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Draft Environmental Impact Statement for the Siting, Construction, and Operation of New Production Reactor Capacity

Volume 1: Summary

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COVER SHEET

Responsible Agency

U.S. Department of Energy (DOE)

Activity

Draft Environmental Impact Statement for the Siting, Construction, and Operation of New Production Reactor Capacity

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Abstract

This EIS assesses the potential environmental impacts, both on a broad programmatic level and on a project-specific level, concerning a proposed action to provide new tritium production capacity to meet the nation's nuclear defense requirements well into the 21st century. A capacity equivalent to that of about a 3,000-megawatt (thermal) heavy-water reactor was assumed as a reference basis for analysis in this EIS; this is the approximate capacity of the existing production reactors at DOE's Savannah River Site near Aiken, South Carolina. The EIS programmatic alternatives address Departmental decisions to be made on whether to build new production facilities, whether to build one or more complexes, what size production capacity to provide, and when to provide this capacity. Project-specific impacts for siting, constructing, and operating new production reactor capacity are assessed for three alternative sites: the Hanford Site near Richland, Washington; the Idaho National Engineering Laboratory near Idaho Falls, Idaho; and the Savannah River Site. For each site, the impacts of three reactor technologies (and supporting facilities) are assessed: a heavy-water reactor, a light-water reactor, and a modular high-temperature gas-cooled reactor. Impacts of the no-action alternative also are assessed. The EIS evaluates impacts related to air quality; noise levels; surface water, groundwater, and wetlands; land use; recreation; visual environment; biotic resources; historical, archaeological, and cultural resources; socioeconomics; transportation; waste management; and human health and safety. The EIS describes in detail the potential radioactive releases from new production reactors and support facilities and assesses the potential doses to workers and the general public.

Comment Period

The DOE will consider written comments mailed to its Office of New Production Reactors and postmarked by June 17, 1991, in preparation of the final EIS. The DOE also will hold 13 public hearings to accept comments on the draft EIS. Comments received during those hearings will be considered in preparation of the final EIS.

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SUMMARY

S.1 INTRODUCTION

Under the Atomic Energy Act, a primary obligation of the U.S. Department of Energy (DOE) is to produce nuclear materials to meet national defense requirements. These nuclear materials are used mainly in building and maintaining the nation's stockpile of nuclear weapons. The primary materials that DOE provides for this purpose are tritium and weapons-grade plutonium (plutonium-239), which are generated in nuclear reactors known as "production reactors." In addition, DOE uses existing production reactors to provide plutonium-238 and other isotopes for applications such as the National Aeronautics and Space Administration's (NASA's) outer planetary space exploration program.

Tritium is a radioactive form of hydrogen; it differs from hydrogen in that it has two neutrons in its nucleus, while hydrogen has none (see Figure S.1). The use of tritium in nuclear weapons makes it possible to build smaller, yet more powerful weapons and also makes it possible to reduce the amount of plutonium in each weapon.

Unlike plutonium-239, which has a radioactive half-life of about 25,000 years (meaning that after 25,000 years half of the original amount of plutonium would be present), tritium has a relatively short half-life of 12.3 years, decaying at a rate of 5.5% per year. Because of this depletion by radioactive decay, tritium must be replenished periodically in nuclear weapons to ensure their effectiveness. Therefore, DOE must have an ensured means of producing new tritium to replace these decay losses.

Over the past 40 years, DOE has built and operated as many as 14 reactors to produce nuclear materials. Today, however, most of these reactors have been shut down. Although the remaining reactors that can produce nuclear materials have undergone safety and operational enhancements, they cannot be considered a reliable source of tritium production to meet requirements through the first half of the next century.

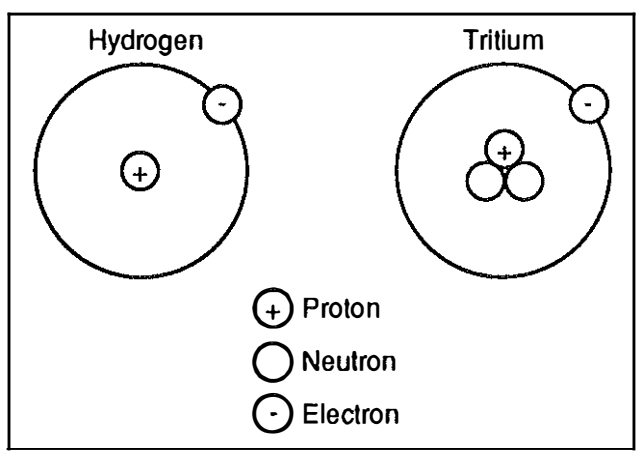

FIGURE S.1 Atomic Structures of Hydrogen and Tritium

In view of the critical importance of tritium -- and the fact that planning, building, testing, and starting up a new reactor requires approximately 10 years -- DOE must proceed on an urgent schedule to acquire new capacity to produce tritium in a safe, assured, sustained, environmentally sound, cost-effective, and institutionally acceptable manner. In order to reduce the risk that DOE may not be able to meet its

responsibilities to provide any tritium quantities projected to be required beyond the year 2000, the Department proposes to provide new production capacity for tritium on an urgent schedule (that is, in or about the year 2000). A capacity equivalent to that of about a 3,000-megawatt (thermal) heavy-water reactor was assumed as a reference basis for analysis in this environmental impact statement. This capacity is the nominal capacity of the existing production reactors at SRS and is in the range of prudent long-term capacity requirements.

The Department has conducted many studies to identify and evaluate alternatives for the production of nuclear weapons materials. These studies have identified concerns over aging facilities, the need for new production facilities, and production assurance. In addition, these studies have examined possible new production options, including alternative sites and technologies. The National Security Council, United States Congress, Secretary of Defense, Nuclear Weapons Council, White House Office of Science and Technology Policy, and National Research Council have all determined that new production capacity for tritium is needed if the nation is to have an assured future supply of this material -- an essential component of the nuclear weapons that support the U.S. nuclear deterrent policy.

Under the National Environmental Policy Act (NEPA) of 1969, a Federal agency proposing a major action that may have significant impacts on the quality of the human environment must, at an early stage in the planning for the action, prepare an analysis of the impacts of the proposed action and alternatives. The agency must also provide an opportunity for the public to comment on the proposal and analysis, consider and respond to comments, and then publicly announce its final decision before proceeding.

In September 1988, DOE issued a Notice of Intent to prepare an environmental impact statement (EIS) analyzing the potential impacts of providing new production capacity for both tritium and weapons-grade plutonium, in compliance with NEPA. This was immediately followed by a period of comment and public meetings to determine scope. In January 1990, DOE issued an implementation plan describing the proposed scope of the EIS for "new production reactor" (NPR) capacity. More recently, DOE decided to prepare a programmatic EIS (PEIS) for the planned reconfiguration of its nuclear weapons production complex (a PEIS is a broad environmental analysis of a program or policy, whereas a project-specific EIS evaluates the environmental consequences of specific actions for a given project). The "Reconfiguration PEIS" will evaluate, among other things, the need and alternatives for production of weapons-grade plutonium. In a related study of the nuclear weapons complex reconfiguration, DOE has determined that there is no need to produce new weapons-grade plutonium in the foreseeable future.

As a result of DOE's decision to prepare the Reconfiguration PEIS and the reassessment of the short-term need for plutonium, the scope of this NPR EIS differs from that described in the implementation plan. The proposed action for new capacity to produce nuclear materials no longer includes production of weapons-grade plutonium. However, this EIS does analyze potential impacts from plutonium production in NPR facilities so that, if an NPR alternative is selected for new tritium production capacity, that alternative will be available as an option for producing plutonium (or isotopes for other applications, such as NASA programs) if the Reconfiguration PEIS supports the determination that production capacity is required for plutonium or other isotopes. If an NPR alternative was later considered for the production of weapons-grade plutonium, DOE would follow appropriate NEPA procedures at that time. This NPR EIS similarly analyzes the potential environmental impacts that might result if spent fuel were reprocessed to recover any remaining useful uranium or plutonium.

This EIS addresses both DOE's proposed broad programmatic action to provide new tritium production capacity and the Department's proposed project-specific action to build and operate one or more specific NPRs at specific sites. The summary is divided into two parts:

- The first part (Sections S.1-S.2) describes the background of the EIS and the results of the programmatic portion of the EIS.
- The second part (Sections S.3-S.7) describes the project-specific alternatives, including no action; identifies the affected environment; and summarizes and compares the potential environmental impacts of constructing and operating NPRs at specific sites.

The proposed programmatic action addressed in this EIS is to provide new capacity to produce tritium safely and reliably, while protecting the environment, to meet the nation's defense requirements well into the 21st century. On that level, the EIS identifies reasonable programmatic alternatives and discusses their impacts. These alternatives consider such decisions as whether to build new tritium production facilities, whether to build more than one facility, what level of production capacity to provide, and when to provide the capacity.

The proposed project-specific action is to site, construct, and operate one or more NPRs on an urgent schedule (that is, in or about the year 2000). This action would enable DOE to maintain a safe and reliable long-term capacity to produce tritium as required to meet defense requirements. On this level, the EIS addresses the potential environmental consequences associated with each of three proposed reactor technologies at each of three proposed sites.

On both the programmatic and project-specific levels, the "no-action alternative" is to continue to rely on DOE's existing tritium production facilities.

S.2 PROGRAMMATIC ASSESSMENT

This level of assessment analyzes the programmatic alternatives considered for the proposed action. These alternatives embody the issues that must be addressed to arrive at a range of project-specific proposals for evaluation. The programmatic course of action will be determined in the Record of Decision for this NPR EIS.

Figure S.2 identifies the alternatives considered in this EIS, on both the programmatic and project-specific levels. Four distinct programmatic decisions may be made as a result of this EIS:

- Whether to build new tritium production facilities.
- The number of new facilities to build.
- The level of tritium production capacity to provide.
- The schedule for providing new tritium production capacity.

The evaluation of these programmatic alternatives is summarized in the sections below.

