveled = 1.609 vehicle kilometers traveled.

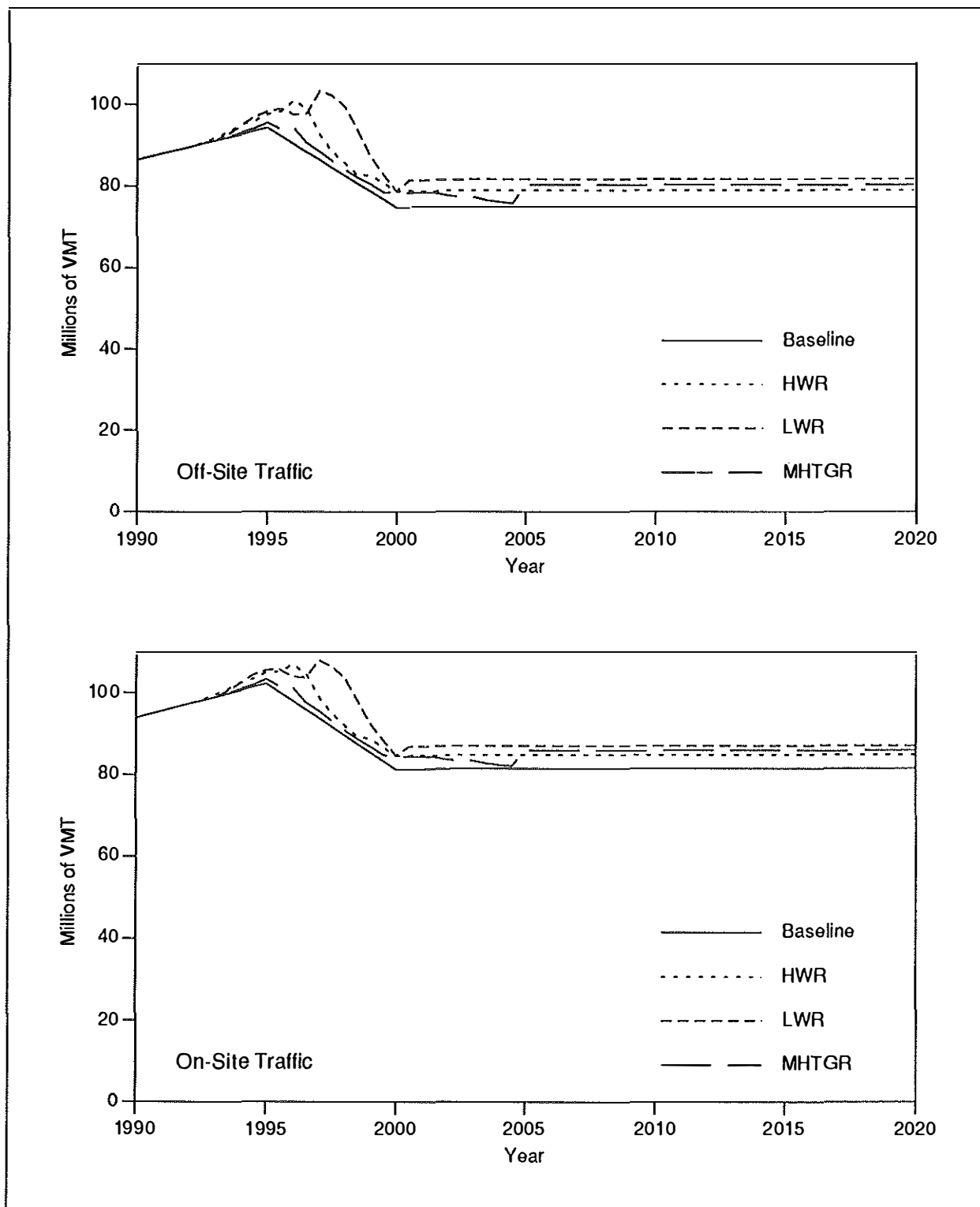


FIGURE 5.4.9-1 On-site and Off-site Traffic at SRS

TABLE 5.4.9-1 Potential Impacts on Peak Period Performance of Off-site Transportation Routes due to Transportation of Workers and Nonradioactive Materials in the SRS Vicinity

Reactor	Typical Route ^a	Impact (Level of Service) ^b		
		1988 Baseline	Construction	Operation
HWR	US 1	Free flow to stable flow (upper speed limit)	Free flow to stable flow (upper speed limit)	Free flow to stable flow (upper speed limit)
	SR 19	Forced flow	Forced flow	Forced flow
	SR 64	Stable flow (upper speed limit) to stable flow	Stable flow to approaching unstable flow	Stable flow to approaching unstable flow
	SR 125	Approaching unstable flow to unstable flow	Unstable flow to forced flow	Unstable flow to forced flow
LWR	US 1	Free flow to stable flow (upper speed limit)	Free flow to stable flow (upper speed limit)	Free flow to stable flow (upper speed limit)
	SR 19	Forced flow	Forced flow	Forced flow
	SR 64	Stable flow (upper speed limit) to stable flow	Stable flow to approaching unstable flow	Stable flow to approaching unstable flow
	SR 125	Approaching unstable flow to unstable flow	Unstable flow to forced flow	Unstable flow to forced flow
MHTGR	US 1	Free flow to stable flow (upper speed limit)	Free flow to stable flow (upper speed limit)	Free flow to stable flow (upper speed limit)

TABLE 5.4.9-1 (Cont'd)

Reactor	Typical Route ^a	Impact (Level of Service) ^b		
		1988 Baseline	Construction	Operation
MHTGR (cont'd)	SR 19	Forced flow	Forced flow	Forced flow
	SR 64	Stable flow (upper speed limit) to approaching unstable flow	Stable flow (upper speed limit) to approaching unstable flow	Stable flow (upper speed limit) to approaching unstable flow
	SR 125	Approaching unstable flow to unstable flow	Unstable flow to forced flow	Unstable flow to forced flow

^aUS = Federal (U.S.) Route; SR = State Route. The amount of NPR-related traffic on these routes would not represent a significant degree of nuisance.

^bEstimated levels of service based on NUS-1 (Table 7-2). See Section 5.1.10 for definitions.

TABLE 5.4.9-2 Potential Fatalities from Transportation of
Workers and Nonradioactive Materials at SRS and Vicinity

Reactor	NPR Activity	Applicable Time Period (years)	Fatality Rate ^a (per year)	
			On-site	Off-site
HWR	Construction	7	0.09	0.11
	Operation	41	0.09	0.11
LWR	Construction	7	0.19	0.23
	Operation	40	0.16	0.19
MHTGR	Construction	12	0.05	0.05
	Operation	35	0.13	0.15
Baseline population		50	2.44	2.25

^aFatalities based on state rates for all vehicles.

for the HWR, 10 trips for the LWR, and 21 trips for the MHTGR. Such truck traffic would not be a nuisance. Given compliance with state and Federal loading and speed regulations, truck traffic would not significantly damage the roadbed.

Vehicular Accidents

The expected increase in fatal accidents during the construction of the NPR was estimated from the statewide statistics for 1988. The estimated total number of additional annual fatalities at SRS during construction would be 0.09 for the HWR, 0.19 for the LWR, and 0.04 for the MHTGR. Additional annual off-site traffic fatalities would number 0.11 for the HWR, 0.23 for the LWR, and 0.05 for the MHTGR. The baseline rates during this period are 2.44 and 2.25 for on-site and off-site fatalities, respectively. Therefore, the increases caused by the NPR would not be significant. This analysis is based on traffic fatality data from the state of South Carolina, which experienced higher fatality rates than Georgia.

Barge and Rail Transportation

Barge and rail transport of heavy equipment and coal to SRS are not proposed at this time. Therefore, NPR construction would not cause a significant impact to barge or rail transport at SRS or in its vicinity.

5.4.9.3 Impacts of NPR Operation

Traffic Congestion

During NPR operations, congestion along SR 125 and similar routes could cause delays during peak traffic hours for all reactor technologies.

Truck Traffic

The amount of truck traffic would be considerably less during NPR operation than during construction. If nonhazardous operational material were transported by truck, the total number of trucks transporting operational material on-site and off-site per day would be about 1 for the HWR, 2 for the LWR, and 12 for the MHTGR.

Vehicular Accidents

The additional annual on-site fatalities estimated during operation of the NPR would be 0.09 for the HWR, 0.16 for the LWR, and 0.13 for the MHTGR. Additional annual fatalities off-site would number 0.11, 0.19, and 0.15, respectively. The annual baseline fatality rates are 2.44 and 2.25 (on-site and off-site, respectively).

5.4.9.4 Mitigation and Conclusions

The SRS is attempting to reduce congestion on roadways by implementing flexible and staggered working hours. Congestion during peak traffic times along certain frequently used sections of roadways might require further analysis of highway design, which is outside the scope of this document.

5.4.10 Waste Management

This section describes the impacts to site waste management facilities from the construction and operation of the three NPR technologies at SRS. The impacts of the no-action alternative are also discussed. The analysis is organized by major activity: no-action alternative, construction, and operation. The section on the impacts of NPR operations is subdivided by waste type. Where applicable, differences in impacts between the candidate technologies are also presented. The last section presents conclusions and mitigation requirements.

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

The quantities and types of wastes to be managed depend upon whether or not spent fuel is reprocessed and whether or not plutonium is produced, as well as on the extent to which existing reactors continue to operate in the future. Estimates in this section were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium produced. If it is decided not to continue those activities, the impacts upon waste management systems from NPR operations would be less than presented in this section. In addition, this section was prepared assuming that all three of the existing SRS reactors would operate at 100% power. On February 11, 1991, the Department of Energy issued a Record of Decision for the RO EIS which determined that P Reactor shall be placed in cold standby and that K and L reactors will remain operational. This would also reduce the amounts of cumulative wastes presented in this section.

5.4.10.1 Impacts of No Action

The no-action alternative at SRS would result in the continued operation of the P, K, and L reactors at SRS at 100% capacity. The DOE has prepared an EIS in which the impacts of continued operation of the P, K, and L reactors at SRS are assessed (DOE-10). The SRS waste management system would remain as described in Section 4.3.10. The waste that would be

generated under this alternative are summarized in Table 4.3.10-1. The principal function of the site waste management system would be treatment and disposal of the HLW and LLW now stored in tanks on-site. HLW would be immobilized in glass at the Defense Waste Processing Facility, placed in interim storage at that facility, and eventually shipped to the Federal repository for final disposal. The mixed waste inventory would be processed at the Hazardous Waste/Mixed Waste Disposal Facility in accordance with DOE and EPA regulations, and TRU waste would be retrieved, packaged, and shipped for off-site disposal at WIPP. LLW would be disposed of on-site. Hazardous and other waste would continue to be handled in a manner necessary to meet regulatory requirements.

5.4.10.2 Impacts of NPR Construction

Construction of an NPR and any necessary support facilities at SRS would generate wastewater, solid waste, and hazardous wastes. A description of construction wastes is given in Appendix M. These construction wastes would be managed within the existing site waste management system (Section 4.3.10) in a manner similar to the wastes generated by on-going construction projects. The waste volumes for the construction of NPR for each of the technologies are listed in Table 5.4.10-1. No impacts on the waste management system are expected from the handling of NPR construction wastes at SRS. No new facilities would be required to handle NPR construction wastes (WSRC-2, 4; 1990).

5.4.10.3 Impacts of NPR Operation

Normal operation of the NPR and its support facilities at SRS would generate waste that requires environmentally sound treatment, storage, and disposal procedures that comply with applicable regulations. This waste would be similar to the solid and liquid waste generated by non-NPR facilities at SRS (Section 4.3.10) (WSRC-2, -4, -5, -6, -13). The various waste types are described in Appendix M.

TABLE 5.4.10-1 Construction Waste Volumes at SRS, by NPR Technology (m³/yr)

Waste Type	HWR	LWR	MHTGR
Wastewater ^a	30,000	40,000	4,000 ^b
Nonhazardous solid waste ^c	15,000	23,000	9,000
Hazardous waste ^c	20	30	25

^aWastewater volumes based on total peak year use for system flushing.

^bWastewater volume for MHTGR based on a flush of secondary system 10 times, and no primary system flush.

^cNonhazardous solid waste and hazardous waste are yearly average over the construction period.

Sources: Values derived from data in WSRC-2, -4.

The environmental effects of NPR-generated waste would depend on the ability of SRS waste management facilities to effectively treat and dispose of waste from both NPR and non-NPR sources. For this EIS, it was assumed that SRS waste management facilities would be capable of operating at design capacities throughout the active life of the NPR project. Potential adverse impacts are noted for situations in which the addition of NPR-related waste would exceed by 80% or more the available capacity of a site facility to process or store waste streams containing NPR and non-NPR waste.

The "available capacity" of a site waste management facility refers to the difference between the design capacity of that facility and the input of waste from active non-NPR operations at SRS. Inputs from stored waste awaiting treatment are not included in this determination because, in general, this waste is processed with unused capacity. The processing of inventory waste would remain flexible and would be accomplished at whatever rate leaves sufficient capacity to process all newly generated waste from both NPR and non-NPR sources.

The processing and disposal of NPR waste would be integrated into the existing SRS waste management system, with most NPR wastes processed through the facilities outlined in Section 4.3.10. Schematics describing the routing of NPR-related waste at SRS are presented in Figures M.40 through M.57. Based on waste amounts from the figures, SRS has sufficient waste handling capacity to accommodate the expected additional loading of all waste from NPR facilities during operations (2000-2040).

Additional disposal vaults would have to be constructed at the Hazardous Waste/Mixed Waste Disposal Facility by the year 2000 to process NPR-generated hazardous and mixed waste. A detailed study and assessment of waste facilities will be addressed in DOE's Waste Management PEIS.

The quantities of waste generated would vary among reactor technologies. Also, the volume of waste generated would be different for the tritium and plutonium production modes. The waste management assessments in this EIS are based on upper-bound estimates of waste volumes, that is, on the larger of the waste volumes for each waste stream generated by full-time tritium production or full-time plutonium production.

Effects of NPR-Related Waste on SRS Waste Management Facilities

The quantities and types of waste that would be generated by NPR operations at SRS are summarized in Tables 5.4.10-2 and 5.4.10-3. The utilization of site waste management capacities resulting from NPR waste inputs is given in Tables 5.4.10-4 and 5.4.10-5. The discussions of the percentage of available capacity are based on data in these tables. The non-NPR operations input at SRS and the capacities of the affected SRS waste management facilities are also given in the tables.

For treatment facilities, the processing of the current SRS waste inventory would proceed at near facility capacity, with an allowance being made for the additional input from NPR facilities after 2000. This pattern would continue until the inventory is depleted. To simplify these tables, all waste loads are assumed to remain constant (including inventory waste) from 2000 to 2040. Both HLW and TRU waste would be held in interim storage at SRS until such time as the Federal repository (for HLW) and/or WIPP (for TRU waste) can accept shipments of this waste.

TABLE 5.4.10-2 Comparison of Annual Waste Management Facility Inputs from NPR Operations in the Tritium Production Mode^a and Non-NPR Operations at SRS between 2000 and 2040

Waste Identification	Facility Description	Facility Input Capacity ^b (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^c (m ³ /yr)
			HWR	LWR	MHTGR	
High-level waste						
Liquid	Storage tanks	132,000	1,100	1,100	1,100	6,000
Solid	Defense Waste Processing Facility ^d	300	15	15	15	90
	Interim storage	1,800	15	15	15	90
Transuranic waste						
Solid ^e	Transuranic Waste Facility	710	1	2	1	120
	Waste Certification Facility	1,100	26	62	26	650
	Interim storage	Expandable	13	30	13	650
Low-level waste						
Liquid	Tank Farm Evaporator	34,000	2,200	2,200	2,200	5,800
	Effluent Treatment Facility	400,000	18,000	18,000	18,000	140,000
	Z-Area Saltstone Facility	34,000	2,200	2,200	2,200	10,000
Solid	Saltstone Disposal Vault	Expandable	3,400	3,400	3,400	10,000
	Consolidated Incineration Facility	30,000 ^e	4,200	3,100	4,200	18,000
	Burial Ground Expansion (LLW area)	Expandable	3,100	4,100	3,100	31,000
Mixed waste						
Liquid	Waste Solidification and Disposal Facility	4,400	300	0	2	1,400
Solid	Saltstone Disposal Vault	Expandable	510	0	3	3,000
	Consolidated Incineration Facility	30,000 ^f	140	1,400	100	500
	Hazardous/Mixed Waste Disposal Facility	4,500	35	480	20	890
Hazardous waste						
Liquid and solid	Processed with mixed waste					
Other waste						
Nonhazardous						
Liquid	Tower blowdown	Regulated	6,900,000	4,000,000	6,800,000	30,000,000
	All other	Regulated	350,000	360,000	270,000	140,000
Solid	G-Area Central Landfill	Expandable	2,100	3,800	2,700	23,000
Sewage						
Liquid ^g	Sewage Treatment Plant-NPR	Regulated	16,000	27,000	20,000	0
	Sewage treatment plants	Regulated	13,000	24,000	16,000	560,000
Solid ^h	Land application	Expandable	50	92	72	1,100

TABLE 5.4.10-2 (Cont'd)

^aThe analyses in this EIS use the highest waste generation rate from either the tritium or the plutonium production mode in assessing impacts on existing waste management facilities.

^bFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^cNon-NPR operations values projected from 1988 data; values do not include processing of stored waste.

^dAll numbers in this table associated with this facility are output numbers.

^eLiquids containing transuranics are processed as HLW.

^fIncinerator is to be used for several waste types; capacity is for the sum of all waste processed.

^gLiquid effluents from sewage treatment operations.

^hSolids from sewage treatment operations.

Sources: Bean 1990a; Williamson 1989; McClain 1990b-c; McGough 1990; WSRC-2, -4, -5, -6, -13, -14.

High-Level Waste

Overall, the HLW produced by each of the NPR technologies would represent a minor portion of the total HLW generated at SRS. Annual inputs to the tank farm from NPR operations would range from a high of 4% of available capacity for MHTGR and HWR to a low of about 2% for the LWR. Annual inputs of HLW non-NPR operations would account for 11% of the capacity available at the tank farm. The NPR inputs to the vitrification process at the Defense Waste Processing Facility would represent 6-14% of the capacity of that facility; non-NPR inputs to that facility would require about 43% of its vitrification capacity. The Defense Waste Processing Facility would operate at near 100% capacity, with the excess capacity being used to reduce the large inventory of liquid HLW currently in storage at the Tank Farm. SRS must increase the interim storage capacity for vitrified waste at SRS so that these wastes can be stored before shipment to the Federal repository (Section 4.3.10.1). The environmental impact of such facility expansion will be discussed as part of the programmatic environmental restoration and waste management EIS that is currently being prepared. This additional storage capacity is needed as long as the Defense Waste Processing Facility operates at 100% capacity and the Federal repository is not accepting wastes, that is, regardless of NPR's operational status.

There is another potential problem for HLW at SRS. Currently, little usable excess capacity is available at the High Level Waste Tank Farm. The flexibility of this tank farm system would be greatly reduced if further problems (e.g., leakage) were to occur with the tanks before the Defense Waste Processing Facility becomes fully operational. The planned operation of that facility at full capacity is scheduled to occur before start-up of the NPR. This facility converts the liquid HLW stored at the tank farm into a vitrified glass material, thereby opening up space at the tank farm for the storage of additional liquid HLW from the operation of the P, K, and L reactors and NPR. Any major slippage (in years) in operating the Defense Waste Processing Facility at full capacity might require the construction of additional double-shell tanks at SRS to store newly generated liquid HLW from the P, K, and L reactors or NPR. If the facility starts up in 1992 as scheduled, inventories of liquid HLW will occupy 57% of the available capacity at the tank farm in 2000. Under these circumstances, start-up of NPR facilities would create no important impacts at the tank farm.

TABLE 5.4.10-3 Comparison of Annual Waste Management Facility Inputs from NPR Operations in the Plutonium Production Mode and Non-NPR Operations at SRS between 2000 and 2040

Waste Identification	Facility Description	Facility Input Capacity ^a (m ³ or m ³ /yr)	NPR Operations Input (m ³ /yr)			Non-NPR Operations Input ^b (m ³ /yr)
			HWR	LWR	MHTGR	
High-level waste						
Liquid	Storage tanks	132,000	2,000	780	2,000	6,000
Solid	Defense Waste Processing Facility ^c	300	29	13	29	90
	Interim storage	1,800	29	13	29	90
Transuranic waste						
Solid ^d	Transuranic Waste Facility	710	7	7	8	120
	Waste Certification Facility	1,100	220	230	260	650
	Interim storage	Expandable	110	110	150	650
Low-level waste						
Liquid	Tank Farm Evaporator	34,000	4,000	1,600	4,000	5,800
	Effluent Treatment Facility	400,000	54,000	23,000	54,000	140,000
	Z-Area Saltstone Facility	34,000	4,600	2,100	4,600	10,000
Solid	Saltstone Disposal Vault	Expandable	7,200	3,400	7,200	10,000
	Consolidated Incineration Facility	30,000 ^e	4,900	2,500	7,200	18,000
	Burial Ground Expansion (LLW area)	Expandable	3,800	3,400	5,400	31,000
Mixed waste						
Liquid	Waste Solidification and Disposal Facility	4,400	300	0	57	1,800
Solid	Saltstone Disposal Vault	Expandable	510	0	97	3,000
	Consolidated Incineration Facility	30,000 ^e	250	880	200	500
	Hazardous/Mixed Waste Disposal Facility	4,500	60	190	38	890
Hazardous waste						
Liquid and solid	Processed with mixed waste					
Other waste						
Nonhazardous						
Liquid	Tower blowdown	Regulated	6,900,000	4,000,000	6,800,000	30,000,000
	All other	Regulated	490,000	330,000	730,000	140,000
Solid	G-Area Central Landfill	Expandable	2,300	3,300	3,000	23,000
Sewage						
Liquid ^f	Sewage Treatment Plant-NPR	Regulated	16,000	27,000	23,000	0
	Sewage treatment plants	Regulated	15,000	17,000	17,000	560,000
Solid ^g	Land application	Expandable	54	92	75	1,100

TABLE 5.4.10-3 (Cont'd)

^aFor storage and disposal facilities, input capacity is the total holding capacity in cubic meters; for treatment facilities, capacity is the input processing capacity in cubic meters per year.

^bNon-NPR operations values projected from 1988 data; values do not include processing of stored waste.

^cAll numbers in this table associated with this facility are output numbers.

^dLiquids containing transuranics are processed as HLW.

^eIncinerator is to be used for several waste types; capacity is for the sum of all waste processed.

^fLiquid effluents from sewage treatment operations.

^gSolids from sewage treatment operations.

Sources: Bean 1990a; Williamson 1989; McClain 1990b-c; McGough 1990; WSRC-2, -4, -5, -6, -13, -14.

Transuranic Waste

The NPR-related inputs of TRU waste to the Waste Certification Facility at SRS would range from a high of 55% of available capacity for MHTGR waste in the plutonium production mode to a low of 6% for HWR and LWR waste in the tritium mode. Non-NPR inputs of TRU waste from SRS operations would account for 57% of the process design capacity for TRU waste at this facility. Thus, combined inputs of TRU waste would range from 60% to 81% of the facility's design capacity for TRU waste for the three technologies.

The excess capacity at the Transuranic Waste Facility will be used to work off the inventory of TRU waste in retrievable storage from about 20 years of operations at the site. Problems (e.g., radioactive contamination) might arise at this facility if the retrievably stored TRU waste were not to achieve the design 20-year storage life. Widespread container failure could force SRS to retrieve this waste earlier than anticipated to reduce the likelihood of a serious radioactive spill.

Low-Level Waste

The impacts of NPR-related LLW to the SRS waste management system would generally be quite small. Tables 5.4.10-2 and 5.4.10-3 list the waste volumes generated and the percentage of facility capacity represented for each of the three technologies. The LLW management facilities at SRS include four waste treatment facilities and two waste disposal facilities. For each of these six facilities, the volume of LLW from NPR operations would be small compared with that from non-NPR operations. For example, the Z-Area Saltstone Facility would operate at 2-19% of available capacity for NPR waste compared with 29% of capacity for non-NPR waste. The two waste disposal facilities, the Burial Ground Expansion and the Z-Area Saltstone Disposal Vaults, could readily expand their disposal capacity. The volume of solid LLW from NPR operations would be small compared with that from non-NPR operations. At the Consolidated Incineration Facility capacity use numbers would be substantial. This use level is primarily due to the LLW from non-NPR activities accounting for 60% of the facility's capacity.

TABLE 5.4.10-4 Impacts to SRS Waste Management Facilities Resulting from NPR Operation in the Tritium Production Mode between 2000 and 2040

Waste Identification	Facility Description	Percentage of Available Capacity Used ^a		
		HWR Input	LWR Input	MHTGR Input
High-level waste				
Liquid	Storage tanks	2	2	2
Solid	Defense Waste Processing Facility	7	7	7
	Interim storage	b	b	b
Transuranic waste				
Solid ^c	Transuranic Waste Facility	<1	<1	<1
	Waste Certification Facility	6	13	6
	Interim storage	b	b	b
Low-level waste				
Liquid	Tank Farm Evaporator	8	8	8
	Effluent Treatment Facility	7	7	7
	Z-Area Saltstone Facility	9	9	9
Solid ^d	Saltstone Disposal Vault	b	b	b
	Consolidated Incineration Facility	35	26	35
	Burial Ground Expansion (LLW area)	b	b	b
Mixed waste				
Liquid	Waste Solidification and Disposal Facility	10	0	<1
Solid ^d	Saltstone Disposal Vault	b	b	b
	Consolidated Incineration Facility	<1	5	<1
	Hazardous/Mixed Waste Disposal Facility	1	13	1
Hazardous waste				
Liquid and solid	Processed with mixed waste	Processed with mixed waste		
Other waste				
Nonhazardous				
Liquid	Tower blowdown	b	b	b
	All other	b	b	b
Solid	G-Area Central Landfill	b	b	b

TABLE 5.4.10-4 (Cont'd)

Waste Identification	Facility Description	Percentage of Available Capacity Used ^a		
		HWR Input	LWR Input	MHTGR Input
Sewage Liquid ^e	Sewage Treatment Plant-NPR	b	b	b
Solid ^f	Sewage treatment plants	b	b	b
	Land application	b	b	b

^aAvailable capacity is the facility capacity reduced by the amount needed for non-NPR operations; non-NPR operations do not include the processing of stored waste.

^bPercent capacity used is not applicable because the facility capacity is expandable. A separate Environmental Impact Statement will review expansions in waste management facility capacities.

^cLiquids containing transuranics are processed as HLW.

^dSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^eLiquid effluents from sewage treatment operations.

^fSolids from sewage treatment operations.

The NPR-related LLW ranges in available capacity use from a low of 21% for the LWR technology to a high of 60% for the MHTGR technology. The combined NPR and non-NPR operations inputs of LLW to the incinerator range from a low of 70% of capacity use for the LWR technology to a high of 83% of capacity use for the MHTGR technology. These percentages indicate that only a modest safety margin would be obtained at SRS for this facility, especially for the MHTGR technology.

Mixed Waste and Hazardous Waste

Mixed waste and hazardous waste would be treated and disposed of at the Hazardous Waste/Mixed Waste Disposal Facility. Treatment standards for mixed waste are not fully developed. Once these standards are developed and the associated regulations approved, this facility would be able to treat and dispose of all mixed and hazardous waste generated by each of the three technologies. The NPR operations inputs would require 23,000 m³ of additional disposal capacity for the HWR technology. The LWR and MHTGR technologies would require 19,000 and 5,400 m³, respectively. Construction of this additional disposal capacity must begin in 2000. The environmental impact of such facility expansion will be discussed as part of the

TABLE 5.4.10-5 Impact to SRS Waste Management Facilities Resulting from NPR Operation in the Plutonium Production Mode between 2000 and 2040

Waste Identification	Facility Description	Percentage of Available Capacity Used ^a		
		HWR Input	LWR Input	MHTGR Input
High-level waste				
Liquid	Storage tanks	4	2	4
Solid	Defense Waste Processing Facility	14	6	14
	Interim storage	b	b	b
Transuranic waste				
Solid ^c	Transuranic Waste Facility	1	1	1
	Waste Certification Facility	47	49	55
	Interim storage	b	b	b
Low-level waste				
Liquid	Tank Farm Evaporator	14	6	14
	Effluent Treatment Facility	21	9	21
	Z-Area Saltstone Facility	19	9	19
Solid ^d	Saltstone Disposal Vault	b	b	b
	Consolidated Incineration Facility	41	21	60
	Burial Ground Expansion (LLW area)	b	b	b
Mixed waste				
Liquid	Waste Solidification and Disposal Facility	10	0	2
Solid ^d	Saltstone Disposal Vault	b	b	b
	Consolidated Incineration Facility	1	3	1
	Hazardous/Mixed Waste Disposal Facility	2	5	1
Hazardous waste				
Liquid and solid	Processed with mixed waste	Processed with mixed waste		
Other waste				
Nonhazardous				
Liquid	Tower blowdown	b	b	b
	All other	b	b	b
Solid	G-Area Central Landfill	b	b	b

TABLE 5.4.10-5 (Cont'd)

Waste Identification	Facility Description	Percentage of Available Capacity Used ^a		
		HWR Input	LWR Input	MHTGR Input
Sewage Liquid ^e	Sewage Treatment Plant-NPR	b	b	b
Solid ^f	Sewage treatment plants	b	b	b
	Land application	b	b	b

^aAvailable capacity is the facility capacity reduced by the amount needed for non-NPR operations; non-NPR operations do not include the processing of stored waste.

^bPercent capacity used is not applicable because the facility capacity is expandable. A separate Environmental Impact Statement will review expansions in waste management facility capacities.

^cLiquids containing transuranics are processed as HLW.

^dSolidified or absorbed liquid waste quantities are included in the solid waste quantity.