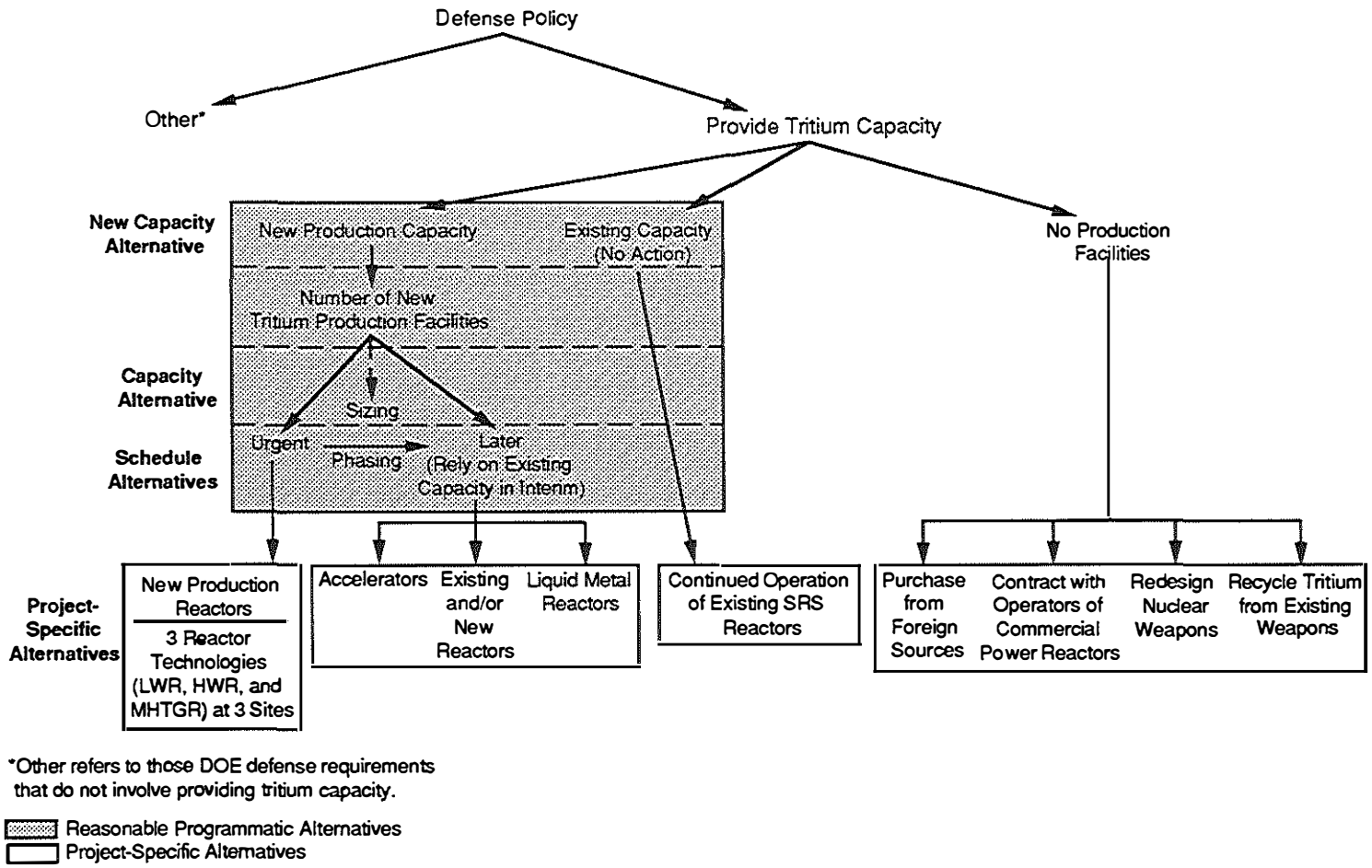

FIGURE S.2 Programmatic Alternatives Regarding Tritium Production for National Defense Requirements

S.2.1 Whether to Build New Tritium Production Facilities

The reasonable alternatives for DOE's proposed action are to either (1) rely on existing tritium production capacity, which consists of reactors at the Savannah River Site (SRS) in South Carolina, or (2) provide new production capacity. A third option, to obtain tritium from elsewhere, without relying on DOE production facilities, is not a reasonable alternative on an urgent schedule, for a variety of reasons:

- Purchase of tritium from foreign sources is contrary to national security policy because DOE could not reliably ensure that it could fulfill its statutory obligations under the Atomic Energy Act.

- The production of nuclear material for defense purposes by commercial power reactors licensed by the U.S. Nuclear Regulatory Commission would be contrary to the long-standing national policy to separate commercial nuclear power generation from the nuclear weapons program.

- Tritium from existing weapons is presently recycled, but reliance on recycling alone would diminish the supply of tritium at a rate of 5.5% per year.

The DOE weapons laboratories are continuing to explore the design of low-tritium weapon technology. However, a long-term capacity to supply new tritium would still be needed to maintain low-tritium weapons.

The alternative of reliance on existing tritium production capacity at SRS has been evaluated in an EIS for continued operations of the K, L, and P reactors at SRS. These reactors were designed and built in the 1950s and are expected to require more maintenance as they age, providing considerable uncertainty about the length of time they can be prudently relied upon to meet the nation's future requirements for tritium production.

New production capacity could be provided in or about the year 2000 by thermal fission reactors that would provide assurance of a level of safety that meets or exceeds that afforded the public by modern commercial nuclear power plants. New production facilities would also provide an ensured, reliable source of tritium well into the 21st century, and they would give DOE a greater ability to meet tritium production requirements than the Department now has or would have if it continued to rely on the SRS reactors.

S.2.2 Number of New Tritium Production Facilities

One programmatic issue is whether to site, construct, and operate more than one new tritium production facility. The analyses in this EIS support a decision to build one or more NPRs. However, these analyses do not support locating more than one NPR at a particular site.

S.2.3 Level of Tritium Production Capacity

This NPR EIS addresses the alternatives for long-term tritium production capacity, but it does not address specific requirements for quantities of tritium produced. With regard to the programmatic evaluation of various capacity alternatives, the environmental analysis presented in this EIS is intended to be bounding, based on consideration of the reasonably foreseeable long-term tritiun production capacity that may be required well into the 21st century. A capacity equivalent to that of about a 3,000-megawatt (thermal) heavy-water reactor was assumed as a reference basis for analysis in this EIS. The selection of this capacity as a reference does not impose a requirement that production facilities of this particular capacity be chosen. A decision to build smaller-capacity facilities, or to operate facilities at a lower capacity, is not precluded.

The construction of a smaller-capacity NPR complex would not result in any major changes in work-force, material, or land requirements, with one exception: if blowdown water from wet cooling towers were discharged to evaporation ponds at an NPR site, a smaller-capacity NPR would result in a proportionately smaller land requirement for those ponds. The containment building for a smaller-capacity reactor would be the same as for the reactor size analyzed in the EIS. Thus, construction impacts for smaller facilities would be similar to those for the facility sizes analyzed here. The impacts of operations on air and water quality and socioeconomics for a smaller-capacity NPR would also be similar to those for the full-scale facility. A smaller-capacity NPR complex would also result in a proportional reduction in spent fuel generation and in the radioactive releases from normal operations and postulated nonsevere accidents.

S.2.4 Schedule for Providing New Tritium Production Capacity

There are three programmatic alternatives related to when new tritium production capacity would be provided: on an urgent schedule (in or about the year 2000), on a later schedule (more than a few years beyond the year 2000), or on a schedule that provided some capacity in or about the year 2000 and some capacity later. The assessment of the schedule for providing new tritium production capacity has a direct relationship to the evaluation of the technologies that could be used in achieving that schedule.

Future tritium production capacity provided on a later schedule might be based on the use of new and innovative technologies, such as liquid-metal fast reactors or accelerators. Liquid-metal reactors would not be available on an urgent schedule because they would require development of the target materials needed to produce tritium. Liquid-metal reactor designs, which are based on a modular concept, could include inherent safety features that offer potentially significant advancements in safety over current commercial reactors. As with other reactor technologies, the most significant environmental concern associated with liquid-metal reactors is the generation of radioactive materials, including effluents and wastes, that require environmentally sound management. Construction and operation of a liquid-metal reactor would be expected to have environmental effects similar to those of the reactor technologies examined in the NPR EIS.

Instead of a reactor, an accelerator could be used to produce tritium later than the year 2000. When used to produce only tritium, this type of accelerator could provide important safety and environmental advantages compared to a reactor. These advantages include the absence of uranium, plutonium, and fission-product inventories; low residual radioactivity and

heat; and low operating temperature and pressure. If production of plutonium and other isotopes were required, handling of fission products and waste would significantly offset the advantages.

One significant effect of a tritium production accelerator is related to its electric power requirement. An accelerator with tritium production capacity comparable to the reactors assessed in this EIS would require electric power comparable to the capacity of a large commercial nuclear power plant. Construction of a new electrical generating facility would thus diminish the environmental advantages of the accelerator (a smaller-capacity accelerator would require a smaller-capacity electrical generating facility).

Furthermore, there is no experience with an accelerator of the size needed, nor have the needed target technologies been developed. An extensive research and development program would be required to demonstrate the feasibility of the accelerator technique and to establish that it would be a reliable source of tritium.

S.3 PROJECT-SPECIFIC ASSESSMENT

Following an evaluation of the various tritium production technologies, DOE identified three reactor technologies capable of meeting the urgent schedule of the NPR program. These three reactor concepts have, thus, been proposed as NPR alternatives:

- Heavy-water reactor (HWR).
- Light-water reactor (LWR).
- Modular high-temperature gas-cooled reactor (MHTGR).

Other tritium production technologies are not evaluated in detail because they are not considered "reasonable" alternatives. Similarly, a number of possible sites were evaluated as potential NPR locations. Three sites have been proposed as alternative locations for NPR facilities:

- The Savannah River Site (SRS), near Aiken, South Carolina.
- Idaho National Engineering Laboratory (INEL), near Idaho Falls, Idaho.
- The Hanford Site, near Richland, Washington.

All three reactor concepts being considered are based on the nuclear fission process. As shown in Figure S.3, fission occurs when an atom of fissile material (in these cases, uranium-235) in the reactor's fuel absorbs a neutron and breaks into two or more lighter atoms, called fission products. Many of these fission products are radioactive, and they eventually must be disposed of as high-level radioactive waste.

The fission process also produces a number of fast-moving neutrons, which are not readily absorbed by uranium atoms. In order to continue a chain reaction and fission, or "burn," the uranium fuel, these fast neutrons must be slowed down. The process of slowing down the fast neutrons is called "moderation," and the material used to effect the slowing process is called a fission reaction "moderator." The moderation of neutrons, and hence the requirement for a

moderator, is an essential factor in the physics of thermal reactor operation. If, on the average, somewhat more than one slow neutron is available from a previous fission for absorption by a uranium-235 nucleus, an exponentially growing chain reaction will occur, with each fission giving rise to more neutrons to produce more fissions. The process can readily be controlled by inserting neutron-absorbing materials into the reactor. This is accomplished by the use of "control rods," usually containing material that readily absorbs neutrons but does not undergo fission.

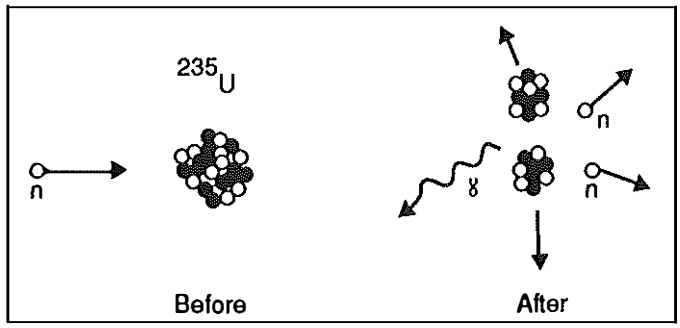

FIGURE S.3 Neutron-Induced Fission of Uranium-235

In addition to producing neutrons, the fission process produces large amounts of energy, in the form of heat that must be removed from the reactor. The material used to cool the fuel is called the primary coolant. The same material used as the moderator might also be used as the primary coolant. In commercial nuclear reactors operated by electric utilities, the heat from the fission process is harnessed to generate electric power. As noted below, two of the three proposed NPR technologies could be used to produce electric power.

In a reactor being used to produce tritium, neutrons in excess of those required to sustain the chain reaction are absorbed by another material placed into the reactor in the form of "targets." If these targets contain lithium enriched in its isotope of mass 6, the lithium-6 atoms absorb slow neutrons to produce lithium-7, which immediately splits to form an alpha particle (helium nucleus) and a tritium nucleus, as shown in Figure S.4. (If the targets contain uranium-238, the uranium-238 can absorb a neutron and decay radioactively to become plutonium-239. Thus, by loading the reactor with different targets, tritium or plutonium can be produced.)

A variety of facilities would be required to support any of the proposed reactors. These would include facilities for fabricating the reactor fuel, fabricating the lithium targets used to produce tritium, and processing those targets to extract the tritium after they had been irradiated in the reactor. (If the reactor were used to produce weapons-grade plutonium, fabrication and processing facilities for plutonium targets would be required.)

In addition to facilities to fabricate and process fuel and targets, NPR operations would require office space; utility services; waste treatment and disposal systems; heat-dissipation systems; cooling towers; and, in the case of the HWR, a heavy-water processing facility. The impacts of building and operating these facilities are included in the EIS analyses. Some of the above facilities already exist at some of the locations proposed as NPR sites, or their function could be carried out in existing facilities at the proposed sites. Some of these existing facilities might need to be modified or eventually replaced over the life of the NPR program; however, such measures would also be required under the no-action alternative.

The no-action alternative assumes continued reliance on the existing tritium production capacity at SRS. In the NPR EIS, the analysis of the consequences of no action and the description of baseline environmental conditions assume that the K, L, and P reactors at SRS

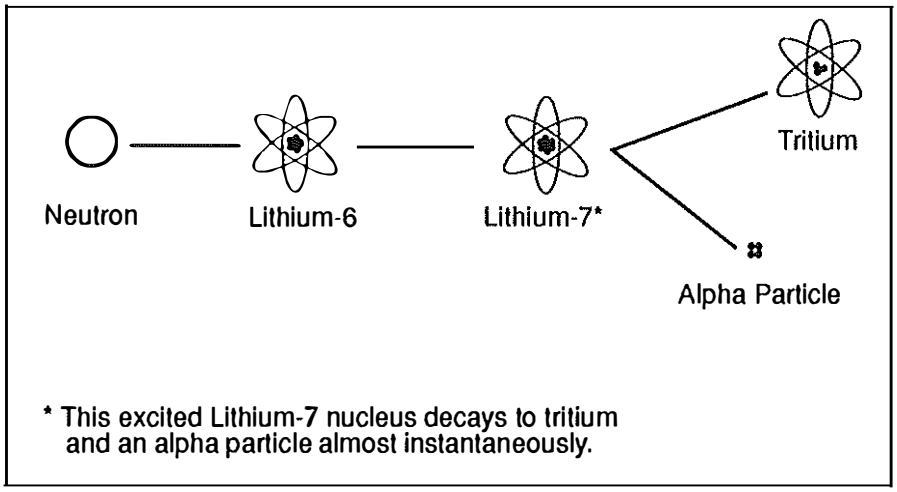

FIGURE S.4 Tritium Production

continue to operate at full capacity until 2040, as evaluated in DOE's "continued operations" EIS. The recent Record of Decision for continued operations of the existing production reactors at SRS selected continued operation of K Reactor and L Reactor and placement of P Reactor on cold standby. Therefore, this EIS identifies cases in which a three-reactor baseline is not appropriate as a bounding case and qualifies the analysis.

S.3.1 Alternative Reactor Designs

Nuclear reactors are classified in part by the kind of material used to moderate the chain reaction and cool the fuel. The three reactor types that are NPR alternatives are described briefly below:

- *Heavy-water reactor.* The HWR uses "heavy" water (deuterium oxide)* both as the moderator and the primary coolant. It operates at relatively low temperature and pressure. This type of reactor has been used by DOE for more than 30 years to produce both tritium and plutonium at SRS. While the heavy-water NPR would use the fuel and target technology developed and employed at SRS over this period, it would have advanced safety features reflecting the lessons learned from production and commercial reactors.

- *Light-water reactor.* The LWR uses ordinary (light) water as both the moderator and the coolant. With more than 100 operating reactors, this is the most common type of reactor used in the United States to generate

*Deuterium is a form of hydrogen. A deuterium atom contains a proton and a neutron in its nucleus, whereas the nucleus of a normal hydrogen atom contains only a proton. A deuterium atom is thus about twice as heavy as a regular hydrogen atom. Chemically, deuterium is essentially the same as hydrogen, so two deuterium atoms combine with one oxygen atom to form heavy water (D_2O), just as two hydrogen atoms combine with one oxygen atom to form ordinary "light" water (H_2O).

electricity. While an LWR has never been used in the United States to produce tritium or plutonium, there is an extensive industry base to support this technology.

- *Modular high-temperature gas-cooled reactor.* A high-temperature gas-cooled reactor (HTGR) uses graphite as the moderator and helium gas as the coolant; an MHTGR is a small version of this reactor. Six or eight MHTGR modules (depending on the module design size) would provide the same tritium production capacity as the proposed HWR or LWR. One large HTGR and several smaller MHTGRs have been built and operated to produce electricity. While never used to produce tritium or plutonium, the MHTGR is one of the latest reactor technologies and has advanced safety features and a modular design that reduces the size of the reactor core.

As discussed previously, the reactors require support facilities to fabricate their fuels and targets, recover tritium from the targets, process wastes, and store spent reactor fuel. The alternative NPR designs would require different support facilities at the alternative sites, depending on the capabilities of the existing site facilities to meet the particular reactor support requirements. The impacts addressed in this EIS include those of the new and existing support facilities associated with each reactor type as well as those associated with the reactor itself.

The LWR and MHTGR operate at fairly high temperatures and coolant pressures and could economically generate electricity in addition to producing tritium. On the other hand, HWRs that produce tritium operate at fairly low temperature and pressure and cannot economically generate electricity. Although the proposed action does not include the use of the NPR facilities to generate electricity for commercial use, this EIS does discuss impacts associated with providing the on-site capability to generate electricity. If a decision were made in the future to use NPR facilities for commercial generation of electricity, additional NEPA documentation could be required in conjunction with transmission line locations.

Current plans indicate that an HWR could be available for use as a new production reactor in 2000 at SRS and in 2002 at Hanford and INEL. An LWR alternative at Hanford could be completed in 1997, but at other sites the date would be 2000 (SRS) or 2001 (INEL). The first module of an MHTGR could be completed in 1999, with subsequent modules being completed in six- to nine-month intervals thereafter. If required, the MHTGR schedule might be accelerated by building modules concurrently; the impact analysis assumes that modules would be built concurrently.

S.3.2 Alternative Sites

The DOE initially considered 13 possible locations for the NPR but narrowed the alternative sites to Hanford, INEL, and SRS before preparing the EIS. The NPR EIS scoping process did not identify any additional sites for consideration. The three alternative locations are all DOE-owned, contractor-operated sites; they were selected because they are large and relatively isolated, they already contain some of the reactor support facilities that would be required, and they have staffs trained and experienced in reactor construction and operation.

S.4 AFFECTED ENVIRONMENT

The EIS describes the environments that would be affected by building and operating NPR complexes at each of the three alternative sites. Figures S.5-S.10 show the locations of Hanford, INEL, and SRS within the states of Washington, Idaho, and South Carolina as well as the proposed locations of NPR facilities at each site.

For the proposed sites, existing conditions in the following areas are described in the EIS: geology; air resources; water resources; land use, recreation, and visual environment; biotic resources; cultural resources; environmental radiation sources and exposure; socioeconomics; transportation; and waste management. Appropriate extracts from these descriptions are included in the following summary of environmental consequences.

S.5 ENVIRONMENTAL CONSEQUENCES

The EIS describes the consequences of building and operating NPR complexes based on each of the three alternative technologies at each of the three alternative sites. The following summary of consequences is organized by environmental resource, following the organization of the EIS. Additional numerical estimates for certain types of impacts are given in Section S.6 (in Table S.1).

All of the analyses of potential NPR consequences are based on generic designs of the NPR facilities. Therefore, calculations and estimates of consequences are based on conservative assumptions about detailed designs. Because the design assumptions are conservative, the consequences projected in the EIS are expected to be equal to or greater than those that would actually be experienced during NPR construction and operation.

S.5.1 Impacts to Air Resources and Noise Levels

During the peak NPR construction period, concentrations of total suspended particulates (TSP) would be expected to exceed 24-hour ambient TSP standards, and it might be necessary to control fugitive dust by watering construction areas, construction roads, and spoil piles, particularly at Hanford and INEL during dry periods of the year. However, no construction dust would be expected to reach site boundaries under any circumstances.

Neither construction nor operational emissions of regulated air pollutants from NPR facilities would exceed national ambient air quality standards, and all emissions would be less than the applicable maximum allowable Prevention of Significant Deterioration increments. During NPR operations, water drift emissions from reactor cooling towers would result in some salt deposition on the ground below the clouds of water vapor (called "plumes"). Possible effects of this deposition on plant life are discussed in Section S.5.4. The plumes could also cause fogging or icing on nearby on-site roads on rare occasions (a few times per year).

Emissions of radioactivity to the atmosphere during normal operations would be well below regulatory limits (see Section S.5.6). The impacts of possible releases of radioactive material or hazardous chemicals to the air as a result of postulated accidents are discussed in Sections S.5.6 and S.5.7.

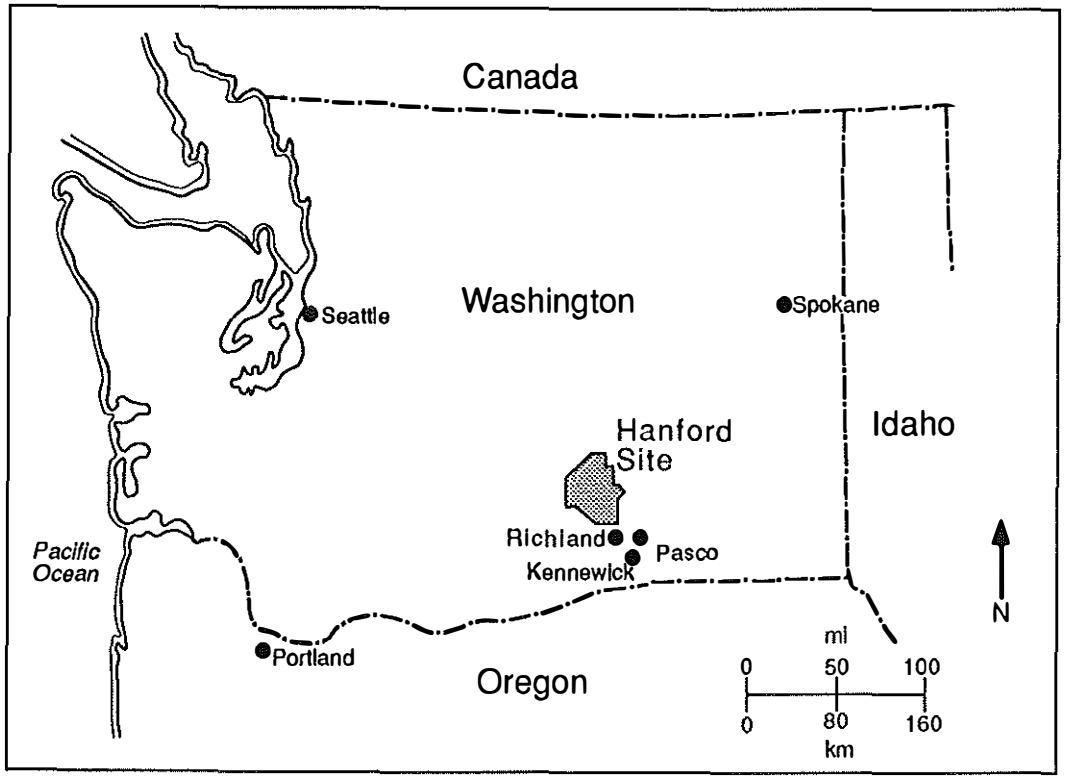

FIGURE S.5 Location of the Hanford Site

During construction of NPR facilities, vehicles used for activities such as excavation, earthmoving, and concrete handling would generate considerable on-site noise at each of the proposed sites. Noise sources during NPR operations would include cooling towers, diesel generators, transformers, pumps, and fans. Neither construction nor operations activities would raise noise levels at site boundaries sufficiently to cause any individual annoyance or community reaction. Vibrations from any blasting that might be required would be kept well below a level that might damage buildings or sites.

S.5.2 Impacts to Water Resources

Water requirements for both construction and operation of all NPR technologies at all sites are large, particularly for operations. Large quantities of water would be needed to absorb and carry away heat from the operating reactors. The water, warmed in the process and containing small but measurable concentrations of tritium, would be transferred to cooling towers where its heat would be dissipated to the atmosphere before the water was reused to cool the reactor.

At Hanford and SRS, water would be withdrawn from the Columbia and Savannah rivers, respectively. Water withdrawals for NPR operations, although large, would be below the limits of measurability (less than 5%), even when river flows were at their minimum.