^eLiquid effluents from sewage treatment operations.

^fSolids from sewage treatment operations.

programmatic environmental restoration and waste management EIS that is currently being prepared. Both DOE and EPA approval must be obtained before land disposal of hazardous and mixed waste could be undertaken at SRS.

The substantial amount of solidified mixed waste (510 m³/yr) generated by the HWR at SRS compared to that from the other two technologies (see Tables 5.4.10-2 and 5.4.10-3) needs explanation. With the HWR technology, large amounts of liquid low-level waste from the fuel and target fabrication facilities would be combined at the existing M-Area Effluent Treatment Facility (ETF) with small amounts of liquid mixed waste from an electroplating process on depleted uranium. The resulting waste slurry from the M-Area ETF would be a mixed waste. (Segregation of these two wastes must be carried out, thus substantially reducing the amount of material classified as mixed waste and furthering the effort at waste minimization at SRS.)

At SRS, hazardous wastes would be processed by incineration to the extent possible. The ash product would be solidified in grout and placed in on-site vaults for disposal. The incineration and solidification processes would result in overall volume reduction by a factor of 20. Thus, the quantity of disposed hazardous waste at SRS would be relatively small.

Other Waste

The NPR operation would not adversely affect the ability of SRS to manage nonradioactive and nonhazardous types of waste through disposal at the SRS landfill. The landfill area at SRS would be expanded, as needed. All nonhazardous, nonradioactive effluents from SRS effluent treatment facilities would meet outfall criteria required by permits issued under the National Pollutant Discharge Elimination System before being discharged to streams.

5.4.10.4 Mitigation and Conclusions

The NPR project would be managed in accordance with a waste reduction program that covers the entire project life from conceptual engineering design to decommissioning. The program will define the specific steps in which the contractor plans to minimize all wastes (including hazardous and nonhazardous wastes) generated during construction, operations, and decommissioning. To achieve an effective waste reduction program, primary emphasis will be given to source reduction and, alternatively, recycling to minimize the quantities and toxicities of materials and substances before they enter the waste streams for treatment or disposal. For waste that is generated, waste reduction will include treatment to reduce the volume, toxicity, or mobility of such waste prior to storage or disposal.

The adverse impacts to SRS waste management facilities resulting from NPR operations are summarized in Table 5.4.10-6. Mitigation of these adverse impacts would require development of additional waste disposal capacity. After mitigation, there would be no adverse impacts to waste management facilities. The analysis of environmental impacts associated with

TABLE 5.4.10-6 Summary of Cumulative Impacts to Savannah River Waste Management Facilities^a

Waste Type/Facility	HWR	LWR	MHTGR	Mitigation
High-level waste Interim storage	On-site interim storage capacity would be exceeded prior to NPR operations	On-site interim storage capacity would be exceeded prior to NPR operations	On-site interim storage capacity would be exceeded prior to NPR operations	Plan for and provide additional on-site interim storage capacity
Mixed waste Y-Area Saltstone Disposal Vaults	About 20,000 m ³ (T or P) of disposal capacity needed for mixed waste	Not required	About 120 m ³ (T) to 3,900 m ³ (P) of disposal capacity needed for mixed waste	Segregate processing of the small volume mixed waste stream from the large volume low-level waste stream
Mixed and hazardous waste Y-Area Saltstone Disposal Vaults and Hazardous Waste/ Mixed Waste Disposal Facility	About 22,000 m ³ (T) to 23,000 m ³ (P) of disposal capacity needed for mixed and hazardous wastes	About 7,600 m ³ (P) to 19,000 m ³ (T) of disposal capacity needed for mixed and hazardous wastes	About 920 m ³ (T) to 5,400 m ³ (P) of disposal capacity needed for mixed and hazardous wastes	Plan for and provide needed disposal capacity

^aT indicates values for NPR operations in 100% tritium production mode between the years 2000 and 2040;
P indicates values for NPR operations in 100% plutonium-239 production mode between the years 2000 and 2040.

the expansion of waste management facilities would be completed as part of the design of each of the facilities.

5.4.11 Institutional Issues

Construction and operation of NPR facilities at SRS would not affect any institutional issues related to U.S. national or international policy regarding fisheries or nuclear nonproliferation.

5.4.12 Decontamination and Decommissioning

Decontamination and decommissioning (D&D) activities are carried out at the end of a nuclear facility's life to permit the facility to be removed safely from service and to enable the property to be used for other purposes. D&D activities can range from performing a simple radiological survey to confirm that contamination of a facility is within acceptable limits to completely dismantling and removing a contaminated facility. An analysis of D&D impacts is included in the EIS to demonstrate whether D&D of the alternative NPRs is reasonably achievable and to determine if there are any major differences in the D&D of the alternative reactor technologies at any of the alternative sites. The methodology and details of the D&D analysis are presented below and in Appendix O.

5.4.12.1 Impacts of No Action

If it were decided not to site, construct, and operate an NPR at SRS, no additional D&D requirements would arise. Existing facilities proposed for NPR use (Figures 3.4.3-3, 3.4.4-3, and 3.4.5-3), such as the Plutonium-Target Fabrication Facility (Building 313-M), the Tritium-Target Fabrication Facility (Building 320-M), the Fuel Fabrication Facility (Building 321-M), the H-Canyon (Building 221-H), F-Canyon (Building 221-F), and Replacement Extraction and Purification Facility (H Area), would become available for D&D within the original time frame.

5.4.12.2 Impacts of Decontamination and Decommissioning

Three broadly defined D&D options for the NPR would be considered (Appendix O, Section O.2):

- *DECON* -- decontamination (removal of radioactive materials so that levels of radioactivity would be within acceptable limits),
- *SAFSTOR* -- storage for as long as 60 to 100 years, followed by decontamination, and
- *ENTOMB* -- encasement or entombment of the radioactive facilities in a long-lived material such as concrete to allow the radioactive material to decay to safe levels.

The objective of D&D is to reduce contamination of facilities to "acceptable levels of radioactivity" so that facilities can be released for "unrestricted use." Levels of radioactivity remaining at a facility would be low enough that the facility and its surroundings could be used by the general public without any radiologically related restrictions on the type of use or duration of occupancy.

The EIS analysis evaluates the following D&D options recommended by NRC for commercial facilities: DECON for all nonreactor support facilities and SAFSTOR for reactor facilities. An analysis and comparison of various D&D options are presented in the NRC final generic decommissioning document (NRC-3).

Three D&D impacts to NPR facilities are analyzed: dose to workers, volume of waste generated, and cost. For each reactor technology, three cases are analyzed: (1) D&D of the reactor and its support facilities for the tritium production mode, (2) case 1 plus the support facilities for spent fuel processing, and (3) case 2 plus the support facilities for the plutonium production mode. The methodology used to estimate D&D costs, doses to workers, and volume of waste generated is described briefly in Section 5.1.11 and in greater detail in Section O.3.

The impacts associated with the decontamination and decommissioning of the NPR and its support facilities would be reevaluated twice during the life of the NPR. The first evaluation would occur during the detailed design phase, when a D&D plan would be prepared. The design-phase D&D plan would address regulatory compliance, decommissioning options, controls and limits on procedures and equipment to protect occupational and public health and safety, a final radiation survey, quality assurance, safeguards, mitigation of environmental impacts, volumes of radioactive and other hazardous wastes generated, disposal sites, occupational and public radiation exposure, costs and schedule. The plan would specifically address the disposal of low-level waste, high-level waste (HLW), and transuranic (TRU) waste; hazardous waste storage requirements; and compliance with RCRA and CERCLA. The plan would include the transportation impacts for off-site waste disposal.

Near the end of the useful life of NPR, a final D&D plan would be prepared. The final plan would present the D&D procedures, using then-current technology and addressing any waste disposal requirements and regulations. The final plan would also address, compare, and update all the issues discussed in the design-phase plan. The final D&D plan would be subject to NEPA review.

All D&D activities would be regulated by DOE orders limiting the exposure to the general public. The exposures to the general public from airborne radioactive contaminants are expected to be less than the exposures from normal operations (Sections 5.2.6, 5.3.6, and 5.4.6). Table 5.4.12-1 presents an evaluation of the D&D impacts to the NPR and its support facilities at SRS. The occupational doses from D&D at SRS would range from 160 to 500 person-rem for the tritium production mode, and from 1,600 to 2,300 person-rem for the combined tritium and plutonium production mode with spent fuel processing. The occupational doses represent between 0.06 and 0.8 cancer fatalities to D&D workers and can be compared with the annual occupational dose of 67 to 700 person-rem/yr for 5 or 6 years of D&D activities. Radioactive exposures to any individual performing D&D would also be limited by DOE orders regulating occupational exposures in effect at the time of D&D. Currently, DOE Order 5480.11, *Radiation Protection for Occupational Workers*, limits occupational exposure to 5 rem/yr from existing facilities and to 100 mrem/yr from operations in new facilities.

TABLE 5.4.12-1 D&D Impacts at SRS for HWR, LWR, and MHTGR Technologies

D&D Impact	HWR	LWR	MHTGR
Facility volume (m ³)			
Tritium production only	300,000	550,000	570,000
Tritium production with spent fuel processing	490,000	810,000	810,000
Tritium and plutonium production with spent fuel processing	900,000	1 × 10 ⁶	1.1 × 10 ⁶
Cost (millions of 1989 dollars)			
Tritium production only	60	160	170
Tritium production with spent fuel processing	290	460	450
Tritium and plutonium production with spent fuel processing	560	800	760
Occupational dose (person-rem)			
Tritium production only	160	460	500
Tritium production with spent fuel processing	810	1,300	1,300
Tritium and plutonium production with spent fuel processing	1,600	2,300	2,200
Waste volume (m ³)			
Tritium production only	23,000	34,000	31,000
Tritium production with spent fuel processing	33,000	47,000	43,000
Tritium and plutonium production with spent fuel processing	78,000	61,000	61,000

The total radioactive waste volume generated by D&D at SRS would range from 23,000 to 34,000 m³ for the tritium production mode, and from 60,000 to 77,000 m³ for the combined tritium and plutonium production mode with spent fuel processing. For the tritium production mode, about 240 m³ would be HLW or TRU waste; between 5,900 and 16,000 m³ would result from the combined tritium and plutonium production mode with spent fuel processing. From this analysis, the HLW or TRU waste would represent between 1% and 17% of the total radioactive D&D waste for the tritium production mode, and between 8% and 27% of the radioactive D&D waste for the combined tritium and plutonium production mode with spent fuel processing. The HLW would be shipped off-site to a Federal Repository; TRU waste would be shipped to the Waste Isolation Pilot Plant or another appropriate facility. The HLW and TRU disposal sites will comply with all applicable Federal, state, and local regulations in effect at the time of disposal. The requirements for HLW and TRU disposal would be assessed in the initial and final D&D plans. Impacts of shipping the HLW and TRU D&D wastes would be similar to the impacts of transporting operational wastes (Section 5.2.6). The low-level waste generated by NPR D&D would be buried on-site (23,000 to 77,000 m³ during a 6-yr period). This volume of waste, mainly solids, would represent 12% to 41% of the estimated annual generation of low-level waste at SRS. On an average annual basis, low-level waste volumes generated by D&D would be equivalent to or less than (and not materially different from) annual waste volumes generated by operation of an NPR and by other sitewide activities. No additional requirements would be necessary for D&D.

As indicated in Table 5.4.12-1, the D&D costs for the three reactor technologies in the tritium production mode would vary from \$60 million to \$170 million. The D&D costs for facilities operating in the combined tritium and plutonium production mode with spent fuel processing would vary from \$560 million to \$800 million. In all three tritium and plutonium production options, the HWR technology would have the lowest D&D costs. The D&D costs would represent about 17% to 21% of the capital cost. The D&D costs normally represent about 15% to 20% of capital costs for D&D of commercial facilities, so this fraction compares favorably with projected costs.

5.4.12.3 Mitigation and Conclusions

The first action to mitigate the impacts of D&D is required by DOE Order 5820.2A, *Radioactive Waste Management*, and DOE Order 6430.1A, *General Design Criteria*. These orders require that DOE facility designs minimize the impacts of D&D. These design features are presented in Table O.1.

This analysis shows that the HWR technology would result in the lowest impacts. The impacts of HWR technology would not be significantly (about 50%) lower than the LWR or MHTGR technology. For spent fuel processing, the D&D costs and occupational doses and their associated health effects would be more than quadruple those for the tritium production mode only, and the waste volumes would be less than double.

The NPR project would be managed in accordance with a waste reduction program that covers the entire project life from conceptual engineering design to decommissioning. The program will define the specific steps in which the contractor plans to minimize all wastes (including hazardous and nonhazardous wastes) generated during construction, operations, and decommissioning. To achieve an effective waste reduction program, primary emphasis will be given to source reduction and, alternatively, recycling to minimize the quantities and toxicities

of materials and substances before they enter the waste streams for treatment or disposal. For waste that is generated, waste reduction will include treatment to reduce the volume, toxicity, or mobility of such waste prior to storage or disposal.

The impacts would be different if other D&D options were selected. For example, if SAFSTOR for 100 years were selected for D&D of spent fuel processing, the estimated D&D cost would increase from \$1,200 to \$2,000/m³ of facility volume. The resultant D&D costs would increase between 10% and 60%, depending on the reactor technology. However, the corresponding occupational doses and their associated health effects and waste volumes would decrease. The option used for the reactor facilities in this analysis (SAFSTOR for 30 years) would result in higher D&D costs, higher occupational doses and their associated health effects, and higher waste volumes than the 60-yr SAFSTOR option recommended by NRC.

As discussed in Section O.5, the decontamination activities at SRS would occur in two distinct time frames: DECON from 1 year before reactor shutdown to 5 years after reactor shutdown; and SAFSTOR from 30 to 36 years after reactor shutdown. The three alternative technologies would show no significant differences in schedules because the controlling effect is the projected time for SAFSTOR of the reactors, which is assumed to be 30 years in this analysis.

5.5 CUMULATIVE IMPACTS

This section discusses potential cumulative impacts from construction and operation of NPR facilities. Cumulative impacts are defined by the Council on Environmental Quality (CEQ) (40 CFR 1508.7) as:

The impact on the environment which results 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 actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Hanford, SRS, and INEL already contain major DOE and non-DOE facilities, unrelated to the NPR, that would continue to operate throughout the life of the NPR (Section 3.2). The activities associated with these existing facilities produce environmental consequences, and those consequences have been included in the baseline environmental conditions (Section 4) against which the impacts of the NPR project are assessed (Section 5). For each site, the impacts of the no-action alternative include the effects of non-NPR facilities. In addition, the baseline environmental conditions include other reasonably foreseeable future actions expected to occur by the time of NPR construction (1996) and operations (in or about 2000). Impacts both for construction and operation of NPR facilities would be cumulative with the impacts of existing and planned non-NPR facilities. The consequences section in each area of impact assessment identifies, as appropriate, the cumulative relationship of NPR impacts to impacts from existing and planned site operations, as well as actions of other agencies. Thus, Section 5 constitutes a cumulative impact assessment. The on-site cumulative effects of NPR waste generation on waste management systems are discussed in Sections 5.2.10.4 (Hanford), 5.3.10.4 (INEL), and 5.4.10.4 (SRS). The cumulative effects of NPR radiological releases are presented in Sections 5.2.6.2 (Hanford), 5.3.6.2 (INEL), and 5.4.6.2 (SRS). The on-site cumulative effects of NPR construction and operations on water resources are presented in Sections 5.2.2 (Hanford), 5.3.2 (INEL), and 5.4.2 (SRS). The cumulative effects of habitat disturbance and loss are discussed below in Section 5.5.2 (Open-Country Birds) and 5.5.3 (Wetlands), since loss of these habitats is of national significance.