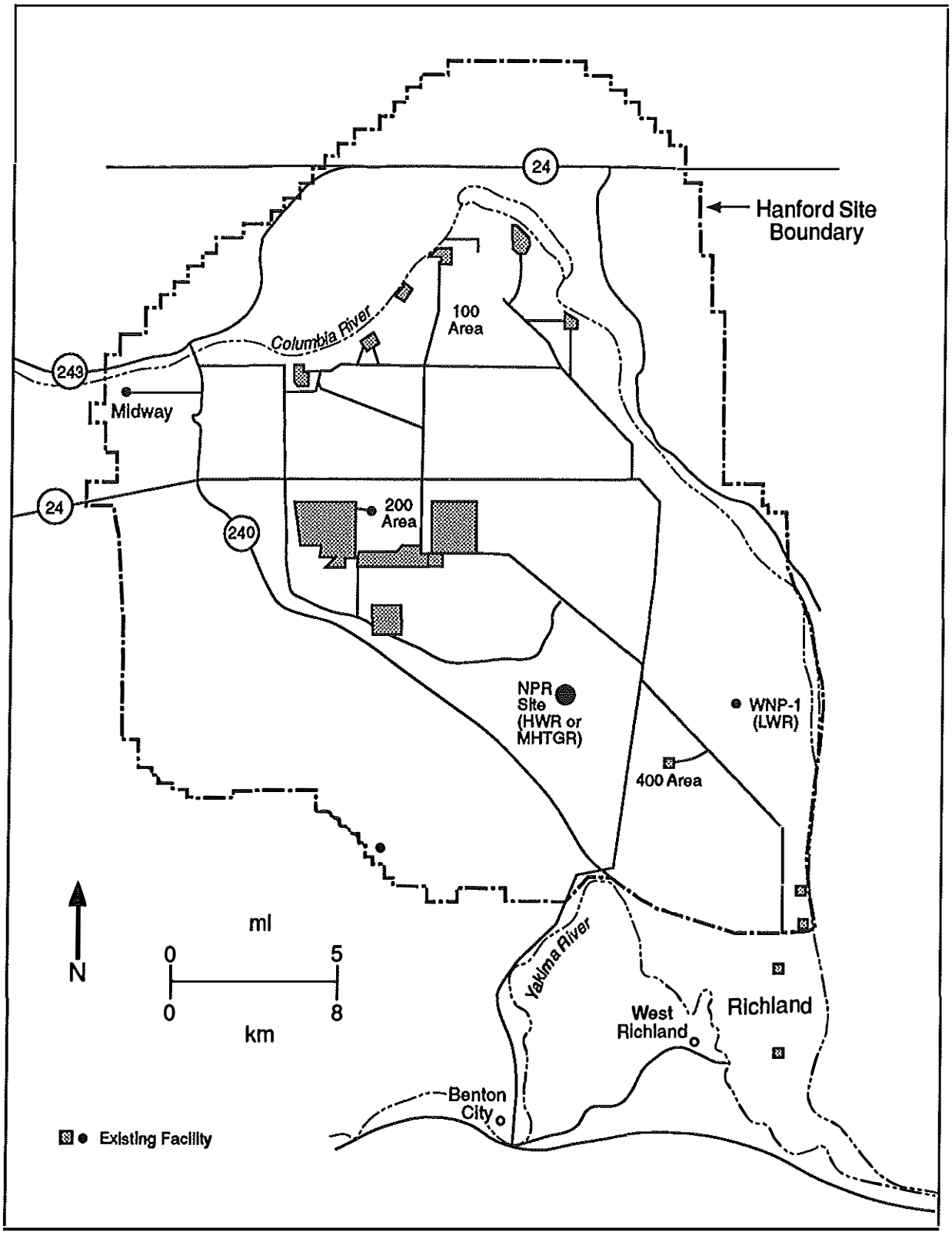

FIGURE S.6 Location of Proposed NPR Sites at Hanford

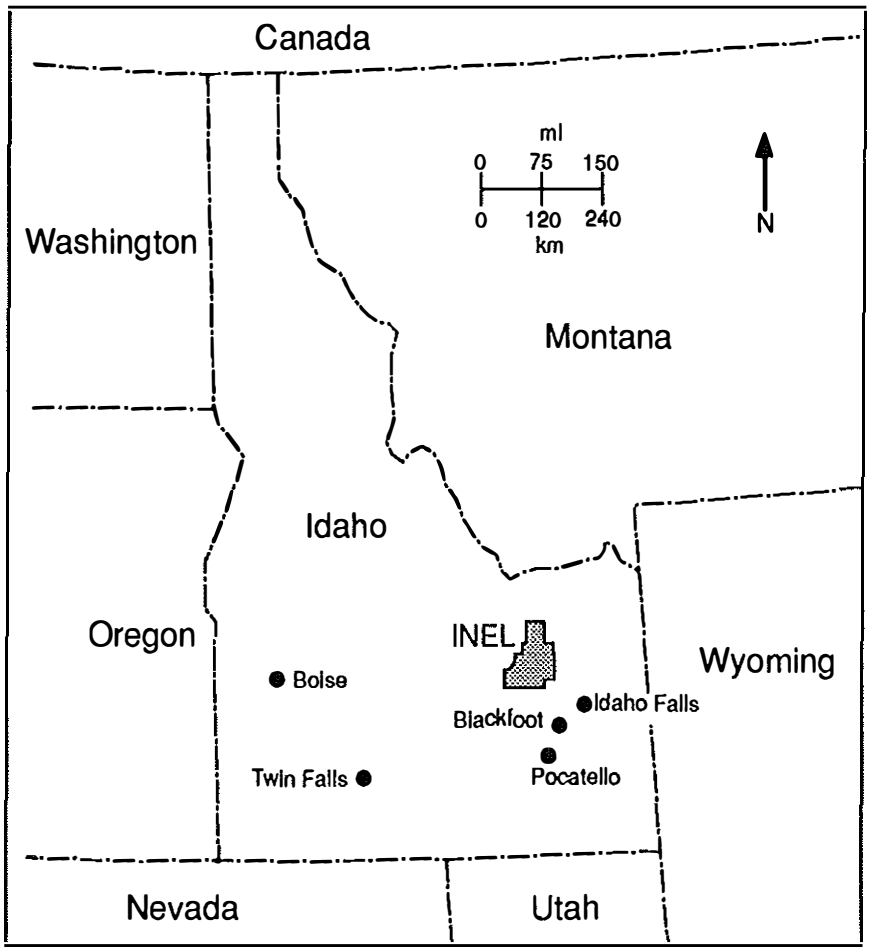

FIGURE S.7 Location of Idaho National Engineering Laboratory

At INEL, water would be withdrawn from the underground Snake River Plain aquifer. The INEL water withdrawal right has historically been 43 million cubic meters per year (m^3/yr). The LWR and HWR each would require 44-45 million m^3/yr of water for operations. This usage, along with existing INEL loads of 7.9 million m^3/yr, would exceed limits set by INEL's present water withdrawal rights permit from the State of Idaho. Thus, an increase of about 25% in water withdrawal rights would be required for operation of the HWR or LWR at INEL. As a result of informal discussions with the State of Idaho, DOE anticipates that such an increase would be granted from water right reserves available to the state to support industrial and commercial development. 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 or mechanical blowdown evaporators instead of wet towers would essentially eliminate the need for a large volume of makeup water and would keep water requirements within the existing INEL water withdrawal rights allocation. Calculations indicate that total INEL pumping at a rate of 44 million m^3/yr for 50 years would cause less than a 0.1-meter (m) decline in the water table at the nearest off-site springs, which are located about 130 kilometers (km) from the site, near Hagerman, Idaho.