The cumulative impact analysis presented below does not reiterate these within-site cumulative impacts. Rather, the following material is intended to identify and discuss cases in which impacts from NPR construction and operation would be cumulative with the impacts of other activities beyond the site boundaries and beyond the control of site operations. Each cumulative impact is discussed separately. Three categories of potential cumulative impacts are discussed: global conditions, open-country species of special concern, and wetlands. For each category, the issues are described and their significance is discussed. In addition, the incremental impact of an NPR at the site is identified, and the NPR contribution to the cumulative impact is discussed.

5.5.1 Global Conditions

The release of certain trace gases into the atmosphere has potential consequences on global conditions. Gases that are strong absorbers of infrared radiation, such as carbon dioxide (CO₂), are known as "greenhouse" gases -- a reference to their ability to contribute to global warming, or the greenhouse effect. Other greenhouse gases are methane (CH₄), nitrous oxide

(NO₂), chlorofluorocarbons, Halon-1301 (CBrF₃), and tropospheric ozone (ozone at the earth's surface). Increases in atmospheric concentrations of these gases from combustion of fossil fuels, release of synthetic chemicals, biomass burning, and deforestation have the potential to increase global temperatures. Potential global warming of the surface air temperature by between 1.5 and 4.5°C has been predicted as a result of a projected doubling of the current concentrations of carbon dioxide in the atmosphere (DOE-64). The combined warming and thermal radiation effects of other greenhouse gases could potentially be as large as that from carbon dioxide (Ramanathan et al. 1985).

Several of the chemicals that are potential contributors to global warming also have also been implicated in depletion of stratospheric ozone, a triatomic molecule of oxygen (O₃). Ozone in the stratosphere (20-35 km above the earth's surface) absorbs short-wavelength ultraviolet solar radiation that can be harmful to human health (e.g., cause skin cancer) and to plant and animal life. The balance of ozone is maintained by a balance of photochemical processes that can be disrupted by the introduction of chlorine, nitrogen, and other catalysts.

Chlorofluorocarbons are among the principal gases associated with ozone depletion. Chlorofluorocarbons are manufactured trace gases with sufficient stability to be transported by atmospheric circulation from the earth's surface to the stratosphere. In the stratosphere, intense ultraviolet radiation breaks down the compounds to release chlorine, which, together with oxygen, nitrogen, and hydrogen oxides, serves as a catalyst in reactions that lead to ozone reduction. The major ozone-reducing chlorofluorocarbons are CFC-11 (trichlorofluoromethane), -12 (dichlorodifluoromethane), -22 (chloro-difluoromethane), and -113 (trichlorotrifluoromethane). Other significant ozone-modifying substances released through human activity are methyl chloroform, carbon tetrachloride, NO₂, CO₂, methane, Halon-1301, and Halon-1211.

Construction and operation of an NPR at Hanford, INEL, or SRS would produce trace gases from combustion of fossil fuels from mobile sources and fossil fuel power generation and from release of process chemicals during routine operations. Emissions of CO₂ during the NPR construction period would be on the order of 10,000 t/yr from vehicles and construction equipment. Power requirements for NPR operations would be approximately 100 MWe. If an LWR or MHTGR were used to generate power, emissions of CO₂ during operations would total less than those of construction because of reduced work force and mobile equipment requirements. However, for the HWR, and for an LWR or MHTGR that did not generate electricity, power requirements would be met from the regional power grid servicing the site.

At Hanford, the power obtained from the BPA grid is primarily from hydroelectric and nuclear sources; therefore, it is unlikely that additional fossil-fueled power generation would be used to support NPR operations. At INEL and SRS, the power supplied from regional sources contains a large component generated from combustion of fossil fuels. Thus, the 100-MWe electrical requirement for operation of an NPR might be supported by additional fossil-fueled power generation, which would produce up to 1 million t/yr of CO₂. The United States currently produces approximately 5 billion t/yr of CO₂ emissions (Piccot and Saeger 1990). That amount is more than 100,000 times the potential emissions of CO₂ during construction of an NPR and more than 1,000 times the potential emissions of CO₂ during generation of electricity to support NPR operations. Thus, activities associated with construction and operation of an NPR would make a contribution of about 0.01% to emissions of a gas (CO₂) with potentially significant cumulative effects on global warming. The cumulative effect of NPR operations would be to slightly enhance the potential rate of global warming discussed earlier.

The operations of NPR support facilities for fuel and target fabrication may involve the use of Freon-113 (trichlorotrifluoromethane), TCA (trichloroethane), and TCE (trichloroethylene), and potentially small quantities of these trace gases would be emitted to the atmosphere during NPR operations (Table 5.5.1). These estimates are based on processes currently used for production of tritium and plutonium. However, the production of these ozone-depleting gases could be phased out before or shortly after the start of NPR operation, in the early 2000s. The chemical industry is currently developing substitute materials to replace chlorofluorocarbons. When suitable substitutes become available, the ozone-depleting gases might be replaced in NPR operations. Even if they were not replaced, up to 70 t/yr of the ozone-depleting gases produced by NPR operations would constitute only a very small fraction of the approximately 400,000 t of chlorofluorohydrocarbons produced yearly in the United States (Piccot and Saeger 1990).

5.5.2 Open-Country Birds

Species of special concern are listed by Federal or state authorities in order to protect the species and their habitats. These species may be rare, localized in distribution, and/or vulnerable to human disturbance. Reduction in population numbers of these species may be due to the cumulative effect of many small, insignificant impacts from many sources.

At Hanford and INEL, species of special concern include open-country birds. In general, undisturbed, native grasslands and desert shrublands that serve as habitat for these species have been greatly reduced due to agricultural use, urban development, and fire. However, the Hanford Site and INEL represent large blocks of relatively undisturbed native grassland and desert scrubland that are largely protected from agriculture and other forms of human disturbance. Industrial development is also controlled and represents less than 5% of the total areas of both sites. Thus, both Hanford and INEL afford excellent habitat for open-country species that are under threat from habitat loss at other locations. Construction and operation either of the HWR or MHTGR at the Hanford NPR site or any of the three technologies at the INEL NPR site would disturb some nesting and foraging habitat for the Swainson's hawk (Federal Category 2 candidate species) and foraging habitat (Hanford) or foraging and nesting habitat (INEL) of the ferruginous hawk (Federal Category 2 candidate and Washington threatened species). Furthermore, nesting birds might be disturbed during NPR construction. These impacts could be mitigated by not scheduling construction during the breeding season and by constructing artificial nest sites to compensate for any removed during construction. If construction occurred in the vicinity of nesting sites, mitigation measures would be developed in consultation with the Fish and Wildlife Service.

The long-billed curlew (a Federal Category 2 candidate and Washington threatened species) is a migratory waterbird that forages and nests in grassland swales, a habitat that is present at the Hanford NPR site. Construction at this site might permanently reduce foraging and nesting habitat occupied by this species by up to 380 ha. However, similar suitable habitat for foraging and nesting of this species is relatively common at Hanford, and, thus, habitat reduction at the NPR site is not expected to have any significant impacts on the long-billed curlew population. If construction occurred in the vicinity of nesting sites, mitigation measures would be developed in consultation with the Fish and Wildlife Service.

5.5.3 Wetlands

Incremental impacts to wetlands and bottomland hardwood forests have led to severe reductions in the quantity of these habitat types in the United States. Wetlands provide important habitats of species of special concern and are important for their floodplain values and because of the role they perform in maintaining the stability of hydrological and ecological systems. Construction of NPR facilities at SRS has the potential both to directly and indirectly affect 5.9 ha of forested wetlands on the NPR site and indirectly affect, through runoff, the Rainbow Bay wetland adjacent to the NPR site (Section 5.4.4). Direct impacts to forested wetlands on the NPR site would be minimized by locating NPR facilities so as to avoid these areas during construction. Indirect impacts to forested wetlands and Rainbow Bay would be avoided by preventing sediment runoff into these areas. In order to comply with DOE's policy of no net loss of wetlands, any wetlands that are disturbed during construction would be replaced. Any such wetland mitigation plan would be developed in consultation with the COE.

TABLE 5.5-1 Emissions of Chlorinated Trace Gases by Operation of an NPR at Hanford, INEL, or SRS

Site/ Technology	Freon-113 (t/yr)	TCA (t/yr)	TCE (t/yr)
Hanford			
HWR	20	0.5	0.1
LWR	- ^a	2.5	-
MHTGR	-	-	0.2
INEL			
HWR	20	0.5	-
LWR	-	2.5	-
MHTGR	-	-	0.2
SRS			
HWR	35	0.6	-
LWR	15	0.4	-
MHTGR	-	70	-

^a"-" denotes no emissions.

Operations of the NPR at SRS also could impact wetlands. The release of blowdown to Fourmile Branch would warm the creek water and double or triple the base flow of the creek. Stream temperatures would be slightly elevated by discharges but would not exceed 32.2°C at the point of release (NUS-4). However, during the cooler periods of the year, the temperature differential between Fourmile Branch and the NPR blowdown discharge may not meet the state requirement of no more than a 2.8°C temperature differential at the point of blowdown, and a Section 316a Demonstration for a balanced biological community might be required. During all seasons, Fourmile Branch would be at ambient temperatures within 2.5 km downstream of the discharge. Discharge temperatures would be within the range of natural temperatures and would have no adverse effects on wetland vegetation.

Even with an NPR-related tripling of the base water flow, the potential instream flow in Fourmile Branch would be within the range of normal flows and less than the flows that occurred during the period before 1985 when effluents from C Reactor were discharged to the creek. Natural succession in the wetland communities damaged by C Reactor discharge in Fourmile Branch would continue toward bottomland forests along the creek and toward a bald cypress/water tupelo community within the Savannah River Swamp. Operations of the NPR would not impede this natural successional process over most of the Fourmile Branch floodplain. With elevated flows, the stream would be slightly wider over much of its length, thus maintaining some areas in open water.

5.6 UNAVOIDABLE ADVERSE IMPACTS AFTER MITIGATION

Siting, construction, and operation of NPR facilities at any of the alternative sites would result in some adverse impacts to the environment. Most of these could be either eliminated, avoided, or reduced to insignificant levels by changes in project design and by other methods of mitigation. Those adverse impacts that could not be mitigated to insignificant levels or avoided altogether are identified below.

Impacts of cooling tower operations would not be significant, except that plumes from NPR wet cooling towers at INEL could be visible from Craters of the Moon National Monument, which is a Class I visual area.

At each of the alternative sites, some biotic habitat would be lost due to NPR construction and occupation of buildings. At each site, the habitat loss would be less than 1% of the site's total land area. At Hanford and SRS, some fish, larvae, and fish eggs would be entrained and entrapped at water intakes in the Columbia and Savannah rivers, respectively. Although the resulting losses of aquatic organisms would be a small fraction of each river's population, the loss would be unavoidable.

The amount of radiation produced by normal NPR operations would be a small fraction of a percent of the existing natural background radiation at each of the sites and would be well below applicable regulatory standards. Medical science has not been able to demonstrate adverse biological effects to individuals from such small increases in very low levels of radiation. Nonetheless, over a broad population base, it is conservatively assumed that such a small increase could statistically increase the number of cancer fatalities in the area near the NPR site by less than one-tenth of one percent.

In the unlikely event of an accident at NPR facilities that released radioactive material, mitigative measures could include temporary relocation of residents and interdiction of consumption of locally grown food, including fish and game. Such mitigative measures would minimize radiation effects; however, they would disrupt residents' normal lifestyle and have a potentially significant impact on local commerce. Such disruptions would constitute unavoidable adverse impacts after mitigation. Substantial costs could also be incurred if such mitigative actions had to be taken.

If a large amount of a toxic material, such as chlorine or ammonia, were accidentally released, fatalities could result, particularly in the immediate vicinity of the release. Possible mitigations include maintaining small inventories of toxic materials and using small storage tanks. With such mitigative measures, it would be highly unlikely that dangerous concentrations of toxic gases would escape beyond site boundaries, but the possibility could not be eliminated completely. Even with smaller or separated tanks, some potential danger to workers would remain from exposure to hazardous toxic gases in the event of a catastrophic tank failure.

The site and regional population would increase as a result of construction and operation of NPR facilities at any of the sites and, as a result, traffic would increase, which implies an increase in traffic congestion, accidents, and fatalities. Although commuter ride-sharing could mitigate this situation somewhat, the adverse impact could not be totally avoided.

The construction and operation of NPR facilities would result in the unavoidable generation of quantities of radioactive and hazardous wastes that would require that processes

and sites become available for their treatment and safe disposal in accordance with applicable regulatory requirements. It is anticipated that such facilities would be available when needed.

5.7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Resources that would be committed irreversibly or irretrievably during NPR construction and operation include materials that could not be recovered or recycled and materials that would be consumed or reduced to irrecoverable forms. The construction and operation of NPR facilities would irretrievably consume electrical energy, fuel, concrete, steel, sand, gravel, and miscellaneous chemicals. Water would be taken from surface and underground sources, but would be returned to those sources or evaporated.

The quantities of materials and expendables consumed or converted to an irretrievable form are listed in Table 3.4-1. Annual electric power requirements for NPR operations are estimated to be about 100 MW for the HWR, about 110 MW for the LWR, and about 90 MW for the MHTGR, independent of site. Requirements for petroleum products (e.g., diesel fuel, gasoline) for NPR operations are estimated to be about 1.3 million L/yr for the HWR, 250,000 L/yr for the LWR, and 200,000-300,000 L/yr for the MHTGR. Irretrievable consumption of other resources, such as construction materials, chemicals, gases, and operating supplies, would not constitute a permanent drain on local sources or involve any material that is in critically short supply in the United States as a whole.

5.8 SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

The short-term effects of NPR construction would include removal of some terrestrial and aquatic habitats from natural productivity. If the existing WNP-1 light water reactor at Hanford were used as an NPR, no additional commitments of land or water areas would be necessary for the reactor facility, but some additional land commitments and disturbance would be required for construction of support facilities. Land at the WNP-1 site and in the 200 and 400 areas at Hanford would be committed to NPR use through the year 2040. For the HWR and MHTGR at Hanford and for all three alternative technologies at INEL and SRS, areas currently in a natural state would be removed from natural productivity by the construction of the reactor and associated support facilities. Areas occupied by buildings and other NPR facilities might not be returned to natural productivity until the year 2100 upon completion of decontamination and decommissioning (D&D), which could extend for 60 years or more beyond the end of NPR operations in the year 2040. One D&D option that might be chosen would be to entomb facilities with residual radioactive contamination. In this case, a return of affected areas to natural productivity might be precluded for hundreds or thousands of years.

At Hanford, construction would disturb 805 ha (HWR), 118 ha (LWR), or 463 ha (MHTGR) of land. At INEL, 1,570 ha (HWR), 1,130 ha (LWR), or 1,200 ha (MHTGR) would be disturbed, and at SRS, 214 ha (HWR), 242 ha (LWR), or 251 ha (MHTGR) of land would be disturbed. Some of this land would be returned to a natural state following completion of construction. However, other areas would remain out of natural productivity to support operations for the life of the NPR. Land areas required during NPR operations would total 277 ha (HWR), 299 ha (LWR), or 267 ha (MHTGR) at Hanford; 1,153 ha (HWR), 1,040 ha (LWR), or 800 ha (MHTGR) at INEL; and 148 ha (HWR), 171 ha (LWR), or 164 ha (MHTGR) AT SRS.

Operations might impact wetlands or wetlands habitat at SRS and aquatic biota at Hanford and SRS due to cooling water withdrawals and thermal effluent discharges. These impacts could be mitigated through avoidance of sensitive areas and reduction of water withdrawals and cooling of thermal discharges through use of cooling towers.

Disposal of solid nonradioactive waste generated from NPR construction and operations would require additional land at on-site sanitary landfills. This land would be unavailable for other uses. Disposal of low-level radioactive solid waste would require additional space at designated on-site burial grounds. High-level radioactive wastes would require temporary on-site storage, waste processing, interim storage of solidified wastes, and disposal in an off-site geologic repository. These steps would involve the commitment of associated land, transportation, processing facilities, and other disposal resources.

6 ENVIRONMENTAL REGULATIONS AND PERMIT REQUIREMENTS

This section identifies the major laws, regulations, Executive Orders, DOE Orders, and compliance instruments that apply to the proposed action and alternatives.

The discussion emphasizes the various Federal statutes that impose environmental protection and compliance requirements upon DOE, as well as those state and local measures applicable to the proposed action because Federal law delegates enforcement or implementation authority to state or local agencies. Table 6.1 lists the environmental permit and notification requirements that would apply to each of the three candidate sites, and Table 6.2 lists consultation requirements.

It is DOE's policy to conduct its operations in an environmentally safe manner in compliance with applicable statutes, regulations, and standards. Although this section does not address pending legislation or regulations that may become effective in the future, DOE recognizes that the regulatory environment is changing rapidly and that construction and operation of NPR capacity must be conducted in compliance with the statutes, regulations, and standards then in effect. NPR activities will be covered under each site's NPR compliance plan, pollution prevention plan, and emergency response plan.

Under the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code [USC] 4321 et seq.), Federal agencies are required to prepare an EIS for proposed major Federal actions that may significantly affect the quality of the human environment. The DOE has determined that the proposed siting, construction, and operation of NPR capacity is such an action. Therefore, this EIS has been prepared in accordance with the Council on Environmental Quality Regulations (40 Code of Federal Regulations [CFR] 1500-1508) implementing the National Environmental Policy Act and the DOE Guidelines for Compliance with the National Environmental Policy Act, as amended (52 Federal Register [Fed. Reg.] 47662; December 15, 1987).

The Atomic Energy Act of 1954 (42 USC 2011 et seq.) authorizes DOE to establish standards to protect health or minimize dangers to life or property. Through a series of DOE orders, the Department has established an extensive system of standards and requirements to ensure safe operation of its facilities. In accordance with the Energy Reorganization Act of 1974 (Public Law [PL] 93-438), DOE defense-related operations are not subject to licensing by the U.S. Nuclear Regulatory Commission.

Executive Order 12088, Federal Compliance with Pollution Control Standards, requires Federal agencies, including DOE, to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Clean Air Act (Section 6.1), the Noise Control Act (Section 6.2), the Clean Water Act (Section 6.3.1), the Safe Drinking Water Act (Section 6.3.3), the Toxic Substances Control Act, and the Resource Conservation and Recovery Act (RCRA) (Section 6.7.1).

TABLE 6.1 Permit and Notification Requirements

Resource/Site	Primary Agency	Permit or Notification	Potential Applicability
Air Resources			
Hanford	Tri-County Air Pollution Control Authority	Air Quality Notice of Construction Review	Necessary before construction of NPR and support facilities.
	Tri-County Air Pollution Control Authority and Department of Social and Health Services, Radiation Control	NESHAPs approval of construction and notification of start-up	Necessary before construction of NPR.
	Department of Ecology	Modification of existing PSD permit	Necessary if construction of NPR would result in significant net emissions for major stationary source, including entire Hanford facility.
	EPA, Region X	NESHAPs approval of construction and notification of start-up	Necessary if NPR will emit more than 1% of effective dose equivalent of 10 mrem/yr to member of the public.
INEL	Department of Health and Welfare, Division of Environmental Quality	Air Quality Construction Permit	Necessary before construction of NPR and support facilities.

TABLE 6.1 (Cont'd)

Resource/Site	Primary Agency	Permit or Notification	Potential Applicability
Air Resources (cont'd)			
INEL (cont'd)	Department of Health and Welfare, Division of Environmental Quality	Modification of existing PSD permit	Necessary if construction of NPR would result in significant net emissions for major stationary source, including entire INEL facility.
	EPA, Region X	NESHAPs approval of construction and notification of start-up	Necessary if NPR will emit more than 1% of effective dose equivalent of 10 mrem/yr to member of the public.
SRS	Department of Health and Environmental Control	Air quality construction permit and operating permit for new sources	Construction permit necessary before construction of NPR and supporting facilities; operating permit must be obtained at least 15 days before operations begin.
	Department of Health and Environmental Control	Modification of existing PSD permit	Necessary if construction of NPR would result in significant net emissions for major stationary source, including entire SRS facility.

TABLE 6.1 (Cont'd)

Resource/Site	Primary Agency	Permit or Notification	Potential Applicability
Air Resources (cont'd)			
SRS (cont'd)	EPA, Region IV	NESHAPs approval of construction and notification of start-up	Necessary if NPR will emit more than 1% of effective dose equivalent of 10 mrem/yr to member of the public.
Water Resources			
Hanford	EPA, Region X	Modification of existing NPDES permit or application for new permit	Modification of NPDES permit issued for outfall to Columbia River from WNP-1, new permit for new outfall to Columbia River from alternative designs; application for permit for storm-water discharge pursuant to new regulations, or if liquid effluent from new sewage treatment plant is discharged to Columbia River.
	Corps of Engineers	Section 404 dredged or fill permit or Section 10 Rivers and Harbors Appropriation Act permit	Necessary for construction of new outfall and intake structures in Columbia River for alternative designs other than WNP-1.

TABLE 6.1 (Cont'd)

Resource/Site	Primary Agency	Permit or Notification	Potential Applicability
Water Resources (cont'd)			
Hanford (cont'd)	Department of Ecology	State permit for discharge to waters of state	Application necessary to obtain approval of Corps of Engineers Section 404 permit.
INEL	EPA, Region X	NPDES permit	New permit for storm-water discharge pursuant to new regulations.
	Corps of Engineers	Section 404 dredged or fill permit	Necessary if fill or dredged material discharged into neighboring playa lakes during construction of NPR.
	Department of Health and Welfare, Division of Environmental Quality	State permit for discharge to waters of state	Application necessary to obtain approval of Corps of Engineers Section 404 permit.
	Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau	Approval of construction and design of new drinking water treatment and supply system under Idaho regulations implementing Safe Drinking Water Act	Necessary if adding drilling wells, treatment or supply facilities to INEL water supply system.

TABLE 6.1 (Cont'd)

Resource/Site	Primary Agency	Permit or Notification	Potential Applicability
Water Resources (cont'd)			
SRS	Department of Health and Environmental Control	Modification of existing NPDES permit or application for new permit	Modification of existing sitewide NPDES permit issued for discharge to on-site streams and outfall to Savannah River from existing SRS facilities to accommodate increased effluent from treatment facilities and increased cooling water discharge; application for NPDES permit for storm-water discharge pursuant to new regulations.
	Corps of Engineers	Section 404 dredged or fill permit or Section 10 Rivers and Harbors Appropriation Act permit	Necessary if any additional dredging of or construction in the Savannah River is required.
	Department of Health and Environmental Control, Bureau of Water Supplies and Special Programs	Approval of construction and design of new drinking water treatment and supply system under South Carolina regulations implementing Safe Drinking Water Act	Necessary for new domestic water supply wells, for construction of treatment facilities, and distribution system for public water supply systems.

TABLE 6.1 (Cont'd)

Resource/Site	Primary Agency	Permit or Notification	Potential Applicability
Wastes			
Hanford	Department of Ecology	RCRA, Subtitle C permit	Any new or modified on-site hazardous or mixed waste treatment, storage, or disposal facilities would require a modification under Part A interim permit or a new Part B permit application.
	Benton-Franklin Health District	RCRA, Subtitle J notification RCRA, subtitle D permit	Any new or modified on-site hazardous or solid waste treatment, storage, or disposal would require a new, or modification of Hanford's existing, solid waste permit.
SRS	Department of Health and Environmental Control	RCRA, Subtitle I notification RCRA, Subpart C permit	Any new or modification of on-site hazardous waste treatment, storage, or disposal facilities would require a new Part B permit application or a modification of SRS's existing Part A interim permit.

TABLE 6.1 (Cont'd)

Resource/Site	Primary Agency	Permit or Notification	Potential Applicability
Wastes (cont'd)			
INEL	Idaho Department of Health and Welfare	RCRA, Subtitle C permit RCRA, Subtitle I notification	Any modification of on-site hazardous waste storage facility, i.e., wastes not included in Part A interim permit or Part B permit application, would require amendment of those existing permits or permit applications. A new RCRA permit application would be necessary if INEL decides to treat mixed waste on-site, dependent on new EPA mixed waste regulations.
Biotic Resources			
All Sites	Bald and Golden Eagle Protection Act	Department of the Interior	If any protected birds are found to inhabit the area, DOE must obtain a permit prior to moving any nests due to construction or operation of the NPR.

TABLE 6.2 Consultation Requirements for All NPR Alternative Sites

Statute	Primary Agency	Necessary Consultation
Endangered Species Act	Department of the Interior, Fish and Wildlife Service and National Marine Fisheries Service	Consultation to identify endangered or threatened species and their habitats, to assess impacts of NPR construction or operation thereon and, if necessary, develop mitigation measures to reduce or eliminate adverse effects pursuant to the biological opinion of the agency.
Migratory Bird Treaty Act	Department of the Interior, Fish and Wildlife Service	Consultation to determine if there are any impacts on migrating bird populations due to construction or operation of NPR and to develop mitigation measures to avoid adverse effects.
Fish and Wildlife Coordination Act	Department of the Interior, Fish and Wildlife Service and state wildlife agency	If there is construction, modification, or control of bodies of water in excess of over 10 acres in surface area, i.e., possibly INEL evaporation ponds, consultation is necessary on the possible effects on wildlife conservation in the area of such bodies of water.

TABLE 6.2 (Cont'd)

Statute	Primary Agency	Necessary Consultation
National Historic Preservation Act	State SHPO and Federal Advisory Council on Historic Preservation	Requires performing field surveys to determine existence, location, recording, and evaluation of archaeological or historic sites that may be affected by NPR construction or operation and to develop mitigation measures to avoid destruction or adverse effects on such sites.
Archaeological and Historic Preservation Act	Department of the Interior	If any archaeological or historic resources are discovered before or during construction of the NPR and support facilities, DOE must not cause irreparable damage thereto and may be required to undertake recovery and preservation thereof.
American Indian Religious Freedom Act	Native American Groups	If any portion of the NPR site is located on or will impact on access to or use of Native American religious or traditional sites or sacred objects, DOE must consult with the tribe and cooperate with them to allow expression of freedom of religion on DOE controlled areas.

6.1 CLEAN AIR ACT (42 USC 7401 et seq.)

Construction and operation of NPR facilities would result in release to the atmosphere of criteria* and noncriteria air pollutants, including sulfur dioxide (SO₂), nitrogen oxides (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO), acetone (for the LWR only), trichlorotrifluoromethane (Freon-113), ammonia (LWR only), trichloroethylene (TCE), nitric acid (HWR only), and 1,1,1-trichloroethane (TCA) (MHTGR only) (Sections 5.2.1, 5.3.1 and 5.4.1). The NPR also will emit some radionuclides to the atmosphere, which would be subject to the Clean Air Act (CAA), as amended. For more specific information, see Sections 5.2.6, 5.3.6, and 5.4.6.

The CAA requires the U.S. Environmental Protection Agency (EPA) to establish national primary and secondary ambient air quality standards as necessary to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 USC 7409). The CAA also requires establishment of (1) national standards of performance for new stationary sources of atmospheric pollutants, (2) emissions limitations for any new or modified building, structure, facility, or installation that emits or may emit an air pollutant (42 USC 7411), and (3) standards for emission of hazardous air pollutants (42 USC 7412). In addition, the CAA requires specific emission increases to be evaluated so as to prevent a significant deterioration in air quality (42 USC 7470).

In compliance with these requirements, the EPA issued the following: (1) Primary and Secondary National Ambient Air Quality Standards (NAAQS), including standards for emissions of SO₂, NO_x, CO, particulate matter with a diameter of ≤10 μm (PM₁₀), ozone (O₃), and lead (Pb) (40 CFR 50); (2) the Standards of Performance for New Stationary Sources within specific source categories enumerated in 40 CFR 60.16, including electric steam generating units, industrial-commercial-institutional steam generating units, and stationary gas turbines (40 CFR 60); (3) the National Emission Standards for Hazardous Air Pollutants (NESHAPs), including radionuclides (40 CFR 61); and (4) the Prevention of Significant Deterioration of Air Quality (PSD) review regulations (40 CFR 52.21).

The CAA provides that each state will develop and submit for approval to EPA implementation plans to control air pollution and air quality in that state. Under EPA regulations, Washington, Idaho, and South Carolina have been delegated authority under the CAA to maintain the NAAQ standards (40 CFR 52, Subparts WW, N, and PP, respectively), to issue permits under the PSD (40 CFR 52.2473, 52.683 and 52.2122, respectively), and to enforce performance standards for new stationary sources (40 CFR 60.4). As of the fall 1990, neither Washington, Idaho, nor South Carolina had authority under NESHAPs to regulate emission of radionuclides. Therefore, applications for approval to release any radionuclides would be made to EPA (Region X for Hanford and INEL and Region IV for SRS).

On November 15, 1990, President Bush signed into law the Clean Air Act Amendments of 1990. Under the amendments, new standards will be imposed on major sources emitting air pollutants in nonattainment areas, and states will have to submit new State Implementation Plans (SIPs) to address these new requirements. Mobile sources of air pollutants, such as cars, trucks, buses and certain off-the-road engines, also will have to meet new standards.

*Criteria air pollutants are those for which national primary and secondary ambient air quality standards have been established.