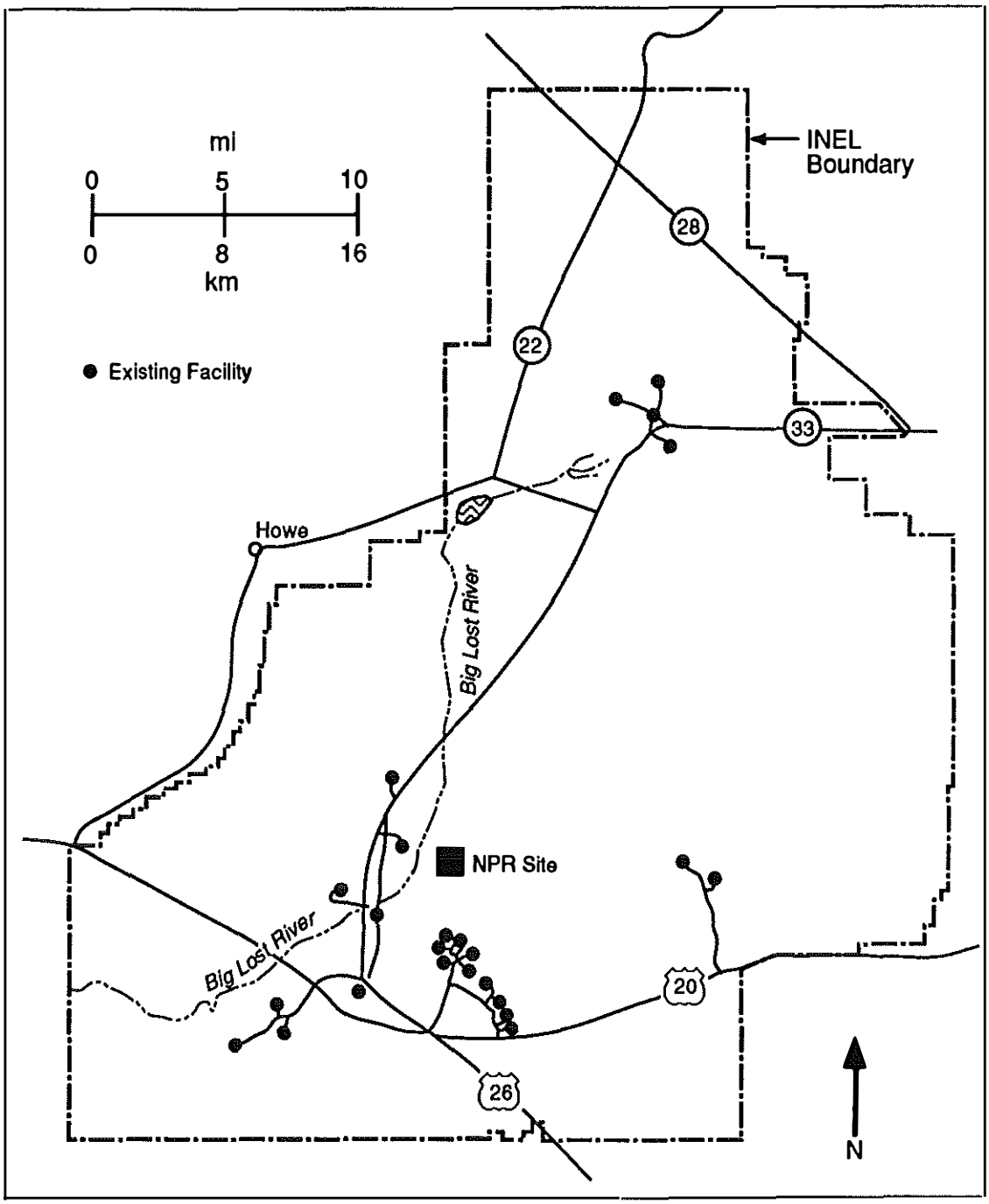

FIGURE S.8 Location of Proposed NPR Site at INEL

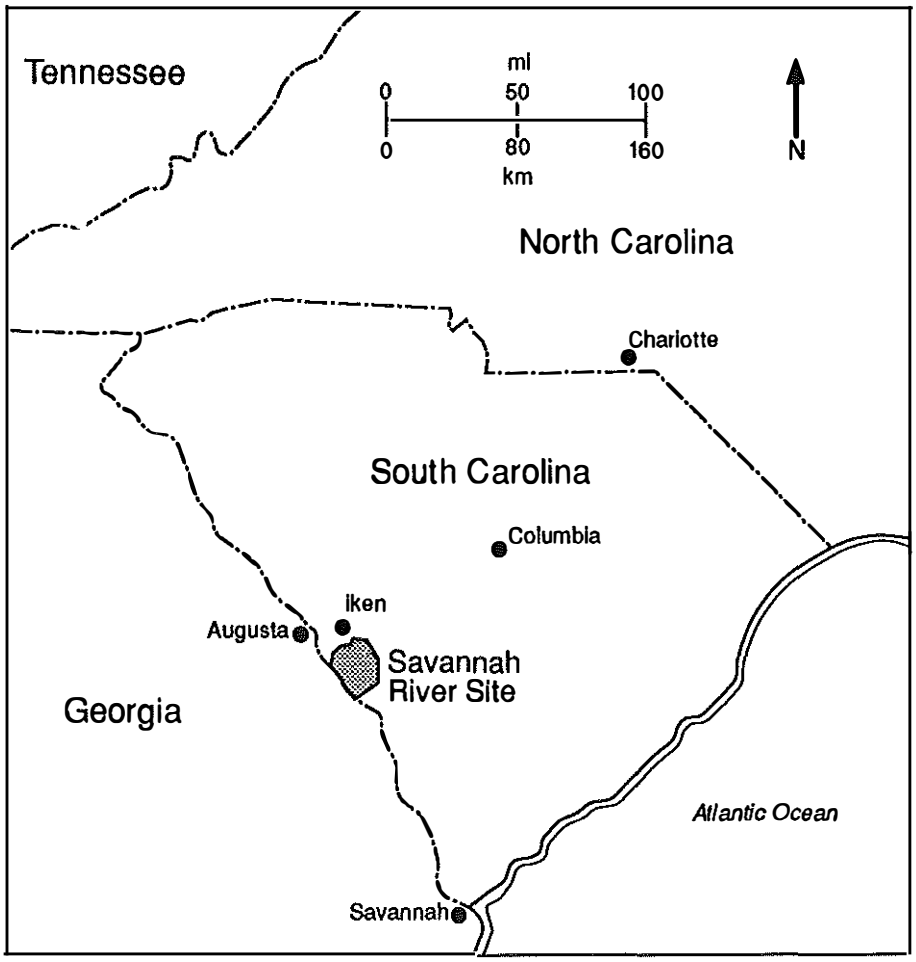

FIGURE S.9 Location of the Savannah River Site

For all technologies, cooling tower blowdown water would be returned directly to the Columbia River from Hanford and to an on-site tributary of the Savannah River from SRS. At INEL, cooling tower blowdown water would be discharged to evaporation ponds.

At Hanford, the water discharged to the Columbia River would contain tritium, other radioactive contaminants, chemical contaminants, and thermal energy (heat). The concentrations of all contaminants would be below applicable regulatory limits. The tritium concentration would rapidly be diluted by the Columbia River so that the concentration at the Richland, Washington, monitoring site would be approximately 20 picocuries per liter (pCi/L) from all sources, which is well below the U.S. Environmental Protection Agency's drinking water standard of 20,000 pCi/L. Thermal and other chemical components in the discharge would also be rapidly diluted by river water.

The effects of dissolved contaminants and thermal discharge on water quality in the Columbia River can be estimated based on monitoring data from the existing commercial reactor operations at the Washington Public Power Supply System's Nuclear Power Project Number 2 (WNP-2) at Hanford. The chemical and thermal character of the Columbia River in the vicinity

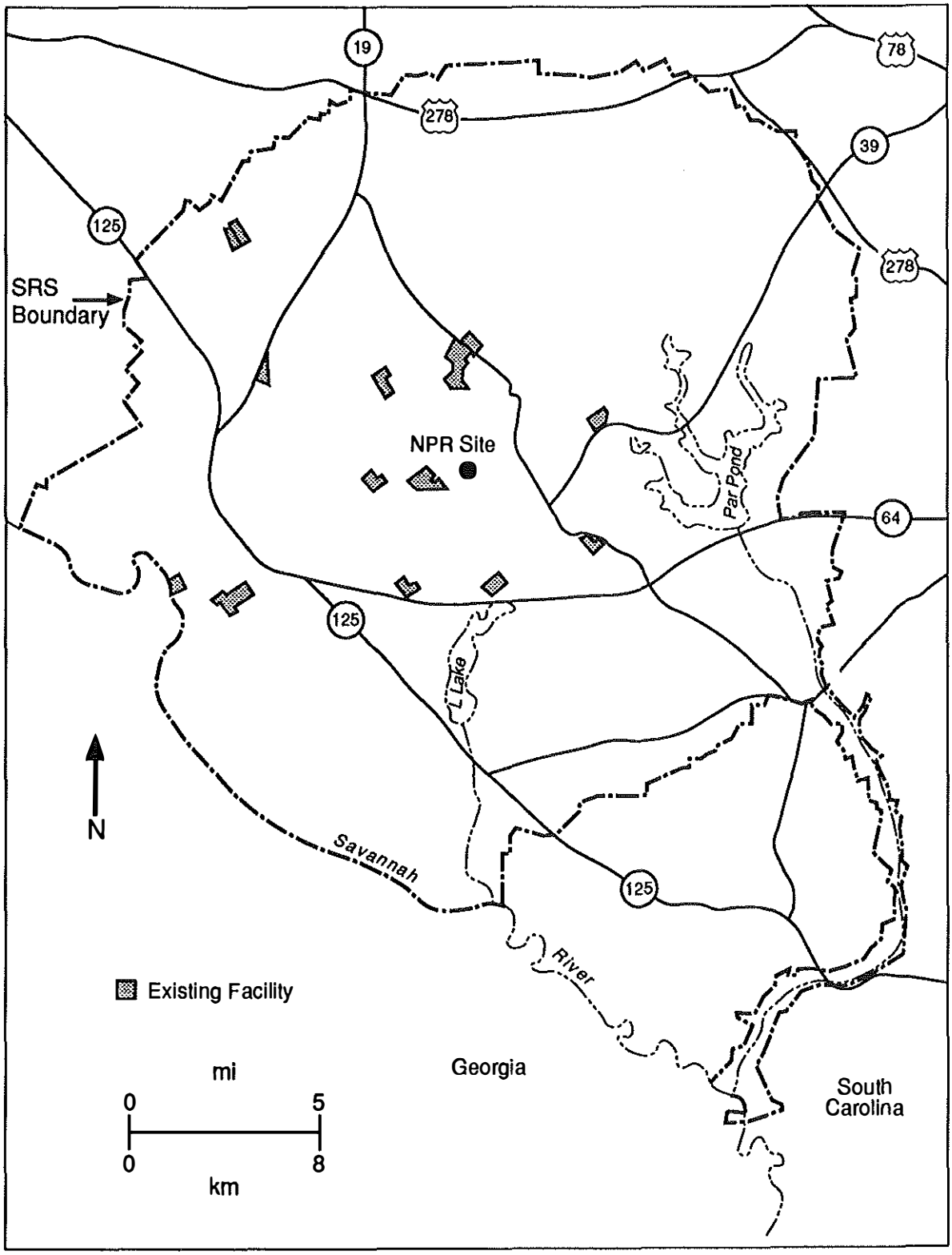

FIGURE S.10 Location of Proposed NPR Site at SRS

of the WNP-2 discharge location has been monitored since 1983. Data from 1988 indicate that at a point 90 m downstream from the WNP-2 discharge, no significant differences in the chemical and thermal character of the river could be detected.

At SRS, cooling tower blowdown water from NPR operations would be returned to the Savannah River through Fourmile Branch (a tributary located on SRS). During cooler months of the year, the water returned to Fourmile Branch would be at a temperature as much as 7 degrees Celsius (°C) above ambient water temperature. This would exceed the 2.8°C temperature differential permitted in these waters under the Clean Water Act. If appropriate mitigations were not available, a "Section 316(a) determination"* would be necessary. The quantities of any chemical or radioactive pollutants discharged to Fourmile Branch from NPR operations would be in full compliance with applicable regulatory limits.

At INEL, the blowdown water from NPR wet cooling towers would be discharged to one or more evaporation ponds, occupying 670-855 ha, that would be constructed on-site for this purpose. The ponds would be lined to minimize seepage into the ground. Tritium levels in the ponds would exceed the U.S. Environmental Protection Agency's limits for drinking water, and the ponds would have to be protected from local or migratory animal usage by netting, fencing, or other methods. Since there would be no direct discharge to streams, there would be no effect on surface waters in the vicinity of INEL. Because of the environmental impacts of the ponds, the use of dry cooling towers or mechanical blowdown evaporators, which either reduce or do not produce blowdown water, is proposed as a possible mitigation measure.

At INEL and SRS, some tritium-contaminated water would be stored in lined ponds. The EIS analysis indicates that even if pond linings failed under extremely unlikely conditions, such as a severe earthquake, there would be no significant aquifer contamination.

At SRS, construction of the MHTGR would require excavation and installation of below-grade reactor vessels. These would extend to a depth of approximately 40 m, which is some 31 m below the water table at the NPR site. The MHTGR vessels would not extend below the base of this unconfined aquifer. In order to prevent groundwater from flooding the excavation for an MHTGR, a recirculating freezing-brine slurry technology might be required. This technique has been proven to be feasible. Engineering designs are not yet well enough established to evaluate hydrologic impacts and measures to minimize or eliminate any impacts.

At Hanford, water intake, water discharge, and pumphouse structures for the HWR and MHTGR would be constructed in the Columbia River floodplain. These structures would not be flow impediments in the event of a flood. However, construction would require a permit from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act.

S.5.3 Impacts to Land Use, Recreation, and Visual Environment

While areas that would be disturbed by new facilities can be identified, other potential impacts on land use, recreation, and visual environment are not readily quantifiable. Each of

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*As specified in Section 316(a) of the Clean Water Act, such a determination involves a study of existing biological species and their survival characteristics under the specific modified environmental conditions expected, in order to ascertain whether such modified conditions would continue to maintain a balanced biological community.

the alternative NPR sites is already dedicated to purposes similar to those of the NPR; thus the NPR would not constitute any significant change in land use. Each has restricted public access and is not normally available for public recreation. Each already has facilities similar, both in function and in appearance, to proposed NPR facilities. Except for the Washington Public Power Supply System's Nuclear Power Project Number 1 (WNP-1) at Hanford, the existing facilities at all three sites are relatively isolated from public view because of the large land areas occupied by the sites.

Construction and operation of the NPR complex at any of the alternate sites would bring an influx of workers to the area, as discussed in Section S.5.8. Generally, adequate opportunities for public recreation exist near each site to accommodate the potential recreational requirements of in-migrating workers and their families.

Construction activities associated with the NPR complex would not cause any adverse visual impacts for the general public, since such activities would be well within site boundaries and not readily visible to the public. During operations, NPR cooling towers would produce plumes of vapor that at times might be visible for considerable distances, depending on atmospheric conditions. Cooling towers producing plumes already exist at each of the sites, so the proposed new facilities would not represent a significant change from current conditions. However, plumes from evaporative (wet) NPR cooling towers at INEL would occasionally be visible from Craters of the Moon National Monument, a Class I visual area.

S.5.4 Impacts to Biotic Resources

Assessments of impacts to biotic resources considered the potential effects of NPR construction or operation on any animals or plants. Federal laws protect wetlands as well as threatened and endangered species of plants and animals. Therefore, special attention is given to determining whether construction or operation of NPR facilities might encroach on or damage wetlands or any habitat (or potential habitat) for threatened and endangered species. Consistent with DOE policy, appropriate mitigations would be applied to ensure no net loss of wetlands.

At all sites, for all technologies, some habitat for native animal and plant species would be lost at the construction sites. Smaller, less mobile animals and local plants would be destroyed by the construction activity. This loss would not be expected to be significant in terms of the local populations since the local species are typically widespread throughout the sites and would be naturally replenished. The following sections discuss additional impacts for specific biotic resources.