Of the various new provisions in the amendments, those regulating toxic air pollutants would have the greatest impact on environmental compliance at NPR sites. The amendments repeal the current CAA Section 112(b), which directs the administrator of the EPA to publish a list of hazardous air pollutants and pertinent regulations (NESHAPs). Instead, the amendments establish a list of 189 toxic air pollutants, including radionuclides and all other NESHAPs-governed contaminants to be addressed. Within 1 year from enactment of the amendments, EPA is to establish a list of categories and subcategories of sources that emit the listed toxic air pollutants (based on similar industry, facility, or operations). For each category of sources, EPA must issue standards for applicable maximum achievable control technology (MACT) by source and pollutant. Standards must be issued for 40 source categories within 2 years, another 25% within 4 years, an additional 25% within 7 years, and the remainder of the categories within 10 years from enactment. For each category, a major source will be defined as a source that emits more than 10 tons/yr of a single listed pollutant or 25 tons/yr of a combination of such pollutants. The MACT must be installed during construction of new sources, and existing sources would have to comply within 3 years of the issuance of standards for the applicable category.

It is not yet clear how the new amendments will affect regulation of radionuclides currently governed under NESHAPs. Under the amendments, the EPA is not required to regulate radioactive air emissions if the agency determines that Nuclear Regulatory Commission (NRC) standards governing such releases will provide an ample margin of safety. Should EPA retain jurisdiction, it is not known at this time, but a new permitting process may be required.

Another provision of the amendments is that a list of at least 100 extremely hazardous air pollutants (20 of which are enumerated in the amendments) must be established. Once the list is established, regulations will be promulgated to govern accidental releases of such pollutants. Appropriate response actions are to be identified in the regulations.

The amendments also require EPA to issue regulations within 1 year of enactment to establish standards for permitting programs to be carried out by the states. Such programs must be operating within 4 years of enactment, with permitting existing sources being phased in over 3 years.

To comply with the provisions of the new amendments, DOE will monitor the development of the regulations governing toxic air pollutants. Once the additional CAA requirements are determined at each site, DOE will develop and implement a compliance strategy for meeting those requirements and file the necessary applications according to the final determinations of the EPA and the affected states. As these amendments are implemented, the compliance processes described in this section will change.

6.1.1 Clean Air Act Requirements for Washington

The Washington Clean Air Act (Revised Code of Washington, Title 70, Chapter 94) authorizes the Washington Department of Ecology to secure and maintain such levels of air quality as will protect human health and safety and comply with the requirements of the CAA. Pursuant thereto, the Department of Ecology promulgated the Washington Air Pollution Control Regulations (Washington Administrative Code [WAC], Title 173). Under those regulations, the Department of Ecology enforces (1) ambient air quality standards for particulate matter, carbon monoxide, ozone, nitrogen dioxide, radionuclides, fluorides, and volatile organic compounds;

(2) new source performance standards; (3) and prevention of significant deterioration of air quality limitations.

Under WAC 173-403-020, the Department of Ecology regulations may be enforced by a local air pollution control authority. The area of Hanford Site is within the jurisdiction of one such local authority -- the Tri-County Air Pollution Control Authority for Benton, Franklin, and Walla Walla counties. Pursuant to WAC 173-400-10, no construction may start on any new pollutant source until a notice of construction has been approved by the cognizant local authority. Pursuant to WAC 173-403-050, the local authority will review the application to verify that the source will not violate any ambient air quality standard and to determine if the source meets the new source performance standards (WAC 173-400-115); Federal NESHAPs regulations for asbestos, benzene, beryllium, mercury, and vinyl chloride; and state regulations for arsenic.

The standards for radionuclide emissions, as specified in WAC 173-480, are enforced through a separate state permitting process administered jointly by the Tri-County Air Pollution Control Authority and the Washington Department of Social and Health Service, Radiation Control, pursuant to WAC 402-80 et seq. For the emission of hazardous air pollutants, written approval to construct must be obtained from the EPA, Region X, in accordance with 40 CFR 61, Subpart A. Special regulations for emissions of radionuclides, including radon-222, from DOE facilities are established in 40 CFR 61, Subparts H and Q (54 Fed. Reg. 51654, December 15, 1989). Pursuant to 40 CFR 61.07, an application for approval of construction is to be filed before construction begins. Furthermore, DOE must provide written notification to EPA no more than 60 days nor less than 30 days before the anticipated date of initial startup of operations (40 CFR 61.09). However, if it is estimated that radionuclide emissions from the new facility construction or modification will be less than 1% of the effective dose equivalent of 10 mrem/yr to any member of the public, no application for approval of construction or notification of start-up is necessary (40 CFR 61.96). At Hanford, current calculations indicate that the NPR radionuclide emissions may exceed that limit, and thus application and notification would be necessary (Section 5.2.6).

Construction of a major stationary source (one that emits or has the potential to emit 250 tons/yr or more of any air pollutant subject to regulations under the Federal CAA) must be reviewed by the Department of Ecology, not the local authority, for PSD compliance (WAC 173-403-080). The Washington PSD permitting regulations adopt the Federal regulations set forth in 40 CFR 52.21, with few changes, including the Federal definitions. Thereunder, no stationary source or major modification of an existing source shall begin actual construction without a permit.

The entire Hanford Site is treated as a single source, and is considered a major stationary source for PSD review. Therefore, the construction of an NPR complex would be considered a modification to an existing source. A major modification is any physical change in a major stationary source that would result in a significant net emissions increase of any pollutant subject to regulation under the CAA. It is necessary to reference WAC 173-403-030 to determine if an NPR complex would result in significant net emissions. Under that regulation, the potential of a source to emit certain pollutants at a certain emission rate would be designated significant and require PSD review. For an NPR complex, these rates would include CO, 100 tons/yr; NO_x, 40 tons/yr; SO₂, 40 tons/yr; TSP, 25 tons/yr; and PM₁₀, 15 tons/yr. For Hanford (Table E.16), it appears that these emissions rates would be exceeded for CO during operation of the MHTGR, NO_x during normal operations of the HWR and MHTGR, and PM₁₀ during normal operations. Therefore, unless the facility could show that reductions in other

components would result in no net increase in current sitewide significant emissions, a PSD review would be necessary. Emissions of NO_x , CO, and SO_2 from mobile sources during construction are not included in the calculation of significant net emissions; emissions of TSP and PM_{10} during construction are exempt under 52.21(f)(1)(iii) as adopted in WAC 173-403-080.

6.1.2 Clean Air Act Requirements for Idaho

The Idaho Environmental Protection and Health Act (Idaho Code, Title 39, Chapter 101 et seq.) created the Idaho Department of Health and Welfare and its subordinate Division of Environmental Quality, thus consolidating all state public health and environmental protection activities under one department. Pursuant to the Rules and Regulations for the Control of Air Pollution in Idaho (Idaho Administrative Procedures Act [IDAPA] Title 1, Chapter 1), the Department of Health and Welfare established ambient air quality standards for particulate matter, sulfur dioxide, ozone, nitrogen oxides, carbon monoxide, and fluorides.

No owner or operator may begin construction or modification of any stationary source or major facility without first obtaining a permit to construct from the Department of Health and Welfare. A permit would not be granted for a new major facility or modification of an existing facility located in an attainment or unclassifiable area, such as INEL, unless the applicant could show that the new facility (1) would use the best available control technology for each air contaminant for which the new facility would have significant allowable emissions, (2) would not cause or significantly contribute to violations of any ambient air quality standard or any applicable PSD increment, (3) has been granted NESHAPs approval to construct by the EPA, and (4) would not have an adverse effect on the air quality, including visibility, of any Federal Class I area.

As with Hanford, the entire INEL facility is treated as a single pollutant source, and, therefore, is a major stationary source for PSD review. Thus, construction of an NPR complex would be considered a modification to an existing source. It would be necessary to reference IDAPA 16-01.1002,83 to determine if an NPR complex would result in significant net emissions. Under that regulation, the potential of a source to emit certain pollutants at a certain emission rate would be designated significant and require PSD review. For an NPR complex, these rates would include, CO, 100 tons/yr; NO_x , 40 tons/yr; SO_2 , 40 tons/yr; and particulate matter, 25 tons/yr. For INEL (Table E.22), it appears that these emissions rates would be exceeded for NO_x during normal operations. Therefore, a PSD review would be necessary, unless the facility could show that reductions in other components would result in no net increase in current sitewide significant emissions. Emissions during construction are considered temporary emissions and are not considered significant net emissions (IDAPA 01.1021,07(f)). However, certain sources might require permitting under the routine construction permit.

Idaho has not assumed authority for the regulation of emissions under NESI-IAPs. Therefore, written approval to construct and operate must be obtained from the EPA, Region X, in accordance with 40 CFR 61, Subpart A, as set forth above for Washington.

Current calculations show that radionuclide emissions from an NPR complex might exceed the specified limit of less than 1% of the effective dose equivalent of 10 mrem/yr to any member of the public, and application and notification therefore would be necessary (Section 5.3.6).

6.1.3 Clean Air Act Requirements for South Carolina

The South Carolina Pollution Control Act (Code of Laws of South Carolina, Title 48, Chapter 1) delegates authority to the South Carolina Department of Health and Environmental Control to adopt standards, determine which qualities and properties of air shall indicate a polluted condition, and issue permits for the discharge of air contaminants. Pursuant to that authority, the South Carolina Department of Health and Environmental Control promulgated South Carolina Rules and Regulations, Title 61, Chapter 62, Air Pollution Control Regulations and Standards.

Under those regulations, any person who plans to construct or modify a source of air contaminants must first obtain a construction permit from the Department of Health and Environmental Control. No permit to construct will be issued if emissions will interfere with attainment or maintenance of any state or Federal standard. Furthermore, an operating permit must be obtained no later than 15 days before placing any new, increased, or altered source into operation. Operating permits require that these sources must meet, and may not be excepted from, the Federal New Source Performance Standards, NESHAPs, lowest achievable emission rates for emissions of VOCs over 100 tons/yr, and the state PSD regulations. The regulations specify ambient air quality standards, prevention of significant deterioration permitting regulations, and ambient air quality limits. The regulations also require an analysis of the impairment of visibility at any Federal Class I area that the new construction or modification would effect.

As with Hanford and INEL, the entire SRS facility is treated as a single source and, therefore, is considered a major stationary source for PSD review. The construction of an NPR complex would be a modification to an existing source. Regulation 62.5, Standard No., Section I, Part V, must be referenced to determine if an NPR complex would result in significant net emissions. Thereunder, the potential of a source to emit certain pollutants at a certain emission rate would be designated significant and would require PSD review. For an NPR complex, these rates would include, CO, 100 tons/yr; NO_x, 40 tons/yr; SO₂, 40 tons/yr; PM₁₀, 15 tons/yr; and particulate matter, 25 tons/yr. For SRS (Table E.27), it appears these emission rates would be exceeded for CO, NO_x, and SO₂ during normal MHTGR operations. Therefore, a PSD review would be necessary unless the facility could show that reductions in other components would result in no net increase in current sitewide emissions. Emissions of NO_x, CO and SO₂ from mobile sources during construction are not included in the calculation of significant emissions; particulate matter emissions during construction are excluded from increment consumption calculations (Regulation 62.5, Standard No. 7, Section II, Part D(1)(c)).

South Carolina has not assumed authority under NESHAPs for the regulation of radionuclide emissions. Therefore, written approval to construct and operate must be obtained from the EPA, Region IV, in accordance with 40 CFR 61, Subpart A, as set forth above for Washington. Current calculations show the radionuclide emissions from the NPR at SRS might exceed 1% of the 10 mrem/yr standard, and, therefore, application under 40 CFR 61.07 and notification under 40 CFR 61.09 would be necessary (Section 5.4.6).

6.2 NOISE CONTROL ACT OF 1972 (42 USC 4901 et seq.)

Section 4 of the Noise Control Act of 1972 directs all Federal agencies to carry out programs in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health or welfare. The noise impacts of the proposed NPR facilities are analyzed in Sections 5.2.1.3, 5.3.1.3, and 5.4.1.3. Those analyses indicate that no mitigative measures to reduce noise levels at the boundaries of the alternative sites would be needed in order to protect human health or welfare.

6.3 WATER QUALITY AND WATER RESOURCE REQUIREMENTS

The NPR facilities would use water for sanitary and domestic purposes, reactor cooling, manufacture and processing of targets and fuel, environmental control of site and facilities, and emergency and safety systems. Water quality and water resource requirements to which NPR facilities and activities would be subject are discussed in this section.

6.3.1 Clean Water Act (33 USC 1251 et seq.)

The Federal Clean Water Act (CWA) makes it illegal to discharge pollutants from a point source into navigable waters of the United States except in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Through administrative and judicial interpretation, the navigable waters of the United States are considered to encompass any body of water the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce. This definition includes, but is not limited to, interstate and intrastate lakes, rivers, streams, wetlands, playa lakes, prairie potholes, mudflats, intermittent streams, and wet meadows.

The NPDES program is administered by the Water Management Division of EPA pursuant to regulations in 40 CFR 122 et seq. Of the three states being considered here, only South Carolina has been delegated NPDES permitting authority by the EPA. Idaho has not received such authority from the EPA, and Washington has not received authority over discharges from Federal facilities. Thus, DOE would file with the EPA, Region X, for an NPDES permit for any NPR activities at INEL or Hanford subject to these requirements.

Sections 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the CWA. Section 402(p) requires that EPA establish regulations for issuing permits for storm-water discharges associated with industrial activity. Proposed regulations were published on December 7, 1988 (53 Fed. Reg. 49416), and the language of the Water Quality Act of 1987 requiring an NPDES permit for storm-water discharge was codified into EPA regulations in 40 CFR 122.26 (54 Fed. Reg. 246, effective January 4, 1989). Now, any storm-water discharge associated with industrial activity requires an NPDES permit application (40 CFR 122.26(a)(1)(ii)), but regulations implementing a separate storm-water permit application process have not yet been adopted.

Under Section 404 of the CWA (33 USC 1344), dredged or fill material may not be discharged into waters of the United States, including rivers, streams, wetlands, and playa lakes (33 CFR 328.3), by or on behalf of any Federal agency, other than the U.S. Army Corps of Engineers, without a permit issued pursuant to Corps of Engineers rules and regulations

(33 CFR 320 through 328). Those regulations prescribe special policies, practices, and procedures to be followed by the Corps of Engineers in reviewing applications for permits to authorize such discharges (33 CFR Parts 320, 323, and 325). Pursuant to 33 CFR 320.4, in issuing such permits, the Corps of Engineers must consider the impact that such activity would have on floodplains and wetlands in accordance with Executive Orders 11988 and 11990.

6.3.1.1 Clean Water Act Requirements for Washington

Washington has not received authority to implement a NPDES permitting program for Federal facilities under the Federal CWA. Therefore, any application for a new NPDES permit for storm-water discharges or the discharge of wastewater into the Columbia River through a newly constructed intake/discharge structure for an HWR or MHTGR, or for a modification of the current NPDES permit for discharges through the existing intake/discharge structure for the LWR (WNP-1), would have to be made to the EPA, Region X, under 40 CFR 122 et seq. If liquid effluent were to be discharged to the Columbia River from the new sewage treatment plant through existing or newly constructed outfalls, application for a new NPDES permit or modification of an existing permit would be necessary. Any application for a permit for the discharge of dredged or fill material during construction of any new intake/discharge structure in the Columbia River for an HWR or MHTGR should be made to the Corps of Engineers. Such a permit would be reviewed by the Washington Department of Ecology.

Pursuant to 33 CFR 320.4(j)(1), the Corps of Engineers may not issue a Federal Section 404 permit if a state permit application is denied or if the discharge will violate any state water quality standards. Therefore, to secure a Federal Section 404 permit, an applicant for the discharge of dredged or fill material into waters in the state must also apply to the Department of Ecology.

Under the Washington Water Pollution Laws (Revised Code of Washington, Title 90, Chapter 48), it is the policy of the state of Washington to maintain standards to ensure the purity of all waters of the state consistent with protection of public health, protection of wildlife, and effects of industrial development. The Washington Water Pollution Control Regulations (Washington Administrative Code 173 et seq.) establish effluent limitations, water quality standards, and other permitting requirements.

6.3.1.2 Clean Water Act Requirements for Idaho

Idaho has not accepted authority to implement an NPDES permitting program under the federal CWA. Therefore, any application for an NPDES permit for any storm-water discharges would be made to the EPA, Region X, under 40 CFR 122 et seq. During normal NPR operations, liquid discharges would be disposed of in lined evaporation ponds, and there would be no direct release of wastewater to any existing surface waters or groundwaters on the site; therefore, no NPDES permit would be necessary. No floodplains or wetlands occur in the area of the NPR site on INEL; however, if discharge of dredged or fill materials from construction to neighboring playa lakes was planned, applications would have to be submitted to the Corps of Engineers and the Idaho Department of Health and Welfare for appropriate permits.

The Idaho Water Pollution Control Act (Idaho Code, Title 39, Chapter 36) establishes general provisions for the prevention of water pollution in the state. Provisions of the Idaho

Water Quality Standards and Wastewater Treatment Requirements (Idaho Department of Health and Welfare, Rules and Regulations, Title 1, Chapter 2) control point-source and non-point-source discharges and other activities that may adversely affect surface water and groundwater of the state. These regulations identify water use classifications, specifically prohibited discharges, water quality criteria, and requirements for treatment of wastewater before discharge into Idaho waters.

6.3.1.3 Clean Water Act Requirements for South Carolina

The South Carolina Pollution Control Act (Code of Laws of South Carolina, Title 48, Chapter 1) establishes a state policy to maintain reasonable standards of water quality. The Act authorizes the South Carolina Department of Health and Environmental Control to develop regulations to implement this policy and to adopt water quality standards. The South Carolina Department of Health and Environmental Control implements and enforces its delegated authority to issue NPDES permits. However, EPA, Region IV, still acts as a review agency for permit applications. The South Carolina NPDES Permit Regulations include requirements of dischargers, application and filing procedures, terms and conditions of permits, duration of permits, and recordkeeping responsibilities of dischargers.

A new NPDES permit may be required for storm-water discharges under new regulations or for discharge of cooling water from new NPR outfall structures constructed in the Savannah River or Fourmile Branch. The existing sitewide NPDES permit may have to be modified for discharge of additional sanitary wastewater, cooling tower blowdown, boiler blowdown, laboratory wastewater, process wastewater, effluent streams from the treatment facilities, and for the additional discharge of cooling water into the Savannah River or Fourmile Branch through existing on-site surface drainage systems. Discharge of blowdown to Fourmile Branch may require review under Section 316a of the Clean Water Act. Also, for any construction in wetland areas or dredging of the Savannah River channel, a Corps of Engineers permit would have to be applied for under Section 404 of the CWA.

6.3.2 Rivers and Harbors Appropriations Act of 1899

Section 10 of the Rivers and Harbors Appropriations Act of 1899 (33 USC 401 et seq.) prohibits the unauthorized obstruction or alteration of any navigable water of the United States. The construction of any structure in or over navigable water, the excavation from or depositing of material in such waters, or the accomplishment of any such work affecting the course, location, condition, or capacity of such waters is unlawful unless the work has been recommended by the Corps of Engineers and authorized by the Secretary of the Army.

Permits may be required under Section 10 for structures or work in or affecting navigable waters pursuant to regulations in 33 CFR Parts 320, 322, and 325. Application for a permit under Section 10 of this Act can be submitted to the Corps of Engineers in conjunction with any application for a permit for the discharge of dredged or fill materials under Section 404 of the CWA (33 CFR 325.1(d)(2)). Pursuant to Corps regulations, consultation with the state agency responsible for fish and wildlife must take place before a Section 10 permit is issued. If new cooling water intake structures were constructed for an HWR or MHTGR at the Hanford Site, or if construction for additional cooling water discharges was necessary in the Savannah River or Fourmile Branch at SRS, DOE would consult with the Corps of Engineers to determine

which requirements might apply under the Rivers and Harbors Appropriations Act and 33 CFR 320 et seq. It is not contemplated that any structure would be constructed in or over navigable waters at either INEL or SRS; therefore, no permit under this Act would be necessary.

6.3.3 Safe Drinking Water Act (42 USC 300(f) et seq.)

The primary objective of the Safe Drinking Water Act is to protect the quality of public water supplies, water supply and distribution systems, and all sources of drinking water. Sections of the Act address public water systems, protection of underground sources of drinking water, emergency powers, general provisions, and additional requirements to regulate underground injection wells. The National Primary Drinking Water Regulations (40 CFR 141 et seq.), administered by EPA, establish standards applicable to public water systems. The regulations promulgate maximum contaminant levels, including those for radioactivity, in community water systems. No new public water supply system is anticipated to be constructed at Hanford or INEL. A new potable water supply system might be constructed at SRS, and approval for such construction would have to be obtained from the South Carolina Department of Health and Environmental Control pursuant to delegation by EPA under the Federal Safe Drinking Water Act (S.C. Primary Drinking Water Regulations 61-58.5 and 61-58.6). It also may be necessary for INEL to obtain approval for any modification to the drinking water supply system necessitated by NPR construction and operation. Such approval would come from the Department of Health and Welfare, Water Quality Bureau, pursuant to EPA delegation of authority under the Federal Safe Drinking Water Act.

Sanitary liquid waste will be discharged to septic tile fields at both INEL and Hanford (liquid sanitary wastes at SRS are discharged to on-site streams under an NPDES permit). Such discharges are not underground injection wells requiring a permit under the Safe Drinking Water Act, Underground Injection Control, as implemented in the states of Washington or Idaho. No other injection wells are contemplated at any site. Furthermore, no site is located over a sole source aquifer or wellhead protection area as designated by the state under the Safe Drinking Water Act. Therefore, this act does not apply to the construction or operation of the NPR complex except as set forth above.

6.3.4 Wild and Scenic Rivers Act (16 USC 1274 et seq.)

The Wild and Scenic Rivers Act provides for protection of the free-flowing, scenic, and natural values of rivers designated as components or potential components of the National Wild and Scenic Rivers System. No license, permit, or other authorization can be issued for a Federally assisted water resources project that could have a direct or adverse impact on the values for which a river was designated as a wild and scenic river or study river. No component river or adjacent lands designated as wild or scenic rivers will be affected by construction or operation of an NPR complex at INEL or SRS.

Although the Hanford Reach of the Columbia River has not been listed as a study river, Federal legislation (PL 100-605; Study of the Hanford Reach of the Columbia River) directs the Secretary of the Interior, in consultation with the Secretary of Energy, to prepare a study that identifies and evaluates outstanding features of the Hanford Reach (which includes the section of the river adjacent to the Hanford Site) relative to fish and wildlife, geologic, scenic, recreational, natural, historical, and cultural values. The Secretary of the Interior is to

(1) examine alternatives for the preservation of such values, (2) recommend a preferred alternative for the protection and preservation of the identified values, and (3) consider the potential addition of all or a portion of the study area to the National Wild and Scenic River System.

The legislation provides for an 8-year period following the November 4, 1988, enactment date during which no Federal agency may construct a dam, channel, or navigation project on the Columbia River. During the 8-year protection period, existing projects may be operated in accordance with existing licenses, permits, and agreements. New Federal and non-Federal projects are allowed during the 8-year period, but they must be planned, designed, located, and constructed to minimize direct and adverse effects on the values for which the river is under study, and they must use existing structures and facilities to the greatest extent practicable. Pursuant to PL 100-605, Section 2, consultation with the Secretary of the Interior is required before construction of any new Federal project so as to minimize and mitigate any direct and adverse effects on the values for which the river is under study. The current outfall/intake structure for WNP-1 is already constructed, so no such consultation would be required, but construction of any new structures in the Columbia River would be subject to PL 100-605, Section 2.

6.3.5 Executive Order 11988, Floodplain Management; Executive Order 11990, Protection of Wetlands

Executive Order 11988 (May 21, 1977) requires Federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken in a floodplain, and that floodplain impacts be avoided to the extent practicable. Executive Order 11990 (May 24, 1977) requires all Federal agencies to consider protection of wetlands in decision making for a proposed action.

The DOE has established procedures (10 CFR 1022, Compliance with Floodplain/Wetlands Environmental Review Requirements) for compliance with the Executive Orders. These regulations require DOE to assess the effects of a proposed action on the survival, quality, and natural or beneficial values of wetlands and to avoid impacts to floodplains to the extent practicable. Pursuant to the regulations and concurrent with DOE's review of a proposed action, DOE shall prepare a floodplain/wetlands assessment. In the action being considered here, the assessment must consider the positive and negative, direct and indirect, and long- and short-term effects of NPR construction on wetlands and floodplains, alternatives to the proposed action that may avoid adverse effects in the floodplain or wetland, and measures to mitigate the adverse effects of actions in a floodplain or wetlands area (10 CFR 1022.12). Such an assessment is included in the water and biotic resource analyses presented in Sections 4 and 5 of this EIS. For actions that would take place in a floodplain, DOE must publish a statement of findings, either in the FEIS or separately, as provided in 10 CFR 1022.15. The findings must include a brief description of the proposed action, an explanation indicating why the action is proposed to be located in the floodplain, a list of alternatives considered, a statement that the action conforms to applicable state and local floodplain protection standards, and a brief description of steps to be taken to minimize potential harm to or within the floodplain.

6.4 BIOTIC RESOURCES

6.4.1 Endangered Species Act (16 USC 1531 et seq.)

The Endangered Species Act is intended to prevent the further decline of endangered and threatened species of animals and plants and to restore these species and their habitats. The act is jointly administered by the U.S. Department of Commerce (marine species and their habitat under 50 CFR 222.23 and 227.4) and the U.S. Department of the Interior (all other plant and animal species and their habitats). Section 16 USC 1536 requires DOE to consult with the Department of the Interior, Fish and Wildlife Service; and/or Department of Commerce, National Marine Fisheries Service, to determine if endangered and threatened species are known to have critical habitats on or in the vicinity of the site of the proposed action.

The identification of endangered and threatened species and their habitats is found in 50 CFR, Parts 17 and 402. Authorities at each NPR candidate site have consulted with the Fish and Wildlife Service, and Hanford also has consulted with the National Marine Fisheries Service concerning salmon species in the Columbia River. Each site has filed a biological assessment concerning potential impacts on endangered and threatened species and migratory birds or their critical habitats in the vicinity of the proposed locations for the NPR complex (see Sections 5.1.4, 5.2.4, 5.3.4 and 5.4.4). The resulting lists of endangered, threatened, and candidate species found at each site are presented in Appendix G. It is anticipated that any biological opinion issued by the Fish and Wildlife Service or the National Marine Fisheries Service will be included in the FEIS.

6.4.2 Migratory Bird Treaty Act (16 USC 703 et seq.)

The Migratory Bird Treaty Act is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and the Union of Soviet Socialist Republics. The Act regulates the harvest of migratory birds by specifying the mode of harvest, hunting seasons, and bag limits. The Act stipulates that it is unlawful at any time, by any means, or in any manner to "kill ... any migratory bird." Although no permit is required under this act, DOE would consult with the U.S. Fish and Wildlife Service, as appropriate, regarding impacts to migratory birds and ways to avoid or minimize those impacts.

6.4.3 Bald and Golden Eagle Protection Act (16 USC 668-668d)

The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States. No permits or approval procedures are required unless a nest interferes with resource development; in that case, a permit must be obtained from the U.S. Department of the Interior to relocate the nest. If a bald (American) or golden eagle nest was found in the vicinity of NPR activities during NPR development, DOE would consult with the Department of the Interior regarding requirements under this Act.

Bald and golden eagles and their habitats are also protected under the Endangered Species Act and will be included on any biological assessment (see Sections 5.1.4, 5.2.4, 5.3.4 and 5.4.4 and Appendix G) and biological opinion issued under that Act.

6.4.4 Fish and Wildlife Coordination Act (16 USC 661 et seq.)

The Fish and Wildlife Coordination Act is intended to ensure that wildlife conservation receives equal consideration and is coordinated with other features of water resource development programs through effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation. The Act applies whenever the waters of any stream or other body of water greater than or equal to 10 acres (4 ha) in surface area are proposed or authorized to be controlled or modified for any purpose whatever by any department or agency of the United States, or by any public or private agency under Federal permit or license. The proposed evaporation ponds at INEL would exceed this limit and this Act would be applicable. The proposing department or agency is required to first consult with the U.S. Fish and Wildlife Service and then with the head of the state agency administering the wildlife resources of the state in which the modification is to be constructed. The department or agency is also requested to provide for the development and improvement of wildlife resources in conjunction with the proposed action.

The DOE would consult with representatives of the U.S. Fish and Wildlife Service and representative state agencies regarding development of an NPR at any of the candidate sites.

6.5 HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCE REQUIREMENTS

Executive Order 11593, Protection and Enhancement of the Cultural Environment (May 15, 1971) requires Federal agencies, including DOE, to locate, inventory, and nominate qualifying properties under their jurisdiction or control to the National Register of Historic Places. This process requires DOE to provide the opportunity for the Advisory Council on Historic Preservation to comment on the possible impacts of the proposed action on any potential eligible or listed resources.

6.5.1 National Historic Preservation Act (16 USC 470 et seq.)

The National Historic Preservation Act provides that places with significant national historic value be placed on the National Register of Historic Places. No permits or certifications are required under this act. However, pursuant to regulations set forth in 36 CFR 800 et seq., if a proposed action might impact an historic property resource, consultation with the State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation is required. Such consultation generally results in execution of a Memorandum of Agreement that includes stipulations that must be followed to minimize adverse impacts.

In Washington, the SHPO is the Preservation Officer in the Office of Archaeology and Historic Preservation (RCW 27.34.210). In Idaho, the SHPO is the Director of the State Historical Society (Idaho Code, Title 67, Chapter 41). In South Carolina, the SHPO is the Director of the State Historic Preservation Office in the Department of Archives and History.