Terrestrial Resources

The area that would be disturbed by construction of NPR facilities at both Hanford and INEL consists of shrub-steppe habitat, supporting plants such as sagebrush and various grasses. At SRS, the affected area consists primarily of loblolly and slash pine forest. Areas dedicated for the life of the project for any of the NPR technologies would total 270-300 hectares (ha), where a hectare is equivalent to approximately 2.5 acres, at Hanford; 150-170 ha at SRS; and 800-1,150 ha at INEL. The relatively large areas at INEL are due to the evaporation ponds that would be required for all of the reactor technologies with wet cooling towers. If dry cooling towers or mechanical blowdown evaporators were used, total dedicated areas would be about 130-325 ha.

During operations, some local salt deposition from cooling tower plumes would occur. This deposition would diminish rapidly with distance from the source. At 1 km from the cooling towers, the estimated maximum deposition would be 0.59 kilogram per hectare per month (kg/ha·mo) at Hanford, 0.16 kg/ha·mo at INEL, and 0.26 kg/ha·mo at SRS. These estimates are well below the 17.1 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.

Aquatic Resources

At Hanford, cooling water taken from the Columbia River would be returned to the river after use. During construction of intake and discharge structures for the HWR and MHTGR technologies, some habitat in the Columbia River would be disturbed (the necessary structures for LWR operations already exist). During operation of any of the reactor technologies at Hanford, some minnows, suckers, and mountain whitefish would be lost due to entrainment and impingement on intake screens. Because the intakes are located deep in the main stream of the Columbia River, salmonid species, which tend to frequent shallows, would not be affected.

For all reactor technologies at Hanford, water would be discharged to the Columbia River at a temperature some 9.4-10.9°C above ambient river temperature, resulting in a thermal plume (an area of the river warmed) extending some 90 m downstream of the discharge point. However, the plume would be expected to be narrow enough relative to the width of the river that fish could easily swim around it. Estimated amounts of radioactivity in the plume of discharged water would result in doses to fish calculated to be less than 1 millirad per day (mrad/day), which would be well below the limit of 1,000 mrad/day established in DOE Order 5400.5 for the protection of native aquatic organisms.

Since at INEL water would be taken from wells and discharged as surface water, there would be no effects on aquatic life from any of the NPR technologies at that site. The evaporation ponds for cooling tower blowdown would need to be screened or netted to prevent use by local or migratory animals. Use of dry cooling towers, which do not produce blowdown water, or mechanical blowdown evaporators is proposed as a mitigation measure.

At SRS, for all reactor technologies, water would be taken from the Savannah River and returned to the river via its Fourmile Branch tributary. No new intake or discharge structures would be required at SRS. Fish, larvae, and eggs would be lost through entrainment and impingement at intake structures. Estimates indicate that approximately 1,000 fish, 2-3 million fish larvae, and 1-1.5 million fish eggs would be lost annually due to NPR operations. The discharge water from NPR operations to Fourmile Branch would be 2.8-7°C warmer than the ambient water temperature during the cooler months of each year. If appropriate mitigation measures were not available, a Section 316a Determination might be necessary. Estimated amounts of radioactivity in the discharge water would result in doses to fish calculated to be less than 1 mrad/day, which would be well below the limit of 1,000 mrad/day established by DOE.

Wetlands

At Hanford, the LWR technology would not result in any disturbance of wetlands, since the WNP-1 structures already exist. Some 0.25 ha of wetlands could be temporarily disturbed by construction of water intake and discharge structures along the Columbia River for the HWR

and MHTGR technologies. At INEL, no wetlands would be disturbed by either construction or operations. At SRS, there is a potential for impacting about 8 ha of wetlands; however, impacts could probably be avoided by design. If the impacts could not be avoided by design, mitigative measures would be taken after consultation with the U.S. Army Corps of Engineers. DOE policy is that no net loss of wetlands would result from construction of DOE facilities.

Threatened and Endangered Species

A biological assessment that describes the impacts for Federally listed species has been developed for each site and submitted to the U.S. Fish and Wildlife Service (FWS). As required by applicable regulations, a conservation plan would be developed in consultation with the FWS.

At Hanford, the LWR technology would rely on existing WNP-1 facilities and would not result in any disturbance to threatened or endangered species. For the HWR and MHTGR technologies at Hanford, there could be some disturbance of bald eagles because of destruction of potential perching sites during the construction of the pumphouse and intake structures on the Columbia River. For the HWR and MHTGR, some nesting and foraging habitat could be destroyed on the NPR site and some potential nest sites could be destroyed for the following Federal Category 2 species (a Federal Category 2 species is one which, by virtue of its population, is of special concern and is being considered for listing as a threatened species): long-billed curlew, Swainson's hawk, and ferruginous hawk. For the following Federal Category 2 species, some individuals and habitat could be destroyed during construction of the pumphouse and intake structures along the Columbia River: giant Columbia River limpet, giant Columbia River spire snail, and Columbia yellowcress; however, the disturbed areas should be recolonized after the disturbance. Some habitat for two state endangered species, sandhill crane and white pelican, could be disturbed by construction.

At INEL, for all technologies, there could be some attraction of the following species to the evaporation pond(s), where they could be exposed to contaminants, including radionuclides: bald eagle, peregrine falcon (Federal endangered), Townsend's western big-eared bat (Federal Category 2), and white-faced ibis (protected species designated as a "special concern" in the state). For these reasons, the ponds would need to be screened or netted to prevent use by local or migratory animals. Use of dry cooling towers, which do not produce blowdown, or mechanical blowdown evaporators is proposed as a mitigation measure. There would be some destruction of foraging habitat and potential destruction of nesting habitat on the NPR site for Swainson's hawk, ferruginous hawk (Federal Category 2), burrowing owl, and bobcat (state special concern). Any necessary mitigations would be developed in the conservation plan in consultation with the FWS. There could be some destruction of individuals and habitat on the NPR site for oxytheca (state special concern).

At SRS, for all technologies, there would be a potential impact during construction if individuals of the following species were present within the construction area: Elliott's croton, crowned meadow brantis, smooth purple coneflower, swamp lobelia, nestronia, and Carolina crawfish frog (Federal Category 2). The following aquatic species could be impinged and entrained at water intake structures: bighead redhorse (Federal Category 2); Atlantic sturgeon (state threatened); and blueback herring, hickory shad, and American shad (state special concern).

S.5.5 Impacts to Cultural Resources

Cultural resources include archaeological sites, historic structures, Native American religious concerns, and paleontological localities. Federal agencies proposing actions that have the potential to adversely affect sites or structures eligible for the National Register of Historic Places must consult with the appropriate state historic preservation officer (SHPO) and the Advisory Council on Historic Preservation (ACHP). Potential effects to Native American religious practices and beliefs require consultation with affected tribes.

Sites and structures that have been or could be determined to be eligible for the National Register of Historic Places could be adversely affected at all three NPR sites. Impacts at Hanford probably could be avoided by design modifications. Unavoidable impacts at INEL and SRS could be mitigated through data recovery at eligible sites. Additional details concerning the precise location and size of the proposed NPR and associated facilities must be specified before impacts to particular sites and structures can be identified and any necessary mitigations proposed. The DOE is in the process of developing programmatic agreements with the SHPOs and ACHP, where necessary, and consulting affected tribes. Impacts to significant paleontological localities appear unlikely.

S.5.6 Radiological Impacts

All radiological impacts from normal (incident-free) operations of the NPR and associated activities at all of the proposed sites have been determined to be within applicable Federal guidelines and standards. Since calculated impacts are based on conservative assumptions, the results are considered to indicate an upper bound on impacts. All activities would be subject to the "as low as reasonably achievable" principle, as stipulated under DOE Orders 5480.11 and 5400.5, which would tend to reduce the exposures to workers and the general public to levels below the estimates in the EIS. Radiological impacts at the three sites differ somewhat, primarily due to variations in population size, population distribution, and meteorological conditions.

During normal operations, the radioactive releases from NPR facilities would be comparable for all technologies and sites. As a result of NPR operations (all technologies), a maximally exposed member of the public would receive a radiation dose [committed effective dose equivalent (CEDE)] of no more than 0.00036 rem/yr from Hanford, 0.00012 rem/yr from INEL, and 0.00035 rem/yr from SRS. These doses, when combined with existing baseline doses at each site, would be well within the regulatory limits, which are 0.01 rem/yr for airborne releases under the Clean Air Act and 0.004 rem/yr for drinking water under the Safe Drinking Water Act.

In the bounding case accidents postulated in the EIS, differences in impacts among the three reactor technologies are considered to be minor. The bounding case accidents, evaluated for each reactor technology and its support facilities at each site, included potential "nonsevere"

and "severe" accidents.* For postulated nonsevere accidents, the highest estimated consequence per accident would not exceed 30 additional cancer fatalities over a 50-year period. 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 intake of contaminated food would reduce the estimated incremental impact to less than 1 additional cancer fatality over that 50-year 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 risk from severe accidents is no more than 0.0006 cancer fatality per year in all cases.

Differences exist among the sites in dose risks and health risks from 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 NPR site and the Federal repository for high-level wastes. However, in all cases the risks are comparable to or less than the nonradiological risks from the same transportation activities.

In the event of accidents involving reactor operations or transportation of radioactive material, effective short-term mitigation measures would be implemented to reduce the radiological impacts, according to the emergency preparedness procedures in effect at each proposed site. Long-term mitigation measures, such as land decontamination and crop interdiction, would be implemented by appropriate government authorities according to Federal guidelines, thus lowering the impacts, as noted above for food ingestion.

S.5.7 Impacts from Nonradioactive Hazardous Materials

Accidents involving storage and transportation of hazardous materials could create significant impacts to on-site workers or off-site members of the public. Releases of large amounts of ammonia or chlorine from the rupture of on-site storage tanks or from transportation accidents could require public evacuation within a radius of several kilometers from the release. Off-site response to such accidents would normally be handled by local law-enforcement agencies under local emergency plans. For any of the alternative sites, these materials would normally be transported by a public or private carrier (i.e., the vendor for the material) that would be required to operate under all local, state, and Federal regulations for transport of hazardous material.

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*The term "nonsevere accident" denotes a class of postulated accidents traditionally known as design-basis accidents (DBAs), which are accidents 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. 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.
The term "severe accident" denotes 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.

S.5.8 Socioeconomic Impacts

Socioeconomic effects in the regions near the alternative sites would be due primarily to the influx of workers needed to build and operate the NPR complex. In every case, there could be a considerable demand for housing for in-migrating workers and their families. New school classroom facilities might be required, and some additions to fire and police forces might be necessary. Although housing and classroom demand would peak during the construction period, when NPR employment would be highest, demands well above the capacity of existing facilities would continue throughout the projected NPR lifetime.

The analysis in the EIS is carried out for a "region of influence" around each of the proposed sites rather than for municipalities, since it cannot be ascertained in advance which municipalities near the sites would be preferred by in-migrating workers. In fact, the preferred locations of in-migrating families would be influenced considerably by the available housing and the quality of existing schools and public services in the various municipalities near the prospective sites.

S.5.9 Transportation Impacts

The EIS assesses the effects on existing on-site and off-site roadways from the increased population near each of the candidate sites during NPR construction and operation. During construction, these effects include additional commuter, truck, and other traffic directly related to construction.

Based on the estimated increase in on- and off-site vehicle-miles traveled due to NPR employee commuting and construction traffic, traffic fatalities would increase only slightly (see Section S.6), since the NPR-associated increase in traffic would be a small percentage of the total vehicle-miles traveled by all traffic in the site areas. The number of construction-related fatalities would be small. For all three technologies, the level of service would decline slightly due to increased traffic congestion during peak hours for State Road 240 near Hanford and for State Roads 19, 64, and 125 near SRS. There is estimated to be no impact on the level of service on highways in the vicinity of INEL.