6.5.2 Archaeological and Historic Preservation Act (16 USC 469a et seq.)

The Archaeological and Historic Preservation Act is directed at the preservation of historic and archaeological data that would otherwise be lost as a result of Federal construction or other federally licensed or assisted activities. It authorizes the Department of the Interior to undertake recovery, protection, and preservation of archaeological and historic data. If a Federal agency determines that a proposed action might cause irreparable damage to archaeological resources, that agency is required to notify the Department of the Interior in writing. The agency involved may then undertake recovery and preservation or may request that the Department of the Interior undertake preservation measures. If any NPR activities might result in irreparable damage to historic and/or archaeological resources, DOE would notify the Department of the Interior.

6.5.3 American Indian Religious Freedom Act (42 USC 1996)

The purpose of the American Indian Religious Freedom Act is to protect and preserve for Native Americans their inherent right of freedom to believe, express, and protect the traditional religions of Native Americans, including, but not limited to, access to religious or traditional sites, use and possession of sacred objects, and freedom to worship through ceremonies and traditional rites. The DOE will cooperate with Native Americans in expressing their religious beliefs on DOE-controlled sites that are also traditional Native American religious sites.

6.6 HEALTH AND SAFETY

Under the authority of the Atomic Energy Act, DOE has the responsibility to establish a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanism through which DOE manages its facilities is issuance of DOE orders. For the NPR facilities, construction and operation must also satisfy the General Safety Requirements Document and the Environmental Requirements Document. These requirements generally establish policies and set programs and responsibilities for implementing those policies. The major DOE orders pertaining to the construction and operation of NPRs are listed in Table 6.3.

6.7 MANAGEMENT OF WASTES AND HAZARDOUS MATERIALS

Generation and management of wastes from proposed NPR activities are described in Sections 5.2.10, 5.3.10, and 5.4.10.

6.7.1 Resource Conservation and Recovery Act (42 USC 6901 et seq.)

The treatment, storage, or disposal of solid, both nonhazardous and hazardous, waste is regulated under the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA) and the Hazardous Solid Waste Amendments (HSWA) of 1984. Under 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 that program. Washington,

TABLE 6.3 DOE Orders Applicable to the NPR Project

Order	Subject
1540.2	Hazardous Material Packaging for Transport - Administrative Procedures
1540.4	Base Technology for Radioactive Material Transportation Packaging Systems
5000.3	Unusual Occurrence Reporting System
5400.1	General Environmental Protection Program
5400.2A	Environmental Compliance Issue Coordination
5400.3	Hazardous and Radioactive Mixed Waste Program
5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements
5400.5	Radiation Protection of the Public and the Environment
5440.1D	National Environmental Policy Act
5480.1B	Environmental, Safety, and Health Program for DOE Operations
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Waste
5480.4	Environmental Protection, Safety, and Health Protection Standards
5480.5	Safety of Nuclear Facilities
5480.6	Safety of DOE-Owned Nuclear Reactors
5480.7	Fire Protection
5480.9	Construction Safety and Health Program
5480.11	Radiation Protection for Occupational Workers
5481.1B	Safety Analysis and Review System
5482.1B	Environmental Protection, Safety, and Health Protection Appraisal Program
5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements
5500.1A	Emergency Management System
5500.3	Reactor and Nonreactor Nuclear Facility Emergency Planning, Preparedness, and Response Program for DOE operations

TABLE 6.3 (Cont'd)

5630.11	Safeguards and Security Program
5630.12	Safeguards and Security Inspection and Evaluation Program
5700.6B	Quality Assurance
5820.2A	Radioactive Waste Management
6430.1A	General Design Criteria

Idaho, and South Carolina have received authorization to enforce hazardous waste programs under Subpart C of RCRA. Approved state programs are not static, and as new Federal regulations, limitations, and restrictions are promulgated by EPA, state programs must be appropriately revised. Before enactment of HSWA, changes to Federal requirements were not enforced in authorized states until the state's program was appropriately modified and approved by EPA. Now, EPA enforces HSWA requirements in an authorized state until that state receives approval under Section 3006(g). Therefore, as of August 1990, Idaho, Washington, and South Carolina did not have authorized hazardous waste programs that incorporated all HSWA amendments to RCRA and operated under a dual state-Federal regulatory system.

An operating NPR with support facilities would generate hazardous and radioactive mixed waste that would have to be managed in accordance with RCRA and authorized state hazardous waste regulations. It is possible that wastes generated at an NPR complex would contain hazardous constituents or additional quantities of hazardous waste not covered in an existing RCRA Part B permit application; modification of the application would then be necessary. Both INEL and Hanford have plans to design and construct treatment, storage, and/or disposal facilities in the near- and long-term, which would require compliance with RCRA permitting. Under the 5-year plan and based on other existing DOE and EPA reports, neither existing nor planned future treatment, storage, or disposal capacity would be adequate to properly manage DOE's radioactive mixed waste.

6.7.1.1 Washington RCRA program

The Washington Hazardous Waste Management Act (Revised Code of Washington, Title 70, Chapter 105) establishes a comprehensive statewide framework for planning, regulating, controlling, and managing hazardous wastes to prevent land, air, and water pollution and to conserve the natural, economic, and energy resources of the state. This Act designates the Washington Department of Ecology as the state agency responsible for implementing RCRA. The Act authorizes the Department of Ecology to establish a permit system for owners or operators of facilities that treat, store, or dispose of dangerous wastes and establishes standards for the safe transport, treatment, storage, and disposal of dangerous wastes. This Act also requires the Department of Ecology to conduct site inspections and to monitor and sample dangerous wastes. The Dangerous Waste Regulations (Washington Administrative Code 173-303 et seq.) establish procedures for implementing Washington's Hazardous Waste Management Act and Subtitle C of RCRA.

Hanford's existing facilities may not be adequate to accommodate all of the hazardous or mixed wastes that would be generated by an NPR. Therefore, new facilities might have to be constructed, or existing facilities, such as the Fuels and Materials Examination Facility, Uranium Oxide Plant, or Fuel Processing Plant, might have to be modified. Hazardous waste facilities at Hanford will operate in conformance with 40 CFR 264. If that is the case, an application for a new permit or modification of the existing RCRA Part B permit application for existing facilities at Hanford would have to be filed. New solid waste facilities at Hanford will operate in conformance with 40 CFR 258.

The DOE would have to comply with the general hazardous waste regulations (WAC 173-303 et seq.), identification of hazardous waste regulations (WAC 173-303-070), and regulations for generators of hazardous waste (WAC 173-303-170), for any additional hazardous waste resulting from NPR construction or operation. These regulations include, but are not limited to, container requirements (WAC 173-303-160 and 161); packaging, labeling, and marking of containers before transportation (WAC 173-303-200); preparedness and prevention requirements and contingency plan and emergency procedures (WAC 173-303-145); and reporting and recordkeeping (WAC 173-303-220).

Washington has EPA authorization for its solid waste program under Subtitle D of RCRA. The Solid Waste Management-Recovery and Recycling Act (Revised Code of Washington, Title 70, Chapter 95) establishes a comprehensive statewide program for solid waste handling and solid waste recovery and/or recycling. The Minimum Functional Standards for Solid Waste Handling (Washington Administrative Code 173-304) sets minimum functional performance standards for the proper handling of solid (nonhazardous) waste. At Hanford, nonhazardous, solid waste will be disposed of on-site in existing landfill areas. Hanford has sufficient waste-handling capacity to accommodate the expected additional nonradioactive and nonhazardous solid waste from NPR construction and operations; however, if new facilities or an expansion of existing facilities results from NPR construction, then modification of the existing permit with the Benton-Franklin Health District may be necessary. New solid waste facilities at Hanford will operate in conformance with 40 CFR 258.

Subtitle I of RCRA requires regulation of underground storage tanks containing petroleum products and any substance defined as hazardous under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Subtitle I does not regulate tanks storing hazardous wastes as defined by RCRA, however. Any new tanks installed must meet EPA standards for environmental protection. For existing tank systems, Subtitle I requires DOE to notify the Department of Ecology of the age, size, type, location, and contents of the tanks. Regulations have been promulgated for tanks storing petroleum products, and regulations for tanks holding hazardous substances are expected soon.

6.7.1.2 Idaho RCRA Program

The Idaho Department of Health and Welfare is responsible for enforcement and implementation of the Hazardous Waste Management Act of 1983, as amended (Idaho Code, Title 39, Chapter 44), which provides for the protection of human health and the environment from the effects of improper or unsafe management of hazardous wastes and for the establishment of a tracking or manifesting systems for these wastes. The Idaho Act establishes requirements for the development of plans that address identification of hazardous wastes;

unauthorized treatment, storage, release, use, or disposal of those wastes; and permit requirements for hazardous waste facilities.

The Idaho Hazardous Waste Management Regulations (Idaho Department of Health and Welfare, Rules and Regulations, Title 1, Chapter 5) establish procedures to implement Idaho's Hazardous Waste Management Act and Subtitle C of RCRA. The Department of Health and Welfare adopts, with few exceptions, the Federal regulations, effective July 1, 1987. No new hazardous waste storage, treatment, or disposal facilities are planned at INEL. However, additional waste-handling capacity would be needed to accommodate the NPR-generated radioactive mixed waste, and an application for a new permit or modification of INEL's existing RCRA Part B Permit application would be necessary. For any hazardous wastes generated by NPR activities, DOE would have to comply with the general hazardous waste regulations (40 CFR 260), identification of hazardous waste regulations (40 CFR 261), and regulations for generators of hazardous waste (40 CFR 262). These regulations include manifest requirements (40 CFR 262, Subpart B), packaging, labeling, marking, and placarding prior to and during transportation (40 CFR 262, Subpart C), and recordkeeping and reporting (40 CFR 262, Subpart D).

Idaho has EPA authorization for its solid waste program under Subtitle D of RCRA. Idaho Solid Waste Management Regulations (Idaho Department of Health and Welfare, Rules and Regulations, Title 1, Chapter 6), as developed by the Idaho Department of Health and Welfare, provide standards for the management of solid wastes to minimize the detrimental effects of disposal. These standards include requirements for the review of plans and the approval of procedures and operational and postoperational standards for landfills, incinerators, and processing facilities, and for transportation and storage of solid waste. At INEL, nonhazardous, solid waste generated at an NPR complex would be disposed of on-site in existing landfill areas. The INEL has sufficient waste-handling capacity to accommodate the expected additional nonradioactive and nonhazardous solid waste from NPR construction and operations; however, if new facilities or an expansion of existing facilities results from NPR construction, modification of the existing permit with Department of Health and Welfare might be necessary.

Subtitle I of RCRA requires regulation of underground storage tanks containing petroleum products and any substances defined as hazardous under CERCLA. Subtitle I does not regulate tanks storing hazardous wastes as defined by RCRA, however. Any new tanks installed must meet EPA standards for protection. For existing tank systems, Subtitle I requires DOE to notify the Department of Health and Welfare of the age, size, type, location, and contents of the tanks. Regulations have been promulgated for tanks storing petroleum products, and regulations for tanks holding hazardous substances are expected soon.

6.7.1.3 South Carolina RCRA Program

The South Carolina Hazardous Waste Management Act (Code of Laws of South Carolina, Title 44, Chapter 56) authorizes the South Carolina Department of Health and Environmental Control to promulgate such regulations, procedures, or standards as may be necessary to protect the health and safety of the public and the environment from the effects of improper, inadequate, or unsound management of hazardous wastes. The act requires that a permit be issued before constructing, substantially altering, or operating any hazardous waste treatment, storage, or

disposal facility. Other sections of the act address manifest systems, inspections, hearings, and a hazardous waste contingency fund.

The SRS has sufficient waste handling capacity to accommodate the expected additional nonradioactive, nonhazardous solid waste from NPR construction and operations. However, additional waste-handling capacity may be needed to accommodate NPR-generated mixed waste and hazardous waste. Therefore, an application for or modification of the existing RCRA treatment, storage, or disposal facility Part B permit would be necessary under Regulation 61-79.270.

For any hazardous or mixed wastes generated by NPR activities, DOE would have to comply with the general hazardous waste program requirements (Regulation 61-79.260), identification of hazardous waste regulations (Regulation 61-79.261), and regulations for generators of hazardous waste (Regulation 61-79.262). These regulations include manifest requirements (Regulation 61-79.262 Subpart B); packaging, labeling, marking, and placarding before and during transportation (Regulation 61-79.262 Subpart C); and recordkeeping and reporting (Regulation 61-79.262 Subpart D). For the construction of new treatment, storage, or disposal facilities, DOE would have to comply with the permitting requirements and regulations applicable to owners and operators of hazardous waste facilities (Regulations 61-79.124, 79.270, 79.264, and 61-79.265).

South Carolina has EPA authorization for its solid waste program under Subtitle D of RCRA. At SRS, nonhazardous, solid waste would be disposed of on-site in existing landfill areas. If new facilities or an expansion of facilities resulted from NPR construction, modification of the existing permit might be necessary pursuant to South Carolina Solid Waste Regulations (South Carolina Code of Regulations, Chapter 61, Regulation 60). New solid waste facilities at SRS will operate in conformance with 40 CFR 258.

Subtitle I of RCRA requires regulation of underground storage tanks containing petroleum products and any substance defined as hazardous under CERCLA. Subtitle I does not regulate tanks storing hazardous wastes as defined by RCRA, however. Any new tanks installed must meet EPA standards for protection. For existing tank systems, Subtitle I requires DOE to notify the Department of Health and Welfare, Bureau of Water Supply and Special Programs, of the age, size, type, location, and contents of the tanks. Regulations have been promulgated for tanks storing petroleum products, and regulations for tanks holding hazardous substances are expected soon.

6.7.2 Comprehensive Environmental Response, Compensation, and Liability Act (42 USC 9601 et seq.)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (PL 99-499), provides liability, compensation, cleanup, and emergency response by the Federal government for hazardous substances released into the environment and for the cleanup of inactive hazardous waste disposal sites. All three candidate sites are listed on the National Priority List (NPL) for remedial action under CERCLA. Therefore, in performing such remedial actions, or in the case of a release of a reportable substance, DOE must observe the reporting, response, removal, and remediation provisions of CERCLA, in compliance with the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300 et seq; 55 Fed. Reg 8666,

March 8, 1990) and DOE Order 5400.4, Comprehensive Environmental Response, Compensation and Liability Requirements.

6.7.3 Emergency Planning

Under the Emergency Planning and Community Right to Know Act of 1986 (42 USC 1101 et seq.), industrial facilities are required to provide information, such as inventories of specific chemicals used or stored, to the appropriate State Emergency Response Commission and Local Emergency Planning Committee to ensure that emergency plans are sufficient to respond to accidental releases of hazardous substances. This Act does not apply to Federal agencies. The DOE will voluntarily comply with respect to the NPR complex chosen.

The National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300) applies to all Federal agencies and is in effect for discharges or potential threats of discharges of oil and hazardous substances into the environment. The plan provides for efficient, coordinated, and effective response to discharges by providing for the division and specification of responsibilities among Federal, state, and local governments. It establishes requirements for Federal, regional, and local contingency plans.