S.5.10 Waste Management Impacts

The NPR EIS assumes that existing waste generation at each proposed site would continue at the present levels and that existing waste management facilities would be used to process NPR wastes. It also assumes the existence of a Federal disposal facility for high-level radioactive waste, a transuranic waste disposal facility, and a mixed waste disposal facility.

The analyses in this EIS indicate that, in a number of instances, existing capacities for waste treatment, storage, or disposal might need expansion to handle NPR wastes. The DOE is preparing a programmatic EIS on environmental restoration and waste management that will address strategies and policies for future operation of the Department's waste management complex. Specific decisions on new facilities to process NPR wastes may not be made until after the Record of Decision for the environmental restoration and waste management PEIS; any such facilities would have their own NEPA documentation.

S.6 COMPARISON OF ALTERNATIVES

This section compares NPR consequences for the alternative sites and technologies (see following text and Table S.1); it also summarizes and compares the programmatic alternative discussions in Section S.2 (see Table S.2).

S.6.1 Impacts to Air Resources

There are no significant differences in air quality impacts among technologies or sites. All potential releases of pollutants would be below applicable Federal, state, and local requirements. Some dust control measures might be required during construction at Hanford and INEL (or during unusually dry periods at SRS).

The only air resources consequences of possible significance are associated with the vapor plumes produced by cooling towers. Under certain meteorological conditions at Hanford and INEL, the plumes could cause some fogging or icing of on-site roads. The plumes would not degrade off-site air quality, but NPR plumes from INEL could be visible from Craters of the Moon National Monument under certain meteorological conditions.

S.6.2 Impacts to Water Resources

All three candidate sites have adequate water supplies for all NPR technologies, assuming that INEL's pumping rights from the Snake River Plain aquifer are increased by the State of Idaho. At all sites, the MHTGR would use about 25% less cooling water for operations than would either the HWR or LWR, which have about the same requirements.

At SRS, operation of existing reactors requires a flow in the Savannah River of 3.7 billion m^3/yr of water. By comparison, during 1988, which reflects the 1985-1989 drought conditions, the mean annual flow of the Savannah River at Augusta was 4.8 billion m^3/yr. At SRS, the LWR would be the largest NPR user of water, at a rate of about 38 million m^3/yr, which is less than 1% of the minimum flow in 1988.

Blowdown water from NPR cooling towers would be returned to the Columbia River at Hanford and to the Savannah River (via an on-site tributary) at SRS. Water returned to the Columbia River would contain tritium and other contaminants (all at concentrations below regulatory levels), in a thermal plume. These would dissipate to concentrations below measurable levels 90 m downstream from the discharge point. At INEL, the blowdown water from NPR cooling towers would contain tritium. The evaporation ponds proposed to hold this water could have tritium concentrations well above drinking water standards (see Section S.6.4). Alternative cooling methods could be used to avoid evaporation pond impacts and reduce cooling water requirements, as discussed in Section S.5.2.

At Hanford, a permit from the U.S. Army Corps of Engineers would be required, under Section 404 of the Clean Water Act, for construction of water intake, water discharge, and pumphouse structures for the HWR or MHTGR. At SRS, construction of the MHTGR would require excavation below the top of the water table. Various construction techniques (such as use of a recirculating brine slurry or employment of a flow diversion wall to direct groundwater

TABLE S.1 Summary and Comparison of the Consequences for Alternative NPR Sites and Technologies

Impact Type and Site	Impact Description[a]
Air Quality	Any pollutant releases would be well below national ambient air quality standards as well as state and local regulations and standards. Watering of roads and spoils piles might be necessary to control dust during construction, particularly at Hanford and INEL.
Water Resources	All sites: MHTGR would require about 25% less water for operations than would HWR or LWR.
Hanford	Water withdrawn from and returned to Columbia River without significant impact to flow rate. Permit required for construction of new cooling water system in floodplain (HWR and MHTGR only).
INEL	Water withdrawn from Snake River Plain aquifer. Increased water withdrawal rights required for HWR and LWR. Nearest off-site springs would experience less than 0.1-m drawdown from 10 yr of pumping for NPR operations. If used, evaporation ponds would contain tritium levels above U.S. EPA drinking water standard.
SRS	Water withdrawn from and returned (via Fourmile Branch tributary) to Savannah River. Section 316a determination required (under Clean Water Act) due to exceedance of temperature differential standard for Fourmile Branch. Maximum NPR withdrawal of 38 million m^3/yr is about 0.7% of average flow in 1988, a severe drought year. MHTGR construction would require special techniques for excavation below water table.
Land Use, Recreation, and Visual Environment	
Hanford	Land dedicated for life of project: HWR, 277 ha; LWR, 51 ha (299 ha total, including existing land for WNP-1); and MHTGR, 267 ha. Short-term (construction period) disturbance of land: HWR, 804 ha; LWR, 118 ha; and MHTGR, 463 ha. Cooling tower plumes sometimes visible beyond site boundary; no Class I visual areas affected.
INEL	Land dedicated for life of project: (1) with evaporation ponds -- HWR, 1,152 ha; LWR, 1,041 ha; and MHTGR, 804 ha; or (2) with dry cooling towers or mechanical blowdown evaporators – HWR, 323 ha; LWR, 186 ha; and MHTGR, 131 ha. Short-term (construction period) disturbance of land: (1) with evaporation ponds – HWR, 1,565 ha; LWR, 1,128 ha; and MHTGR, 1,203 ha; or (2) with dry cooling towers or mechanical blowdown evaporators – HWR, 737 ha; LWR, 273 ha; and MHTGR, 530 ha. Cooling tower plumes sometimes visible beyond site boundary, occasionally from Craters of the Moon National Monument, a Class I visual area.
SRS	Land dedicated for life of project: HWR, 148 ha; LWR, 170 ha; and MHTGR, 163 ha. Short-term (construction period) disturbance of land: HWR, 214 ha; LWR, 242 ha; and MHTGR, 251 ha. Cooling tower plumes sometimes visible beyond site boundary; no Class I visual areas affected.

TABLE S.1 (Cont'd)

Impact Type and Site	Impact Description
Biotic Resources	
Hanford	LWR: Little new loss of habitat (see *Land Use*), since this technology would use existing facilities, including the partially completed WNP-1 reactor. Entrainment and impingement of fish at water intakes on Columbia River but effects small because intake in deep water with high flow rate.
	HWR and MHTGR: Loss of habitat (see *Land Use*). Possible short-term disturbance to potential perching site for bald eagles. May require development of protective measures in consultation with U.S. Fish and Wildlife Service. Impingement and entrainment at water intakes on Columbia River but effects small because intake in deep water with high flow rate.
INEL	Loss of habitat (see *Land Use*). No impingement and entrainment impacts, since surface water is not used for cooling. No impacts to Federal endangered or threatened species. Exclusion of wildlife, including waterfowl, from cooling water evaporation ponds would be required. Suggested mitigation of these and other impacts by adopting dry cooling towers or mechanical blowdown evaporators.
SRS	Loss of habitat (see *Land Use*). Possible indirect impacts to small areas of bottomland hardwoods and wetlands could be avoided through proper construction techniques. Impacts from impingement and entrainment of fish, fish eggs, and larvae at existing cooling water intakes on the Savannah River (would represent 1.1 to 1.5% loss from all such organisms passing SRS). If discharged into Fourmile Branch, need Section 316(a) determination under Clean Water Act.
Cultural Resources	All sites: Disturbance of cultural sites might require mitigation by avoidance or data recovery in consultation with State Historic Preservation Officer.
Hanford	Possible disturbance of one historical site for MHTGR or HWR.
INEL	Possible disturbance of up to five archaeological sites eligible for listing on the National Register of Historic Places.
SRS	Possible disturbance of one to three archaeological sites eligible for listing on the National Register of Historic Places.

TABLE S.1 (Cont'd)

Impact Type and Site	Impact Description
Radiological Impacts	Radiation dose to maximally exposed off-site individual from 1 yr of normal NPR operations: highest value – 0.00036 rem (LWR at Hanford); lowest value -- 0.000068 rem (MHTGR at Hanford). Radiation dose to average individual from natural background: 0.3 rem. DOE regulatory standard for maximum permitted dose to average individual (not a radiation worker): 0.1 rem. Radiation dose to maximally exposed off-site individual as a result of nonsevere reactor accident: highest value -- 0.041 rem (LWR at Hanford); lowest value -- 0.003 rem (HWR at SRS). Radiation dose to population as a result of highest-consequence accident at NPR facilities: Hanford, 25,000 person-rem; INEL, 16,000 person-rem; and SRS, 5,500 person-rem. Annual radiation dose to population from natural background: Hanford, 100,000 person-rem; INEL, 80,000 person-rem; and SRS, 300,000 person-rem.
Nonradioactive Hazardous Material	All sites and technologies would have some very low probability risk related to catastrophic failure of storage vessels containing chlorine or ammonia. Large quantities of ammonia used only for MHTGR technology; releases could affect many persons at Hanford and SRS. Effects range from odor perception to mild transient health effects and impairment of ability to take protective action; no expected severe health effects or fatalities. Similarly, transportation accidents involving these materials would present a risk.

Socioeconomics

	Impact Measure	*HWR*	*LWR*	*MHTGR*
Hanford	Construction Period			
	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			
	Number of housing units	1,551	4,180	1,239
	Number of new students	711	1,913	569
	Construction duration (months)[b]	120	63	120
	Operational Period			
	Regional population increase			
	Number of people in-migrating	3,306	4,766	4,958
	Percentage increase in region of interest	2	3	3
	Incremental facilities and services			
	Number of housing units	1,114	1,605	1,670
	Number of new students	523	753	784

TABLE S.1 (Cont'd)

Impact Type and Site	Impact Description			
Socioeconomics (Cont'd)	*Impact Measure*	*HWR*	*LWR*	*MHTGR*
INEL	Construction Period			
	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			
	Number of housing units	1,963	3,304	806
	Number of new students	1,264	2,128	854
	Construction duration (months)[b]	120	111	120
	Operational Period			
	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			
	Number of housing units	1,560	1,706	2,202
	Number of new students	1,037	1,129	1,456
SRS	Construction Period			
	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			
	Number of housing units	1,060	2,251	284
	Number of new students	567	1,240	152
	Construction duration (months)[b]	102	105	120
	Operational Period			
	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			
	Number of housing units	790	1,538	1,111
	Number of new students	256	498	360
Transportation	At all sites for all technologies, some increased traffic accidents and increased traffic fatalities due to construction traffic and increased number of commuting workers.			

TABLE S.1 (Cont'd)

Impact Type and Site	Impact Description			
Waste Management		*Total NPR-generated waste[c] over life of project (m^3)*		
	Waste type	*HWR*	*LWR*	*MHTGR*
Hanford	High-level waste (no identified additional disposal requirement)	600	720	1,500
	Transuranic waste (no identified additional disposal requirement)	3,500	10,000	5,200
	Low-level waste (additional grout vault disposal required)	270,000	290,000	140,000
	Mixed and hazardous waste (additional disposal required)	47,000	44,000	17,000
INEL	High-level waste (no identified additional disposal requirement)	160	840	120
	Transuranic waste (no identified additional disposal requirement)	4,400	800	2,000
	Low-level waste (additional subsurface disposal required)	91,000	144,000	220,000
	Mixed and hazardous waste (additional interim storage capacity required)	17,000	6,400	240
SRS	High-level waste (additional interim storage capacity required)	1,200	600	1,200
	Transuranic waste (no identified additional disposal requirement)	4,400	4,400	6,000
	Low-level waste (no identified additional disposal requirement)	150,000	160,000	220,000
	Mixed and hazardous waste (additional disposal capacity required)	23,000	19,000	5,400

[a]Abbreviations used for technologies: HWR = heavy-water reactor and support facilities; MHTGR = modular high-temperature gas-cooled reactor and support facilities; LWR = light-water reactor and support facilities.

[b]Construction duration for MHTGR assumes that 8 modules would be built concurrently.

[c]These values are the largest quantities of wastes generated by either the tritium or the plutonium production mode.

TABLE S.2 Comparative Summary of Alternatives for Tritium Capacity Technology

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. 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 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 be designed with advanced safety systems, passive systems, and containment, resulting 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 needed. Technology could only be operating later than about the year 2000; thus, existing capacity would be relied on 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.
Accelerators	Reliability unproven for production of tritium. Significant R&D required to apply technology to tritium production. Uncertainties about tritium production rates. Technology could only be operating later than about the year 2000; thus, existing capacity would be relied on 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' potential safety advantages over nuclear reactors include no uranium and fission product inventory, low residual radioactivity, low operating temperature and pressure, and ease of rapid shutdown.	Accelerators' potential environmental advantages over nuclear reactors include no uranium and fission product inventory, low residential radioactivity, and low operating temperature and pressure. Accelerators also have significant environmental impact potential due to a substantial electricity requirement. If production of plutonium and other isotypes were required, handling of fission products and waste would significantly offset advantages.

around the construction area) and use of common dewatering techniques for seepage control would permit construction of the MHTGR with only minimal impact to groundwater flow in the localized area of construction.

S.6.3 Impacts to Land Use and Visual Environment

If evaporation ponds were used at INEL, land requirements would be larger there for all technologies than at Hanford and SRS. If dry cooling towers or mechanical blowdown evaporators were used, the land requirement at INEL would be reduced considerably. New land requirements for the LWR at Hanford are lower than for HWR or MHTGR since the reactor and its building (WNP-1) already exist.

At Hanford, the LWR (WNP-1) would continue to be visible from the Columbia River area (along with WNP-2). The MHTGR and HWR at Hanford would not be visible off-site. Cooling tower plumes from all technologies at all sites would occasionally be visible off-site; in particular, plumes from NPR wet cooling towers at INEL would sometimes be visible from Craters of the Moon National Monument, a Class I visual area.

S.6.4 Impacts to Biotic Resources

The total land area disturbed during both construction and operation would be significantly larger at INEL than at Hanford or SRS, for all technologies, because of the need to accommodate one or more large evaporation ponds. The EIS suggests the possible use of dry cooling towers or mechanical blowdown evaporators instead of wet cooling towers as a mitigative alternative to evaporation ponds at INEL. This would make the land area disturbed at INEL approximately similar to the areas disturbed at the other sites.

Although the following biotic impacts are not considered significant, they differ by site. At Hanford, the potential exists for the destruction of some perching sites for bald eagles during construction of a pumphouse and intake structure along the Columbia River (in the case of the HWR and MHTGR only). This impact could be mitigated by avoidance. Habitats for a number of Federal Category 2 and state endangered species could also be disturbed during construction at Hanford. Impacts would be temporary, however, and no significant long-term impacts would be expected.

At INEL, for all technologies, individuals in the categories of Federal endangered, Federal Category 2, and special concern species could be attracted to the evaporation ponds, where they could be exposed to contaminants, including radionuclides. Alternative cooling methods that would not require evaporation ponds could be used to mitigate this potential impact and are being considered. There would be some destruction of foraging habitat and potential destruction of nesting habitat for a number of Federal Category 2 species, as well as Federal and state special concern species. A conservation plan for mitigation would be developed in consultation with the U.S. Fish and Wildlife Service.

At SRS, there could be a potential impact during construction to a number of Federal Category 2 species. This would not be significant because of the small percentage of local available habitat disturbed by NPR construction and operation.

At Hanford and SRS, water intakes in the Columbia and Savannah rivers, respectively, would entrain and entrap fish eggs, larvae, and fish. At SRS, water withdrawal would amount to about 25% of that withdrawn for three existing SRS reactors operating at 100% capacity and would have a proportionate impact on the number of organisms entrapped and entrained.

S.6.5 Impacts to Cultural Resources

At Hanford, there is a potential for the water intake and discharge corridor for MHTGR and HWR to cross one of two potentially significant sites, but this could be avoided by design. A number of potentially significant sites could be disturbed at INEL for all three technologies: probabilistic estimates on the basis of the total number of sites and the area to be disturbed set the number at approximately five. At SRS, one to three sites would be potentially affected by any of the NPR alternative technologies. At each site, consultations would be held with the State Historic Preservation Officer if it appeared that there would be impacts to significant sites on the basis of detailed NPR designs, and mitigative plans would be developed.

S.6.6 Radiological Impacts

All radiological impacts from normal NPR operations would be well below regulatory limits. Radiological impacts associated with both normal operations and postulated accidents differ somewhat for different technologies at a particular site, although it should be emphasized that even the highest estimated doses to off-site personnel would be well below DOE and EPA regulatory limits and NPR safety goals. At Hanford, radiological impacts would generally, but not always, be lowest for the MHTGR, and highest for the LWR, particularly in dosages to off-site individuals. The main reason for the higher LWR impacts is that the LWR would be located closer to the site boundary (at WNP-1) than would the MHTGR or HWR. The impacts differ by as much as a factor of 20 between the MHTGR and the LWR. At INEL, the impacts differ among technologies by only a factor of 2 or 3; MHTGR impacts would still generally, but not always, be smaller than those associated with the LWR or HWR. At SRS, the situation in terms of ranges is similar to that at INEL, but generally HWR impacts are smaller than those of the LWR or MHTGR.

In terms of the same technology at different sites, there are also some differences in impacts. In the case of the HWR, impacts would generally, but not always, be smallest at INEL and largest at Hanford. In the case of the LWR, impacts would be largest at Hanford (for the reasons stated previously), but smallest at INEL for some analyses and at SRS for others. For the MHTGR, Hanford would generally, but not always, tend to have the largest impacts, while sometimes INEL and sometimes SRS impacts would be smallest.

Projected radiation doses and health risks from off-site transportation of radioactive material differ among the sites, although the risks themselves would be insignificant compared to risks from natural background radiation. The risk differences for accident-free transportation are directly related to the distance between the alternative site and the assumed radioactive waste disposal site. The risk differences for the accident cases are the result of a requirement to transport tritium from Hanford and INEL to the Savannah River Site if NPR capacity were located at either of the former two sites.

S.6.7 Impacts from Nonradioactive Hazardous Material

At all sites, for all technologies, there would be some risk related to catastrophic failure of on-site storage vessels containing hazardous materials, even though such failure would be extremely unlikely. The MHTGR technology would require large quantities of ammonia, and large amounts could be released if there were a catastrophic tank failure. Because of local population levels and distributions near Hanford and SRS, there could be serious (but not life-threatening) off-site effects. Effects would range from odor perception to mild transient health effects and impairment of ability to take protective action, depending on an individual's distance from the accident and the amount of material spilled.

S.6.8 Socioeconomic Impacts

The estimates of the required construction work force, and particularly the peak construction work force, vary significantly by site and technology. The LWR would require the largest peak construction work force, regardless of location, and the resultant in-migration could have significant impacts on housing availability and classroom demand. At Hanford, these impacts would be due primarily to a scheduled completion date of 1996, made possible by the mostly constructed status of WNP-1 at that site. The smallest effect would be from construction of the MHTGR at SRS.

The actual consequences would depend on existing conditions in the affected communities and on the ability of the communities to respond to such requirements. A socioeconomics monitoring and mitigation plan would be a suitable mechanism for tracking changes in work-force projections as NPR design and planning proceed. Such a plan would also track changing local conditions.

S.6.9 Transportation Impacts

Increased traffic due to construction and operation of any of the NPR technologies would add to existing congestion on State Road 240 near Hanford and on State Roads 19, 64, and 125 near SRS. A small number of traffic accidents would result from the increased traffic associated with NPR construction and operation, for any of the technologies at any of the sites.

S.6.10 Waste Management Impacts

The quantities and types of waste generated for alternative technologies at alternative sites differ significantly. Impacts are compared here in terms of requirements beyond present waste handling and storage capacities at the sites. DOE's environmental restoration and waste management PEIS will deal more generally with the adequacy of existing facilities and the environmental impacts of waste management at the sites.

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 EIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

At Hanford, the following additional expansion of existing facilities would be needed for NPR wastes. For both the HWR and LWR, Hanford would require some 50 new near-surface grout disposal vaults for low-level waste as well as additional mixed waste receiving and processing capacity. New long-term storage capacity would be required for all technologies. There would also be a need for an additional increase in off-site shipments of hazardous waste to a permitted disposal facility.

At SRS, the following additional expansion of existing facilities would be needed for NPR wastes. For all technologies, both the interim storage and the waste tank farm for high-level radioactive waste could require additional capacity until Federal repositories are available; additional storage capacity for mixed and hazardous waste also would be required.

At INEL, the following additional expansion of existing facilities would be needed for NPR wastes. The LWR would require additional capacity for the low-level waste liquid effluent disposal facility and process equipment waste evaporator, while the MHTGR would need additional capacity for the low-level waste experimental reduction facility. All technologies would require additional subsurface disposal area for low-level waste after 2011.

S.7 CUMULATIVE IMPACTS

Cumulative impacts are the impacts to the environment that result from the incremental impacts of a proposed 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.

This section identifies and discusses the impacts from NPR construction and operation that would be cumulative with the impacts of other activities beyond the site boundaries and beyond the control of site operations. These are (1) impacts of air pollutant emissions on global conditions, (2) loss of habitat for open-country bird species, and (3) disturbance of wetlands.

S.7.1 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, are known as "greenhouse" gases -- a reference to their ability to contribute to global warming, or the greenhouse effect. Other greenhouse gases are methane, nitrous oxide, chlorofluorocarbons, Halon-1301, 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 1.5-4.5°C has been predicted as a result of a projected doubling of the current concentrations of carbon dioxide in the atmosphere. The combined warming and thermal radiation effects of other greenhouse gases could potentially be as large as that from carbon dioxide.

Several of the chemicals that are potential contributors to global warming, as well as chloroflurocarbons, have been implicated in depletion of stratospheric ozone, a triatomic molecule of oxygen (O_3). Ozone in the stratosphere (the region 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.

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 carbon dioxide during the NPR construction period would be on the order of 10,000 metric tons per year (t/yr) from vehicles and construction equipment. Power requirements for NPR operations would be approximately 100 megawatts (electric). This electrical requirement for operation of an NPR at INEL or SRS might be supported by fossil-fueled power generation, which would produce up to 1 million t/yr of carbon dioxide. Thus, activities associated with construction and operation of an NPR would make a contribution of about 0.01% to total U.S. emissions of a gas (carbon dioxide) 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 as described in this EIS may involve the use of Freon-113 (trichlorotrifluoromethane), trichloroethane (TCA), and trichloroethylene (TCE), and potentially small quantities of these trace gases would be emitted to the atmosphere during NPR operations. 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, the ozone-depleting gases produced by NPR operations (up to 70 t/yr) would constitute only a very small fraction of the approximately 400,000 t of chlorofluorohydrocarbons produced yearly in the United States.

S.7.2 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, Hanford 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 of either 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 U.S. 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 would not be 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 U.S. Fish and Wildlife Service.

3.7.3 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 for species of special concern and are important for their floodplain values and their role in maintaining the stability of hydrological and ecological systems. Construction of NPR facilities at SRS has the potential 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. 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 disturbed during construction would be replaced. Any such wetland mitigation plan would be developed in consultation with the U.S. Army Corps of Engineers.

Operations of the NPR at SRS also could impact wetlands. The release of cooling-tower blowdown water 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. However, during the cooler periods of the year, the temperature differential between Fourmile Branch and the NPR blowdown discharge might not meet the state requirement of no more than a 2.8°C temperature differential at the point of discharge, and a Section 316a demonstration for a balanced biological community would be required under the Clean Water Act. (It is also possible that blowdown water could be discharged to Par Pond rather than Fourmile Branch; this is suggested as a possible mitigation measure.) 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.

S.8 UNAVOIDABLE ADVERSE IMPACTS

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 would 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 materials, 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 accidently 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.